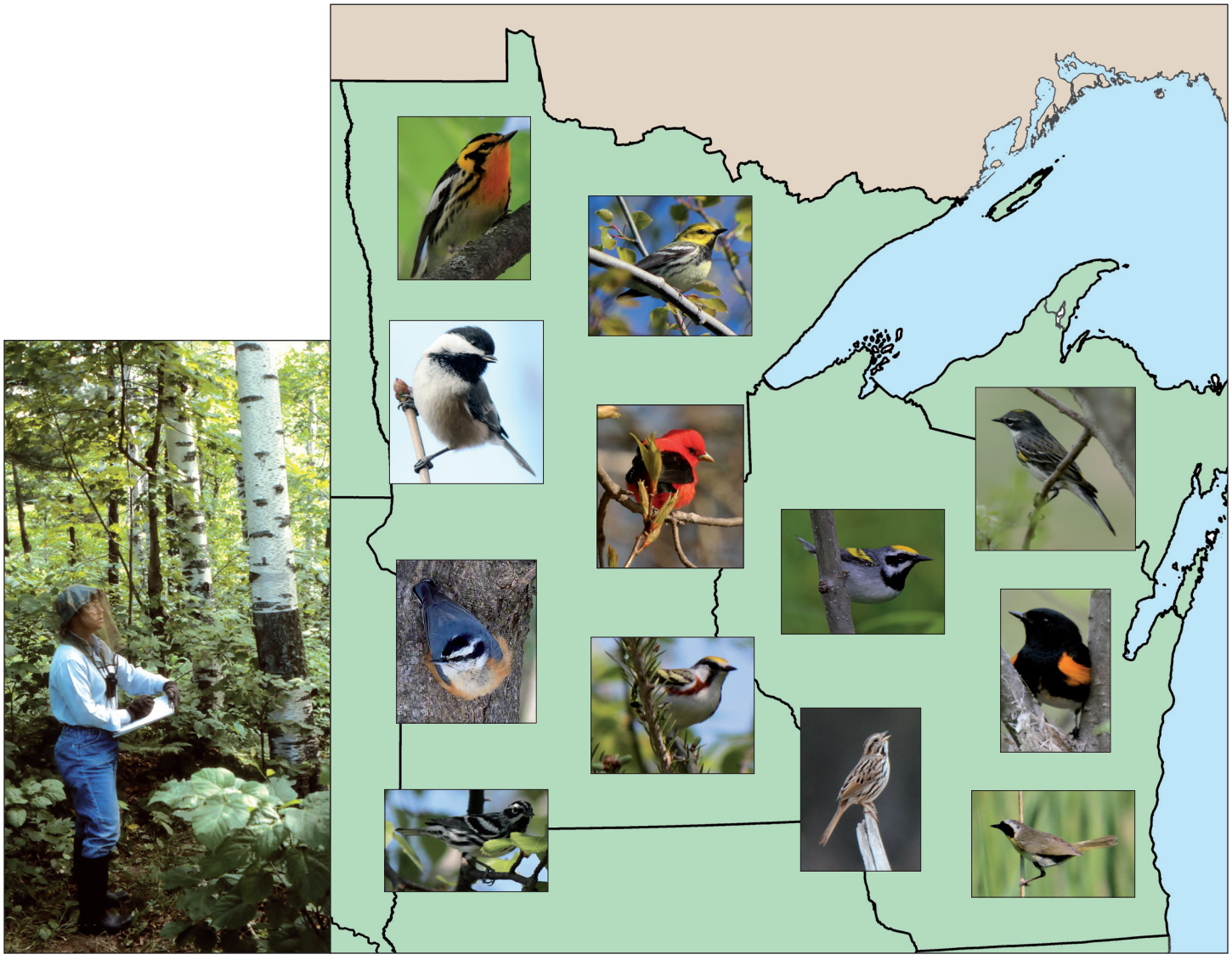
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Analysis of Long-term Forest Bird Monitoring Data from National Forests of the Western Great Lakes Region



Forest Service

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ABSTRACT

Breeding bird communities in forests of the western Great Lakes region are among the most diverse in North America, but the forest environment in this region has changed dramatically during the past 150 years. To address concerns about loss of biodiversity due to ongoing forest harvesting and to better inform forest planning, researchers have systematically monitored forest birds in the region for more than two decades. This report summarizes forest bird data collected from 1995 through 2011 in four national forests of the western Great Lakes region (the Chequamegon and Nicolet in Wisconsin and the Chippewa and Superior in Minnesota). Of 187 bird species detected, 127 nest in forest or woodland habitats. Population trends were evaluated by national forest for 98 of the forest bird species, and across all 4 national forests for 49 species. Numbers of most species were stable or increased within and across the national forests during these 17 years. Habitat analyses are presented for 123 forest bird species and are discussed in the context of concurrent trends in climate, land cover, disturbance, and forest structure. Results suggest that different migratory guilds showed different responses to the regional warming during this period. Eight species that were in decline or otherwise of special concern were selected to demonstrate how knowledge gained from analysis of their populations, habitat, and life history could supplement current literature to inform regional conservation management. Ways to improve or optimize the bird monitoring methods are suggested. This report is the most comprehensive compilation to date of quantitative information on the population trends, habitat use, and community assemblages of forest breeding birds of this region.

Cover Photos:

Chippewa, Superior, and Chequamegon National Forest Bird Survey counter; bird species, top to bottom, left to right: Blackburnian warbler, black-capped chickadee, red-breasted nuthatch, black-and-white warbler, black-throated green warbler, scarlet tanager, chestnut-sided warbler, golden-winged warbler, song sparrow, yellow-rumped warbler, American redstart, and common yellowthroat. Photo at far left by Carol Carter, used with permission; red-breasted nuthatch by Gary Garton, used with permission; scarlet tanager by Sparky Stensaas, www.ThePhotoNaturalist.com, used with permission; all other photos by Edmund Zlonis, Natural Resources Research Institute, used with permission.

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TABLE OF CONTENTS

Executive Summary 1

Introduction 3
- History of the Surveys 4
- Study Areas 5
- Habitat and Landscape Perspectives 6

Methods 9
- Sample Design 9
- Breeding Bird Counts 12
- Population Analyses 14
- Community Analyses 18
- Habitat Associations 19
- Ecological Context 23
- Demonstration Species 24

Results 25
- General Trends in Bird Abundance and Species Richness 27
- Comparison of Forest Bird Communities Among National Forests 28
- Individual Species Trends 29
- Trends in Breeding Bird Guilds 37
- Comparison of National Forest Trends with USGS Breeding Bird Surveys 37
- Habitat Associations 40
- Community Assemblages 41
- Regional Distributions 45
- Ecological Context 46

Discussion 53
- Species Detection and Trends 53
- Habitat and Community Associations 55
- Limitations and Monitoring Recommendations 55
- Ecological Context 57
- Demonstration Species 60
- Gaps in Knowledge 67

Concluding Remarks 71

Acknowledgments 73

Literature Cited 75

Appendix 1. Average Abundances of 187 Bird Species in Point Counts at 4 National Forests in the Western Great Lakes Region 89

Appendix 2. Summary of the 20 Most Common Bird Species by Habitat Cover Type in 4 National Forests in the Western Great Lakes Region 93

Appendix 3. Percent Perfect Indication Values with Respect to 20 Habitat Categories for 123 Bird Species Recorded in 4 National Forests in the Western Great Lakes Region, 2001–2010 124

Appendix 4. Migration, Nesting, and Habitat Preferences of 98 Bird Species in 4 National Forests in the Western Great Lakes Region 132

Appendix 5. Summary of Species Life History Information, Abundance Trends, and Habitat Distribution for 90 Bird Species in 4 National Forests in the Western Great Lakes Region 137

Appendix 6. Participants in Bird Counts in the Cheqamegon, Chippewa, Nicolet, and Superior National Forests, 1988–2011 318

EXECUTIVE SUMMARY

Bird monitoring programs in four national forests (NFs) of the western Great Lakes region (the Chequamegon and Nicolet in Wisconsin and the Chippewa and Superior in Minnesota) have documented trends in forest bird abundances across multiple forested habitats and helped inform the development of management policies and conservation initiatives. This report summarizes forest bird monitoring data gathered over 20 yr within these four NFs, providing one of the most comprehensive, long-term analyses of regional bird populations in North America. A database containing all of the raw data collected from 1991 through 2011 is available (Niemi et al. 2015) and will be updated periodically as new observations are added. We document population trends for forest birds within each of the NFs and the NFs combined; summarize the distribution, relative abundance, and habitat use of species occurring regularly within the NFs; provide an ecological context and discuss management implications of the observed patterns both generally and specifically for eight demonstration species; and identify gaps in knowledge and future issues of concern for forest birds of the region.

More than 200 species of birds breed regularly in the forests of the western Great Lakes region. Systematic surveys of breeding birds were begun in the eastern (Nicolet) portion of the Chequamegon-Nicolet NF in 1987, the western (Chequamegon) portion of the Chequamegon-Nicolet NF in 1992, the Chippewa NF in 1991, and the Superior NF in 1991. Standardized, 10-min point counts in these forests have been conducted annually at 1,403–1,475 permanent, georeferenced points since 1995. These surveys recorded 187 bird species, 127 of which nest in forest or woodland habitats. Among the 187 species recorded, 98 had acceptable sample sizes to test the significance of population trends, and 123 species were included in habitat analyses. Other rare, secretive species and species requiring specific methods for detection such as owls and waterfowl were excluded from our analyses due to inadequate detection and low sample size.

Species trends were generally consistent across the region. Most species had stable or increasing numbers within and among these NFs from 1995 through 2011. Four species significantly increased since 1995 in all four NFs: yellow-bellied sapsucker, blue jay, red-breasted nuthatch, and ovenbird. Nineteen species exhibited significant increases in two or more NFs and either no significant change or insufficient numbers in the others. Five of these 19 species are permanent or semi-permanent residents and 7 are short-distance migrants. No species declined significantly in all four forests, but five species (great crested flycatcher, Connecticut warbler, scarlet tanager, song sparrow, and evening grosbeak) declined significantly in two or three forests. Among the 49 species for which we were able to calculate a pooled trend for all 4 NFs, 25 showed a significant increase, 4 showed a significant decrease, and 20 showed no significant trend in counts between 1995 and 2011. Direct comparison with the U.S. Geological Survey's Breeding Bird Survey (BBS) roadside survey routes sampled between 1995 and 2010 indicated both poor correlations between trends estimated by each survey and greater power of the NF surveys to detect significant population trends. These results suggest the BBS with its current density of roadside routes cannot serve as a substitute for the more detailed point count surveys described here to estimate bird species trends for an area the size of these NFs.

Habitat associations and geographic distributions of breeding birds in this region are complex. Nearly all land bird species (about 80 percent of which are migratory) occur in a range of habitat types, and many species differ in abundance across the four NFs. We used indicator species analysis to document habitat affinities of species recorded in at least 10 point locations across all 4 NFs (n=123). In most cases, bird associations among 20 widespread habitat types were statistically significant and are consistent with known avian life history attributes. These species-habitat associations, combined with climate data and results from other bird surveys in the region, provided the basis for generating species distribution maps for the Laurentian Mixed Forest Province of Minnesota, Michigan's Upper Peninsula, and Wisconsin. At the community level, we also used multivariate cluster analyses to identify bird species assemblages irrespective of the 20 habitat/land cover categories. Together these results illustrate the relative importance of habitat, climate, geography, and human development as drivers of bird species distributions in the study area. The several appendixes contain basic information and additional analyses: average abundance values for all species observed during the counts (Appendix 1); abundance and frequency of common birds observed by habitat type (Appendix 2); an analysis of strength of indicator species by habitat type (Appendix 3); ecological attributes of the 98 bird species included in trend analyses (Appendix 4); guild information, trends, habitat profile, and regional probability distribution (if available) for 90 of the 98 species (Appendix 5); and a list of all participants in bird counts in each forest (Appendix 6).

Although a full analysis of climate and forest management effects on bird populations was beyond the scope of this report, concurrent trends in climate, land cover, disturbance, and forest structure provided context for the observed bird species trends. Notably, temperatures increased across the region during the survey period—particularly in winter, mid-spring, and mid-summer. Bird trend analyses suggest that different migratory guilds may have had differential responses to the regional warming trends. We found circumstantial evidence that insect outbreaks may have influenced populations of certain bird species, and two moderate drought years may have affected breeding bird populations more generally. Timber harvest activity has declined across each of the NFs, with concurrent decreases in open land cover types that may have contributed to the relative stability in trends for bird species associated with mature forests as compared with those species associated with open and early successional habitats.

Development of management guidelines based on the occurrences of 123 forest bird species is a significant challenge in light of other, sometimes competing, beneficial uses of the NFs. We selected eight demonstration species that were in decline or otherwise of special concern in the NFs to illustrate how species population trends, community relationships, and habitat affinities can be coupled with published literature to guide conservation management strategies on a regional scale. We further suggest areas where the bird monitoring methods may be improved or optimized.

In conclusion, this document represents the most comprehensive volume of quantitative information ever compiled on the trends, habitat use, and community assemblages of forest breeding birds of the western Great Lakes region. The results suggest that overall breeding bird populations of many species were stable or increasing between 1995 and 2011, with relatively few species indicating declining trends over these 17 yr. These results have important implications for the regional health of forest communities in this hotspot of avian diversity. Knowledge, planning, and ongoing monitoring will be essential to maintain healthy forest bird communities in the face of inevitable natural and anthropogenic changes in the region.

INTRODUCTION

The breeding bird communities of forests in the western Great Lakes region are among the most diverse in North America (Green 1995, Howe et al. 1997a, Robbins et al. 1986). Migrant wood warblers, New World flycatchers, and thrushes have particularly high diversity in these forests (Price et al. 1995). The importance of this rich avifauna coupled with evidence of declines of some species, especially Neotropical migrants (Terborgh 1992), has led to a strong interest in inventorying and monitoring forest bird populations in the region (Matteson et al. 2009). In addition, the concerns about loss of biological diversity in the United States' Pacific Northwest in the late 1980s and early 1990s (Lamberson 1992), concern about increased forest harvesting such as that occurring in Minnesota (Jaakko Pöyry Consulting 1992), and growing public demand for informed forest planning (Kohm and Franklin 1997) motivated researchers to start a forest bird monitoring program in this region.

Systematic monitoring of breeding bird populations provides a necessary foundation for assessing the conservation status of species (Robbins et al. 1989). Breeding bird monitoring also serves as a way to measure the ecological condition of the forests (Gnass 2012, Gnass Giese et al. 2015) and provides an early-warning system for identifying potential threats to forest health (Niemi and McDonald 2004). Breeding bird trends and distributions have illuminated potential impacts of ecological stressors such as climate change (Hitch and Leberg 2007, Wiens et al. 2009), disease (LaDeau et al. 2007), forest fragmentation (Aldrich and Coffin 1980), and disturbances on avian wintering grounds (Sanderson et al. 2006). Monitoring of breeding bird populations in the western Great Lakes region is especially important because the heavily forested landscapes of northern Minnesota and Wisconsin have been identified as population "sources" for many forest bird species and may be compensating for population "sinks" in the agricultural landscapes of the lower Midwest (Donovan et al. 1995, Robinson et al. 1995, Temple and Flaspohler 1998).

Analyses of avian population trends and habitat preferences are potentially valuable tools for assessing forest health and the cumulative impacts of regional forest policies. Forest management practices clearly can have an effect on the composition and sustainability of bird communities in the western Great Lakes national forests (NFs) (Niemi et al. 1998). General and specific guidelines have been published for the management of forest birds in this region (e.g., DeGraaf and Evans 1979, Green 1995, Howe et al. 1997a, Matteson et al. 2009, U.S. Forest Service 2004, Wisconsin Department of Natural Resources [WDNR] 2005). Avian monitoring programs such as the U.S. Geological Survey (USGS) Breeding Bird Survey (BBS) are in place to track large-scale avian population change and continental distribution patterns. But limited coverage in some areas weakens the utility of BBS data for characterizing local or regional population trends (Peterjohn et al. 1995). Furthermore, continental trends may mask important regional population trends that are significant for conservation strategies (Holmes and Sherry 1988). Regional monitoring programs provide information about landscape-scale population dynamics and bird-habitat associations that are not adequately addressed by either continental or short-term, local investigations (Howe et al. 1997b).

Bird monitoring programs were established within four NFs of the western Great Lakes region (the Chequamegon and Nicolet in Wisconsin and the Chippewa and Superior in Minnesota) to document trends in forest bird abundance across the range of forested habitats in these NFs. Our primary objectives were to: 1) document population trends for forest birds within each of the NFs and the NFs combined; 2) summarize the distribution, relative abundance, and habitat use of species occurring regularly within the NFs; 3) provide an ecological context and discuss management implications for the observed patterns, both generally (i.e., community-wide) and for eight specific demonstration species; and 4) identify gaps in knowledge and future issues of concern for forest birds of the region. These objectives set the stage for more detailed and comprehensive analyses of the population trajectories of individual bird species in relation to underlying drivers affecting their abundance and breeding success in the region.

History of the Surveys

The U.S. Forest Service is mandated to monitor the status of federally endangered and threatened species and focal species (i.e., management indicator species) that indicate ecological conditions of each NF (Manley et al. 1993). The National Forest System Land Management Planning Rule of 2012 further clarifies the agency's responsibility for maintaining a viable population of each species of conservation concern and for developing plans for sustaining "ecosystems and watersheds with ecological integrity and diverse plant and animal communities." In response to earlier versions of this mandate, breeding bird monitoring programs were established in 1987 in the former Nicolet NF, in 1991 in the Chippewa and Superior NFs, and in 1992 in the Chequamegon NF. The Chequamegon and Nicolet NFs were combined into one NF in 1993; however, bird data are reported separately for these administrative units to preserve the historical and spatial integrity of the respective datasets.

These bird monitoring programs were specifically designed to complement the USGS BBS by strategically and systematically sampling forest habitat types away from edges associated with roads (where BBS routes are located) using standardized point-count methods. Nicolet NF bird surveys (Howe and Roberts 2005) were conducted during a single weekend every June by volunteer groups, each led by at least one bird identification expert. In contrast, bird surveys in the Chequamegon, Chippewa, and Superior NFs were spread over the breeding season (late May to early July) with counts completed by experienced observers from the Natural Resources Research Institute at the University of Minnesota Duluth (Niemi et al. 2012). These data are compatible because they are based on 10-min point counts, with some minor differences described later in the "Methods" section. Results from all 4 administrative units (Chippewa, Superior, Chequamegon, and Nicolet) have been combined here for the first time, providing an unprecedented regional database consisting of more than 1,400 sampling locations monitored for more than two decades. This database is available to the public (Niemi et al. 2015) and will be updated periodically as additional data are collected.



Nicolet National Forest Bird Survey volunteer sketching bird locations during a 10-minute point count. Photo by Scott Giese, used with permission.

Study Areas

Chippewa National Forest

The Chippewa NF, located in north-central Minnesota (Fig. 1), was established in 1908. It includes more than 260,000 ha (1 ha = 2.47 acres) of forested uplands, plus 1,300 lakes and ponds (including the massive Leech, Winnibigoshish, and Cass Lake systems), more than 1,500 km (1 km = 0.62 mi) of running water, and more than 178,000 ha of wetlands, making it one of the

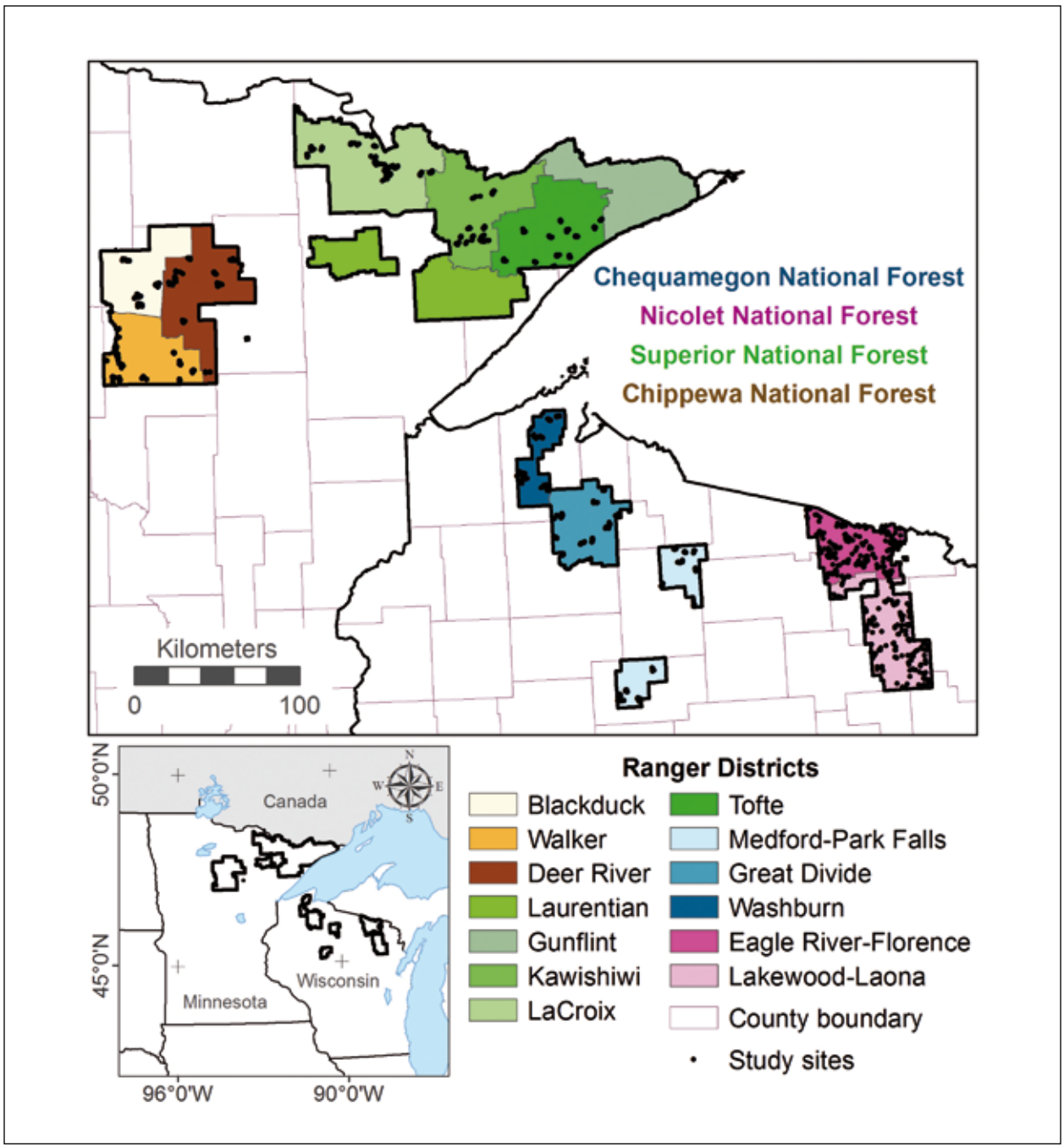


Figure 1.—Sample site locations stratified by administrative units of the four national forests. The Chippewa, Superior, and Chequamegon National Forests appear to have fewer sample points, but this is not the case because three points were sampled per stand and stands were grouped into clusters for logistical reasons. The clusters appear close or may overlap at the scale of this map.

most aquatic in the U.S. Forest Service system. The forest is situated on the Continental Divide, with the northern portion of the forest within the Hudson Bay-Arctic Ocean watershed, and the southern portion in the Mississippi River-Gulf of Mexico watershed. Each national forest has a "proclamation boundary" originally established to create a target area for land acquisition; this boundary represents the outer boundary for a given NF and contains lands of multiple ownerships. Of the NFs monitored in this report, the Chippewa NF contains the most diverse land ownership within its proclamation boundary. The U.S. Forest Service manages about 41 percent of the land area, and more than 75 percent of the land area is within the proclamation boundaries of the Leech Lake Indian Reservation.

Superior National Forest

The Superior NF, established in 1909, comprises more than 1,580,000 ha including more than 440,000 ha of the Boundary Waters Canoe Area Wilderness (Fig. 1). The Superior NF represents a significant portion of the northeastern "Arrowhead" region of Minnesota. The forest also includes over 180,000 ha of open water with more than 2,000 lakes and more than 3,500 km of streams. The forest is located on the Canadian Shield and includes the Laurentian Divide, which separates the Great Lakes-Atlantic Ocean watershed from the Hudson Bay-Arctic Ocean watershed. The forest has many lakes with thin glacial deposits over bedrock; hummocks of undulating plains with deep glacial drift; and large, poorly drained peatlands. The proclamation boundary of the Superior NF contains a patchwork of land ownerships, such as territory ceded by the Ojibwe in the Treaty of 1854, state- and county-owned forest, private inholdings, and both incorporated and unincorporated towns and townships. Unlike the other NFs surveyed, bird sample locations do not cover all administrative units within the Superior NF (Fig. 1).

Chequamegon-Nicolet National Forest

The Chequamegon and Nicolet NFs were each established in 1933 and were combined into one administrative unit in 1993. The Nicolet NF comprises the eastern administrative units of the Chequamegon-Nicolet NF in northern Wisconsin and covers 267,659 ha in Florence, Forest, Langlade, Oconto, and Oneida Counties (Fig. 1). The Chequamegon NF, located in northwestern and north-central Wisconsin, covers nearly 351,771 ha and is composed of three geographically separated units. Forest bird surveys in these areas were initiated by different principal investigators (Nicolet: Howe; Chequamegon: Niemi) before their administrative merger. The proclamation boundary of the Chequamegon-Nicolet NF encompasses numerous parcels of privately owned land, including commercially managed forests and nonforested agricultural uplands. The area also contains many rural unincorporated townships, state and county forests, territory ceded by the Ojibwe in the Treaty of 1854, and 1,200 parcels owned by the Wisconsin Board of Commissioners of Public Lands. Nonetheless, all but a few points in the Nicolet portion of the NF (in special habitats like towns and open fields) were located on Forest Service property. Surficial geology of northern Wisconsin consists of a complex mosaic of glacial moraines, drumlins, outwash plains, depressions, and scoured bedrock ridges (Albert 1995), with abundant nonforested peatlands, open marshes and meadows, more than 2,000 lakes, and roughly 440 spring ponds. The Chequamegon-Nicolet NF includes parts of six ecological landscapes as defined by the WDNR (2013).

Habitat and Landscape Perspectives

The four NFs[1] lie within the Laurentian Mixed Forest Province (Bailey et al. 1994). This province broadly includes northern Minnesota, Wisconsin,

[1] Although the two Wisconsin NFs were combined to form the Chequamegon-Nicolet NF in 1993, bird data are reported separately for these administrative units to preserve the historical and spatial integrity of the respective datasets. Most forest inventory data are also reported separately.

Michigan, and southern Ontario as well as the less mountainous regions of Pennsylvania, New York, and New England. The province represents a transition zone between three biomes: the Eastern Temperate Forest biome to the south and east, the Boreal Forest biome to the north, and the Grassland biome to the west (Pastor and Mladenoff 1992). Quaternary geology and mesoclimatic gradients are the primary determinants of environmental variation in the region. The Superior NF, where variation in soil moisture is primarily determined by depth to bedrock over the Canadian Shield, contains more diverse topography than the other forests monitored (Sturtevant et al. 2012). Surficial geology of the remaining NFs is dominated by glacial moraines and associated till, including some extensive sandy outwash plains located within the Chequamegon and Nicolet NFs (U.S. Forest Service 2012b). The region falls within Bailey's (1998) Warm Continental Division, which is characterized by humid, warm summers and cold winters. Winter temperatures generally increase from north to south, whereas summer temperatures increase from northeast to southwest, and precipitation increases from west to east (Host and Polzer 1995). Both natural and human-induced disturbances, including urban and exurban development, continue to be the major drivers of change within the forests and landscapes of the province (Mattson and Schriner 2001, Wolter and White 2002).

Before Euro-American logging and settlement in the 19th century, fire and wind disturbance shaped the forest mosaic of this region (Mladenoff et al. 1997, Pastor and Mladenoff 1992). Presettlement vegetation for the forested uplands of the NFs in Minnesota was dominated by a combination of pine (*Pinus* spp.) forest types, aspen (*Populus* spp.)-birch (*Betula papyrifera*), and mixed deciduous-coniferous forests containing spruce (*Picea mariana*, *P. glauca*) and balsam fir (*Abies balsamea*) (Friedman et al. 2001). Presettlement vegetation for the forested uplands of the NFs in Wisconsin consisted mainly of northern hardwoods and mixed-conifer forest dominated by sugar maple (*Acer saccharum*), eastern hemlock (*Tsuga canadensis*), American basswood (*Tilia americana*), yellow birch (*Betula alleghaniensis*), and white pine (*P. strobus*) on glacial moraine deposits (White and Mladenoff 1994) and pine systems containing jack pine (*P. banksiana*), red pine (*P. resinosa*), and oaks (*Quercus ellipsoidalis*, *Q. macrocarpa*) on sandy outwash plains (Radeloff et al. 2000). All NFs in the western Great Lakes region were established to help reforest lands and watersheds extensively logged and burned in the 19th century.

Second-growth forests following the logging era were more homogeneous than primary forests of presettlement landscapes, with widespread declines in coniferous forest types (primarily white pine, red pine, and eastern hemlock) and increases in deciduous forest types (primarily aspen and sugar maple) (Schulte et al. 2007). Much of today's coniferous forest cover was established in widespread plantations of red pine, jack pine, and white spruce. All of the NFs in the region are covered by significant areas of lowland forests, such as lowland conifers (black spruce, balsam fir, tamarack [*Larix laricina*], or northern white cedar [*Thuja occidentalis*]) and lowland hardwoods (primarily black ash [*Fraxinus nigra*] and American elm [*Ulmus americana*]).

Widespread fire suppression has largely removed fire as a regional disturbance force (Sturtevant et al. 2004), although the rare large fires that escape control can have lasting effects on landscape structure and composition, particularly on sandy outwash plains (Radeloff et al. 2000) and dry boreal jack pine and spruce-fir forests (Sturtevant et al. 2012). Wind is an important natural disturbance throughout the region. Among its many forms are tornadoes and straight-line thunderstorm winds ranging in scale from microbursts to downburst families (known as derechos) that can damage hundreds of thousands of hectares (Frelich 2002). Timber harvest activity by contrast is generally more consistent from year to year and remains the prevalent form of stand-replacing disturbance within these managed forests

(Sturtevant et al. 2014). Clearcut harvest practices still dominate forestry activities in northern Minnesota (D'Amato et al. 2009), whereas a mixture of harvest techniques, such as selection harvest within northern hardwood forest types, has been applied in the Wisconsin NFs. Insect disturbances are also common within this region. In particular, three native forest defoliators cause widespread damage across the region: spruce budworm (*Choristoneura fumiferana*), particularly within the Superior NF; jack pine budworm (*Choristoneura pinus pinus*); and forest tent caterpillar (*Malacosoma disstria*).

With few exceptions, the NFs of the western Great Lakes region share the same tree species but differ in the relative abundances of forest types within their borders. Deciduous cover is dominated by aspen-birch forest types in the Minnesota NFs and by northern hardwood forest types in the Wisconsin NFs (Fig. 2). Oak forest types are present in small amounts in all NFs. Upland spruce-fir is common within the Minnesota NFs, especially the Superior NF, and rare within the Wisconsin NFs. The Nicolet NF is the most heavily dominated by deciduous forests (83 percent of upland forest cover), whereas the Superior NF has the most coniferous forest cover (approximately evenly distributed among deciduous, mixed, and coniferous forested uplands). The Chippewa NF is closest to the Prairie biome and has the most nonforested uplands and open wetlands of the NFs in this study. Forested wetlands are an important component of all these NFs, accounting for 25 to 35 percent of the land cover.

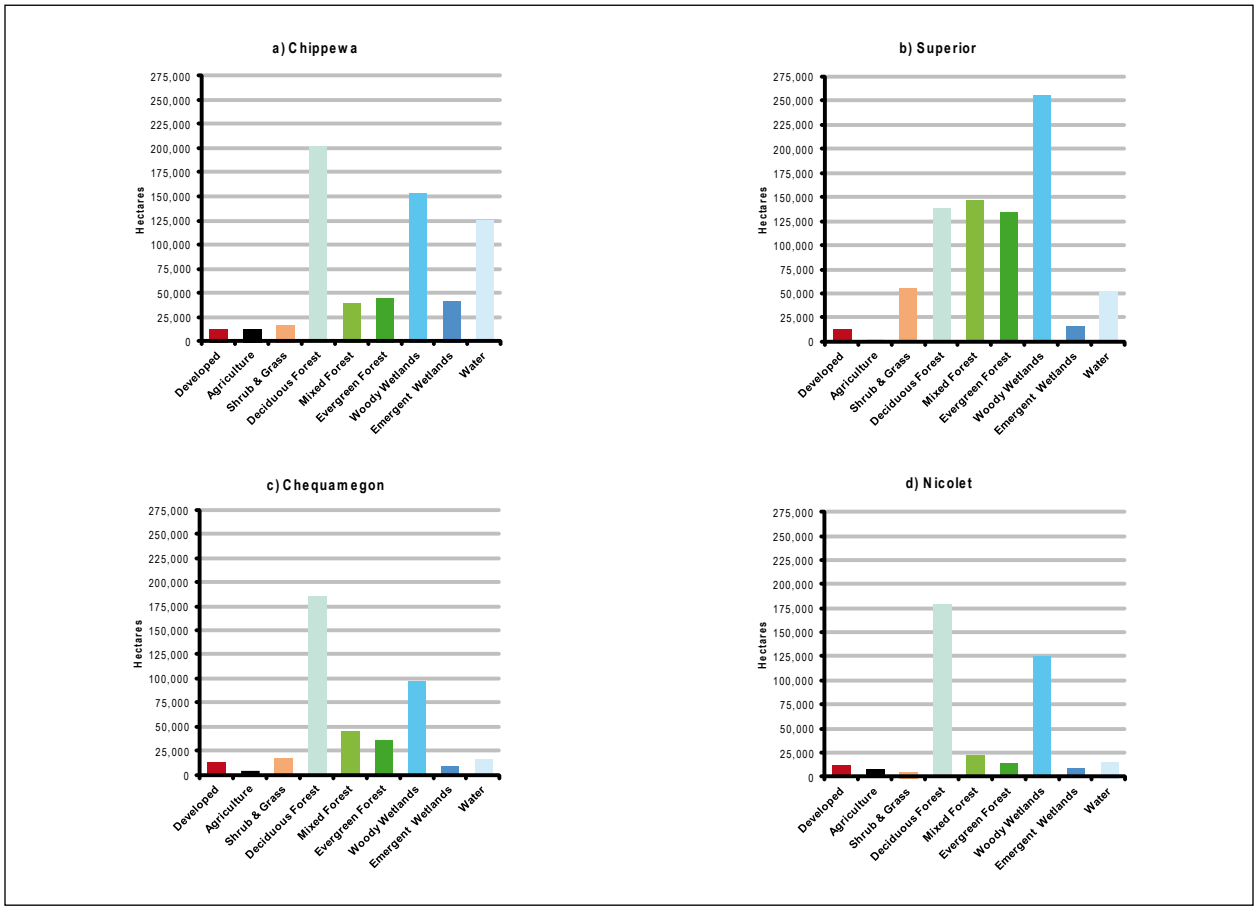


Figure 2.—Summary of land use classes in four national forests based on National Land Cover data for 2001 (Fry et al. 2009, 2011; Homer et al. 2001).

METHODS

Sample Design

Bird monitoring programs within NFs in northern Minnesota and Wisconsin were originally designed to: 1) establish an inventory of local breeding bird assemblages to inform the forest planning process, 2) monitor population changes of forest bird species over time, and 3) identify bird-habitat associations, particularly those relevant to regional forest management policies. We describe first the design used in the Chippewa, Superior, and Chequamegon NFs, and then the different approach used in the Nicolet NF. The sample design was constrained to points located on NF lands, except for special habitats (e.g., towns, open fields).

Chippewa, Superior, and Chequamegon National Forests

In a classic paper on bird counting techniques, Verner (1985) concluded that greater care in planning and executing counts of birds should include prior consultation with biometricians, training of personnel, and testing of the bird identification skills and sensory capabilities (e.g., hearing) of field observers. Our design in the Chippewa, Superior, and Chequamegon NFs adheres to these recommendations and has been peer-reviewed as part of national breeding bird monitoring meetings (Hanowski and Niemi 1994, Hanowski et al. 2005) and in several publications (e.g., Etterson et al. 2009, Lapin et al. 2013).

We distributed sampling locations across the forest mosaic in a stratified random manner in consultation with a statistician (R. Regal, University of Minnesota Duluth). For each NF, stands ≥16 ha were grouped from their respective compartment inventories into strata defined by dominant tree species (i.e., forest cover type) and stocking density. Because the Superior NF is large, we randomly selected three of the six districts to sample (Tofte, Kawishiwi, and LaCroix). We also excluded the Boundary Waters Canoe Area Wilderness because there is no timber management and the area is difficult to reach. For each NF, stands were randomly selected from each stratum so the final proportion of stands was equal to the proportion of forested land area of each cover type and stocking density for each of the NFs (Tables 1 and 2) (Hanowski and Niemi 1994). A total of 135, 169, and 133 stands were originally selected in the Chippewa, Superior, and Chequamegon NFs, respectively. Thirteen habitat types were sampled in the Chippewa NF, 12 habitat types in the Superior NF, and 17 habitat types in the Chequamegon NF (Table 3).

Table 1.—Number of sample points and total number of point counts (in parentheses) during two decades in four western Great Lakes national forests

	Decade	
Forest	1991–2000	2001–2010
Chippewa	420 (3,888)	399 (3,840)
Superior	525 (4,854)	566 (5,033)
Chequamegon	407 (3,470)	391 (3,818)
Nicolet	320 (1,562)	317 (1,566)
Total	1,672 (13,774)	1,673 (14,257)

Table 2.—Crosswalk of habitat classifications used in Appendix 2 (breeding birds by 29 habitat types) and the 20 habitat categories used in indicator species analysis (Appendix 3)

Habitat cover type in Appendix 2	Appendix 3—indicator species	Abbreviation
Pole-size aspen-birch forest	Aspen-birch forest	AspBir
Mid-successional aspen-birch forest	Aspen-birch forest	AspBir
Mature aspen-birch forest	Aspen-birch forest	AspBir
Pole-size aspen-spruce-fir forest	Aspen-spruce-fir forest	AspSprFir
Mid-successional aspen-spruce-fir forest	Aspen-spruce-fir forest	AspSprFir
Mature aspen-spruce-fir forest	Aspen spruce-fir forest	AspSprFir
Mature beech-maple-birch forest	Beech-maple-birch forest	BeMapBir
Mature black spruce-tamarack forest	Black spruce-tamarack forest	BSprTam
Mature hemlock forest	Hemlock forest	Hemlock
Pole-size jack pine forest	Jack pine forest	Jack Pine
Mid-successional jack pine forest	Jack pine forest	Jack Pine
Mature jack pine forest	Jack pine forest	Jack Pine
Mature lowland hardwood forest	Lowland hardwood forest	LHwds
Lowland shrub habitat	Lowland shrub habitat	Lshrub
Mature oak forest	Oak forest	Oak
Open dry habitat	Open dry habitat	OpenDry
Open wet habitat	Open wet habitat	OpnWet
Pole-size red pine forest	Red pine forest	Red Pine
Mid-successional red pine forest	Red pine forest	Red Pine
Mature red pine forest	Red pine forest	Red Pine
Regenerating conifer forest	Regenerating conifer forest	RegCon
Regenerating nonconifer forest	Regenerating nonconifer forest	RegNCon
Sedge habitat	Sedge meadow	Sedge
Mature swamp conifer forest	Swamp conifer forest	SwmpCon
Urban habitat	Town	Town
Mid-successional upland hardwood forest	Upland hardwood forest	UpHwds
Mature upland hardwood forest	Upland hardwood forest	UpHwds
Open water habitat	Water	Water
Mature white pine forest	White pine forest	W Pine

Nicolet National Forest

A different monitoring approach was used on the Nicolet NF (Howe and Roberts 2005). In June 1987, U.S. Forest Service biologists, scientists from the University of Wisconsin-Green Bay, and members of the Northeastern Wisconsin Audubon Society organized a volunteer bird monitoring event for 65 bird monitoring points in the southern two districts (Lakewood and Laona) of the Nicolet NF. Success of this effort led to the establishment of 116 points in the northern districts (Eagle River and Florence), which were sampled by a larger group of volunteers the next year (1988). More points were added in 1989 and 1990, leading to the current array of 152 points in the southern half

Table 3.—Distribution of bird survey points among 20 habitat categories in 4 western Great Lakes national forests (NFs), 2001–2010

Habitat category	Chippewa NF	Superior NF	Chequamegon NF	Nicolet NF
Aspen-birch forest	62 (13.9)[a]	142 (26.3)	25 (6.0)	35 (11.0)
Aspen-spruce-fir forest	8 (1.8)	83 (15.4)	16 (3.9)	17 (5.2)
Beech-maple-birch forest	--	5 (0.9)	3 (0.7)	12 (3.6)
Black spruce-tamarack forest	46 (10.3)	17 (3.2)	13 (3.1)	16 (4.9)
Hemlock forest	--	--	26 (6.3)	15 (4.6)
Jack pine forest	16 (3.6)	44 (8.2)	9 (2.2)	12 (3.6)
Lowland hardwood forest	31 (7.0)	--	21 (5.1)	9 (2.7)
Lowland shrub	--	--	3 (0.7)	23 (7.0)
Oak forest	28 (6.3)	--	21 (5.1)	9 (2.7)
Open dry habitat	15 (3.4)	12 (2.2)	29 (7.0)	16 (4.9)
Open wet habitat	--	--	--	9 (2.7)
Red pine forest	79 (17.7)	34 (6.3)	47 (11.0)	22 (6.7)
Regenerating conifer forest	34 (7.6)	34 (6.3)	10 (2.4)	7 (2.1)
Regenerating nonconifer forest	47 (10.5)	112 (20.8)	25 (6.0)	9 (2.7)
Sedge meadow	--	--	3 (0.7)	4 (1.2)
Swamp conifer forest	51 (11.4)	34 (6.3)	34 (8.2)	19 (5.8)
Town	--	--	--	6 (1.8)
Upland hardwood forest	17 (3.8)	9 (1.7)	117 (28.0)	72 (22.0)
Water (edge of lake or river)	--	--	--	8 (2.4)
White pine forest	12 (2.7)	13 (2.4)	12 (2.9)	9 (2.7)
Total	**446**	**539**	**414**	**329**

[a] Numbers in parentheses indicate the percentage of points for the respective NF. Note that a given locality might be represented in more than one category if the habitat changed (e.g., as a result of clearcutting, natural disturbance, or ecological succession) during the study period. If the habitat did not change from 2001 to 2010, the point is represented only once. Habitat types shown in bold are considered forest/woodland habitats. These 1,728 point locations were used for indicator species (percent perfect indication) analysis and community analysis. Dashes indicate that no survey points were located in that category in the NF.

of the forest and 165 points in the northern half. These "habitat-based points" represent the major vegetation or landform types recognized by the U.S. Forest Service land classification database (Table 2, Appendix 2).

For each habitat type, point selection was based on two criteria: contiguous area of the target habitat (usually >6 ha) and accessibility (Howe et al. 1994). Large areas of fairly uniform habitat that could be reached with a short hike from a road were selected whenever possible; typically the bird census points are located 100–200 m off roads within the target habitat. Because of the wide variation in size and configuration of stands, these points were not placed within the centroid of the stand per se, but were placed such that the habitat within a minimum radius of 125 m was representative of the stand. Some of the points (<5 percent) were located at ecotones between riparian zones, lakes, or wetlands and adjacent forest. The selection process took into account sampling logistics; sample points were organized into local groups of 5–7 points to minimize travel time. In all but one case, selected points were located at least 500 m from any other point (the exception consists of two points more than 250 m apart).

Although this selection process did not use a rigorous stratified random approach, it was designed (like that in the other NFs) to represent habitats and geographic regions roughly in proportion to their extent. Uncommon habitats were sampled by a minimum of 4–10 points even if they covered a lower proportion of the NF area. Whenever possible, habitat classifications were changed over time to reflect the modifications to the habitat; for example, when a mature aspen forest was logged, the point was reclassified as a regenerating forest (Table 3). Despite differences in site selection methods, the distribution of points in the Nicolet and Chequamegon NFs is remarkably similar (Table 3). A permanent marker (wooden post) was established at each Nicolet NF sampling point during the early 1990s. In 2002 a durable, numbered Carsonite® (Carsonite Composites, Newberry, SC) post was installed at the corresponding road access point. Beginning in 2002 field teams recorded global positioning system (GPS) coordinates at each survey point with best available recreation-grade GPS receivers.

The Nicolet NF bird survey sampled 20 different habitat types, many of which were similar to those in the Chequamegon NF (Table 3). Notably different from the other NFs is the rather large number of points (23) in lowland shrub habitats, primarily alder (*Alnus* spp.) thickets and woody peatlands. The Nicolet also is the only NF with points at lake or river edges (2.4 percent of all points), open marsh wetlands (2.7 percent), and rural towns (1.8 percent). Town points are located at parking areas adjacent to local landmarks such as post offices.

The sample points described above were visited during alternating years; points in the southern districts were sampled during odd-numbered years, and points in the northern districts were sampled during even-numbered years. In 1992 an additional 200 survey points were established at random locations (irrespective of habitat) along roads throughout the forest. From randomly selected geographic coordinates within the NF boundary, a straight line was projected to the nearest road. These "roadside points," 100 in the southern half of the forest and 100 in the northern half, were visited every other year until 2001. Since 2002 only the 317 habitat-based points have been monitored. None of these "roadside points" is included in any of the analyses presented here. We mention them only to document that the data are available for future analyses.

Breeding Bird Counts

Chippewa, Superior, and Chequamegon National Forests

In 1991 we established three point locations within each stand using the guidance for point counts available at the time (Ralph and Scott 1981, Reynolds et al. 1980). Point count locations were initially located at least 220 m apart and at least 100 m from the edge of the forest stand by using a combination of forest inventory maps and pacing (Blake et al. 1992; Hanowski et al. 1990, 1996). Sample points were subsequently recorded by using a recreation-grade GPS when the technology became available. Point counts were designed to be 10 min long, conducted by trained observers (see later paragraph on observer training), and completed from 0.5 hr before to 4 hr after sunrise on days with low wind (<15 km/hr) and light or no precipitation. All counts were conducted between late May and early June in the Chequamegon NF, early-to-mid June in the Superior NF, and late June to early July in the Chippewa NF. Before 1995, only birds recorded up to 100 m from the sample point were tallied. In 1995 we changed the protocol to include unlimited-distance sampling, but continued to estimate distances within 50 m, 100 m, and beyond 100 m following a series of coordination workshops (Howe et al. 1997b). The number of individuals observed for each species was recorded at 0- to 3-, 3- to 5-, and 5- to 10-min intervals. In 2010 we began to gather data at 1-min intervals after the first 2 min of sampling to gain a better understanding of bird detectability (Etterson et al. 2009). Bird counters were randomly assigned to forest stands so that each counter sampled about

the same number of stands of each forest cover type. Weather data (cloud cover, temperature, and wind speed) and time of day were recorded before each count.

Testing and training of counters has been an important component of the monitoring program. Before the field season, tapes or compact disks (CDs) of more than 120 bird songs were provided to all potential counters. Each counter was tested on his or her ability to pass an identification test of 75 bird songs. Songs on the tape were grouped by habitat (e.g., upland deciduous, lowland coniferous) to simulate field cues that would aid in song identification. A standard for number of correct responses was established by giving the test to observers who had 4–5 yr of field experience. Based on their results, the standard for passing was set at 85 percent correct responses. In late May of each monitoring year, observer field training was conducted over 3 or 4 days in the Superior NF or in the vicinity of Duluth, MN. Observers conducted simultaneous practice counts at several points used in the monitoring program. Data were compiled for each observer and compared with data for experienced observers. In addition to field training and testing, all observers were required to have a hearing test to ensure their hearing was within normal ranges, as established by audiologists, for all frequencies (125 to 8,000 Hz).

Nicolet National Forest

The Nicolet NF bird survey is completed during a single weekend in early June. Standard 10-min point counts (Howe et al. 1997b, Ralph et al. 1995, Reynolds et al. 1980) were conducted at each sample point between sunrise and 9:00 a.m. on Saturday and Sunday of the Nicolet NF bird survey weekend unless prevented by high winds or rain. When such conditions precluded surveys on the designated weekend, expert birders (defined in the next paragraph) completed the survey over the following several weeks. All birds seen or heard were recorded on standardized forms following the standard protocol for unlimited-radius point counts (Howe et al. 1997b, Knutson et al. 2008), with separate fields for distance from observer (0–25 m, 25–50 m, 50–100 m, >100 m) and time interval when the bird was first observed (0–3 min, 3–5 min, 5–10 min). Like the other NF surveys, time when first observed was recorded at minute intervals (as of 2010), and detection codes and distance categories followed the recommendations of Knutson et al. (2008).

The Nicolet NF bird survey is a volunteer project where point counts are performed by teams of observers led by at least one expert experienced in the auditory identification of birds in northern Wisconsin forests. Each team is able to sample 4–6 points during a single morning (10–11 points during the entire weekend). Because this is a volunteer effort, formal training such as that used by contracted observers in the Chippewa, Superior, and Chequamegon NFs was not feasible. However, several measures have been implemented to help assure data quality. The Nicolet NF bird



A Nicolet National Forest bird survey volunteer filling out a data sheet during a 10-minute point count. Photo by Scott Giese, used with permission.

survey has attracted many of Wisconsin's most skilled birders, and the team approach helps improve bird identification and data acquisition. Working as teams also has helped groom less skilled observers. Since 1995, all or nearly all of the 15–16 field teams during the weekend event have been led by experts with 5 or more years of experience in the Nicolet NF bird survey or equivalent bird survey projects. Typically, at least two-thirds of the group experts in a given year have participated in the project for a decade or more; the remaining experts usually consist of graduate students, professional biologists, or experienced bird watchers who have conducted bird-related research in Wisconsin. Many of the other observers return to participate in the Nicolet NF bird survey every year.

A custom CD with recordings of Nicolet NF bird species was prepared by the Cornell Laboratory of Ornithology in 1989 to help participants learn and practice bird identification. Beginning in 2009, high-quality audio recorders (PCM-D50; Sony Corp., Tokyo, Japan) have been deployed during the point counts, enabling teams to check auditory identifications after the count is completed. These recordings have been archived and provide a reference for eventual analysis of observer accuracy. The recorders are generally able to detect all of the bird species audible to observers at the survey points except during windy conditions.



An audio recorder used to record bird choruses during a Nicolet National Forest bird survey 10-minute point count. Photo by Scott Giese, used with permission.

Population Analyses

Population/Abundance Estimates

In this report we use an index of bird population defined as the annual mean number of detections of a species in a 10-min point count for each NF and for the NFs combined. Stand-level abundance estimates for species trend analyses only in the Chippewa, Superior, and Chequamegon NFs were calculated by summing the numbers of individuals across the two farthest-apart points per stand. The middle point in each stand was excluded because an unlimited-radius count from the center of the middle point sometimes overlapped areas counted on the other points. In addition, Hanowski and Niemi (1994) analyzed these data and determined that two points per stand were nearly as powerful in detecting change as were three points per stand. The midpoint of the stand has been recorded regardless because 1) it may be used as a test point for habitat prediction modeling, 2) little time is saved by skipping the point, 3) occupancy models require at least three replications in a stand (MacKenzie et al. 2006), and 4) data collected annually from the point still can be used to estimate population change. During training sessions observers were urged to use best judgment to avoid double counting of individual birds while sampling within a stand. Because of the change to unlimited distances, all of our trend analyses were based on unlimited-radius counts and were restricted to the period from 1995 through 2011, with the exception of the Chequamegon NF, where bird monitoring concluded in 2010. Trend analyses in the Nicolet NF treated each point count independently.

We used the following criteria to help ensure that our trend analyses provided reliable population information. Stands were included in the analysis only if they had been sampled during at least 6 yr. Species were evaluated only if individuals were observed at a minimum of five stands per NF and during at least 3 yr at each of these stands. Hence the focus of the analysis is on the trend rather than the total number of observations. For species that were observed at a minimum of five stands in each of the four NFs, we pooled all results and carried out an additional analysis with data from all forests pooled.

Detectability analysis attempts to correct for species-level biases in detectability and has been applied to bird point count data recently (MacKenzie et al. 2006). We previously applied detectability analysis to a subset of the data described in this report for the period 1992 through 2006 to explore how our counts compared with detectability-adjusted counts for 16 species with varying detectability by using the same methods and equations from Etterson et al. (2009). These 16 species ranged from species of low detectability (e.g., golden-crowned kinglet) to highly detectable species (e.g., ovenbird). In brief, we compared trend estimates from raw counts with detectability-adjusted counts by using the zero-inflated Poisson distribution and the removal mixtures model (Farnsworth et al. 2002) for these 16 species, as analyzed by Etterson et al. (2009) (Table 4). The occurrence of each of the 3 possible outcomes from these trend estimates and 48 comparisons (3 forests by 16 species, Table 4) is as follows: 1) consistent trends (whether significant or insignificant) for count and adjusted count in comparisons for species by each forest (40 of 48,

Table 4.—Calculated slopes of trends for 16 species using the number of individuals observed per point (Counts) and detectability-adjusted counts (Adjusted)[a] as described in Etterson et al. (2009) using the stand-by-forest model in 3 western Great Lakes national forests (NFs)[b]

	Chippewa NF		Superior NF		Chequamegon NF	
Bird species	**Counts**	**Adjusted**	**Counts**	**Adjusted**	**Counts**	**Adjusted**
Black-and-white warbler	0.19	0.12	0.03	-0.04	0.04	-0.02
Blackburnian warbler	**-0.01**	**-0.07**	**0.02**	**-0.04**	**0.19**	**0.14**
Black-capped chickadee	0.29	0.34	**0.37**	**0.43**	-0.01	0.05
Black-throated green warbler	0.11	0.52	**-0.08**	0.34	-0.08	0.32
Brown creeper	0.07	0.06	**0.18**	**0.18**	-0.04	-0.05
Golden-crowned kinglet	0.27	0.26	**0.32**	**0.32**	0.12	0.12
Least flycatcher	0.07	0.06	-0.01	-0.01	**-0.12**	**-0.12**
Nashville warbler	**-0.03**	0.08	**0.03**	**0.14**	**0.01**	**0.13**
Ovenbird	**-0.08**	**-0.06**	**-0.07**	**-0.06**	**-0.10**	**-0.09**
Red-breasted nuthatch	0.30	0.54	0.18	0.44	0.12	0.34
Red-eyed vireo	0.07	0.06	0.02	0.00	0.00	-0.01
Rose-breasted grosbeak	0.05	0.14	**-0.30**	**-0.21**	**0.07**	**0.16**
Veery	0.02	0.10	**-0.17**	-0.10	**-0.25**	**-0.15**
White-throated sparrow	**-0.05**	**-0.08**	**-0.07**	**-0.10**	**-0.19**	**-0.22**
Winter wren	**-0.30**	**-0.12**	**-0.22**	**-0.10**	**-0.40**	**-0.25**
Yellow-rumped warbler	0.02	**0.02**	**-0.15**	**-0.19**	**-0.32**	**-0.33**

[a] The detectability-adjusted results used the best model from Etterson et al. (2009), which was a zero-inflated Poisson distribution using the removal mixtures model.

[b] Significant ($P < 0.05$) slope values are shown in bold.

or 83 percent), 2) inconsistent trend signs but an insignificant trend for both count and adjusted count (5 of 48, or 10 percent), and 3) inconsistent interpretation of trend between count and adjusted count (3 of 48, or 6 percent).

The only comparisons that would require caution in the interpretation of a trend are those showing inconsistency between the two methods of calculating trends (number 3 above). Of the 48 comparisons, 94 percent (1 and 2 above) were consistent or were insignificant, so a trend would not be interpreted incorrectly. Three species, the Blackburnian warbler in the Superior NF, the black-throated green warbler in the Chequamegon NF, and the Nashville warbler in the Chippewa NF, had trend estimates that would need to be interpreted with caution; however, the differences for both the Blackburnian warbler and Nashville warbler were relatively minor but with different signs. Results indicated consistent trend interpretations between raw counts and detectability-adjusted counts, as previously concluded in Etterson et al. (2009). Considering the lack of evidence for species detectability issues in our dataset, we used raw counts for the remaining analyses in this paper and review the implications of this choice in the Discussion.

Population Trajectories

A population trajectory is defined as the relative change in size of a population across years. Because we do not detect every individual bird present in our study areas, we cannot know true population size. Instead, we must assume that our sample design gives a representative index of population size for each year. We used locally weighted (LOESS) regression to smooth the time series of species abundances for each stand (James et al. 1996). In LOESS regression, fitted values (points along the curve) for years are calculated by giving a small amount of weight to neighboring years. For example, a year with high raw abundance for a species would tend to bring up the fitted values for the year before and the year after. We then computed the arithmetic mean and 95-percent confidence intervals by using the fitted values from the within-stand regressions for each species in each year. The mean fitted value represents the annual index of population size, and the respective confidence intervals represent the uncertainty in the estimated index. The time series of the fitted mean population index and confidence intervals graphically defines a species' population trajectory. For the Nicolet NF, annual population indices for sites that were not sampled during that year were interpolated from the previous and succeeding year. This method does not affect the direction of trend estimates because no new information is introduced into the analysis (i.e., interpolated points are based on existing points).

Population Trends

A population trend defines the direction and magnitude of population change over a given time period (Link and Sauer 1997). Nonlinear trends notwithstanding, we view a significant trend as a unidirectional change; therefore linear methods can be used to detect a trend without asserting that the population trajectory is linear (Urquhart and Kincaid 1999). Population trends were assessed by using simple linear regression applied to an annual index of population size for a study area (described earlier) and time. We used the slope coefficient to characterize direction and magnitude of the trend. To facilitate comparisons, slopes were converted to units of percent annual change by dividing annual population indices by the predicted value of the index at the midpoint of the entire survey period (1995 to 2011) before regressing the index with time (Bart et al. 2003). We assessed the significance of the regressions by using a bootstrap procedure (Manly 1991) in which trends were computed for 500 bootstrap resamples of the stands used to calculate the annual population index. For each bootstrap resample, trend was calculated by using the same steps as for the original trend. For each original trend, an exact p-value was calculated as the percentile at which zero occurred in the distribution of 500 bootstrapped slopes. For example, $p = 0.01$ would be equivalent to 99 percent of bootstrapped slopes being greater than zero, which would give us a high degree of confidence that the true

population slope was different from zero, where 95-percent confidence intervals are defined as the observations at the 2.5th and 97.5th percentiles in the distribution of 500 bootstrapped resamples, respectively. Future analyses of trends will explore the recent approach by Sauer and Link (2011) by using a hierarchical modeling approach for trend detection in the BBS.

An alternative to linear regression for detecting temporal changes in regional bird populations is a simple point-by-point comparison of average abundance between decades for all points where the species was recorded at least once. A binomial test (Zar 2009) can be used to compare the number of points showing an increase in average abundance with the number of points showing a decrease. Data from the Nicolet NF, which used unlimited-distance counts during all years, are appropriate for this analysis because they span the entire periods of 1991–2000 and 2001–2010, enabling comparisons of average bird abundances between the two decades by using a two-tailed binomial/sign test. As with the linear regression analysis, we did not correct for multiple comparisons because of the large number of species being tested (Moran 2003), so some fraction of the "significant" trends (i.e., $p < 0.05$) may be expected based on chance alone. The binomial test is advantageous because it can be used for uncommon species that did not meet the criteria for inclusion in the linear regression analysis and it is not affected by interannual variation within each decade.

Guild Analyses

Each species was categorized within three different guild types: migration, nesting, and habitat preference (Appendix 4). Information for categorizing species was obtained primarily from Ehrlich et al. (1988), Freemark and Collins (1992), Jaakko Pöyry Consulting Inc. (1992), and personal experience with forest birds within the western Great Lakes region. All individuals of a species that were assigned to each guild were included in the same analysis described earlier for individual species. Species guilds are not mutually exclusive, so the species pool in, for example, a migration guild can include many of the same species that were assigned to a nesting guild (Sauer et al. 1996).

Directional trends in abundant species (e.g., ovenbird or red-eyed vireo) can strongly influence the trend of the guilds of which these species are members. Given this limitation, trend analyses of ecological guilds often warrant further examination of common patterns of change among species within the guild. If all or many species within a guild show similar trends in relative abundance, then factors affecting the guild-related life history attributes deserve attention. For instance, a severe drought in the late 1980s was correlated with a decline in the population levels of many breeding bird species found in the habitat guild of aspen forests of northern Wisconsin (Blake et al. 1992).

Comparison with USGS Breeding Bird Surveys

The volunteer-based USGS BBS is potentially an alternative to monitoring forest birds at off-road points within the region. At the time of this publication, 16 breeding bird roadside count routes were located more than 50 percent within the boundaries of the Chippewa, Superior, or Chequamegon NF. The habitats traversed by the BBS routes were generally similar to those in the three NFs; however, the comparisons were primarily based on forest-associated species and not species associated with nonforested habitat. In addition, the comparison was made to assess the extent to which both methods detect trends at a larger regional scale. Bird trends for these NFs' data were analyzed by John Sauer (USGS-Patuxent Wildlife Research Center, Laurel, MD) by using the techniques described in Sauer and Link (2011); we compared these results with the overall trends for the Chippewa, Superior, and Chequamegon NFs from 1995 through 2010 (Niemi et al. 2011) by using simple correlation analysis.

Community Analyses

Regional Avifaunas

Differences in observed bird lists among the four NFs may be attributed to two interrelated factors: composition of the regional avifauna and the array of habitats that were sampled. For example, several species of urban habitats (European starling, house finch, and house sparrow) were recorded almost exclusively in the Nicolet NF because that was the only forest where urban habitats were sampled (Appendix 1). The widest range of habitat types was sampled in the Nicolet NF, and the fewest types of habitats were sampled in the Superior NF (Table 3). To minimize the effects of sample design, we limited our community analyses of NF bird assemblages to species recorded within forest and woodland habitats. Specifically, we analyzed the subset of sample points classified as one of the following habitat categories: aspen-birch, aspen-spruce-fir, beech-maple-birch, black spruce-tamarack, hemlock, jack pine, lowland hardwoods, oak, red pine, swamp conifers, upland hardwoods, and white pine (i.e., 12 of the 20 habitat types sampled; see "Habitat Associations" on the following pages).

We evaluated the general structure of forest bird communities in each NF by plotting rank abundances of forest/woodland bird species (May 1975). These diagrams illustrate patterns of relative bird abundance among species ranked in descending order from most abundant. Community metrics like species richness and species diversity are less informative summaries of this fundamental ecological pattern of relative abundance (Hurlbert 1971). Distinctive species in each of the NFs were identified by applying the indicator species analysis developed by Dufrêne and Legendre (1997). This method yields a species-specific metric, percent perfect indication (PPI), which represents the degree of affinity to preassigned categories (e.g., one of the four NFs), by using a combination of abundance (i.e., average number of individuals per 10-min point count) and frequency (i.e., number of years the species was observed at the point, divided by total number of years sampled). Values of PPI can theoretically range from 0 to 100, where 100 represents a situation where all individuals of a species were counted in just one category (in this case, NF) and the species was always present in samples of that category. To minimize temporal changes in habitat condition at each sample point, we limited the analysis to the more recent decade, 2001–2010. If the habitat type at a given point changed during this decade (e.g., recent harvest), the point was treated as two independent points representing different habitats, yielding a total of 1,728 points for analysis. Values of PPI were calculated by PCORD v6.08 (McCune and Mefford 2006). We defined "distinctive" species as those that yielded a PPI value for a given NF that was at least twice as large as its PPI value for every other NF. This was a conservative criterion because the Monte Carlo randomization test described by Dufrêne and Legendre (1997) and McCune and Mefford (2006) yielded a significant maximum PPI (in most cases $p < 0.001$) for all but two species, downy woodpecker and purple finch. The probability value from the randomization test represents the proportion of times that the maximum PPI from a randomized dataset equals or exceeds the maximum PPI from the actual dataset. In other words, the null hypothesis is that maximum PPI is no larger than would be expected by chance. In all cases our criterion to identify "distinctive species" for a given NF was much stricter than the $p < 0.05$ standard. Hence "distinctive" species may be interpreted as bird species that were highly associated with just a single NF.

Community Assemblages

Local bird communities are commonly described with respect to their associated vegetation types (i.e., habitat). However, birds might respond to combinations of traditional habitat types and landscape features (e.g., ecotones between two habitat types) that are not adequately described by a single attribute such as dominant canopy tree species or aquatic habitat type. An alternative approach to understanding patterns of species' ecological needs and habitat preferences is to evaluate community assemblages without initially linking the sample sites to standard habitat

categories. We applied hierarchical cluster analysis (McCune and Grace 2002, Sneath and Sokal 1973) by using mean log-transformed average bird species abundances from 1,728 sample points from 2001 through 2010 to illustrate relationships among points based on bird species composition. These abundance estimates ignore differences in detectability among habitats, so caution is advised in interpreting the results (see "Discussion"). However, this approach reveals assemblages of species that tend to occur together irrespective of traditionally defined habitat types. Subsequent analysis of the bird associations may identify environmental or geographic features that are important (and not widely recognized) for bird conservation and habitat management.

From the hierarchical dendrogram, we defined the 20 most distinctive groups (i.e., "communities") based on bird species co-occurrences. We selected 20 groups because this number corresponds to the number of habitat types that we used in our indicator analysis of habitat affinities. Many other levels of groupings could have been derived from the cluster analysis, but this approach provided a manageable number of groups and shed light on the efficacy of using dominant tree species or dominant vegetation type as the defining attributes of bird–habitat categories on a regional scale. Both forest and nonforest points were included in this analysis, and all three points within stands of the Chippewa, Superior, and Chequamegon NFs were included as independent samples. Species occurring at fewer than 10 points (28 of 154 species recorded during the decade) were excluded in order to minimize spurious group assignments. The cluster algorithm used Ward's method (hierarchical grouping) based on Euclidean distances (Wishart 1969) and was implemented by PC-ORD v6.08 (McCune and Mefford 2006). Once the 20 groupings were identified, we again used Dufrêne and Legendre's (1997) indicator species analysis to identify the most characteristic bird species for each community assemblage. Values of PPI were calculated by using the methods described previously, including a randomization test for significance of the maximum PPI for each species. The resulting groupings represented naturally occurring bird communities that are not necessarily associated with traditional habitat categories. This habitat-independent method of bird community analysis is therefore complementary to more traditional analysis of habitat associations, described next.

Habitat Associations

Bird Habitat Summaries

We summarized habitat information in two ways: average abundance and frequency percentage of bird species within a habitat cover type. We initially assigned each bird survey point to one of 29 habitat cover types represented by reasonable sample sizes (Table 2, Appendix 2). Four of these habitat cover types (aspen-birch, aspen-spruce-fir, jack pine, and red pine cover types) contained up to four age classes (<10 yr, 10 to 20 yr, 21 to 60 yr, and >60 yr) (Appendix 2). Each cover type in Appendix 2 includes a summary of the 20 most commonly observed bird species based on the average number of individual birds detected (standardized to 10-min unlimited-distance point counts for ease in interpretation). Because this is a simple summary of species found within different forest cover types, we included each of the three points in stands of the Chippewa, Superior, and Chequamegon NFs, in addition to those in the Nicolet NF. We report average abundances and frequency percentages of bird species among all point counts within a given cover type.

Bird Habitat Affinities

Preliminary analyses of bird communities indicated that species composition was similar among age classes within a given habitat cover type. We therefore aggregated age class-specific types into 20 unique habitat types based on cover type alone (Table 2). The aggregation was a combination of statistical analyses such as the calculation of PPI values for a variety of habitat cover types, examination of predominant bird species and relative abundance in various age-classes, and best judgment by the investigators. Habitat affinities of individual bird species were estimated by using the Dufrêne and Legendre (1997) indicator species analysis described earlier

(see "Community Analyses" subsection). In this case, PPI values described the degree of affinity to the 20 habitat categories by using the combination of abundance (i.e., average number of individuals per 10-min point count in a given habitat category during the sampling period) and frequency (i.e., number of years the species was observed at the point, divided by total number of years sampled). We estimated habitat-specific PPI values for 123 breeding bird species that were recorded at 10 or more points across all 4 NFs combined (Appendix 3). Indicator species analysis was limited to the 1,728 point samples during the decade 2001–2010 to minimize longer-term (unmeasured) changes in habitat and to best represent the current avifauna (Table 3). In cases where habitat type changed at a point within the decade (e.g., as a result of timber harvest), the point location was treated as two point samples. All points (including three samples per stand in the Chippewa, Superior, and Chequamegon NFs) were treated as independent samples. We applied a Monte Carlo test for randomness (Dufrêne and Legendre 1997, McCune and Mefford 2006) to determine the statistical significance of the maximum habitat indicator value.

Species-level Summaries and Distribution Maps

A summary of migration, nesting, and habitat preferences for 98 species is provided in Appendix 4. For the 90 species that were observed during at least 2 percent of the sample points, detailed species-level summaries were constructed (Appendix 5). These accounts show the overall trend for each species among all of the NFs, the trend within each NF in which it was abundant enough, a guild summary, and results of the Dufrêne and Legendre (1997) analysis of habitat affinities (PPI) described earlier. Also presented is a probability map illustrating each species' expected distribution in the western Great Lakes region.

The probability distribution maps were generated for the area included in the Laurentian Mixed Forest Province of northeastern Minnesota, the Upper Peninsula of Michigan, and northern Wisconsin. We used results from our NF bird surveys as well as comparable point count data from several other regional bird studies. Overall, 3,500 points were used in this analysis. In this case, we used only two of the three points in stands of the Chippewa, Superior, and Chequamegon NFs. All points used to generate the species distribution models were at least 250 m apart, as determined by geographic information systems (GIS) analysis, and were collected following the 10-min unlimited-radius point count protocol described by Howe et al. (1997b), Knutson et al. (2008), and Danz (2009). We chose to include only points that were at least 250 m apart because the maximum detection range for most bird species in the region is between 100 m and 200 m (Wolf et al. 1995). Although point independence may have been violated to some degree by applying the 250-m criterion, bird distributions are both spatially and temporally variable; point counts at different times at distances of 250 m (and probably 220 m) apart yielded mostly independent and unique information about habitat use by local breeding birds (Ralph et al. 1995).

In addition to surveys in the Chippewa and Superior NFs, sites in Minnesota included point counts conducted by the Natural Resources Research Institute (NRRI) in the Saint Croix National Scenic Riverway and across much of northeastern Minnesota as part of the Minnesota Breeding Bird Atlas Project. Wisconsin points included: Chequamegon and Nicolet NF point counts, NRRI-sponsored point counts in the St. Croix Riverway, a 2003 study of birds in the Marshfield Clinic's Marshfield Ecological Study Area (Cassini 2005), an assessment of the Peshtigo River State Forest and Governor Thompson State Park (unpublished data from 2003) funded by the WDNR, an ecological forest indicator study conducted in the Wild Rivers Legacy Forest (Gnass 2012) in 2009–2010 by The Nature Conservancy (TNC) and the University of Wisconsin-Green Bay's Cofrin Center for Biodiversity, and a 2010 survey of highly

fragmented northeastern Wisconsin landscapes jointly funded by TNC and the Cofrin Center for Biodiversity (Gnass 2012). Point counts conducted in northeastern Wisconsin and western Michigan were from an old-growth and managed forest study during the early 1990s funded by the WDNR (Howe and Mossman 1996). The intent here was to use as much point count information as possible for the western Great Lakes region, encompassing the NFs as well as the surrounding landscape. Unlike the earlier analyses, where average abundances at a point during multiple years (decades) were used as dependent variables, development of the probability distribution maps used only a single 10-min count per point, the year corresponding to the most recent available digital imagery (up to 2010) used to generate land cover/landscape variables. Although points in the NFs were sampled during multiple years, we used only a single count so that we could include points (outside the national forests) that were sampled only once.

Independent predictor variables were 20 land cover variables (percent cover of each of 20 land cover classes within a 500-m radius), distance to nearest stream (m), stream density (m/m^2) within the 500-m radius, distance to nearest lake (m), distance to nearest road or railroad (m), average minimum June temperature (°C), and average annual precipitation (mm/day). Land cover classes were derived from Landscape Fire and Resource Management Planning Tools (LANDFIRE; Rollins et al. 2006). Walton (in review)[2] describes how LANDFIRE Existing Vegetation Types (LANDFIRE 2001, 2008) were combined into the 20 classes used here. LANDFIRE was chosen over other land use/land cover datasets because it has a reasonably small grain (cell size = 30 m × 30 m), covers our entire study area, was updated more recently, and has adequate resolution of habitat classes. The LANDFIRE habitat model uses classification and regression trees with a combination of field reference data, remotely sensed imagery from Landsat, and information on biophysical gradients (USGS 2010).

We used the version of LANDFIRE Existing Vegetation Type which most closely matched the year the bird data were collected at each count site. For each point count, the proportion of area in each of the 20 habitat classes within a 500-m circular buffer was calculated by using the IAN image analysis program (DeZonia and Mladenoff 2004). Topologically Integrated Geographic Encoding and Referencing (TIGER) roads and railroads (U.S. Census Bureau 2000, 2007, 2009, 2011, 2012a, 2012b) were used to calculate distance to nearest road or railroad. Flow line data from the National Hydrography Dataset (NHD) (Data Model 2.1, USGS 2014) were used to calculate distance to nearest stream and stream density. Water body data from the same NHD database were used to calculate distance to nearest lake. All of these variables were calculated by using ArcGIS 10.0 (Esri 2011). As with LANDFIRE, every effort was made to match the year that a point was surveyed with the most appropriate geospatial datasets. We used the 20-yr mean values for minimum June temperature and average annual precipitation for the period 1981–2010 from the PRISM Climate Group (2012). These were calculated for the cell value corresponding to the geographic coordinates of each point count.

Predictive species distribution models (Guisan and Zimmermann 2000, Rotenberry et al. 2006) were generated for abundance of each bird species by using zero-inflated Poisson (ZIP) and zero-inflated negative binomial (ZINB) models (Cameron and Trivedi 1998, Jones et al. 2002, Lambert 1992), with log abundance in a single 10-min point count as the dependent variable. Zero-inflated models are a type of general linear model (GLM; McCullagh and Nelder 1989) that can account for an excess number of zeroes compared to that expected under the specified distribution by coupling a binomial process with a Poisson

[2] Walton, N.G. [In review]. Patterns of avian distribution, diversity, and relative abundance in the western Great Lakes region, USA. Green Bay, WI: University of Wisconsin-Green Bay. M.S. thesis.

or negative binomial process. Zero inflation is common in analysis of count data (White and Bennetts 1996). Excess zero counts were expected a priori for any given species in this analysis for several reasons (Kuhnert et al. 2005, Martin et al. 2005): 1) Many points are simply unsuitable; 2) many suitable points are unoccupied; and 3) some points are suitable and occupied, but the species was not detected. We did not model detection probabilities explicitly for species in this analysis. However, Etterson et al. (2009), looking at bird count data from the same system, found that detection heterogeneity had little significant impact on estimating population trends in this region. They also found that ZIP models were generally the best choice of model (as compared to standard Poisson and negative binomial GLMs) for datasets like ours, where overdispersion and zero-inflation are widespread.

The linear predictor for the full model used for each species was:

$$\log(\lambda) = \alpha + \beta_1 \times (\%\ \text{habitat}_1) + \beta_2 \times (\%\ \text{habitat}_2) + \ldots + \beta_{20} \times (\%\ \text{habitat}_{20}) + \beta_{21} \times (\text{distance to nearest road or railroad}) + \beta_{22} \times (\text{distance to nearest lake}) + \beta_{23} \times (\text{distance to nearest stream}) + \beta_{24} \times (\text{stream density}) + \beta_{25} \times (\text{average minimum June temperature}) + \beta_{26} \times (\text{average annual precipitation}) + \varepsilon$$

where λ = mean predicted abundance in a 10-min point count, α = a constant (y-intercept), β_x is the best-fit regression coefficient for habitat x or the stated variable, % habitat_x = the proportion of habitat type x within a 500-m radius around the point, and $\varepsilon \sim \text{Normal}(0, \sigma^2)$.

With the exception of average minimum June temperature and average annual precipitation, all variables were natural logarithm-transformed to improve the linearity of the regression relationships. Only the intercept was estimated for the binomial portion of the model.

All statistical analyses were conducted by using the software package R version 2.13.1 (R Development Core Team 2011). Only species that were recorded at 30 or more point counts were considered for model selection. All ZIP and ZINB models were fitted by using function "zeroinfl" (R package "pscl"; Jackman 2011, Zeileis et al. 2008). The choice between ZIP and ZINB models for each species was made based on a likelihood ratio test (function "lrtest" in R package "lmtest"; Zeileis and Hothorn 2002) applied to both full models. Both p-value and Akaike information criterion (AIC; Akaike 1974) were considered when choosing between the two models. After we chose between distributions, we used backwards elimination using a likelihood ratio test to select one "best" model. A significance level of 0.05 was used for variable elimination, but we also examined the AIC values. In one case (gray jay) we chose to add one variable back into the "best" model based on AIC. In two cases (Canada goose and purple finch), where backwards elimination failed to converge on a stable model, forward selection was applied starting with the null model; then backward elimination was applied to the subset of variables selected by forward selection. See Walton (in review)[2] for the full details of the selected models.

After model selection, mean count predictions were generated for 500-m circular buffers evenly spaced every 1,000 m across the entire study area (i.e., one buffer per 1 km^2 [1 km^2 = 0.39 mi^2]). These predictions were then used to generate species distribution probability maps in ArcGIS 10.0 (Esri 2011). We used the Natural Breaks (Jenks) classification method in ArcGIS to display the species distributions to maximize visual detail in maps and to emphasize the heterogeneity in expected distributions at the individual species level. Consequently, colors representing different abundance classes do not follow a standard scale among species. Further details of these maps and justification for the visual mapping conventions can be found in Walton (in review)[2].

Ecological Context

The effects of climate change on bird populations and community composition are a complex and rapidly developing area of research (Knudsen et al. 2011). Likewise, a considerable amount of literature has emerged on how timber harvest practices and forest management can influence forest composition and forest structure and, consequently, regional breeding bird populations (Green 1995, Howe et al. 1997a, Niemi et al. 1998). Monitoring data such as those presented here may be used to assess the potential impact of environmental covariates such as climatic trends and disturbances such as forest management activities on wildlife populations. Given the number of species involved and the potential interactions among multiple drivers operating simultaneously, however, a full analysis of climate and forest management effects on bird populations is beyond the scope of this report. Instead, we have described concurrent trends in some key climate variables, disturbance indicators, and forest composition and structure variables to provide a regional ecological context for the observed bird population trends. Contextual data were summarized at the NF scale by using the proclamation boundary for each NF. For the Superior NF we excluded administrative units not sampled for forest birds (Fig. 1).

We extracted seasonal temperature trends most relevant to breeding bird populations of the region: minimum winter temperatures, which may affect overwinter survival of residents; spring temperatures, which may affect migration processes; and summer temperatures, which may affect breeding and post-fledging success (Knudsen et al. 2011). Monthly temperature variables were derived from 1-km^2-resolution interpolated climate data (McKenney et al. 2006). Using these data, we estimated minimum and average winter temperatures (December-February) and average monthly temperatures for March, April, May, June, and July. Resulting climate variables were averaged across the land area for each NF for each year from 1990 through 2010. We then qualitatively compared temperature trends with potential indicators of avian response to changing climate among migratory guilds (e.g., Gienapp et al. 2007).

Extreme drought has been shown to affect forest bird populations in the Great Lakes region, presumably through impacts on food resources during the breeding season (Blake et al. 1992, 1994). We extracted monthly Palmer drought severity index (PDSI) values for climatic divisions containing each NF. Where NF boundaries crossed climatic divisions, we estimated PDSI by using an area-weighted average defined by the land area of each NF falling within a given climatic division. We then examined simple linear regressions between spring–summer moisture conditions (i.e., average April-July PDSI) for the previous year as the predictor variable and average species-specific bird abundances at the NF scale. Species that were recorded during fewer than 5 yr from 1989 through 2010 for the Nicolet NF and from 1995 through 2010 for the other NFs were excluded. The Holm-Bonferroni correction (Holm 1979) was used to adjust p-values to account for multiple comparisons.

Disturbances and consequent successional patterns are known to influence the community composition of forest birds, in particular species with habitat affinities for open and early successional habitats, species with specific habitat requirements related to the biological legacies of disturbances (e.g., standing dead trees after wildfire; Niemi and Probst 1990), and species with habitat affinities for closed-canopy and mature forests (Howe et al. 1997a, Niemi et al. 1998). Land cover changes during the survey period were estimated by using the National Land Cover Database for 1992, 2001, and 2006 (Fry et al. 2009, 2011; Homer et al. 2001). Additional land cover change data were available based on a more detailed regional analysis of Landsat imagery over time for Minnesota NFs only (Wolter

et al. 2012). These data sources provided rates of stand-replacing disturbance, including both harvesting and natural disturbances such as fire and wind, irrespective of land ownership within the proclamation boundaries of the Minnesota NFs. Annual harvest rates (volume) were also acquired from the records of each NF as an integrated indicator of harvesting activity during the survey period. Finally, insect outbreaks are thought to dramatically affect food resources during the breeding season (Crawford and Jennings 1989). We therefore estimated annual area disturbed by the three most widespread insect defoliators in each NF (i.e., spruce budworm, jack pine budworm, and forest tent caterpillar) by using aerial survey data (Minnesota Land Management Information Center 1999, U.S. Forest Service 2012a).

Finally, forest bird communities are sensitive to both forest tree species composition and structure. In particular, the ratio of conifer to deciduous tree species, size or age of trees, and the abundance of standing dead trees (snags) all have important consequences for both bird community composition and the relative breeding success for different guilds of birds (Green 1995). Forest Inventory and Analysis (FIA) data were used to estimate gross changes in forest composition (i.e., forest types) and structure (i.e., tree diameter classes and snag densities) between roughly 1980 and 2010 (dependent on state-specific FIA inventory periods). We extracted FIA plots falling within the same boundaries by using EVALIDatorPC (Version 5.01.02; Miles 2011) to estimate trends in forest land area, tree composition, and size class distributions. The land ownership attribute was used to evaluate trends with respect to NF lands versus all other land ownerships. Where justified by FIA sample size, we further evaluated results by NF ranger district to assess within-NF heterogeneity in trends. We estimated the density of snags (standing dead stems/ha) by diameter class (of at least 5 inches [12.7 cm] at breast height [4.5 ft or 1.4 m]), using a minimum height criterion of 6 ft (1.8 m) tall (Society of American Foresters 2008).

Demonstration Species

The Western Great Lakes National Forest Breeding Bird Surveys were initiated to provide monitoring data to inform land management decisions. An exhaustive species-specific analysis of bird trends and habitat relationships is beyond the scope of this report. Instead, we identified eight species that serve as examples of how these monitoring data can be considered in a management context. These eight species show negative population trends or are species of concern (Matteson et al. 2009) but by no means represent a complete list of birds deserving conservation attention in these NFs. We reviewed the published literature for each species and compared our NF trends with results for the Breeding Bird Surveys. The resulting narratives demonstrate how the combination of trend data, habitat relationships, and mapped potential habitat derived within this report can be coupled with national bird surveys and the published literature to generate more specific management guidance at the NF or bird species level.

RESULTS

Over the course of 26 field seasons (1987–2012), participants in the 4 NF monitoring programs counted over 400,000 birds during more than 30,000 ten-minute point counts (>5,000 hr of sampling). The actual numbers of points varied from year to year due to accessibility, weather, and changes in the number of sample points, especially at the start of the project. During the two decades 1991–2000 and 2001–2010, the numbers of points sampled were fairly consistent (Table 1), ranging between 399 and 420 point counts in the Chippewa NF, 525 and 566 point counts in the Superior NF, 391 and 407 point counts in the Chequamegon NF, and 317 and 320 point counts (sampled every other year) in the Nicolet NF. The number of point counts sampled per year from 1995 to 2011, the period covering most of our analyses, ranged between 350 and 396 in the Chippewa NF, 470 and 557 in the Superior NF, 362 and 391 in the Chequamegon NF, and 149 and 165 in the Nicolet NF. Overall, the collective number of samples across all 4 NFs ranged from 1,403 to 1,475 point counts annually between 1995 and 2011.

Since 1991, observers in our forest monitoring projects have recorded 187 of the 200 bird species and one recognized hybrid that breed regularly in the forests of the western Great Lakes (Appendix 1); 13 species (e.g., black-crowned night-heron) were recorded only once. The species list also includes vagrants that are not regularly found within these NFs (e.g., western kingbird) and late migrants that breed farther north (e.g., blackpoll warbler). The point counts do not represent a random sample of points across the region, so comparisons among forests and comparisons with other data sources are most useful when limited to specific habitat types. Because of our sampling design, however, results from the point counts are representative of major cover types within the NFs. Additional cover types like towns and open wetlands were sampled in the Nicolet NF. Consequently, the total number of species recorded in the Nicolet NF was 21 to 22 species higher than the total numbers of species in the other three forests (Table 5).

Table 5.—Cumulative species richness in point counts from four national forests (NFs) in the western Great Lakes region, 1991–2011

	Chippewa NF	Superior NF	Chequamegon NF	Nicolet NF
All species[a]	151	152	151	173
Open wetland species (W)	21	24	17	32
Nonwetland species	130	128	134	141
Closed-canopy forest (F)	64	64	63	65
Early-to-mid successional forest (FM)	26	27	28	27
Forest/shrub wetland (FSW)	16	16	15	16
Grassland (G)	17	15	20	21
Aerial (A)	7	6	6	7
Introduced (I)	0	0	2	5

[a] Species assigned to each group are given in Appendix 1. In this document we define forest/woodland species as those belonging to the closed-canopy forest (F), early-to-mid successional forest (FM), and forest/shrub wetland (FSW) categories.

The numbers of bird species associated with closed forest, forest/shrub wetland, and forest edge/mixed woodland (subsequently defined as forest/woodland species) were remarkably similar among the four NFs (Table 5), so we limited our general comparisons of mean bird abundances and species richness to these forest/woodland bird species. We recorded 119 forest/woodland bird species across the entire study area, 90 (76 percent) of which are regular seasonal migrants. Additionally, many of the species we categorized as permanent or semi-permanent residents undergo partial migrations (e.g., pileated woodpecker, blue jay, white-breasted nuthatch) or irregular movements (e.g., red crossbill, pine siskin), so the character of the avifauna in this region is dominated by strong seasonal movements. Two forest birds, ovenbird (a ground feeder) with a total of 50,629 observations and red-eyed vireo (a canopy feeder) with a total of 38,632 observations (Appendix 1), were the most abundant species (Fig. 3); together these two species represented almost 25 percent of all individuals recorded during our surveys (Appendixes 1 and 2). Overall the 10 most abundant species accounted for 54 percent of all birds recorded.

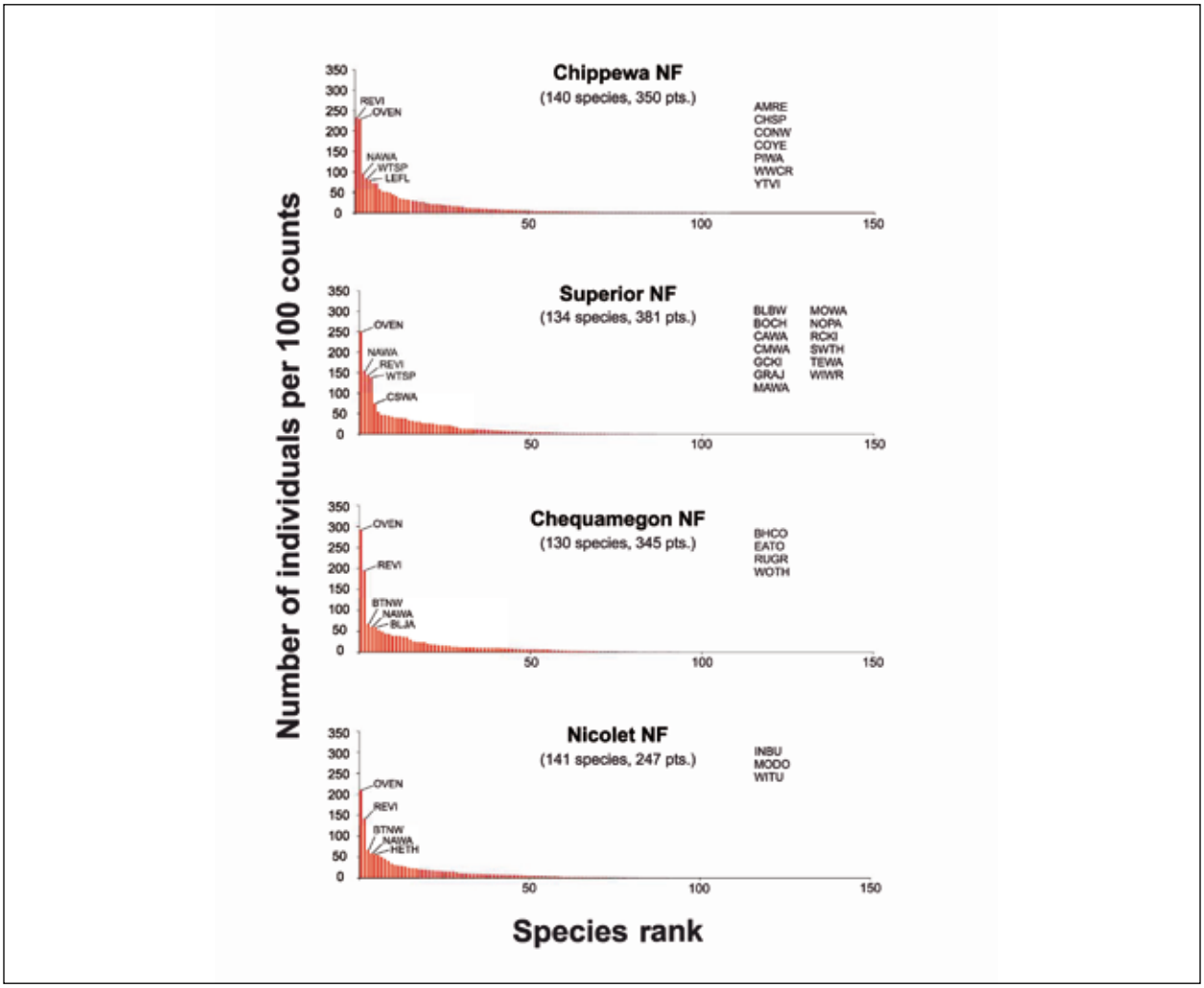


Figure 3.—Relative abundances of all bird species recorded at points in forest or woodland habitats (12 of the 20 categories in Table 3) from 2001 through 2010. Each vertical bar represents a species, ordered from most abundant (left) to least abundant (right). Four-letter bird species abbreviations correspond to the codes given in Appendix 1. Species abbreviations on the right represent the most distinctive species in each national forest based on indicator species analysis (Dufrêne and Legendre 1997).

General Trends in Bird Abundance and Species Richness

In the westernmost NFs (Chippewa, Superior, and Chequamegon), average counts of individuals (including all points) increased steadily from 1995 to the early 2000s, exemplified by particularly high counts in the Superior and Chequamegon NFs in 2002 and in the Chippewa NF in 2004 (Fig. 4). Standard errors of mean count estimates were generally low, on the order of about 1–2 percent of the mean for the Superior, Chippewa, and Chequamegon NFs, and slightly higher (about 2–4 percent) for the Nicolet NF. Average numbers of birds in the Chippewa and Superior NFs have more recently returned to levels observed during the late 1990s. In the Nicolet NF, patterns of change in average abundance were similar to the western NFs in the late 1990s and post-2004, but average counts showed comparatively low numbers in 2003 and 2004 (Fig. 4). Moderately increasing trends in numbers of individuals were widespread across forest cover types in the western NFs and in some Nicolet NF forest types, such as black spruce-tamarack and hemlock (Table 6). Trends in average numbers of species per count (Fig. 5) exhibited similar patterns to average abundance, with general increases in the western NFs and unusually low values in 2003 and 2004 for the Nicolet NF. Increases in richness were widespread in the western NFs, whereas significant increases in the Nicolet NF were observed only for the beech-maple-birch habitat type (Table 6).

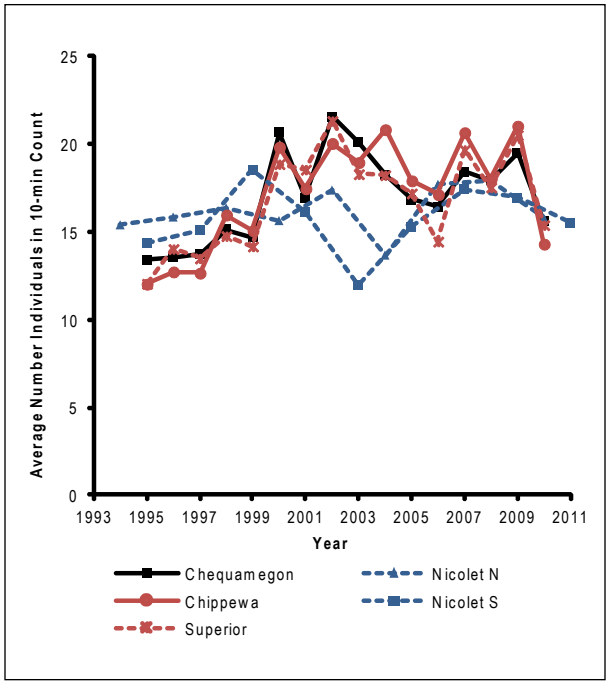


Figure 4.—Average numbers of individual birds (all species) recorded during 10-minute point counts from 1995 through 2011 in the Chippewa, Superior, Chequamegon, and Nicolet (northern [N] and southern [S] halves) National Forests. Standard errors for samples within a given year (not shown) ranged from 0.15 to 0.30 (n=458–491) for the Superior NF to 0.44 to 1.07 (n=158–165) for Nicolet N. Samples within the Nicolet NF included nonforest points in towns and open habitats in addition to forest points.

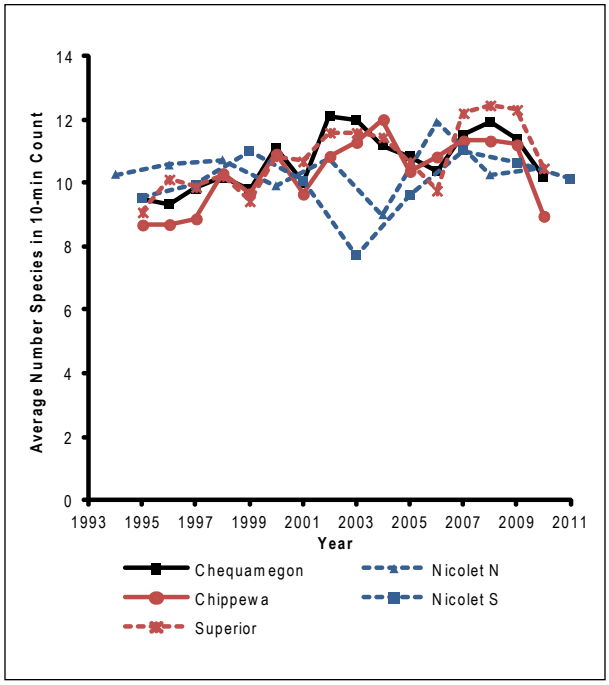


Figure 5.—Average numbers of species recorded during 10-minute point counts from 1995 through 2011 in the Chippewa, Superior, Chequamegon, and Nicolet (northern [N] and southern [S] halves) National Forests. Standard errors for samples within a given year (not shown) ranged from 0.12 to 0.18 (n=458–491) for the Superior NF to 0.27 to 0.34 (n=148–152) for Nicolet S. Samples within the Nicolet NF included nonforest points in towns and open habitats in addition to forest points.

Table 6.—Pearson correlation coefficients (r)[a] for association between year and mean numbers of individuals and of species in 10-minute point counts in different habitat types in four western Great Lakes national forests (NFs), 1995–2011

	Chippewa NF		Superior NF		Chequamegon NF		Nicolet NF	
Habitat category	Individual	Species	Individual	Species	Individual	Species	Individual	Species
Aspen-birch forest	**0.63**	**0.68**	**0.54**	**0.71**	0.40	0.41	0.03	0.03
Aspen-spruce-fir forest	**0.60**	**0.48**	0.38	**0.48**	**0.53**	0.40	0.08	0.25
Beech-maple-birch forest	--	--	0.43	0.24	0.26	-0.07	0.43	**0.59**
Black spruce-tamarack forest	**0.63**	**0.54**	**0.54**	**0.66**	0.33	0.36	0.42	0.47
Hemlock forest	--	--	--	--	**0.56**	**0.55**	0.34	0.37
Jack pine forest	**0.63**	**0.65**	**0.58**	**0.64**	0.41	**0.59**	-0.20	-0.06
Lowland hardwood forest	**0.51**	**0.48**	--	--	0.42	0.38	0.21	-0.17
Lowland shrub	--	--	--	--	0.36	-0.02	0.06	-0.06
Oak forest	**0.65**	**0.65**	--	--	0.34	0.30	-0.15	-0.16
Open dry habitat	0.35	0.22	**0.50**	0.41	0.34	0.48	0.15	-0.03
Open wet habitat	--	--	--	--	--	--	-0.01	-0.19
Red pine forest	0.38	0.34	**0.65**	**0.77**	0.47	**0.55**	-0.06	0.16
Regenerating conifer forest	**0.66**	**0.53**	**0.55**	**0.64**	0.14	-0.11	-0.12	-0.21
Regenerating nonconifer forest	0.36	-0.08	0.47	0.47	0.15	0.33	0.26	0.35
Sedge meadow	--	--	--	--	0.47	0.36	-0.12	-0.12
Swamp conifer forest	0.46	0.35	0.37	0.43	**0.54**	0.46	-0.15	-0.13
Town	--	--	--	--	--	--	-0.43	-0.29
Upland hardwood forest	**0.49**	**0.49**	0.37	0.33	**0.51**	**0.49**	0.31	0.20
Water	--	--	--	--	--	--	-0.06	0.42
White pine forest	**0.62**	**0.59**	**0.44**	**0.53**	**0.19**	**0.35**	0.08	0.18

[a] Significant values of r (df = 15, $p < 0.05$) are shown in bold. Dashes indicate that no survey points were located in that category in the NF.

Comparison of Forest Bird Communities Among National Forests

The avifauna of the western Great Lakes region consists largely of forest species that breed in broadleaved and mixed forests of Bailey's (1998) Humid Temperate Domain of eastern North America. In all four NFs, bird species of mixed conifer-deciduous forests of the northern United States and Canada (ovenbird, red-eyed vireo, black-throated green warbler, least flycatcher, hermit thrush, veery, and yellow-bellied sapsucker) were prominent in our field surveys. Bird species of the more northern boreal forest (part of Bailey's Polar Domain) extend into the United States locally along mountain ranges and in northern states, including Minnesota, Michigan, and Wisconsin. Not surprisingly, boreal birds like spruce grouse, black-backed woodpecker, great gray owl, boreal chickadee, gray jay, ruby-crowned kinglet, and several boreal warbler species were most likely to be found in the Superior NF, the northernmost NF in our study area. These and other northern species (Fig. 3) contributed significantly to the uniqueness of the Superior NF's regional avifauna.

The three other NFs encompass significant areas of mesic temperate forests, which once covered most of eastern North America. Bird communities in these three NFs were dominated

by ovenbird and red-eyed vireo and had relatively high abundances of other species (e.g., blue jay, black-capped chickadee, eastern wood-pewee, scarlet tanager, white-breasted nuthatch) that are characteristic of eastern North America's temperate deciduous forests (Appendixes 1 and 2, Fig. 3). These species were present in the Superior NF but were relatively less abundant there. Ovenbird and red-eyed vireo were the two most abundantly recorded species in the Chippewa, Chequamegon, and Nicolet NFs; ovenbird and Nashville warbler were the most abundantly recorded species in the Superior NF (red-eyed vireo was third). The four most abundantly recorded species in the Chequamegon and Nicolet NFs were identical in order, but the fifth most abundantly recorded species were blue jay in the Chequamegon NF and hermit thrush in the Nicolet NF (Fig. 3). Such differences probably reflect genuine differences in relative abundances of these species, but the results also are influenced by differences in detectability among species in these forests.

Like almost all naturally occurring species assemblages, the ranked relative abundances of forest/woodland bird species within each NF followed a highly skewed distribution, where a few species were very abundant and most other species were uncommon or rare (Fig. 3). More than half of all individual forest/woodland birds recorded in our surveys belonged to the 10 most abundant species. Conversely, the 100 least abundant species collectively contributed less than 7 percent of all individual birds in counts within forest/woodland habitats.

Bird species showing high affinity to specific NFs (i.e., high PPI values; Appendix 3) were most numerous in the Superior NF (average PPI = 13.2). The most distinctive species (Blackburnian warbler, Canada warbler, Cape May warbler, ruby-crowned and golden-crowned kinglets, gray jay, magnolia warbler, Swainson's thrush, and winter wren) were present in all four NFs, but their numbers and frequencies were significantly higher in the Superior NF. A smaller number of geographically distinctive species favored the Chippewa NF (average PPI = 10.2), including American redstart (which also had a high PPI in the Superior NF), chipping sparrow, Connecticut warbler, common yellowthroat, pine warbler, white-winged crossbill, and yellow-throated vireo. Species with a fairly high PPI in the Chequamegon NF (average PPI = 10.7) were brown-headed cowbird, eastern towhee, ruffed grouse, and wood thrush. Only a handful of forest/woodland species exhibited unusually high PPI values in the Nicolet NF (average PPI = 6.6), notably indigo bunting, mourning dove, and wild turkey.

Individual Species Trends

Ninety-eight species had adequate sample sizes for statistical analysis of trends in at least one NF, of which the Chequamegon NF had 75 from 1995 through 2010, and the Chippewa NF had 63, the Superior NF had 62, and the Nicolet NF had 82 from 1995 through 2011 (Tables 7 and 8). Additionally, 49 species were tested for a "pooled" (4 NFs combined) trend from 1995 through 2011 (Tables 7 and 8). To facilitate comparisons in bird species population trends between NFs, we listed the direction and statistical significance of trends across NFs in Table 7, with summaries of species with significantly ($p < 0.05$) increasing and decreasing trends in Tables 9 and 10, respectively. Importantly, the p-value was influenced not only by the size of the linear trend but also by the sample size (i.e., the number of stands meeting our minimum criteria) and the number and distribution of observations across time. Despite these limitations, our experience with this dataset suggests that the traditional level of significance ($p < 0.05$) serves as a useful threshold for defining biologically relevant trends. The magnitude and precision (95-percent confidence intervals) of percent annual change is listed by species and NF in Table 8. Appendix 5 graphically displays the population trajectories and consequent trends for species within each NF as well as regionally. We recommend that all of these trend indicators be used to interpret the population status of bird species and guilds monitored on the NFs.

Table 7.—Population (relative abundance) trends[a] for 98 bird species in 4 individual national forests (NFs) and pooled NFs based on linear regression of LOESS-smoothed annual index of abundance (see Methods), 1995–2011

Common name	Chippewa NF	Superior NF	Chequamegon NF	Nicolet NF		Pooled NFs
Alder flycatcher	ns	ns	I**	I*		I**
American crow	ns	ns	I**	ns	(D)**	I*
American goldfinch	I**	ns	I**	ns		I**
American redstart	ns	ns	ns	ns		I*
American robin	ns	I**	I**	ns		I**
Baltimore oriole	--	--	--	ns		--
Barred owl	--	--	ns	--		--
Black-and-white warbler	I**	I**	I**	ns		I**
Black-billed cuckoo	--	--	--	ns		--
Blackburnian warbler	ns	I*	I*	I*		I**
Black-capped chickadee	I**	I**	ns	ns		I**
Black-throated blue warbler	--	ns	--	ns		--
Black-throated green warbler	I**	I*	ns	ns		I**
Blue jay	I*	I**	I**	I**		I**
Blue-headed vireo	ns	ns	ns	ns		ns
Brewer's blackbird	--	--	D**	--		--
Broad-winged hawk	--	D**	--	--		--
Brown creeper	ns	ns	ns	ns		ns
Brown thrasher	--	--	ns	D**	(D)**	--
Brown-headed cowbird	ns	--	ns	D**	(D)**	--
Canada goose	--	--	I*	--	(I)**	--
Canada warbler	ns	ns	ns	ns		ns
Cape May warbler	--	I**	--	ns		--
Cedar waxwing	ns	I**	ns	D**	(D)*	ns
Chestnut-sided warbler	ns	ns	ns	ns		I*
Chimney swift	--	--	--	ns		--
Chipping sparrow	I**	ns	ns	ns		ns
Clay-colored sparrow	--	--	ns	ns		--
Common grackle	--	--	--	ns		--
Common loon	ns	ns	ns	ns		ns
Common raven	ns	ns	I*	ns		ns
Common yellowthroat	ns	ns	ns	ns		ns
Connecticut warbler	D**	D**	--	--		--
Downy woodpecker	ns	ns	--	ns		--
Eastern bluebird	--	--	I*	ns	(D)*	--
Eastern kingbird	--	--	I**	D*	(D)**	--
Eastern phoebe	--	--	--	ns		--
Eastern towhee	--	--	I*	ns		--
Eastern wood-pewee	ns	ns	ns	ns		ns
European starling	--	--	--	ns		--
Evening grosbeak	--	D*	D**	D**		--
Field sparrow	--	--	ns	D**		--
Golden-crowned kinglet	I*	I**	ns	ns		I**
Golden-winged warbler	D*	ns	I**	ns	(D)*	ns
Gray catbird	ns	--	I**	ns		--
Gray jay	ns	I**	--	--	(D)**	--
Great blue heron	--	--	--	ns	(D)**	--
Great crested flycatcher	ns	--	D**	D**	(D)**	--
Hairy woodpecker	ns	I*	ns	I*		I**

(continued on next page)

Table 7 (continued).—Population (relative abundance) trends[a] for 98 bird species in 4 individual national forests (NFs) and pooled NFs based on linear regression of LOESS-smoothed annual index of abundance (see Methods), 1995–2011

Common name	Chippewa NF	Superior NF	Chequamegon NF	Nicolet NF		Pooled NFs
Hermit thrush	I**	I*	ns	ns	(I)[b]	I**
House wren	--	--	I*	ns		--
Indigo bunting	ns	--	I**	ns		--
Least flycatcher	ns	ns	ns	ns	(D)**	ns
Lincoln's sparrow	--	--	ns	I*		--
Magnolia warbler	ns	D*	ns	ns		ns
Mallard	--	--	--	ns		--
Mourning dove	I**	--	I**	ns	(I)**	--
Mourning warbler	ns	ns	ns	ns	(D)**	ns
Nashville warbler	I**	I**	I**	ns		I**
Northern flicker	ns	I**	ns	ns		I**
Northern parula	ns	I**	ns	ns	(D)*	I**
Northern waterthrush	ns	ns	D*	ns		ns
Olive-sided flycatcher	ns	ns	--	--	(D)*	--
Ovenbird	I**	I*	I**	I**	(I)**	I**
Palm warbler	ns	--	--	--		--
Pileated woodpecker	I**	I**	I**	ns	(I)**	I**
Pine warbler	ns	ns	I**	ns		I**
Purple finch	ns	I*	ns	ns		ns
Red-breasted nuthatch	I**	I**	I**	I**	(I)**	I**
Red-eyed vireo	I**	ns	I**	ns		I**
Red-winged blackbird	ns	ns	D*	ns		ns
Rose-breasted grosbeak	ns	ns	I**	ns	(D)*	I**
Ruby-crowned kinglet	--	I**	--	--		--
Ruby-throated hummingbird	ns	--	--	--		--
Ruffed grouse	--	D**	ns	ns	(I)*	--
Sandhill crane	--	--	I**	--	(I)**	--
Scarlet tanager	D*	ns	D*	ns	(D)**	D**
Sedge wren	--	--	ns	ns		--
Song sparrow	D*	ns	ns	D**	(D)**	D*
Swainson's thrush	--	D**	--	--		--
Swamp sparrow	ns	ns	ns	ns		ns
Tennessee warbler	--	ns	--	--		--
Tree swallow	--	--	ns	D**	(D)**	--
Upland sandpiper	--	--	ns	--		--
Veery	I**	ns	D*	ns		ns
Vesper sparrow	--	--	I**	--		--
Warbling vireo	--	--	--	ns		--
White-breasted nuthatch	ns	--	ns	ns	(I)*	--
White-throated sparrow	I**	I**	I*	ns		I**
Wild turkey	--	--	--	--	(I)**	--
Wilson's snipe	--	D*	--	ns		--
Winter wren	ns	I**	ns	D**	(D)**	ns
Wood thrush	ns	ns	ns	ns	(D)*	ns
Yellow warbler	ns	--	I**	ns		--
Yellow-bellied flycatcher	ns	D**	ns	ns		D**
Yellow-bellied sapsucker	I**	I**	I**	I**	(I)**	I**
Yellow-rumped warbler	D*	I**	D**	ns		D*
Yellow-throated vireo	D**	--	ns	ns		--

[a] I = significantly increasing; D = significantly decreasing at the * $p < 0.05$ or ** $p < 0.01$ level; ns = no significant trend. Dashes indicate that the species was not common enough to test for a trend. Responses in parentheses for the Nicolet NF correspond with results of binomial test for difference between 1990s and 2000s (see Methods).

[b] $p > 0.05$ and $p < 0.01$

Table 8.—Average annual percent change (trend) and confidence intervals (CIs) for 97 species from 4 individual national forests (NFs) and pooled NFs based on linear regression of LOESS-smoothed annual index of abundance versus year (see Methods), 1995–2011

Species	Chippewa NF			Superior NF			Chequamegon NF			Nicolet NF			Pooled NFs		
	Percent change	2.50% CI	97.5% CI	Percent change	2.50% CI	97.5% CI	Percent change	2.50% CI	97.5% CI	Percent change	2.50% CI	97.5% CI	Percent change	2.50% CI	97.5% CI
Alder flycatcher	-0.95	-4.39	2.02	1.36	-2.35	5.13	2.89**	0.89	5.51	1.99*	0.02	3.91	2.07**	0.60	3.44
American crow	1.39	-0.01	2.81	-1.77	-3.48	0.14	2.23**	1.04	3.39	0.00	-1.53	1.32	0.99*	0.21	1.64
American goldfinch	9.28**	4.83	12.60	5.23	-6.06	15.98	6.93**	2.53	10.86	-0.22	-2.51	1.84	2.27*	0.45	4.25
American redstart	1.38	-0.38	3.03	-0.23	-2.38	2.09	2.42	-1.53	6.04	0.82	-5.69	6.02	1.48*	0.09	2.68
American robin	0.30	-1.25	1.76	1.72**	0.68	2.95	2.15**	0.92	3.33	0.71	-0.12	1.62	1.27**	0.74	1.80
Baltimore oriole	--	--	--	--	--	--	--	--	--	-0.86	-4.26	2.42	--	--	--
Barred owl	--	--	--	--	--	--	-3.49	-11.34	3.71	--	--	--	--	--	--
Black-and-white warbler	5.58**	3.94	7.37	3.68**	2.46	4.87	5.30**	3.40	7.39	-0.02	-2.01	1.99	3.76**	2.95	4.55
Black-billed cuckoo	--	--	--	--	--	--	--	--	--	-1.57	-11.71	7.90	--	--	--
Blackburnian warbler	0.69	-1.80	3.03	1.26*	0.08	2.59	2.08*	0.36	3.66	2.06*	0.07	4.25	1.53**	0.55	2.39
Black-capped chickadee	2.90**	1.55	4.14	4.05**	2.63	5.49	-0.32	-1.77	1.18	-0.92	-2.21	0.40	1.28**	0.59	2.01
Black-throated blue warbler	--	--	--	0.95	-3.78	5.72	--	--	--	0.91	-5.39	6.64	--	--	--
Black-throated green warbler	3.76**	2.22	5.26	1.43*	0.10	2.95	0.04	-0.96	0.94	-0.24	-1.16	0.71	0.83*	0.20	1.47
Blue jay	1.43*	0.34	2.46	2.56**	1.59	3.62	1.50**	0.69	2.39	2.02**	0.93	3.04	2.04**	1.50	2.54
Blue-headed vireo	1.36	-1.53	4.10	2.15	-1.08	5.21	0.78	-4.23	5.19	-1.73	-7.10	2.80	1.50	-0.45	3.47
Brewer's blackbird	--	--	--	--	--	--	-6.83**	-11.81	-3.49	--	--	--	--	--	--
Broad-winged hawk	--	--	--	-9.5**	-14.81	-3.73	--	--	--	--	--	--	--	--	--
Brown creeper	-0.06	-2.32	2.36	-0.41	-2.97	2.35	-0.82	-3.45	1.89	-1.49	-5.10	1.92	-0.35	-1.70	1.02
Brown thrasher	--	--	--	--	--	--	-1.91	-5.39	1.12	-13.27**	-22.32	-7.37	--	--	--
Brown-headed cowbird	0.60	-6.58	6.56	--	--	--	0.29	-3.70	4.02	-11.04**	-15.24	-7.61	--	--	--
Canada goose	--	--	--	--	--	--	10.93*	2.62	17.20	--	--	--	--	--	--
Canada warbler	5.16	-1.31	10.06	0.39	-1.04	1.77	-2.36	-5.40	1.04	-3.70	-9.55	0.86	0.51	-1.13	1.87
Cape May warbler	--	--	--	7.05**	2.36	10.76	--	--	--	--	--	--	--	--	--
Cedar waxwing	2.22	-1.55	5.83	7.15**	3.27	10.17	5.04	-1.56	12.87	-4.56**	-6.74	-2.38	-1.65	-3.68	0.33
Chestnut-sided warbler	-0.06	-1.78	1.64	0.05	-1.03	1.34	2.04	-0.02	3.94	-0.31	-2.27	1.52	0.92*	0.04	1.76
Chimney swift	--	--	--	--	--	--	--	--	--	0.20	-10.29	3.71	--	--	--
Chipping sparrow	1.95**	0.41	3.34	-1.00	-3.25	1.24	-0.51	-2.98	1.69	-1.86	-3.86	0.15	0.30	-0.73	1.37
Clay-colored sparrow	--	--	--	--	--	--	0.19	-2.06	2.38	6.54	-2.09	16.90	--	--	--
Common grackle	--	--	--	--	--	--	--	--	--	2.89	-0.48	6.98	--	--	--
Common loon	-0.16	-1.97	1.74	-3.23	-6.24	0.02	2.74	-4.20	8.57	-2.33	-4.90	0.59	-0.70	-2.15	0.74
Common raven	0.60	-2.19	3.81	0.86	-1.71	3.47	3.25*	0.32	5.82	-0.80	-2.96	1.18	0.77	-0.56	2.24
Common yellowthroat	0.14	-1.19	1.46	1.49	-0.94	3.67	-0.43	-2.24	1.59	-1.02	-2.21	0.01	0.08	-0.87	0.86
Connecticut warbler	-7.11**	-11.52	-3.79	-8.42**	-14.71	-5.56	--	--	--	--	--	--	--	--	--

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Table 8 (continued).—Average annual percent change (trend) and confidence intervals (CIs) for 97 species from 4 individual national forests (NFs) and pooled NFs based on linear regression of LOESS-smoothed annual index of abundance versus year, 1995–2011

Species	Chippewa NF			Superior NF			Chequamegon NF			Nicolet NF			Pooled NFs		
	Percent change	2.50% CI	97.5% CI	Percent change	2.50% CI	97.5% CI	Percent change	2.50% CI	97.5% CI	Percent change	2.50% CI	97.5% CI	Percent change	2.50% CI	97.5% CI
Downy woodpecker	1.33	-4.17	6.41	-5.98	-12.98	4.40	--	--	--	2.71	-2.29	6.56	--	--	--
Eastern bluebird	--	--	--	--	--	--	6.00**	1.39	9.40	-4.84	-16.59	1.95	--	--	--
Eastern kingbird	--	--	--	--	--	--	5.74**	2.58	9.80	-4.62*	-8.36	-0.98	--	--	--
Eastern phoebe	--	--	--	--	--	--	--	--	--	0.65	-5.25	5.50	--	--	--
Eastern towhee	--	--	--	--	--	--	5.10**	1.62	8.90	1.23	-5.48	9.21	--	--	--
Eastern wood-pewee	-0.47	-1.72	0.85	-1.19	-5.42	3.70	-1.39	-3.03	0.51	0.05	-1.70	1.68	-0.60	-1.54	0.39
European starling	--	--	--	--	--	--	--	--	--	-2.35	-8.49	6.31	--	--	--
Evening grosbeak	--	--	--	-8.29*	-15.73	-1.27	-12.95**	-17.95	-6.98	-8.70**	-12.35	-5.28	--	--	--
Field sparrow	--	--	--	--	--	--	5.58	-2.80	13.62	-7.12*	-16.53	-0.98	--	--	--
Golden-crowned kinglet	2.93*	0.58	6.36	3.50**	1.45	5.38	1.88	-5.31	8.83	1.47	-1.99	5.08	3.33**	1.81	4.86
Golden-winged warbler	-4.85*	-8.83	-1.16	4.53	-1.50	9.38	8.76**	3.71	13.04	-1.92	-5.44	1.72	0.72	-1.91	3.23
Gray catbird	-0.14	-6.82	7.48	--	--	--	11.01**	7.06	15.09	-0.01	-8.34	9.03	--	--	--
Gray jay	2.99	-3.34	9.69	5.84**	3.06	8.44	--	--	--	--	--	--	--	--	--
Great blue heron	--	--	--	--	--	--	--	--	--	2.91	-3.97	5.19	--	--	--
Great crested flycatcher	-2.30	-5.19	0.24	--	--	--	-3.45**	-5.43	-1.36	-2.71**	-4.60	-0.98	--	--	--
Hairy woodpecker	2.68	-1.84	7.52	5.66*	0.88	10.30	1.81	-1.43	5.28	5.91**	0.90	12.13	3.33**	1.06	5.56
Hermit thrush	2.19**	1.23	3.14	1.17**	0.33	1.90	-0.45	-1.60	0.89	0.75	-0.26	1.78	0.95**	0.47	1.55
House wren	--	--	--	--	--	--	3.54*	0.20	8.27	2.48	-1.49	6.85	--	--	--
Indigo bunting	-2.30	-8.88	4.24	--	--	--	5.85**	2.46	9.32	-0.40	-2.79	2.16	--	--	--
Least flycatcher	-0.40	-1.85	1.10	1.88	-0.86	4.85	-2.45	-4.78	0.11	-1.43	-3.51	0.57	-0.57	-1.56	0.47
Lincoln's sparrow	--	--	--	--	--	--	-0.21	-12.46	4.67	7.29*	2.27	13.48	--	--	--
Magnolia warbler	-3.06	-8.58	1.56	-1.62*	-2.90	-0.41	2.56	-5.32	9.41	-0.08	-10.14	5.13	-0.71	-1.77	0.40
Mallard	--	--	--	--	--	--	--	--	--	3.42	-0.74	5.65	--	--	--
Mourning dove	10.28**	6.12	13.89	--	--	--	13.46**	11.62	15.49	2.43	-0.16	5.00	--	--	--
Mourning warbler	-0.24	-2.11	1.50	-0.79	-2.13	0.66	-2.45	-5.51	0.64	-1.09	-3.09	0.86	-0.56	-1.58	0.43
Nashville warbler	2.38**	1.47	3.28	2.76**	2.28	3.25	3.14**	1.90	4.23	0.50	-0.21	1.24	2.31**	1.93	2.69
Northern flicker	3.59	-0.09	7.40	4.05**	2.15	5.97	3.16	-1.39	8.28	-0.79	-5.40	3.78	3.41**	1.76	5.24
Northern parula	2.05	-0.85	4.86	3.41**	2.02	4.97	2.21	-0.83	5.03	-2.07	-4.44	0.40	2.04**	0.96	3.12
Northern waterthrush	1.64	-1.87	7.31	3.46	-0.02	7.86	-3.14*	-5.28	-0.15	-0.22	-4.43	3.07	-0.19	-1.96	2.00
Olive-sided flycatcher	-3.12	-9.68	3.20	1.07	-3.53	4.65	--	--	--	--	--	--	--	--	--
Ovenbird	2.80**	2.01	3.55	0.74*	0.18	1.29	1.21**	0.75	1.71	0.60**	0.20	0.97	1.39**	1.13	1.67
Palm warbler	-0.67	-4.64	3.51	--	--	--	--	--	--	--	--	--	--	--	--
Pileated woodpecker	8.98**	5.14	12.29	4.57**	2.15	7.14	7.91**	4.21	11.74	2.86	-1.40	8.11	6.38**	4.48	8.15

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Table 8 (continued).—Average annual percent change (trend) and confidence intervals (CIs) for 97 species from 4 individual national forests (NFs) and pooled NFs based on linear regression of LOESS-smoothed annual index of abundance versus year, 1995–2011

Species	Chippewa NF			Superior NF			Chequamegon NF			Nicolet NF			Pooled NFs		
	Percent change	2.50% CI	97.5% CI	Percent change	2.50% CI	97.5% CI	Percent change	2.50% CI	97.5% CI	Percent change	2.50% CI	97.5% CI	Percent change	2.50% CI	97.5% CI
Pine warbler	0.75	-0.70	2.48	3.37	-0.07	7.11	4.63**	1.88	7.74	1.87	-2.19	6.34	2.34**	0.98	3.70
Purple finch	0.18	-3.57	4.50	5.35*	0.99	9.79	-0.33	-6.07	5.61	-2.91	-6.63	1.51	0.72	-1.97	3.55
Red-breasted nuthatch	6.97**	5.36	8.51	5.02**	3.64	6.32	7.22**	5.40	9.05	5.14**	3.41	6.71	6.17**	5.41	6.96
Red-eyed vireo	1.20**	0.79	1.61	0.04	-0.52	0.60	1.81**	1.28	2.32	-0.01	-0.49	0.47	1.02**	0.74	1.28
Red-winged blackbird	1.34	-2.48	4.47	3.28	-4.60	10.50	-5.16*	-12.38	-0.37	0.66	-1.62	2.47	0.46	-1.84	2.27
Rose-breasted grosbeak	1.70	-0.28	3.59	0.71	-0.82	2.19	3.80**	2.57	4.86	0.71	-0.35	1.73	1.87**	1.22	2.55
Ruby-crowned kinglet	--	--	--	9.40**	6.66	12.29	--	--	--	--	--	--	--	--	--
Ruby-throated hummingbird	1.76	-6.53	9.29	--	--	--	--	--	--	--	--	--	--	--	--
Ruffed grouse	--	--	--	-7.17**	-10.96	-2.99	0.26	-1.98	2.55	2.27	-3.78	6.88	--	--	--
Sandhill crane	--	--	--	--	--	--	5.30**	2.24	8.12	--	--	--	--	--	--
Scarlet tanager	-1.80*	-3.30	-0.17	-0.79	-5.36	3.90	-3.04**	-5.25	-0.89	-1.37	-3.15	0.76	-1.78**	-2.93	-0.80
Sedge wren	--	--	--	--	--	--	0.76	-1.97	8.21	-0.94	-8.91	5.21	--	--	--
Song sparrow	-4.62*	-8.14	-1.74	-0.84	-4.25	2.37	1.84	-0.97	4.89	-2.16**	-3.80	-0.59	-1.44*	-2.54	-0.17
Swainson's thrush	--	--	--	-2.69**	-4.50	-0.68	--	--	--	--	--	--	--	--	--
Swamp sparrow	0.33	-2.97	3.34	1.62	-0.53	4.18	-2.91	-6.51	0.72	1.86	-0.31	3.76	1.08	-0.48	2.58
Tennessee warbler	--	--	--	-6.65	-16.93	4.98	--	--	--	--	--	--	--	--	--
Tree swallow	--	--	--	--	--	--	-3.49	-6.27	8.67	-4.68**	-7.29	-1.71	--	--	--
Upland sandpiper	--	--	--	--	--	--	-3.96	-12.19	1.38	--	--	--	--	--	--
Veery	2.83**	1.75	4.04	-0.63	-1.74	0.38	-2.17*	-4.03	-0.36	1.40	-0.74	3.16	0.65	-0.04	1.37
Vesper sparrow	--	--	--	--	--	--	4.85**	2.07	9.14	--	--	--	--	--	--
Warbling vireo	--	--	--	--	--	--	--	--	--	0.21	-5.42	3.58	--	--	--
White-breasted nuthatch	0.13	-2.79	3.14	--	--	--	1.12	-2.52	4.79	2.45	-5.84	9.00	--	--	--
White-throated sparrow	2.27**	1.29	3.21	2.07**	1.23	2.98	1.78*	0.11	3.48	-0.35	-1.36	0.65	1.81**	1.26	2.41
Wilson's snipe	--	--	--	-3.68*	-7.73	-0.47	2.48	-3.48	0.98	--	--	--	--	--	--
Winter wren	-1.49	-3.06	0.01	1.67**	0.70	2.67	-1.10	-3.47	0.98	-3.53**	-5.03	-1.95	-0.54	-1.31	0.21
Wood thrush	2.50	-1.69	8.62	0.79	-8.52	9.49	-1.73	-6.63	3.41	-0.89	-7.15	4.70	-0.42	-4.13	2.95
Yellow warbler	1.69	-5.34	7.98	--	--	--	3.47**	2.26	5.26	0.27	-3.56	5.42	--	--	--
Yellow-bellied flycatcher	-0.37	-3.40	2.31	-4.53**	-6.00	-3.24	-1.56	-3.85	0.54	-0.24	-3.05	2.52	-2.18**	-3.34	-1.12
Yellow-bellied sapsucker	4.20**	2.74	5.76	2.34**	0.95	3.76	3.69**	2.59	4.86	6.20**	4.27	7.98	4.11**	3.42	4.81
Yellow-rumped warbler	-1.91*	-3.35	-0.36	2.16**	0.67	3.67	-6.16**	-7.95	-4.42	-0.96	-2.80	1.01	-1.25**	-2.24	-0.30
Yellow-throated vireo	-6.43**	-9.09	-3.74	--	--	--	0.59	-2.40	3.13	-3.94	-14.44	3.41	--	--	--

* $p < 0.05$; ** $p < 0.01$. Dashes indicate that the species was not common enough to test for a trend.

Table 9.—Summary of species with increasing trends (p < 0.05) in one, two, and three or four national forests, 1995–2011

One national forest
American crow
Canada goose
Cape May warbler
Cedar waxwing*
Chipping sparrow
Common raven
Eastern bluebird
Eastern kingbird*
Eastern towhee
Golden-winged warbler*
Gray catbird
Gray jay
House wren
Indigo bunting
Lincoln's sparrow
Northern flicker
Northern parula
Pine warbler
Purple finch
Rose-breasted grosbeak
Ruby-crowned kinglet
Sandhill crane
Veery*
Vesper sparrow
Winter wren*
Yellow warbler
Yellow-rumped warbler*
Two national forests
Alder flycatcher
American goldfinch
American robin
Black-capped chickadee
Black-throated green warbler
Golden-crowned kinglet
Hairy woodpecker
Hermit thrush
Mourning dove
Red-eyed vireo
Three or four national forests
Black-and-white warbler
Blackburnian warbler
Blue jay
Nashville warbler
Ovenbird
Pileated woodpecker
Red-breasted nuthatch
White-throated sparrow
Yellow-bellied sapsucker

* Species significantly increased in one national forest, but significantly decreased in another.

Table 10.—Summary of species with decreasing trends (p < 0.05) on one, two, and three or four national forests, 1995–2011

One national forest
Brewer's blackbird
Broad-winged hawk
Brown-headed cowbird
Brown thrasher
Cedar waxwing*
Eastern kingbird*
Field sparrow
Golden-winged warbler*
Gray catbird
Magnolia warbler
Northern waterthrush
Red-winged blackbird
Ruffed grouse
Swainson's thrush
Tree swallow
Veery*
Wilson's snipe
Winter wren*
Yellow-bellied flycatcher
Yellow-throated vireo
Two national forests
Connecticut warbler
Great crested flycatcher
Scarlet tanager
Song sparrow
Yellow-rumped warbler*
Three or four national forests
Evening grosbeak

* Species significantly decreased in one national forest but significantly increased in another.

Common Species Trends Among National Forests

Trends in forest bird populations showed remarkable consistency among the NFs. Four species significantly increased over the study period in all four NFs: yellow-bellied sapsucker, blue jay, red-breasted nuthatch, and ovenbird. Nineteen species exhibited significant increases in two or more NFs and either no significant change or insufficient numbers in the others (Table 9). Five of these 19 species are permanent or semi-permanent residents and 7 others are short-distance migrants. No species declined significantly in all four forests, but five species (great crested flycatcher, Connecticut warbler, scarlet tanager, song sparrow, and evening grosbeak) declined significantly in two or more forests and showed no significant trends in the others (Table 10). Three of these species are long-distance migrants, one is a short-distance migrant, and one is a permanent resident. Inconsistent trends (significant increase in 1 or more NFs but significant decrease in 1 or more of the others) were recorded for only 6 of the 98 species (eastern kingbird, cedar waxwing, winter wren, veery, golden-winged warbler, and yellow-rumped warbler). Further investigation on why these patterns exist and whether they are consistent over time is warranted. Among the 49 species for which we were able to calculate a pooled trend for all 4 NFs, 25 showed a significant increase and 4 showed a significant decrease in numbers between 1995 and 2011.

The total number of trend calculations included 280 species-by-NF combinations. The number of significantly increasing trends (78, or 28 percent) greatly exceeded the number of significantly decreasing trends (32, or 11 percent). No significant trends were detected for 170 species-by-NF combinations (61 percent). Therefore, 89 percent of the species-by-NF combinations were either significantly increasing or stable.

Chippewa National Forest—Of the 63 species tested, 17 species (27 percent) increased significantly and 6 (10 percent) declined (Tables 7 and 8). Both the Connecticut warbler and golden-winged warbler are species of concern in Minnesota and, therefore, the trends for these species warrant particular concern. Data from the BBS (Sauer and Link 2011) provide evidence of a widespread decline in Connecticut warbler populations in the United States and Canada. Additional discussion on conservation and management issues for the golden-winged warbler, yellow-rumped warbler, Connecticut warbler, and scarlet tanager is included in the "Demonstration Species" subsection of the Discussion.

Superior National Forest—Of the 62 species tested, 24 species (38 percent) increased significantly and 8 (13 percent) decreased significantly (Tables 7 and 8). Yellow-bellied flycatcher, Swainson's thrush, and Connecticut warbler, all of which declined, were associated with lowland coniferous forest. The declining trend of evening grosbeak in the Superior, Chequamegon, and Nicolet NFs is consistent with reported declines across the northern United States and Canada for unknown reasons (Niemi 2012). The observed trends for broad-winged hawk and Wilson's snipe should be interpreted with caution because these non-passerines were found in low numbers during our point counts.

Chequamegon National Forest—Of the 75 species tested, 29 species (39 percent) increased significantly and 8 (11 percent) decreased (Tables 7 and 8). Sample sizes were rather small for Brewer's blackbird, northern waterthrush, and evening grosbeak, so those decreases should be viewed with caution. In addition, red-winged blackbird (which also decreased) is typically found in open wetlands and other nonforested areas, and Brewer's blackbird is found near human habitations and roads. Neither of these species is dependent on forested habitat.

Nicolet National Forest—Regression analysis revealed significant trends in 18 of the 82 species tested (22 percent). Unlike results from the other NFs, the number of significantly increasing trends in the Nicolet NF (8) did not exceed the number of significantly decreasing trends (10).

Binomial tests comparing point-by-point average abundances for the Nicolet NF point counts for 1991–2000 and 2001–2010 supported many but not all of the significant regression trends reported for 1995–2011 (Table 7). The binomial test provided a valid test of change for species that were not observed frequently enough to apply trend analysis, such as Canada goose, sandhill crane, wild turkey (Fig. 6), and gray jay (Fig. 6). In many cases (e.g., mourning dove, pileated woodpecker, hermit thrush, and scarlet tanager) results from the binomial analysis in the Nicolet NF were consistent with regression trends from the other NFs (Tables 7 and 8).

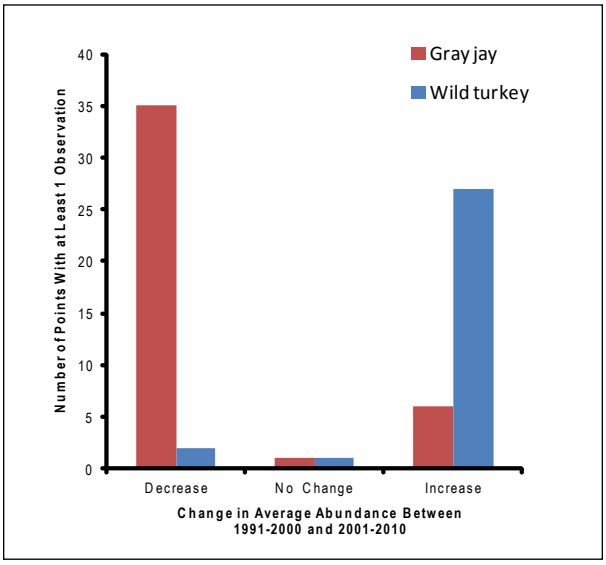


Figure 6.—Point-by-point comparison of average abundances of gray jay and wild turkey between two decades (1991–2000 vs. 2001–2010) in the Nicolet National Forest. Points were included only if the species was recorded at least once. Average abundance is the total number of individuals divided by the total number of counts (usually 5, every other year). Increases or decreases are simple tallies of the numbers of points where the average abundances were greater (increase) or less (decrease) in 2001–2010 compared with the average abundance in 1991–2000.

Trends in Breeding Bird Guilds

Almost all of the analyses of migratory, nesting, and habitat association guilds showed significant increases in the Chippewa, Superior, and Chequamegon NFs (Table 11, Appendix 4). The only exceptions were species associated with early successional and mixed forest in the Chequamegon NF and species associated with early successional vegetation in the Chippewa NF. No guilds significantly decreased in abundance in these three NFs. In the Nicolet NF, however, significant increases were documented only for permanent residents and species associated with coniferous forest habitats. A significant decrease in abundance was observed for birds associated with lowland coniferous forests.

Noteworthy is the pattern of increasing trends exhibited by the migratory guilds. Permanent residents showed the greatest overall percentage increase in all NFs with a pooled increase of 2.4 percent per year (Table 11). Short-distance migrants showed the next largest percentage increase of 1.2 percent, and the long-distance migrants exhibited an overall increase of 0.7 percent per year (also highly significant). Note that an increase of 2.4 percent per year between 1995 and 2011 represents an approximate 46-percent increase in the number of permanent resident individuals within these NFs. Guild analyses are often influenced by the most abundant species within the guild; however, numerous other species contributed to the observed increases in abundance (Table 9).

Comparison of National Forest Trends with USGS Breeding Bird Surveys

Results from 49 bird species in our surveys were compared with corresponding results from 16 roadside routes in the USGS BBS from 1995 through 2010 in the Chippewa, Superior, and Chequamegon NFs. Overall the correlation in trends among these 49 species was insignificant

Table 11.—Average annual percent change (trend) and confidence intervals (CIs) for bird guilds for four individual national forests (NFs) and pooled NFs based on linear regression of LOESS-smoothed annual index of abundance versus year (see Methods), 1995–2011

Guild category	Chippewa NF N=119-126			Superior NF N=146			Chequamegon NF N=112-129			Nicolet NF N=295			Pooled NFs N= 676-697		
	Percent change	2.50% CI	97.5% CI	Percent change	2.50% CI	97.5% CI	Percent change	2.50% CI	97.5% CI	Percent change	2.50% CI	97.5% CI	Percent change	2.50% CI	97.5% CI
Migrant (short distance)	1.15**	0.68	1.66	1.87**	1.41	2.36	1.44**	0.80	2.06	0.39	-0.23	1.05	1.18**	0.89	1.49
Migrant (long distance)	1.34**	1.04	1.60	0.74**	0.53	0.95	1.02**	0.74	1.30	-0.09	-0.38	0.23	0.72**	0.56	0.88
Permanent resident	2.81**	2.11	3.44	3.29**	2.67	3.90	2.28**	1.59	2.94	1.22**	0.50	1.89	2.44**	2.06	2.77
Ground nesting	1.73**	1.39	2.08	1.10**	0.83	1.37	1.01**	0.65	1.35	0.39	-0.05	0.79	0.91**	0.72	1.09
Subcanopy nesting	0.80**	0.25	1.28	0.51*	0.02	1.03	1.59**	1.07	2.10	-0.09	-0.61	0.41	0.80**	0.53	1.04
Canopy nesting	1.05**	0.54	1.55	2.08**	1.60	2.61	0.80**	0.33	1.28	0.40	-0.07	0.83	1.01**	0.75	1.26
Cavity nesting	3.33**	2.69	4.08	3.81**	3.12	4.53	2.52**	1.73	3.33	0.61	-0.29	1.56	2.49**	2.10	2.87
Coniferous forest	1.69**	1.00	2.39	1.84**	1.29	2.40	1.50**	0.60	2.39	1.25**	0.39	2.10	1.45**	1.09	1.84
Lowland coniferous	0.93*	0.24	1.65	1.75**	1.28	2.18	1.15**	0.25	2.13	-0.84*	-1.63	-0.08	0.71**	0.33	1.08
Deciduous forest	1.70**	1.38	2.00	0.86**	0.50	1.22	1.11**	0.78	1.40	0.37	-0.02	0.79	1.00**	0.82	1.19
Early successional	0.61	-0.54	1.57	1.02*	0.24	1.83	1.63	-0.01	3.20	-0.77	-1.98	0.40	0.78*	0.16	1.42
Mixed forest	2.58**	1.87	3.24	1.58**	1.05	2.06	0.03	-0.74	0.70	0.38	-0.43	1.17	0.90**	0.56	1.27

* $p < 0.05$; ** $p < 0.01$.

($r^2 = 0.03$) (Fig. 7). Five species had significantly ($p < 0.10$) consistent trends (three positive and two negative) (Table 12). The NF trend analyses had greater power to detect population changes. Significant trends were detected for 16 of the 49 species (32 percent) at $p < 0.05$ and for 20 of the 49 species (41 percent) at $p < 0.10$. In comparison, the BBS trend data detected trends for only 7 of 49 species (14 percent) at $p < 0.05$ and 11 of 49 species (22 percent) at $p < 0.10$.

When the criteria for statistical significance were relaxed to examine qualitative trends for each species using both methods, results from the different surveys were more consistent. Positive trends were detected for 11 species in both the NF and BBS datasets (Table 12). Negative trends were observed for 10 species in both datasets. Inconsistent trends, where 1 of the datasets indicated a positive trend and the other a negative trend, were observed for 11 species; however, only 2 of these species had significant ($p < 0.05$) positive or negative trends. The black-throated green warbler had a significant positive trend

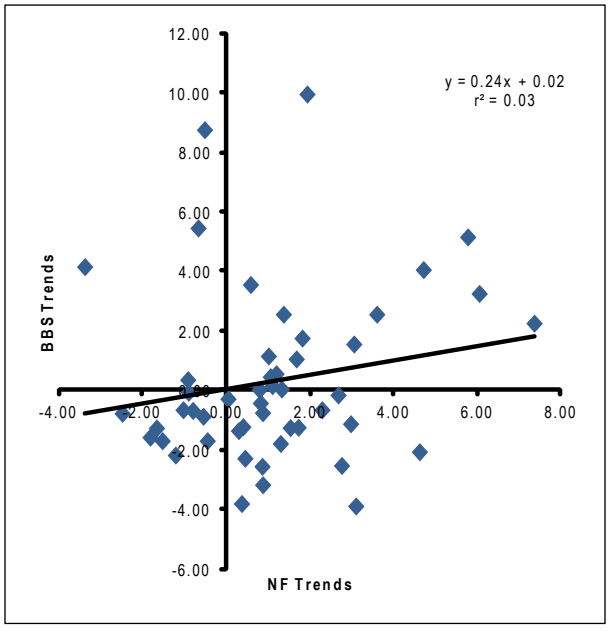


Figure 7.—Correlation between trends of 49 breeding bird species counted in 3 national forests (Chippewa, Superior, and Chequamegon) (Niemi et al. 2011) compared with the trends from the USGS Breeding Bird Surveys (Sauer and Link 2011) from 1995 through 2010.

Table 12.—Combined regional trends for 49 bird species in the Chippewa, Superior, and Chequamegon National Forests compared with trends from 16 Breeding Bird Surveys completed within the general boundaries of these national forests (percent change per year in national forests/percent change per year in Breeding Bird Surveys) from 1995 through 2010

Common name	Consistent positive trends[a]	Consistent negative trends[a]	Inconsistent trends[a]	No trend
Alder flycatcher	1.0/1.1			
American crow				0.8/-0.5
American goldfinch	7.4**/2.2			
American redstart				1.1/-0.1
American robin				1.3/-0.01
Black-and-white warbler			4.6**/-2.1	
Blackburnian warbler			1.3**/-1.8	
Black-capped chickadee	1.8*/1.7			
Black-throated green warbler			0.9**/-3.2**	
Blue jay	1.7*/1.0			
Blue-headed vireo				1.6/-1.3
Brown creeper			-0.5/8.7**	
Canada warbler				0.4/-1.3
Cedar waxwing	**4.7*/4.0***			
Chestnut-sided warbler				0.3/-1.4
Chipping sparrow				0.5/-2.3
Common loon				-0.9/0.3
Common raven	1.1/2.5			
Common yellowthroat				0.1/-0.3
Eastern wood-pewee		-1.0/-0.7		
Golden-crowned kinglet			3.1**/-3.9	
Golden-winged warbler				0.8/-2.6
Hairy woodpecker				2.7/-0.2
Hermit thrush	1.1*/0.4			
Least flycatcher		-0.4/-1.8**		
Magnolia warbler		**-1.5**/-1.8***		
Mourning warbler		-0.9/-0.1		
Nashville warbler			3.0**/-1.2	
Northern flicker	3.6**/2.5			
Northern parula			2.8**/-2.6	
Northern waterthrush			-0.7/5.4*	
Ovenbird				1.2/0.5
Pileated woodpecker	**5.8**/5.1***			
Pine warbler	**1.9**/9.9****			
Purple finch				0.6/3.5
Red-breasted nuthatch	6.1**/3.2			
Red-eyed vireo				0.8/-0.0
Red-winged blackbird		-1.7/-1.3		
Rose-breasted grosbeak			1.7**/-1.3	
Scarlet tanager		-2.5**/-0.8		
Song sparrow		**-1.8**/-1.6****		
Swamp sparrow		-0.5/-0.9		
Veery				0.9/-0.8
White-throated sparrow				2.3/-0.7
Winter wren			0.4/-3.9**	
Wood thrush		-1.2/-2.2		
Yellow-bellied flycatcher			-3.4**/4.1**	
Yellow-bellied sapsucker				3.1/1.5
Yellow-rumped warbler		-0.8/-0.7		

[a] Significant or nearly significant trends ($p < 0.10$) consistent for species are shown in bold. * $p < 0.10$; ** $p < 0.05$.

according to the NF dataset, whereas the BBS data indicated a significant negative trend. In contrast, yellow-bellied flycatcher had a significant negative trend with the NF data but a significant positive trend with the BBS data. The remaining 17 species had neither a positive nor negative trend with either dataset, and their trend would be considered stable over this time period. Therefore, with this relaxed interpretation, 38 of 49 species (78 percent) exhibited consistent direction of trends between datasets, and 11 of 49 (22 percent) indicated opposing trends.

Habitat Associations

Maximum percent perfect indication (PPI) values among habitats (on a scale from 0 to 100) ranged from a value of 2 for red crossbill to a high of 98 for European starling, which was found almost exclusively in towns (Appendix 3). The low value for the red crossbill was probably due to the low sample size for this species. In addition to the European starling, many of the highest PPI values identified strong associations between bird species and towns, including chimney swift (PPI = 74), house wren (59), warbling vireo (42), killdeer (38), common grackle (37), chipping sparrow (33), American goldfinch (32), mourning dove (30), tree swallow (27), American robin (25), American crow (22), Baltimore oriole (22), cedar waxwing (20), and eastern phoebe (17). Other high PPI values (in parentheses) were observed for the following species/habitat combinations:

- Sedge habitat: Savannah sparrow (39), sedge wren (37), olive-sided flycatcher (27), alder flycatcher (23), and Lincoln's sparrow (21)
- Open wet habitat: mallard (36), red-winged blackbird (26), Wilson's snipe (26), eastern kingbird (24), swamp sparrow (23), tree swallow (21), bald eagle (18), wood duck (17), American bittern (16), and pied-billed grebe (15)
- Open dry habitat: clay-colored sparrow (35), brown thrasher (28), vesper sparrow (27), eastern towhee (25), Brewer's blackbird (25), eastern bluebird (19), field sparrow (19), and upland sandpiper (18)
- Black spruce-tamarack forest: Connecticut warbler (29), palm warbler (21), yellow-bellied flycatcher (20), white-winged crossbill (16), and Nashville warbler (15)
- Lowland hardwood forest: northern waterthrush (28)
- Lowland shrub habitat: alder flycatcher (25), swamp sparrow (14), common yellowthroat (14), and yellow warbler (14)
- Red pine forest: pine warbler (25)
- White pine forest: pine warbler (19) and Blackburnian warbler (15)
- Oak forest: yellow-throated vireo (22), least flycatcher (16), eastern wood-pewee (15), and white-breasted nuthatch (13)
- Swamp conifer forest: yellow-bellied flycatcher (20) and winter wren (14)
- Hemlock forest: black-throated green warbler (17) and Blackburnian warbler (15)
- Beech-maple-birch forest: black-throated green warbler (15)
- Aspen-spruce-fir forest: magnolia warbler (13)

Altogether 41 percent of the species analyzed yielded maximum PPI values of 15 or greater (Appendix 3). Even though virtually all species occurred in multiple habitats, significant evidence of habitat preference or avoidance (indicator species analysis, $p < 0.05$) was observed in 87 of the 123 species. Common species such as red-eyed vireo, ovenbird, blue jay, rose-breasted grosbeak, yellow-bellied sapsucker, and black-and-white warbler tended to occur in many forest cover types, including openings bordered by forested habitats.

Average PPI values for birds in each habitat category (Appendix 3) reflected the distinctiveness of each habitat for breeding birds within these NFs. As expected, towns (average PPI for birds present = 14.67) and water habitats (average PPI = 6.87) yielded the highest average PPI values. Other relatively distinctive habitats (average PPI in parentheses) included open dry habitat (6.06), sedge habitat (5.91), black spruce-tamarack forest (5.11), oak forest (4.30), and lowland shrub habitat (4.01). The least distinctive habitats were aspen-birch forest (2.64), regenerating conifer forest (2.75), and regenerating nonconifer forest (2.80), the latter two of which are early successional forest types. Upland hardwood forest, the most widespread habitat in the western Great Lakes region, also yielded a rather low average PPI (3.07).

Community Assemblages

Cluster analysis using average bird abundances from 2001 through 2010 (Fig. 8) illustrated relationships among 1,728 points (Table 3) based on bird associations alone (i.e., ignoring the assigned habitat categories). To assess patterns of species' co-occurrence, we examined the 20 most distinctive groups (clusters of sites)—the same number as the number of different habitat types described in Table 2 and Appendix 3. The relationships between these groups (Fig. 8, Tables 13 and 14) paint a complex picture of bird community composition within the region.

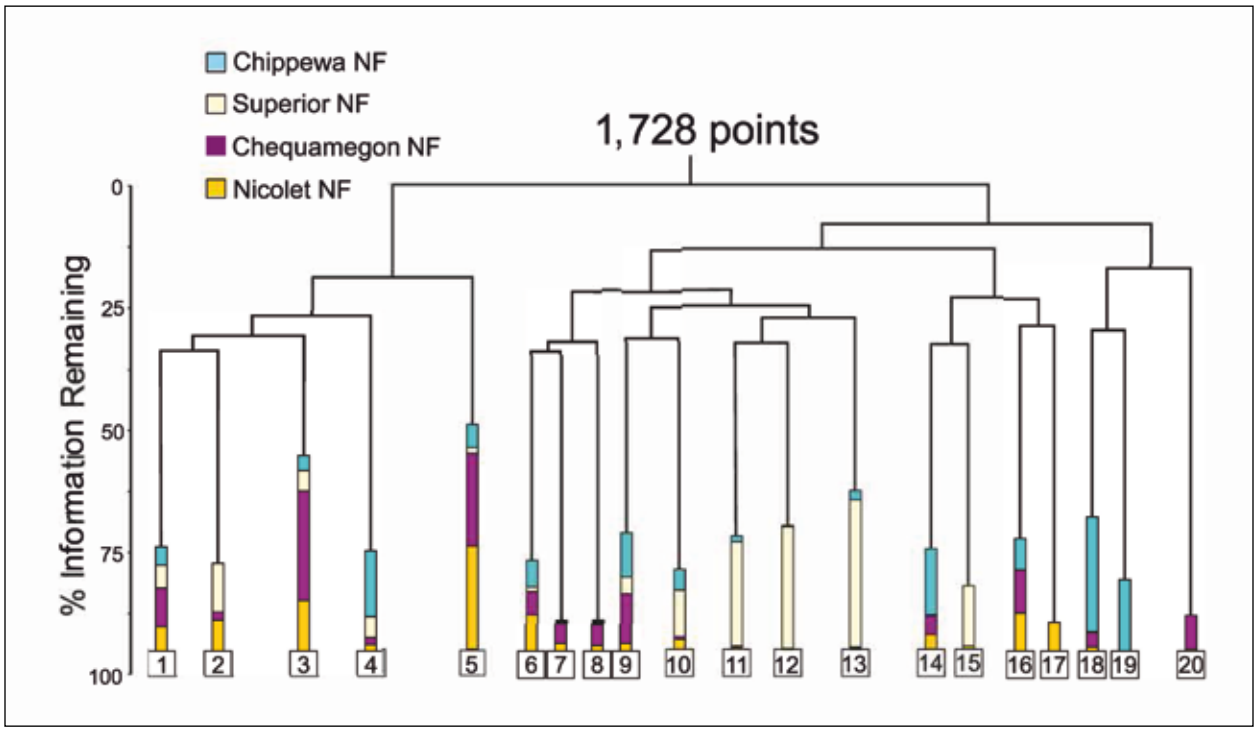


Figure 8.—Bird community assemblages based on hierarchical cluster analysis of 1,728 bird census points in 4 national forests. Numbers in squares represent the cluster identification numbers described in the text and in Tables 13 and 14. Heights of bars are proportional to the number of points in each cluster, separated into the four NF units. The variable used for the classification process was the log-transformed average abundance of a species at a point during 2001 through 2010.

Table 13.—Results of multivariate cluster analysis of 1,728 bird survey points (Table 3) sampled in 4 national forests (NFs) in the western Great Lakes region, 2001–2010[a]

Cluster	# Points	Chippewa NF (446)	Superior NF (539)	Chequamegon NF (414)	Nicolet NF (329)	Major habitat type(s)
1	90	16	20	33	21	swamp conifers, aspen-spruce
2	76	0	42	7	27	regenerating nonconifers, aspen-birch, aspen-spruce, jack pine
3	169	13	18	94	44	upland hardwoods, red pine, hemlock, aspen-birch
4	87	57	18	6	6	red pine, white pine
5	194	20	5	80	89	upland hardwoods, aspen-birch, beech-maple, oak
6	77	23	4	20	30	red pine, white pine, open dry
7	25	1	0	17	7	red pine, jack pine, open dry
8	25	1	1	18	5	regenerating conifers, jack pine, red pine
9	101	38	15	41	7	lowland hardwoods, aspen-birch, upland hardwoods
10	69	18	40	2	9	aspen-birch, regenerating nonconifers
11	98	5	90	1	2	aspen-birch, regenerating nonconifers, aspen-spruce, open dry
12	107	1	105	0	1	aspen-birch, regenerating conifers, regenerating nonconifers
13	137	8	127	1	1	aspen-spruce, aspen-birch, jack pine, swamp conifers
14	87	57	1	16	13	black spruce-tamarack, swamp conifers
15	55	0	52	0	3	black spruce-tamarack, swamp conifers
16	97	27	0	37	33	black spruce-tamarack, aspen-spruce
17	25	0	0	0	25	town, water, lowland shrub, aspen-birch
18	116	99	1	12	4	aspen-birch, oak, red pine, regenerating nonconifers, regenerating conifers
19	62	62	0	0	0	red pine, regenerating nonconifers, regenerating conifers, jack pine, open dry
20	31	0	0	29	2	open dry, regenerating nonconifers

[a] Similarities or dissimilarities among points were based on the log-transformed average abundances of all species recorded at the points during the decade. The clusters described here and in Figure 8 represent the 20 most distinct groupings of points based only on bird species composition, irrespective of habitat type. Major habitat types in this table describe the most common types of habitats included (a posteriori) in each cluster of points. Numbers in the table give the distribution of a cluster's points among the four NFs (totals in parentheses). Note that a single geographic point might be treated as two sample points if the habitat type was transformed by harvesting or ecological succession during the decade.

Table 14.—Characteristic bird species found within the 20 clusters of sample points (Fig. 8, Table 13) based on log-transformed average bird abundances, 2001–2010

Cluster	Habitat description[a]	Characteristic bird species[b]
1	Lowland conifers	NOPA, BTNW, WIWR, YBFL, BLBW, BRCR
2	Regenerating aspen-spruce	NAWA, YRWA, HETH, WTSP
3	Mixed conifers-hardwoods	BTNW, EAWP, WOTH, OVEN, REVI, HETH, SCTA, YBSA
4	Mature red pine-white pine	PIWA, BRCR, BLBW, EAWP, RBNU, BTNW
5	Northern hardwoods-oak	BTNW, EAWP, LEFL, OVEN, REVI, YBSA, HETH, RBGR, SCTA, WBNU
6	Red pine-white pine (dry)	MOWA, CSWA, AMRO, EAWP, PIWA
7	Red pine-jack pine (dry)	GWWA, INBU, EATO, SOSP, MOWA, CHSP
8	Young conifers	BHCO, MODO, CHSP, BRTH, HETH, RBGR, AMRO
9	Lowland mesic hardwoods	YBSA, BAWW, WOTH, GCFL, other woodpeckers
10	Regenerating aspen-birch (Chippewa and Superior National Forests)	VEER, CSWA, AMRE, MOWA
11	Regenerating aspen-birch (Superior National Forest)	MOWA, MAWA, WTSP, CSWA, VEER, BAWW
12	Regenerating aspen-birch and conifers	MAWA, YBFL, GRAJ, MOWA, WTSP, RCKI, CSWA, NAWA
13	Regenerating aspen-spruce (Superior National Forest)	SWTH, MAWA, CAWA, NOPA, BTBW, WIWR
14	Spruce-tamarack	YBFL, NOWA, WIWR, COYE, WTSP, WWCR, NAWA, YRWA, CONW, PAWA
15	Spruce-tamarack lowlands (Superior National Forest)	RCKI, SWTH, GCKI, YBFL, BOCH. MAWA, GRAJ, WIWR, BHVI, WTSP, CONW
16	Open spruce-tamarack, aspen	SWSP, ALFL, LISP, PAWA, SEWR, COYE, SOSP, GWWA, AMGO, RWBL, WTSP
17	Town, water, shrub	COGR, TRES, MALL, RWBL, WODU, SORA, KILL, GBHE, EUST, EAKI, SWSP, BAOR, WAVI, PBGR, OSPR
18	Young aspen-pine	AMRE, YTVI, SCTA, VEER, EAWP, LEFL, WBNU
19	Regenerating mixed pine-aspen (Chippewa National Forest)	GRCA, AMRE, GWWA, SCTA, YEWA, INBU, YTVI
20	Open dry	VESP, BRBL, BRTH, CCSP, FISP, EABL, EATO, EAKI, UPSA, HOWR, TRES, YEWA, GRCA, ALFL, BHCO

[a] The habitat description for each cluster gives the most common habitat type(s) of points in the cluster; however, these are not the only habitat types included in the cluster, which was defined independently by bird species composition.

[b] Bird species abbreviations are given in Appendix 1.

Although several of the groups (e.g., 1, 3, and 5) corresponded to broad regional habitat types, bird associations were not necessarily linked with traditional habitat categories. In some cases (e.g., clusters 11, 12, 13, and 19) bird groupings had a strong geographic bias, revealing unexpected associations that were not easily predicted from habitat affinities alone. We used PPI values to identify bird species that were most characteristic of each cluster (Table 14). These PPI values did not always identify the most abundant species in a given cluster. For example, ovenbird and red-eyed vireo, the most abundant species in many forest habitat types in this region, were not the most characteristic indicators of any habitat type. Distinctive habitat types like upland pine forest were represented in several clusters (4, 6, 7), with differences in bird species assemblages most likely corresponding to differences in forest disturbance history (Table 13). Fairly high average abundances of mourning warbler, chestnut-sided warbler, and indigo bunting, for example, indicated the presence of shrubby forest edges or openings based on these species' known habitat preferences. General habitat classifications do not always acknowledge the presence of within-stand features like forest openings or edges, but bird assemblages might provide valuable local information about the extent of these microhabitats.

In general, early successional habitats seemed to exhibit the greatest regional differentiation. Cluster 19, with points exclusively in the Chippewa NF, contained points classified as red pine (18 points), regenerating nonconifers (11), regenerating conifers (8), jack pine (8), and open dry habitat (8) (Table 13). Gray catbird was the most characteristic species (PPI = 21; Table 14). Cluster 12 also contained numerous regenerating conifer (24) and nonconifer (20) points, in addition to points characterized as aspen-birch (27), red pine (12), and jack pine (10). All but 2 of the 107 points in this cluster were located in the Superior NF. Bird species composition was very different from that of points in cluster 19, showing stronger affinities with wetter, boreal (northern) habitats (Tables 13 and 14).

Lowland conifer sites also showed significant regional differentiation of bird species assemblages. Cluster 15 represented the most boreal assemblage of points and species, with all but three points located in the Superior NF (Table 13). Most of the points in this cluster were black spruce-tamarack (19 points) or swamp conifers (15). Species characteristic of this group of points were highly distinctive and included ruby-crowned kinglet (32), Swainson's thrush (30), golden-crowned kinglet (23), yellow-bellied flycatcher (22), and boreal chickadee (19) (Table 14). All of the species in this cluster have relatively northern breeding distributions in conifer-dominated habitats. Points in cluster 16 were largely from black spruce-tamarack (28) or swamp conifers (12), but unlike cluster 15, none of these points was located in the Superior NF. Birds in cluster 16 were generally associated with semiopen or shrubby habitats, including bog-muskeg. In general, the lowland conifer sites in this cluster appeared to be more open than those belonging to cluster 14 (Table 14). These results suggest that the categories used by forest managers to describe lowland conifer forests might not be fine enough to distinguish important habitat differences recognized by bird species.

Many bird species found in conifer forests dominated by balsam fir, black spruce, white spruce, or tamarack occurred commonly in mature or late successional upland forests. In other words, many species of old-growth or mature hardwood forests in this region were derived from bird assemblages in lowland conifer forests (or vice versa). Clusters 13, 14, and 15 were defined by many of these species in addition to species of more open lowland conifer habitats, but significant geographic variation was apparent (Tables 13, 14). All but 10 of the 137 points in cluster 13 were found in the Superior NF; most of these points were classified as mid-successional and mature aspen-birch, aspen-spruce, and mixed swamp conifer forests. Cluster 14 included points classified as black spruce, tamarack, and swamp conifer forests; only 1 of these 87 points was in the Superior NF. Prominent species of cluster 14, such

as yellow-bellied flycatcher, northern waterthrush, winter wren, Connecticut warbler, and palm warbler breed in wet boreal forests. In our study area, Connecticut warbler and palm warbler occurred primarily in the Chippewa NF.

No assemblage identified by our community analysis was associated exclusively with mature forest types. Most of the bird species present in older forests, such as pileated woodpecker, winter wren, black-throated green warbler, and Blackburnian warbler, also occurred in mid-successional forests, albeit less frequently (Appendix 2).

Our cluster analysis revealed complex patterns that probably reflected multiple ecological drivers like habitat, landscape context, and geography. For instance, cluster 1 was defined by bird species with wide breeding distributions across all of the NFs, including northern parula, black-throated green warbler, Blackburnian warbler, and brown creeper—all species that showed affinity to mature forests (Howe and Mossman 1996). Points in this cluster, however, represented cover types of both mid-successional and older forests. Cluster 3 represented bird species found commonly in mid-successional and older mixed hardwood-conifer forests of the Chequamegon and Nicolet NFs. Species prominent in these cover types included black-throated green warbler, wood thrush (an uncommon species northward), scarlet tanager, and eastern wood-pewee—again, species that regularly occurred in mature hardwood-conifer forests of the western Great Lakes region. Cluster 4 was defined mainly by pine warbler, brown creeper, Blackburnian warbler, eastern wood-pewee, and red-breasted nuthatch, bird species of mid-successional and older pine forests, especially in the Chippewa NF. Bird species in cluster 5 were generally associated with mid-successional and older northern hardwood forests of the Chequamegon and Nicolet NFs. Species prominent in these habitat types were many of the same species that defined cluster 1 such as black-throated green warbler and cluster 3 such as eastern wood-pewee; cluster 5, however, lacked species associated with coniferous shrubs or trees. Least flycatcher, scarlet tanager, and white-breasted nuthatch, important species in cluster 5, are typical of northern hardwood forests. In all of these bird-defined clusters of points (clusters 1–5), species typical of older forests were present, but none of these clusters consisted exclusively of points in old forests.

Lowland hardwood forests supported a more predictable group of bird species. Cluster 9 was defined by species associated with mid-successional and older lowland hardwood forests, primarily within the Chippewa and Chequamegon NFs. Many of the bird species characterized by cluster 5 also were found here, but yellow-bellied sapsucker, black-and-white warbler, and great crested flycatcher were consistently more prominent in cluster 9. Nearly 60 percent of our lowland hardwood survey points were included in this cluster.

Regional Distributions

Maps of species distributions in the western Great Lakes region (Appendix 5) based on results from this and other regional bird surveys (Walton, in review)[2] revealed fine-scale variation in predicted abundances, which can be a valuable guide for bird conservation strategies and recreation planning. For example, landscape features such as the urbanized corridor in Minnesota's Iron Range region are prominent in predicted abundance maps for species like European starling and American robin. Likewise, the importance of northeastern Minnesota for Canada warbler and several other species is apparent in these maps. In general, our maps predicted that most species are distributed widely across the study region, but within any local area the distributions are uneven and patchy. Identification of patches with highest abundances of priority species can help target places where conservation management will be most effective.

[2] Walton, N.G. [In review]. Patterns of avian distribution, diversity, and relative abundance in the western Great Lakes region, USA. Green Bay, WI: University of Wisconsin-Green Bay. M.S. thesis.

Ecological Context

Climate

Minimum winter temperatures were generally warmer after 2000 than before 2000, and average April and July temperatures increased detectably over the 20-yr time period (Fig. 9). These trends were not apparent for March, May, or June. Seasonal temperatures were broadly correlated across NFs for any given year, and the multiyear oscillations in temperatures were associated in part with the El Niño-Southern Oscillation—particularly noticeable in spring (Fig. 9). According to the Palmer drought severity index (PDSI) (Fig. 10) the most widespread drought occurred during the 2007 breeding season in all four NFs and during 2009 in the Chequamegon and Nicolet NFs. Each of these moderate-to-severe drought periods was followed by overall reductions in the total number of individuals observed the next year (2008 and 2010, respectively; Fig. 4). However, at the individual species level, correlations of the number of individuals with the PDSI for all species examined were not consistent for the following year in any of the four NFs.

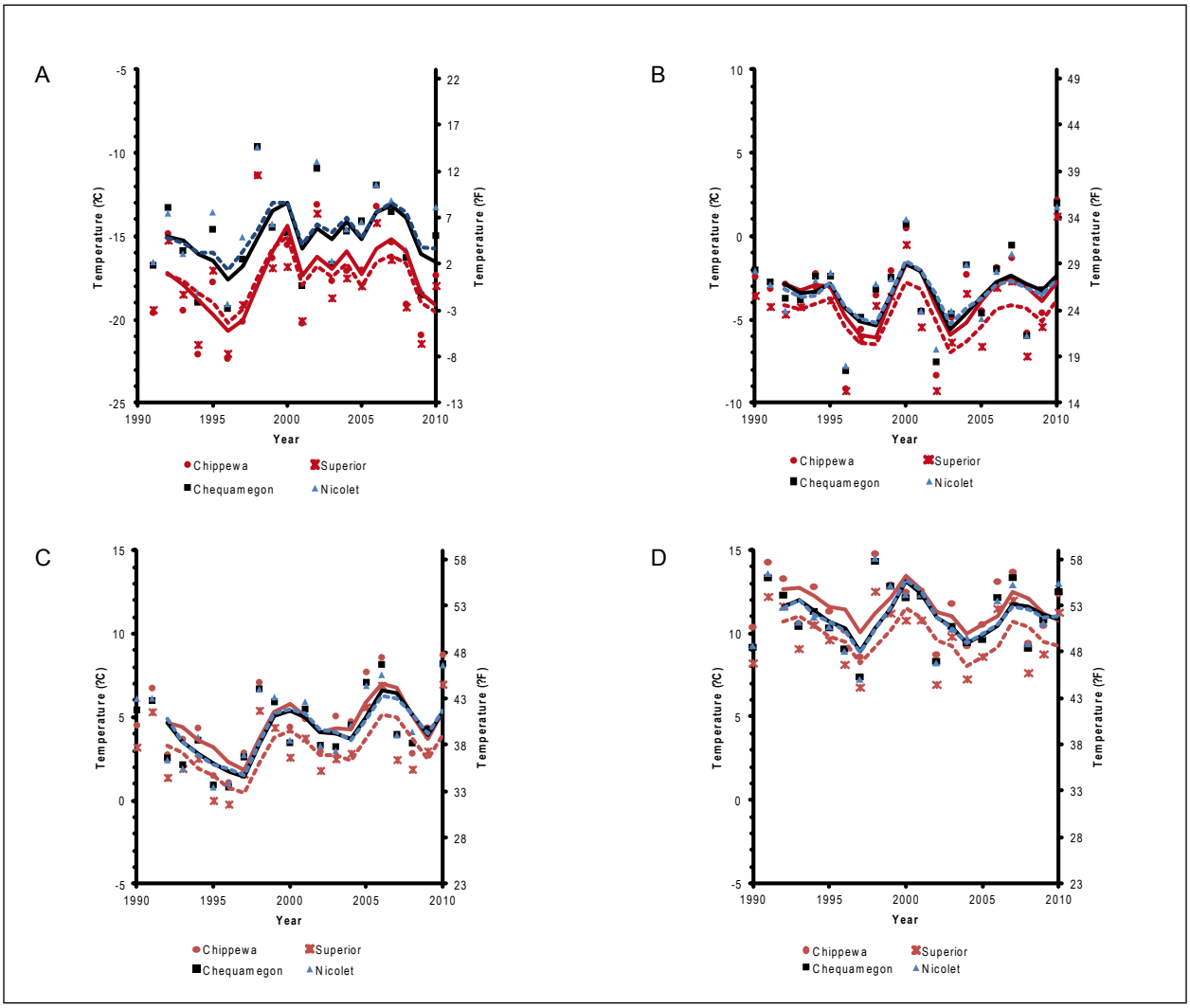


Figure 9.—Seasonal temperature by national forest from 1990 through 2010. A) Minimum winter temperature, B) average March temperature, C) average April temperature, D) average May temperature, E) average June temperature, F) average July temperature. Lines indicate 3-year moving averages for each NF (Chippewa = solid red, Superior = dashed red, Chequamegon = solid black, Nicolet = dashed blue).

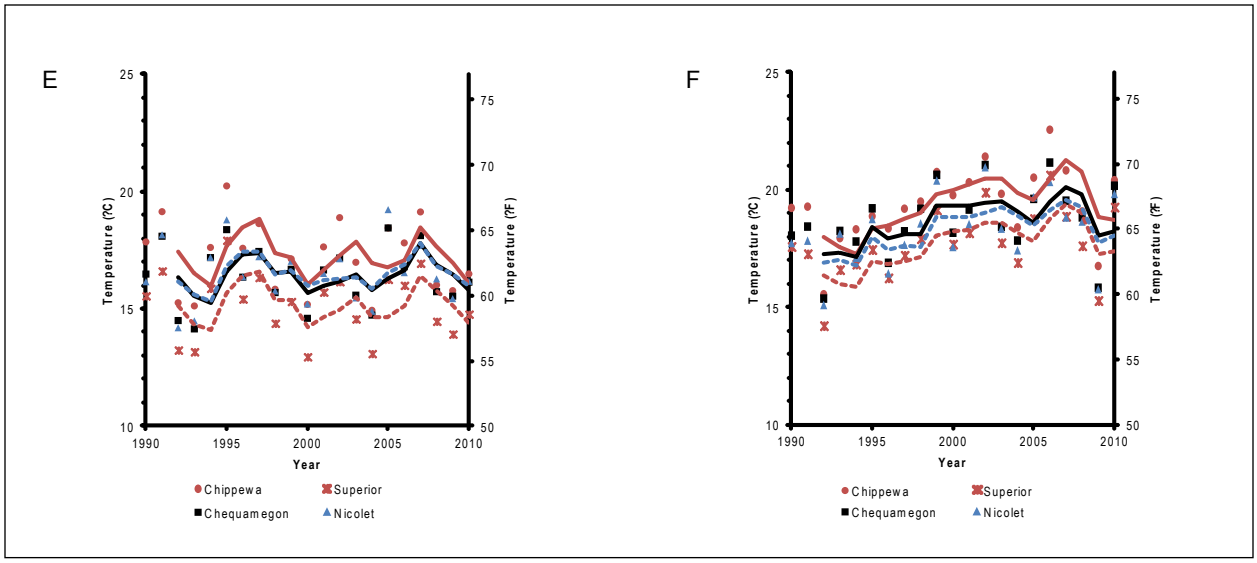


Figure 9 (continued).—Seasonal temperature by national forest from 1990 through 2010. A) Minimum winter temperature, B) average March temperature, C) average April temperature, D) average May temperature, E) average June temperature, F) average July temperature. Lines indicate 3-year moving averages for each NF (Chippewa = solid red, Superior = dashed red, Chequamegon = solid black, Nicolet = dashed blue).

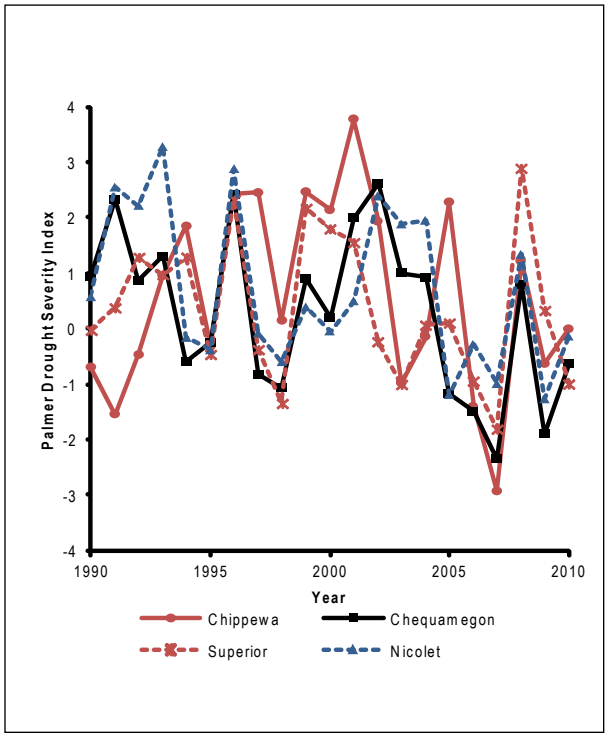


Figure 10.—Palmer drought severity index (April–July) from 1990 through 2010 for four national forests. Zero represents normal; positive values indicate wet spells. Negative values represent dry spells, with light, moderate, and severe drought indicated by values -1, -2, and -3, respectively.

Natural Disturbances

Even though large-scale and severe natural disturbances including blowdown and wildfire occurred near the monitored study areas (in particular the Boundary Waters Canoe Area Wilderness of the Superior NF), most of these events did not affect any of the bird surveys directly. However, on June 7, 2007, 2 days before the annual Nicolet NF bird survey, a violent wind event (including a tornado) swept through northern Oconto County in the Nicolet NF. Three bird survey sites were affected and were inaccessible during the 2007 survey. In 2009 and 2011 these sites were resampled. No other bird survey sites were affected directly by large-scale wind or fire events.

Unlike fire or wind, insect disturbance affected nearly all the survey plots during the sample period. The entire region experienced a widespread forest tent caterpillar outbreak in the late 1980s and again starting in 2000 and 2001 for Minnesota NFs and Wisconsin NFs, respectively. Outbreaks ended in 2002 (Chippewa NF) and 2003 (all other

NFs). Aerial surveys indicated 50, 65, 80, and 95 percent of forest land areas were affected by forest tent caterpillar defoliation at their respective peak years for the Chippewa, Nicolet, Superior, and Chequamegon NFs, respectively (Fig. 11). The Chippewa NF had low spruce budworm activity, but during the mid-2000s moderate defoliation occurred within the Chequamegon and Nicolet NFs. The Superior NF has undergone spruce budworm defoliation nearly continuously since the 1950s, but the outbreaks varied temporally across different areas of the forest. The most recent widespread event spanning the Superior NF occurred just before our bird surveys, but defoliation records suggest that budworm populations have been elevated near the Superior NF bird sample plots for most of the sample years, particularly in the LaCroix, Laurentian, and Kawishiwi Ranger Districts (Fig. 1). Jack pine budworm defoliation occurred primarily in the mid-1990s and again in the mid-2000s. However, the bulk of the defoliation by jack pine budworm occurred within jack pine concentrations south and west of the Chippewa NF, and south and west of the Washburn Ranger District of the Chequamegon NF (Fig. 1). Limited defoliation occurred in the Washburn District and in the northern tip of the Nicolet NF.

Timber Harvest Activities and Land Cover Changes

Harvest records show consistent declining trends in harvested timber volume during the period of our bird monitoring programs (Fig. 12). Indeed, harvest records for the Superior NF (excluding the Gunflint Ranger District) fluctuated consistently between 50 and 90 million board ft (MMBF; 1 MMBF = 2,360 m^3) between 1950 and 1990, but starting in 1997 timber output was consistently below 50 MMBF (Fig. 12). Analysis of land cover change (Wolter et al. 2012) indicated an annual forest disturbance rate of 0.8 percent per yr in the late 1980s and early 1990s in the Superior NF; the rate declined to 0.25 percent per yr by the late 1990s. By comparison, the Chippewa NF had a high forest disturbance rate in the late 1980s

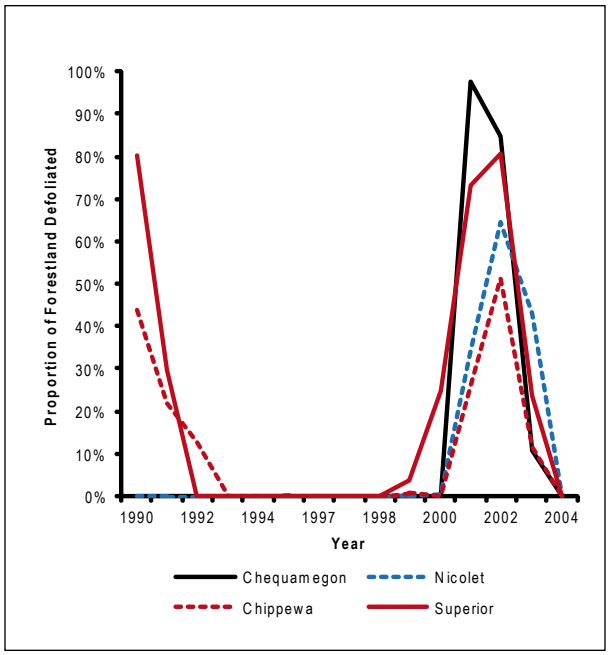


Figure 11.—Percentage of forest land cover affected by forest tent caterpillar defoliation for each national forest as estimated by aerial surveys (Minnesota Land Management Information Center 1999, U.S. Forest Service 2012a).

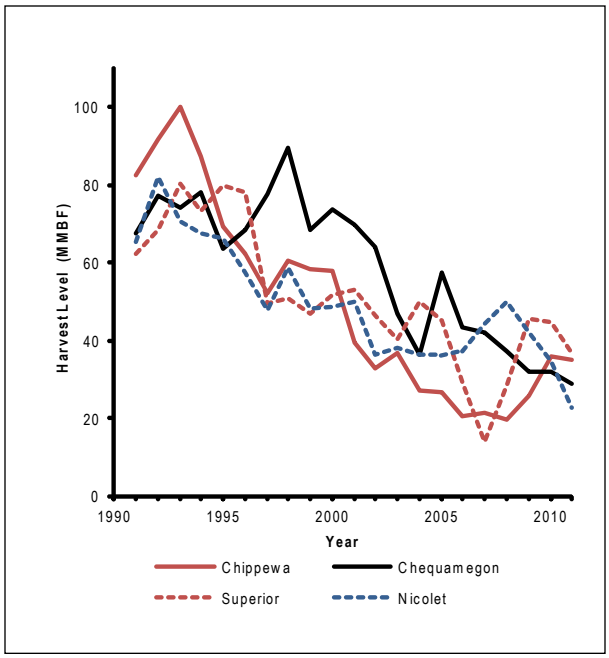


Figure 12.—Harvested tree volume in million board feet (MMBF) for four national forests from 1991 through 2011.

(3 percent per yr), declining to 0.9 percent and 0.6 percent in the early and late 1990s, respectively. The reduction in harvest activity over the past decade suggests that open habitats—at least within managed forests—may have declined as well. Changes in data from the National Land Cover Database (NLCD) (Fry et al. 2009, 2011; Homer et al. 2001) were not as effective as the Wolter et al. (2012) data for detecting forest disturbances associated with timber harvest. However, the NLCD data did indicate that open areas, which are relatively rare within these primarily forested areas, converted disproportionately to forested land cover. Conversion of agricultural land to forest cover was most common within the Chippewa and Chequamegon NF proclamation boundaries, and conversion of grass/shrub to forest was most common within the Chippewa and Superior NF proclamation boundaries.

Forest Composition and Structure

Forested land area based on FIA plot data has remained relatively stable in the four study areas (Figs. 13, 14, and 15), increasing slightly since the late 1970s or early 1980s. The six forest-type groups that predominated in the study area varied geographically in their composition but remained fairly stable across time within the Chippewa, Superior, Chequamegon, and Nicolet NFs (Fig. 13).

In contrast to forest composition (i.e., forest-type group), forest structure, as portrayed by tree diameter classes, showed significant changes during the period of our analysis. In the Chippewa and Superior NFs, area of forest land in the large diameter class decreased since the 1990s (Fig. 14). In the Chequamegon and Nicolet NFs, the area in the large diameter class increased substantially since the 1990s (Fig. 14).

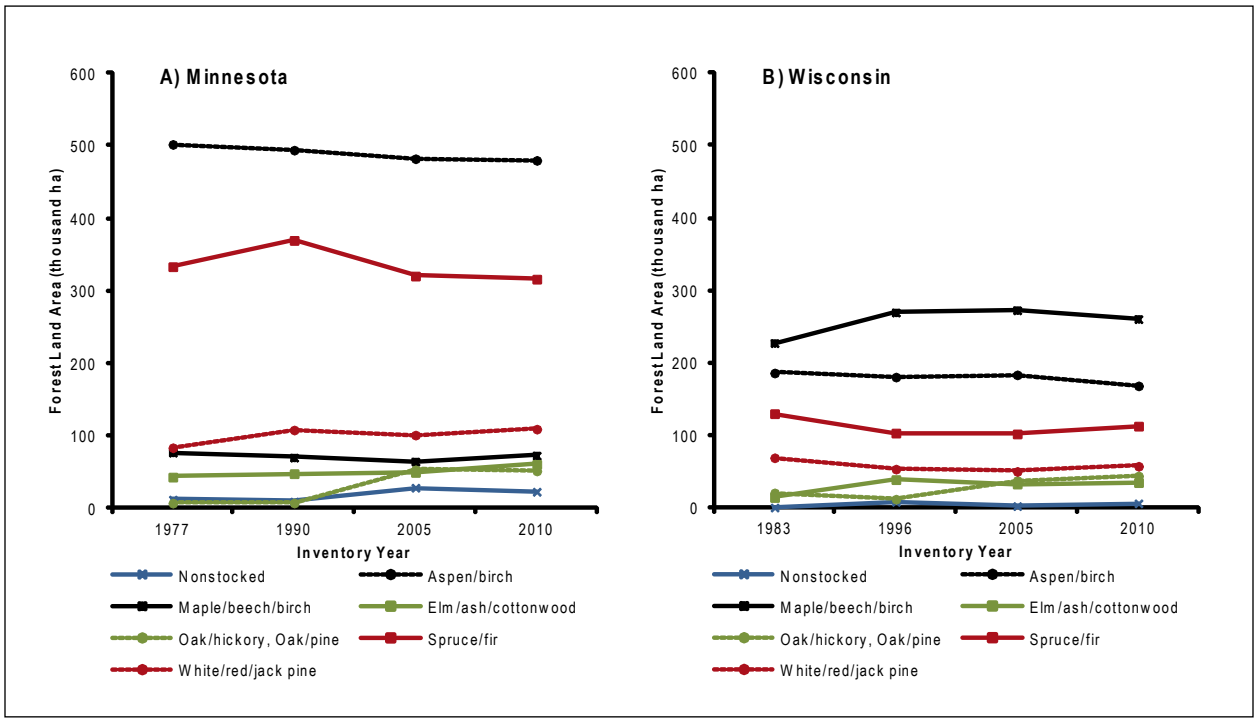


Figure 13.—Trends in forest land area by forest-type group within study areas encompassing portions of the A) Chippewa and Superior National Forests (Minnesota) and B) Chequamegon-Nicolet National Forest (Wisconsin) (Miles 2011). Note that early inventories in Minnesota (1977, 1990) and Wisconsin (1983, 1996) did not distinguish between oak/hickory and oak/pine forest-type groups; later inventories (2005, 2010) did. Thus, most of the changes in the oak/hickory and oak/pine forest-type groups between the 1990s and 2005 are probably due to changes in definition.

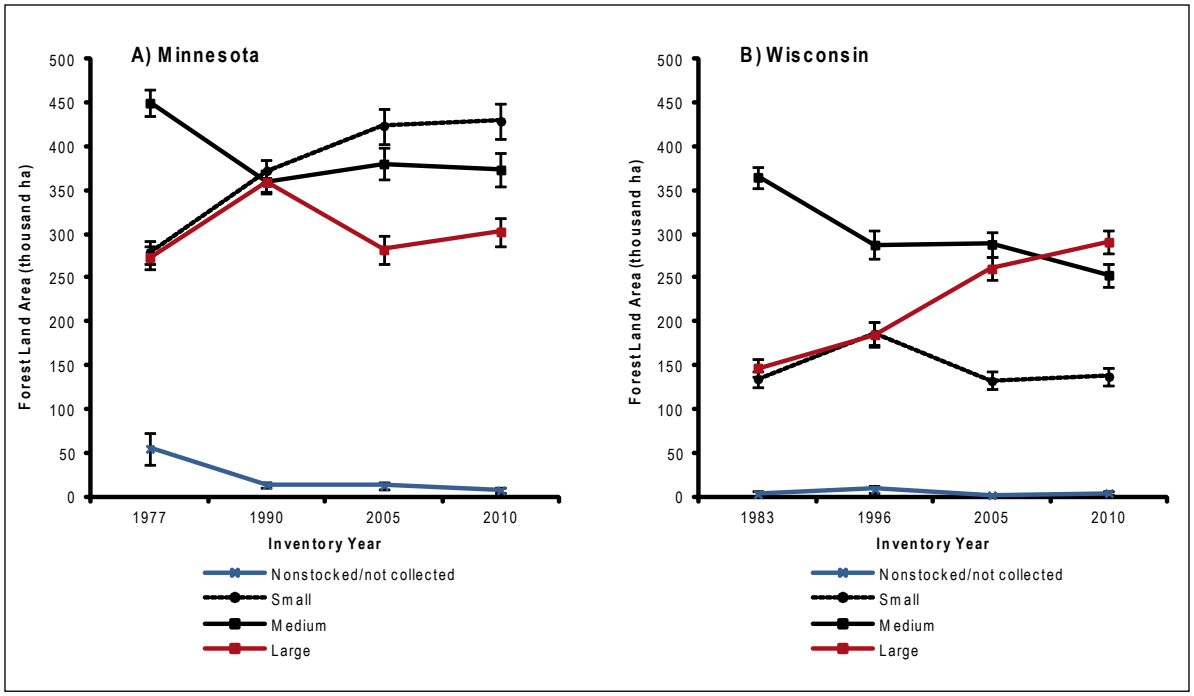


Figure 14.—Trends in forest land area by tree diameter class within study areas encompassing portions of the A) Chippewa and Superior National Forests (Minnesota) and B) Chequamegon-Nicolet National Forest (Wisconsin) (Miles 2011). Large-diameter trees are at least 27.9 cm diameter at breast height (d.b.h.) for hardwoods and at least 22.8 cm d.b.h. for softwoods. Medium-diameter trees are at least 12.7 cm d.b.h. but smaller than large-diameter trees. Small-diameter trees are less than 12.7 cm d.b.h. Error bars represent one standard error of each estimate of forest land area.

Area of forest land in the small diameter class, which is an indicator of early successional habitat, remained fairly stable since the 1990s for most ranger districts, including all three in the Chippewa NF. Overall, small diameter forest area increased moderately in the Chippewa and Superior NFs since the 1990s after a sizable increase between the late 1970s and 1990. However, small diameter forest area increased substantially since the 1990s in the LaCroix district of the Superior NF and decreased substantially in three of five Chequamegon-Nicolet NF districts: Eagle River-Florence, Great Divide, and Lakewood-Laona (Fig. 15). Area of forest land in the medium diameter classes remained fairly constant in all four NFs since the 1990s.

During the past three decades, volume per hectare of timberland remained relatively stable across the Chippewa NF, increased across most districts of the Chequamegon-Nicolet NF, and varied among districts of the Superior NF (Fig. 16). These trends appear to be consistent with changes in forest land area by diameter class, suggesting that forest structure is shifting to larger trees with more volume in the Wisconsin NFs and is locally variable in the Minnesota NFs. Estimates of standing dead trees exceeded 50 million for Minnesota and 30 million for Wisconsin study areas, with slightly higher densities in the Minnesota NFs in comparison with the Wisconsin NFs. The distributions of standing dead trees with respect to size followed a consistent log-linear relationship for our most recent inventories, but the functional parameters differed slightly between Minnesota and Wisconsin (Fig. 17).

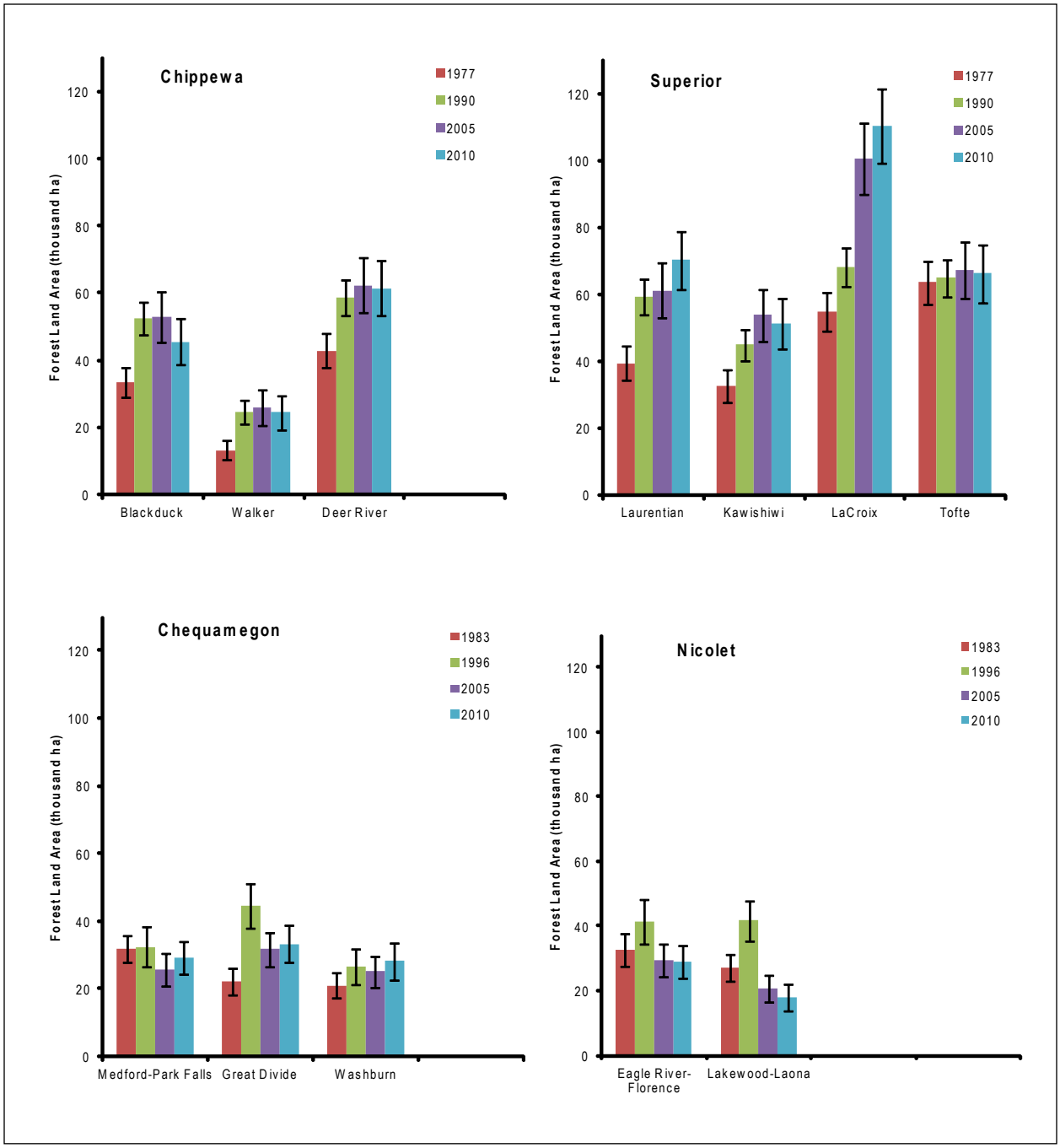


Figure 15.—Trends in small-diameter forest land area within study areas encompassing portions of four national forests (Miles 2011). Small-diameter trees are less than 17.6 cm d.b.h. Error bars represent one standard error of each estimate of forest land area.

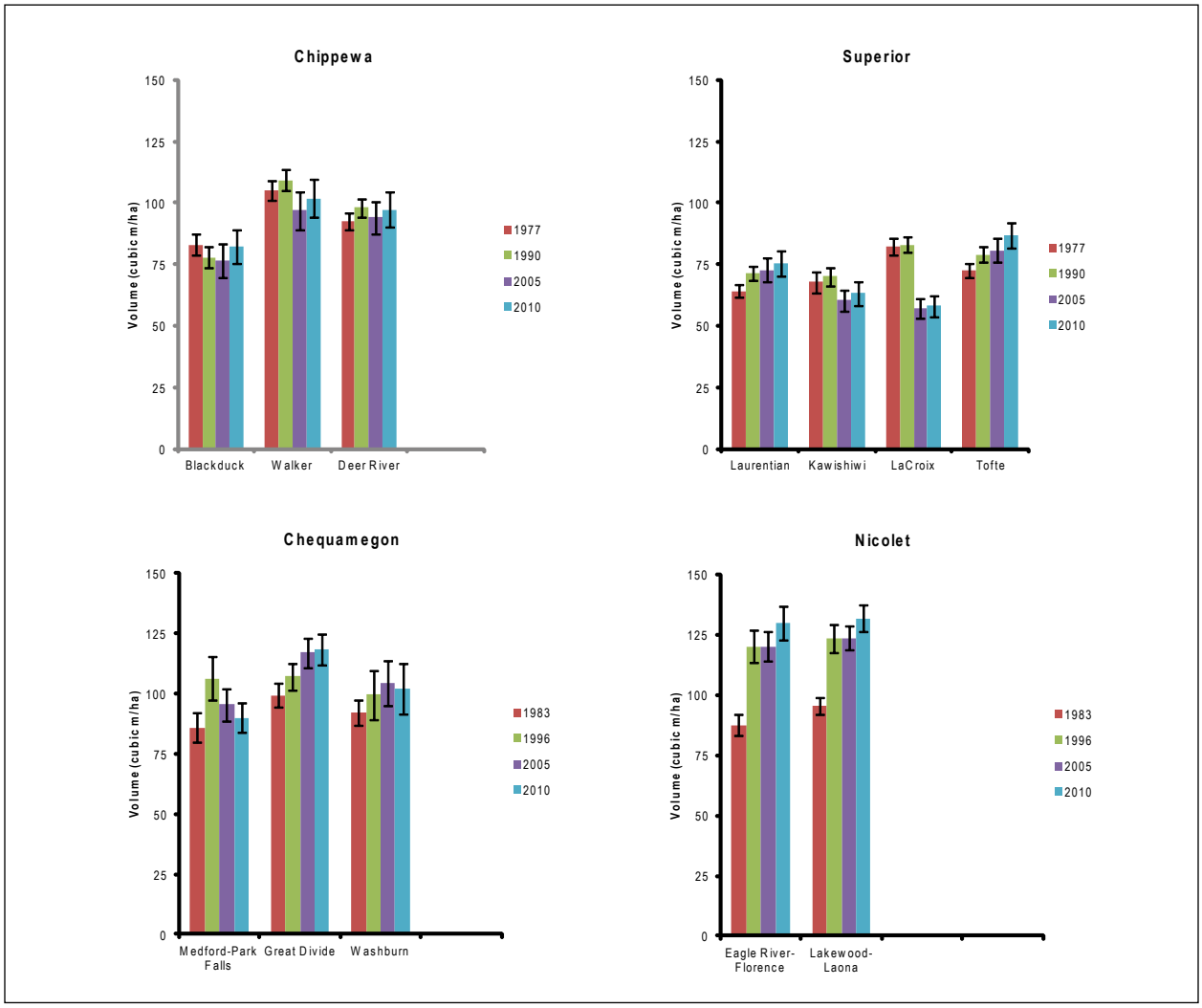


Figure 16.—Net volume of all live trees (at least 12.7 cm d.b.h.) per hectare of timberland, on study areas within districts of four national forests (Miles and Hansen 2011). Error bars represent one standard error of each ratio estimate.

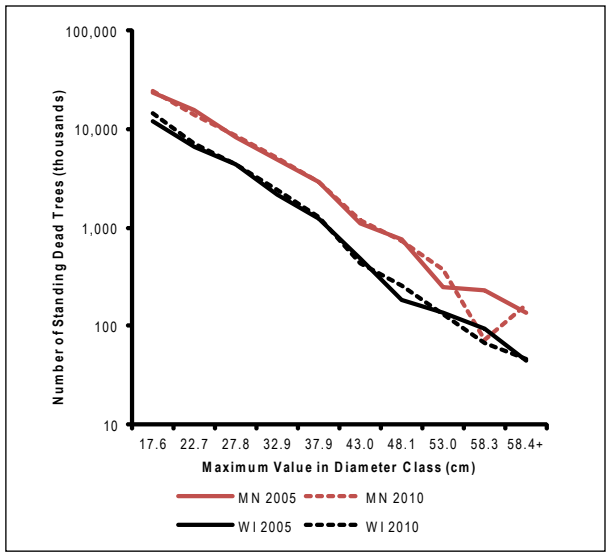


Figure 17.—Number of standing dead trees (at least 12.7 cm d.b.h.) on timberland within study areas encompassing portions of the Chippewa and Superior National Forests (Minnesota) and Chequamegon-Nicolet National Forest (Wisconsin) (Miles 2011).

DISCUSSION

Species Detection and Trends

During the course of monitoring programs in western Great Lakes NFs from 1991 through 2010, observers identified 187 bird species. Many of the recorded bird species, however, are not associated with forests or are not monitored effectively with early morning point counts. Species not monitored effectively include waterfowl—a variety of species associated with wetlands and water (herons, bitterns, rails, gulls, terns, and various species associated with open wetlands)—raptors, nocturnal species (owls and goatsuckers like the common nighthawk), and species associated with human settlements. The complete list also includes rare species, many of which are on the periphery of their breeding range such as bay-breasted warbler, cerulean warbler, northern cardinal, and blue-gray gnatcatcher. Among all 4 NFs, we included 98 species in our trend analyses, 52 percent of the bird species that observers recorded during the entire monitoring period. Because 127 of the 187 species are associated with forests, the proportion of effectively monitored forest-associated species is more than 75 percent (98 out of 127).

The large sample size, length of sampling, and careful attention to data quality issues (Etterson et al. 2009) lead us to believe that the overall trends reported here reflect genuine changes in population levels during the period of study. Our conclusions are especially convincing for species where the trend data were consistent among NFs and with other long-term datasets such as the USGS Breeding Bird Survey. Differences in overall mean bird abundance (Fig. 4) and species richness (Fig. 5) between the western NFs and the Nicolet NF, notably in 2003 and 2004, may reflect genuine geographic variation in bird population dynamics among these NFs, or they may be a consequence of sampling anomalies. For example, because the annual Nicolet NF bird survey is conducted during only a single weekend, bad weather conditions probably caused low average observed bird abundance and diversity for certain years. Indeed, temperatures were unseasonably cold and mixed with scattered rain during the 2003 Nicolet NF bird survey weekend, leading to unusually low bird detection probabilities (Fig. 4). Scattered rain also was encountered during the 2004 weekend. The much longer sampling period (6–7 weeks) in the Chippewa, Superior, and Chequamegon NFs reduced the effects of unfavorable weather conditions on any particular day. If these 2 years (2003 and 2004) are excluded, patterns in the number of individuals and number of species in all of the NFs are remarkably consistent.

Other subtle differences in methods between the Nicolet NF and the other three NFs may have contributed to differences in detected trends. For example, counts in the western NFs are more subject to observer bias, because counts are conducted annually by only a few (four to six) paid counters, with each point surveyed by only one person. In the western NFs, surveyors also tended to participate in the project for only 1 or a few years. Points in the Nicolet NF were surveyed by a greater variety of volunteer counters (15–16 expert birders each year plus field assistants) with a high level of continuity in the expert participants across years. Hence, effects of weather events (as seen in the Nicolet NF data in 2003) and potential differences in sample methods between the Nicolet NF and the western NFs need to be scrutinized. Despite variations in sampling design, however, results from the two NF monitoring programs are

not as different as they might first appear. The higher number of significant declining trends in the Nicolet NF can be attributed largely to species of shrubby or open country (e.g., brown thrasher, brown-headed cowbird, eastern bluebird, eastern kingbird, and tree swallow; Table 7), reflecting differences in the array of sampling habitats rather than subtle differences in methods. The lack of significant change (e.g., black-and-white warbler and white-throated sparrow) or opposite trends (e.g., cedar waxwing and winter wren) in birds of the Nicolet NF are more likely to reflect meaningful regional differences in bird population change. In several cases (e.g., hermit thrush and scarlet tanager), however, results from the binomial analysis of Nicolet NF data are consistent with results from the other NFs. These suggest that either the trends are weaker in the Nicolet NF or the less frequent sampling (every other year for individual points) resulted in less power for detecting trends in species abundances (Table 7).

Populations of many bird species in the western NFs increased significantly since 1995, including numerically dominant species such as ovenbird and white-throated sparrow (Tables 7, 8, and 9). Because so many species are represented, causes of observed increases in overall bird numbers (Fig. 4) are difficult to pinpoint. However, changes in abundances of individual species, coupled with spatially explicit information about their habitat preferences, provide meaningful insights into the effects of environmental stressors on regional bird communities. Our NF bird surveys have acquired standardized information for more than two decades, yet the period of time is still short enough that results from a few aberrant years can affect trends and overall bird abundance estimates, especially at the beginning or end of the study period. Unusually low counts between 1995 and 1999, for example (Fig. 4), are largely responsible for the increasing trends reported in the Chippewa, Superior, and Chequamegon NFs. Likewise, low numbers during 2003 and 2004 contributed significantly to lower average bird abundances in the Nicolet NF. As the length of bird monitoring efforts in these NFs increases, the effects of unusual years and subtle differences in sampling design should be mitigated. One fact does seem to be consistently supported by our analyses. None of the four NFs appears to have had an overall decline in bird numbers or diversity between 1995 and 2011. If anything, bird numbers appear to have increased slightly since the mid-1990s.

The western Great Lakes NF bird monitoring program differs from the BBS primarily in terms of field effort, geographic focus, scale, and land ownership. The NF monitoring program represented about five times the survey intensity of the BBS. Unlike the BBS, our NF bird survey points were located off-roads within specific habitats and, with a few exceptions, included only NF-owned lands within NF proclamation boundaries. Howe and Roberts (2005) showed that birds of open country and disturbed habitats tended to be reported more commonly from BBS routes within and near the Nicolet NF than in the Nicolet NF bird survey. Hence the NF surveys are more likely to document trends in bird populations at scales and locations relevant to forest land management decisions within and across NFs. By contrast, the continental scale of the BBS network, combined with the long duration of the project, enables trend detection at the scale of biomes and regions, and across all land ownerships with diverse management practices (Sauer et al. 2003). The two datasets are complementary to each other, and each is best suited for its intended scale.

Comparisons of the NF trends with trends from the BBS exemplified the greater relevance of the NF trends to the NFs because of the greater intensity of effort, sampling off-roads, and the focus on forested habitats within the NFs. Similar results were also reported by Howe and Roberts (2005) in the Nicolet NF and by LeBrun et al. (2012) in Minnesota. We conclude that the BBS with its current density of routes cannot serve as a substitute for more detailed monitoring such as those gathered in these NFs, unless BBS route coverage is greatly expanded. Nonetheless, the

trend data gathered at the NF level should always be viewed in the context of larger spatial and temporal scales, which today are best provided by the BBS. Data from the NF bird surveys are more sensitive to short-term changes in regional forest bird populations, so our reported trends must be treated cautiously. In both the BBS and NF survey programs, long-term data become increasingly important for forecasting future trends in bird populations, and the longevity and geographic breadth of the BBS make it a valuable complement to more detailed local or regional survey efforts like those reported here.

Habitat and Community Associations

Species-specific habitat profiles (Appendix 5) illustrate that most bird species in western Great Lakes NFs use a variety of habitat types, so regional forest management is not simply a matter of providing a prescribed habitat type for a target species. The complexity of bird–habitat associations is not surprising given the mobility of birds and the migratory character of this region's avifauna. Many habitats may provide the essential microhabitat characteristics (e.g., nesting cavities or a shrubby understory) that are necessary for a species, but that species might be absent locally because of historical, geographic, or demographic factors. Likewise, a species might be present in suboptimal habitat because its population is thriving in the regional landscape (Brawn and Robinson 1996, Donovan et al. 1995, Howe et al. 1991). Given the inexact nature of many bird–habitat associations, long-term regional monitoring of populations, together with adaptive forest management, becomes especially important. For instance, as the climate in the region changes, there are likely to be effects on the structure and plant composition within specific forest types. These changes would presumably be reflected in population trends for bird species.

Our cluster analysis of bird-defined community assemblages illustrates the complex ecological structure and spatial distribution of birds in these western Great Lakes forests. Groups of points (clusters) with similar bird assemblages generally were associated with both habitat and geography. In fact, we documented geographic variation in bird species assemblages for nearly every forest habitat type (Fig. 8). Bird species composition was particularly variable for lowland conifer and early successional habitats. Lowland conifer forests are present in all four NFs, but characteristic species like gray jay and boreal chickadee were found frequently only in lowland forests of the Superior NF. Aspen-dominated points were distributed among 11 of the 20 bird-defined community clusters, implying that bird assemblages in this widespread forest type are difficult to predict and reflect significant local or regional variation. These and other examples show that habitat type alone is not adequate to predict bird species composition in western Great Lakes forest landscapes, especially for habitats that are ephemeral (like early successional forests) or geographically marginal (like lowland conifers). By contrast, upland hardwood forest, the most widespread pre-European habitat type in this region (Mladenoff and Pastor 1993), was associated with only two bird-defined clusters (3 and 5), illustrating that birds in this characteristic late-successional habitat type were relatively predictable in the western Great Lakes region.

Limitations and Monitoring Recommendations

The use of point count data to estimate species-level relative abundances implies that the bird species monitored have equivalent detectability among the surveyed points. Some species with far-reaching vocalizations (e.g., common raven) may be represented in local assemblages more often than expected based on their true density, whereas quieter species (e.g., brown creeper) will be represented less often than expected. In the heterogeneous landscapes of these NFs, quieter species will be expected to show stronger affinity with specific habitats because they are less likely

to be detected beyond the boundaries of the habitat associated with a point count. Overall, the use of detectability adjustments remains a very active area of research and at this time there is no consensus on a method to be used to adjust raw counts.

In our case, consistency between raw and adjusted counts in terms of population trend interpretation (Table 6) is most likely due to the long time series used in the trend estimate, the standardization of data gathering, and the large sample sizes for both number of stands sampled and species observations (Etterson et al. 2009). This conclusion is further supported by Johnson (2008: 857) in his invited review on the use of raw counts (indices) and detection adjustments. Referring to detection adjustments, he states that "their practical application may well be limited, likely to intensive studies focusing on a small number of species." He further emphasized that they "are not generally applicable to extensive, multi-species surveys." Detection adjustments often introduce new and sometimes dubious assumptions (e.g., accurate and consistent estimation of distances and time of first detection by multiple observers or lack of movement by birds into and out of detection range during the count period), and few of our conclusions rest on the assumption that birds are equally detectable in the first place. We do, however, recognize that bird detectability may vary among habitats and between years, and evaluation of this variation is an important area of research that may help improve the interpretation of data from large-scale studies such as ours.

Population trends reported here do not tell a complete story about conservation of breeding birds in western Great Lakes forests. Many species of interest were too rare to be included in our statistical analyses even though they are historically well-established elements of the western Great Lakes avifauna (Cutright et al. 2006). Indeed, the fact that these species are rare makes them attractive for birdwatchers, photographers, and nature tourists, who bring economic benefits to local communities in or near the NFs. Preserving local populations of rare species should be a goal of sustainable forest management, despite incomplete information about their status and population trends.

Rare species associated with northern conifers are a particularly significant group in western Great Lakes NFs (Green 1995: 45). Representatives include ecological generalists (boreal chickadee and gray jay), seed-eaters (dark-eyed junco, evening grosbeak, pine siskin, red crossbill, and white-winged crossbill), raptors (boreal owl, northern hawk owl, and great gray owl), postdisturbance habitat specialists (black-backed woodpecker and olive-sided flycatcher), and a large herbivore (spruce grouse). Virtually all of these species are boreal or sub-boreal birds, and regional populations are potentially vulnerable to the effects of climate change due to expected range shifts of boreal habitat (Frelich and Reich 2010). Most of these species are either permanent residents or short-distance migrants. Frequency of occurrence during our breeding bird surveys ranged from just a single observation for boreal owl and northern hawk owl, to presence in 3–6 percent of all point counts for evening grosbeak and gray jay in the Superior NF. Targeted sampling—perhaps using the maps provided in Appendix 5—may be required to reliably estimate trends in these rare species.

Raptors are poorly represented in our trend analyses even though they are an important element of the western Great Lakes avifauna. The exception was the significant declining trend documented for broad-winged hawk in the Superior NF (Tables 7 and 8), consistent with regional declines of this species reported by the North American BBS (Sauer et al. 2011). Otherwise, our surveys have recorded extremely low encounter rates for resident raptors like sharp-shinned hawk, long-eared owl, and northern saw-whet owl (which has never been recorded during our surveys). Effective monitoring of raptors requires more directed studies because of

their large home ranges, low population densities, and in some cases secretive nature (Niemi and Hanowski 1997). Monitoring efforts for northern goshawk, red-shouldered hawk, osprey, and bald eagle have been ongoing for many years and are critical for identifying and protecting nest sites (e.g., Donner et al. 2013).

Automatic recording devices are being increasingly used to gather information on singing activity by birds at specific locations. The technology associated with these devices is improving every year, but widespread application is currently limited by the lack of an automated process to identify the species from the recordings. We suspect that this technology will improve further and will increasingly become a part of bird monitoring activities in the future. We have recorded hundreds of 10-min counts at survey points in the Nicolet NF since 2009, but analysis of the archived recordings is beyond the scope of this report.

Ecological Context

We emphasize that the trends in potential drivers simply provide context for the observed trends in bird species and guild abundances. Some of the correlations between species trends and these potential drivers are indeed thought-provoking. However, the relative contribution of any given driver is difficult or impossible to identify without extensive analyses beyond the scope of this report. For example, our analysis of species responses to spring moisture conditions as measured by the Palmer drought severity index yielded no consistent relationships for all species combined or for any individual species. The effects of this climatic factor may be difficult to separate from the effects of forest management and many other confounding influences, such as insect outbreaks, temperature fluctuations, and events outside the breeding season. Despite these limitations, we suggest the species trends and observed habitat and community relationships will be decipherable with more detailed analytical approaches and continued monitoring, which will increase the power of more sophisticated multivariate statistical analyses.

Climate

In the guild analyses, we found higher annual rates of increase (all statistically significant) among permanent residents (2.4 percent) compared with short-distance migrants (1.2 percent) and long-distance migrants (0.7 percent, Table 11). Knudsen et al. (2011) reviewed several hypotheses to explain why permanent or semi-permanent residents may be increasing at a greater rate than the short- and long-distance migrants. Among the hypotheses are the following: 1) Overwinter survival has increased for permanent residents because the climate is warming and winters are less severe in terms of temperature; 2) Winter feeding of birds has been increasing over the past 16 yr and supplemental food aids in overwinter survival; and 3) Climatic warming results in earlier emergence of food (such as insects, berries, and buds) and, hence, earlier-nesting permanent residents would benefit disproportionately from this shift in phenology. Short-distance migrants' greater increase compared to long-distance migrants may indicate that short-distance migrants have also benefited from these factors, but perhaps not as much as the permanent residents. Changes in seasonal temperature data from within the NFs—particularly winter, April, and July temperatures (Fig. 9)—are consistent with hypotheses 1 and 3 above (e.g., Fig. 9). Although our trend results for migratory guilds suggest a positive influence of warming climate on permanent and short-distance migrants, Knudsen et al. (2011) caution that loss of wintering habitat may also be a contributing factor for both short-distance and long-distance migrants.

Additional data support the idea that the climate of the western Great Lakes region is warming. For instance, Austin and Colman (2007) showed that summer (July–September) surface water temperatures of Lake Superior, a body of water in the middle of our study region, have increased

about 2.5 °C (4.5 °F) from 1979 to 2006. In the northeastern United States, differences among migration guilds have been documented, with short-distance migrants arriving disproportionately earlier than long-distance migrants (Butler 2003). These findings support the hypothesis that short-distance migrants are better able to respond to meteorological cues than are long-distance migrants, which rely on subtle changes in photoperiod or internal biological rhythms.

The decline in total numbers of individuals after the moderate droughts in 2007 and 2009 (Figs. 4 and 10) illustrates the negative effects of droughts, which most likely decrease food availability with subsequent reductions in bird populations (Blake et al. 1992). Blake et al. (1994) reported similar patterns in northern Wisconsin and Michigan following severe droughts in 1987 and 1988. These authors also suggested that population fluctuations were related to conditions on the breeding grounds, emphasizing the need to consider temporal variation in abundance at several spatial scales. The overall effect of drought conditions, however, could not be demonstrated with these trend data when analyzed for individual species. This result suggests that the impacts of drought (and perhaps other factors such as insect abundance) are episodic and may be apparent at the forest-wide scale only during or after extreme events.

Insect Outbreaks

Food pulses provided by spruce budworm outbreaks are thought to affect the distribution and numbers of many bird species, particularly migratory wood warblers (Crawford and Jennings 1989, Niemi 2010, Patten and Burger 1998, Zach and Falls 1975). Two wood warbler species recognized as budworm specialists, Cape May warbler and Tennessee warbler (Patten and Burger 1998), exhibited increasing and stable population trends, respectively, in the Superior NF, where chronic spruce budworm outbreaks occur. These species were uncommon elsewhere in the study (Tables 6 and 7). In contrast, magnolia warbler indicated a declining trend within the Superior NF, but stable populations in all other NFs. Magnolia warbler populations have been shown to decrease in response to budworm activity, presumably due to competition from other bird species (Patten and Burger 1998). The dynamics of these warbler species, their role in insectivory within the NFs, and their potential competitive interactions with respect to population trends deserve additional scrutiny and study. This is especially relevant to spruce budworm cycles given the renewed interest in the processes that maintain budworm populations at nondamaging endemic levels (Régnière et al. 2013).

Aspen forests sustained near complete defoliation during peak years (primarily 2001 and 2002) from forest tent caterpillars, with other hardwood tree species undergoing collateral defoliation damage (Fig. 11). If bird populations responded to the associated caterpillar food resources, such responses could be expected in any year the outbreak was active. The two primary bird species that respond to forest tent caterpillars are the black-billed and yellow-billed cuckoos. Both species, however, are relatively rare in these northern NFs and neither was common enough for a statistical analysis of trends. The average numbers of black-billed cuckoos observed per year within the combined Chippewa, Superior, and Chequamegon NFs were less than 20. However, somewhat large numbers were observed in 2000 (42), 2001 (73), 2006 (55), and 2007 (78). The average numbers of yellow-billed cuckoos observed per year in these three NFs combined were below 10 observations during the course of this study. The highest numbers of yellow-billed cuckoos observed were 50 in 1998 and 25 in 1995. Our results document only a slight signal for either of these species with the 2000–2002 forest tent caterpillar outbreaks in the western forest units. But black-billed cuckoo was more abundant in 2002 than during any other year in the Nicolet NF, and the less frequent yellow-billed cuckoo was more abundant in 2002 than in all but 2 other years (1989 and 1991).

Timber Harvest Activities and Land Cover Changes

The general pattern of decreased timber harvest activity across all NFs (Fig. 12) most likely benefited many species of breeding birds in this region, especially those that prefer more mature forests. Among species associated with older forests are the ovenbird, red-eyed vireo, black-throated green warbler, and black-and-white warbler, all of which showed increasing trends (Koch et al. 2012, Schulte and Niemi 1998, Zlonis and Niemi 2014). These trends suggest that the monitoring data can capture management effects on bird species at the scale of the NFs, though we caution that more direct analyses are required to evaluate cause and effect.

Clearcut harvest methods create temporary openings in the forests that can increase the diversity of local bird communities through creation of open and shrublike habitats. Our land cover analysis showed that these open habitats declined during the study period, consistent with reduced harvesting rates. Open dry uplands exhibited several of the strongest habitat associations based on indicator (PPI) analysis of birds observed in this study, and the bird community assemblages further indicated strong regional differences with respect to early successional bird communities. Several species associated with open habitats and early successional vegetation have declined in some NFs. For instance, eastern kingbird, brown thrasher, gray catbird, and field sparrow have all significantly declined in the Nicolet NF, although these species have significantly increased or remained stable in the Chequamegon NF. Song sparrow, a species associated with shrubby habitat and early successional vegetation, has declined in the Chippewa and Nicolet NFs and regionally when all of the NFs are pooled. Declining populations of these species are consistent with reports of declining grassland and early successional bird species elsewhere in the Midwest (Ribic et al. 2009, Thompson et al. 2001). Of course, populations of these species might simply be declining toward presettlement levels, after widespread and unprecedented increases during the logging era of the early 1900s.

Forest Composition and Structure

Best management practices for modern forestry invariably include the retention of both live trees and standing dead trees (snags) for cavity-nesting birds, mammals, and other species (Green 1995: 41–44). Studies from forests in the Great Lakes region show that cavities increase in frequency on larger diameter trees and are disproportionately common in snags (Goodburn and Lorimer 1998, Nelson and Roy 2012). Analyses by FIA indicate similar size distributions of standing dead trees in Minnesota and Wisconsin NFs, with slightly higher densities found in Minnesota. For context, these NF average densities fall midway between densities observed in managed versus unmanaged pine stands (Duvall and Grigal 1999) and are comparable to selectively harvested northern hardwood stands, which fall between even-aged and old-growth northern hardwoods, respectively (Goodburn and Lorimer 1998). Population trends of cavity-nesting bird species (Tables 7 and 8) and guilds (Table 11) have exhibited consistently positive trends in the western Great Lakes NFs. Pileated woodpecker, hairy woodpecker, yellow-bellied sapsucker, and red-breasted nuthatch showed significant population increases in at least two of the NFs. No primary cavity-nesting species showed a decline from 1995 to 2011. Two secondary cavity-nesting species, great crested flycatcher and tree swallow, significantly declined in the Chequamegon and Nicolet NFs, respectively (Tables 7 and 8). In contrast, three secondary cavity-nesting species significantly increased: eastern bluebird in the Chequamegon NF, black-capped chickadee in the Chippewa and Superior NFs, and red-breasted nuthatch in all four NFs (Tables 7 and 8).

Historical reductions in the conifer component of this region's extensive mixed hardwood-conifer forests have been well documented by Curtis (1959), Mladenoff and Pastor (1993), and others.

The status of conifer-associated bird species therefore is of great interest as a conservation concern and potential ecological restoration opportunity. Analyses by FIA indicate that the area of forest in conifer types has been stable in recent decades, with the exception of the spruce-fir type, which has declined slightly in Minnesota NFs (Fig. 13). Correspondingly, bird species with a high affinity for conifers (Appendix 3) exhibited either stable or increasing trends, and several of these species are among the most commonly encountered bird species in the NFs. Black-throated green warbler, Blackburnian warbler, Cape May warbler, hermit thrush, golden-crowned kinglet, northern parula, pine warbler, and red-breasted nuthatch all exhibited stable or increasing numbers during our study period. Only winter wren (decreasing in the Nicolet NF but increasing in the Superior NF) and yellow-bellied flycatcher (decreasing in the Superior NF) exhibited decreasing trends among conifer-associated species with adequate sample sizes.

Demonstration Species

Development of practical management recommendations based on a group as diverse and adaptable as breeding birds is a significant challenge, especially for an entire region like the western Great Lakes. Our goals for this subsection were to demonstrate how the trend data can be coupled with the published literature to generate NF- and species-specific management guidance. We focused on eight examples of birds that potentially need special attention based on regional or global population declines. The accounts below are intended to be used along with other information provided in this document such as Appendix 5, a summary of information on potential high-priority areas and habitat types most used by the species. In particular, the maps included in Appendix 5 can convey to managers the relative importance or uniqueness of a particular area compared with other areas in the regional landscape. Providing this context can help managers identify where limited resources or management focus might be most needed and where targeted management actions are likely to be most effective.

Olive-sided Flycatcher

This species deserves special attention because 1) it is listed as a Regional Forester Sensitive Species (U.S. Forest Service 2012c); 2) it is a species of conservation concern in Bird Conservation Region (BCR) 12 (Matteson et al. 2009), which is the boreal hardwood transition zone that includes the region of all the NFs in our study; and 3) its population has shown severe declines regionally and continentally (Matteson et al. 2009). Sauer et al. (2011) reported declines in BCR 12 of 4.7 percent and 4.1 percent per year during 1996–2010 and 2000–2010, respectively. Similar significant negative BBS trends were reported for Minnesota, but trends in Wisconsin and Ontario for the same periods were insignificant. We estimated a comparable decline (3.1 percent) in the Chippewa NF and a slight increase (1.1 percent) in the Superior NF, but we have low confidence in these trend estimates ($p > 0.05$) due to small sample size (Table 8). Decline in olive-sided flycatcher



Olive-sided flycatcher. Photo by Sparky Stensaas, www.ThePhotoNaturalist.com, used with permission.

has been attributed to reduction in the availability of large live and dead trees, suppression of forest fires, habitat losses on migratory routes and wintering grounds (Altman and Sellabanks 2000), and other factors.

Breeding habitat for the olive-sided flycatcher generally has been described as boreal forests, including uplands, lowlands, beaver meadows, and recently harvested and burned areas (Green and Niemi 1978, Niemi and Pfannmuller 1979, Roberts 1932). Matteson et al. (2009: 21) summarized the habitat as "open and semi-open conifer bogs; scattered large trees" and stand associations as "lowland coniferous; spruce, tamarack, fir." The most common aspect in many detailed descriptions is the presence of standing live or dead trees where the species can forage in the open for flying insects (Roberts 1932). The most commonly used and available trees are large pine (often white pine), spruce, or tamarack. Interestingly, although this species uses a wide variety of habitats, its highest PPI value in our study area occurred in sedge habitat (Appendix 3). This result is largely because of its association with beaver flowages and the presence of large standing trees on the edges. Therefore, retention of large standing live trees or snags adjacent to open areas, especially after disturbance events such as fire, windstorms, or timber harvests, will be beneficial for conservation of this species. Because it is often associated with large burned areas, maintaining natural patterns of forest fire that create suitable forest openings can also benefit the olive-sided flycatcher (WDNR 2005). Peterson and Fichtel (1992) suggested that relatively large blocks of boreal forest are beneficial because 20 ha may be necessary to support a single territorial pair.

Magnolia Warbler

This species has declined significantly in the Superior NF, where it is most frequently recorded (Tables 7 and 8, Appendixes 1 and 5). The conservation plan for BCR 12 does not mention magnolia warbler as a species of concern (Matteson et al. 2009). Sauer et al. (2011) indicated a significantly positive trend based on 221 routes in BCR 12, but slightly negative though insignificant trends were documented in Minnesota from 1966 to 2010 and from 2000 to 2010. A detailed analysis of BBS routes near the Chippewa, Superior, and Chequamegon NFs, however, is consistent with our results, showing significantly negative trends around 1.5 to 1.8 percent per year (Table 12). Therefore, in this region magnolia warblers appear to be declining. We are unaware of published literature describing potential reasons for population declines in this species.



Magnolia warbler. Photo by Edmund Zlonis, Natural Resources Research Institute, used with permission.

General breeding habitat descriptions for the magnolia warbler emphasize small, close-growing young conifers either in pure stands or mixed with hardwoods (Hall 1994). In Minnesota, magnolia warblers tend to be found in intermediate stages of coniferous forest regeneration and in some coniferous lowlands (Green and Niemi 1978, Niemi and Pfannmuller 1979). Magnolia warblers were more common in aspen-spruce-fir stands (PPI = 13) compared with aspen-birch stands (PPI = 4) (Appendixes 3 and 5), illustrating a preference for stands with a conifer component. Management for mixed stands of aspen, spruce, and fir with a dense understory is an effective

management strategy for magnolia warblers (Pearson and Niemi 2000). Forest management, such as fuel reduction activities and aspen clearcuts that result in balsam fir removal, could reduce habitat for this species. The effects of these activities should be considered in areas where magnolia warbler is likely to be found, particularly in the Superior NF (Appendixes 1 and 5). Finally, as previously mentioned, magnolia warblers have been shown to have negative interactions with other warblers, especially the spruce budworm specialists, Cape May and bay-breasted warblers (Patten and Burger 1998). The extent of these competitive interactions and potential effects on population levels are a ripe area for future research.



Connecticut warbler. Photo by Edmund Zlonis, Natural Resources Research Institute, used with permission.

Connecticut Warbler

Populations of this Regional Forester Sensitive Species (U.S. Forest Service 2012c) have declined 7.1 percent per year in the Chippewa NF and 8.4 percent per year in the Superior NF (Tables 7 and 8, Appendix 5). Sauer et al. (2011) showed significant declines for Connecticut warbler of 1.8 percent and 1.4 percent per year in the BBS for BCR 12 and even greater negative trends in Minnesota, Wisconsin, Manitoba, and the continental United States overall. The species was not abundant enough in the Chequamegon or Nicolet NF or in the BBS analysis (Table 12) to include comparisons of BBS routes with the NF bird-monitoring program. However, the consistency of the negative trends for this species across a large geographic area and especially within BCR 12 (Matteson et al. 2009) suggests that attention is warranted on potential causes for the trends.

Population declines have been attributed to nest predation, changes in landscapes, loss of nesting habitat as a result of fragmentation and climate change (Binford 1991, Matteson et al. 2009), habitat loss in overwintering areas (Rappole 1995), and even collisions with structures (Arnold and Zink 2011, Robbins 1991). The modest literature on breeding habitat for this species in this region emphasizes mature black spruce-tamarack bogs (Niemi and Hanowski 1992). Binford (1991) and a U.S. Forest Service (2002) report stressed the importance of coniferous forests with an open, ericaceous understory and a dense herb layer up to 1 meter high. Our indicator species analysis strongly supports the importance of mature black spruce-tamarack stands as primary breeding habitat for the Connecticut warbler (Appendix 3, PPI = 29). In northwest Wisconsin, Connecticut warblers have also been reported as associated with jack pine forests (Robbins 1974). A recent analysis of habitat and landscape factors in northern Minnesota indicated that Connecticut warbler breeding habitats were consistently associated with large, contiguous landscapes consisting of lowland black spruce and upland coniferous forest, but negatively associated with upland deciduous forest (Lapin et al. 2013).

This species is most common in the northern regions of our study area, primarily the Chippewa and Superior NFs. Because of the rarity of Connecticut warbler and its population declines, protection and maintenance of large tracts of mature black spruce and tamarack stands, especially stands found in association with upland coniferous forests, will most likely be

critical to continued presence of this species in Minnesota. The WDNR (2005) has recommended the management of jack pine forest in Wisconsin, especially naturally regenerated stands, to benefit Connecticut warblers in that region. Further study is warranted on the species' nesting biology, postbreeding dispersal, and other potential factors contributing to population declines.

Golden-winged Warbler

More than half of the golden-winged warbler's known breeding population occurs in Minnesota and Wisconsin (Matteson et al. 2009). Based on the BBS, the species also exhibited long-term population declines in BCR 12 of 1.1 percent per year from 1966 to 2010 and 0.8 percent per year from 2000 to 2010 (Sauer et al. 2011). Declines of >2.0 percent per year in the BBS have been estimated for Wisconsin, for the entire eastern BBS region, for the entire United States, and among all BBS surveys (United States and Canada); however, when considering Minnesota, Ontario, or all of Canada's BBS routes, the trend estimates are insignificant (Sauer et al 2011).



Golden-winged warbler. Photo by Sparky Stensaas, www.ThePhotoNaturalist.com, used with permission.

The NF bird monitoring program shows geographically varying results, with the species significantly increasing in the Chequamegon NF, but significantly decreasing in the Chippewa NF (Tables 7 and 8). Comparisons of NF trends with the BBS routes within the NFs are consistent in showing no significant trend (Table 12). These data suggest that the species is declining in the eastern and southern regions of its breeding range, but the inconsistency between the increasing trend in the Chequamegon NF and the decreasing trend in the Chippewa NF does not support this general pattern. No alder or upland brush habitats were surveyed in the Chippewa NF (Hanowski 2002), but these habitats were sampled in the Chequamegon NF. Lowland and upland brush habitats are used for courtship, nesting, and foraging by the golden-winged warbler (Appendix 3). The lack of surveys in this nonforested habitat in the Chippewa NF may explain why we detected a negative trend for golden-winged warblers in that NF. Our predictive map (Appendix 5) for the golden-winged warbler illustrates that the species is most commonly found in the Chippewa NF. Therefore, to better monitor this species in the Chippewa NF, additional nonforested habitat types such as alder or upland brush habitat should be sampled.

Lowland and upland brush habitats were well sampled in the Nicolet NF; however, no overall significant trends were documented. It is likely that considerable spatial variation in the pattern of trends within the species range of Minnesota and Wisconsin exists. The pattern of change also needs to be considered in light of the distribution of the blue-winged warbler, which hybridizes introgressively with golden-winged warbler and may ultimately replace the species in some areas (Gill 1997). Currently, the blue-winged warbler is still a very rare warbler in these NFs and has been detected (rarely) only in the Nicolet and Chequamegon NF counts (Appendix 1). If this species increases northward, then it may become another threat to populations of golden-winged warbler.

Breeding habitat for the golden-winged warbler is commonly associated with wetland shrubby habitats, such as lowland grassy-shrub or regenerating forest stands (Hanowski 2002, Matteson et al. 2009, Niemi 2014); however, recent radio-telemetry by Streby et al. (2012) found that golden-winged warblers in Minnesota also used intermediate and mature forests for nesting and the postbreeding periods. Sampling over the past 20+ yr in the NFs recorded the species in nine different habitats, with lowland shrubs and sedge habitat having the highest indicator values (7 for each, Appendix 3). Hanowski (2002) found that the amount of lowland shrub within a 100-meter buffer was the best predictor of golden-winged warbler occurrence on the Chippewa, Superior, and Chequamegon NFs. However, a study in north-central Wisconsin concluded that 1- to 10-yr-old aspen stands harbored a higher abundance of golden-winged warblers than other early seral habitats (Martin et al. 2007). In Wisconsin's Bayfield County peninsula, biologists conducting surveys for Kirtland's warbler (*Setophaga kirtlandii*) in young jack pine stands documented high densities of golden-winged warbler, especially in stands with a heavy aspen sapling component (S. Posner, wildlife biologist, Chequamegon-Nicolet National Forest, Washburn, WI, pers. comm., 2012). Understanding and responding to the spatial variation in habitat use will probably be important to conservation of this species because it appears to use a wide variety of local habitats as suggested by point counts gathered across a gradient of habitats and recent radio-telemetry research (Niemi 2014).

Swainson's Thrush

This species exhibited a significantly declining trend of 2.7 percent per year in the Superior NF (Tables 7 and 8). The downward trend was particularly drastic during the past 9 yr in the Superior NF, where it most commonly occurs (Appendixes 1 and 5). The species was not common enough in the other NFs for inclusion in trend analyses or for comparisons with BBS routes, although in the Nicolet NF, its average abundance decreased at twice as many sites (18) as it increased (9) during 1991–2000 and 2001–2010. Matteson et al. (2009) did not identify it as a species of concern in BCR 12. Sauer et al. (2011) estimated a slight negative but insignificant trend for the species in BCR 12; however, significant negative trends in the species were estimated for Canada (0.8 percent per year), the United States (0.5 percent per year), and survey-wide (0.8 percent per year) from 1966 to 2010. Trend estimates for Minnesota, Wisconsin, and Ontario were insignificant for the same period (Sauer et al. 2011). The most detailed and largest sample size available for Swainson's thrush trend analysis is from the Superior NF. This analysis may reveal an early indication of declines for the species, and future trends should be monitored carefully. Threats to Swainson's thrush populations include loss of mature coniferous forest breeding habitat due to timber harvest and forest fire (Mack and Yong 2000), mortality during migration due to hazards such as tower kills (Mack and Yong 2000) and window kills (Bracey 2011), and loss of wintering habitat in Central America due to deforestation (Petit et al. 1995).

Breeding habitat of the Swainson's thrush varies considerably across the species' range in the United States and Canada (Mack and Yong 2000). It is primarily a species of mature spruce-fir forests in the upper Midwest (Erskine 1977, Green and



Swainson's thrush. Photo by Scott Giese, used with permission.

Niemi 1978, Niemi and Pfannmuller 1979, Roberts 1932). The indicator species analysis (Appendix 3) identified the primary habitat as aspen-spruce-fir forests (PPI = 9) and mixed swamp conifer forests (PPI = 5). This result suggests that the species is associated with a combination of mature upland and lowland conifer-associated forests. Pure spruce-fir forests in this region are rare; spruce and fir generally occur in mixed stands with aspen and birch. Throughout the region, increasing or maintaining the density of conifers in both the understory and overstory may be the single most beneficial management action for this species. Prohibiting disturbance in stands with known nest locations is prudent, given the relative rarity of Swainson's thrush in the western Great Lakes region.



Boreal chickadee. Photo by Sparky Stensaas, www.ThePhotoNaturalist.com, used with permission.

Boreal Chickadee

This species is rare and locally distributed in the four NFs, which are located near the southern edge of the boreal chickadee's geographic range. Consequently, local populations in our study area are vulnerable to climate change and other environmental perturbations. In the Nicolet NF, decreases in average abundance were reported at seven points, and increases occurred at four points during 1991–2000 and 2001–2010. The species was not common enough for trend estimate in the NFs, and BBS estimates are all generally unreliable because of its rarity (Sauer et al. 2011). Boreal chickadees were counted most often in the Superior and Nicolet NFs with 0.51 and 0.54 observations per hundred 10-min point counts, respectively (Appendix 1). The overall status of this species in these NFs is unclear and will remain so unless there is a larger effort to sample potential breeding habitats for this species, especially during the early spring periods when the species nests and is more vocal.

The boreal chickadee breeds in boreal coniferous and mixed coniferous-deciduous woodlands throughout its range (Ficken et al. 1996); in the western Great Lakes region, it is known to occur in lowland coniferous forest consisting of black spruce, tamarack, and white cedar (Roberts 1932). Breeding habitat can also be described as more open, ericaceous muskeg-bog communities (Green and Niemi 1978). Gillespie and Kendeigh (1982) suggested that the species is a forest interior species, avoiding forest edge habitats. The indicator species analysis provided somewhat unusual associations with the highest PPI values in sedge habitat (PPI = 4) and black spruce-tamarack stands (PPI = 4) (Appendix 3). The association with sedge habitat most likely represents edges of bog lakes or other stands where sedge meadows are surrounded by lowland conifer forest and muskeg. Maintenance of lowland conifer forest (dominated by black spruce, tamarack, or white cedar) should therefore benefit this species. Likewise, factors that can degrade this habitat include altered hydrology (from roads and trails), timber harvest, and invasive plant species. Forest management practices that increase conifers are beneficial across northern Wisconsin and Minnesota; however, they are especially important in boreal chickadee high-priority habitat areas (and those of several other birds in need of special attention such as the Connecticut warbler and Swainson's thrush). Other key practices to maintain high-priority habitats include the retention of snags and trees with nest cavities,

retention of some stands affected by spruce budworm or spruce decline, reforestation efforts that emphasize conifers, and deer protection for conifer regeneration.

Scarlet Tanager

Long-term population declines at local and regional scales (Tables 7 and 8) justify serious conservation concern for this species. The BBS in BCR 12 indicates a significant decline of 1.4 percent per year from 1966 to 2010 and 1.7 percent per year from 2000 to 2010 (Sauer et al. 2011). These results are consistent with the more detailed analysis of BBS routes within the region of the NFs and with the overall trends based on the NF monitoring programs (Table 12). Our data indicated a significant decline of this species of 3.0 percent per year in the Chequamegon NF, 1.8 percent per year in the Chippewa NF, and 2.5 percent per year in the pooled NF dataset (Appendix 5). As is the case with many declining species, the downward trend was most pronounced from 2000 to 2011 (Appendix 5). Suggested causes of population declines in this species across the eastern United States include habitat loss and forest fragmentation (Mowbray 1999, Robbins et al. 1989). Scarlet tanagers are common hosts of the brown-headed cowbird, and the effects of cowbird brood parasitism may be exacerbated by forest fragmentation (Brittingham and Temple 1983). However, brown-headed cowbirds declined in our study area (Tables 7 and 8), and timber harvest activity decreased during the past 17 yr. Therefore, the effects of brown-headed cowbirds, or fragmentation of forested habitat due to timber harvest, are an unlikely explanation for scarlet tanager declines in this region. Mowbray (1999) found some evidence that mortality during migration or on wintering grounds is responsible for declines in breeding populations, so disturbances on the wintering grounds cannot be eliminated as a potential factor.



Scarlet tanager. Photo by Scott Giese, used with permission.

Breeding habitat for the scarlet tanager has been described in broad terms as deciduous and mixed deciduous-coniferous forest types (Mowbray 1999). In the upper Midwest, the descriptions of breeding habitat associations are equally broad, including variables ranging from oak and mixed oak-pine forest and dry deciduous forest, to mesic deciduous and mixed deciduous-coniferous forests (Brewer et al. 1991, Mowbray 1999). Our data suggest that oak forests (PPI = 11, Appendix 3) are used extensively by scarlet tanagers in these NFs. Other forested habitats commonly used by the scarlet tanager included beech-maple-birch (PPI = 5), upland hardwoods (PPI = 5), hemlock (PPI = 4), red pine (PPI = 4), and white pine (PPI = 4). Its primary distribution (Appendix 5) is in the southern edges of the region and in the Keweenaw Peninsula, where oak and northern hardwoods are most common. Extensive mature deciduous or mixed coniferous-deciduous forests with a moderate density of larger diameter trees and an oak component should benefit this species (Anderson and Shugart 1974, Prescott 1965).

Yellow-rumped Warbler

The eastern form of the yellow-rumped warbler that breeds in this region is known as the myrtle warbler (subspecies *Setophaga coronata coronata*). We include this species for special attention primarily because our bird monitoring programs detected a significant population decline in the Chequamegon NF (6.2 percent per year) and Chippewa NF (1.9 percent) and a declining overall trend (Tables 7 and 8, Appendix 5). In contrast, the species significantly increased in the Superior NF (2.2 percent, Appendix 5) and was stable in the Nicolet NF (Tables 7 and 8). Data from both the NF surveys and the BBS for the yellow-rumped warbler from 1995 to 2010 showed negative but insignificant trends (Table 12). It was not identified as a species of concern in BCR 12 by Matteson et al. (2009). Sauer et al. (2011) indicated significantly positive trends of 2.0 percent per year in both Minnesota and Wisconsin BBS from 1966 to 2010 and no significant trends in BCR 12 or in Ontario. The trends for this species in the NFs indicate that future populations, potential causes for declines within the Chequamegon and Chippewa NFs, and reasons for increases in the Superior NF should be examined. Little has been published about conservation concerns for this species.



Yellow-rumped warbler. Photo by Scott Giese, used with permission.

The yellow-rumped warbler was highly associated with coniferous forest habitats, including both upland and lowland spruce, fir, and pine (Green and Niemi 1978, Niemi and Hanowski 1992, Niemi and Pfannmuller 1979, Roberts 1932). Indicator species analysis revealed that the species was found in 14 different habitat types, but was most abundant in conifer-associated forests and especially in lowland black spruce-tamarack forests (PPI = 14, Appendix 3). The species was most abundant in the Chippewa and Superior NFs, where coniferous forests were most abundant (relative abundance >19 per 100 point counts, Appendix 1). Yellow-rumped warblers were found in the same habitats as Connecticut warbler, Swainson's thrush, and boreal chickadee. The yellow-rumped warbler is more abundant than these species within Minnesota and Wisconsin NFs, but its decline might serve as an early warning for declines of other species within coniferous habitats of the western Great Lakes region.

Gaps in Knowledge

Any data-gathering exercise inevitably leads to new questions and directions for future research. The length of time and spatial extent of NF bird surveys in the western Great Lakes region provide an unprecedented opportunity to increase our understanding of spatiotemporal variation in breeding bird populations and communities. This report has established a baseline of information about relative species abundances; breeding habitat distributions; local bird community assemblages; and potential relationships between bird populations and weather, climate, land use, and landscape disturbances. Statistically robust information is available for more than 100 species, yet the potential drivers affecting these bird populations operate simultaneously and at different spatiotemporal scales. Simple correlative analyses are therefore prone to misinterpretation of underlying causality, requiring more sophisticated analyses to address inherent multicolinearity among potential drivers and scale-specific responses of breeding bird populations.

Data gathered here were almost exclusively based on singing territorial males during the late-May to early-July breeding season. Links between bird song activity, nesting success, and habitat quality have been a point of some controversy, as articulated by van Horne (1983), who questioned whether bird density was an appropriate indicator of habitat quality. Unfortunately, assessing productivity (i.e., nest success) is time-consuming and expensive. However, Perot and Villard (2009) have recently shown that productivity was highly correlated with density in the ovenbird. Such relationships between nest productivity and bird song activity remain a critical research need affecting the interpretation of broad-scale bird monitoring programs like ours. If the presence of singing males is indeed closely tied to reproductive success, then point counts of these breeding birds can provide one of the most ecologically meaningful and cost-effective indicators of forest condition.

Another area of study that has received recent attention is habitat use by breeding bird species during the postbreeding season, a critical period during which young individuals learn to forage, older individuals undergo molt, and both young and old individuals acquire energy reserves before migrating. Recent studies have begun to address the habitat needs and local movements of postbreeding birds in more detail (e.g., Anders et al. 1998, Major and Desrochers 2012, Streby et al. 2012). A better understanding of the totality of habitat and landscape used by birds during their annual breeding cycle is another important research need, especially for an avifauna like that of the western Great Lakes, where the vast majority of species are migratory.

Species-habitat relationships reported here were derived from U.S. Forest Service stand definitions and qualitative field observations of vegetation composition and structure. Standardized habitat evaluation protocols should be established to enable upscaling of sample data to broad-scale forest inventory data (e.g., Rowland and Vojta 2013) and geospatial datasets. Quantitative GIS analysis of sample points was used to model species distribution, shown in the Appendix 5 maps, but these results have not yet been used to refine descriptions of sites and to evaluate species' habitat preferences. Improved spatial technology (use of GPS receivers by field observers and availability of high-resolution aerial imagery) has enabled accurate, multi-scale analyses of bird–habitat relationships. Continued use of emerging technologies, such as light detection and ranging (LiDAR; Lefsky et al. 2002), for habitat assessment should be a high priority for future research.

A principal result of our habitat and community assemblage analysis is that habitat management prescriptions for birds in one area (e.g., the Superior NF) may be only partly effective for bird conservation in other areas (e.g., the Chequamegon-Nicolet NF) because bird assemblages vary geographically, even for the same habitat and ecological province. Furthermore, the habitat features associated with co-occurring bird assemblages (Table 14) do not always correspond to habitat definitions currently used by forest managers or by us (Tables 2 and 3, Appendix 2). In short, an understanding of both the ecological and geographical dimensions of community dynamics is critical for effective biodiversity management. Our analysis provides a starting point for addressing ecology and biogeography simultaneously in western Great Lakes NFs.

The ecological health of forest ecosystems is of growing interest and concern. Important issues involve a host of ecosystem functions such as carbon sequestration, predator-prey interactions, plant productivity, pollination, and seed dispersal. Forest bird populations are integral to many of these key ecosystem functions. For instance, predation by forest birds on defoliating insects (e.g., spruce budworm or forest tent caterpillars) may play a significant role in maintaining healthy growth and productivity of trees. Our knowledge

about the effects of natural and anthropogenic changes on predator-prey dynamics and other forest functions is increasing, but it is still rudimentary in many respects. Among the major threats that may significantly affect forest birds at various spatial scales are changing climates, fragmentation, and the establishment of nonnative invasive species. The short-term and long-term bird population changes we have observed may also be affected by changing silvicultural practices, land use on adjacent non-NF land, and the influence of migration or overwintering areas on bird species survival. Integration of these factors will continue to be a challenge in the interpretation of bird population trends in these NFs.

Invasive species can have many direct and indirect effects on forest birds in the western Great Lakes forests; these effects are manifested at widely varying spatial scales. Depending on the species, some of the effects are positive and others negative. The interactions among native and invasive species are complex and difficult to study in isolation. For example, Gandhi and Herms (2010: 389) observed that as "alien insects continue to establish and spread in forests of eastern North America, their already pervasive effects on ecological interactions and ecosystem processes will continue to magnify." Aslan and Rejmanek (2010: 1017) point out that "birds and nonnative plants have clear conservation and management implications, but remain poorly understood at all spatial scales."

Research is needed to identify the degree of risk from an invasive species and to help determine the best management strategy for dealing with problems (e.g., eradication or maintenance at low densities). The general threats of invasive species to birds underscore the importance of systematic monitoring of bird populations in western Great Lakes forests. If significant and relevant changes in bird populations are detected, the monitoring design might need to be modified to focus on specific disturbance issues. The potential effects of white-tailed deer (*Odocoileus virginianus*) on breeding bird populations in this region have been identified as a concern (Alverson et al. 2005). White-tailed deer are known to reduce the nesting and foraging understory habitat used by many species of birds (Beals et al. 1960, Ostrowski 2009) and to prey on bird nests (Pietz and Granfors 2000). Deer densities have increased substantially in the northern forests of Wisconsin and Minnesota since 1980. In Wisconsin, deer reached a peak in the mid-1990s that was nearly double the target herd size set by the WDNR before returning to target levels in 2007 (Rolley 2011). Our results provide little evidence that ground-nesting species, those species most susceptible to effects of reduced ground and shrub cover from deer herbivory, have declined uniformly. More detailed experimental studies are necessary to determine whether there has been an overall effect of deer on forest breeding birds in this region.

A key insight from our characterization of potential drivers affecting forest bird populations (see "Ecological Context," earlier) is that multiple factors that affect breeding bird populations and community composition are changing simultaneously, making it challenging to attribute individual species population trends to any specific cause. For example, numerous studies project range shifts for many bird species as a result of interactions between climate change, habitat preferences, and bird population dynamics (Matthews et al. 2011, Price and Root 2001, Root and Schneider 2002, Virkkala et al. 2008, Wiens et al. 2009). Some studies have clearly demonstrated that a northward shift in bird distributions has occurred over the last 40 yr (Hitch and Leberg 2007, Nicholls 2011, Niven et al. 2009). We do observe some species trends that are consistent with range shifts, but many others are not, indicating that other factors such as differential response of different migratory guilds, regional declines of open habitats, increasing maturity of the forest, and pulsed disturbances such as drought and insect outbreaks are at play. Detailed, spatially

explicit analyses of our trend data with lagged time periods and simultaneous consideration of multiple factors or simply more time will therefore be necessary to determine how environmental, anthropogenic, and ecological drivers influence population levels of breeding bird species.

Hence there are still questions about forest bird trends, their detectability, and the integration of factors associated with these trends that beg to be explored further. Among the efforts underway are the power analyses of trends that are planned for the Superior NF, the link between climate change and disturbance scenarios with responses by breeding birds in the Chippewa NF, and further scrutiny of detectability of breeding birds in on-road versus off-road point counts in Minnesota. The scale and scope of the potential threats to birds and the need for the analyses that are essential to build our knowledge base for breeding birds underscore the importance of systematic monitoring of their populations in western Great Lakes forests.

CONCLUDING REMARKS

This document describes the most comprehensive volume of quantitative information ever compiled on the trends, habitat use, and community assemblages of forest breeding birds of the western Great Lakes region. Long-term bird surveys of this intensity and geographic breadth are rare, so continuation of surveys of these NFs will be increasingly important for understanding the dynamics of western Great Lakes bird populations and the landscapes in which they occur. These data add to the many other important documents on the natural history, distribution, and relative abundance of birds of the region, such as Roberts (1932), DeGraaf and Evans (1979), Brewer et al. (1991), and Cutright et al. (2006), and the extensive publications available in the peer-reviewed literature, many of which are cited here.

The results of our trend analyses indicate that overall breeding bird populations of many species were stable or increasing between 1995 and 2011. These results are positive reflections of forest condition; only a few species show a declining trend over this recent period of time. Our results contrast with the historical perspective on many breeding bird populations, especially Neotropical migrants, highlighted in the 1980s and 1990s by Terborgh (1989, 1992) and Rappole (1995) and most recently by Wells (2011). Given the vast changes in habitat and landscape over the past 150 yr in North America, such as the conversion of forest land to other uses, many forest bird populations unquestionably have declined from historical levels. Broader analyses in North America based on the roadside BBS routes for 1968 through 2008 have shown continued declines for eastern-forest-obligate birds, boreal-forest-obligate birds, and Neotropical migrant birds, though these overall trends are not as severe as the declines in grassland-obligate birds (Sauer and Link 2011).

Although limited information is available on breeding bird trends in this region during the past 100 yr (see Schulte et al. 2005), the creation of these NFs in the early 1900s has contributed significantly to the stabilization of many breeding bird populations within the western Great Lakes region. Our trend data suggest that this may be the case for the past 15 to 20 yr. In contrast, large changes in the forests outside of the NFs have continued; loss and fragmentation of forested habitat, primarily due to conversions to agricultural, industrial, and residential land uses, have been documented by others (Mladenoff et al. 1997, Radeloff et al. 2005, Wolter et al. 2006). Demographic studies from this region support the notion that forest fragmentation can influence the ability of the remaining forested habitat to act as population sources or sinks for several forest-obligate species (Howe et al. 1997a, Robinson et al. 1995, Rodewald 2009). Combined, these findings suggest that large areas of public forest play an important role in the maintenance of forest breeding bird populations in a region harboring forest bird communities among the most diverse in the United States and Canada (Price et al. 1995, Robbins et al. 1986).

Nonetheless, breeding bird populations within the NFs are influenced by many factors beyond the boundaries of the NFs such as the adequacy of migratory stopover habitats and migration hazards like buildings, windows, communication towers, and wind turbines. Overwintering habitats in the central and southern United States for short-distance migrants and in Central and

South America for long-distance migrants are also ongoing concerns. The potential impacts of climate change and invasive species represent shifts and threats to the biological diversity of breeding birds within the NFs.

We trust that the data and synthesis presented here will provide a stronger basis for wise forest management decisions within public lands central to the long-term maintenance of forest avifauna within the upper Midwest.

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APPENDIX 1

Average Abundances of 187 Bird Species in Point Counts at 4 National Forests in the Western Great Lakes Region

Values in the table below are the mean numbers of individuals of species detected in 100 unlimited-radius 10-min point counts from 1995 through 2010 for the Chippewa (Chip), Superior (Sup), and Chequamegon (Cheq) National Forests (NFs) and from 1991 through 2010 for the Nicolet (Nic) NF. "Code" is the standard abbreviation for the species following Pyle and DeSante (2012). "Group" is the general habitat affinity of the species according to categories described in Table 5. Scientific names for species are from Chesser et al. (2012) and previous supplements of the American Ornithologists' Union Check-list of North American Birds (American Ornithologists' Union 1998). Total numbers of counts for each NF are given in parentheses, and the Total column shows the total numbers of individuals observed during all counts during these periods. Note that several additional species (canvasback, *Aytha valisineria*; gray-cheeked thrush, *Catharus minimus*; northern mockingbird, *Mimus polyglottos*; and northern saw-whet owl, *Aegolius acadicus*) were observed in point counts outside the period covered by this appendix.

Common name	Scientific name	Code	Group	Chip (6,182)	Sup (7,705)	Cheq (6,130)	Nic (3,124)	Total
Alder flycatcher	*Empidonax alnorum*	ALFL	FSW	7.97	11.12	19.36	15.52	3,022
American bittern	*Botaurus lentiginosus*	AMBI	W	0.02	1.28	1.00	1.02	193
American black duck	*Anas rubripes*	ABDU	W	0.00	0.05	0.00	0.10	7
American coot	*Fulica americana*	AMCO	W	0.00	0.00	0.00	0.32	10
American crow	*Corvus brachyrhynchos*	AMCR	FM	32.87	11.37	35.91	40.30	6,368
American goldfinch	*Spinus tristis*	AMGO	G	10.61	3.61	10.62	17.86	2,143
American kestrel	*Falco sparverius*	AMKE	G	0.03	0.06	0.10	0.10	16
American redstart	*Setophaga ruticilla*	AMRE	F	46.28	16.05	10.69	5.60	4,928
American robin	*Turdus migratorius*	AMRO	FM	34.29	40.79	50.39	59.38	10,207
American white pelican	*Pelecanus erythrorhynchos*	AWPE	W	0.21	0.05	0.00	0.00	17
American wigeon	*Anas americana*	AMWI	W	0.00	0.00	0.00	0.06	2
American woodcock	*Scolopax minor*	AMWO	F	0.10	0.08	0.08	0.13	21
Bald eagle	*Haliaeetus leucocephalus*	BAEA	FSW	0.16	0.04	0.00	1.25	52
Baltimore oriole	*Icterus galbula*	BAOR	FM	0.65	0.31	1.73	4.13	299
Bank swallow	*Riparia riparia*	BANS	A	0.03	0.01	0.02	0.00	4
Barn swallow	*Hirundo rustica*	BARS	A	0.05	0.01	0.05	0.32	17
Barred owl	*Strix varia*	BADO	F	0.40	0.29	1.66	1.09	183
Bay-breasted warbler	*Setophaga castanea*	BBWA	F	0.06	0.31	0.10	0.16	39
Belted kingfisher	*Megaceryle alcyon*	BEKI	W	0.52	0.60	0.07	1.47	128
Black tern	*Chlidonias niger*	BLTE	W	0.00	0.00	0.00	3.94	123
Black-and-white warbler	*Mniotilta varia*	BAWW	F	19.77	29.51	17.13	15.75	5,038
Black-backed woodpecker	*Picoides arcticus*	BBWO	F	0.49	0.45	0.08	0.06	72
Black-billed cuckoo	*Coccyzus erythropthalmus*	BBCU	F	1.04	2.47	1.73	3.04	455
Blackburnian warbler	*Setophaga fusca*	BLBW	F	16.92	34.28	20.67	15.52	5,439
Black-capped chickadee	*Poecile atricapillus*	BCCH	F	25.62	18.43	28.81	33.45	5,815
Black-crowned night-heron	*Nycticorax nycticorax*	BCNH	W	0.00	0.00	0.00	0.03	1
Blackpoll warbler	*Setophaga striata*	BLPW	FSW	0.03	0.04	0.02	0.10	9

(continued on next page)

Common name	Scientific name	Code	Group	Chip (6,182)	Sup (7,705)	Cheq (6,130)	Nic (3,124)	Total
Black-throated blue warbler	*Setophaga caerulescens*	BTBW	F	0.16	3.02	1.21	4.74	465
Black-throated green warbler	*Setophaga virens*	BTNW	F	30.44	29.94	63.15	53.84	9,742
Blue jay	*Cyanocitta cristata*	BLJA	F	46.33	51.16	61.42	57.23	12,359
Blue-gray gnatcatcher	*Polioptila caerulea*	BGGN	F	0.00	0.00	0.05	0.00	3
Blue-headed vireo	*Vireo solitarius*	BHVI	F	8.99	8.03	5.82	6.37	1,731
Blue-winged teal	*Anas discors*	BWTE	W	0.00	0.00	0.00	0.67	21
Blue-winged warbler	*Vermivora cyanoptera*	BWWA	F	0.00	0.00	0.11	0.48	22
Bobolink	*Dolichonyx oryzivorus*	BOBO	G	0.00	0.01	0.05	0.06	6
Boreal chickadee	*Poecile hudsonicus*	BOCH	F	0.31	0.51	0.07	0.54	79
Boreal owl	*Aegolius funereus*	BOOW	FM	0.00	0.01	0.00	0.00	1
Brewer's blackbird	*Euphagus cyanocephalus*	BRBL	G	0.26	0.03	8.12	0.26	524
Brewster's warbler	*Vermivora chrysoptera x pinus*	BRWA	FSW	0.00	0.00	0.02	0.00	1
Broad-winged hawk	*Buteo platypterus*	BWHA	F	1.33	1.95	1.17	1.41	348
Brown creeper	*Certhia americana*	BRCR	F	10.30	8.44	8.69	8.48	2,085
Brown thrasher	*Toxostoma rufum*	BRTH	FM	0.21	0.10	8.69	1.70	607
Brown-headed cowbird	*Molothrus ater*	BHCO	FM	4.92	0.35	11.08	5.54	1,183
Canada goose	*Branta canadensis*	CANG	W	0.27	0.66	10.88	22.22	1,429
Canada warbler	*Cardellina canadensis*	CAWA	F	4.92	21.84	8.66	2.78	2,605
Cape May warbler	*Setophaga tigrina*	CMWA	F	0.37	3.21	0.90	1.57	374
Cedar waxwing	*Bombycilla cedrorum*	CEDW	FM	13.23	12.91	7.86	32.52	3,311
Cerulean warbler	*Setophaga cerulea*	CERW	F	0.00	0.00	0.00	0.06	2
Chestnut-sided warbler	*Setophaga pensylvanica*	CSWA	FM	78.15	90.88	49.05	32.49	15,855
Chimney swift	*Chaetura pelagica*	CHSW	A	0.26	0.09	0.11	2.66	113
Chipping sparrow	*Spizella passerina*	CHSP	FM	25.15	12.32	11.99	18.50	3,817
Clay-colored sparrow	*Spizella pallida*	CCSP	G	0.91	0.16	14.93	1.50	1,030
Cliff swallow	*Petrochelidon pyrrhonota*	CLSW	A	0.19	0.00	0.00	1.18	49
Common goldeneye	*Bucephala clangula*	COGO	W	0.00	0.06	0.00	0.29	14
Common grackle	*Quiscalus quiscula*	COGR	G	0.91	0.51	1.34	10.08	492
Common loon	*Gavia immer*	COLO	W	14.53	6.44	2.59	7.78	1,796
Common merganser	*Mergus merganser*	COME	W	0.18	0.21	0.00	0.26	35
Common nighthawk	*Chordeiles minor*	CONI	A	0.19	0.09	0.33	0.10	42
Common raven	*Corvus corax*	CORA	F	11.11	10.93	16.69	27.18	3,401
Common yellowthroat	*Geothlypis trichas*	COYE	FSW	46.12	14.96	25.42	26.09	6,377
Connecticut warbler	*Oporornis agilis*	CONW	FM	4.64	1.67	0.73	0.26	469
Cooper's hawk	*Accipiter cooperii*	COHA	F	0.10	0.03	0.03	0.10	13
Dark-eyed junco	*Junco hyemalis*	DEJU	FM	0.55	0.79	0.62	0.51	149
Dickcissel	*Spiza americana*	DICK	G	0.00	0.00	0.03	0.00	2
Double-crested cormorant	*Phalacrocorax auritus*	DCCO	W	0.00	0.00	0.18	0.16	16
Downy woodpecker	*Picoides pubescens*	DOWO	FM	3.30	2.23	1.60	4.35	610
Eastern bluebird	*Sialia sialis*	EABL	G	0.44	0.05	1.44	1.73	173
Eastern kingbird	*Tyrannus tyrannus*	EAKI	G	0.94	0.23	3.10	5.60	441
Eastern meadowlark	*Sturnella magna*	EAME	G	0.00	0.00	0.05	0.10	6
Eastern phoebe	*Sayornis phoebe*	EAPH	FM	0.74	0.43	1.03	2.59	223
Eastern screech-owl	*Megascops asio*	EASO	F	0.00	0.00	0.00	0.06	2
Eastern towhee	*Pipilo erythrophthalmus*	EATO	F	0.99	0.00	14.40	2.78	1,034
Eastern whip-poor-will	*Antrostomus vociferus*	EWPW	F	0.06	0.04	0.08	0.03	13
Eastern wood-pewee	*Contopus virens*	EAWP	F	29.17	5.91	25.19	20.45	4,441
European starling	*Sturnus vulgaris*	EUST	I	0.00	0.00	0.15	5.57	183
Evening grosbeak	*Coccothraustes vespertinus*	EVGR	F	1.99	5.67	4.78	5.60	1,028
Field sparrow	*Spizella pusilla*	FISP	G	0.02	0.00	0.96	1.92	120
Golden-crowned kinglet	*Regulus satrapa*	GCKI	F	6.97	12.94	3.36	7.49	1,868
Golden-winged warbler	*Vermivora chrysoptera*	GWWA	FSW	6.75	1.91	4.85	6.27	1,057
Grasshopper sparrow	*Ammodramus savannarum*	GRSP	G	0.00	0.00	0.00	0.10	3
Gray catbird	*Dumetella carolinensis*	GRCA	FM	4.37	0.30	2.37	2.18	506
Gray jay	*Perisoreus canadensis*	GRAJ	F	4.01	7.02	0.57	2.27	895
Great blue heron	*Ardea herodias*	GBHE	W	0.60	0.12	0.82	12.52	487
Great crested flycatcher	*Myiarchus crinitus*	GCFL	F	6.97	1.60	11.81	12.71	1,675
Great gray owl	*Strix nebulosa*	GGOW	F	0.03	0.01	0.00	0.00	3
Great horned owl	*Bubo virginianus*	GHOW	FM	0.06	0.04	0.07	0.32	21
Green heron	*Butorides virescens*	GRHE	W	0.08	0.01	0.02	0.16	12
Green-winged teal	*Anas crecca*	GWTE	W	0.10	0.14	0.00	0.06	19
Hairy woodpecker	*Picoides villosus*	HAWO	F	4.51	4.35	6.33	5.28	1,167

(continued on next page)

Common name	Scientific name	Code	Group	Chip (6,182)	Sup (7,705)	Cheq (6,130)	Nic (3,124)	Total
Helmeted guineafowl	*Numida meleagris*	HELG	I	0.00	0.00	0.00	0.10	3
Hermit thrush	*Catharus guttatus*	HETH	F	54.08	45.26	52.94	50.93	11,666
Herring gull	*Larus argentatus*	HERG	W	0.05	0.13	0.00	0.06	15
Hooded merganser	*Lophodytes cucullatus*	HOME	W	0.05	0.00	0.02	0.83	30
House finch	*Haemorhous mexicanus*	HOFI	I	0.00	0.00	0.00	0.80	25
House sparrow	*Passer domesticus*	HOSP	I	0.00	0.00	0.00	0.93	29
House wren	*Troglodytes aedon*	HOWR	FM	0.61	0.23	2.58	2.94	306
Indigo bunting	*Passerina cyanea*	INBU	FM	5.08	1.00	6.93	13.86	1,249
Killdeer	*Charadrius vociferus*	KILL	G	0.16	0.14	0.10	1.95	88
Least bittern	*Ixobrychus exilis*	LEBI	W	0.00	0.00	0.00	0.16	5
Least flycatcher	*Empidonax minimus*	LEFL	F	68.34	27.48	39.09	33.87	9,796
LeConte's sparrow	*Ammodramus leconteii*	LCSP	W	0.00	0.00	0.13	0.00	8
Lesser scaup	*Aythya affinis*	LESC	W	0.02	0.01	0.00	0.03	3
Lincoln's sparrow	*Melospiza lincolnii*	LISP	FSW	1.13	0.96	2.50	2.50	375
Long-eared owl	*Asio otus*	LEOW	F	0.05	0.00	0.00	0.00	3
Magnolia warbler	*Setophaga magnolia*	MAWA	F	3.91	31.93	3.31	3.27	3,007
Mallard	*Anas platyrhynchos*	MALL	W	0.52	0.42	0.44	7.33	320
Marsh wren	*Cistothorus palustris*	MAWR	W	0.03	0.01	0.03	0.38	17
Merlin	*Falco columbarius*	MERL	G	0.03	0.05	0.00	0.06	8
Mourning dove	*Zenaida macroura*	MODO	FM	2.05	0.16	9.28	16.71	1,230
Mourning warbler	*Geothlypis philadelphia*	MOWA	F	20.17	37.51	15.68	21.38	5,766
Nashville warbler	*Oreothlypis ruficapilla*	NAWA	F	84.08	136.61	65.19	63.28	21,697
Northern cardinal	*Cardinalis cardinalis*	NOCA	FM	0.00	0.00	0.08	0.26	13
Northern flicker	*Colaptes auratus*	NOFL	FM	5.47	9.47	6.82	7.97	1,735
Northern goshawk	*Accipiter gentilis*	NOGO	F	0.06	0.00	0.03	0.22	13
Northern harrier	*Circus cyaneus*	NOHA	G	0.02	0.00	0.20	0.10	16
Northern hawk owl	*Surnia ulula*	NHOW	FM	0.00	0.01	0.00	0.00	1
Northern parula	*Setophaga americana*	NOPA	F	12.41	18.83	8.79	10.56	3,087
Northern rough-winged swallow	*Stelgidopteryx serripennis*	NRWS	A	0.00	0.01	0.00	0.29	10
Northern waterthrush	*Parkesia noveboracensis*	NOWA	F	6.13	3.92	9.77	3.01	1,374
Olive-sided flycatcher	*Contopus cooperi*	OSFL	FSW	2.64	0.93	0.96	1.92	354
Osprey	*Pandion haliaetus*	OSPR	FSW	0.08	0.01	0.07	0.93	39
Ovenbird	*Seiurus aurocapilla*	OVEN	F	191.83	224.79	263.44	169.69	50,629
Palm warbler	*Setophaga palmarum*	PAWA	FSW	3.48	0.30	1.76	0.64	366
Pectoral sandpiper	*Calidris melanotos*	PESA	W	0.00	0.00	0.00	0.03	1
Philadelphia vireo	*Vireo philadelphicus*	PHVI	F	0.00	0.01	0.03	0.35	14
Pied-billed grebe	*Podilymbus podiceps*	PBGR	W	0.24	0.16	0.18	0.80	63
Pileated woodpecker	*Dryocopus pileatus*	PIWO	F	4.42	7.61	4.65	7.17	1,368
Pine siskin	*Spinus pinus*	PISI	F	1.13	1.70	0.91	0.64	277
Pine warbler	*Setophaga pinus*	PIWA	F	23.46	3.74	9.56	6.34	2,522
Purple finch	*Haemorhous purpureus*	PUFI	F	3.93	3.66	3.56	4.87	895
Purple martin	*Progne subis*	PUMA	A	0.06	0.00	0.05	0.22	14
Red crossbill	*Loxia curvirostra*	RECR	F	1.36	0.65	1.26	0.13	215
Red-bellied woodpecker	*Melanerpes carolinus*	RBWO	F	0.06	0.03	0.13	0.38	26
Red-breasted nuthatch	*Sitta canadensis*	RBNU	F	20.33	21.71	16.79	16.20	4,465
Red-eyed vireo	*Vireo olivaceus*	REVI	F	210.50	140.27	175.06	130.60	38,632
Red-headed woodpecker	*Melanerpes erythrocephalus*	RHWO	FM	0.05	0.01	0.03	0.19	12
Red-shouldered hawk	*Buteo lineatus*	RSHA	F	0.05	0.03	0.13	0.32	23
Red-tailed hawk	*Buteo jamaicensis*	RTHA	G	0.81	0.06	0.38	0.35	89
Red-winged blackbird	*Agelaius phoeniceus*	RWBL	FSW	6.20	2.23	7.29	38.96	2,219
Ring-billed gull	*Larus delawarensis*	RBGU	W	0.13	0.27	0.07	0.10	36
Ring-necked duck	*Aythya collaris*	RNDU	W	0.03	0.04	0.00	1.12	40
Ring-necked pheasant	*Phasianus colchicus*	RNEP	I	0.00	0.00	0.02	0.03	2
Rose-breasted grosbeak	*Pheucticus ludovicianus*	RBGR	F	22.66	25.31	43.82	47.86	7,532
Ruby-crowned kinglet	*Regulus calendula*	RCKI	F	0.73	4.65	0.41	0.64	448
Ruby-throated hummingbird	*Archilochus colubris*	RTHU	FM	2.54	1.34	2.38	2.72	491
Ruffed grouse	*Bonasa umbellus*	RUGR	F	1.54	4.40	12.51	6.34	1,399
Rusty blackbird	*Euphagus carolinus*	RUBL	FSW	0.00	0.00	0.03	0.00	2
Sandhill crane	*Grus canadensis*	SACR	G	0.26	0.04	4.68	3.39	412
Savannah sparrow	*Passerculus sandwichensis*	SAVS	G	0.02	0.05	2.58	0.67	184
Scarlet tanager	*Piranga olivacea*	SCTA	F	18.81	3.96	16.08	13.06	2,862
Sedge wren	*Cistothorus platensis*	SEWR	G	0.66	0.51	2.32	2.82	310

(continued on next page)

Common name	Scientific name	Code	Group	Chip (6,182)	Sup (7,705)	Cheq (6,130)	Nic (3,124)	Total
Sharp-shinned hawk	*Accipiter striatus*	SSHA	F	0.06	0.08	0.03	0.13	16
Sharp-tailed grouse	*Tympanuchus phasianellus*	STGR	G	0.06	0.00	0.00	0.00	4
Solitary sandpiper	*Tringa solitaria*	SOSA	FSW	0.02	0.01	0.00	0.03	3
Song sparrow	*Melospiza melodia*	SOSP	FM	16.82	10.51	15.38	28.68	3,689
Sora	*Porzana carolina*	SORA	W	0.11	0.01	0.05	0.80	36
Spotted sandpiper	*Actitis macularius*	SPSA	W	0.00	0.00	0.00	0.29	9
Spruce grouse	*Falcipennis canadensis*	SPGR	F	0.00	0.06	0.00	0.00	5
Swainson's thrush	*Catharus ustulatus*	SWTH	F	1.05	16.76	0.52	1.25	1,427
Swamp sparrow	*Melospiza georgiana*	SWSP	FSW	13.41	5.66	5.89	13.60	2,051
Tennessee warbler	*Oreothlypis peregrina*	TEWA	FM	0.21	1.95	0.33	0.61	202
Tree swallow	*Tachycineta bicolor*	TRES	A	0.44	0.08	5.30	21.45	1,028
Trumpeter swan	*Cygnus buccinator*	TRUS	W	0.00	0.00	0.00	0.48	15
Turkey vulture	*Cathartes aura*	TUVU	FM	0.10	0.17	0.02	0.22	27
Upland sandpiper	*Bartramia longicauda*	UPSA	G	0.00	0.00	1.48	0.13	95
Veery	*Catharus fuscescens*	VEER	F	76.04	59.51	33.15	21.77	11,998
Vesper sparrow	*Pooecetes gramineus*	VESP	G	0.18	0.13	6.36	0.32	421
Virginia rail	*Rallus limicola*	VIRA	W	0.02	0.01	0.02	0.22	10
Warbling vireo	*Vireo gilvus*	WAVI	FM	0.19	0.00	0.20	1.34	66
Western kingbird	*Tyrannus verticalis*	WEKI	G	0.00	0.00	0.00	0.03	1
Western meadowlark	*Sturnella neglecta*	WEME	G	0.00	0.00	0.02	0.00	1
White-breasted nuthatch	*Sitta carolinensis*	WBNU	F	7.99	0.96	6.04	5.35	1,105
White-throated sparrow	*Zonotrichia albicollis*	WTSP	FSW	73.76	141.05	43.15	54.39	19,772
White-winged crossbill	*Loxia leucoptera*	WWCR	F	2.69	0.88	0.00	0.06	236
Wild turkey	*Meleagris gallopavo*	WITU	F	0.05	0.01	0.51	1.41	79
Willow flycatcher	*Empidonax traillii*	WIFL	FSW	0.06	0.00	0.00	0.70	26
Wilson's snipe	*Gallinago delicata*	WISN	W	1.44	1.95	0.60	1.44	321
Wilson's warbler	*Cardellina pusilla*	WIWA	FM	0.06	0.09	0.07	0.10	18
Winter wren	*Troglodytes hiemalis*	WIWR	F	21.58	33.20	17.94	18.76	5,578
Wood duck	*Aix sponsa*	WODU	W	0.36	0.04	0.18	2.98	129
Wood thrush	*Hylocichla mustelina*	WOTH	F	4.43	1.54	9.36	5.51	1,139
Yellow rail	*Coturnicops noveboracensis*	YERA	W	0.00	0.00	0.00	0.03	1
Yellow warbler	*Setophaga petechia*	YEWA	FSW	4.56	0.34	3.21	5.41	674
Yellow-bellied flycatcher	*Empidonax flaviventris*	YBFL	FSW	8.83	22.39	12.76	6.85	3,267
Yellow-bellied sapsucker	*Sphyrapicus varius*	YBSA	F	26.08	22.17	33.02	17.70	5,897
Yellow-billed cuckoo	*Coccyzus americanus*	YBCU	FM	0.61	0.10	1.03	0.99	140
Yellow-rumped warbler	*Setophaga coronata*	YRWA	F	19.96	20.25	15.09	17.32	4,260
Yellow-throated vireo	*Vireo flavifrons*	YTVI	F	6.18	0.23	2.63	2.50	639

Species groups are as follows. W: open wetland. F: closed-canopy forest. FSW: forest/shrub wetland. FM: early-to-mid successional forest. G: grassland. A: aerial. I: introduced.

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APPENDIX 2

Summary of the 20 Most Common Bird Species by Habitat Cover Type in 4 National Forests in the Western Great Lakes Region

Bird survey point data collected in the Chippewa, Superior, Chequamegon, and Nicolet National Forests (NFs) were assigned to a habitat cover type (Table 2). There were sufficient counts to define 29 habitat types, 4 of which (aspen-birch, aspen-spruce-fir, jack pine, and red pine cover types) each contained up to 4 age classes (<10 yr, 10 to 20 yr, 21 to 60 yr, and >60 yr). See Table 15 for common and scientific names for the dominant flora in each habitat type.

The following pages briefly describe each of the 29 habitat cover types and show the 20 bird species most commonly observed in each habitat type (Tables 16 through 44). Each of the three points in stands of the Chippewa, Superior, and Chequamegon NFs, in addition to those in the Nicolet NF, is included in the summaries of bird abundance and frequency. Abundance values for individual and pooled NFs are calculated as the average number of individual birds of a given species detected per 10-min unlimited-distance point counts. Frequency is the proportion of all point counts in which that species was detected. Dashes indicate that the species was not detected in that NF.

For each habitat cover type we also note bird species of state and regional conservation interest. These species are identified according to the following authorities: Minnesota bird species of concern (Minnesota Department of Natural Resources 2006), Wisconsin bird species of concern (Wisconsin Department of Natural Resources 2005), and Regional Forester sensitive animal species (U.S. Forest Service 2012). See Appendix 1 for bird species scientific names.

Table 15.—Common and scientific names for dominant flora in each of 29 habitat cover types

Common name	Scientific name
Alder species	*Alnus* spp.
American basswood	*Tilia americana*
American beech	*Fagus grandifolia*
American elm	*Ulmus americana*
Balsam fir	*Abies balsamea*
Balsam poplar	*Populus balsamifera*
Bigtooth aspen	*Populus grandidentata*
Black ash	*Fraxinus nigra*
Black spruce	*Picea mariana*
Eastern hemlock	*Tsuga canadensis*
Eastern white pine	*Pinus strobus*
Jack pine	*Pinus banksiana*
Northern white-cedar	*Thuja occidentalis*
Oak species	*Quercus* spp.
Paper birch	*Betula papyrifera*
Quaking aspen	*Populus tremuloides*
Red maple	*Acer rubrum*
Red pine	*Pinus resinosa*
Sedges	*Carex* spp.
Sugar maple	*Acer saccharum*
Tamarack	*Larix laricina*
White spruce	*Picea glauca*
Yellow birch	*Betula alleghaniensis*

Pole-Size Aspen-Birch Forest

Upland forest dominated by 10- to 20-yr-old trees of quaking aspen, paper birch, bigtooth aspen, or balsam poplar, or a mix of these species. About 3 percent of all point counts across all four NFs were located in stands of pole-size aspen-birch. This habitat characterized 5 percent of Superior (Sup) NF, 5 percent of Chippewa (Chip) NF, <1 percent of Chequamegon (Cheq) NF, and 3 percent of Nicolet (Nic) NF survey locations.



Young aspen. Photo by Robert Howe, University of Wisconsin.

Table 16.—Abundance and frequency of the 20 most common bird species in pole-size aspen-birch forest*

Species	Pooled NF	Chip NF	Sup NF	Cheq NF	Nic NF	Frequency
Ovenbird †	20.40	20.27	21.54	15.91	17.26	83%
Red-eyed vireo	18.66	26.32	15.88	7.27	10.66	80%
Veery †‡	11.16	14.33	11.27	10.45	--	59%
Chestnut-sided warbler	11.11	9.52	13.87	7.73	5.57	57%
White-throated sparrow †	8.05	3.37	12.70	6.36	3.40	44%
Nashville warbler	7.29	4.71	9.80	8.18	4.53	41%
Rose-breasted grosbeak †	5.49	5.74	4.68	8.64	7.26	41%
Blue jay	4.75	4.12	4.71	6.82	6.23	34%
American robin	4.21	2.41	5.32	5.45	4.62	30%
American redstart	3.64	5.40	3.38	1.36	--	24%
Hermit thrush	3.64	2.85	3.75	5.91	4.91	28%
Mourning warbler	3.36	1.86	4.31	--	4.43	24%
Common yellowthroat	2.79	4.88	--	9.09	3.49	19%
American crow	2.53	3.78	--	--	4.91	20%
Black-and-white warbler	2.38	--	3.31	4.09	--	21%
Black-capped chickadee	2.18	2.75	1.23	5.45	3.58	15%
Yellow-bellied sapsucker †	1.75	2.20	1.64	--	--	14%
Cedar waxwing	1.60	--	--	--	4.91	9%
Winter wren †	1.49	--	1.91	--	--	13%
Scarlet tanager	1.41	2.75	--	--	--	12%

*The following are other common species in this habitat cover type. Chip NF: American goldfinch, gray catbird. Sup NF: Blackburnian warbler, Canada warbler †‡, least flycatcher †‡, magnolia warbler. Cheq NF: American goldfinch, brown-headed cowbird, mourning dove, northern waterthrush, ruffed grouse, song sparrow. Nic NF: common raven, indigo bunting, red-winged blackbird, song sparrow, swamp sparrow †, tree swallow.
† Species of conservation concern, Minnesota.
‡ Species of conservation concern, Wisconsin.

Mid-Successional Aspen-Birch Forest

Upland forest dominated by 20- to 60-yr-old trees of quaking aspen, paper birch, bigtooth aspen, or balsam poplar, or a mix of these species. About 5 percent of all point counts across all four NFs were located in mid-successional aspen-birch stands. This habitat characterized 4 percent of Chippewa (Chip) NF, 8 percent of Superior (Sup) NF, 3 percent of Chequamegon (Cheq) NF, and 6 percent of Nicolet (Nic) NF survey locations.



Quaking aspen forest in early spring. Photo by Mel Baughman, formerly with University of Minnesota Extension, used with permission.

Table 17.—Abundance and frequency of the 20 most common bird species in mid-successional aspen-birch forest*

Species	Pooled NF	Chip NF	Sup NF	Cheq NF	Nic NF	Frequency
Ovenbird †	24.50	22.80	25.40	25.97	22.37	84%
Red-eyed vireo	16.13	23.62	14.40	14.57	12.95	74%
Nashville warbler	8.43	5.94	10.92	7.10	4.74	46%
White-throated sparrow †	7.52	4.13	10.72	4.89	3.68	41%
Chestnut-sided warbler	7.51	6.64	9.37	4.30	5.47	39%
Veery †‡	6.50	6.53	8.03	4.41	3.21	40%
Blue jay	4.85	3.76	5.05	4.30	6.21	34%
Hermit thrush	4.30	2.69	4.53	5.16	4.95	30%
Rose-breasted grosbeak †	3.14	2.58	2.72	3.12	5.42	25%
American robin	3.06	1.73	3.16	3.82	3.84	24%
Black-throated green warbler	2.91	5.39	1.88	4.68	--	20%
Mourning warbler	2.74	--	3.25	--	4.47	20%
Black-capped chickadee	2.62	2.40	1.94	3.82	4.11	19%
Black-and-white warbler	2.24	2.29	2.61	2.20	--	20%
Yellow-bellied sapsucker †	2.16	3.28	--	4.46	--	17%
Least flycatcher †‡	2.04	2.66	1.73	2.90	3.26	11%
American redstart	2.02	4.02	1.91	--	2.47	14%
American crow	1.87	1.92	--	3.44	2.95	15%
Winter wren †	1.74	1.81	1.79	2.37	--	15%
Common yellowthroat	1.72	3.43	--	2.26	2.32	12%

*The following are other common species in this habitat cover type. Chip NF: scarlet tanager. Sup NF: Blackburnian warbler, cedar waxwing, magnolia warbler. Cheq NF: Blackburnian warbler, red-breasted nuthatch. Nic NF: cedar waxwing, common raven, red-winged blackbird, swamp sparrow †, tree swallow.
† Species of conservation concern, Minnesota.
‡ Species of conservation concern, Wisconsin.

Mature Aspen-Birch Forest

Upland forest dominated by >60-yr-old trees of quaking aspen, paper birch, bigtooth aspen, or balsam poplar, or a mix of these species. About 11 percent of all point counts across all four NFs were located in mature aspen-birch stands. This habitat characterized 11 percent of Chippewa (Chip) NF, 22 percent of Superior (Sup) NF, 4 percent of Chequamegon (Cheq) NF, and 3 percent of Nicolet (Nic) NF survey locations.



Mature aspen stand. ©Minnesota Department of Natural Resources.

Table 18.—Abundance and frequency of the 20 most common bird species in mature aspen-birch forest*

Species	Pooled NF	Chip NF	Sup NF	Cheq NF	Nic NF	Frequency
Ovenbird †	23.77	21.86	24.69	24.44	18.11	85%
Red-eyed vireo	17.78	24.53	15.63	14.75	18.56	81%
White-throated sparrow †	8.98	3.25	12.10	4.63	2.56	50%
Nashville warbler	7.77	3.52	10.16	4.24	2.22	45%
Veery †‡	6.76	11.20	5.98	2.57	--	40%
Chestnut-sided warbler	6.66	6.03	7.37	3.97	5.11	37%
Least flycatcher †‡	4.57	9.35	3.08	1.48	7.11	21%
Blue jay	4.36	3.27	4.70	4.59	5.11	32%
Black-throated green warbler	4.00	3.05	4.08	4.94	7.00	28%
Yellow-bellied sapsucker †	3.20	3.73	2.83	4.24	3.67	26%
Winter wren †	2.95	--	3.59	2.53	--	26%
American robin	2.92	--	3.12	4.59	4.22	23%
Blackburnian warbler	2.83	--	3.82	1.79	--	23%
Black-and-white warbler	2.77	1.89	3.26	2.26	--	25%
Hermit thrush	2.72	2.23	2.52	4.90	4.22	21%
Mourning warbler	2.70	--	3.45	--	3.22	20%
American redstart	2.52	6.54	--	--	--	16%
American crow	2.35	3.27	--	4.01	4.00	18%
Black-capped chickadee	2.31	1.99	2.24	3.54	2.67	16%
Magnolia warbler	2.28	--	3.43	--	--	16%

*The following are other common species in this habitat cover type. Chip NF: common yellowthroat, eastern wood-pewee †, rose-breasted grosbeak †, scarlet tanager. Sup NF: Canada warbler †‡, northern parula. Cheq NF: rose-breasted grosbeak †, red-breasted nuthatch, ruffed grouse. Nic NF: common raven, common yellowthroat, eastern wood-pewee †, rose-breasted grosbeak †, red-winged blackbird, scarlet tanager.
† Species of conservation concern, Minnesota.
‡ Species of conservation concern, Wisconsin.

Pole-Size Aspen-Spruce-Fir Forest

Upland forest composed of a mix of 10- to 20-yr-old trees of quaking aspen, white or black spruce, balsam fir, and paper birch. Less than 1 percent of all point counts, in only two of the NFs, were located in stands of pole-size aspen-spruce-fir. This habitat characterized 2 percent of Superior (Sup) NF and 1 percent of Nicolet (Nic) NF survey locations.



Mixed quaking aspen-balsam fir forest. Photo by Mel Baughman, formerly with University of Minnesota Extension, used with permission.

Table 19.—Abundance and frequency of the 20 most common bird species in pole-size aspen-spruce-fir forest*

Species	Pooled NF	Sup NF	Nic NF	Frequency
Ovenbird †	21.06	21.64	17.83	82%
Red-eyed vireo	14.90	15.23	13.04	77%
Nashville warbler	14.70	15.31	11.30	75%
White-throated sparrow †	12.98	13.52	10.00	63%
Veery †‡	8.21	8.75	5.22	46%
American robin	7.88	7.89	7.83	49%
Chestnut-sided warbler	7.28	7.42	6.52	41%
Rose-breasted grosbeak †	5.50	4.53	10.87	42%
Blue jay	5.43	4.84	8.70	40%
Hermit thrush	4.77	4.69	5.22	34%
Mourning warbler	3.44	3.36	3.91	24%
Common yellowthroat	2.52	2.58	2.17	19%
Magnolia warbler	2.52	2.73	--	19%
Song sparrow	2.45	2.11	4.35	13%
Black-and-white warbler	2.12	2.27	--	21%
Least flycatcher †‡	2.05	2.27	--	13%
Yellow-bellied flycatcher ‡	2.05	2.42	--	16%
Yellow-rumped warbler	2.05	1.95	2.61	17%
Winter wren †	1.66	1.88	--	16%
American crow	1.52	--	6.52	12%

* The following are other common species found in this habitat cover type. Sup NF: Canada warbler †‡. Nic NF: black-capped chickadee, cedar waxwing, common raven, great crested flycatcher, golden-winged warbler †‡.
† Species of conservation concern, Minnesota.
‡ Species of conservation concern, Wisconsin.

Mid-Successional Aspen-Spruce-Fir Forest

Upland forest composed of mixed 20- to 60-yr-old trees of quaking aspen, white or black spruce, balsam fir, and paper birch. About 2 percent of all point counts across all four NFs were located in mid-successional aspen-spruce-fir stands. This habitat characterized 1 percent of Chippewa (Chip) NF, 4 percent of Superior (Sup) NF, 2 percent of Chequamegon (Cheq) NF, and 3 percent of Nicolet (Nic) NF survey locations.



Mixed aspen-spruce-fir forest in early spring. Photo by Mel Baughman, formerly with University of Minnesota Extension, used with permission.

Table 20.—Abundance and frequency of the 20 most common bird species in mid-successional aspen-spruce-fir forest*

Species	Pooled NF	Chip NF	Sup NF	Cheq NF	Nic NF	Frequency
Ovenbird †	23.16	34.05	24.92	20.25	14.83	83%
Red-eyed vireo	14.20	33.57	13.77	11.44	10.45	71%
Nashville warbler	10.23	2.38	12.51	8.90	6.52	55%
White-throated sparrow †	5.86	--	6.06	7.46	5.51	38%
Blue jay	4.99	1.90	4.39	6.53	6.85	35%
Chestnut-sided warbler	4.91	2.62	5.61	3.39	5.17	29%
Hermit thrush	4.78	3.33	4.72	5.08	5.28	34%
Black-throated green warbler	3.36	9.52	2.96	3.98	--	25%
Veery †‡	3.01	5.00	3.60	1.95	--	21%
American robin	2.97	1.43	2.77	1.95	5.84	25%
Blackburnian warbler	2.97	--	3.46	3.39	--	24%
Rose-breasted grosbeak †	2.82	1.19	2.49	--	7.30	21%
Black-capped chickadee	2.67	0.95	--	3.90	6.18	20%
Yellow-bellied sapsucker †	2.64	7.38	1.84	4.24	--	20%
Least flycatcher †‡	2.39	18.81	--	--	--	13%
Black-and-white warbler	2.27	0.95	2.18	3.22	--	20%
Winter wren †	2.08	--	2.15	2.63	--	19%
Mourning warbler	2.04	--	2.07	-2.54	3.48	17%
Red-breasted nuthatch	1.94	--	1.84	--	--	17%
Red-winged blackbird	1.70	--	--	--	11.24	4%

* The following are other common species found in this habitat type. Chip NF: American crow, chipping sparrow, common raven, common yellowthroat, eastern wood-pewee †,great crested flycatcher. Sup NF: magnolia warbler, Swainson's thrush ‡, yellow-bellied flycatcher ‡.Cheq NF: American crow, common yellowthroat, ruffed grouse, yellow-rumped warbler. Nic NF: American crow, cedar waxwing, common raven, great crested flycatcher, song sparrow, tree swallow.
† Species of conservation concern, Minnesota.
‡ Species of conservation concern, Wisconsin.

Mature Aspen-Spruce-Fir Forest

Upland forest composed of mature (greater than 60 yr old) trees of quaking aspen, white or black spruce, balsam fir, and paper birch. About 5 percent of all point counts across all four NFs were located in aspen-spruce-fir stands. This habitat characterized <1 percent of Chippewa (Chip) NF, 13 percent of Superior (Sup) NF, 2 percent of Chequamegon (Cheq) NF, and 2 percent of Nicolet (Nic) NF survey locations.



Mixed aspen forest. Photo by Mel Baughman, formerly with University of Minnesota Extension, used with permission.

Table 21.—Abundance and frequency of the 20 most common bird species in mature aspen-spruce-fir forest*

Species	Pooled NF	Chip NF	Sup NF	Cheq NF	Nic NF	Frequency
Ovenbird †	19.14	15.60	19.29	19.41	17.72	81%
Red-eyed vireo	12.67	21.20	12.49	14.26	9.62	69%
Nashville warbler	12.28	16.40	12.88	9.04	8.23	64%
White-throated sparrow †	11.16	8.40	12.58	3.46	5.95	61%
Chestnut-sided warbler	5.69	14.80	6.05	1.76	4.68	35%
Blue jay	5.00	4.40	4.72	6.25	6.96	36%
Veery †‡	4.30	2.00	4.91	1.54	--	28%
Hermit thrush	4.04	5.20	3.99	4.19	4.05	30%
Black-throated green warbler	3.95	5.20	3.68	7.21	--	27%
Blackburnian warbler	3.90	--	4.20	2.65	2.91	32%
Winter wren †	3.74	5.60	3.91	3.46	--	33%
American robin	3.15	2.00	3.15	--	6.84	25%
Magnolia warbler	3.11	--	3.68	--	--	23%
Northern parula	3.00	2.00	3.21	2.21	--	25%
Black-and-white warbler	2.99	6.00	3.04	2.13	2.78	26%
Mourning warbler	2.83	4.00	2.99	--	4.56	22%
Canada warbler †‡	2.80	--	3.09	2.28	--	22%
Yellow-bellied sapsucker †	2.69	8.40	2.59	2.87	2.03	23%
Red-breasted nuthatch	2.63	2.00	2.65	2.43	2.91	23%
Rose-breasted grosbeak †	2.30	--	--	2.35	4.43	20%

* The following are other common species in this habitat cover type. Chip NF: black-capped chickadee, common yellowthroat, eastern wood-pewee †, great crested flycatcher. Sup NF: yellow-bellied flycatcher ‡. Cheq NF: black-capped chickadee, common yellowthroat, yellow-rumped warbler. Nic NF: American crow, black-capped chickadee, cedar waxwing, common raven, common yellowthroat, golden-crowned kinglet.
† Species of conservation concern, Minnesota.
‡ Species of conservation concern, Wisconsin.

Mature Beech-Maple-Birch Forest

Upland forest dominated by a mix of mature (greater than 60 yr old) American beech, maple species, and yellow birch species. About 1 percent of all point counts, in only two of the NFs, were located in mature beech-maple-birch stands. This habitat characterized 1 percent of Chequamegon (Cheq) NF and 4 percent of Nicolet (Nic) NF survey locations.



Mixed American beech stand. Photo by Mel Baughman, formerly with University of Minnesota Extension, used with permission.

Table 22.—Abundance and frequency of the 20 most common bird species in mature beech-maple-birch forest*

Species	Pooled NF	Cheq NF	Nic NF	Frequency
Ovenbird †	24.32	28.25	22.63	88%
Red-eyed vireo	22.05	23.33	21.50	92%
Black-throated green warbler	11.05	8.25	12.26	63%
Least flycatcher †‡	5.68	1.23	7.59	28%
Rose-breasted grosbeak †	5.16	4.91	5.26	42%
American robin	3.79	1.58	4.74	29%
Hermit thrush	3.63	2.81	3.98	28%
Blackburnian warbler	3.53	3.68	3.46	26%
Eastern wood-pewee †	3.47	3.86	3.31	29%
American crow	3.26	2.11	3.76	23%
Veery †‡	3.00	5.79	1.80	19%
Common raven	2.32	--	3.01	16%
Scarlet tanager	2.21	3.51	1.65	22%
Blue jay	2.16	3.51	1.58	18%
Black-capped chickadee	2.00	1.75	2.11	16%
Yellow-bellied sapsucker †	1.84	1.58	1.95	18%
Winter wren †	1.47	1.58	1.43	11%
Mourning dove	1.37	--	1.80	12%
Brown creeper	1.26	--	1.58	12%
Wood thrush †‡	1.11	2.11	--	9%

* The following are other common species in this habitat cover type. Cheq NF: black-and-white warbler, mourning warbler. Nic NF: red-winged blackbird.
† Species of conservation concern, Minnesota.
‡ Species of conservation concern, Wisconsin.

Mature Black Spruce-Tamarack Forest

Lowland forest dominated by mature (greater than 60 yr old) black spruce or tamarack, or a mix of these species. About 7 percent of all point counts across the four NFs were located in mature black spruce-tamarack stands. This habitat characterized 14 percent of Chippewa (Chip) NF, 5 percent of Superior (Sup) NF, 3 percent of Chequamegon (Cheq) NF, and 3 percent of Nicolet (Nic) NF survey locations.



Black spruce bog. ©Minnesota Department of Natural Resources.

Table 23.—Abundance and frequency of the 20 most common bird species in mature black spruce-tamarack forest*

Species	Pooled NF	Chip NF	Sup NF	Cheq NF	Nic NF	Frequency
Nashville warbler	21.10	24.65	16.17	17.92	19.45	74%
White-throated sparrow †	17.17	21.81	10.64	11.23	19.17	69%
Hermit thrush	8.82	12.06	3.78	6.69	7.80	52%
Red-eyed vireo	7.05	8.00	3.19	10.17	8.35	43%
Ovenbird †	6.22	5.30	5.42	9.92	8.72	36%
Common yellowthroat	6.10	7.98	1.25	8.94	4.40	38%
Blue jay	5.11	5.89	2.35	6.06	7.98	37%
Yellow-rumped warbler	4.36	5.60	2.14	3.60	4.95	30%
Yellow-bellied flycatcher ‡	4.17	3.09	5.72	5.81	3.03	29%
Winter wren †	3.47	4.18	3.10	--	3.67	29%
American robin	3.00	3.38	1.50	--	6.88	23%
Alder flycatcher	2.89	2.47	1.46	7.20	2.66	20%
Chestnut-sided warbler	2.79	2.90	0.98	5.93	--	20%
Veery †‡	2.46	3.10	--	4.11	--	17%
Golden-crowned kinglet	2.23	2.36	2.62	--	--	16%
Black-capped chickadee	2.09	2.62	--	--	3.21	15%
Song sparrow	1.99	--	--	4.96	5.96	14%
Black-and-white warbler	1.91	2.37	--	2.75	--	17%
Swamp sparrow †	1.91	2.29	--	3.09	--	13%
American crow	1.78	2.03	--	3.47	2.75	14%

* The following are other common species in this habitat cover type. Chip NF: Connecticut warbler †‡§. Sup NF: blue-headed vireo, Blackburnian warbler, Connecticut warbler †‡§, magnolia warbler, ruby-crowned kinglet ‡, Swainson's thrush ‡. Cheq NF: Lincoln's sparrow, palm warbler, yellow-bellied sapsucker †. Nic NF: cedar waxwing, common raven, Lincoln's sparrow, rose-breasted grosbeak †.
† Species of conservation concern, Minnesota.
‡ Species of conservation concern, Wisconsin.
§ Regional Forester Sensitive Species.

Mature Hemlock Forest

Upland forest dominated by mature (greater than 60 yr old) eastern hemlocks. About 2 percent of all point counts, in only two of the NFs, were located in mature hemlock stands. This habitat characterized 6 percent of Chequamegon (Cheq) NF and 5 percent of Nicolet (Nic) NF survey locations.



Eastern hemlock stand. Photo by Mel Baughman, formerly with University of Minnesota Extension, used with permission.

Table 24.—Abundance and frequency of the 20 most common bird species in mature hemlock forest*

Species	Pooled NF	Cheq NF	Nic NF	Frequency
Ovenbird †	23.57	25.50	17.85	83%
Red-eyed vireo	17.18	17.54	16.14	79%
Black-throated green warbler	11.54	10.81	13.67	64%
Blackburnian warbler	5.81	4.58	9.43	39%
Blue jay	5.26	5.59	4.30	36%
Hermit thrush	4.32	3.94	5.44	33%
American robin	4.30	3.85	5.63	32%
Least flycatcher †‡	3.71	3.98	2.91	18%
Nashville warbler	3.60	3.51	3.86	26%
Rose-breasted grosbeak †	3.54	3.19	4.56	27%
Winter wren †	3.33	2.91	4.56	28%
Black-capped chickadee	3.14	3.10	3.23	23%
American crow	2.27	1.84	3.54	18%
Great crested flycatcher	2.27	2.31	2.15	18%
Yellow-bellied sapsucker †	2.27	2.57	--	20%
Red-breasted nuthatch	1.92	1.86	2.09	18%
White-throated sparrow †	1.92	1.84	2.15	14%
Black-and-white warbler	1.90	1.71	2.47	16%
Eastern wood-pewee †	1.50	--	--	13%
Scarlet tanager	1.50	--	--	14%

* The following are other common species in this habitat cover type. Cheq NF: chestnut-sided warbler, veery †‡. Nic NF: brown creeper, common raven, northern parula.
† Species of conservation concern, Minnesota.
‡ Species of conservation concern, Wisconsin.

Pole-Size Jack Pine Forest

Upland forest dominated by 10- to 20-yr-old jack pines. About 1 percent of all point counts across all four NFs were located in stands of pole-size jack pine. This habitat characterized <1 percent of Chippewa (Chip) NF, 2 percent of Superior (Sup) NF, <1 percent of Chequamegon (Cheq) NF, and 1 percent of Nicolet (Nic) NF survey locations.



Young jack pine. Photo by Robert Howe, University of Wisconsin.

Table 25.—Abundance and frequency of the 20 most common bird species in pole-size jack pine forest*

Species	Pooled NF	Chip NF	Sup NF	Cheq NF	Nic NF	Frequency
Nashville warbler	16.53	10.00	17.17	20.30	17.50	75%
White-throated sparrow †	16.49	13.08	21.38	--	11.07	69%
Ovenbird †	13.20	5.64	13.27	22.42	12.50	71%
Chestnut-sided warbler	13.05	18.46	14.15	9.09	3.93	59%
Hermit thrush	7.61	7.18	6.10	13.94	9.29	51%
Red-eyed vireo	7.61	12.82	7.99	--	6.43	47%
Blue jay	6.99	--	6.10	13.94	10.71	45%
American robin	6.49	5.38	4.59	14.55	9.29	42%
Veery †‡	5.64	4.87	7.17	3.03	--	36%
Rose-breasted grosbeak †	4.86	2.56	4.84	9.70	2.50	37%
Yellow-rumped warbler	4.75	--	4.34	7.88	7.50	32%
Chipping sparrow	3.86	5.38	2.08	9.09	5.71	27%
Mourning warbler	3.78	2.56	4.84	2.12	--	27%
Black-and-white warbler	3.13	--	4.28	--	--	29%
American crow	2.59	5.13	--	--	10.00	15%
Magnolia warbler	2.36	--	3.33	--	--	18%
Common yellowthroat	2.01	5.38	--	--	2.14	14%
Common raven	1.97	--	--	5.15	2.86	17%
Alder flycatcher	1.74	--	2.39	--	--	15%
Winter wren †	1.74	--	2.58	--	--	17%

* The following are other common species in this habitat cover type. Chip NF: American redstart, cedar waxwing, eastern wood-pewee †, least flycatcher †‡, red-breasted nuthatch, song sparrow, yellow-bellied sapsucker †. Sup NF: American redstart, least flycatcher †‡, yellow-bellied flycatcher ‡. Cheq NF: black-capped chickadee, brown-headed cowbird, brown thrasher †‡, clay-colored sparrow, eastern towhee, mourning dove, northern flicker, pine warbler. Nic NF: black-capped chickadee, brown-headed cowbird, dark-eyed junco, field sparrow †‡, mourning dove, ruffed grouse.
† Species of conservation concern, Minnesota.
‡ Species of conservation concern, Wisconsin.

Mid-Successional Jack Pine Forest

Upland forest dominated by 20- to 60-yr-old jack pines. About 3 percent of all point counts, in only three of the NFs, were located in mid-successional jack pine stands. This habitat characterized 8 percent of Superior (Sup) NF, 1 percent of Chequamegon (Cheq) NF, and 1 percent of Nicolet (Nic) NF survey locations.



Jack pine stand. ©Minnesota Department of Natural Resources.

Table 26.—Abundance and frequency of the 20 most common bird species in mid-successional jack pine forest*

Species	Pooled NF	Sup NF	Cheq NF	Nic NF	Frequency
Ovenbird †	22.97	23.36	22.47	18.78	86%
Nashville warbler	17.25	18.11	14.81	10.20	76%
White-throated sparrow †	12.45	14.43	1.98	4.08	62%
Red-eyed vireo	9.78	10.76	5.06	4.90	60%
Hermit thrush	9.06	8.91	9.14	10.82	58%
Chestnut-sided warbler	8.66	9.72	4.32	2.24	45%
Blue jay	6.68	6.42	8.89	6.33	47%
American robin	4.67	4.01	9.26	5.71	34%
Veery †‡	3.72	4.23	--	--	27%
Rose-breasted grosbeak †	3.35	3.08	6.05	2.45	27%
Yellow-rumped warbler	3.35	3.60	--	3.67	24%
Chipping sparrow	2.66	2.26	6.79	--	21%
Mourning warbler	2.62	3.03	--	--	20%
Blackburnian warbler	2.42	2.74	--	--	20%
Black-and-white warbler	2.29	2.44	--	--	21%
Common yellowthroat	2.02	2.19	--	1.84	17%
Magnolia warbler	1.85	2.18	--	--	15%
Yellow-bellied flycatcher ‡	1.78	2.03	--	--	15%
Red-breasted nuthatch	1.62	--	--	2.24	15%
Cedar waxwing	1.58	1.59	--	--	10%

* The following are other common species in this habitat cover type. Sup NF: least flycatcher †‡. Cheq NF: American crow, black-capped chickadee, brown-headed cowbird, brown thrasher †‡, clay-colored sparrow, common raven, eastern towhee, mourning dove, pine warbler, yellow-bellied sapsucker †. Nic NF: American crow, American goldfinch, black-and-white warbler, cedar waxwing, common raven, common yellowthroat, mourning dove.
† Species of conservation concern, Minnesota.
‡ Species of conservation concern, Wisconsin.

Mature Jack Pine Forest

Upland forest dominated by jack pines that are greater than 60 yr old. About 3 percent of all point counts across all four NFs were located in mature jack pine stands. This habitat characterized 2 percent of Chippewa (Chip) NF, 4 percent of Superior (Sup) NF, 1 percent of Chequamegon (Cheq) NF, and 2 percent of Nicolet (Nic) NF survey locations.



Jack pine stand. Photo by Edmund Zlonis, Natural Resources Research Institute.

Table 27.—Abundance and frequency of the 20 most common bird species in mature jack pine forest*

Species	Pooled NF	Chip NF	Sup NF	Cheq NF	Nic NF	Frequency
Ovenbird †	21.23	12.97	25.96	16.07	21.35	81%
Nashville warbler	12.58	5.61	17.23	6.18	11.73	63%
Red-eyed vireo	10.20	16.49	9.38	5.84	5.38	61%
White-throated sparrow †	8.97	5.47	11.50	6.97	5.19	52%
Chestnut-sided warbler	7.06	11.55	5.28	9.78	--	40%
Hermit thrush	6.58	5.88	6.72	4.49	11.15	45%
Blue jay	5.10	4.39	5.37	5.28	5.00	36%
Blackburnian warbler	4.40	3.58	6.05	--	--	34%
American robin	4.03	4.46	2.63	6.97	7.31	29%
Chipping sparrow	3.47	5.14	2.51	4.61	3.27	25%
Red-breasted nuthatch	3.23	3.65	3.19	2.70	3.27	27%
Mourning warbler	2.89	4.86	1.92	4.94	--	20%
Eastern wood-pewee †	2.60	6.22	--	4.49	--	21%
Yellow-rumped warbler	2.57	--	2.88	--	5.19	19%
Least flycatcher †‡	2.53	6.49	--	--	--	15%
Black-capped chickadee	2.47	3.31	1.98	--	5.19	18%
Magnolia warbler	2.47	--	3.53	--	3.08	16%
Winter wren †	2.27	--	3.56	--	--	20%
Rose-breasted grosbeak †	2.22	--	--	5.73	3.46	17%
Veery †‡	1.98	3.24	--	2.81	--	15%

* The following are other common species in this habitat cover type. Chip NF: American redstart, common raven, common yellowthroat, pine warbler. Sup NF: brown creeper, golden-crowned kinglet, yellow-bellied flycatcher ‡, yellow-bellied sapsucker †. Cheq NF: American crow, brown-headed cowbird, common yellowthroat, eastern towhee, pine warbler, song sparrow. Nic NF: American crow, black-and-white warbler, blue-headed vireo, cedar waxwing, common raven, mourning dove.
† Species of conservation concern, Minnesota.
‡ Species of conservation concern, Wisconsin.

Mature Lowland Hardwood Forest

Lowland forest dominated by mature (greater than 60 yr old) trees of black ash, American elm, or red maple, or a mix of these species. About 3 percent of all point counts across all four NFs were located in mature lowland hardwood stands. This habitat characterized 5 percent of Chippewa (Chip) NF, 1 percent of Superior (Sup) NF, 5 percent of Chequamegon (Cheq) NF, and 2 percent of Nicolet (Nic) NF survey locations.



Black ash swamp. ©Minnesota Department of Natural Resources.

Table 28.—Abundance and frequency of the 20 most common bird species in mature lowland hardwood forest*

Species	Pooled NF	Chip NF	Sup NF	Cheq NF	Nic NF	Frequency
Ovenbird †	17.38	20.64	18.77	13.86	18.18	71%
Red-eyed vireo	16.35	22.40	11.93	12.95	13.90	75%
White-throated sparrow †	8.92	12.72	13.86	5.00	4.16	51%
Veery †‡	8.16	12.56	7.81	5.45	3.25	47%
Nashville warbler	5.85	4.04	10.09	6.14	5.58	38%
Blue jay	4.90	3.72	4.56	5.94	5.45	35%
Chestnut-sided warbler	4.56	4.46	15.00	--	--	26%
Northern waterthrush	4.51	2.53	--	7.95	3.51	27%
Common yellowthroat	4.13	5.77	1.84	4.23	--	30%
Least flycatcher †‡	3.98	8.11	1.58	--	3.12	19%
Black-throated green warbler	3.39	2.85	--	4.26	5.58	26%
Hermit thrush	3.35	2.69	6.05	2.64	5.19	24%
Winter wren †	3.31	3.59	--	3.47	5.32	28%
American robin	3.24	2.37	3.51	3.61	4.68	26%
Black-and-white warbler	3.12	3.21	2.98	3.10	3.12	27%
Yellow-bellied sapsucker †	3.04	4.46	1.93	2.13	3.12	24%
Black-capped chickadee	2.67	--	2.11	3.49	4.03	19%
Rose-breasted grosbeak †	2.63	2.24	--	3.18	4.16	22%
Mourning warbler	2.32	4.52	2.28	--	--	17%
Great crested flycatcher	1.96	--	--	3.35	--	17%

* The following are other common species in this habitat cover type. Chip NF: brown creeper, song sparrow. Sup NF: Blackburnian warbler, cedar waxwing, song sparrow, yellow-rumped warbler. Cheq NF: American crow, ruffed grouse, yellow-bellied flycatcher ‡. Nic NF: brown creeper, eastern wood-pewee †, common raven.
† Species of conservation concern, Minnesota.
‡ Species of conservation concern, Wisconsin.

Lowland Shrub Habitat

Lowland (often riparian) area dominated by alder species. About 2 percent of all point counts, in only two of the NFs, were located in lowland shrub habitat. This habitat characterized 2 percent of Chequamegon (Cheq) NF and 7 percent of Nicolet (Nic) NF survey locations.



Alder thicket. ©Minnesota Department of Natural Resources.

Table 29.—Abundance and frequency of the 20 most common bird species in lowland shrub habitat*

Species	Pooled NF	Cheq NF	Nic NF	Frequency
White-throated sparrow †	13.94	15.28	13.04	72%
Nashville warbler	12.92	18.01	9.50	62%
Alder flycatcher	12.69	17.14	9.71	63%
Red-winged blackbird	12.12	--	19.13	28%
Common yellowthroat	11.67	10.81	12.25	70%
Blue jay	7.96	8.70	7.46	52%
Veery †‡	7.68	10.50	5.79	47%
Chestnut-sided warbler	6.53	9.88	4.29	41%
Swamp sparrow †	6.41	5.03	7.33	42%
Red-eyed vireo	6.36	7.89	5.33	41%
American robin	5.69	3.23	7.33	40%
Cedar waxwing	5.69	--	8.42	21%
Song sparrow	5.36	--	7.25	39%
Rose-breasted grosbeak †	4.96	5.47	4.63	39%
Ovenbird †	4.61	4.97	4.38	32%
American crow	3.99	3.91	4.04	27%
Black-capped chickadee	3.94	4.53	--	28%
Black-and-white warbler	3.87	4.16	3.67	34%
Tree swallow	3.84	--	6.00	19%
American goldfinch	3.49	3.11	3.75	23%

* The following are other common species in this habitat cover type. Cheq NF: golden-winged warbler †‡, sedge wren †, yellow-bellied flycatcher ‡, yellow-rumped warbler. Nic NF: yellow warbler.
† Species of conservation concern, Minnesota.
‡ Species of conservation concern, Wisconsin.

Mature Oak Forest

Upland forest dominated by >60-yr-old trees of oak species. About 3 percent of all point counts, in three NFs, were located in mature oak stands. This habitat characterized 3 percent of Chippewa (Chip) NF, 6 percent of Chequamegon (Cheq) NF, and 3 percent of Nicolet (Nic) NF survey locations.



Northern red oak stand. ©Minnesota Department of Natural Resources.

Table 30.—Abundance and frequency of the 20 most common bird species in mature oak forest*

Species	Pooled NF	Chip NF	Cheq NF	Nic NF	Frequency
Red-eyed vireo	24.33	31.70	22.52	18.57	85%
Ovenbird †	20.63	18.57	22.47	16.43	78%
Least flycatcher †‡	11.06	12.03	10.47	11.84	43%
Eastern wood-pewee †	5.39	3.96	5.17	8.98	45%
American crow	5.19	7.58	4.76	2.65	33%
Veery †‡	5.13	12.91	2.14	3.78	29%
Chestnut-sided warbler	4.75	8.74	3.89	--	26%
American redstart	4.68	15.38	1.12	--	21%
American robin	3.81	2.69	4.43	3.16	26%
Black-throated green warbler	3.46	--	4.15	5.92	26%
Rose-breasted grosbeak †	3.27	1.81	3.78	3.78	25%
Yellow-bellied sapsucker †	3.19	2.80	3.64	1.94	25%
Hermit thrush	2.98	--	3.47	4.80	25%
Scarlet tanager	2.68	2.86	2.63	2.55	23%
Blue jay	2.60	--	3.10	3.37	20%
Nashville warbler	1.54	--	2.07	--	11%
Black-capped chickadee	1.40	2.14	--	1.94	11%
White-breasted nuthatch	1.10	2.09	--	1.43	10%
Common raven	1.09	--	1.14	1.53	10%
Clay-colored sparrow	1.04	--	1.72	--	6%

* The following are other common species in this habitat cover type. Chip NF: American goldfinch, black-and-white warbler, common yellowthroat, mourning warbler, yellow warbler. Cheq NF: eastern towhee. Nic NF: black-throated blue warbler †‡, great crested flycatcher, mourning dove, pine warbler.
† Species of conservation concern, Minnesota.
‡ Species of conservation concern, Wisconsin.

Open Dry Habitat

Upland areas that have been recently logged or that are managed as upland brush habitat. About 2 percent of all point counts, in only two NFs, were located in open dry habitat. This habitat characterized 6 percent of Chequamegon (Cheq) NF and 5 percent of Nicolet (Nic) NF survey locations.



Upland aspen forest clearcut. Photo by Mel Baughman, formerly with University of Minnesota Extension, used with permission.

Table 31.—Abundance and frequency of the 20 most common bird species in open dry habitat*

Species	Pooled NF	Cheq NF	Nic NF	Frequency
Clay-colored sparrow	13.29	18.33	--	56%
Eastern towhee	8.20	11.00	--	45%
Brewer's blackbird	8.10	11.74	--	18%
Chestnut-sided warbler	7.77	8.11	8.05	49%
American robin	7.47	6.59	10.75	46%
Brown thrasher †‡	7.05	9.58	--	43%
Song sparrow	6.99	6.14	10.13	47%
Tree swallow	6.75	5.70	10.38	29%
Vesper sparrow ‡	5.55	7.94	--	31%
Common yellowthroat	5.45	7.11	--	38%
Ovenbird †	5.26	--	14.21	32%
Alder flycatcher	5.00	6.87	10.38	33%
Blue jay	4.97	3.11	--	35%
Red-eyed vireo	4.79	--	12.26	32%
American crow	4.02	3.66	5.53	26%
Rose-breasted grosbeak †	3.94	2.74	7.55	32%
Nashville warbler	3.63	--	7.86	23%
Chipping sparrow	3.58	--	10.06	24%
Common raven	3.53	3.71	--	20%
Red-winged blackbird	3.29	4.10	--	15%

* The following are other common species found in this habitat cover type. Cheq NF: eastern kingbird, hermit thrush, veery †‡, yellow warbler. Nic NF: American goldfinch, black-capped chickadee, brown-headed cowbird, cedar waxwing, hermit thrush, indigo bunting, mourning warbler, white-throated sparrow †.
† Species of conservation concern, Minnesota.
‡ Species of conservation concern, Wisconsin.

Open Wet Habitat

Marshes, wet meadows, open bogs, and seasonally inundated floodplains that are mostly treeless. Less than 1 percent of all point counts were located in open wet habitat, which was sampled only in the Nicolet (Nic) NF. This habitat characterized 2.7 percent of Nic NF survey locations.



Emergent wetland. Photo by Robert Howe, University of Wisconsin.

Table 32.—Abundance and frequency of the 20 most common bird species in open wet habitat*

Species	Nic NF	Frequency
Red-winged blackbird	14.95	36%
Nashville warbler	13.30	77%
White-throated sparrow †	11.65	64%
Ovenbird †	10.29	69%
Song sparrow	9.42	54%
Common yellowthroat	8.64	53%
Cedar waxwing	8.16	32%
Blue jay	7.86	49%
Red-eyed vireo	7.57	54%
American robin	7.18	50%
American crow	6.12	32%
Rose-breasted grosbeak †	4.95	36%
Swamp sparrow †	4.95	31%
Hermit thrush	4.56	38%
Black-and-white warbler	4.37	34%
Tree swallow	3.69	20%
Common raven	3.50	21%
Common loon †‡	3.20	17%
Black-capped chickadee	3.01	24%
Winter wren †	3.01	18%

† Species of conservation concern, Minnesota.
‡ Species of conservation concern, Wisconsin.

Pole-Size Red Pine Forest

Upland forest dominated by 10- to 20-yr- old red pines. About 1 percent of all point counts across all four NFs were located in stands of pole-size red pines. This habitat characterized 2 percent of Chippewa (Chip) NF, 1 percent of Superior (Sup) NF, 1 percent of Chequamegon (Cheq) NF, and 1 percent of Nicolet (Nic) NF survey locations.



Young red pine stand. Photo by Joseph O'Brien, U.S. Forest Service, Bugwood.org.

Table 33.—Abundance and frequency of the 20 most common bird species in pole-size red pine forest*

Species	Pooled NF	Chip NF	Sup NF	Cheq NF	Nic NF	Frequency
Chestnut-sided warbler	14.01	27.75	8.16	4.00	3.82	57%
Red-eyed vireo	13.73	24.61	9.51	3.78	7.06	59%
Ovenbird †	10.56	7.45	14.95	11.33	5.59	53%
Nashville warbler	10.21	2.45	19.22	5.78	12.06	52%
White-throated sparrow †	8.45	--	18.83	2.44	7.65	40%
Veery †‡	7.64	14.31	6.80	--	--	41%
American robin	6.44	3.24	10.10	3.78	8.53	43%
Hermit thrush	5.04	2.65	5.83	7.11	7.06	33%
Chipping sparrow	4.58	5.49	--	2.67	11.47	32%
Blue jay	4.44	4.22	4.37	3.11	7.06	35%
American redstart	3.91	9.71	--	--	--	23%
Common yellowthroat	3.52	6.67	2.52	--	--	25%
Rose-breasted grosbeak †	3.49	4.71	2.91	1.33	4.41	27%
Yellow-rumped warbler	3.45	--	5.53	3.78	2.35	24%
American crow	3.42	4.90	--	2.22	7.65	23%
Magnolia warbler	3.17	--	7.86	--	--	20%
Alder flycatcher	3.10	--	7.28	--	--	19%
Mourning warbler	2.89	--	5.15	--	--	21%
Black-capped chickadee	2.64	4.02	--	0.89	4.12	18%
Song sparrow	2.36	--	2.82	--	7.06	16%

* The following are other common species in this habitat cover type. Chip NF: American goldfinch, cedar waxwing, common raven, golden-winged warbler †‡, red-breasted nuthatch. Sup NF: black-and-white warbler, black-throated green warbler, Swainson's thrush ‡, winter wren †. Cheq NF: black-billed cuckoo †‡, brown-headed cowbird, brown thrasher †‡, common raven, pine warbler, red-breasted nuthatch, ruffed grouse. Nic NF: American goldfinch, brown-headed cowbird, cedar waxwing, common raven, indigo bunting, mourning dove.
† Species of conservation concern, Minnesota.
‡ Species of conservation concern, Wisconsin.

Mid-Successional Red Pine Forest

Upland forest dominated by 20- to 60-yr-old red pines. About 3 percent of all point counts across all four NFs were located in mid-successional red pine stands. This habitat characterized 1 percent of Chippewa (Chip) NF, 2 percent of Superior (Sup) NF, 7 percent of Chequamegon (Cheq) NF, and 3 percent of Nicolet (Nic) NF survey locations.



Red pine stand. Photo by Mel Baughman, formerly with University of Minnesota Extension, used with permission.

Table 34.—Abundance and frequency of the 20 most common bird species in mid-successional red pine forest*

Species	Pooled NF	Chip NF	Sup NF	Cheq NF	Nic NF	Frequency
Ovenbird †	25.23	30.24	26.37	25.48	20.51	83%
Red-eyed vireo	10.74	20.95	13.26	9.75	7.35	55%
Nashville warbler	10.25	4.05	17.37	8.35	9.32	53%
Hermit thrush	7.37	3.81	5.84	8.10	7.95	46%
American robin	6.17	--	4.95	7.07	6.15	40%
Chestnut-sided warbler	6.12	11.19	8.74	5.28	3.76	34%
Blue jay	6.08	5.48	4.53	6.33	7.69	41%
Rose-breasted grosbeak †	4.65	2.38	2.37	5.94	3.50	34%
White-throated sparrow †	4.48	--	10.32	2.64	4.62	26%
Chipping sparrow	3.53	2.62	2.26	3.83	4.62	27%
Yellow-rumped warbler	3.01	2.86	2.47	2.78	4.96	22%
American crow	2.81	2.62	--	3.22	4.44	21%
Least flycatcher †‡	2.79	6.67	--	2.80	3.08	14%
Mourning warbler	2.40	--	3.37	--	3.50	20%
Black-capped chickadee	2.38	1.90	2.05	1.96	4.96	18%
Eastern wood-pewee †	2.37	4.29	--	2.80	3.25	19%
Veery †‡	2.34	5.71	3.68	2.00	--	16%
Black-throated green warbler	2.23	--	2.32	2.25	--	17%
Pine warbler	2.07	5.71	--	2.41	--	15%
Red-breasted nuthatch	2.06	--	2.74	--	2.31	18%

* The following are other common species found in this habitat cover type. Chip NF: American redstart, Blackburnian warbler, common raven, scarlet tanager, yellow-bellied sapsucker †. Sup NF: black-and-white warbler, Blackburnian warbler, cedar waxwing, magnolia warbler. Cheq NF: brown-headed cowbird, common raven. Nic NF: cedar waxwing, common raven, mourning dove.
† Species of conservation concern, Minnesota.
‡ Species of conservation concern, Wisconsin.

Mature Red Pine Forest

Upland forest dominated by mature (greater than 60 yr old) red pines. About 9 percent of all point counts across all four NFs were located in mature red pine stands. This habitat characterized 22 percent of Chippewa (Chip) NF, 4 percent of Superior (Sup) NF, 6 percent of Chequamegon (Cheq) NF, and 2 percent of Nicolet (Nic) NF survey locations.



Red pine stand. ©Minnesota Department of Natural Resources.

Table 35.—Abundance and frequency of the 20 most common bird species in mature red pine forest*

Species	Pooled NF	Chip NF	Sup NF	Cheq NF	Nic NF	Frequency
Ovenbird †	26.15	25.42	22.78	31.41	26.75	88%
Red-eyed vireo	17.79	20.78	14.89	11.46	11.45	78%
Least flycatcher †‡	9.37	10.95	10.31	4.44	3.25	38%
Chestnut-sided warbler	7.20	6.54	7.84	8.78	7.59	35%
Pine warbler	6.27	7.55	3.69	4.54	4.46	42%
Nashville warbler	5.73	4.24	12.13	5.46	4.46	35%
Blue jay	5.25	4.13	6.39	7.59	7.59	36%
Eastern wood-pewee †	4.99	5.51	3.66	4.91	2.41	40%
Hermit thrush	4.90	5.18	4.40	4.17	5.90	35%
American robin	4.58	4.28	3.44	6.18	6.63	31%
Red-breasted nuthatch	4.08	4.25	3.44	3.57	6.39	33%
Chipping sparrow	3.86	4.82	--	2.66	3.25	27%
Veery †‡	3.85	4.24	3.84	3.20	--	25%
Black-throated green warbler	3.74	4.43	--	3.13	2.41	27%
White-throated sparrow †	3.61	2.06	8.21	4.96	3.25	24%
Blackburnian warbler	3.46	3.50	4.72	2.56	--	28%
American redstart	3.07	4.27	--	--	--	16%
American crow	2.63	2.54	--	3.65	5.66	20%
Black-capped chickadee	2.48	2.61	--	--	4.34	18%
Rose-breasted grosbeak †	2.43	--	2.19	6.03	3.37	19%

* The following are other common species in this habitat cover type. Chip NF: yellow-rumped warbler. Sup NF: blue-headed vireo, brown creeper, magnolia warbler, mourning warbler, winter wren †. Cheq NF: eastern towhee, mourning warbler. Nic NF: American goldfinch, common raven, indigo bunting.
† Species of conservation concern, Minnesota.
‡ Species of conservation concern, Wisconsin.

Regenerating Conifer Forest

Young (less than 10 yr old) upland conifer forest regenerating from disturbance, usually logging. About 3 percent of all surveys across all four NFs were located in stands of regenerating conifers. This habitat characterized 5 percent of Chippewa (Chip) NF, 5 percent of Superior (Sup) NF, 1 percent of Chequamegon (Cheq) NF, and 1 percent of Nicolet (Nic) NF survey locations.



Young red pine plantation. Photo by Mel Baughman, formerly with University of Minnesota Extension, used with permission.

Table 36.—Abundance and frequency of the 20 most common bird species in regenerating conifer forest*

Species	Pooled NF	Chip NF	Sup NF	Cheq NF	Nic NF	Frequency
Chestnut-sided warbler	22.09	23.36	24.49	15.52	7.38	76%
White-throated sparrow †	20.12	8.61	33.34	11.52	12.62	65%
Red-eyed vireo	13.08	14.72	13.98	7.90	5.24	67%
Ovenbird †	10.13	6.42	10.80	19.05	10.48	55%
Mourning warbler	9.05	6.88	12.41	6.38	--	52%
Song sparrow	8.30	10.68	7.30	4.38	8.57	46%
Nashville warbler	7.70	4.17	11.26	5.33	9.29	42%
American robin	7.08	7.35	5.48	11.71	7.62	45%
Common yellowthroat	6.70	10.74	4.89	--	4.29	41%
Veery †‡	6.11	5.43	8.24	--	--	38%
Blue jay	5.81	5.93	5.08	7.05	8.33	40%
Chipping sparrow	5.28	9.17	--	5.14	8.10	36%
Rose-breasted grosbeak †	4.05	3.15	3.93	7.43	3.57	32%
Hermit thrush	3.94	4.60	3.24	3.24	6.90	29%
Least flycatcher †‡	3.42	4.81	2.65	3.14	--	20%
American crow	2.85	--	--	3.52	8.10	21%
Cedar waxwing	2.77	3.18	2.73	--	--	15%
Indigo bunting	2.69	4.20	--	4.67	4.52	17%
Alder flycatcher	2.59	--	3.85	--	4.05	18%
American redstart	2.33	4.17	--	--	--	15%

* The following are other common species in this habitat cover type. Chip NF: eastern wood-pewee †. Sup NF: black-and-white warbler, common raven, magnolia warbler, winter wren †. Cheq NF: eastern towhee, eastern wood-pewee †, golden-winged warbler †‡, pine warbler, red-breasted nuthatch. Nic NF: American goldfinch, black-capped chickadee, common raven, red-winged blackbird, tree swallow.

† Species of conservation concern, Minnesota.

‡ Species of conservation concern, Wisconsin.

Regenerating Nonconifer Forest

Young (less than 10 yr old) upland deciduous forest regenerating from disturbance, usually logging. About 3 percent of all point counts across all four NFs were located in stands of regenerating nonconifers. This habitat characterized 5 percent of Chippewa (Chip) NF, 3 percent of Superior (Sup) NF, 2 percent of Chequamegon (Cheq), and 2 percent of Nicolet (Nic) NF survey locations.



Regenerating aspen forest. Photo by Robert Howe, University of Wisconsin.

Table 37.—Abundance and frequency of the 20 most common bird species in regenerating nonconifer forest*

Species	Pooled NF	Chip NF	Sup NF	Cheq NF	Nic NF	Frequency
Chestnut-sided warbler	18.21	17.83	20.60	17.36	14.93	74%
Red-eyed vireo	15.63	19.48	11.44	16.09	9.59	75%
Ovenbird †	12.48	11.44	11.67	17.82	6.85	62%
White-throated sparrow †	10.95	4.25	19.30	13.10	11.23	50%
Veery †‡	10.39	15.96	3.56	4.25	9.21	53%
Mourning warbler	6.35	4.86	9.21	5.46	6.71	40%
Nashville warbler	5.77	3.61	9.26	5.98	4.66	36%
Rose-breasted grosbeak †	5.31	4.56	3.35	7.59	9.04	38%
Blue jay	5.21	3.85	5.67	6.49	6.85	38%
American redstart	5.04	8.01	3.30	3.56	--	32%
American robin	4.44	3.39	4.74	5.46	5.75	33%
Least flycatcher †‡	3.70	4.59	1.77	5.46	--	20%
Common yellowthroat	3.61	4.34	--	4.66	3.97	26%
American crow	3.02	2.57	--	5.11	5.07	21%
Song sparrow	2.85	2.45	2.09	3.91	4.38	20%
Yellow-bellied sapsucker †	2.76	2.94	--	4.66	--	22%
Black-and-white warbler	2.70	2.81	3.40	--	--	23%
Hermit thrush	2.62	--	2.00	3.51	4.52	20%
Alder flycatcher	2.45	--	4.23	3.68	2.88	17%
Black-capped chickadee	2.31	--	--	3.45	--	16%

* The following are other common species in this habitat cover type. Chip NF: American goldfinch, golden-winged warbler †‡, scarlet tanager. Sup NF: Canada warbler †‡, magnolia warbler, red-breasted nuthatch, winter wren †.Cheq NF: black-throated green warbler. Nic NF: American goldfinch, cedar waxwing, golden-winged warbler †‡, indigo bunting, red-winged blackbird.
† Species of conservation concern, Minnesota.
‡ Species of conservation concern, Wisconsin.

Sedge Habitat

Lowland areas dominated by sedges and grasses. Less than 1 percent of all point counts were located in sedge habitat, which was surveyed in only two of the NFs. This habitat characterized 1 percent of Chequamegon (Cheq) NF and 1 percent of Nicolet (Nic) NF survey locations.



Sedge meadow. ©Minnesota Department of Natural Resources.

Table 38.—Abundance and frequency of the 20 most common bird species in sedge habitat*

Species	Pooled NF	Cheq NF	Nic NF	Frequency
Alder flycatcher	9.56	10.31	7.75	53%
White-throated sparrow †	9.49	7.40	14.50	60%
Common yellowthroat	9.04	8.23	11.00	55%
Nashville warbler	7.79	7.60	8.25	51%
Song sparrow	7.06	5.63	10.50	52%
Savannah sparrow	6.84	9.69	--	25%
Red-eyed vireo	6.54	5.63	8.75	39%
Blue jay	6.25	6.04	6.75	43%
Sedge wren †	5.59	7.50	0.00	34%
Chestnut-sided warbler	5.22	5.73	4.00	37%
Ovenbird †	5.15	4.17	7.50	35%
Red-winged blackbird	4.04	--	12.75	15%
Cedar waxwing	3.75	1.77	8.50	13%
Swamp sparrow †	3.75	2.19	7.50	26%
Rose-breasted grosbeak †	3.60	2.71	5.75	30%
Veery †‡	3.38	3.85	--	25%
American crow	3.09	2.50	4.50	21%
Hermit thrush	2.94	1.98	5.25	24%
American robin	2.65	1.98	4.25	24%
American goldfinch	2.13	1.67	--	17%

* The following are other common species in this habitat cover type. Cheq NF: black-and-white warbler. Nic NF: black-capped chickadee, common loon †‡, Lincoln's sparrow, mallard.
† Species of conservation concern, Minnesota.
‡ Species of conservation concern, Wisconsin.

Mature Swamp Conifer Forest

Lowland forest dominated by mature (greater than 60 yr old) northern white-cedar, balsam fir, or black spruce, or a mix of these species. About 8 percent of all point counts across all four NFs were located in mature swamp conifer stands. This habitat characterized 8 percent of Chippewa (Chip) NF, 7 percent of Superior (Sup) NF, 9 percent of Chequamegon (Cheq) NF, and 6 percent of Nicolet (Nic) NF survey locations.



Northern white cedar swamp. ©Minnesota Department of Natural Resources.

Table 39.—Abundance and frequency of the 20 most common bird species in mature swamp conifer forest*

Species	Pooled NF	Chip NF	Sup NF	Cheq NF	Nic NF	Frequency
Nashville warbler	12.38	17.19	10.83	9.55	14.06	63%
Ovenbird †	11.00	9.24	12.13	12.51	7.39	56%
White-throated sparrow †	9.50	14.64	10.29	5.24	8.02	50%
Red-eyed vireo	9.08	9.43	8.74	10.19	5.85	54%
Blue jay	5.73	7.64	2.76	6.60	7.10	39%
Winter wren †	5.69	6.61	6.17	4.57	5.56	47%
Black-throated green warbler	5.56	3.02	7.09	6.81	3.38	38%
Yellow-bellied flycatcher ‡	4.92	2.83	6.17	5.35	4.98	35%
Hermit thrush	4.77	7.37	--	5.14	6.47	34%
American robin	4.31	4.68	4.54	3.31	5.85	33%
Northern parula	3.42	4.02	3.01	3.55	2.80	29%
Black-capped chickadee	3.08	3.57	--	3.79	4.20	22%
Common yellowthroat	3.04	7.49	--	2.04	--	18%
Black-and-white warbler	2.94	3.70	2.55	2.59	3.33	26%
Veery †‡	2.23	2.53	3.21	--	2.08	16%
Red-breasted nuthatch	2.21	2.14	2.11	2.06	3.14	19%
American crow	2.14	3.12	--	2.41	4.01	17%
Blackburnian warbler	2.14	--	2.59	2.59	--	18%
Yellow-rumped warbler	2.00	--	--	2.38	3.09	16%
Rose-breasted grosbeak †	1.99	2.42	--	--	3.04	17%

* The following are other common species in this habitat cover type. Chip NF: alder flycatcher, swamp sparrow †. Sup NF: American redstart, Canada warbler †‡, chestnut-sided warbler, golden-crowned kinglet, magnolia warbler, Swainson's thrush ‡. Cheq NF: alder flycatcher, yellow-bellied sapsucker †. Nic NF: common raven, golden-crowned kinglet.
† Species of conservation concern, Minnesota.
‡ Species of conservation concern, Wisconsin.

Urban Habitat

Sampled at point counts in small towns (population <1,500), usually at the post office or other prominent location. A variety of habitats were located near these points, including open lawns, hedgerows, gardens, agricultural fields, patchy woodlands, and wetlands. Less than 1 percent of all point counts were located in urban habitats, which were sampled only in the Nicolet (Nic) NF. This habitat characterized 1.8 percent of Nic NF survey locations.



Urban point count. ©Copyright 2012 Google™.

Table 40.—Abundance and frequency of the 20 most common bird species in urban habitat

Species	Nic NF	Frequency
American robin	31.57	94%
European starling	23.43	63%
Cedar waxwing	17.00	41%
American crow	16.86	63%
Common grackle	16.14	56%
Chipping sparrow	15.71	83%
American goldfinch	14.57	56%
Mourning dove	13.00	67%
Tree swallow	10.57	47%
Chimney swift	8.86	34%
Song sparrow	8.57	57%
Evening grosbeak‡	8.29	9%
Red-eyed vireo	8.14	50%
House sparrow	7.29	31%
Cliff swallow	6.29	17%
Black-capped chickadee	6.00	41%
House wren	6.00	40%
Red-winged blackbird	6.00	23%
House finch	3.71	24%
Baltimore oriole	3.43	31%

‡ Species of conservation concern, Wisconsin.

Mid-Successional Upland Hardwood Forest

Upland forest dominated by 20- to 60-yr-old sugar maple or American basswood, or a mix of these species. About 1 percent of all point counts in three NFs were located in mid-successional upland hardwood stands. This habitat characterized 2 percent of Chippewa (Chip) NF, 1 percent of Chequamegon (Cheq) NF, and 2 percent of Nicolet (Nic) NF survey locations.



Upland hardwood forest. Photo by Mel Baughman, formerly with University of Minnesota Extension, used with permission.

Table 41.—Abundance and frequency of the 20 most common bird species in mid-succesional upland hardwood forest*

Species	Pooled NF	Chip NF	Cheq NF	Nic NF	Frequency
Ovenbird †	28.86	29.33	30.45	26.08	89%
Red-eyed vireo	23.43	30.96	16.82	17.57	83%
Black-throated green warbler	7.91	7.93	7.61	8.24	53%
Veery †‡	6.53	10.52	3.07	3.38	39%
Least flycatcher †‡	5.82	10.22	--	3.65	27%
Hermit thrush	5.42	4.22	6.48	6.35	35%
American crow	4.01	3.19	5.45	3.78	30%
Nashville warbler	3.33	3.78	4.32	--	22%
Blue jay	3.06	2.30	3.07	4.46	25%
Yellow-bellied sapsucker †	3.06	3.48	3.07	2.30	23%
American robin	2.69	1.70	2.61	4.59	20%
Rose-breasted grosbeak †	2.53	--	1.93	5.54	21%
Scarlet tanager	2.53	2.00	2.39	3.65	22%
Common yellowthroat	2.29	4.74	--	--	16%
Eastern wood-pewee †	2.26	1.93	1.93	3.24	18%
Wood thrush †‡	2.09	2.30	2.73	--	14%
Black-capped chickadee	1.89	--	2.39	2.70	15%
White-throated sparrow †	1.89	1.78	2.16	--	13%
American redstart	1.41	2.81	--	--	9%
Black-and-white warbler	1.41	2.00	--	--	13%

* The following are other common species in this habitat cover type. Chip NF: chestnut-sided warbler, winter wren †. Cheq NF: great crested flycatcher, mourning dove, ruffed grouse. Nic NF: brown creeper, black-throated blue warbler †‡, common raven, chestnut-sided warbler, great crested flycatcher, mourning warbler.
† Species of conservation concern, Minnesota.
‡ Species of conservation concern, Wisconsin.

Mature Upland Hardwood Forest

Upland forest dominated by mature (greater than 60 yr old) trees of sugar maple or American basswood, or a mix of these species. About 14 percent of all point counts across all four NFs were located in stands of mature upland hardwoods. This habitat characterized 10 percent of Chippewa (Chip) NF, 2 percent of Superior (Sup) NF, 27 percent of Chequamegon (Cheq) NF, and 21 percent of Nicolet (Nic) NF survey locations.



Mixed maple stand. ©Minnesota Department of Natural Resources.

Table 42.—Abundance and frequency of the 20 most common bird species in mature upland hardwood forest*

Species	Pooled NF	Chip NF	Sup NF	Cheq NF	Nic NF	Frequency
Ovenbird †	29.44	30.13	25.90	30.91	25.93	87%
Red-eyed vireo	22.82	29.75	17.44	22.12	20.33	85%
Black-throated green warbler	8.37	4.49	8.36	8.34	11.73	54%
Least flycatcher †‡	6.72	11.36	7.85	4.98	7.17	30%
Hermit thrush	3.96	3.06	2.15	4.25	4.42	29%
Yellow-bellied sapsucker †	3.62	4.30	2.72	3.70	3.06	29%
Blue jay	3.21	1.90	--	3.77	3.34	24%
Rose-breasted grosbeak †	3.15	--	1.85	3.06	5.51	25%
American robin	3.08	1.74	4.41	3.05	3.91	24%
Veery †‡	3.05	6.92	5.44	1.95	2.12	21%
American crow	3.04	5.17	--	2.82	2.53	22%
Eastern wood-pewee †	3.03	3.15	2.05	2.79	3.85	26%
Chestnut-sided warbler	2.07	4.47	3.64	1.34	1.59	13%
Scarlet tanager	1.85	2.00	--	1.98	1.80	17%
Nashville warbler	1.82	1.79	4.10	1.69	1.55	14%
Black-capped chickadee	1.68	--	1.69	1.93	1.52	13%
American redstart	1.63	6.03	3.23	--	--	9%
Blackburnian warbler	1.42	1.27	--	1.56	--	12%
White-throated sparrow †	1.30	--	4.97	1.12	--	10%
Common raven	1.25	--	--	--	2.78	9%

* The following are other common species in this habitat cover type. Chip NF: black-and-white warbler, common yellowthroat, white-breasted nuthatch. Sup NF: black-and-white warbler, Canada warbler †‡, magnolia warbler, red-breasted nuthatch, winter wren †. Cheq NF: great crested flycatcher, wood thrush †‡. Nic NF: mourning warbler, red-winged blackbird.
† Species of conservation concern, Minnesota.
‡ Species of conservation concern, Wisconsin.

Mature White Pine Forest

Upland forest dominated by mature (greater than 60 yr old) eastern white pines. About 2 percent of all point counts across all four NFs were located in mature white pine stands. This habitat characterized 2 percent of Chippewa (Chip) NF, 2 percent of Superior (Sup) NF, 3 percent of Chequamegon (Cheq) NF, and 3 percent of Nicolet (Nic) NF survey locations.



White pine stand. ©Minnesota Department of Natural Resources.

Table 43.—Abundance and frequency of the 20 most common bird species in mature white pine forest*

Species	Pooled NF	Chip NF	Sup NF	Cheq NF	Nic NF	Frequency
Ovenbird †	25.60	27.16	23.19	27.34	23.41	84%
Red-eyed vireo	15.11	23.24	15.96	12.43	11.10	74%
Nashville warbler	5.83	--	8.16	6.70	5.27	38%
Blackburnian warbler	5.40	4.22	7.23	4.27	6.59	39%
Blue jay	5.24	4.02	3.48	6.79	5.60	36%
Black-throated green warbler	5.22	7.35	--	5.32	9.34	36%
White-throated sparrow †	4.78	--	7.94	4.59	5.49	34%
Chestnut-sided warbler	4.58	4.02	4.04	5.96	2.75	31%
Veery †‡	3.86	6.96	--	4.95	--	25%
Least flycatcher †‡	3.79	5.49	10.21	--	--	16%
Hermit thrush	3.73	2.45	5.39	2.06	6.59	27%
Rose-breasted grosbeak †	3.59	--	--	7.16	1.87	26%
Pine warbler	3.51	4.80	--	3.62	4.95	25%
American redstart	3.42	13.92	--	--	--	16%
Red-breasted nuthatch	3.17	2.55	2.48	3.30	4.62	27%
American robin	2.59	--	1.91	3.26	4.07	20%
Black-capped chickadee	2.50	2.75	2.06	2.39	3.19	20%
Chipping sparrow	2.12	3.24	2.77	--	--	17%
American crow	2.08	3.43	1.56	--	2.42	16%
Yellow-bellied sapsucker †	2.03	2.06	--	2.48	1.87	18%

* The following are other common species in this habitat cover type. Chip NF: eastern wood-pewee †, red-winged blackbird, song sparrow. Sup NF: alder flycatcher, blue-headed vireo, magnolia warbler, mourning warbler, winter wren †, yellow-rumped warbler. Cheq NF: black-and-white warbler, Canada warbler †‡, mourning warbler, scarlet tanager. Nic NF: black-and-white warbler, brown creeper, winter wren †, yellow-rumped warbler.
† Species of conservation concern, Minnesota.
‡ Species of conservation concern, Wisconsin.

Open Water Habitat

Sampled at the edges of lakes or large rivers. Less than 1 percent of all point counts were located in open-water habitat, which was surveyed only in the Nicolet (Nic) NF. This habitat characterized 2.7 percent of Nic NF survey locations.



Lakeshore. Photo by Robert Howe, University of Wisconsin.

Table 44.—Abundance and frequency of the 20 most common bird species in open-water habitat

Species	Nic NF	Frequency
Red-winged blackbird	25.00	69%
Red-eyed vireo	10.00	65%
Common grackle	9.44	19%
Common yellowthroat	8.61	51%
Song sparrow	6.94	56%
Swamp sparrow †	6.81	36%
Tree swallow	6.53	36%
American robin	5.97	42%
Mallard	5.42	22%
Least flycatcher †‡	5.28	29%
American crow	4.86	35%
Eastern kingbird	4.72	36%
Cedar waxwing	4.58	22%
Ovenbird †	4.17	31%
Rose-breasted grosbeak †	4.17	32%
Common loon †‡	4.03	25%
Blue jay	3.47	31%
White-throated sparrow †	3.47	31%
Wilson's snipe	3.06	25%
Black-and-white warbler	2.92	25%

† Species of conservation concern, Minnesota.
‡ Species of conservation concern, Wisconsin.

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APPENDIX 3

Percent Perfect Indication Values with Respect to 20 Habitat Categories for 123 Bird Species Recorded in 4 National Forests in the Western Great Lakes Region, 2001–2010

Percent perfect indication (PPI) values describe a species' affinity to a habitat category by using a combination of relative abundance (i.e., average number of individuals per 10-min point count in a given habitat category) and frequency (i.e., number of years the species was observed at the point count over the years of sampling). Values of PPI can theoretically range from 0 to 100, where 100 represents a situation where all individuals of a species were counted in just one habitat category and the species was always present in samples of that category. The table below lists PPI values for 20 habitat categories for the 123 bird species that were recorded at 10 or more of 1,728 point count locations during the decade 2001–2010 in the Chippewa, Superior, Chequamegon, and Nicolet

Species	p	Asp Birch (264)	Asp SprFir (124)	BeMap Bir (20)	BSpr Tam (92)	Hem lock (41)	Jack Pine (81)	LHwds (61)	Lshrub (26)	Oak (58)	Open Dry (72)
ALFL	0.000	0	0	0	5	0	0	0	25	0	4
AMBI	0.002	0	1	0	0	1	1	0	0	0	0
AMCR	0.000	2	1	1	2	2	2	3	3	5	4
AMGO	0.000	1	0	0	2	1	0	1	4	2	4
AMKE	0.026	0	0	0	0	0	0	0	0	0	2
AMRE	0.048	3	2	0	0	1	3	8	1	11	2
AMRO	0.000	2	2	3	2	4	4	2	6	2	6
AMWO	0.292	0	0	0	0	0	0	0	0	0	0
BAEA	0.003	0	0	0	0	0	0	0	1	0	0
BAOR	0.001	0	0	0	0	0	0	0	2	0	4
BAWW*	0.202	5	7	1	4	4	2	6	6	1	1
BBCU	0.280	1	0	1	0	0	1	0	2	0	4
BBWA*	0.023	0	0	0	0	0	0	0	0	0	0
BBWO	0.042	0	0	0	9	0	0	0	0	0	1
BCCH	0.029	4	4	2	4	4	3	3	5	2	1
BEKI	0.012	0	0	0	0	0	0	0	1	0	0
BHCO	0.022	0	0	0	0	1	1	1	0	2	11
BHVI	0.049	1	1	0	10	3	5	1	1	0	1
BLBW	0.001	4	7	4	3	15	7	2	0	1	0
BLJA*	0.032	4	5	1	6	4	6	4	8	2	4
BOCH*	0.181	0	0	0	3	0	0	0	1	0	0
BRBL	0.001	0	0	0	0	0	0	0	0	0	25
BRCR	0.031	2	6	5	2	4	3	10	0	0	0

National Forests. Habitats with the highest PPI values are highlighted for species that exhibited strong habitat associations ($p < 0.05$). Asterisks designate species for which one or more PPI values probably reflect a sampling artifact; see Appendix 5 for details of most of these species (except for the rarely recorded BBWA, BOCH, EAPH, GBHE, and RBWO). Abbreviations for habitat categories are spelled out below the table on pages 130 and 131. Numbers in parentheses indicate the number of points sampled for each habitat category. The table (and each bird species) spreads across both facing pages.

Species	p	Opn Wet (9)	Red Pine (182)	Reg Con (85)	Reg NCon (193)	Sedge (7)	Swmp Con (138)	Town (6)	Up Hwds (215)	Water (8)	W Pine (46)
ALFL	0.000	3	0	2	2	23	2	0	0	2	0
AMBI	0.002	1	0	0	0	0	0	0	0	16	0
AMCR	0.000	5	3	2	2	4	2	22	3	8	1
AMGO	0.000	7	1	2	1	6	1	32	1	2	0
AMKE	0.026	0	0	0	0	0	0	10	0	0	0
AMRE	0.048	1	4	3	5	0	1	6	1	1	2
AMRO	0.000	6	4	4	3	1	4	25	3	4	2
AMWO	0.292	0	0	2	0	0	0	0	0	0	0
BAEA	0.003	0	0	0	0	8	0	0	0	18	0
BAOR	0.001	7	0	0	0	0	0	22	0	0	0
BAWW*	0.202	7	1	3	5	1	7	0	1	4	3
BBCU	0.280	4	0	2	1	1	0	0	1	0	0
BBWA*	0.023	0	0	0	0	11	0	0	0	0	0
BBWO	0.042	0	0	0	0	0	0	0	0	0	0
BCCH	0.029	5	4	3	3	2	6	10	2	5	5
BEKI	0.012	13	0	0	0	2	0	1	0	5	0
BHCO	0.022	4	1	2	1	0	0	11	1	0	0
BHVI	0.049	0	6	3	1	0	6	0	1	1	4
BLBW	0.001	0	5	1	2	0	3	0	1	1	15
BLJA*	0.032	5	5	7	5	8	6	0	3	2	5
BOCH*	0.181	0	0	0	0	4	1	0	0	0	0
BRBL	0.001	0	0	0	0	0	0	0	0	0	0
BRCR	0.031	0	4	0	0	0	4	0	3	0	9

(continued on next page)

Species	p	Asp Birch (264)	Asp SprFir (124)	BeMap Bir (20)	BSpr Tam (92)	Hem lock (41)	Jack Pine (81)	LHwds (61)	Lshrub (26)	Oak (58)	Open Dry (72)
BRTH	0.000	0	0	0	0	0	0	0	0	0	28
BTBW*	0.243	1	4	0	0	0	1	0	0	1	0
BTNW	0.000	2	5	15	0	17	0	5	0	2	0
BWHA*	0.170	1	1	0	0	0	1	2	0	1	0
CANG*	0.321	0	0	0	1	3	0	1	5	0	2
CAWA	0.017	5	11	1	1	0	1	3	3	0	0
CCSP	0.000	0	0	0	0	0	0	0	0	0	35
CEDW	0.002	1	1	1	3	0	2	1	5	1	2
CHSP	0.000	1	0	0	2	0	8	0	0	0	7
CHSW	0.000	0	0	0	0	0	0	0	0	0	0
CMWA*	0.262	2	4	0	0	0	1	0	0	0	0
COGR	0.000	0	0	0	0	0	0	0	2	0	0
COLO*	0.015	2	0	1	1	1	1	1	0	5	0
COME	0.164	0	0	0	0	0	0	0	0	0	0
CONI	0.361	0	0	0	0	0	0	0	0	0	1
CONW	0.001	0	0	0	29	0	2	0	0	0	0
CORA*	0.146	3	2	3	4	3	4	3	2	1	8
COYE	0.005	1	1	0	7	0	1	4	14	1	4
CSWA	0.006	6	4	0	2	0	7	2	3	3	11
DEJU	0.146	0	0	0	1	0	5	0	0	1	0
DOWO	0.306	2	1	3	0	1	0	2	1	4	0
EABL	0.002	0	0	0	0	0	0	0	0	0	19
EAKI	0.000	0	0	0	0	0	0	0	3	0	7
EAPH*	0.004	0	0	0	0	1	0	0	1	1	1
EATO	0.000	0	0	0	0	0	1	0	0	0	25
EAWP	0.001	2	0	7	0	4	4	3	0	15	2
EUST	0.000	0	0	0	0	0	0	0	0	0	0
EVGR*	0.144	1	1	0	0	0	3	0	3	0	0
FISP	0.003	0	0	0	0	0	0	0	0	0	19
GBHE*	0.022	0	0	12	0	0	0	0	1	0	0
GCFL	0.017	1	0	2	1	8	0	12	5	1	0
GCKI	0.008	1	7	0	14	1	3	0	0	0	0
GRAJ	0.087	2	2	0	7	0	7	0	1	0	1
GRCA	0.004	0	0	0	0	0	0	0	1	1	8
GWWA	0.094	0	0	0	1	0	0	0	7	0	1
HAWO	0.916	2	1	2	3	2	1	3	2	3	2
HETH	0.001	3	4	4	12	6	8	2	2	2	3
HOME	0.166	0	0	0	0	0	0	0	1	0	0
HOWR	0.000	0	0	0	0	0	0	0	0	0	7
INBU	0.024	0	0	0	0	0	1	0	0	2	11

Species	p	Opn Wet (9)	Red Pine (182)	Reg Con (85)	Reg NCon (193)	Sedge (7)	Swmp Con (138)	Town (6)	Up Hwds (215)	Water (8)	W Pine (46)
BRTH	0.000	0	0	1	0	0	0	1	0	0	0
BTBW*	0.243	1	0	0	0	0	0	2	2	0	0
BTNW	0.000	1	3	0	1	0	6	0	12	1	8
BWHA*	0.170	5	0	0	0	0	0	0	1	0	2
CANG*	0.321	0	0	0	0	0	0	1	3	3	0
CAWA	0.017	0	1	1	2	0	5	0	0	3	4
CCSP	0.000	0	0	1	0	2	0	0	0	0	0
CEDW	0.002	10	2	4	2	5	1	20	0	6	0
CHSP	0.000	2	9	8	1	0	0	33	0	1	3
CHSW	0.000	2	0	0	0	0	0	74	0	0	0
CMWA*	0.262	0	0	0	0	0	1	0	0	0	1
COGR	0.000	3	0	0	0	3	0	37	0	13	0
COLO*	0.015	5	1	1	1	2	1	5	1	12	1
COME	0.164	0	0	0	0	0	0	0	0	5	0
CONI	0.361	0	0	1	0	0	0	0	0	0	0
CONW	0.001	0	0	1	0	0	0	0	0	0	0
CORA*	0.146	5	4	4	2	2	2	0	3	1	2
COYE	0.005	10	1	4	2	12	3	0	0	10	0
CSWA	0.006	2	6	12	13	4	1	1	0	1	4
DEJU	0.146	0	0	1	0	0	0	0	0	0	0
DOWO	0.306	0	0	0	1	1	0	1	1	0	0
EABL	0.002	0	0	0	0	1	0	3	0	0	0
EAKI	0.000	5	0	0	0	0	0	1	0	24	0
EAPH*	0.004	0	0	0	0	8	0	17	0	0	0
EATO	0.000	0	2	1	1	0	0	0	0	0	1
EAWP	0.001	3	11	1	0	0	0	1	8	0	2
EUST	0.000	0	0	0	0	0	0	98	0	0	0
EVGR*	0.144	1	2	1	1	1	1	6	0	0	4
FISP	0.003	0	0	0	0	3	0	0	0	0	0
GBHE*	0.022	3	0	0	0	0	0	1	0	1	0
GCFL	0.017	1	0	1	0	0	3	0	3	1	1
GCKI	0.008	0	2	2	0	0	6	0	0	1	5
GRAJ	0.087	0	1	3	1	0	2	0	0	0	0
GRCA	0.004	0	1	2	1	3	0	16	0	0	0
GWWA	0.094	4	1	2	4	7	0	0	0	0	1
HAWO	0.916	1	1	2	1	1	2	0	3	0	1
HETH	0.001	6	6	8	3	4	5	0	5	1	4
HOME	0.166	2	0	0	0	4	0	3	0	2	0
HOWR	0.000	0	0	0	0	0	0	59	0	0	0
INBU	0.024	2	2	1	2	6	0	5	1	0	1

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Species	p	Asp Birch (264)	Asp SprFir (124)	BeMap Bir (20)	BSpr Tam (92)	Hem lock (41)	Jack Pine (81)	LHwds (61)	Lshrub (26)	Oak (58)	Open Dry (72)
KILL	0.000	0	0	0	0	0	0	0	1	0	0
LEFL	0.003	4	1	7	0	3	2	6	0	16	2
LISP	0.002	0	0	0	10	0	0	0	0	0	0
MALL	0.001	0	0	0	0	0	0	0	6	0	0
MAWA	0.008	4	13	0	2	0	5	1	0	0	0
MODO	0.000	0	0	2	1	2	1	1	5	0	2
MOWA	0.014	5	5	0	1	0	3	3	0	1	13
NAWA	0.000	4	6	0	15	2	8	2	7	0	3
NOFL*	0.236	2	2	0	3	0	2	2	4	1	4
NOPA	0.013	3	12	2	2	3	1	5	1	0	0
NOWA	0.000	0	1	0	2	2	0	28	1	0	0
OSFL*	0.001	0	0	0	3	0	0	0	0	0	1
OSPR	0.096	0	0	0	0	0	0	0	4	0	0
OVEN	0.000	7	6	8	2	7	7	6	1	7	2
PAWA	0.001	0	0	0	21	0	0	0	0	0	0
PBGR	0.008	0	0	0	0	0	0	0	2	0	0
PISI	0.456	1	1	0	1	0	0	0	1	0	0
PIWA	0.000	0	0	0	0	0	5	0	0	0	1
PIWO*	0.009	4	1	0	3	3	1	3	1	2	1
PUFI	0.164	1	2	0	4	1	2	1	1	0	0
RBGR*	0.229	3	3	4	2	5	4	3	7	4	4
RBGU	0.018	0	0	0	0	0	0	0	0	0	0
RBNU	0.009	3	5	1	3	4	7	2	5	1	1
RBWO*	0.196	0	0	1	0	0	0	0	0	0	0
RCKI	0.062	1	2	0	8	0	7	0	0	0	0
RECR	0.684	0	0	0	1	0	1	0	0	0	1
REVI	0.000	7	5	7	3	7	4	7	2	10	4
RTHA	0.205	0	0	0	0	0	3	0	0	0	1
RTHU*	0.183	1	1	1	0	0	0	1	2	4	0
RUGR*	0.315	2	2	0	0	2	1	5	4	0	1
RWBL	0.002	0	0	0	0	0	0	0	13	0	1
SACR*	0.078	0	0	0	1	6	0	1	0	0	0
SAVS	0.000	0	0	0	0	0	0	0	0	0	0
SCTA	0.011	2	1	6	1	4	3	3	0	11	1
SEWR	0.000	0	0	0	0	0	0	0	7	0	0
SORA	0.009	0	0	0	0	0	0	0	3	0	0
SOSP	0.010	0	0	0	1	0	0	1	5	0	8
SWSP	0.000	0	0	0	3	0	0	2	14	0	0
SWTH	0.035	2	9	2	2	0	3	1	0	0	0
TEWA	0.363	1	0	0	1	0	0	0	0	0	0

Species	p	Opn Wet (9)	Red Pine (182)	Reg Con (85)	Reg NCon (193)	Sedge (7)	Swmp Con (138)	Town (6)	Up Hwds (215)	Water (8)	W Pine (46)
KILL	0.000	0	0	0	0	0	0	38	0	3	0
LEFL	0.003	0	8	2	1	0	1	1	6	1	2
LISP	0.002	12	0	0	0	21	0	0	0	0	0
MALL	0.001	2	0	0	0	4	0	0	0	36	0
MAWA	0.008	0	2	3	3	1	2	0	0	1	3
MODO	0.000	2	1	1	0	1	1	30	1	2	0
MOWA	0.014	3	4	5	10	2	1	1	1	0	2
NAWA	0.000	8	4	7	5	5	8	0	1	1	3
NOFL*	0.236	2	1	3	4	6	1	6	1	3	1
NOPA	0.013	0	1	0	1	0	11	0	1	8	1
NOWA	0.000	0	0	0	0	0	11	0	0	0	0
OSFL*	0.001	1	0	1	1	27	0	0	0	0	0
OSPR	0.096	0	0	0	0	0	0	0	0	7	0
OVEN	0.000	3	7	4	5	2	3	0	9	1	9
PAWA	0.001	0	0	3	0	3	0	0	0	0	0
PBGR	0.008	0	0	0	0	0	0	0	0	15	0
PISI	0.456	0	1	1	0	0	1	3	0	0	1
PIWA	0.000	0	25	3	0	0	0	0	0	1	19
PIWO*	0.009	2	1	2	3	3	2	0	2	12	1
PUFI	0.164	3	2	1	1	6	2	5	0	0	1
RBGR*	0.229	4	4	6	6	3	3	1	5	2	3
RBGU	0.018	0	0	0	0	0	0	0	0	10	0
RBNU	0.009	1	10	3	2	1	5	1	1	6	11
RBWO*	0.196	0	0	0	0	0	0	0	0	5	0
RCKI	0.062	1	0	2	0	0	1	0	0	0	0
RECR	0.684	0	2	1	0	0	0	0	0	0	0
REVI	0.000	3	5	4	6	4	3	3	8	3	6
RTHA	0.205	4	1	1	0	0	0	0	0	0	0
RTHU*	0.183	0	0	0	1	0	1	5	1	4	1
RUGR*	0.315	2	0	0	1	5	3	0	4	0	1
RWBL	0.002	13	0	0	0	6	0	1	0	26	0
SACR*	0.078	6	0	0	0	7	0	0	3	3	0
SAVS	0.000	0	0	0	0	39	0	0	0	0	0
SCTA	0.011	1	4	2	1	1	1	0	5	0	3
SEWR	0.000	2	0	0	0	37	0	0	0	2	0
SORA	0.009	1	0	0	0	0	0	0	0	13	0
SOSP	0.010	14	1	2	2	14	0	12	0	13	0
SWSP	0.000	9	0	1	0	7	1	0	0	23	0
SWTH	0.035	0	1	1	1	1	5	0	0	0	1
TEWA	0.363	0	0	2	0	0	0	0	0	0	0

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Species	p	Asp Birch (264)	Asp SprFir (124)	BeMap Bir (20)	BSpr Tam (92)	Hem lock (41)	Jack Pine (81)	LHwds (61)	Lshrub (26)	Oak (58)	Open Dry (72)
TRES	0.000	0	0	0	0	0	0	0	5	0	7
TUVU	0.737	0	0	0	0	0	1	0	0	0	0
UPSA	0.003	0	0	0	0	0	0	0	0	0	18
VEER	0.017	7	3	1	2	1	2	11	6	8	3
VESP	0.000	0	0	0	0	0	0	0	0	0	27
WAVI	0.000	0	0	0	0	0	0	0	0	0	0
WBNU	0.006	1	1	3	0	1	1	4	0	13	0
WISN	0.000	0	0	0	1	0	0	1	1	0	0
WITU*	0.174	0	0	0	0	0	0	0	2	0	1
WIWR	0.001	4	7	3	8	6	2	8	2	0	1
WODU	0.005	0	0	0	0	0	0	0	1	0	0
WOTH	0.060	1	0	5	0	5	0	7	0	2	0
WTSP	0.005	4	6	0	12	1	4	4	8	0	4
WWCR	0.005	0	0	0	16	0	0	0	0	0	0
YBCU	0.183	0	0	0	0	0	0	0	4	1	0
YBFL	0.000	1	4	0	20	0	3	1	2	0	0
YBSA*	0.101	7	5	3	2	4	3	8	1	8	2
YEWA	0.014	0	0	0	0	0	0	0	14	1	6
YRWA	0.002	2	3	0	14	2	8	1	2	0	1
YTVI	0.001	1	0	0	0	0	0	1	0	22	1

AspBir: pole-size, mid-successional, and mature aspen-birch forest.
AspSprFir: pole-size, mid-successional, and mature aspen-spruce-fir forest.
BeMapBir: mature beech-maple-birch forest.
BSprTam: mature black spruce-tamarack forest.
Hemlock: mature hemlock forest.
Jack Pine: pole-size, mid-successional, and mature jack pine forest.
LHwds: mature lowland hardwood forest.
Lshrub: lowland shrub.
Oak: mature oak forest.
OpenDry: open dry habitats, including barrens, open woodland, grassy openings, and upland shrublands.

Species	p	Opn Wet (9)	Red Pine (182)	Reg Con (85)	Reg NCon (193)	Sedge (7)	Swmp Con (138)	Town (6)	Up Hwds (215)	Water (8)	W Pine (46)
TRES	0.000	4	0	0	0	3	0	27	0	21	0
TUVU	0.737	0	1	0	0	0	0	0	0	0	0
UPSA	0.003	0	0	0	0	0	0	0	0	0	0
VEER	0.017	1	3	7	11	2	2	1	2	0	2
VESP	0.000	0	0	0	0	1	0	0	0	0	0
WAVI	0.000	1	0	0	0	0	0	42	0	0	0
WBNU	0.006	2	1	0	0	0	0	1	5	0	2
WISN	0.000	0	0	1	1	0	0	0	0	26	0
WITU*	0.174	3	0	0	0	4	0	0	0	0	0
WIWR	0.001	1	1	1	2	1	14	0	1	4	2
WODU	0.005	6	0	0	0	0	0	0	0	17	0
WOTH	0.060	1	0	0	1	0	0	0	8	0	1
WTSP	0.005	5	2	6	7	7	7	0	0	4	3
WWCR	0.005	1	0	0	0	0	0	0	0	0	0
YBCU	0.183	0	0	0	0	0	0	0	0	0	0
YBFL	0.000	0	0	2	0	1	20	0	0	0	0
YBSA*	0.101	2	2	2	3	6	2	0	8	2	4
YEWA	0.014	6	0	0	0	5	0	2	0	0	0
YRWA	0.002	4	4	7	2	2	5	0	0	2	4
YTVI	0.001	0	1	1	0	0	0	0	1	1	0

OpnWet: open wet habitats, including cattail marshes, shoreline wetlands, and open bogs, Nicolet National Forest only.
Red Pine: pole-size, mid-successional, and mature red pine forest.
RegCon: regenerating conifer forest.
RegNCon: regenerating nonconifer forest.
Sedge: sedge meadows and sedge-dominated wetlands with scattered shrubs.
SwmpCon: mature swamp conifer forest.
Town: small towns (e.g., Lakewood, Wabeno, and Long Lake) in Nicolet National Forest only.
UpHwds: mid-successional and mature upland hardwood forest.
Water: open water and shoreline habitats along the edge of a lake or river, Nicolet National Forest only.
W Pine: mature white pine forest.

APPENDIX 4

Migration, Nesting, and Habitat Preferences of 98 Bird Species in 4 National Forests in the Western Great Lakes Region

Species	Migration strategy	Nest site	Habitat preference
Alder flycatcher	Long-distance	Shrub or subcanopy	Early successional
American crow	Short-distance	Canopy	Deciduous forest
American goldfinch	Short-distance	Shrub or subcanopy	Fields and meadows
American redstart	Long-distance	Shrub or subcanopy	Early successional
American robin	Short-distance	Highly variable	Fields and meadows
Baltimore oriole	Long-distance	Canopy	Human settlements, open forests, forest edges
Barred owl	Permanent resident	Cavity	Mixed forest
Black-and-white warbler	Long-distance	Ground	Mixed forest
Blackburnian warbler	Long-distance	Canopy	Coniferous forest
Black-billed cuckoo	Long-distance	Shrub or subcanopy	Deciduous forest
Black-capped chickadee	Permanent resident	Cavity	Deciduous forest
Black-throated blue warbler	Long-distance	Shrub or subcanopy	Deciduous forest
Black-throated green warbler	Long-distance	Canopy	Mixed forest
Blue jay	Semi-permanent resident and short-distance migrant	Canopy	Deciduous forest
Blue-headed vireo	Long-distance	Shrub or subcanopy	Coniferous forest
Brewer’s blackbird	Short-distance	Ground	Fields and meadows
Broad-winged hawk	Long-distance	Canopy	Forested areas, edges for foraging
Brown creeper	Short-distance	Cavity	Deciduous forest
Brown thrasher	Short-distance	Shrub or subcanopy	Early successional
Brown-headed cowbird	Short-distance	Brood parasite	Fields and meadows

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Species	Migration strategy	Nest site	Habitat preference
Canada goose	Short-distance	Ground	Wetlands, open areas
Canada warbler	Long-distance	Ground	Mixed forest
Cape May warbler	Long-distance	Canopy	Coniferous forest
Cedar waxwing	Short-distance	Shrub or subcanopy	Ponds, lakes, streams
Chestnut-sided warbler	Long-distance	Shrub or subcanopy	Early successional
Chimney swift	Long-distance	Large trees, chimneys	Urban, old forests
Chipping sparrow	Short-distance	Canopy	Coniferous forest
Clay-colored sparrow	Short-distance	Ground	Fields and meadows
Common grackle	Short-distance	Shrub or subcanopy	Urban, wetlands
Common loon	Short-distance	Ground	Ponds, lakes, streams
Common raven	Permanent resident	Canopy	Highly variable
Common yellowthroat	Short-distance	Ground, low shrub	Shrub swamp
Connecticut warbler	Long-distance	Ground, low shrub	Lowland coniferous forest
Downy woodpecker	Permanent resident	Cavity	Deciduous forest
Eastern bluebird	Short-distance	Cavity	Open dry areas
Eastern kingbird	Long-distance	Shrub or subcanopy	Fields and meadows
Eastern phoebe	Short-distance	Ledges, bridges	Urban, riparian
Eastern towhee	Short-distance	Ground	Early successional
Eastern wood-pewee	Long-distance	Canopy	Mixed forest
European starling	Permanent resident	Cavity	Human settlements
Evening grosbeak	Permanent resident	Canopy	Mixed forest
Field sparrow	Short-distance	Ground	Open dry areas
Golden-crowned kinglet	Short-distance	Canopy	Coniferous forest
Golden-winged warbler	Long-distance	Ground	Early successional
Gray catbird	Long-distance	Shrub or subcanopy	Early successional
Gray jay	Permanent resident	Shrub or subcanopy	Lowland coniferous forest
Great blue heron	Short-distance	Canopy	Ponds, lakes, streams
Great crested flycatcher	Long-distance	Cavity	Deciduous forest
Hairy woodpecker	Permanent resident	Cavity	Deciduous forest
Hermit thrush	Short-distance	Ground	Mixed forest
House wren	Short-distance	Cavity	Urban

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Species	Migration strategy	Nest site	Habitat preference
Indigo bunting	Long-distance	Shrub or subcanopy	Fields and meadows
Least flycatcher	Long-distance	Shrub or subcanopy	Deciduous forest
Lincoln's sparrow	Long-distance	Ground	Sedge meadows, bogs, open shrubby wetlands
Magnolia warbler	Long-distance	Shrub or subcanopy	Coniferous forest
Mallard	Short-distance	Ground	Ponds, lakes, streams
Mourning dove	Short-distance	Canopy	Human settlements, open areas
Mourning warbler	Long-distance	Ground	Early successional
Nashville warbler	Long-distance	Ground	Lowland coniferous forest
Northern flicker	Short-distance	Cavity	Fields and meadows
Northern parula	Long-distance	Canopy	Lowland coniferous forest
Northern waterthrush	Long-distance	Ground	Lowland coniferous forest
Olive-sided flycatcher	Long-distance	Canopy	Early successional
Ovenbird	Long-distance	Ground	Deciduous forest
Palm warbler	Long-distance	Ground	Lowland coniferous forest
Pileated woodpecker	Permanent resident	Canopy	Forests; species is highly mobile
Pine warbler	Short-distance	Canopy	Coniferous forest
Purple finch	Short-distance	Canopy	Mixed forest
Red-breasted nuthatch	Permanent resident	Cavity	Coniferous forest
Red-eyed vireo	Long-distance	Shrub or subcanopy	Deciduous forest
Red-winged blackbird	Short-distance	Shrub or subcanopy	Ponds, lakes, streams
Rose-breasted grosbeak	Long-distance	Shrub or subcanopy	Deciduous forest
Ruby-crowned kinglet	Short-distance	Canopy	Coniferous forest
Ruby-throated hummingbird	Long-distance	Canopy	Wide variety of habitats, including towns
Ruffed grouse	Permanent resident	Ground	Deciduous forest
Sandhill crane	Short-distance	Ground	Large open wetlands, especially sedge meadows
Scarlet tanager	Long-distance	Canopy	Deciduous forest
Sedge wren	Short-distance	Shrub or subcanopy	Sedge meadows, low shrubs
Song sparrow	Short-distance	Ground	Fields and meadows
Swainson's thrush	Long-distance	Shrub or subcanopy	Lowland coniferous forest

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Species	Migration strategy	Nest site	Habitat preference
Swamp sparrow	Short-distance	Ground	Early successional
Tennessee warbler	Long-distance	Ground	Lowland coniferous forest
Tree swallow	Long-distance	Cavity	Human settlements, open areas, water edges
Upland sandpiper	Long-distance	Ground	Open dry grasslands and meadows
Veery	Long-distance	Ground	Deciduous forest
Vesper sparrow	Short-distance	Ground	Fields and meadows
Warbling vireo	Long-distance	Canopy or subcanopy	Decidous forest, riparian
White-breasted nuthatch	Permanent resident	Cavity	Deciduous forest
White-throated sparrow	Short-distance	Ground	Early successional
Wild turkey	Permanent resident	Ground	Deciduous forest
Wilson’s snipe	Short-distance	Ground	Open wetlands
Winter wren	Short-distance	Ground	Lowland coniferous
Wood thrush	Long-distance	Shrub or subcanopy	Deciduous forest
Yellow warbler	Long-distance	Shrub or subcanopy	Shrub swamp
Yellow-bellied flycatcher	Long-distance	Ground	Lowland coniferous forest
Yellow-bellied sapsucker	Short-distance	Cavity	Deciduous forest
Yellow-rumped warbler	Short-distance	Canopy	Coniferous forest
Yellow-throated vireo	Long-distance	Canopy	Oak forest



A hermit thrush nest. Photo by Stephen M. White, Chequamegon-Nicolet National Forest.

APPENDIX 5

Summary of Species Life History Information, Abundance Trends, and Habitat Distribution for 90 Bird Species in 4 National Forests in the Western Great Lakes Region

Of the 127 forest- or woodland-nesting bird species recorded in the Chippewa, Superior, Chequamegon, and Nicolet National Forests (NFs) over two decades, the sample size for 98 species was large enough for us to analyze population trends. We provide information on life history (habitat, food, nesting, and migratory strategy) for 90 of these 98 species. (Barred owl, black-billed cuckoo, chimney swift, common grackle, eastern phoebe, great blue heron, mallard, and warbling vireo are not included because they were observed during less than 2 percent of the sample points.) Also shown for each of the 90 species are relative abundance trends for the individual national forests and for all four national forests combined, if available (see Table 8 for confidence intervals on percent annual change for each species), habitat distribution as measured by the species' percent perfect indication (PPI) values (see Appendix 3 for an explanation of PPI), and mapped relative abundance (number of birds per 10-min count) predicted for the western Great Lakes region for the decade 2001–2010. Details of calculations can be found in the "Methods" section under "Community Analyses." Color range in the map reflects low (light yellow) to high (dark blue) predicted abundance. Note that the abundance scale varies across species. Also note that where maps are missing, the number of detections in the data was insufficient to generate a reliable model.

The following are abbreviations for habitat categories in the bar graphs.

AspBirch: pole-size, mid-successional, and mature aspen-birch forest.

AspSprFir: pole-size, mid-successional, and mature aspen-spruce-fir forest.

BeMapBir: mature beech-maple-birch forest.

BSprTam: mature black spruce-tamarack forest.

Hemlock: mature hemlock forest.

Jack Pine: pole-size, mid-successional, and mature jack pine forest.

LHwds: mature lowland hardwood forest.

Lshrub: lowland shrub habitat.

Oak: mature oak forest.

OpenDry: open dry habitat.

OpenWet: open wet habitat.

Red Pine: pole-size, mid-successional, and mature red pine forest.

RegCon: regenerating conifer forest.

RegNCon: regenerating nonconifer forest.

Sedge: sedge habitat.

SwmpCon: mature swamp conifer forest.

Town: urban habitat.

UpHwds: mid-successional and mature upland hardwood forest.

W Pine: mature white pine forest.

Water: open water habitat.

Alder Flycatcher ALFL
Empidonax alnorum



Photo by Caleb Slemmons, University of Maine, Bugwood.org.

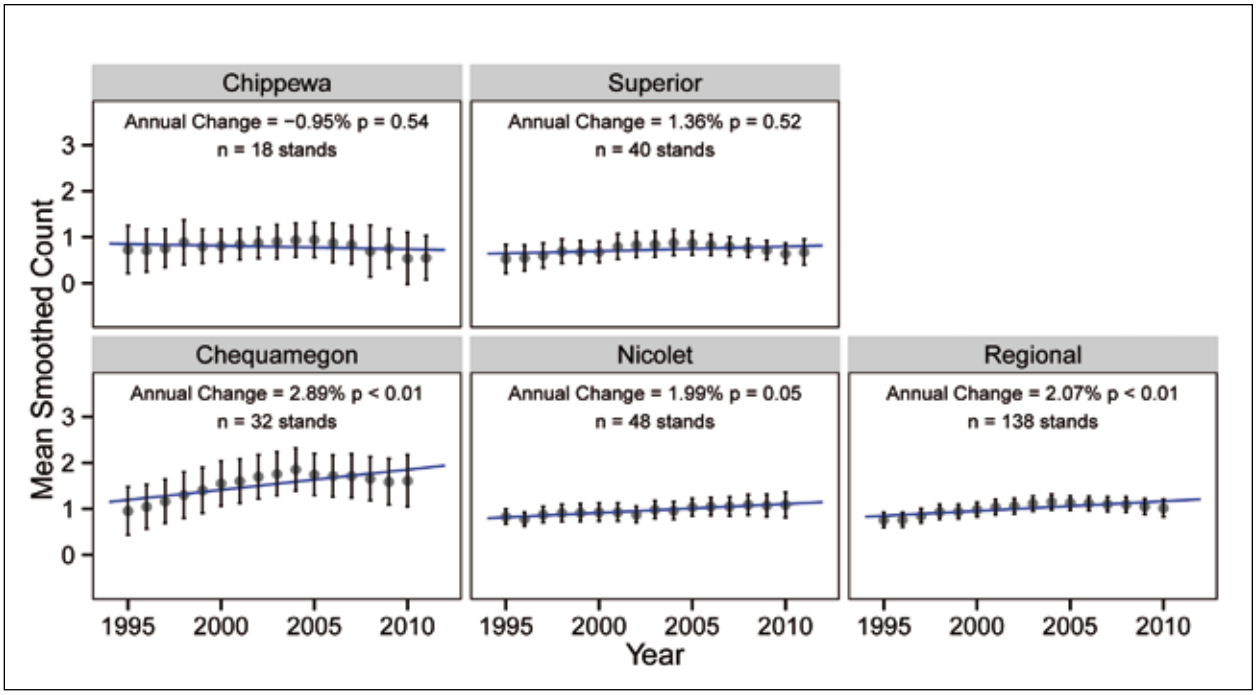
Guild Information

Habitat: Lowland shrubs, semi-open wetlands

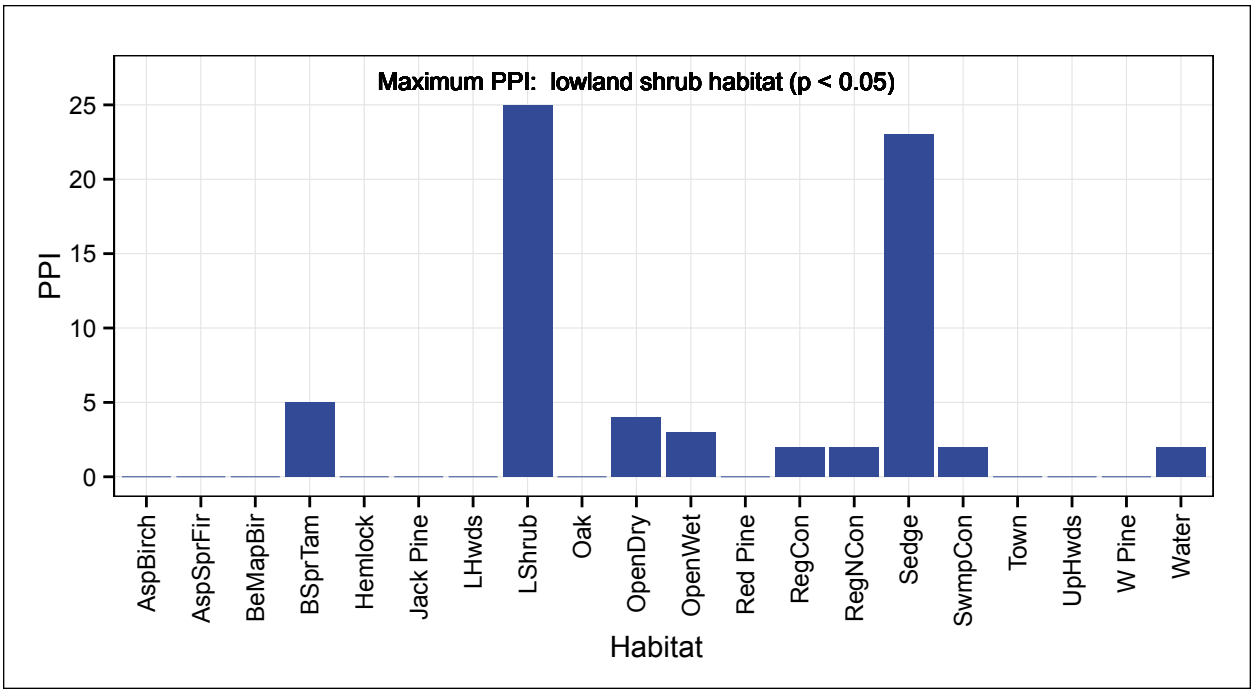
Foraging type: Flycatcher

Nest site: Shrub or subcanopy

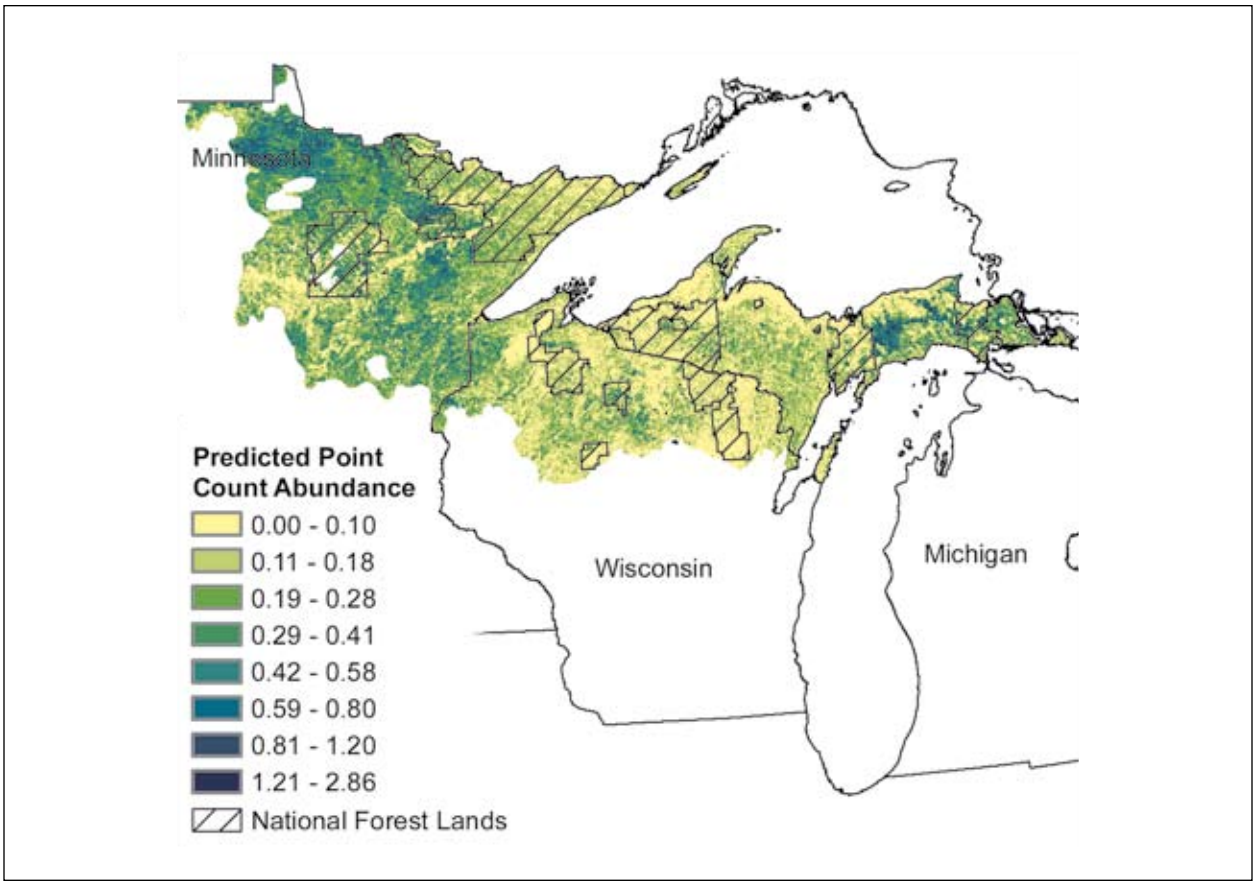
Migration: Long-distance



Trends for alder flycatcher in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for alder flycatcher where at least one bird was observed once during the decade (2001–2010, n=2,481 at 481 points)



Predicted relative abundance (number of birds per 10-minute count) of alder flycatcher for the western Great Lakes region

American Crow AMCR
Corvus brachyrhynchos



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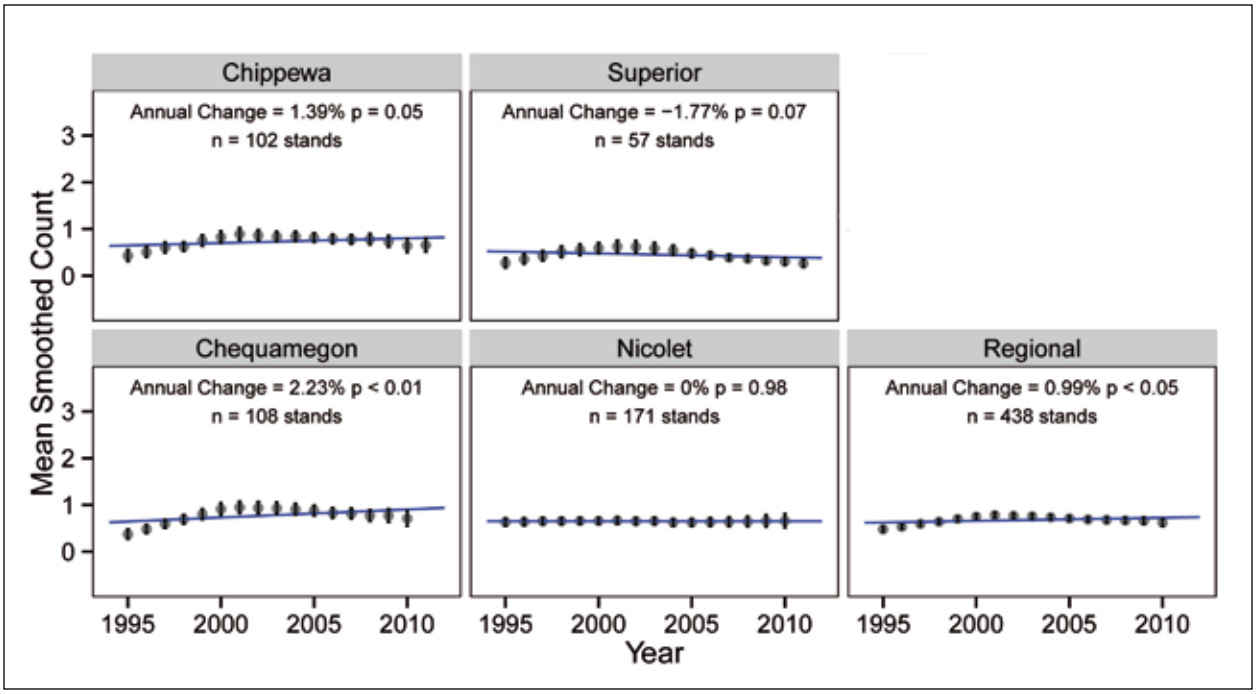
Guild Information

Habitat: Open areas, farmland, human settlements

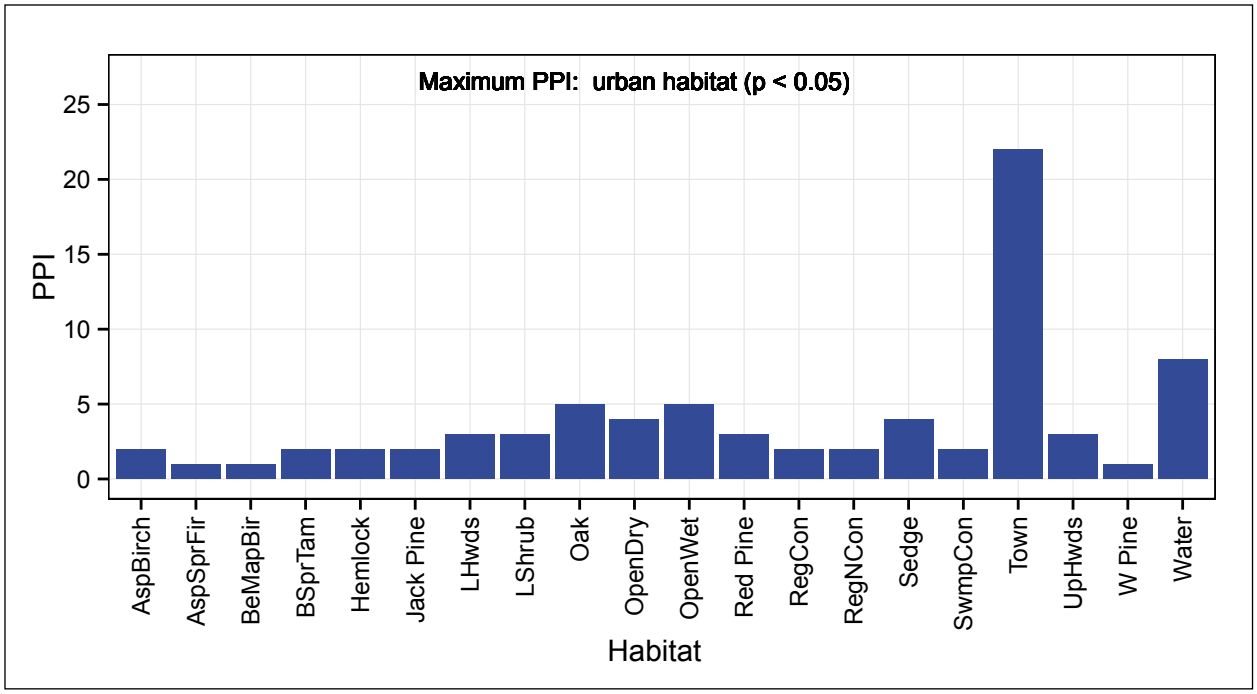
Foraging type: Omnivore

Nest site: Canopy

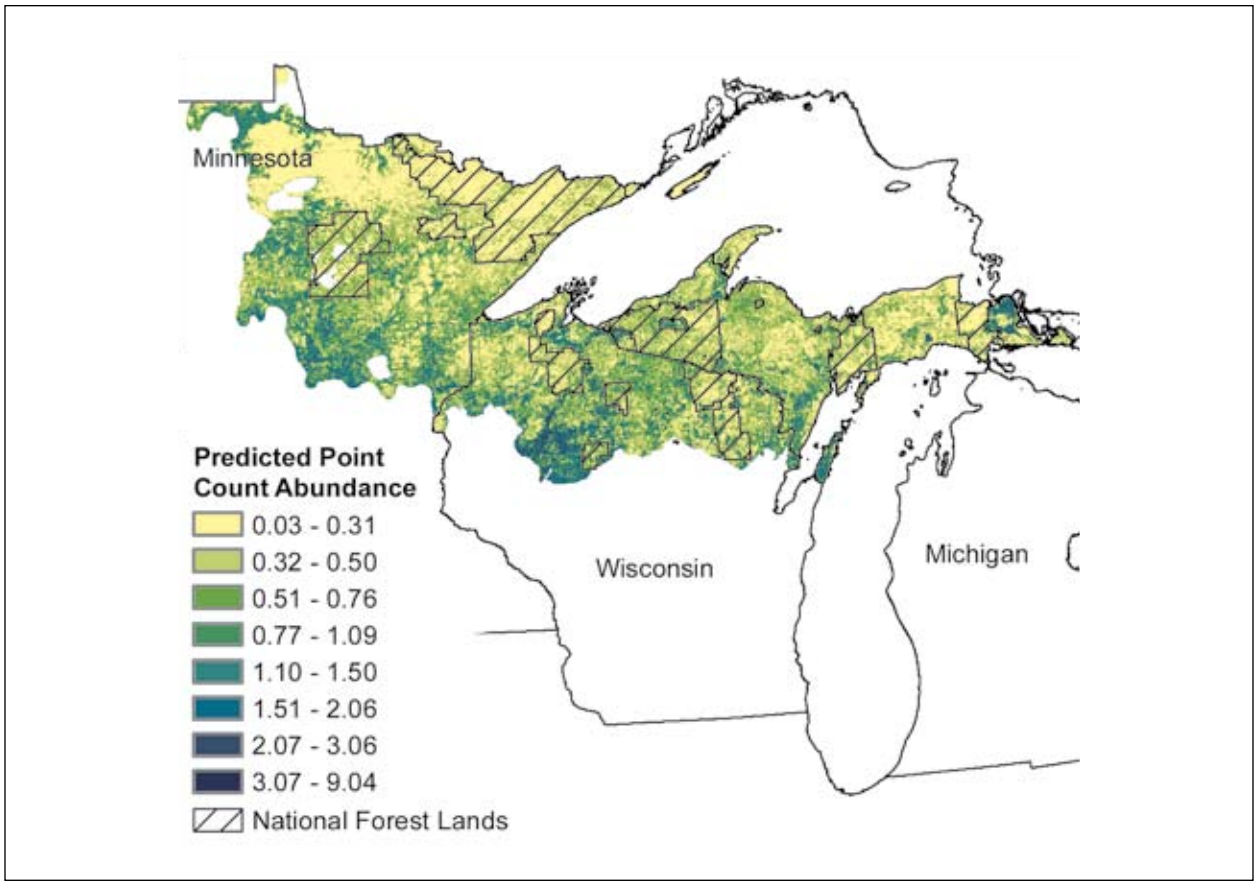
Migration: Short-distance



Trends for American crow in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for American crow where at least one bird was observed once during the decade (2001–2010; n=5,106 at 1,172 points)



Predicted relative abundance (number of birds per 10-minute count) of American crow for the western Great Lakes region

American Goldfinch AMGO
Spinus tristis



Photo by Art Overcott, used with permission.

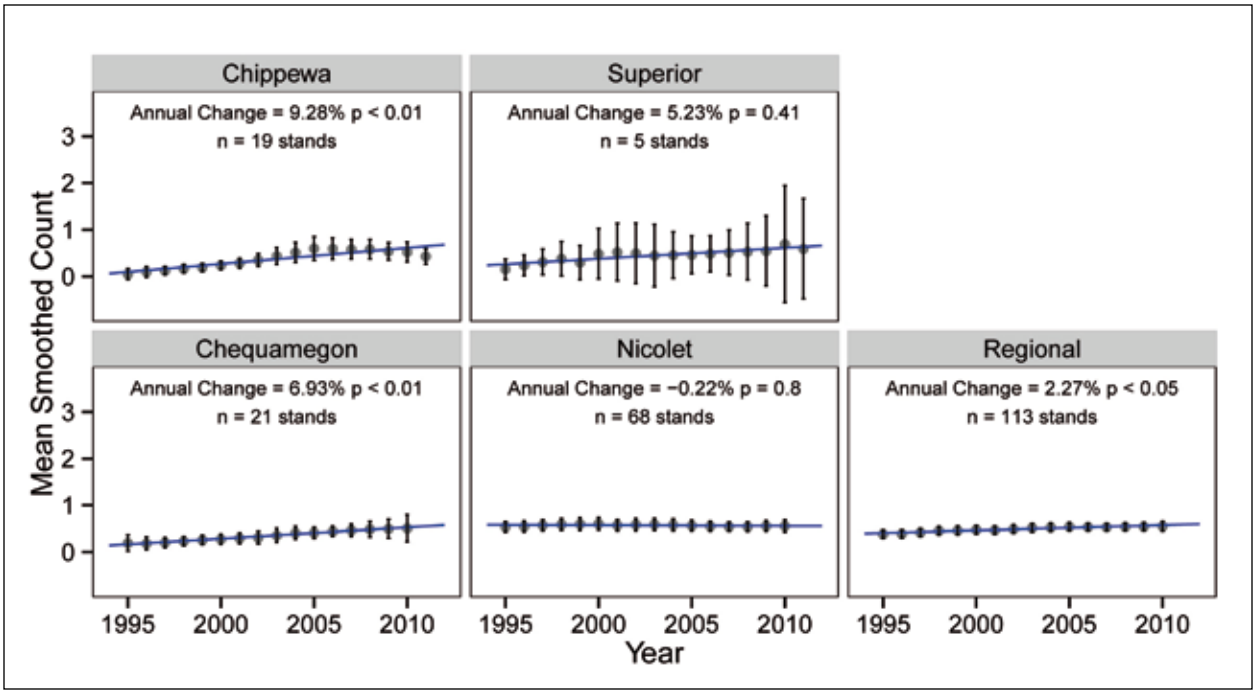
Guild Information

Habitat: Open shrub, human settlements, forest edge

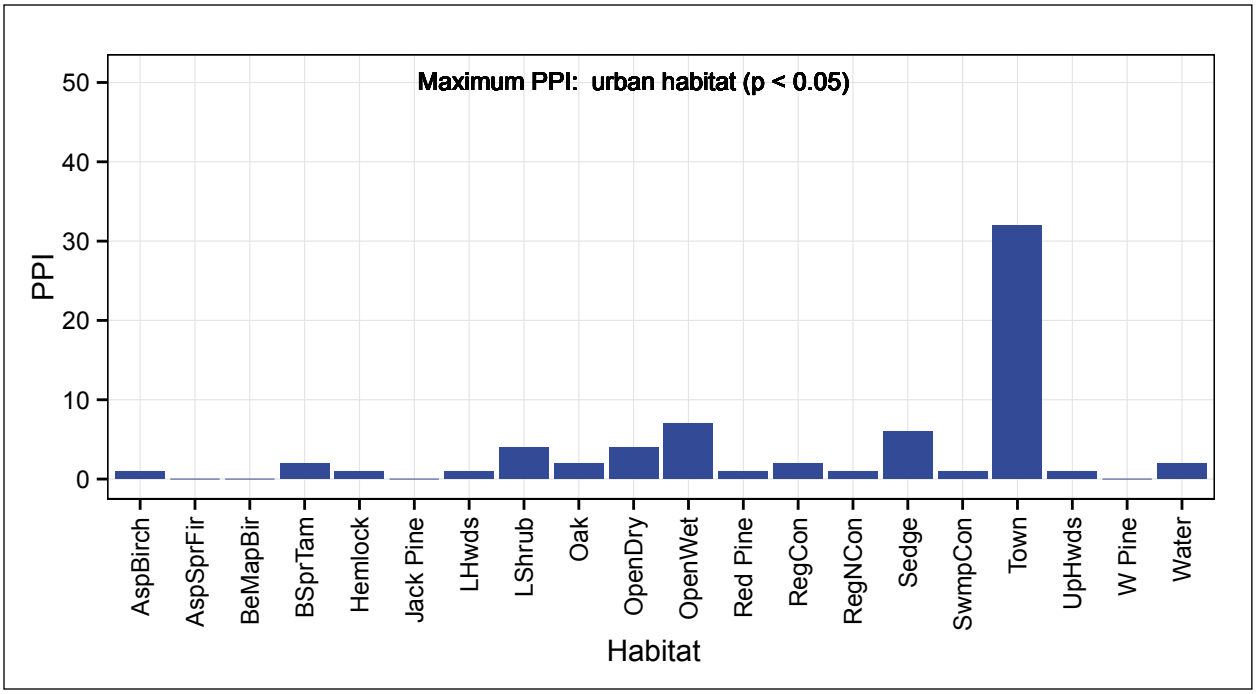
Foraging type: Granivore—seeds

Nest site: Shrub or subcanopy

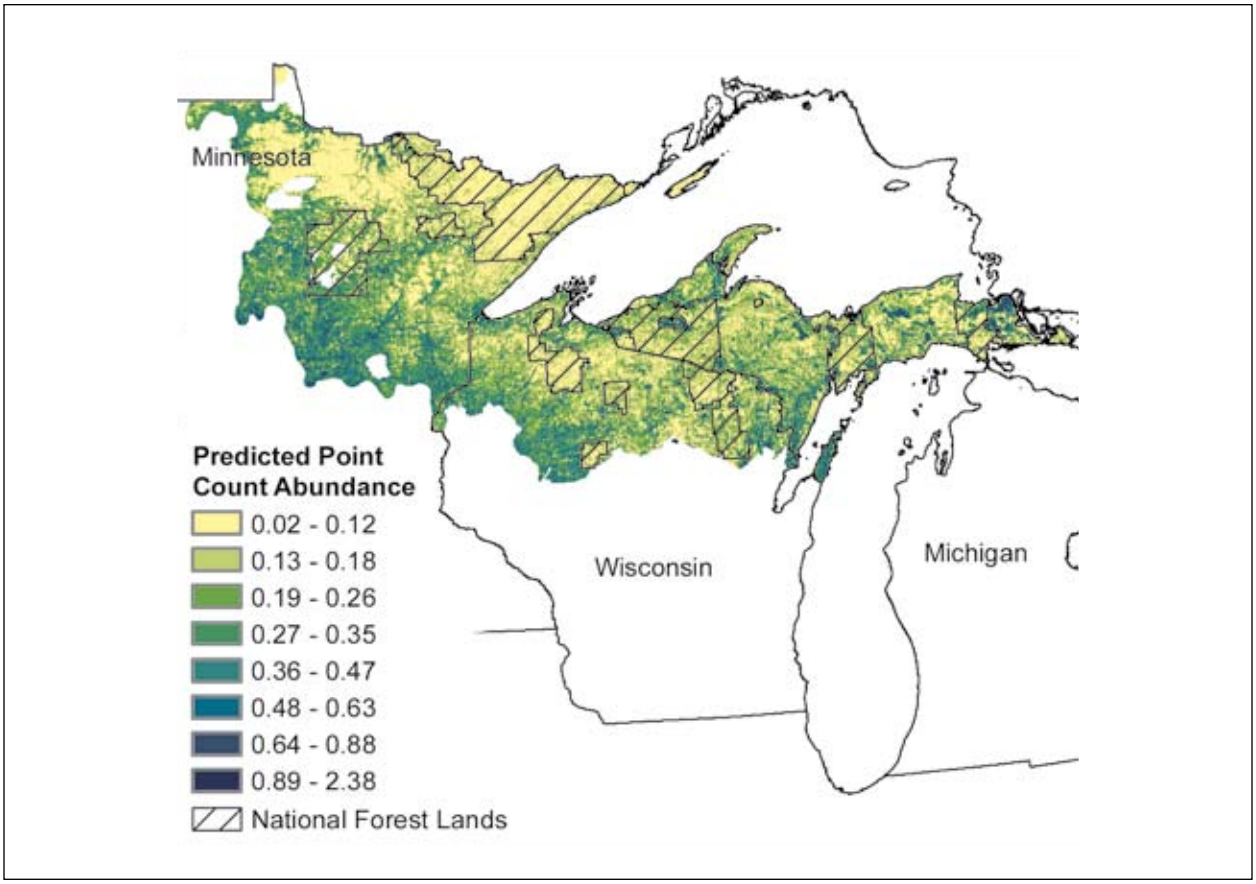
Migration: Short-distance



Trends for American goldfinch in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for American goldfinch where at least one bird was observed once during the decade (2001–2010; n=1,959 at 680 points)



Predicted relative abundance (number of birds per 10-minute count) of American goldfinch for the western Great Lakes region

American Redstart AMRE
Setophaga ruticilla



Photo by Bruce Lees, used with permission

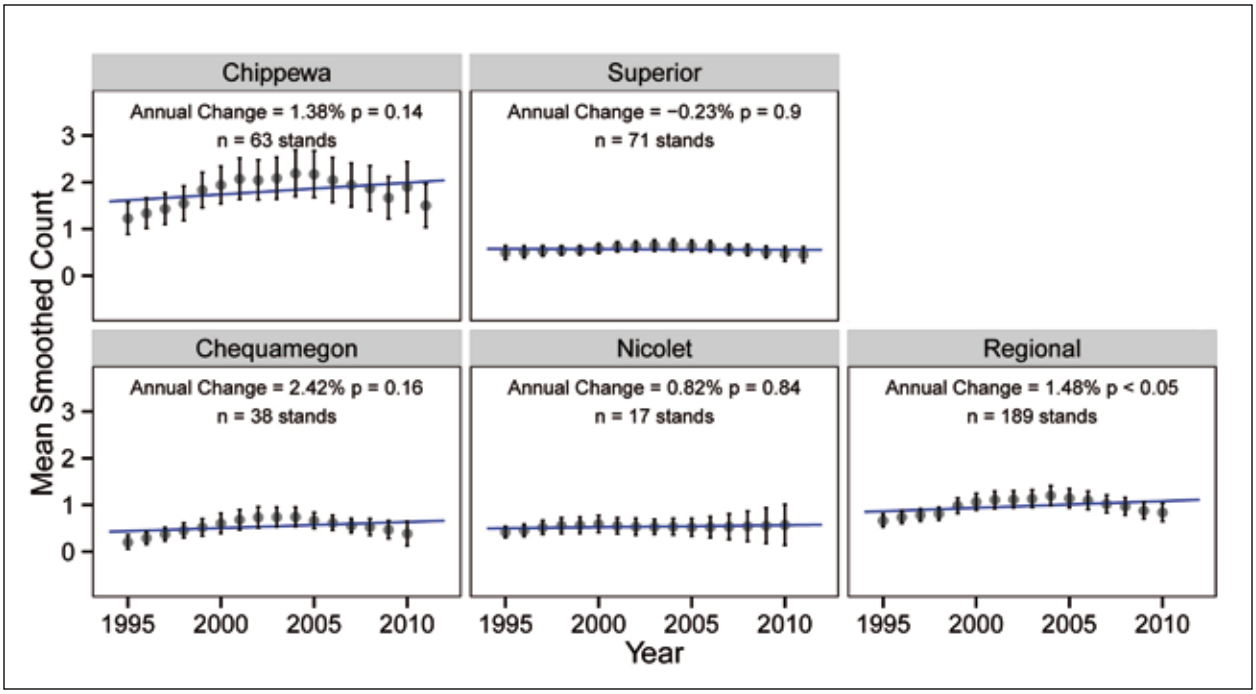
Guild Information

Habitat: Forests, especially oak; shrub understory, often near water

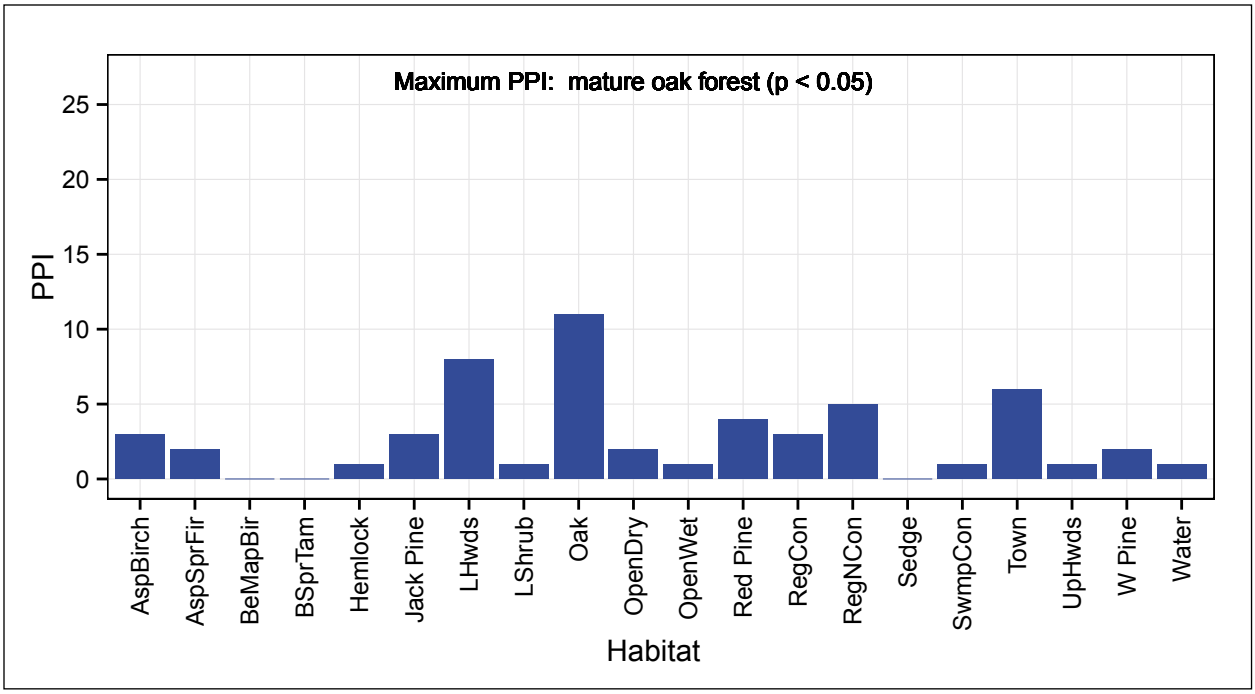
Foraging type: Flycatcher

Nest site: Shrub or subcanopy

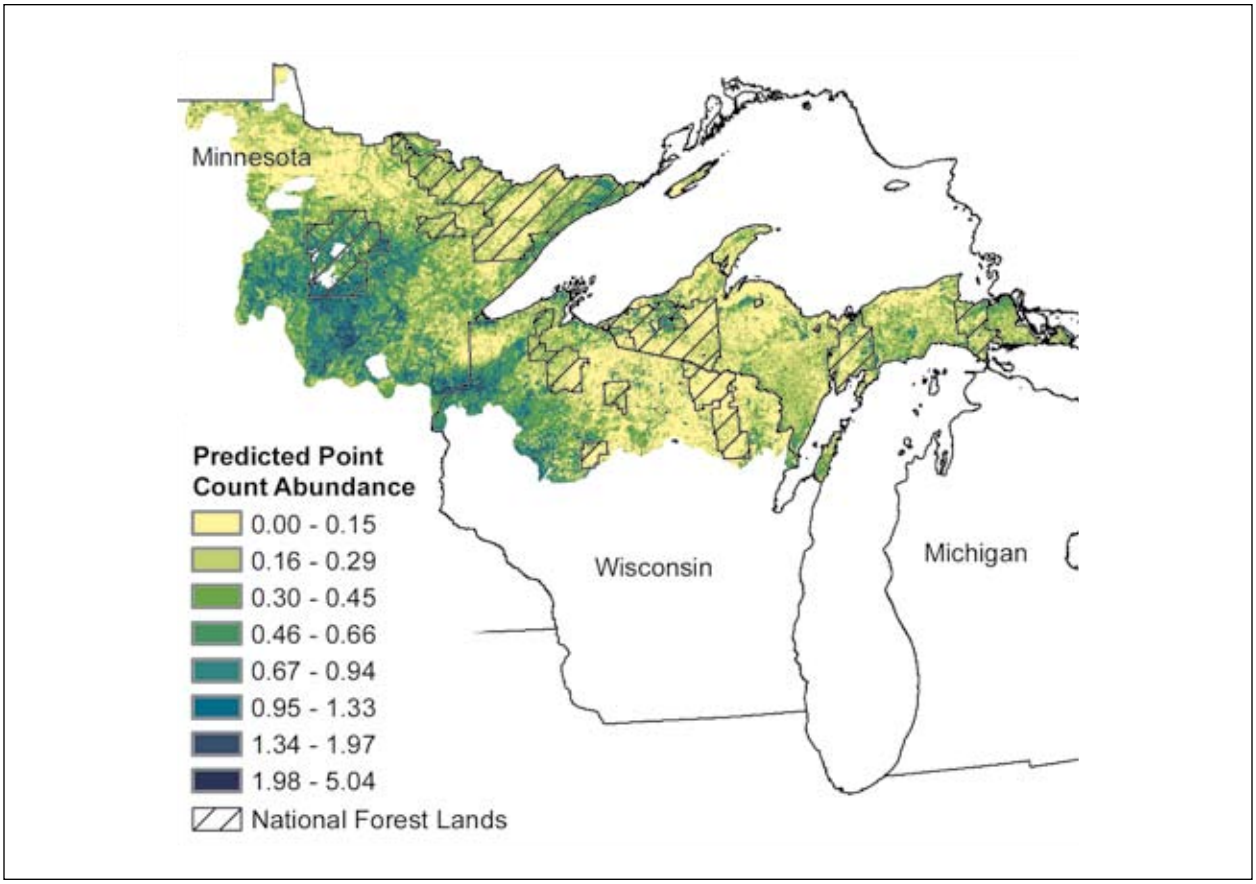
Migration: Long-distance



Trends for American redstart in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for American redstart where at least one bird was observed once during the decade (2001–2010; n=4,062 at 811 points)



Predicted relative abundance (number of birds per 10-minute count) of American redstart for the western Great Lakes region

American Robin AMRO
Turdus migratorius



Photo by Joseph Berger, Bugwood.org.

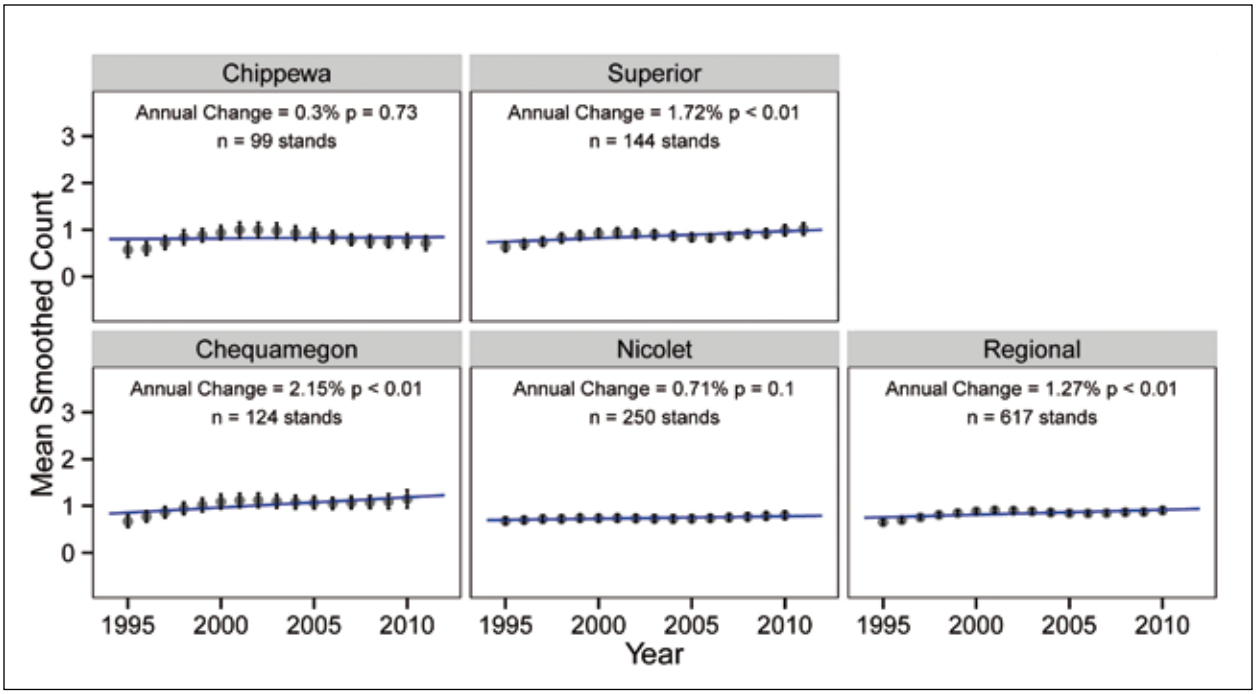
Guild Information

Habitat: Human settlements, open forests, forest roads

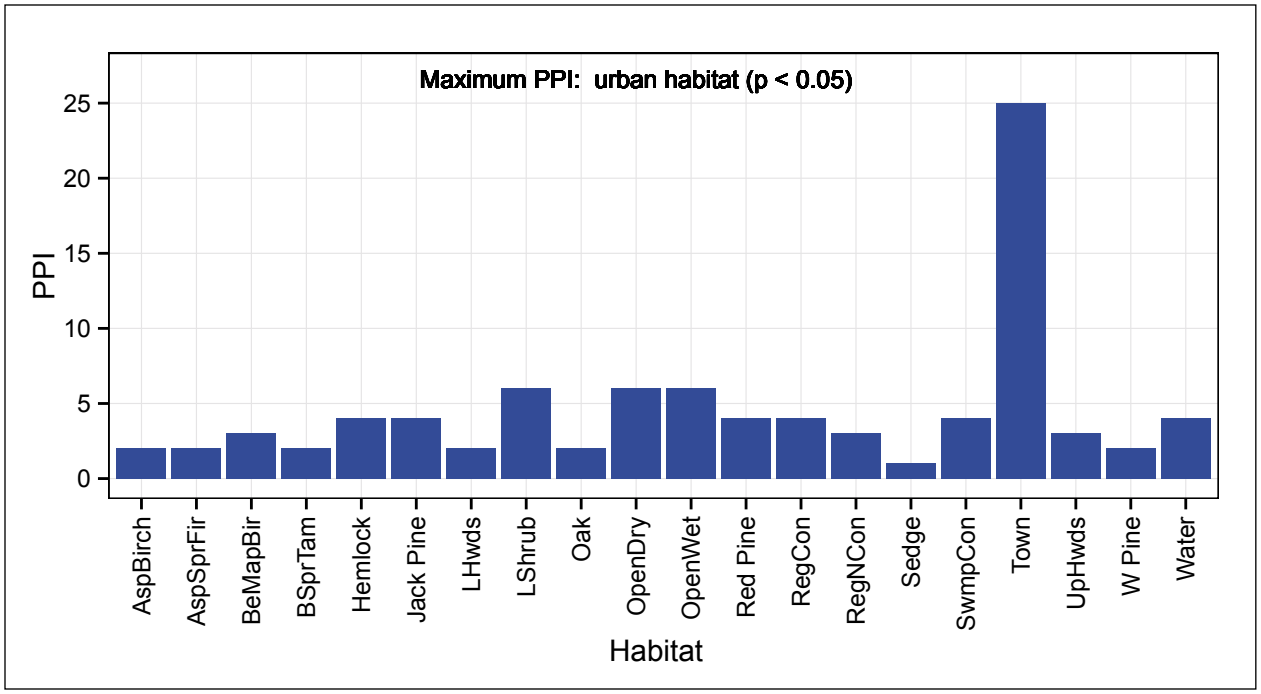
Foraging type: Omnivore—fruit, invertebrates

Nest site: Highly variable

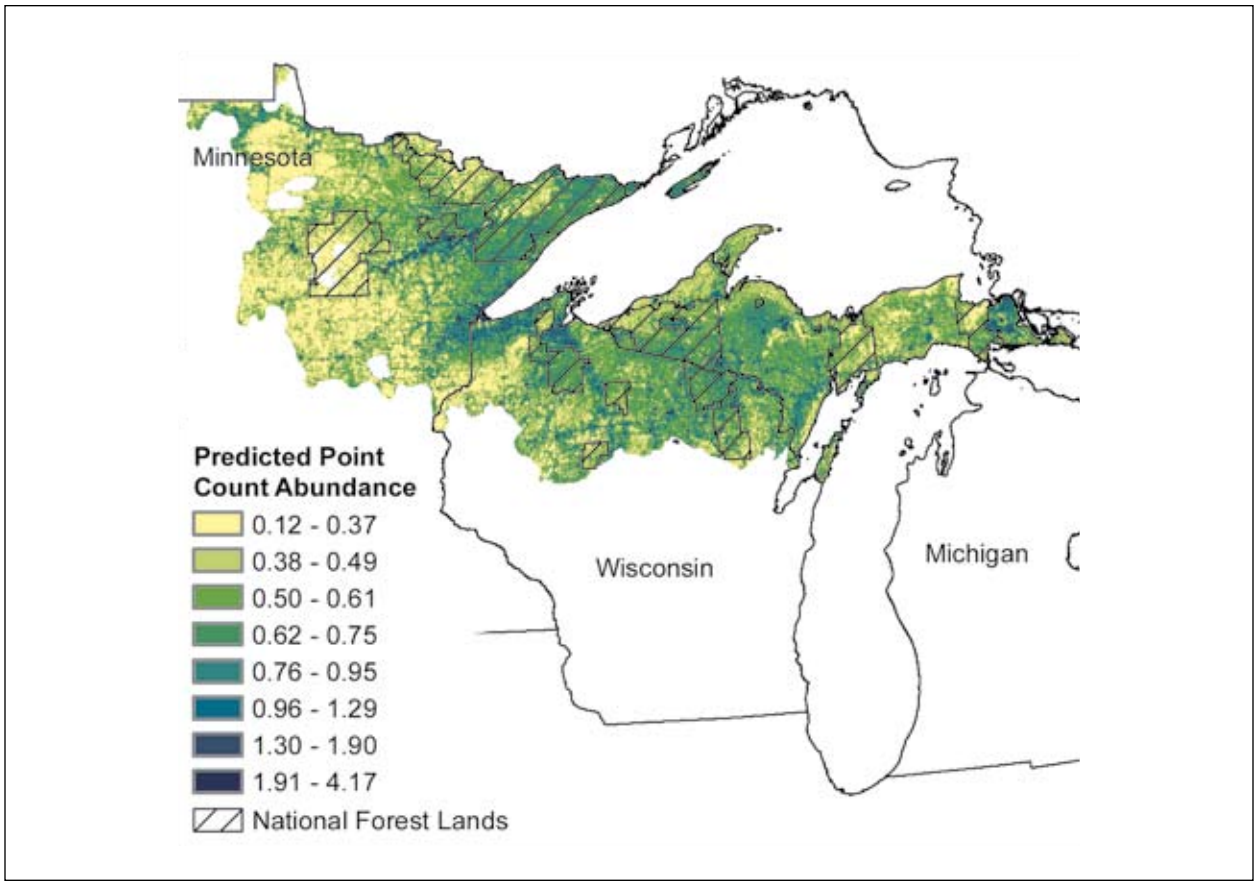
Migration: Short-distance



Trends for American robin in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for American robin where at least one bird was observed once during the decade (2001–2010, n=8,130 at 1,472 points)



Predicted relative abundance (number of birds per 10-minute count) of American robin for the western Great Lakes region

Baltimore Oriole BAOR

Icterus galbula



Photo by Larry Sirvio, used with permission.

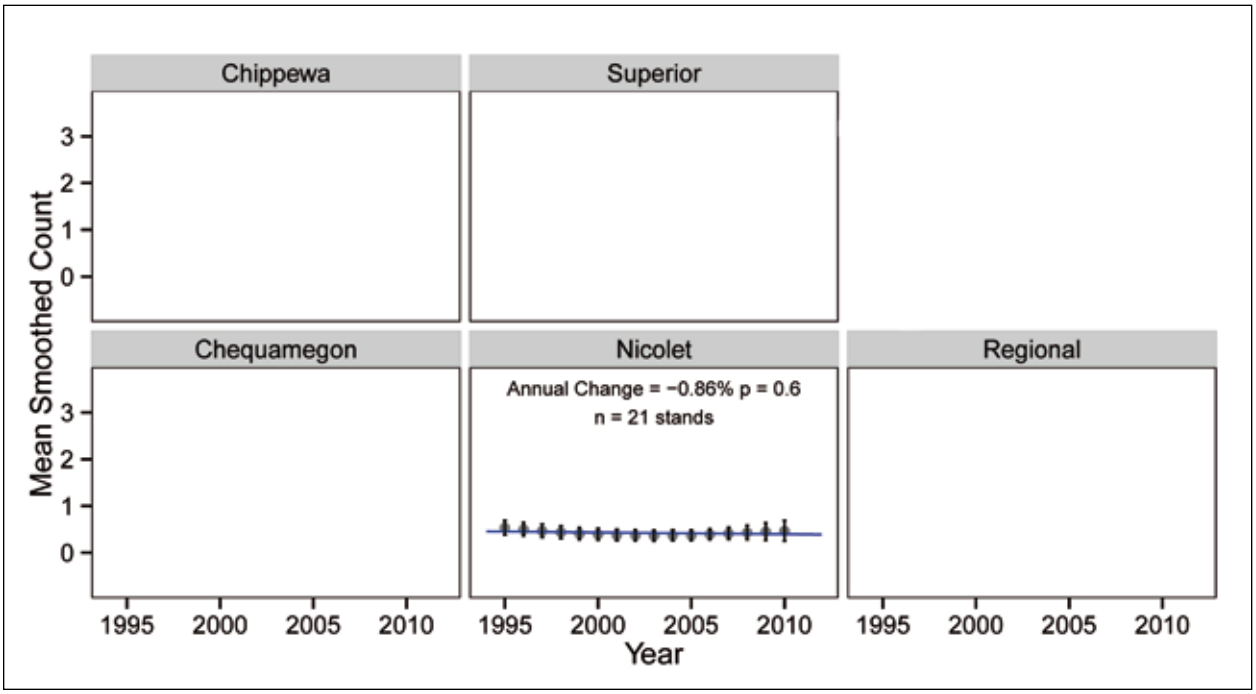
Guild Information

Habitat: Human settlements, open forests, forest edge

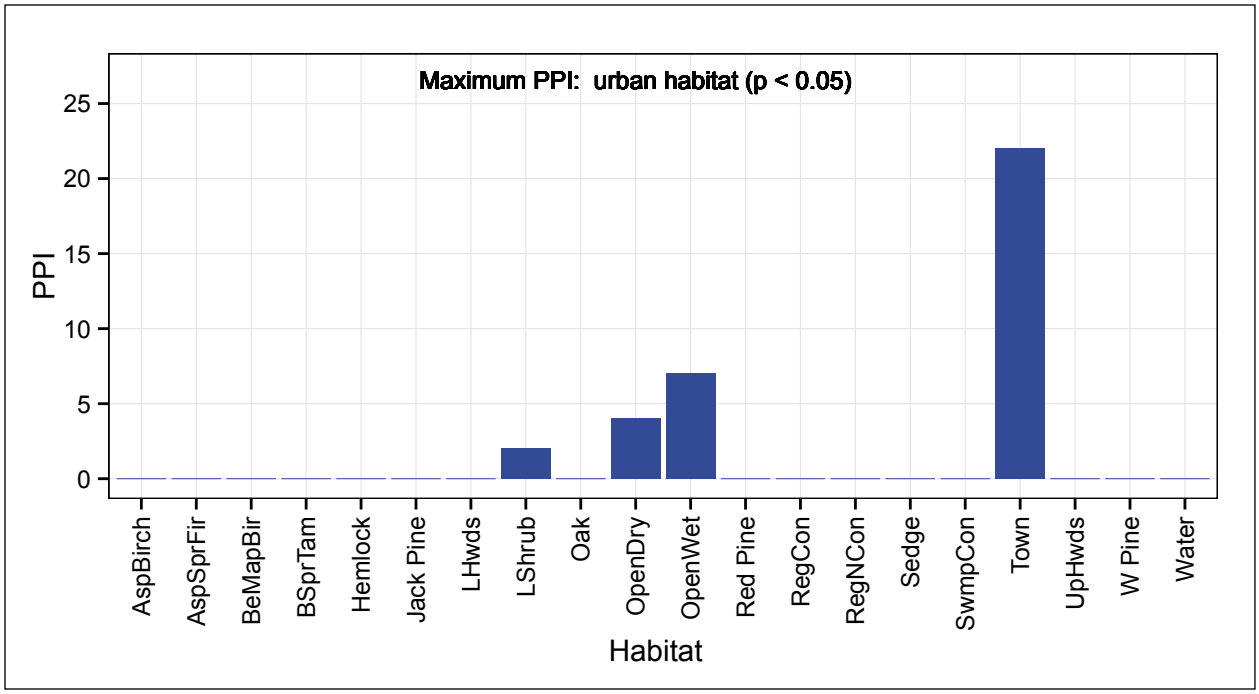
Foraging type: Omnivore—fruit, invertebrates

Nest site: Canopy

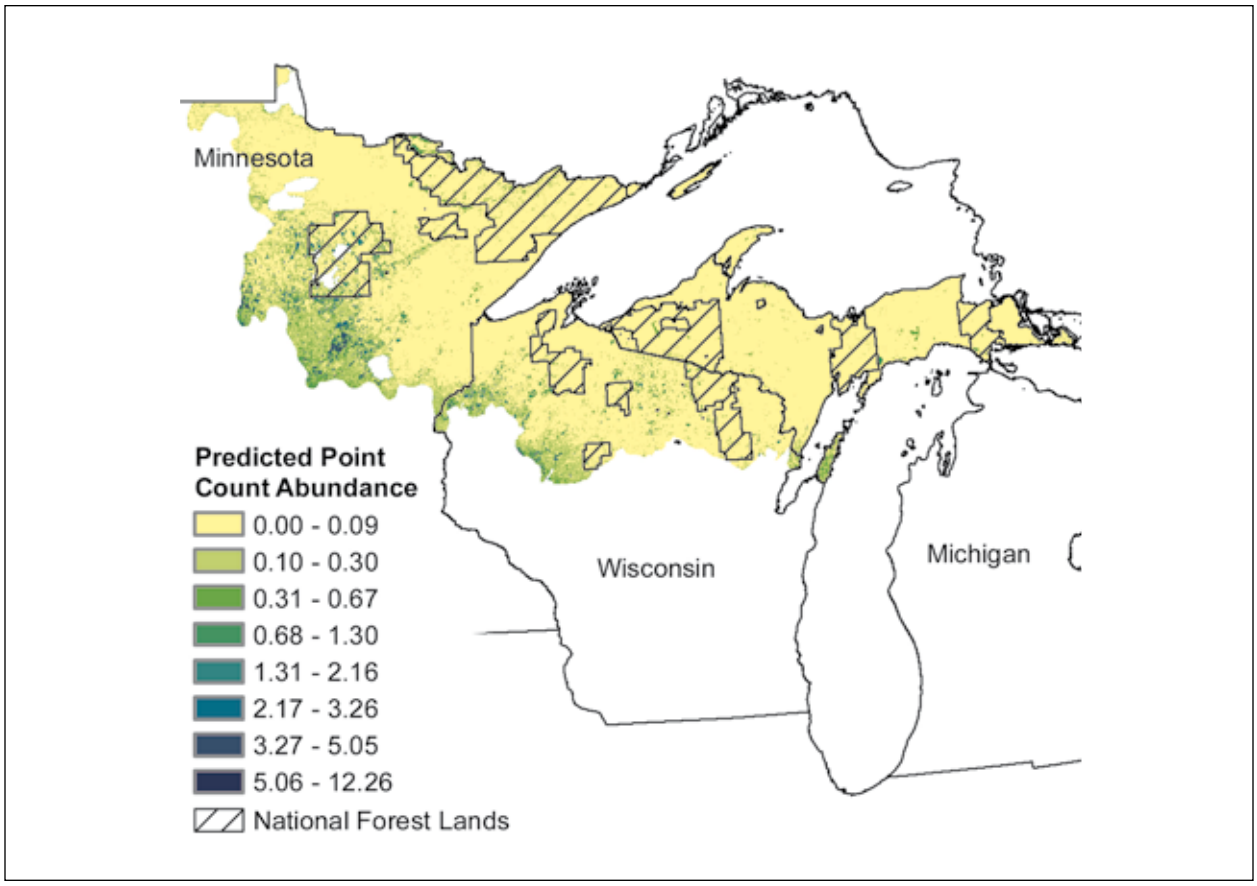
Migration: Long-distance



Trend for Baltimore oriole in one national forest, 1995–2010



Percent perfect indication of habitat association for Baltimore oriole where at least one bird was observed once during the decade (2001–2010; n=253 at 119 points)



Predicted relative abundance (number of birds per 10-minute count) of Baltimore oriole for the western Great Lakes region

Black-and-white Warbler BAWW

Mniotilta varia



Photo by Larry Sirvio, used with permission.

Guild Information

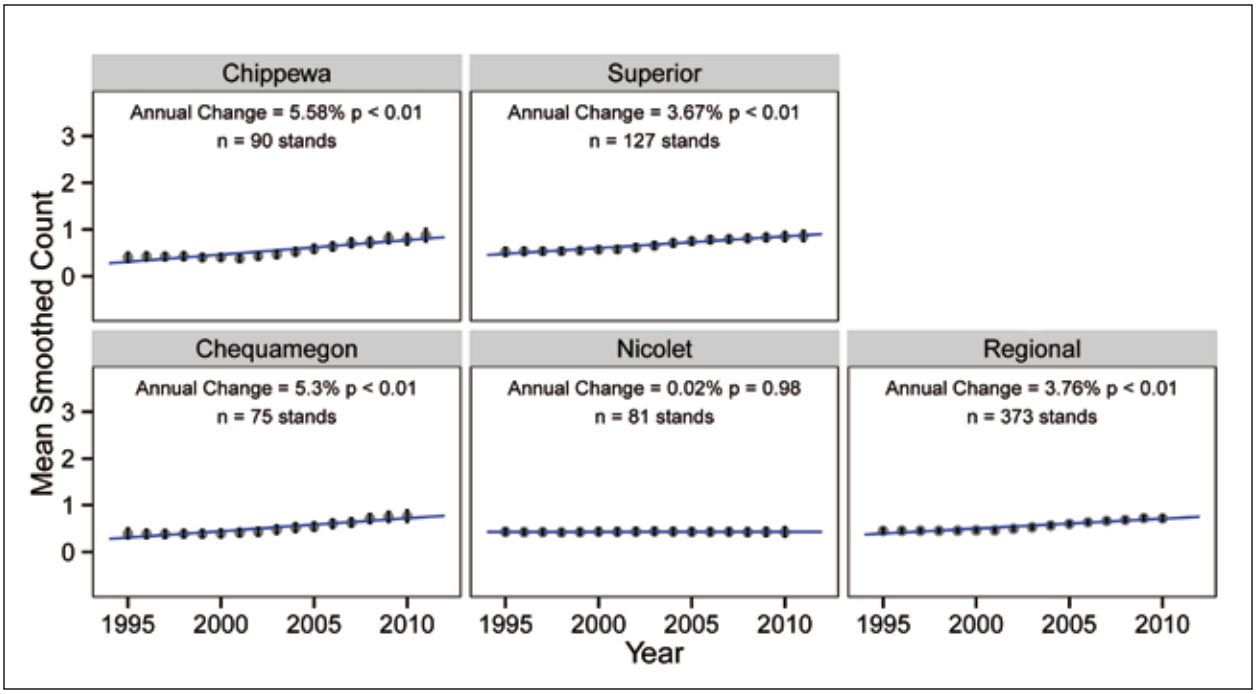
Habitat: Forests—highly variable

Foraging type: Bark gleaner

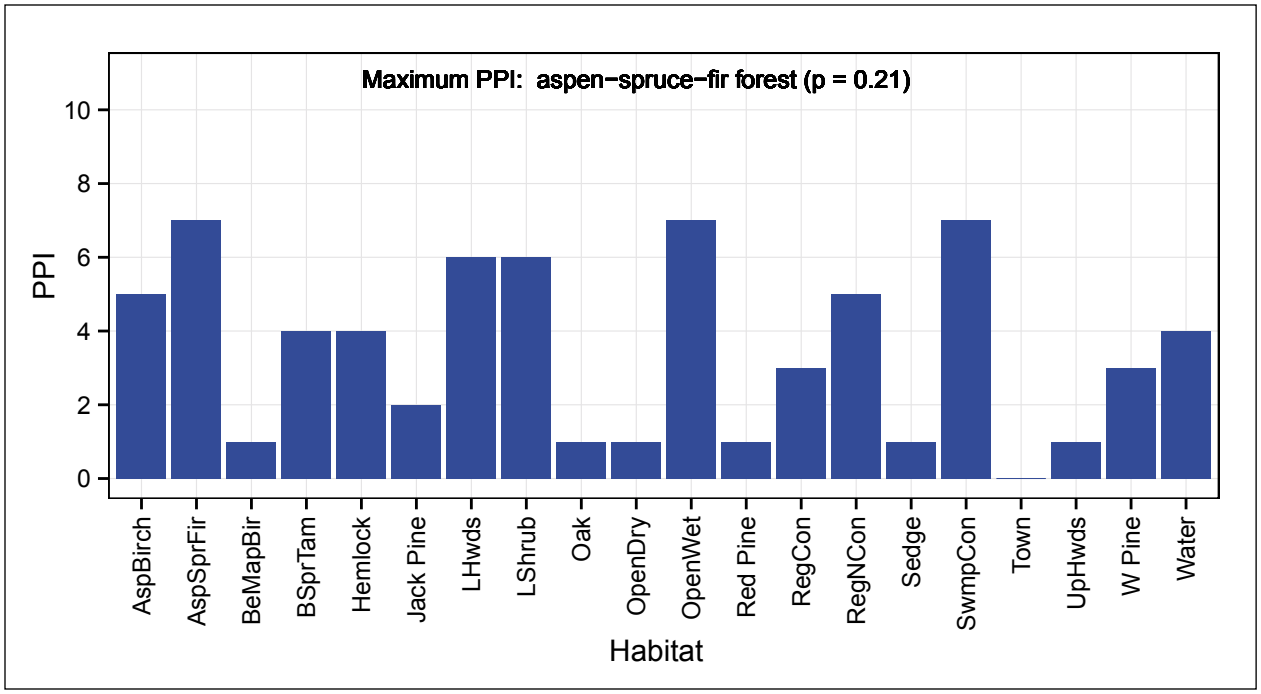
Nest site: Ground

Migration: Long-distance

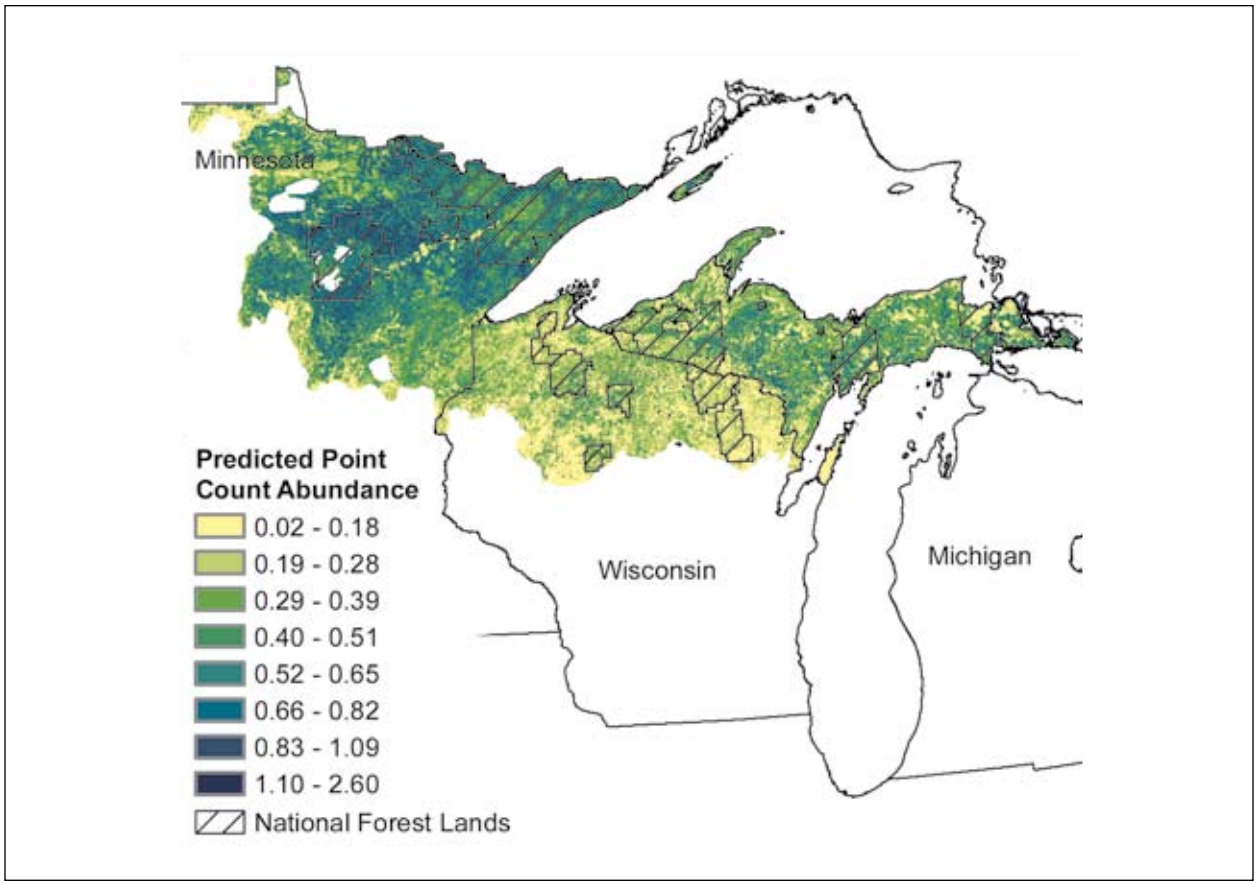
Notes: PPI analysis was not statistically significant for this widespread, moderately common bark forager. Individuals observed in open habitats (OpenDry, OpenWet, Sedge, and Water) probably were transients or residents of adjacent habitats.



Trends for black-and-white warbler in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for black-and-white warbler where at least one bird was observed once during the decade (2001–2010; n=4,117 at 1,151 points)



Predicted relative abundance (number of birds per 10-minute count) of black-and-white warbler for the western Great Lakes region

Blackburnian Warbler BLBW

Setophaga fusca



Photo by Jon Swanson, used with permission.

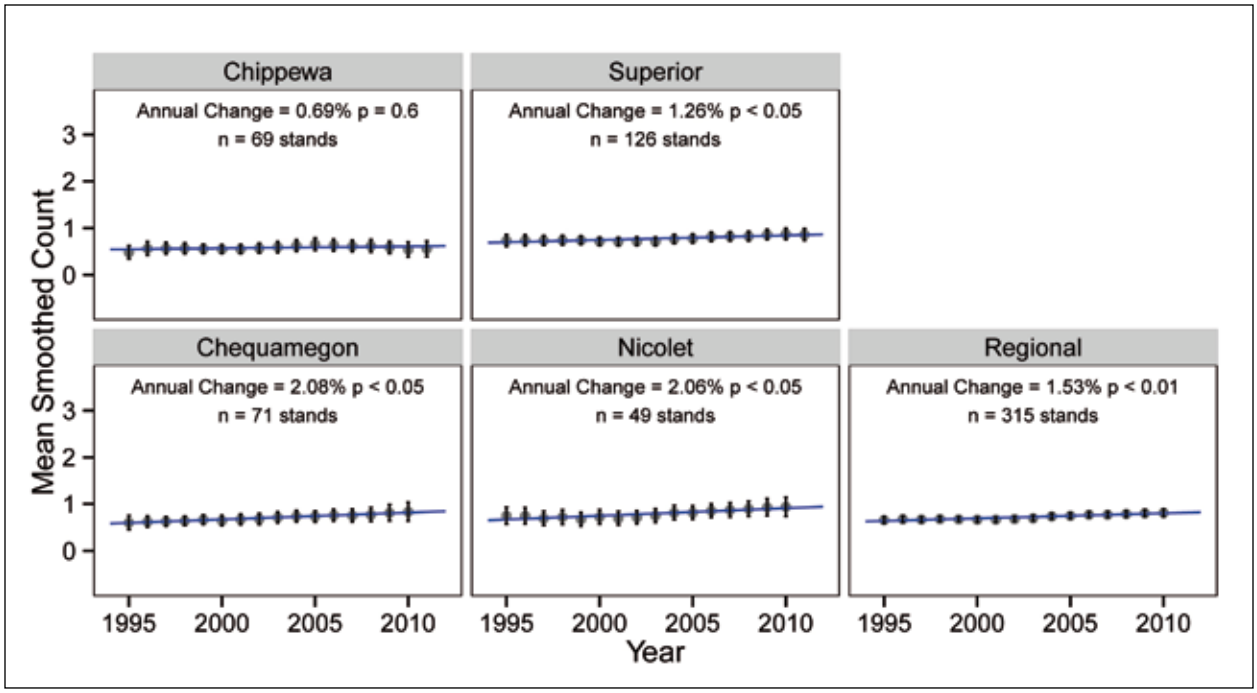
Guild Information

Habitat: Mature conifer forests

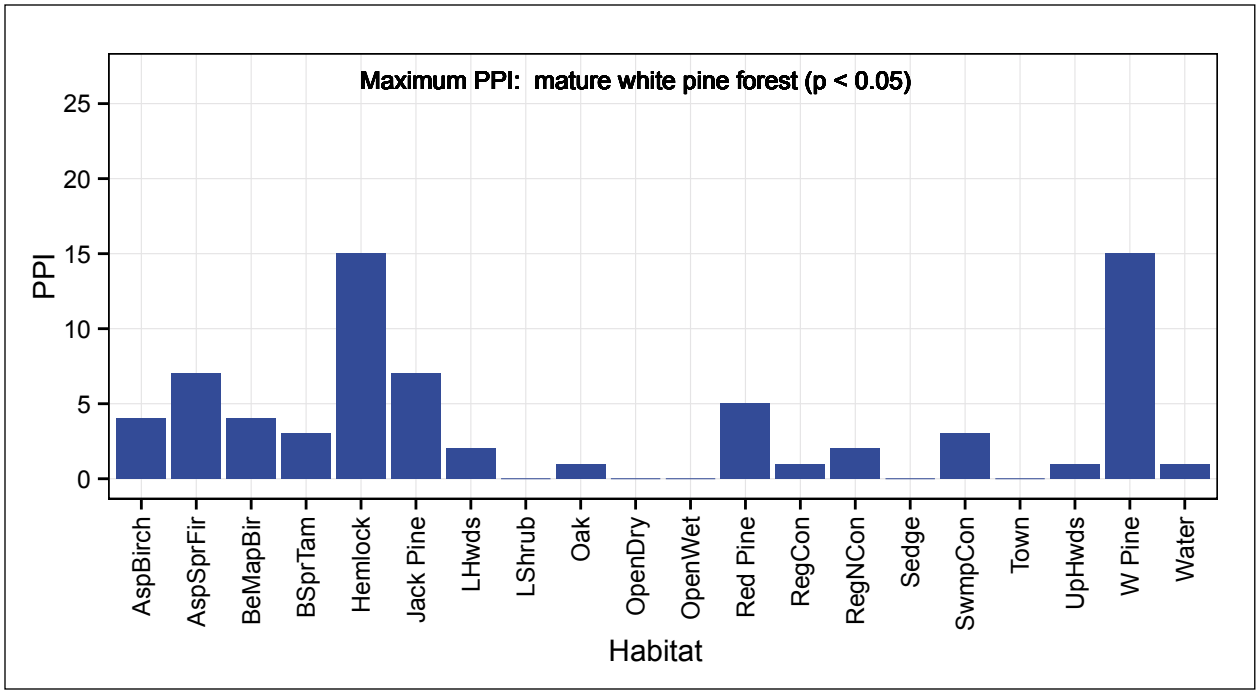
Foraging type: Foliage gleaner

Nest site: Canopy

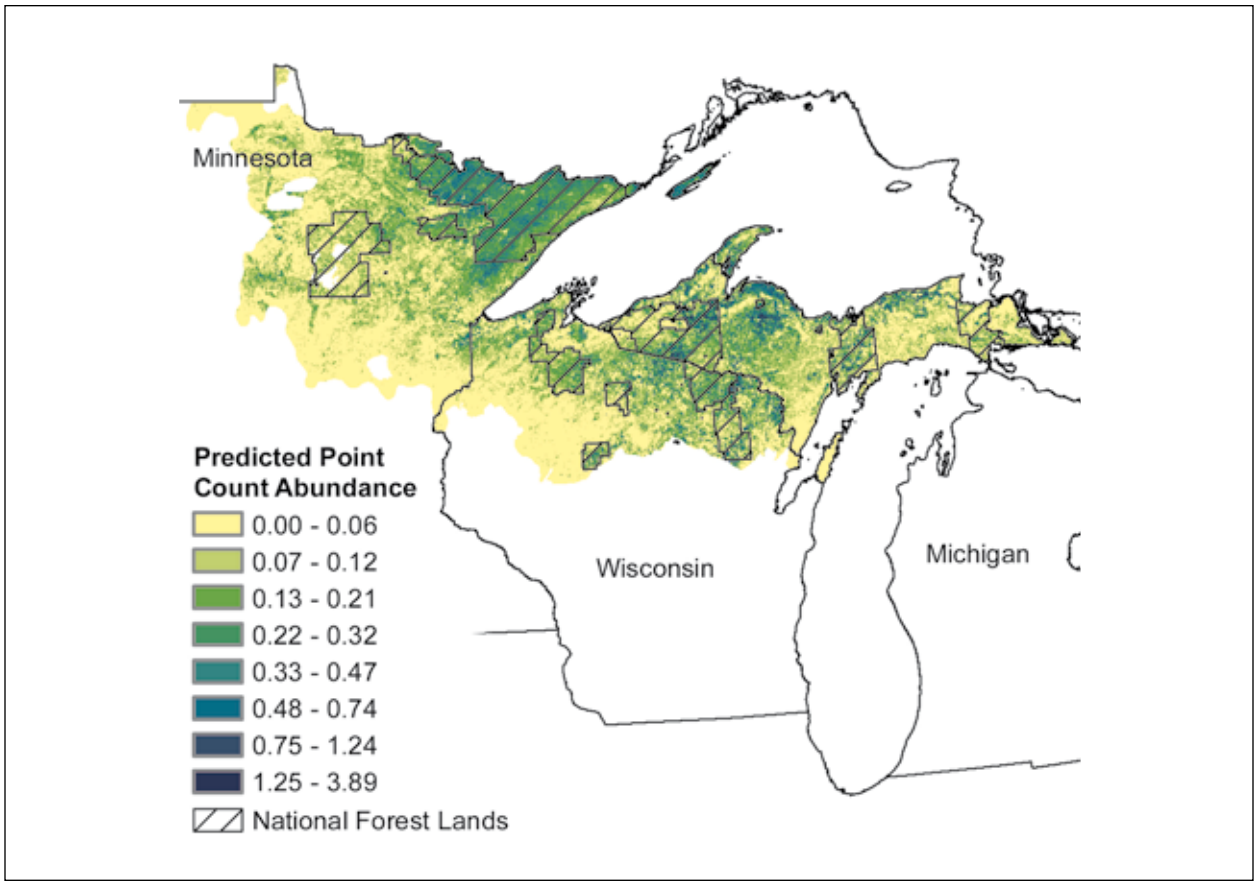
Migration: Long-distance



Trends for Blackburnian warbler in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for Blackburnian warbler where at least one bird was observed once during the decade (2001–2010; n=4,087 at 974 points)



Predicted relative abundance (number of birds per 10-minute count) of Blackburnian warbler for the western Great Lakes region

Black-capped Chickadee BCCH

Poecile atricapillus



Photo by Bruce Lees, used with permission.

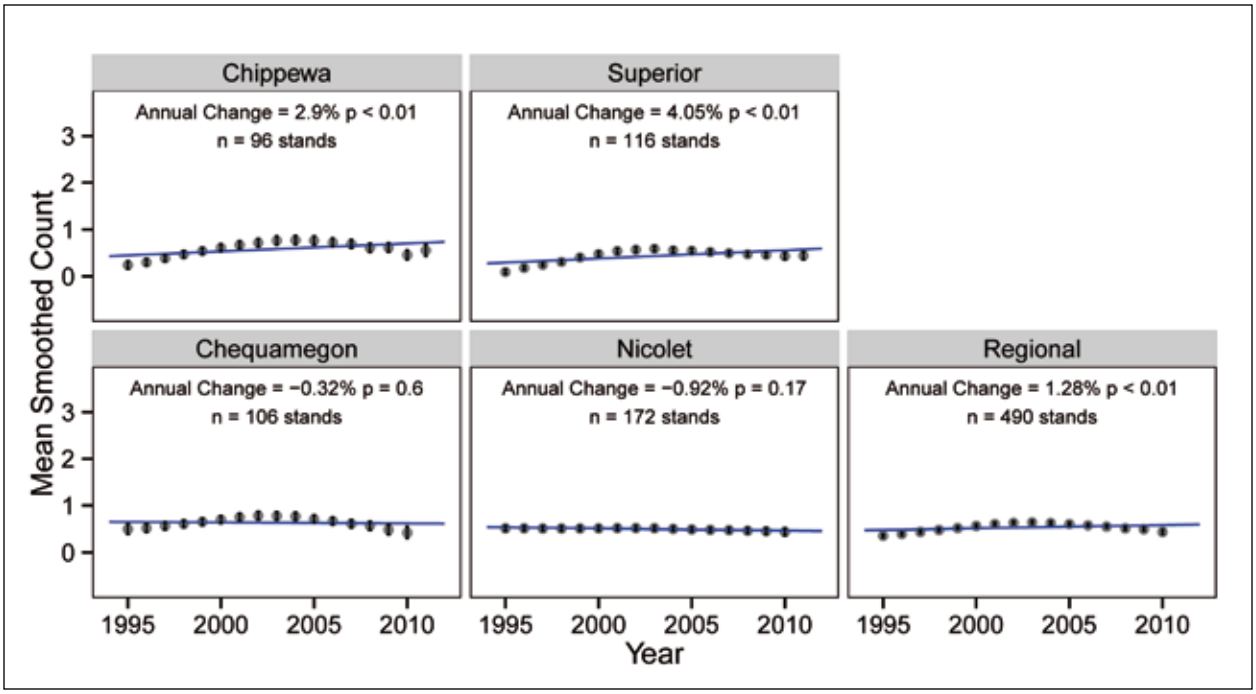
Guild Information

Habitat: Human settlements, forests

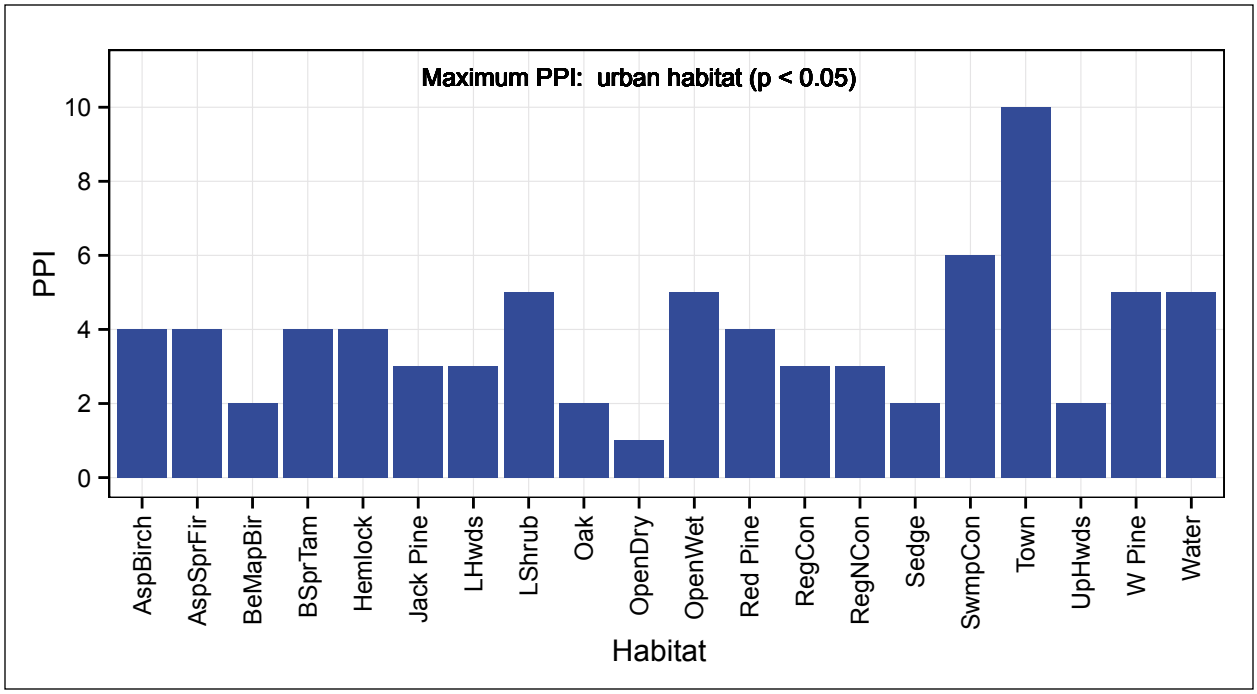
Foraging type: Omnivore—seeds, invertebrates

Nest site: Cavity

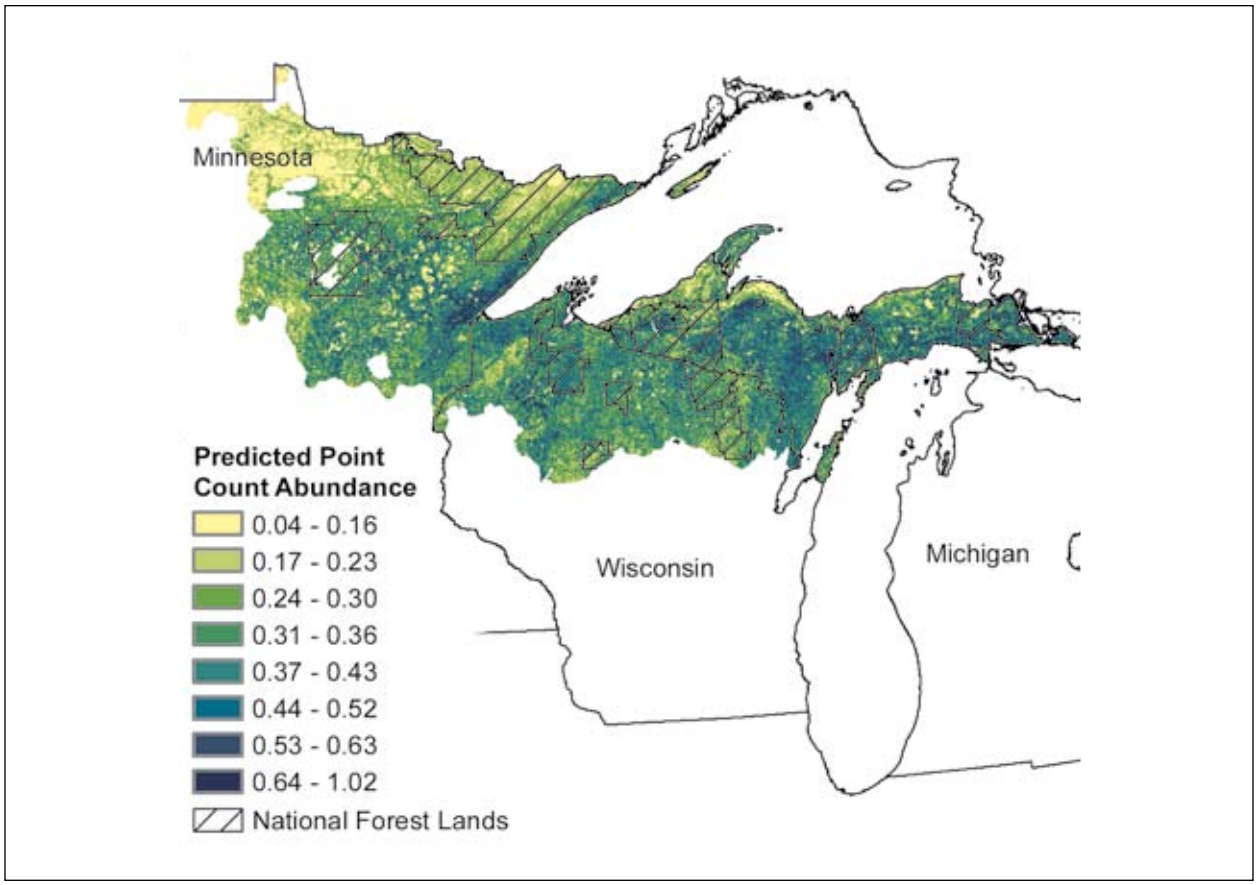
Migration: Permanent resident



Trends for black-capped chickadee in four national forests, 1995–2010



Percent perfect indication of habitat association for black-capped chickadee where at least one bird was observed once during the decade (2001–2010; n=4,950 at 1,304 points)



Predicted relative abundance (number of birds per 10-minute count) of black-capped chickadee for the western Great Lakes region

Black-throated Blue Warbler BTBW

Setophaga caerulescens



Photo by Jon Swanson, used with permission.

Guild Information

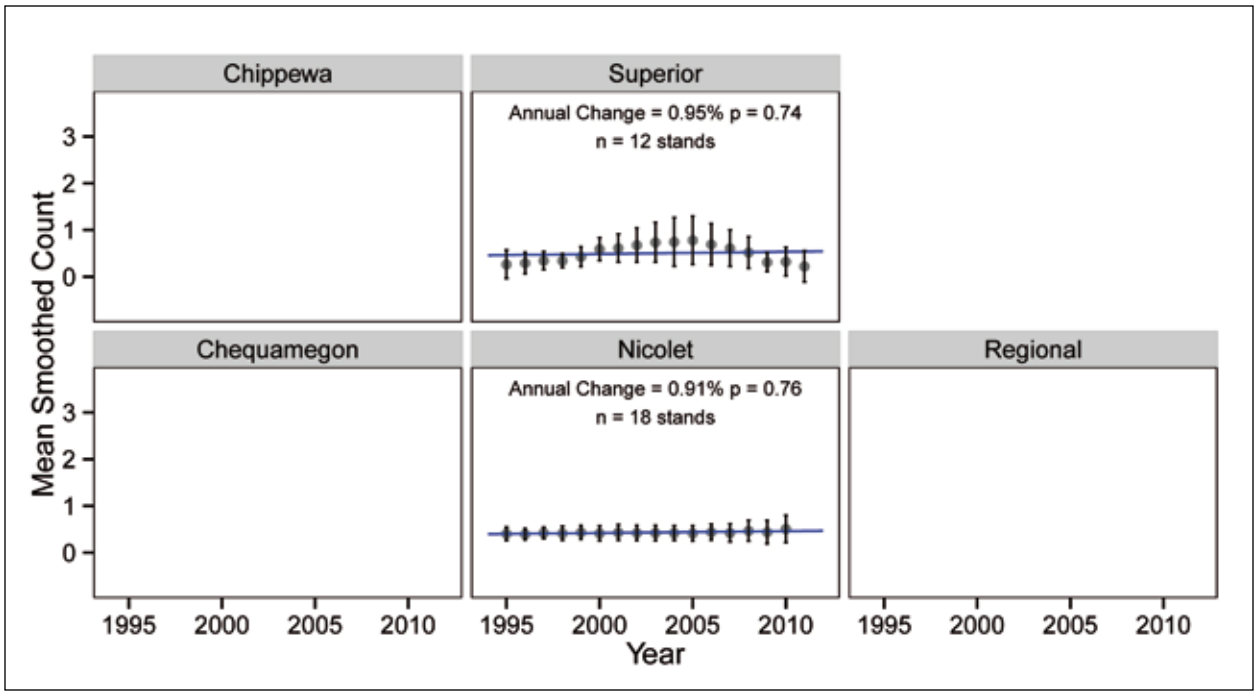
Habitat: Mixed forests with shrub understory

Foraging type: Foliage gleaner

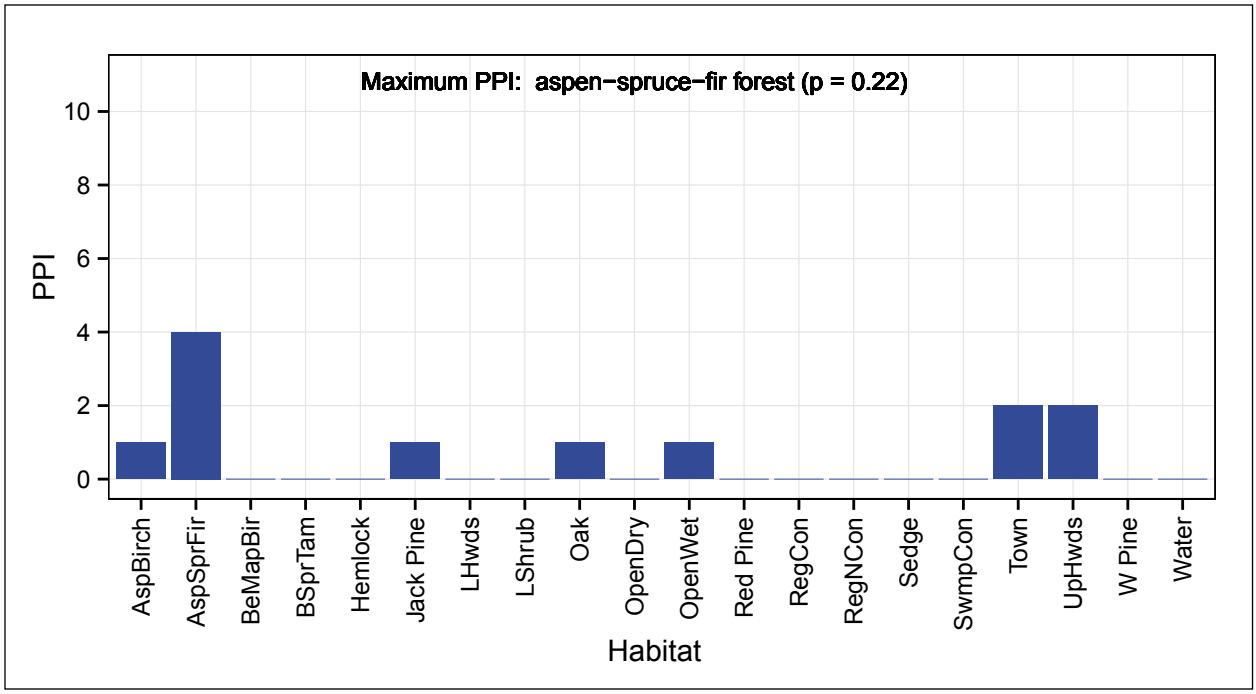
Nest site: Shrub or subcanopy

Migration: Long-distance

Notes: PPI analysis was not statistically significant for this uncommon forest species. Most observations were at sites dominated by hardwoods or aspen (occasionally conifers) with shrubby understory. Individuals observed at OpenWet and Town points probably were transients or residents of adjacent habitats; PPI values for these two habitats reflect the small number of sample points (BTBW was observed at 1 of the 6 Town points and 1 of the 9 OpenWet points).



Trends for black-throated blue warbler in two national forests, 1995–2010



Percent perfect indication of habitat association for black-throated blue warbler where at least one bird was observed once during the decade (2001–2010; n=331 at 130 points)

Black-throated Green Warbler BTNW

Setophaga virens



Photo by Bruce Lees, used with permission.

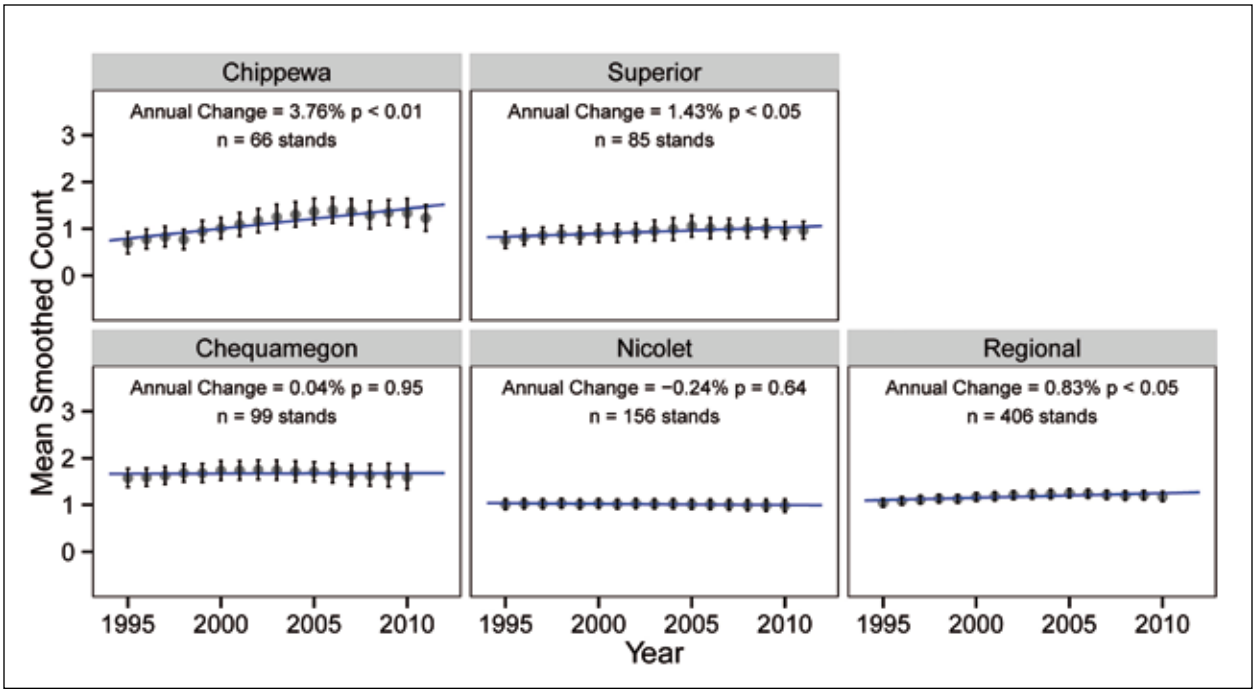
Guild Information

Habitat: Mature mixed forests

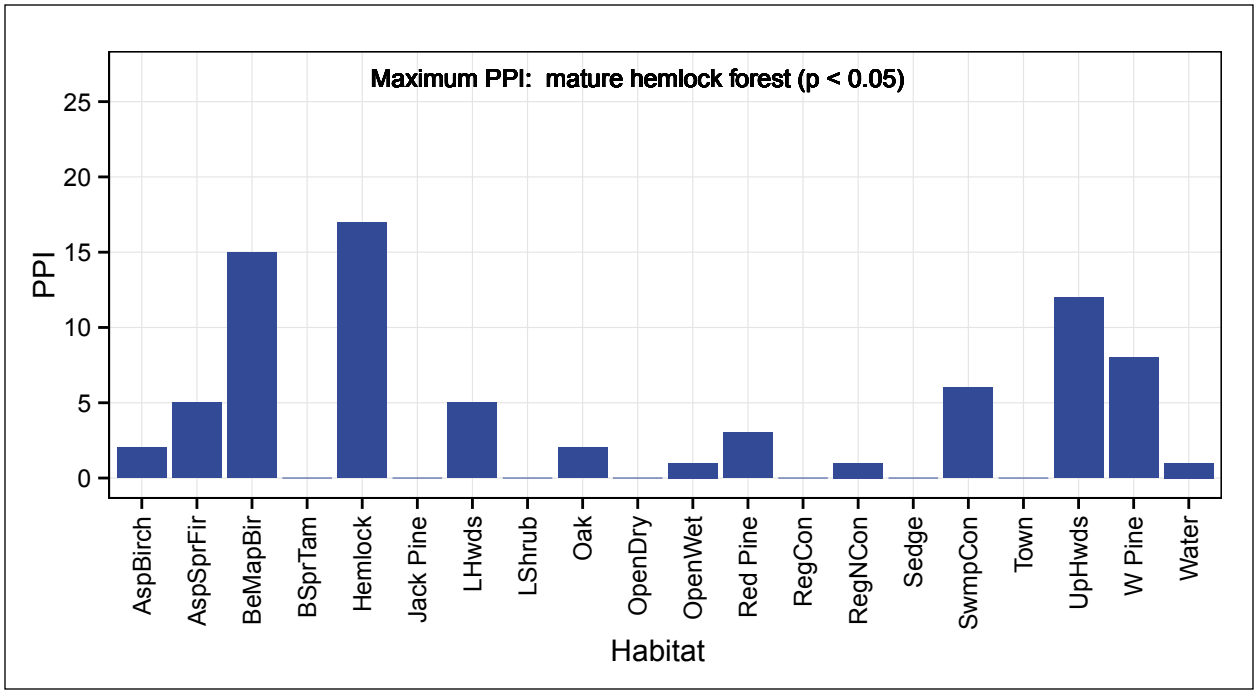
Foraging type: Foliage gleaner

Nest site: Canopy

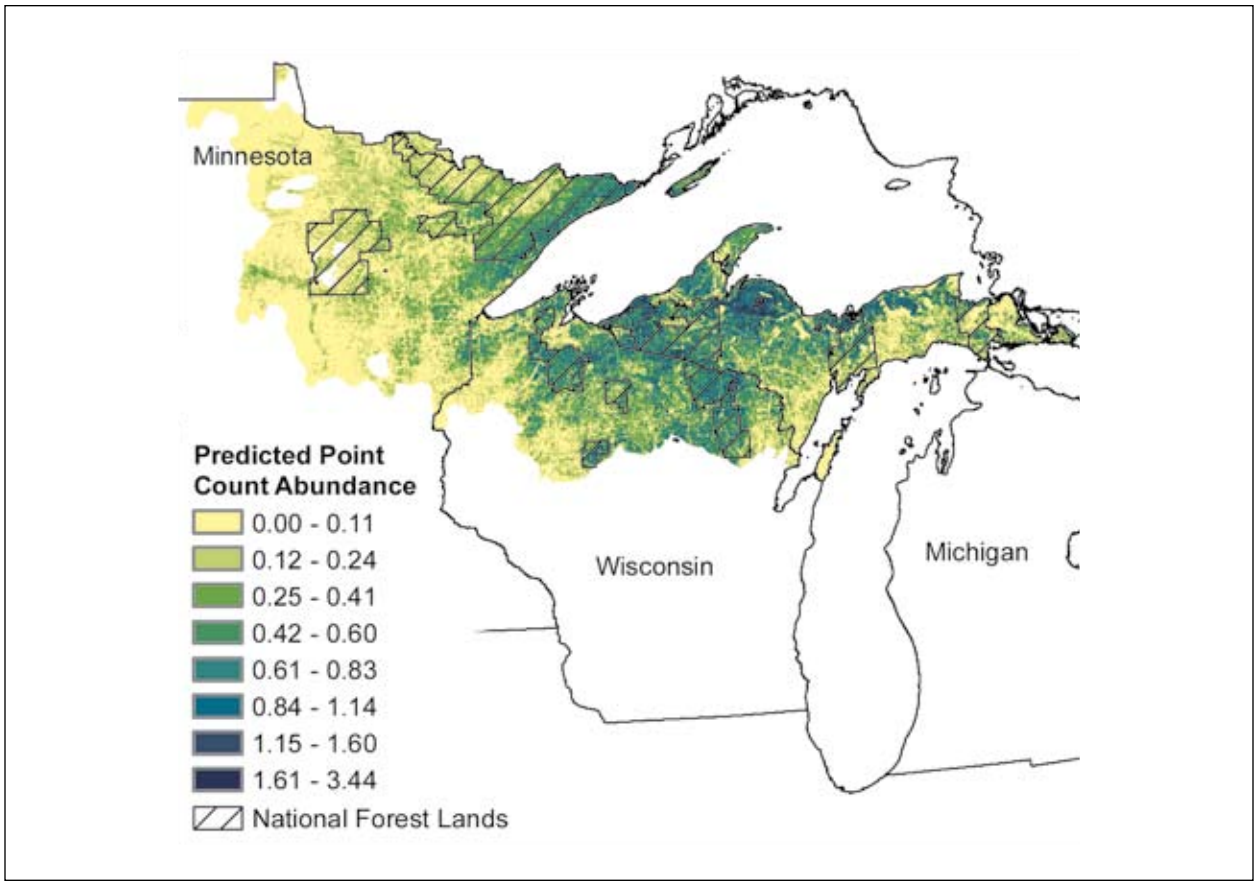
Migration: Long-distance



Trends for black-throated green warbler in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for black-throated green warbler where at least one bird was observed once during the decade (2001–2010; n=7,245 at 1,030 points)



Predicted relative abundance (number of birds per 10-minute count) of black-throated green warbler for the western Great Lakes region

Blue Jay BLJA

Cyanocitta cristata



©Mike Lentz, www.mikelentzphotography.com, used with permission.

Guild Information

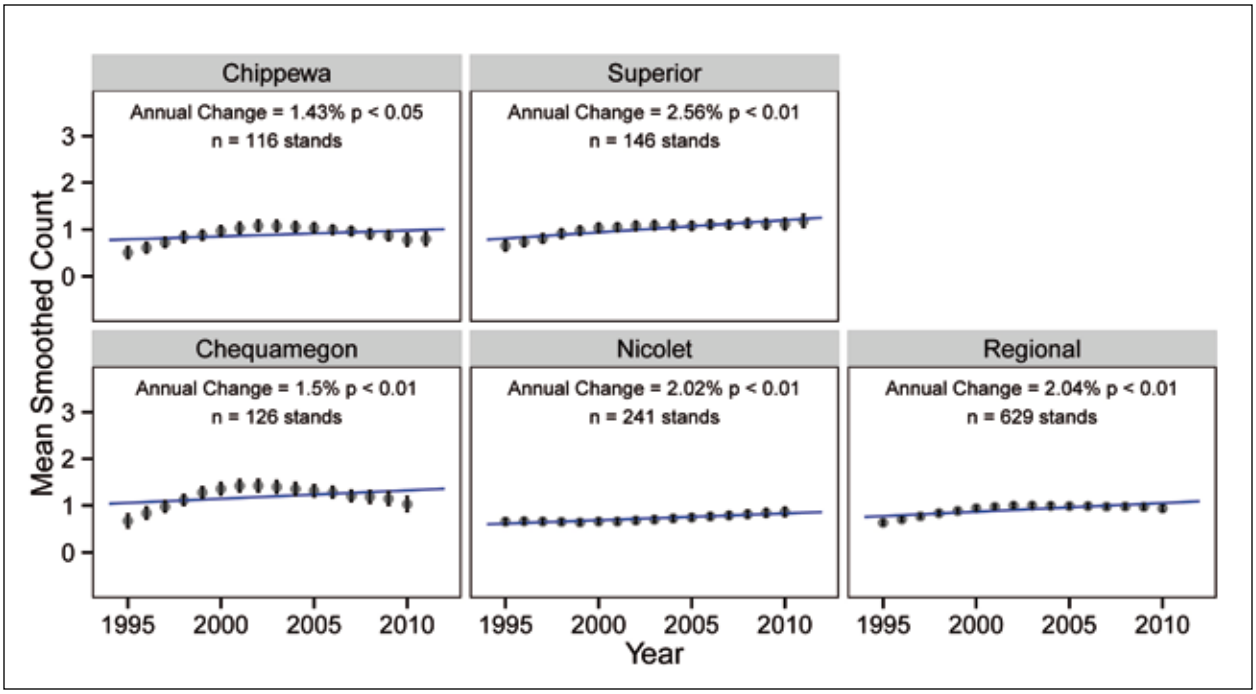
Habitat: Forests, highly variable

Foraging type: Omnivore

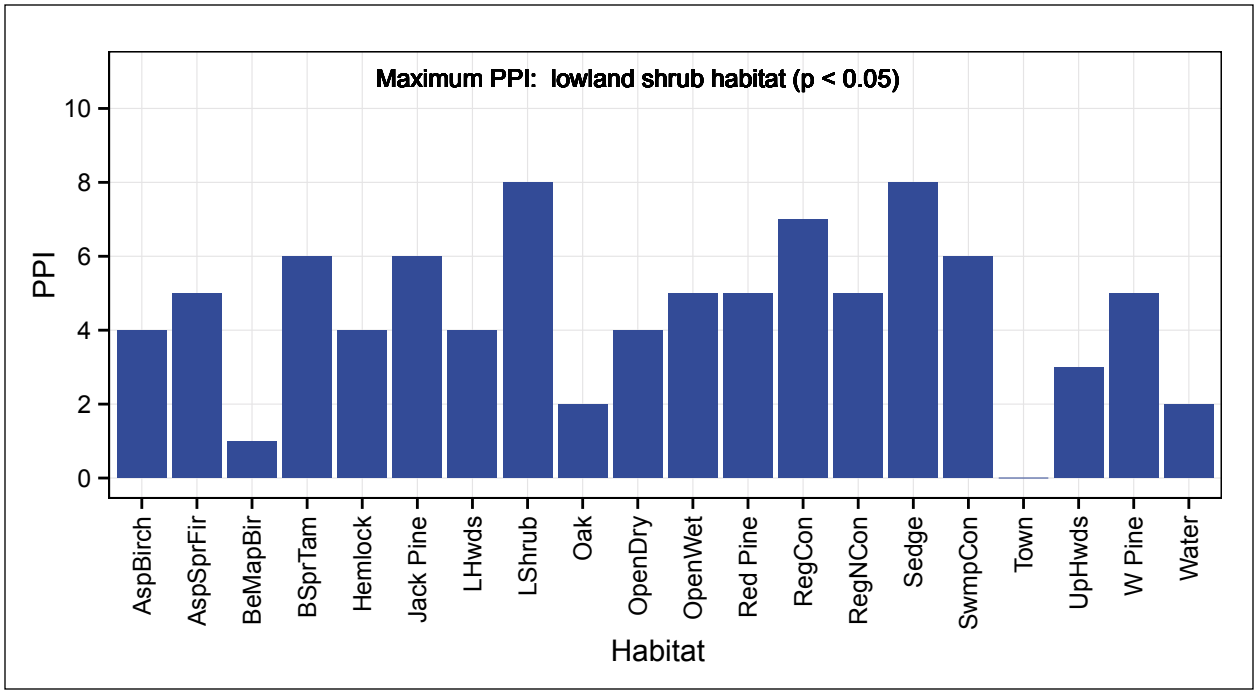
Nest site: Canopy

Migration: Semi-permanent resident, short-distance migrant

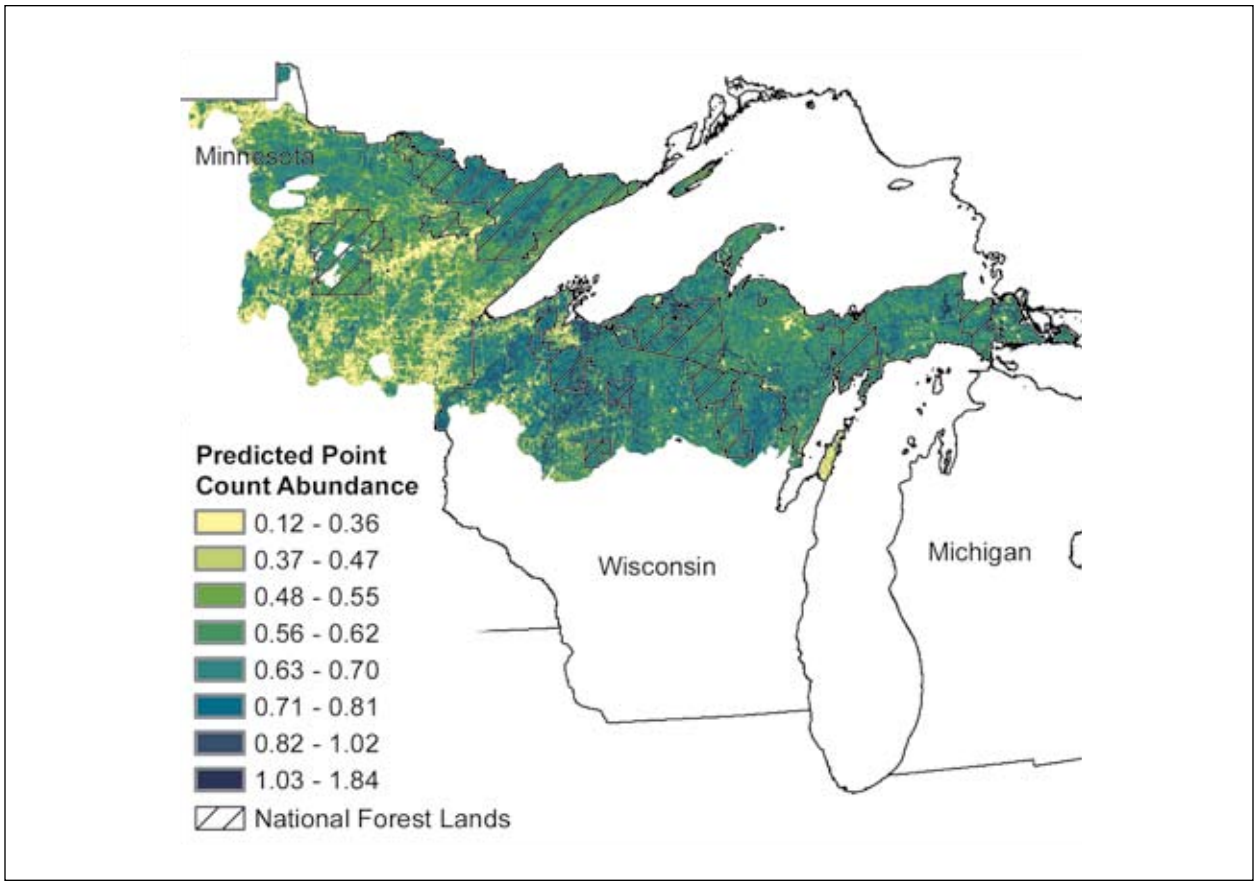
Notes: This conspicuous and easily detected forest/woodland species was observed in most habitats. Individuals observed in nonforest habitats like OpenWet and Sedge probably were transients or residents of adjacent habitats.



Trends for blue jay in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for blue jay where at least one bird was observed once during the decade (2001–2010; n=10,100 at 1,570 points)



Predicted relative abundance (number of birds per 10-minute count) of blue jay for the western Great Lakes region

Blue-headed Vireo BHVI

Vireo solitarius



Photo by Jon Swanson, used with permission.

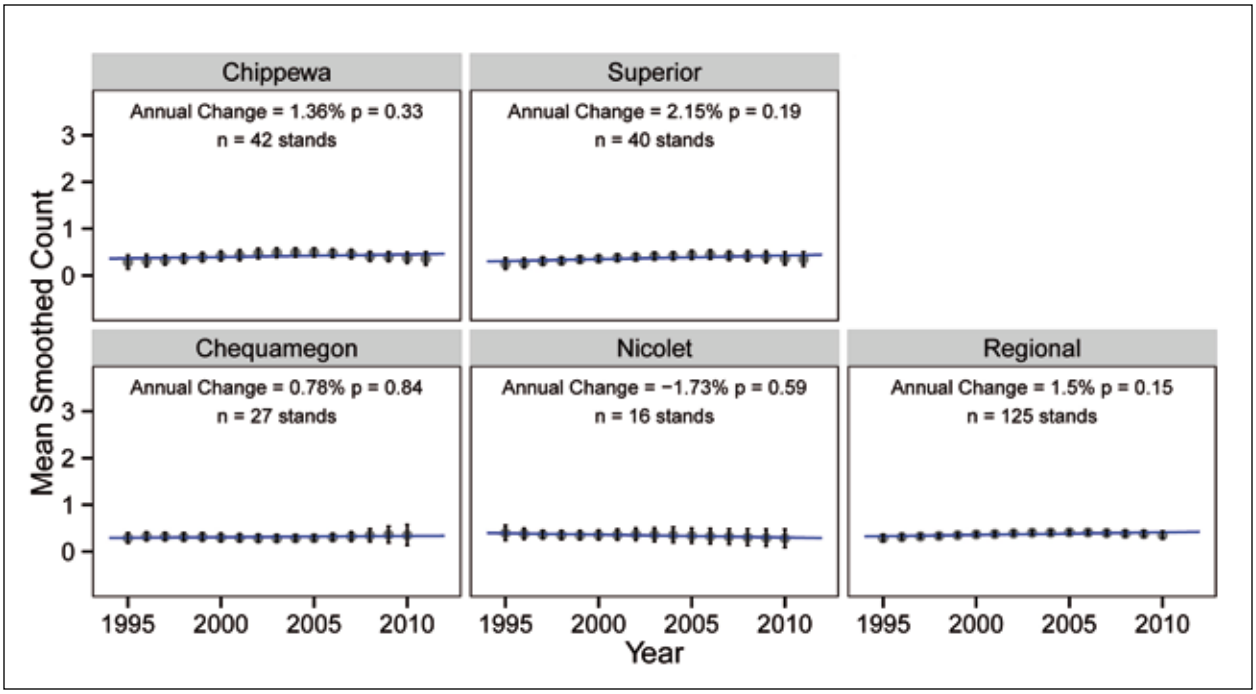
Guild Information

Habitat: Conifer forests, especially black spruce-tamarack lowlands

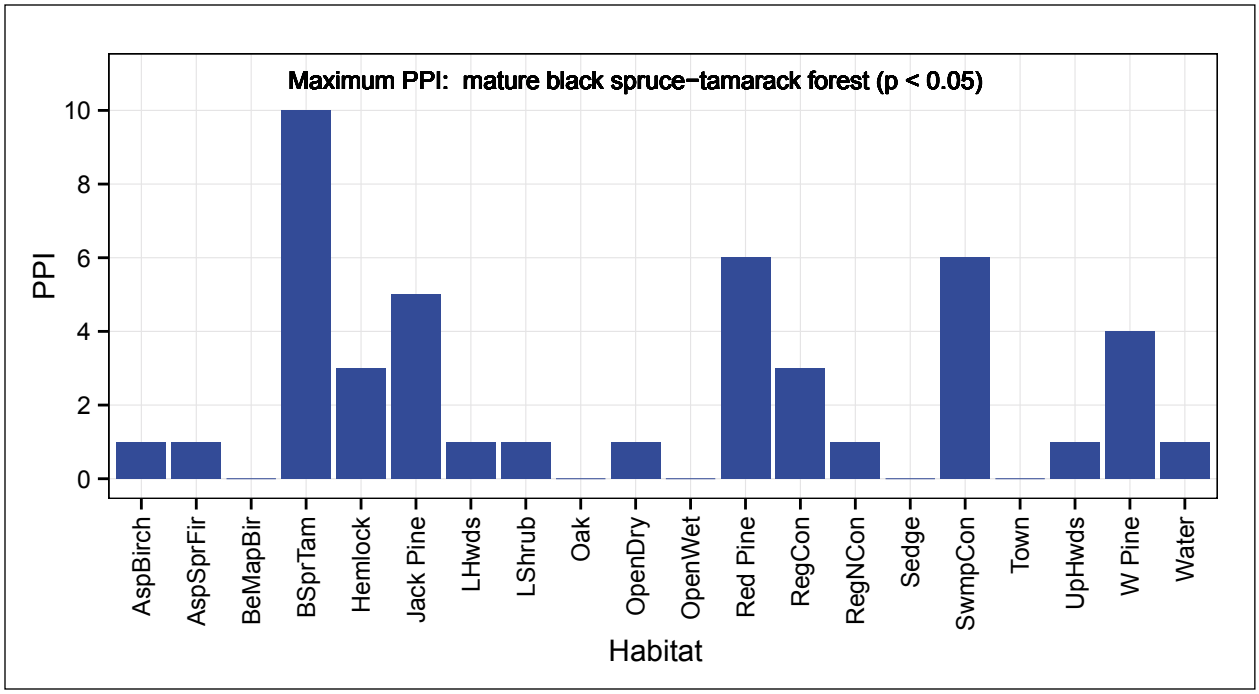
Foraging type: Foliage gleaner

Nest site: Shrub or subcanopy

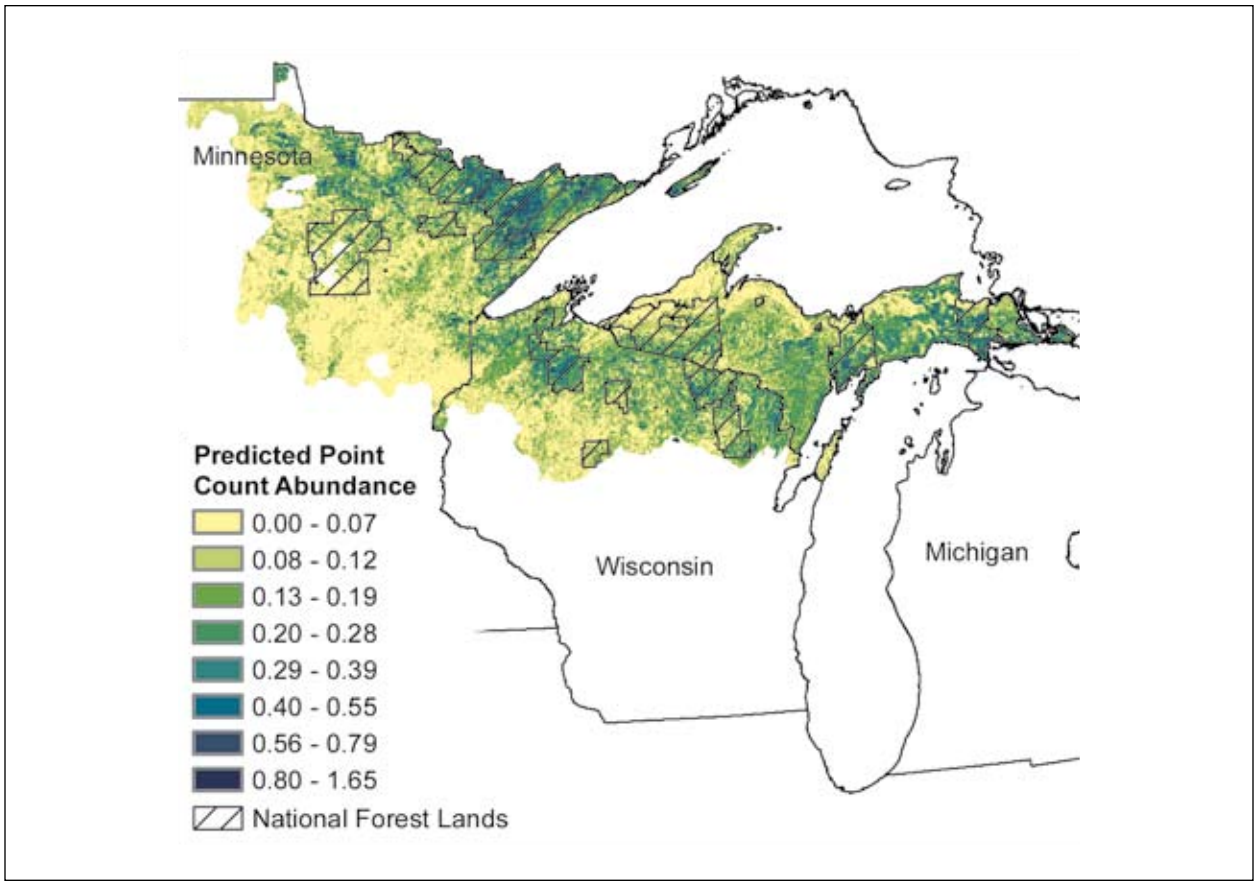
Migration: Long-distance



Trends for blue-headed vireo in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for blue-headed vireo where at least one bird was observed once during the decade (2001–2010; n=1,425 at 624 points)



Predicted relative abundance (number of birds per 10-minute count) of blue-headed vireo for the western Great Lakes region

Brewer's Blackbird BRBL

Euphagus cyanocephalus



Photo by Larry Sirvio, used with permission.

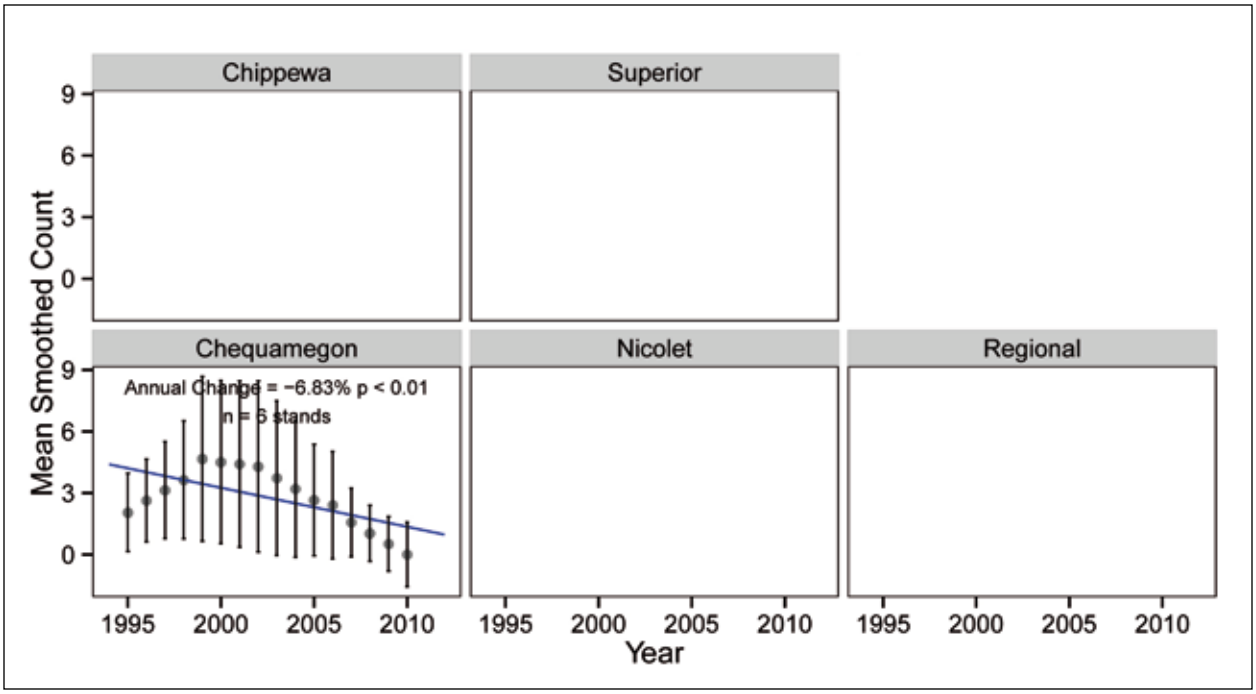
Guild Information

Habitat: Open dry areas, roadsides

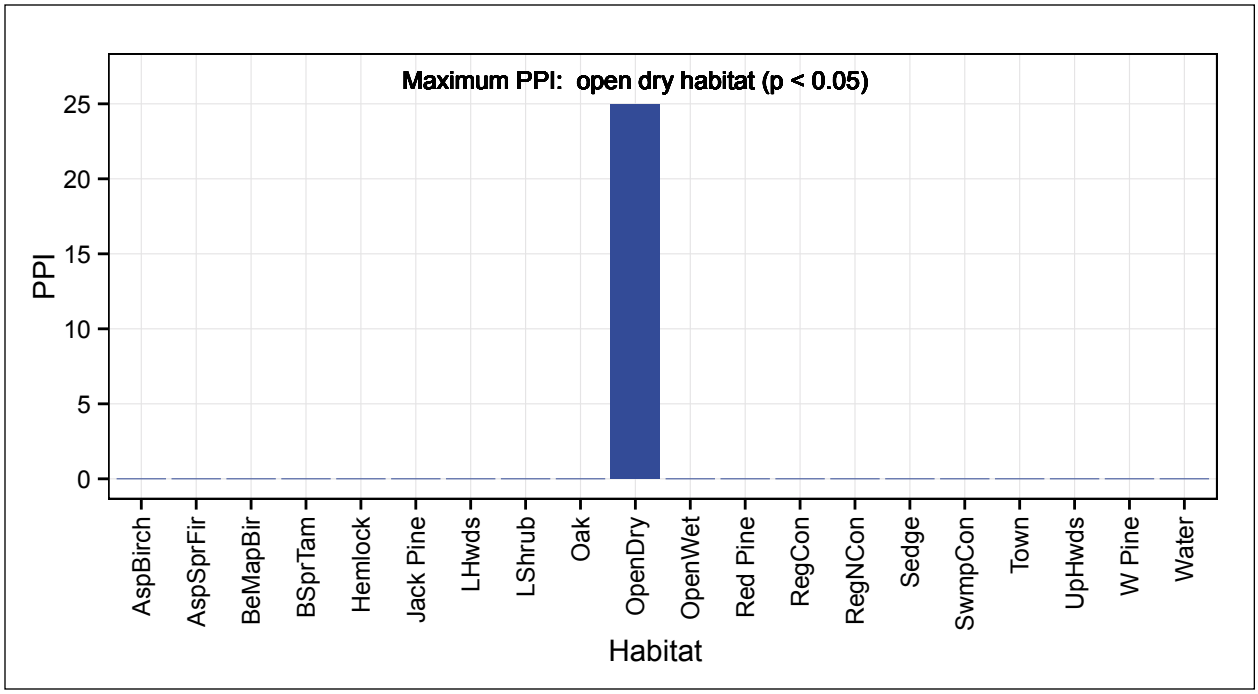
Foraging type: Omnivore

Nest site: Ground

Migration: Short-distance



Trend for Brewer's blackbird in one national forest, 1995–2010



Percent perfect indication of habitat association for Brewer's blackbird where at least one bird was observed once during the decade (2001–2010; n=259 at 32 points)

Broad-winged Hawk BWHA

Buteo platypterus



Photo by Edmund Zlonis, Natural Resources Research Institute, used with permission.

Guild Information

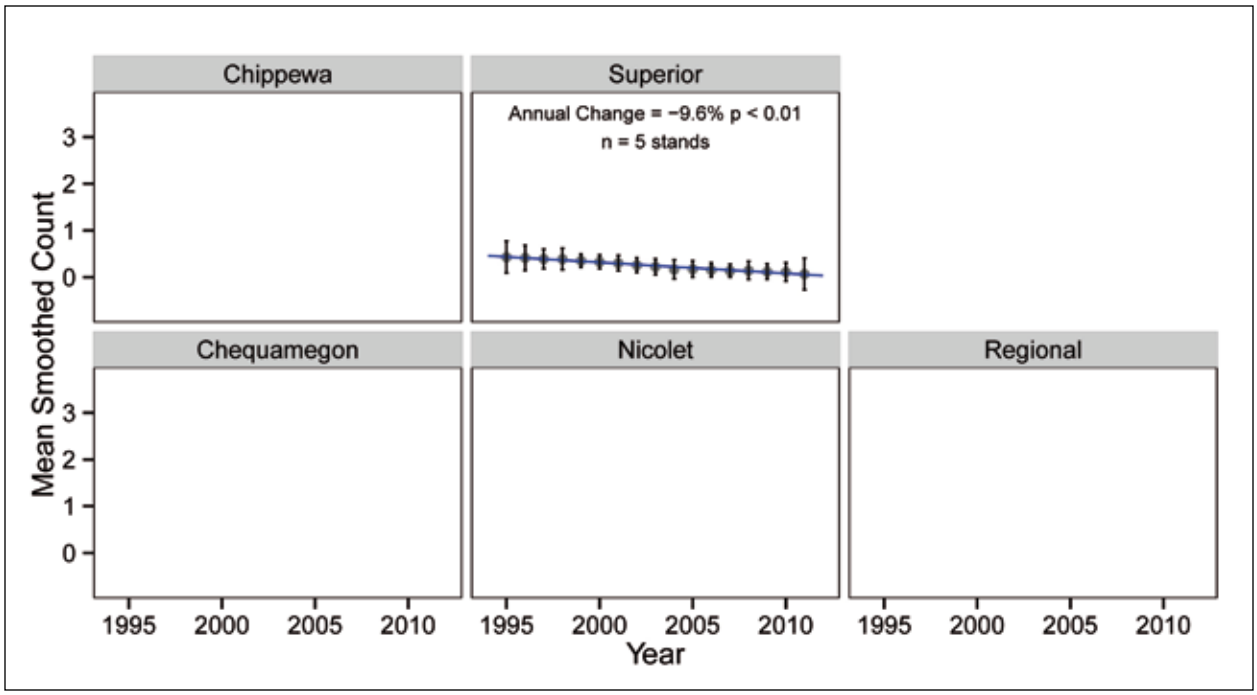
Habitat: Forested areas, edges for foraging

Foraging type: Predator—small vertebrates, large insects

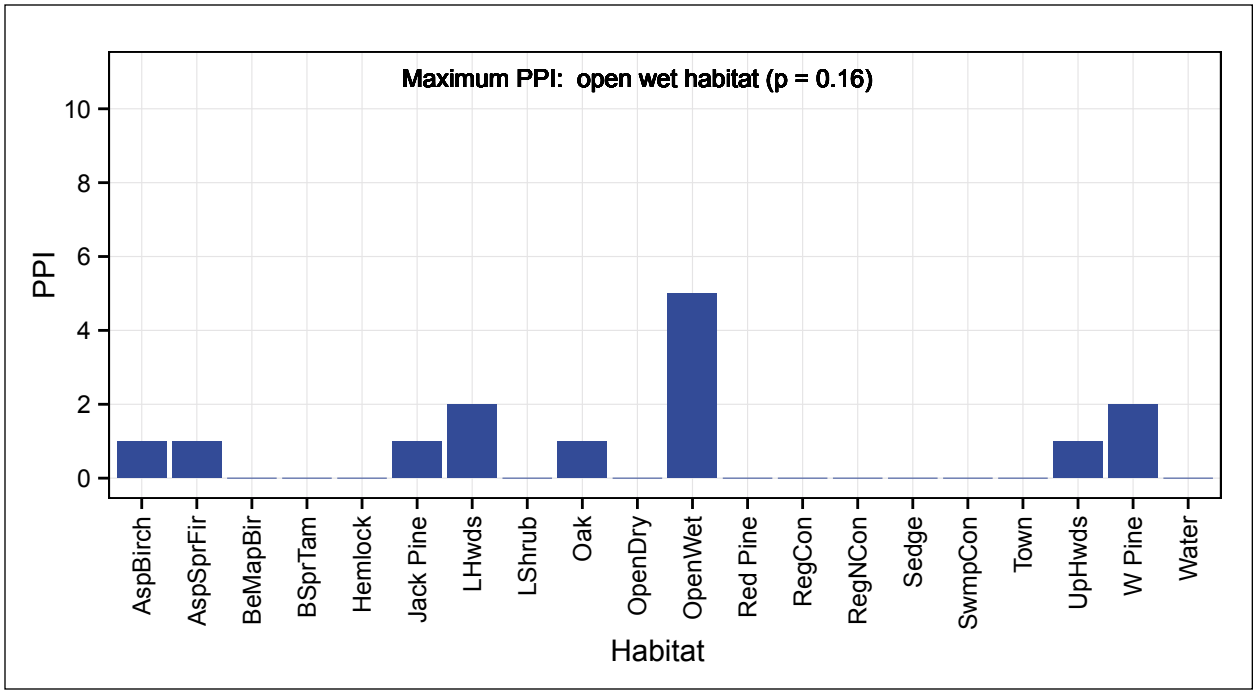
Nest site: Canopy

Migration: Long-distance

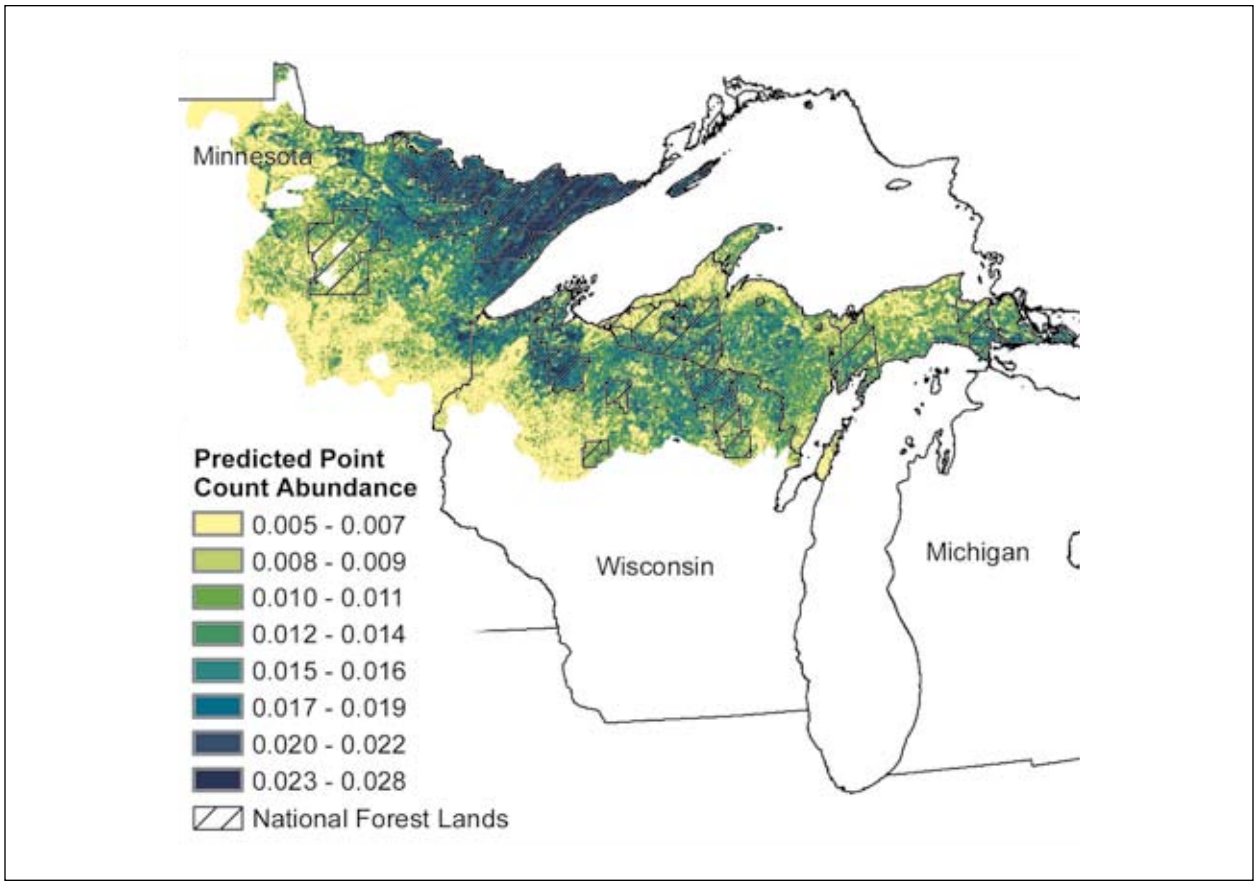
Notes: PPI analysis was not statistically significant for this widespread but secretive forest raptor. Observations in OpenWet probably were transients or residents of adjacent habitat; PPI value for OpenWet also reflects the small number of sample points for that habitat (BWHA was observed at 2 of the 9 OpenWet points).



Trend for broad-winged hawk in one national forest, 1995–2010



Percent perfect indication of habitat association for broad-winged hawk where at least one bird was observed once during the decade (2001–2010; n=271 at 185 points)



Predicted relative abundance (number of birds per 10-minute count) of broad-winged hawk for the western Great Lakes region

Brown Creeper BRCR

Certhia Americana



Photo by Jon Swanson, used with permission.

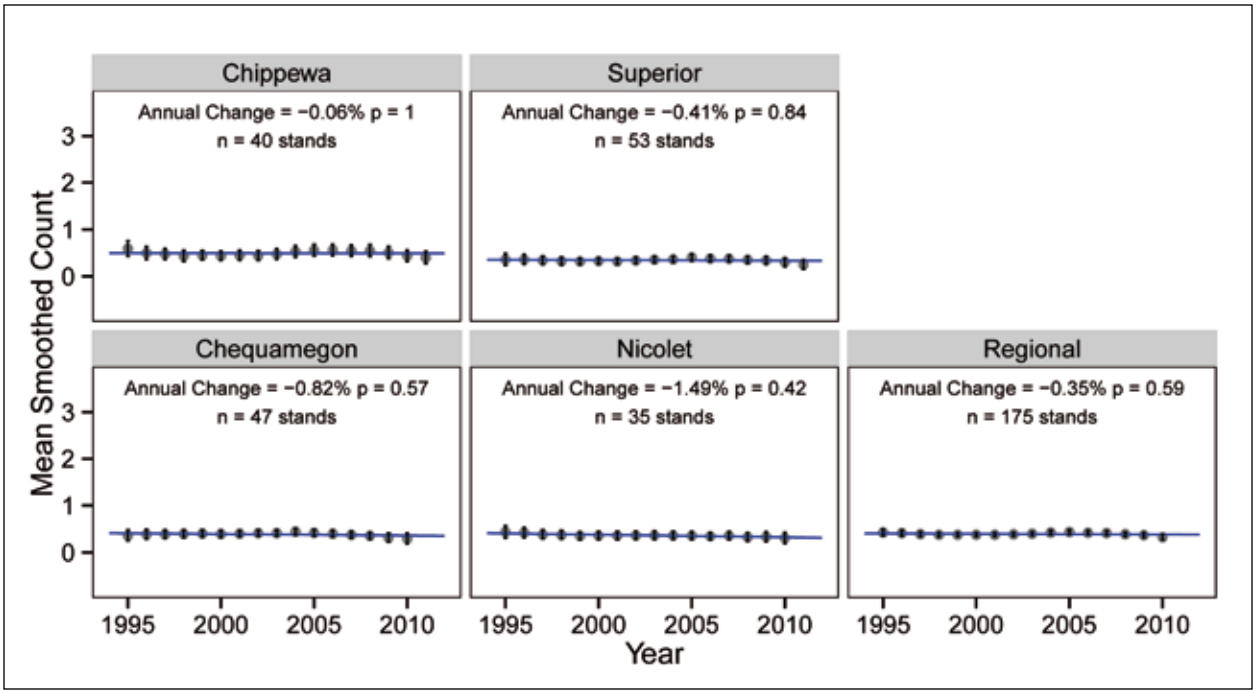
Guild Information

Habitat: Mature forests, lowland forests

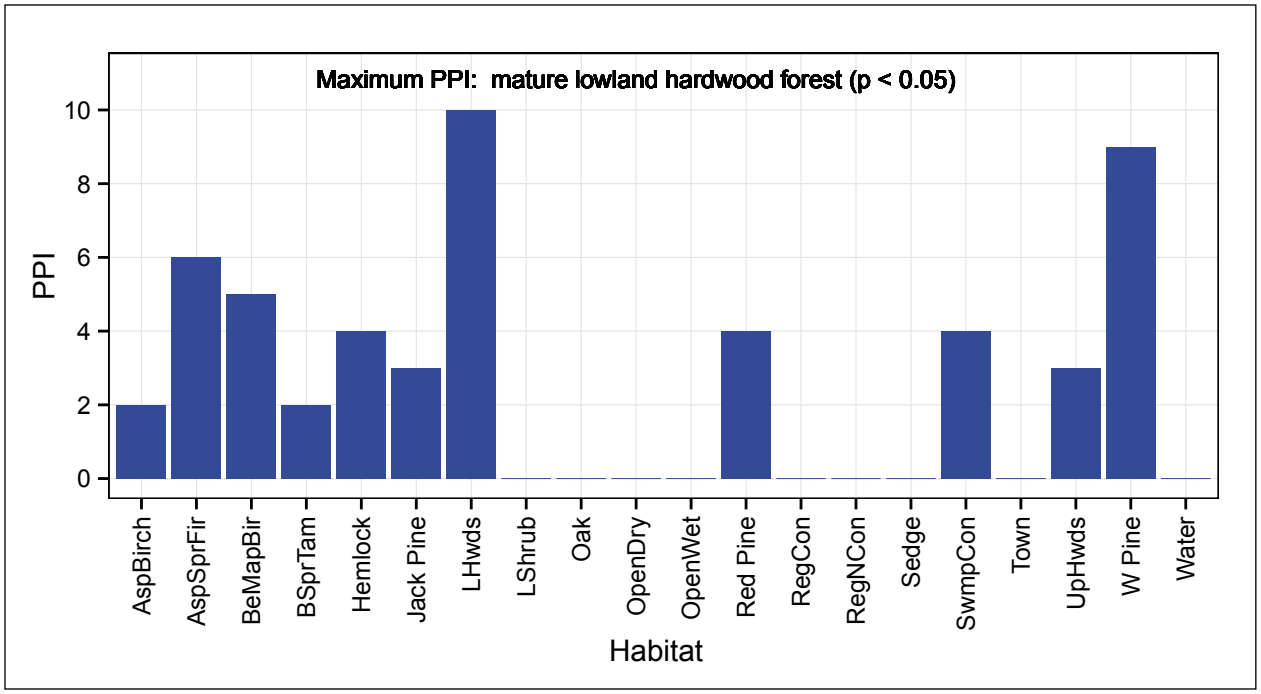
Foraging type: Bark gleaner

Nest site: Cavity

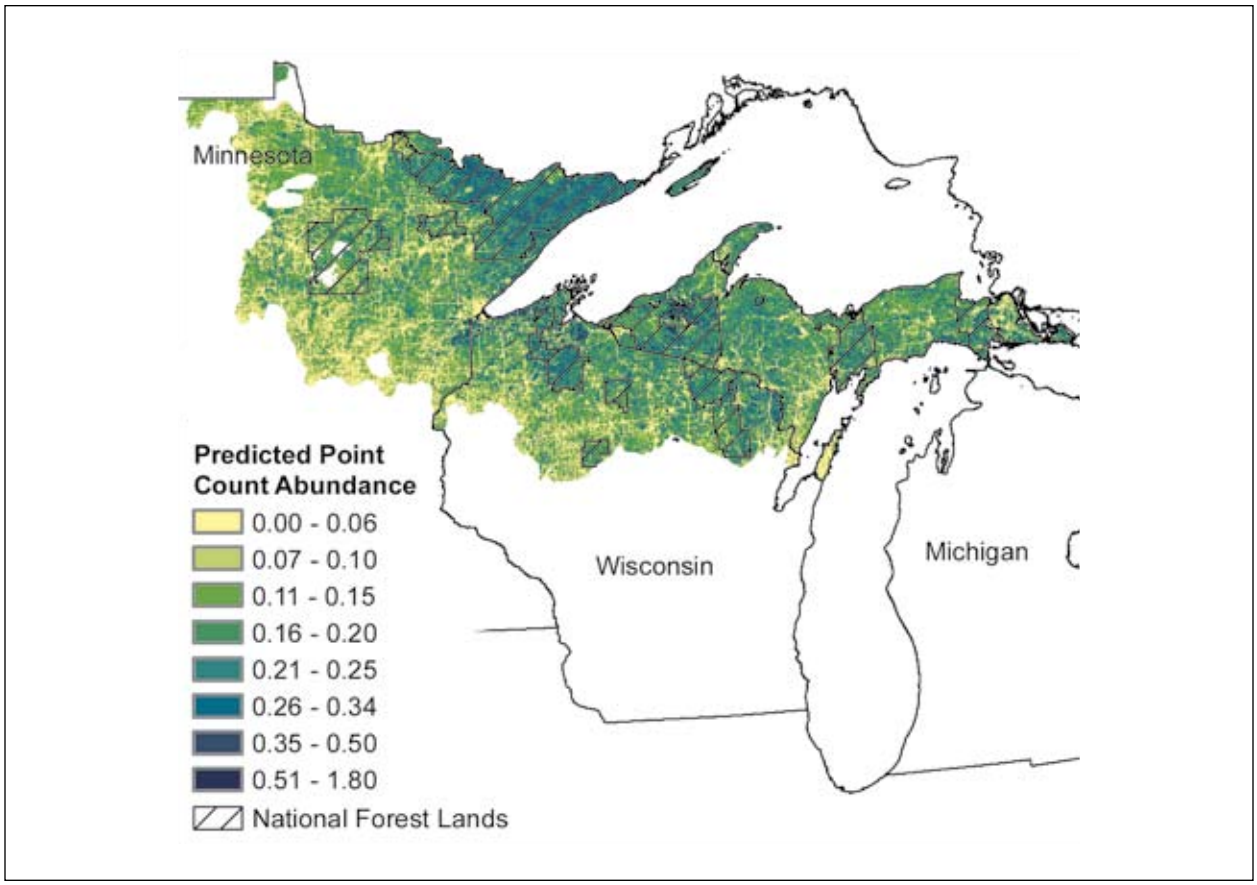
Migration: Short-distance



Trends for brown creeper in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for brown creeper where at least one bird was observed once during the decade (2001–2010; n=1,533 points at 672 points)



Predicted relative abundance (number of birds per 10-minute count) of brown creeper for the western Great Lakes region

Brown Thrasher BRTH

Toxostoma rufum



Photo by Larry Sirvio, used with permission.

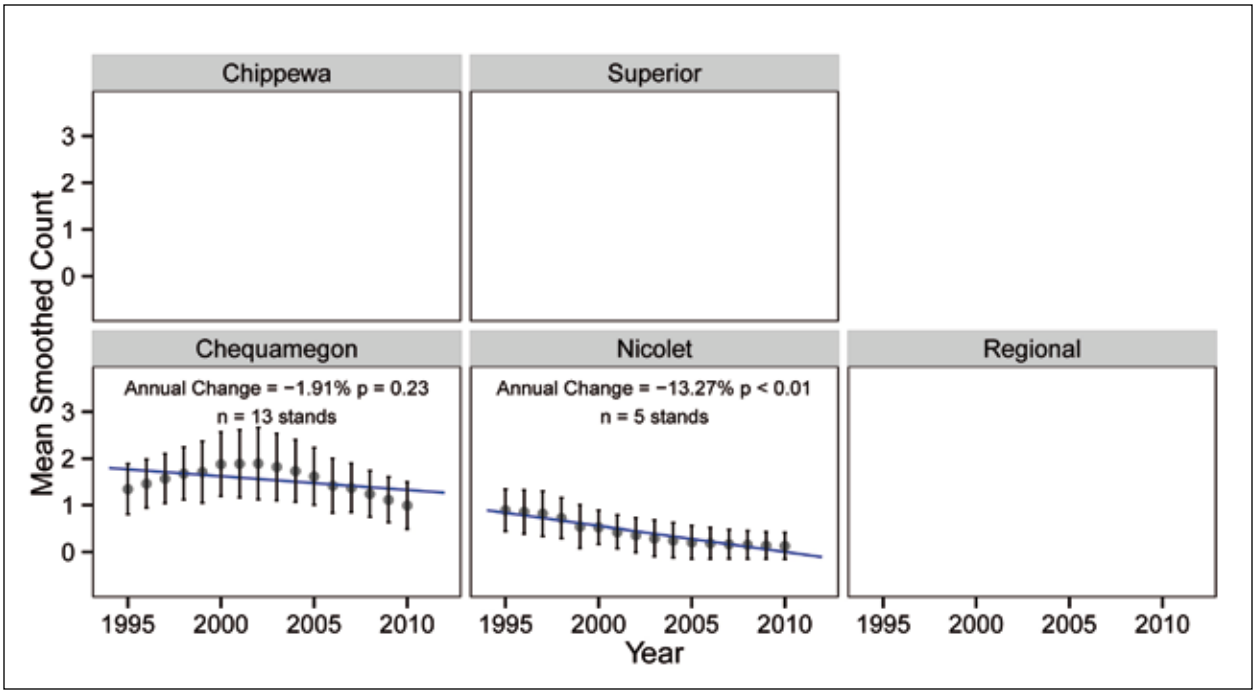
Guild Information

Habitat: Open dry shrubby areas

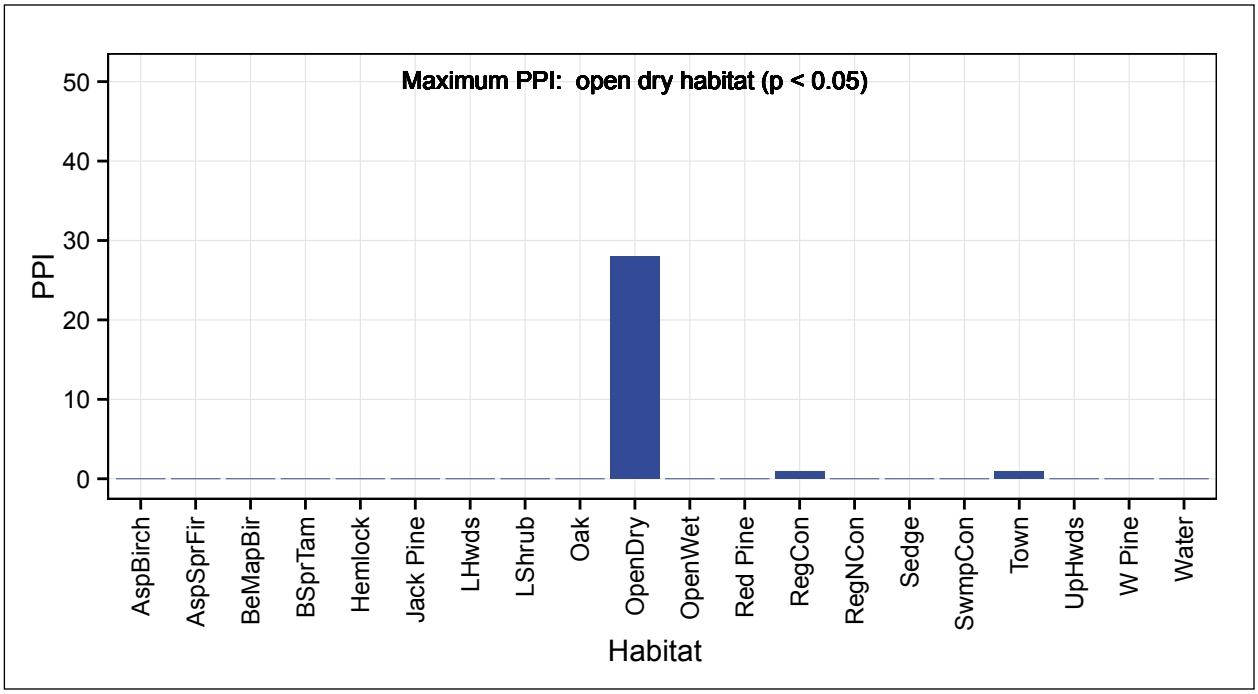
Foraging type: Omnivore—invertebrates, fruit

Nest site: Shrub or subcanopy

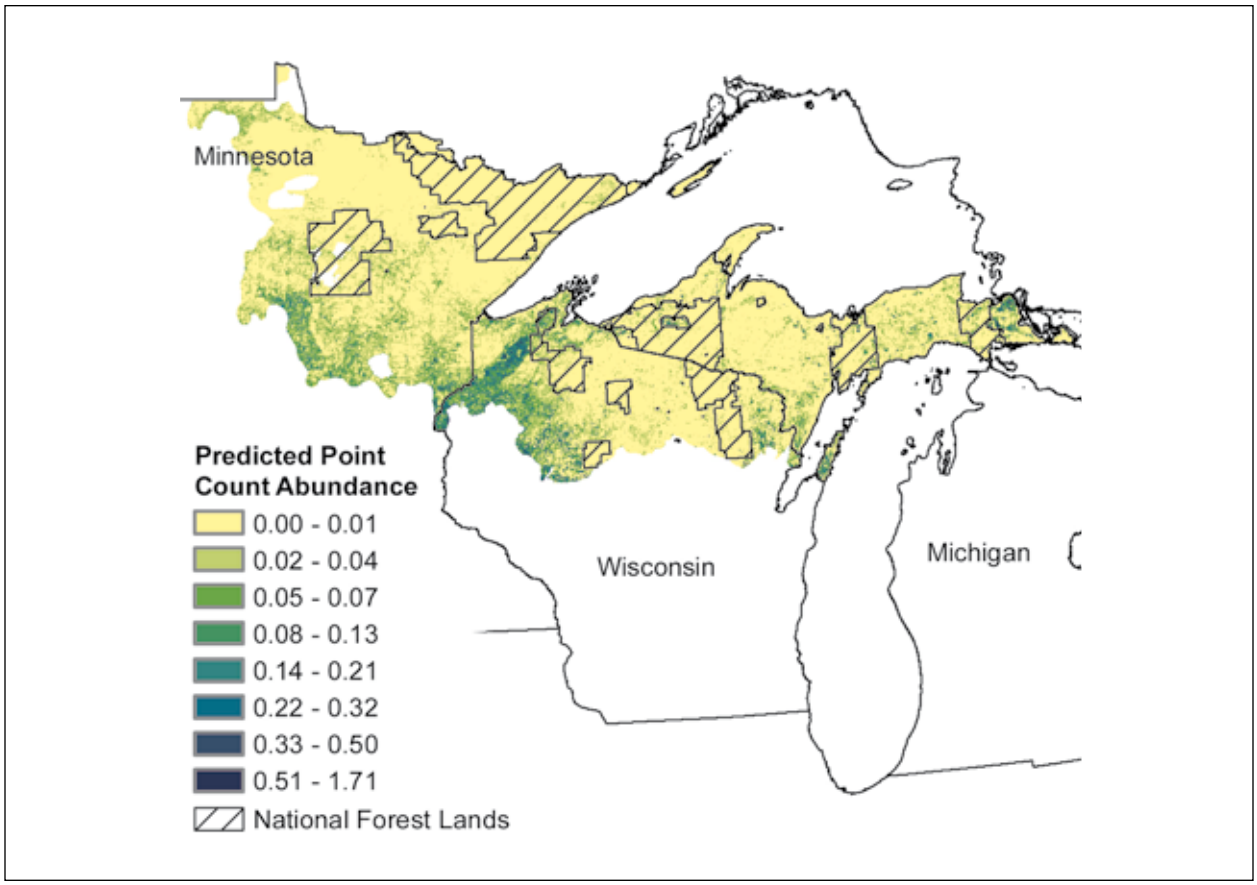
Migration: Short-distance



Trends for brown thrasher in two national forests, 1995–2010



Percent perfect indication of habitat association for brown thrasher where at least one bird was observed once during the decade (2001–2010; n=385 at 69 points)



Predicted relative abundance (number of birds per 10-minute count) of brown thrasher for the western Great Lakes region

Brown-headed Cowbird BHCO

Molothrus ater



©Mike Lentz, www.mikelentzphotography.com, used with permission.

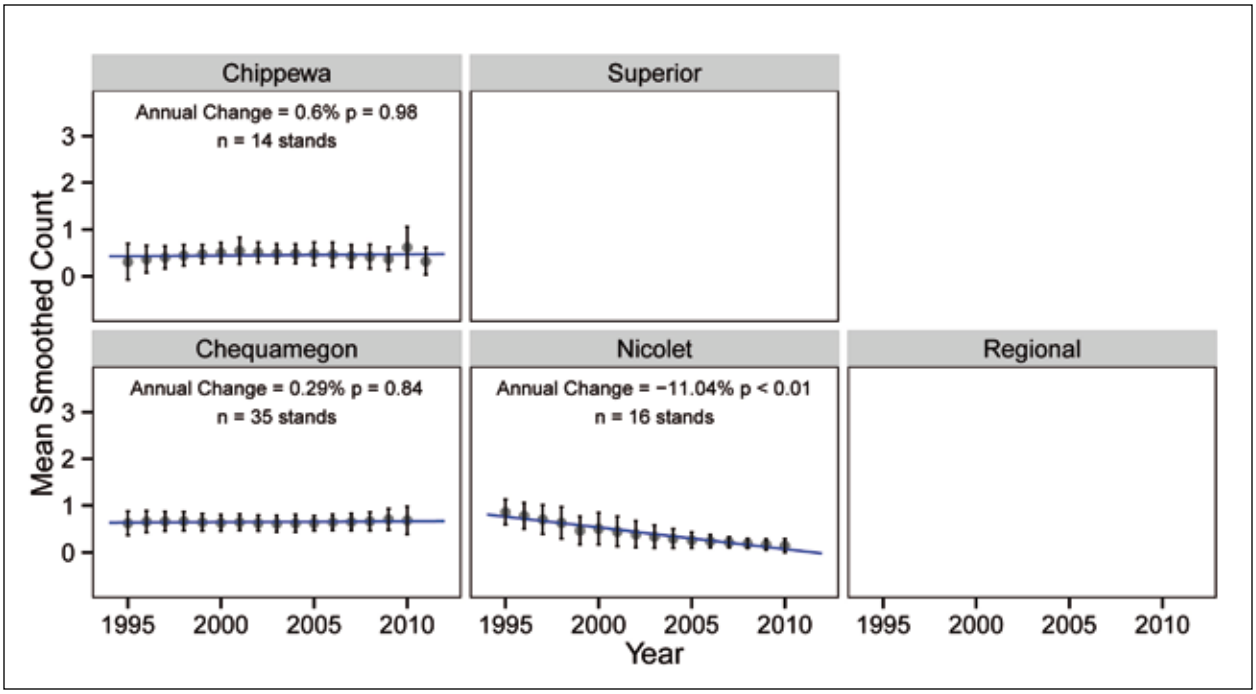
Guild Information

Habitat: Human settlements with livestock, rural towns

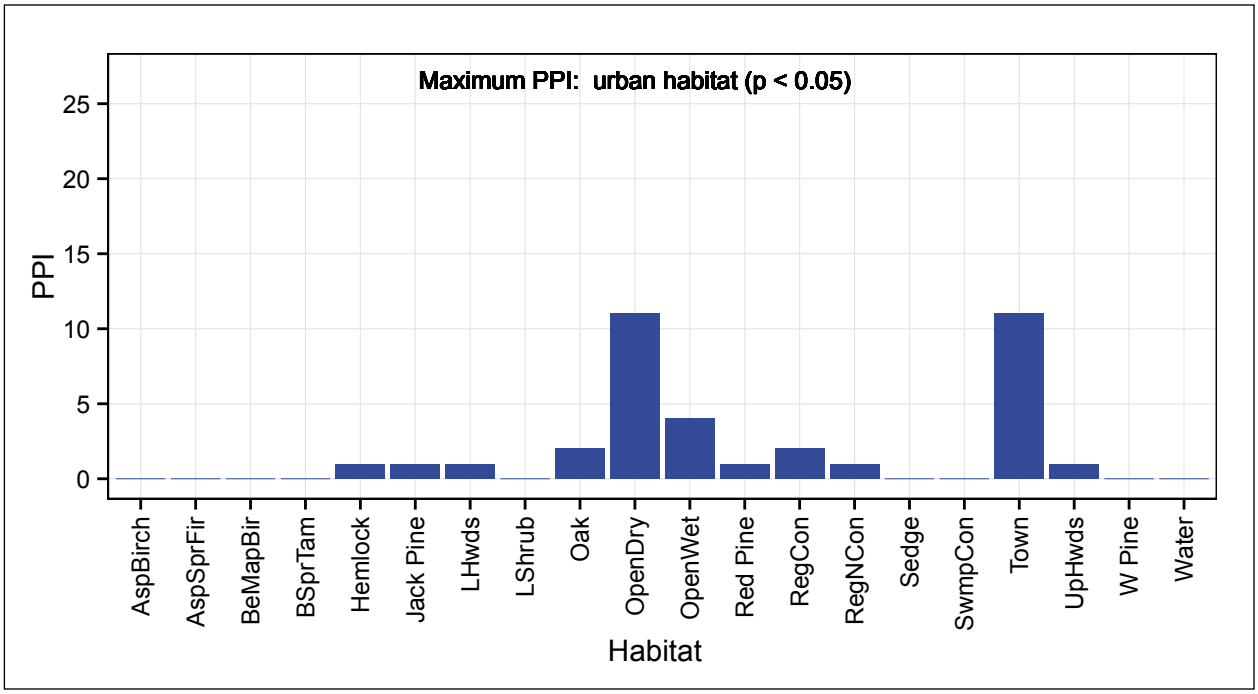
Foraging type: Omnivore—seeds, invertebrates

Nest site: Brood parasite

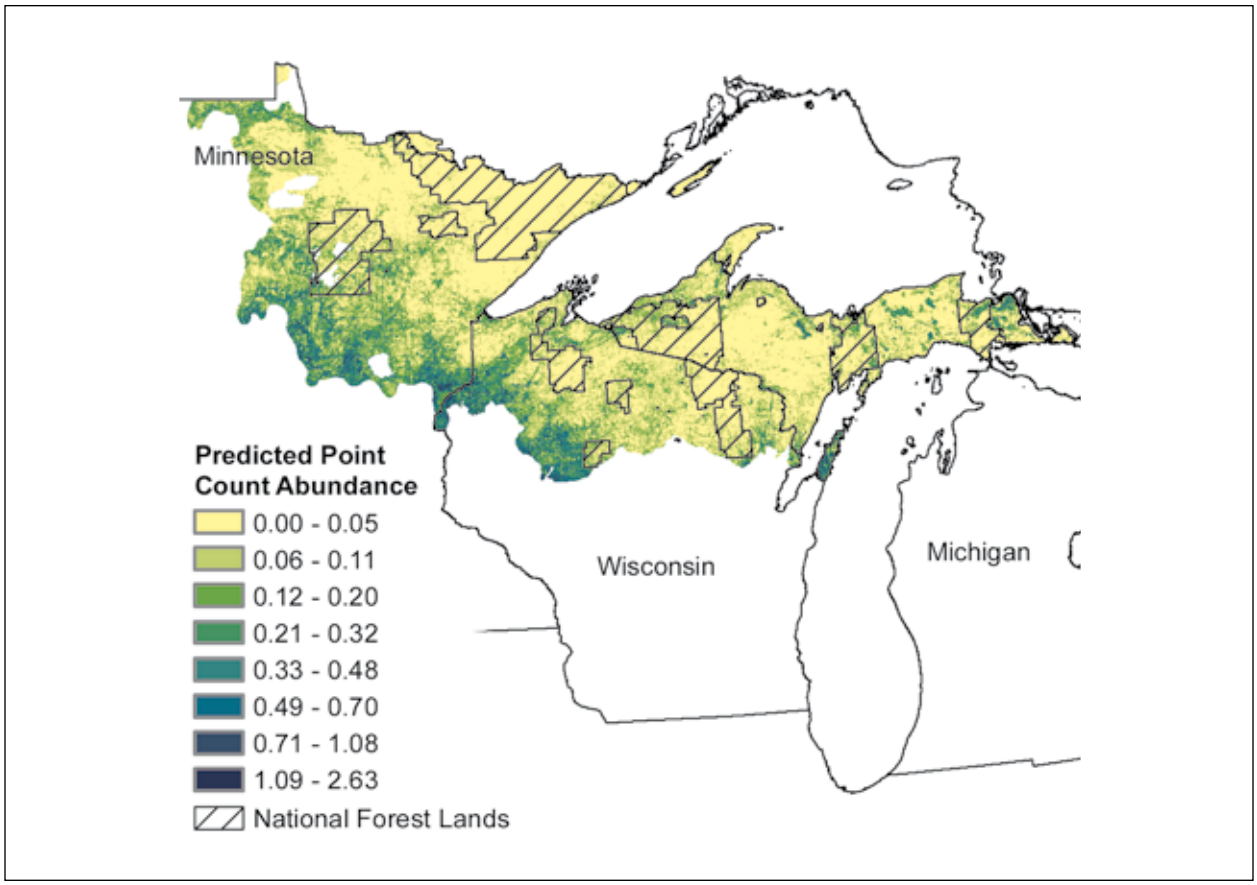
Migration: Short-distance



Trends for brown-headed cowbird in three national forests, 1995–2010



Percent perfect indication of habitat association for brown-headed cowbird where at least one bird was observed once during the decade (2001–2010; n=824 at 255 points)



Predicted relative abundance (number of birds per 10-minute count) of brown-headed cowbird for the western Great Lakes region

Canada Goose
Branta canadensis

CANG



Photo by Bruce Lees, used with permission.

Guild Information

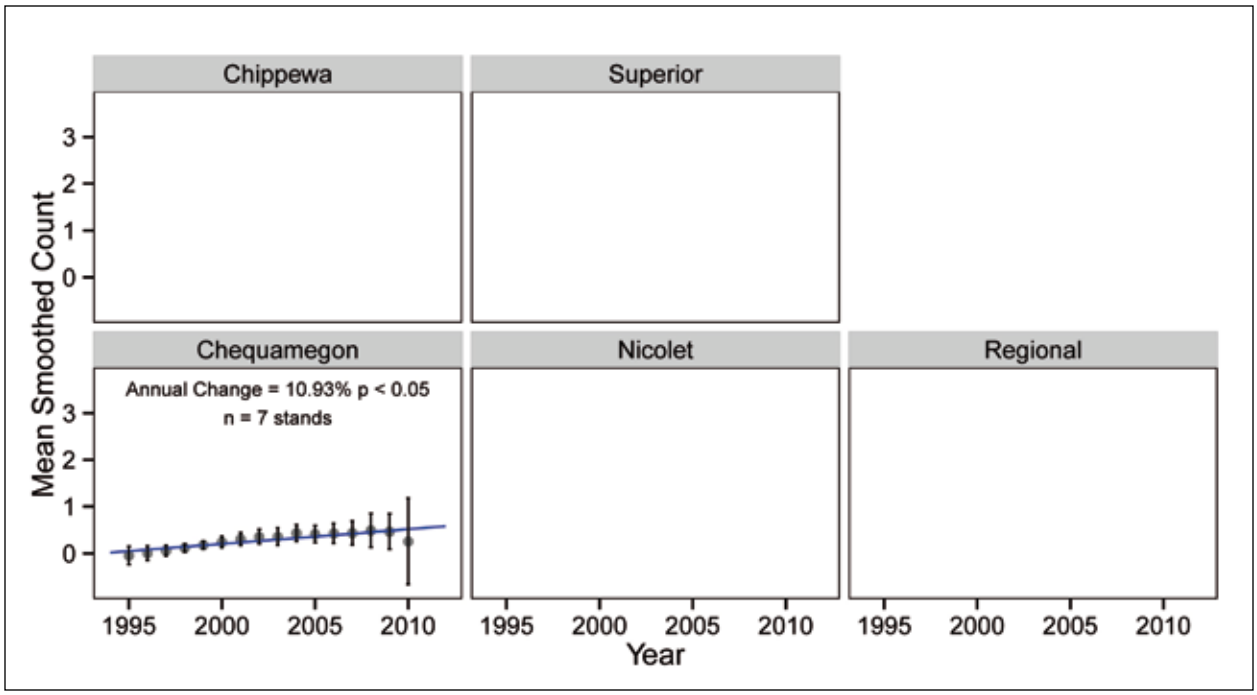
Habitat: Wetlands, open areas

Foraging type: Herbivore

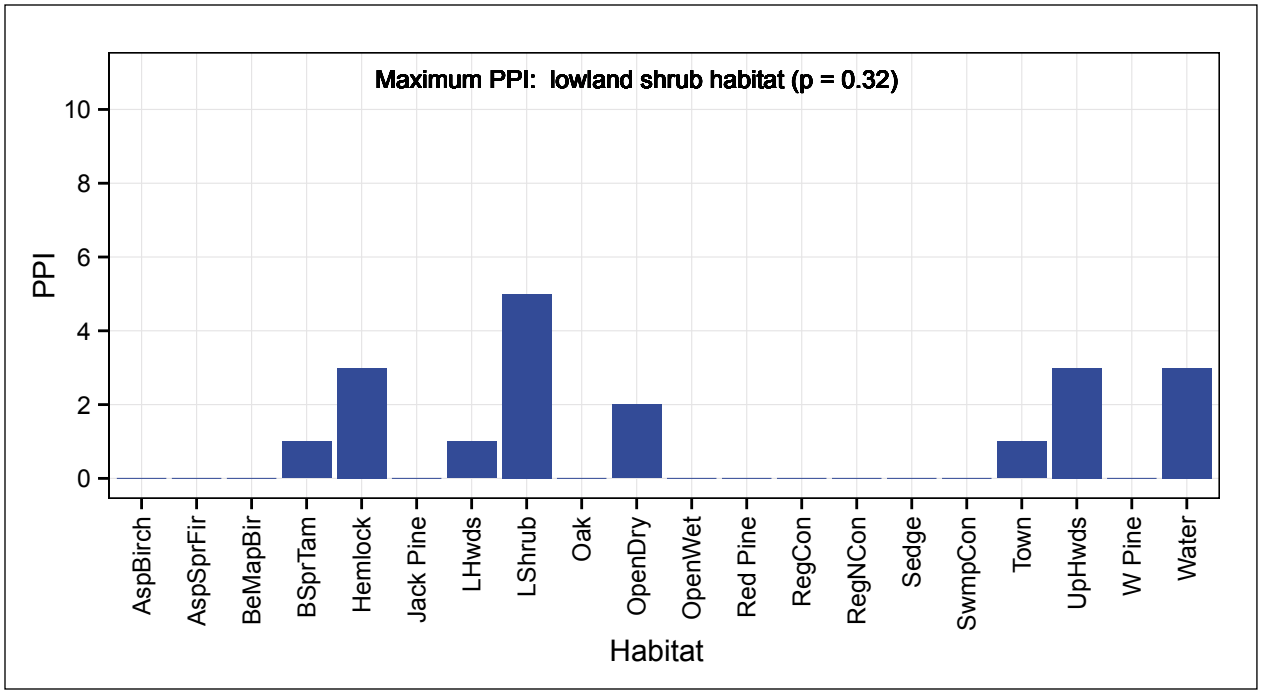
Nest site: Ground

Migration: Short-distance

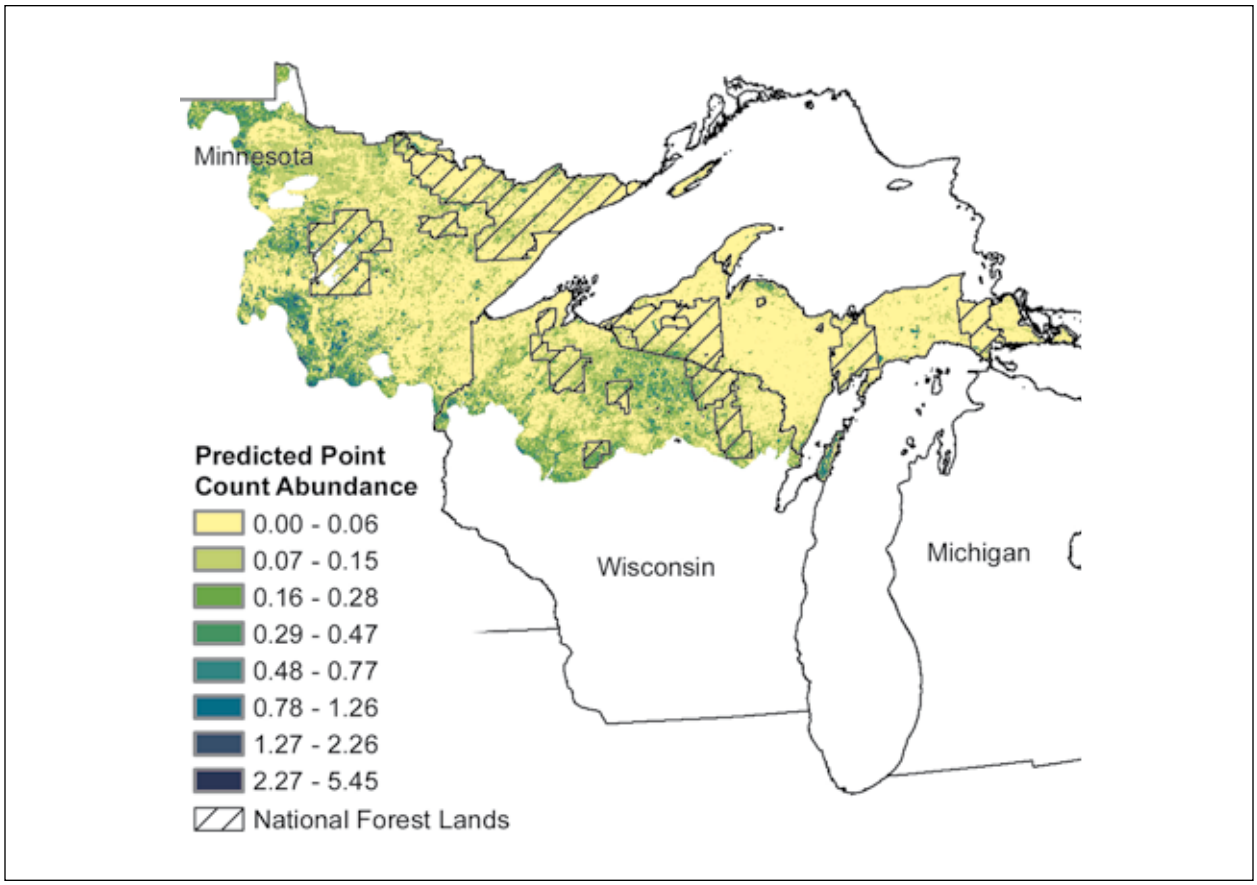
Notes: PPI analysis was not statistically significant for this vocally conspicuous species, which has expanded northward since the 1990s. Individuals recorded at forest and other upland points probably were transients (flyovers) or birds from nearby aquatic habitats.



Trend for Canada goose in one national forest, 1995–2010



Percent perfect indication of habitat association for Canada goose where at least one bird was observed once during the decade (2001–2010; n=1,893 at 243 points)



Predicted relative abundance (number of birds per 10-minute count) of Canada goose for the western Great Lakes region

Canada Warbler CAWA

Cardellina canadensis



Photo by Jon Swanson, used with permission.

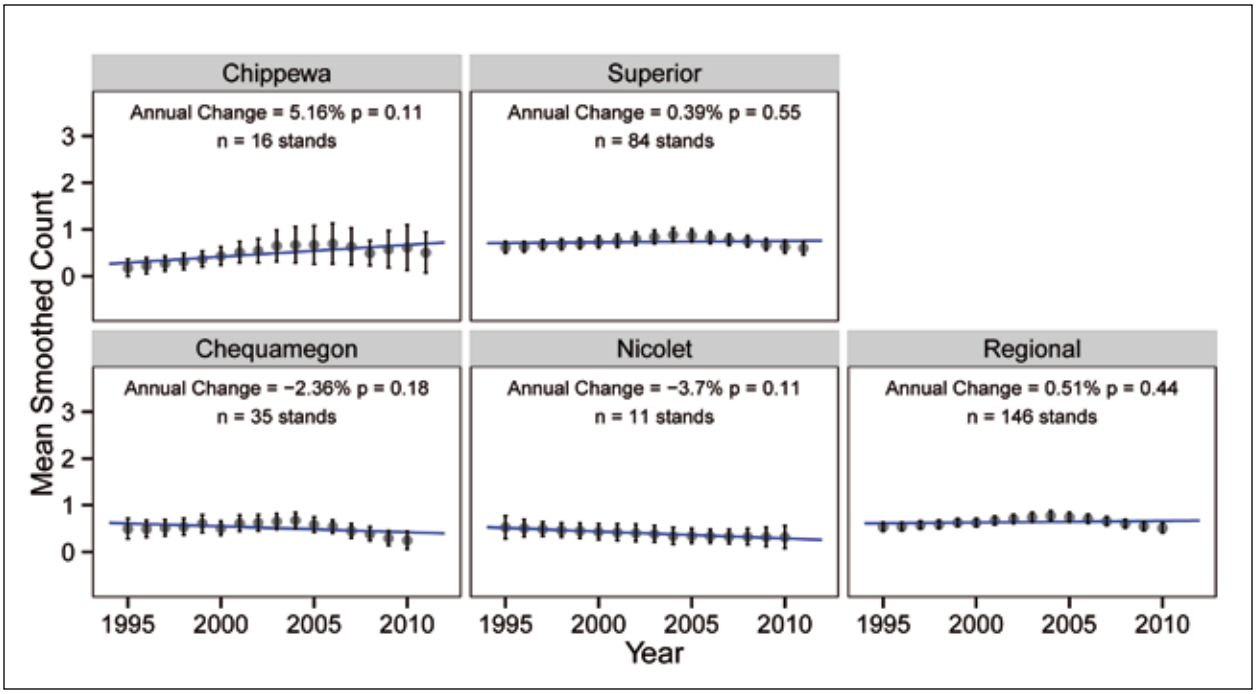
Guild Information

Habitat: Aspen-spruce-fir forests

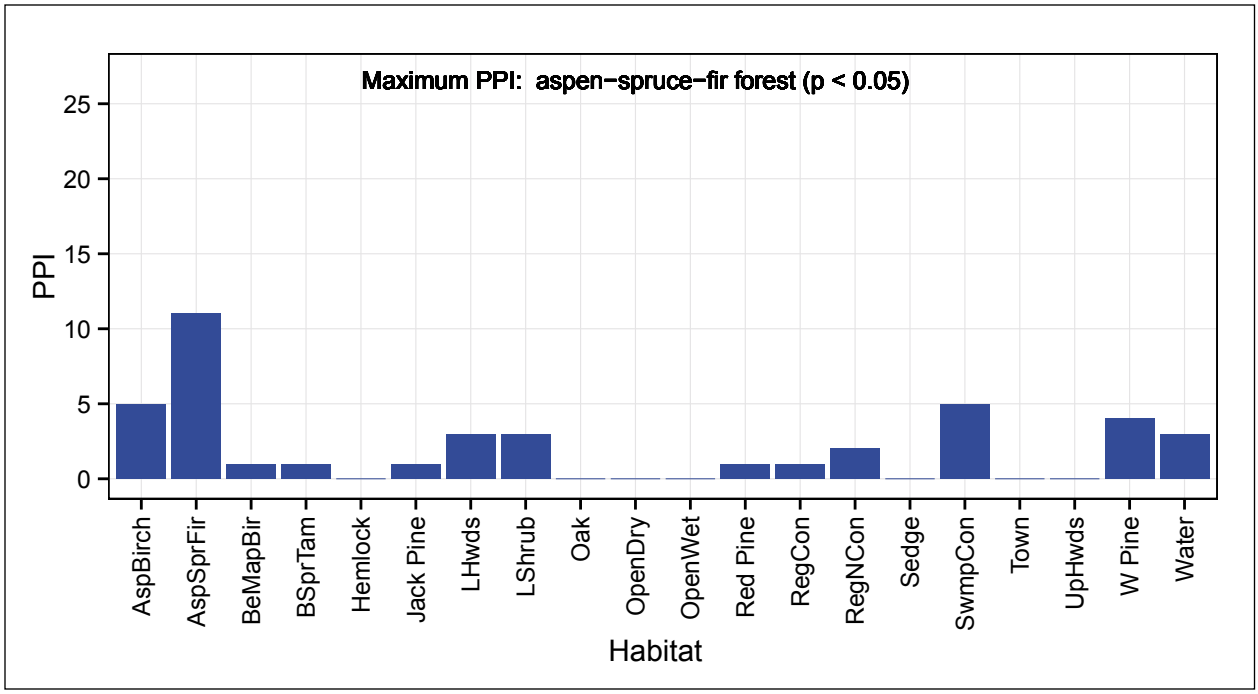
Foraging type: Foliage gleaner

Nest site: Ground

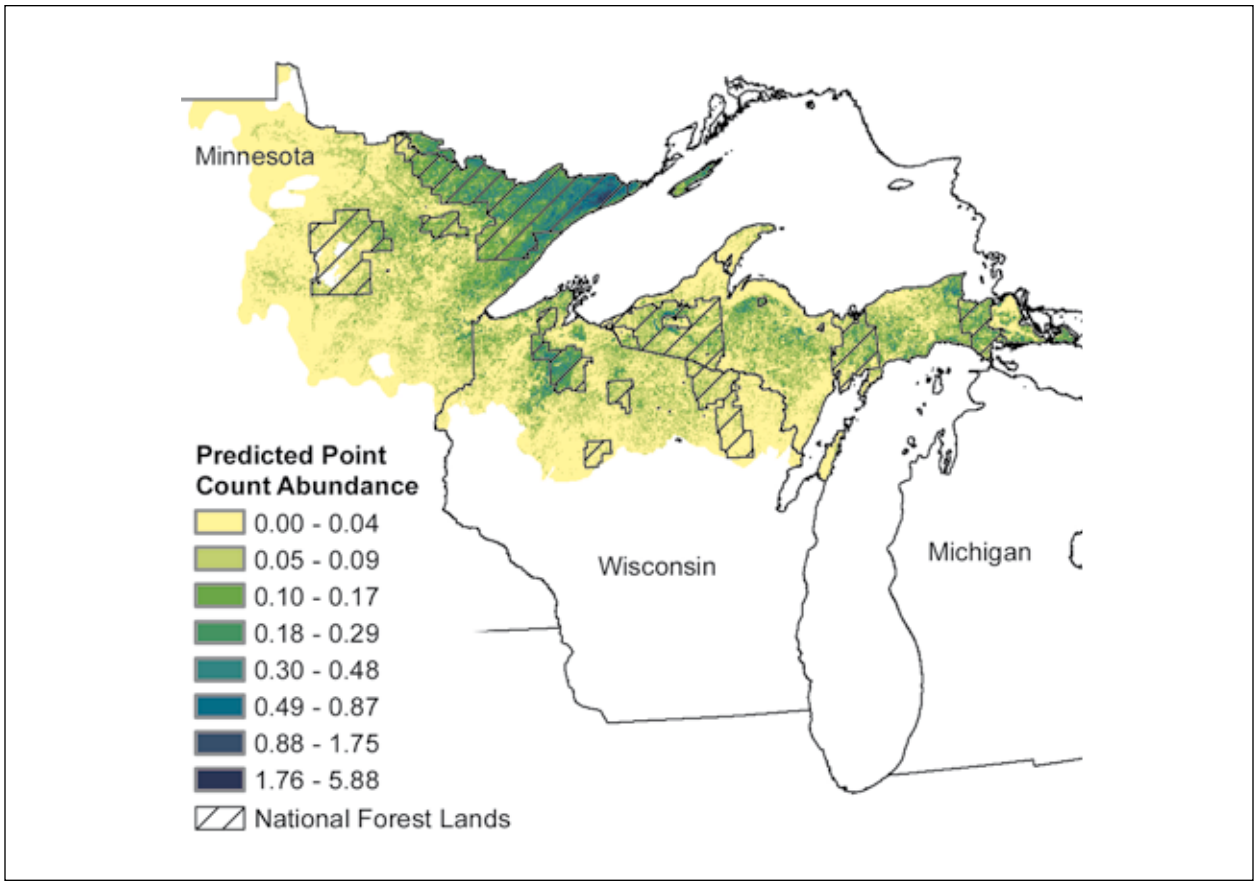
Migration: Long-distance



Trends for Canada warbler in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for Canada warbler where at least one bird was observed once during the decade (2001–2010; n=1,946 at 583 points)



Predicted relative abundance (number of birds per 10-minute count) of Canada warbler for the western Great Lakes region

Cape May Warbler CMWA

Setophaga tigrina



Photo by Bruce Lees, used with permission.

Guild Information

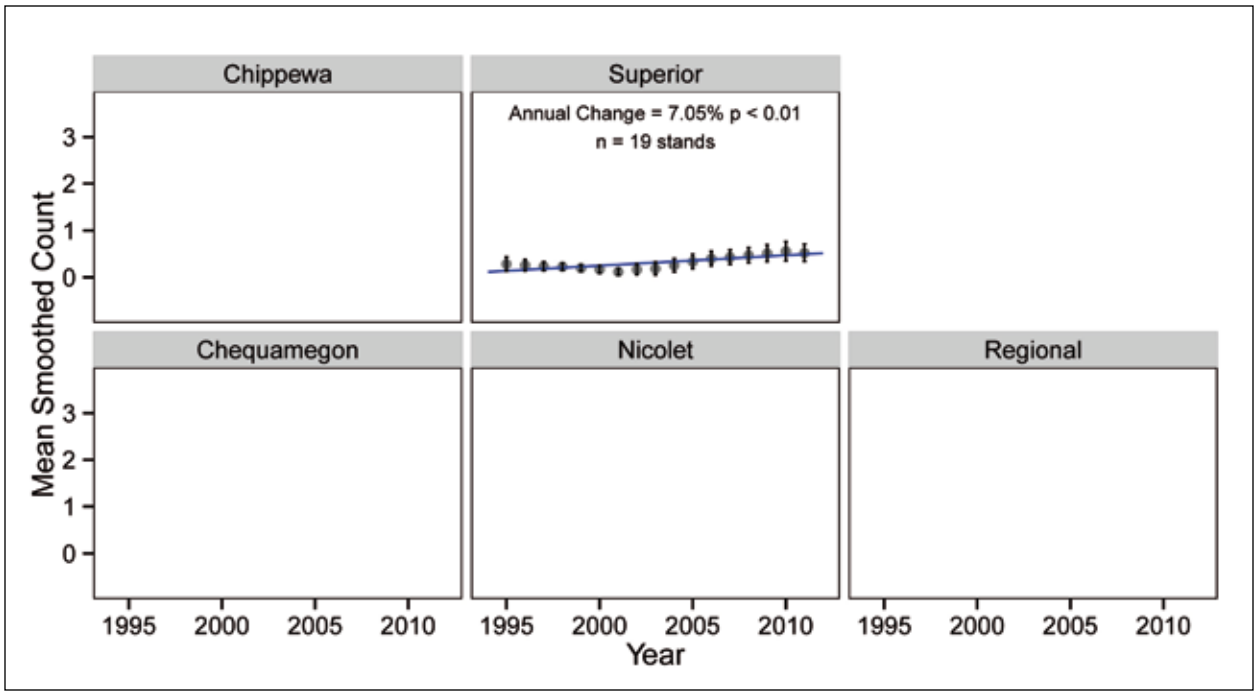
Habitat: Aspen-spruce-fir forests

Foraging type: Foliage gleaner, especially spruce budworm

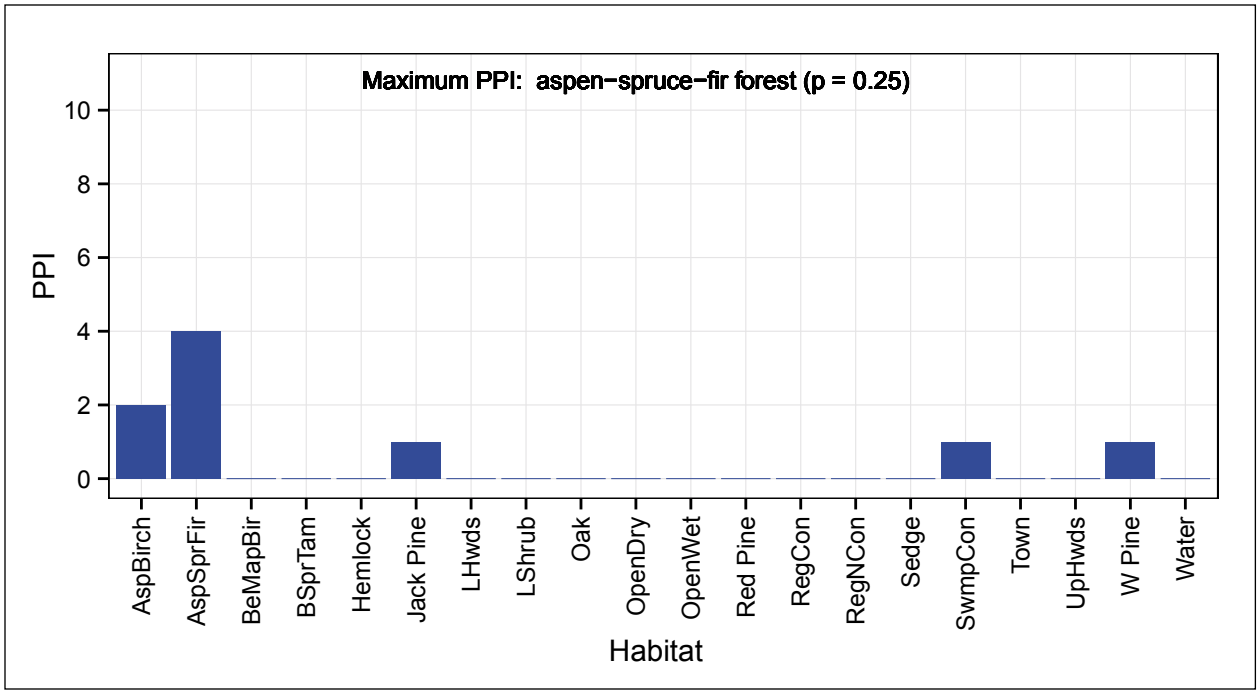
Nest site: Canopy

Migration: Long-distance

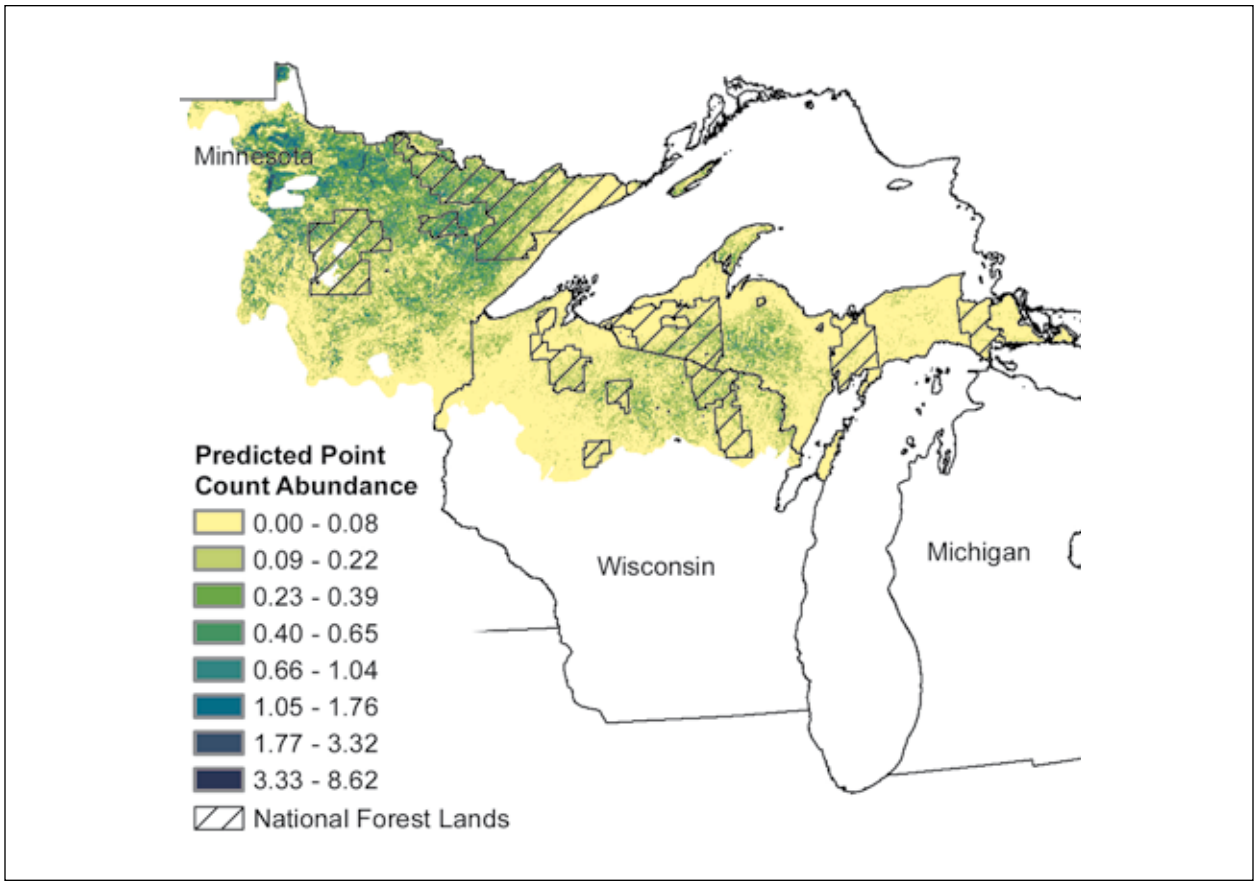
Notes: PPI analysis was not statistically significant for this uncommon boreal species.



Trend for Cape May warbler in one national forest, 1995–2010



Percent perfect indication of habitat association for Cape May warbler where at least one bird was observed once during the decade (2001–2010; n=281 at 149 points)



Predicted relative abundance (number of birds per 10-minute count) of Cape May warbler for the western Great Lakes region

Cedar Waxwing CEDW

Bombycilla cedrorum



Photo by Bruce Lees, used with permission.

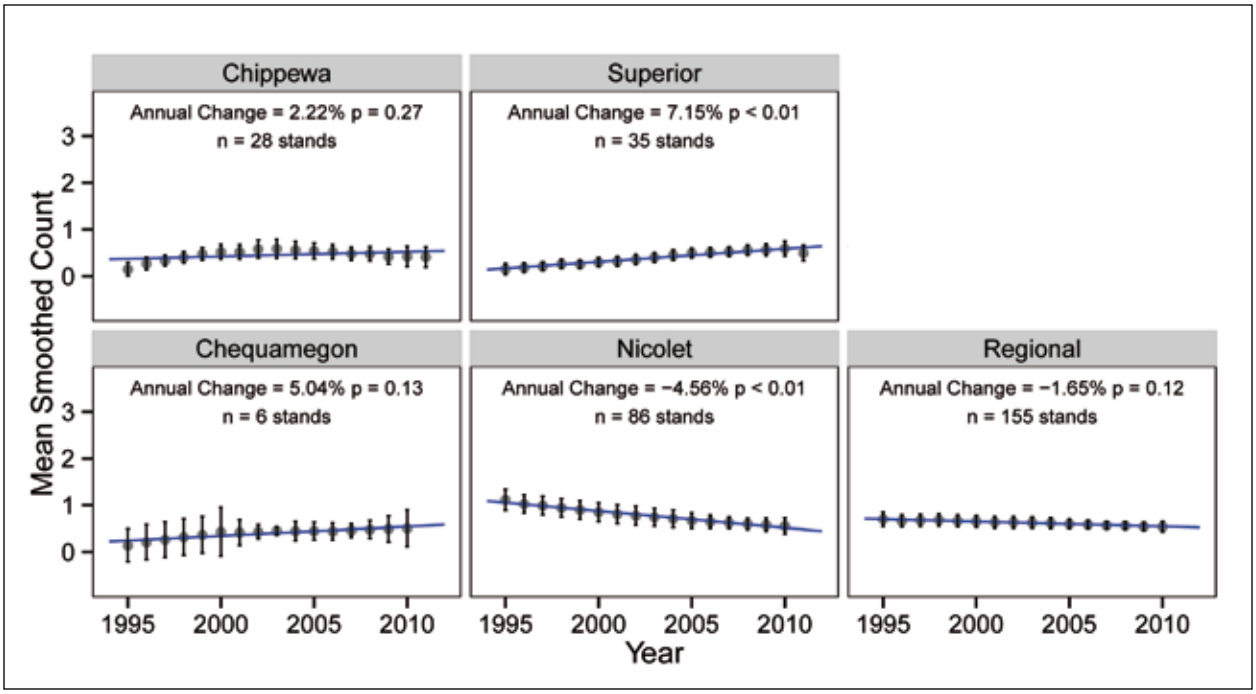
Guild Information

Habitat: Human settlements, riparian areas

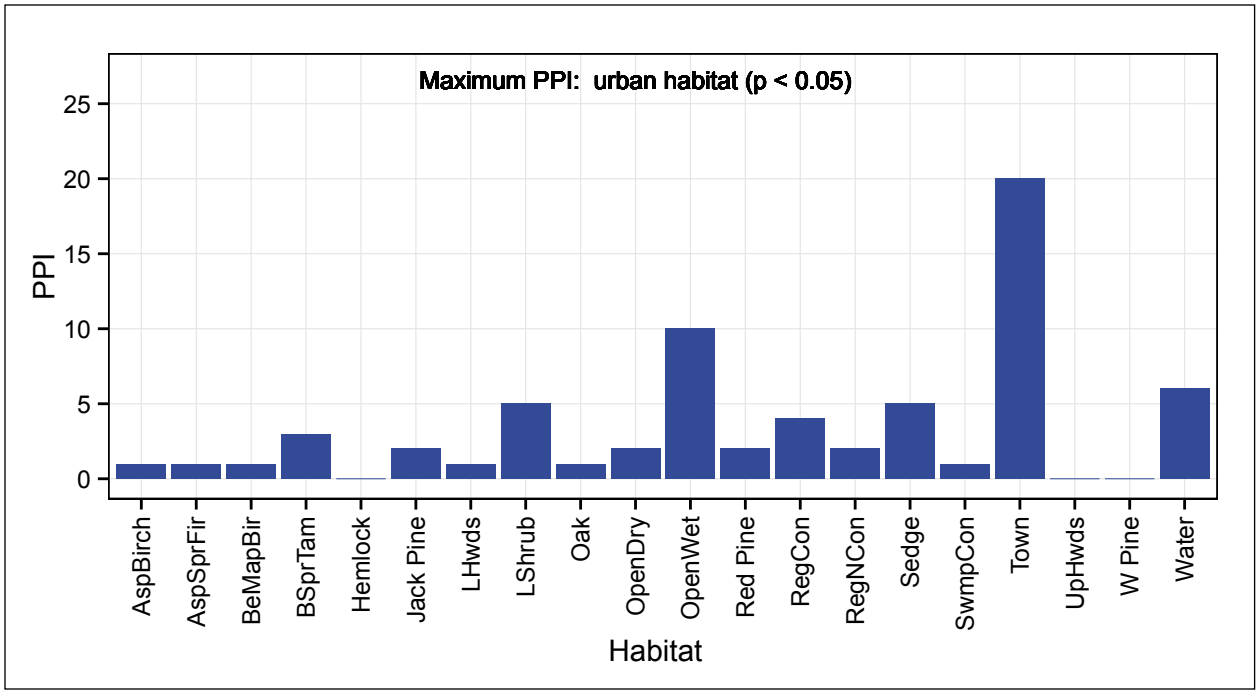
Foraging type: Omnivore—fruit, flying insects

Nest site: Shrub or subcanopy

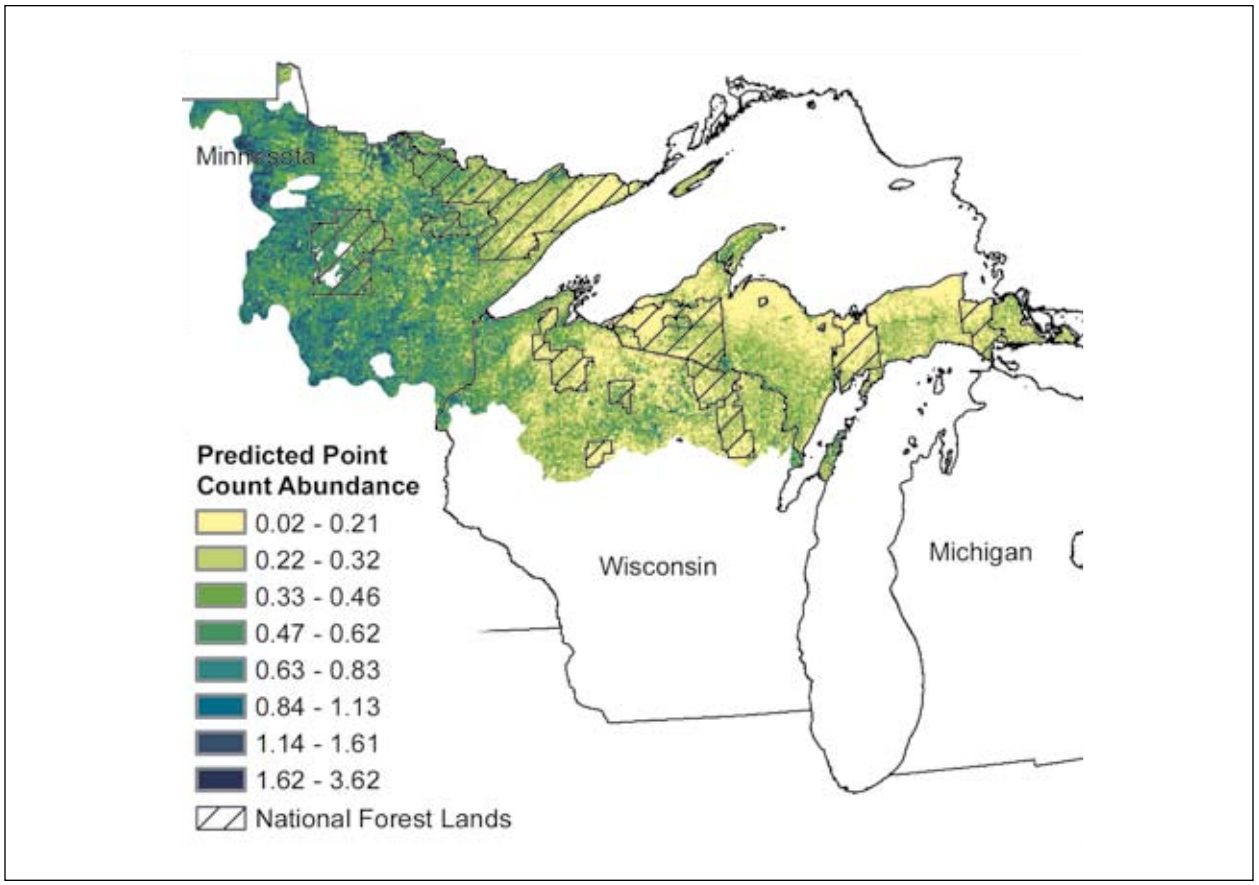
Migration: Short-distance



Trends for cedar waxwing in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for cedar waxwing where at least one bird was observed once during the decade (2001–2010; n=2,936 at 880 points)



Predicted relative abundance (number of birds per 10-minute count) of cedar waxwing for the western Great Lakes region

Chestnut-sided Warbler CSWA

Setophaga pensylvanica



Photo by Jon Swanson, used with permission.

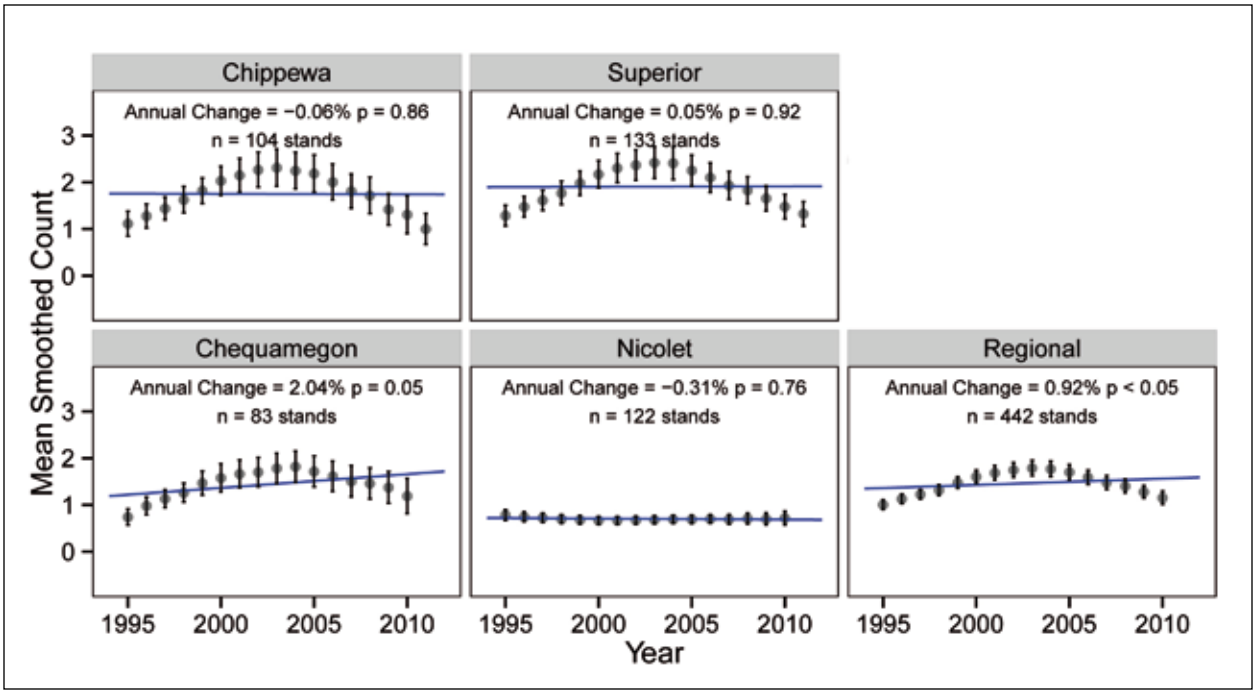
Guild Information

Habitat: Young forests, forest openings

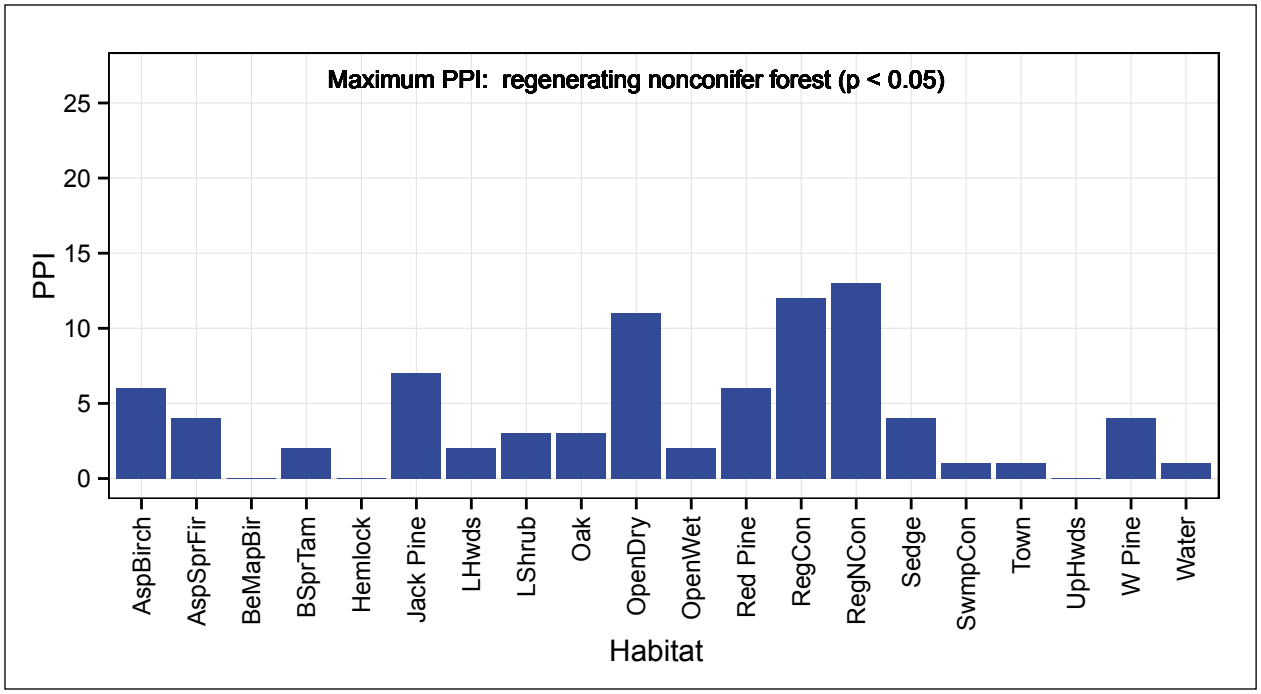
Foraging type: Foliage gleaner

Nest site: Shrub or subcanopy

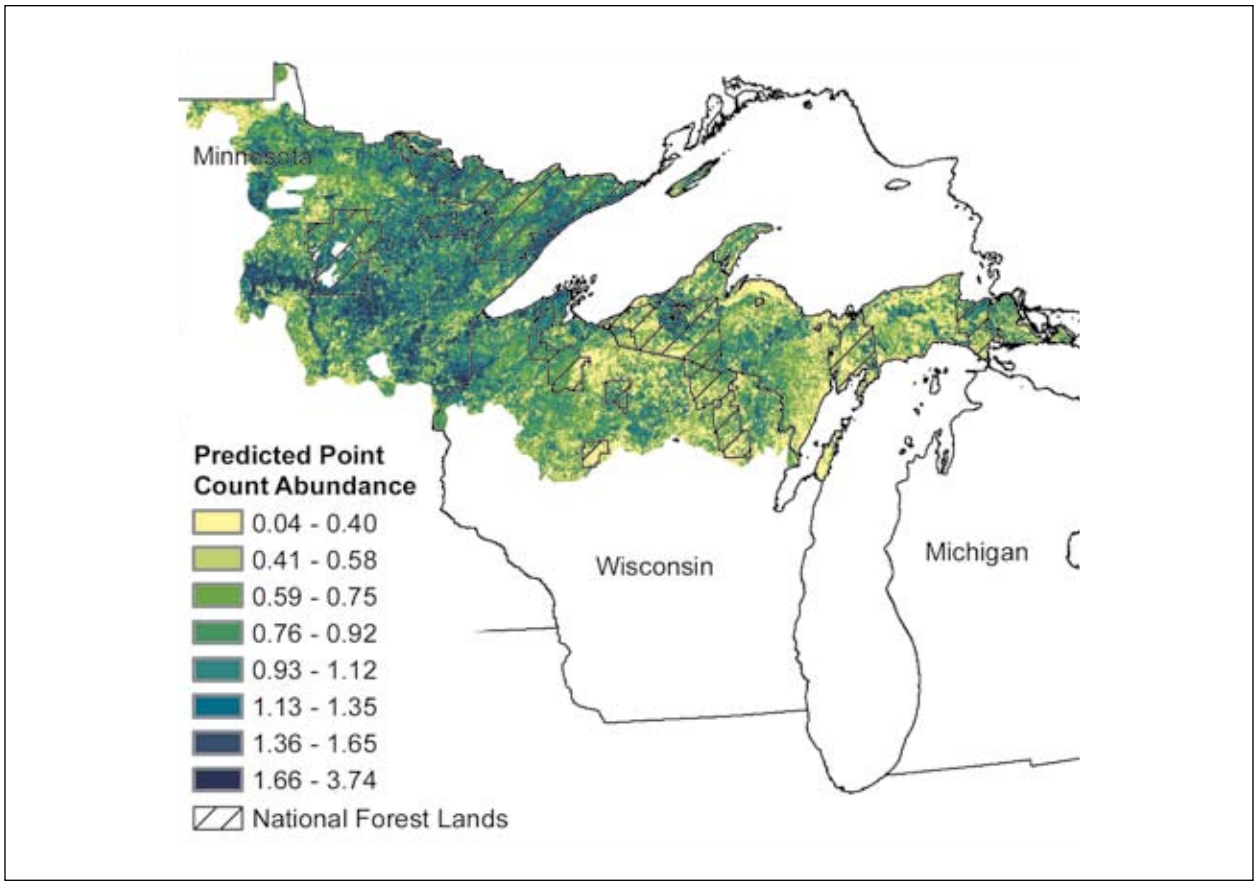
Migration: Long-distance



Trends for chestnut-sided warbler in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for chestnut-sided warbler where at least one bird was observed once during the decade (2001–2010; n=13,638 at 1,264 points)



Predicted relative abundance (number of birds per 10-minute count) of chestnut-sided warbler for the western Great Lakes region

Chipping Sparrow CHSP

Spizella passerina



Photo by Larry Sirvio, used with permission.

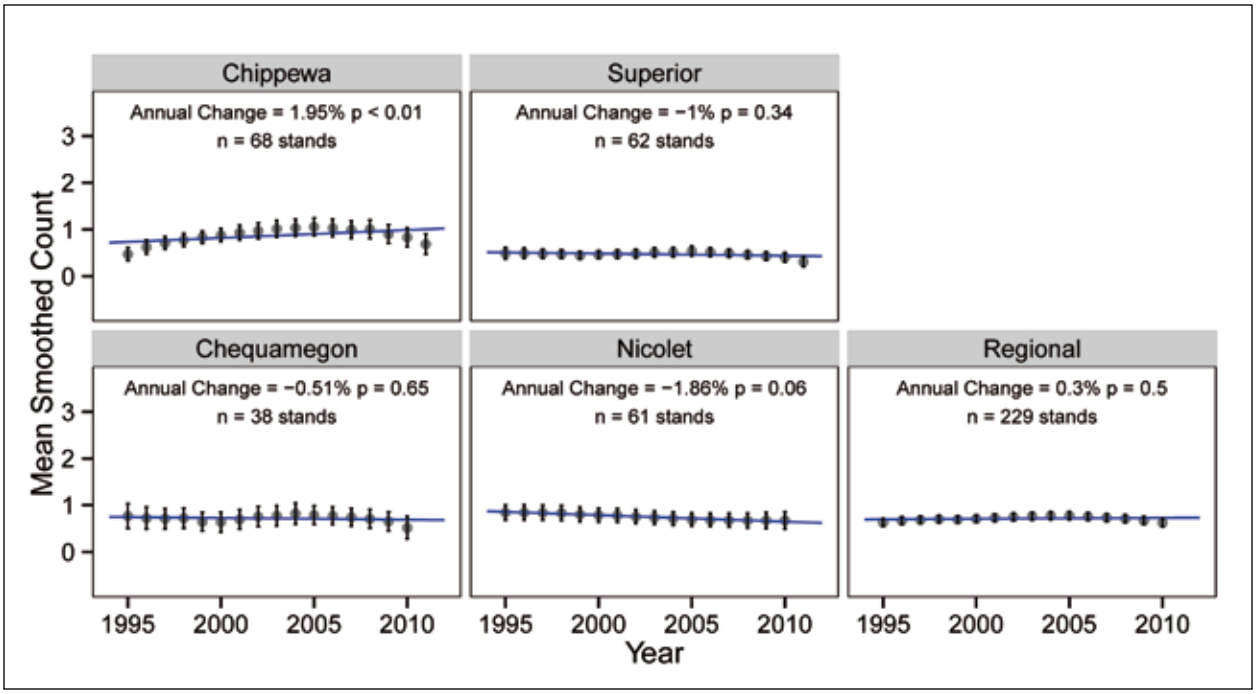
Guild Information

Habitat: Human settlements; open forests, especially conifers

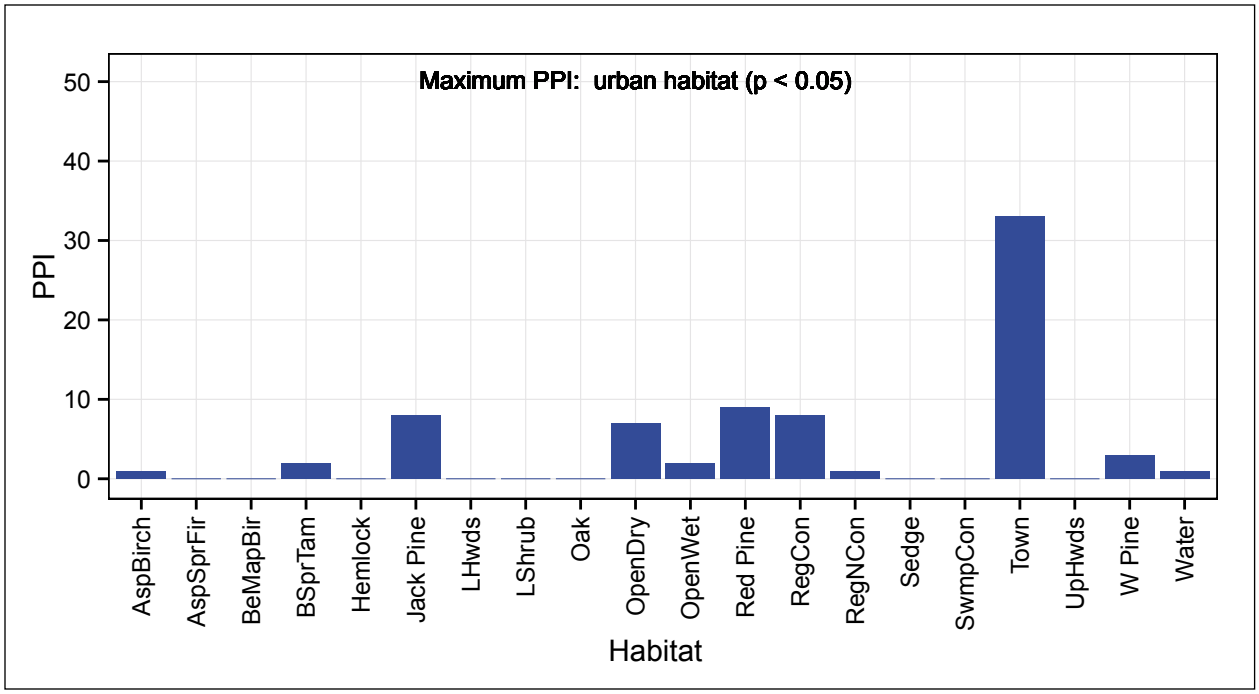
Foraging type: Omnivore—seeds, invertebrates

Nest site: Canopy

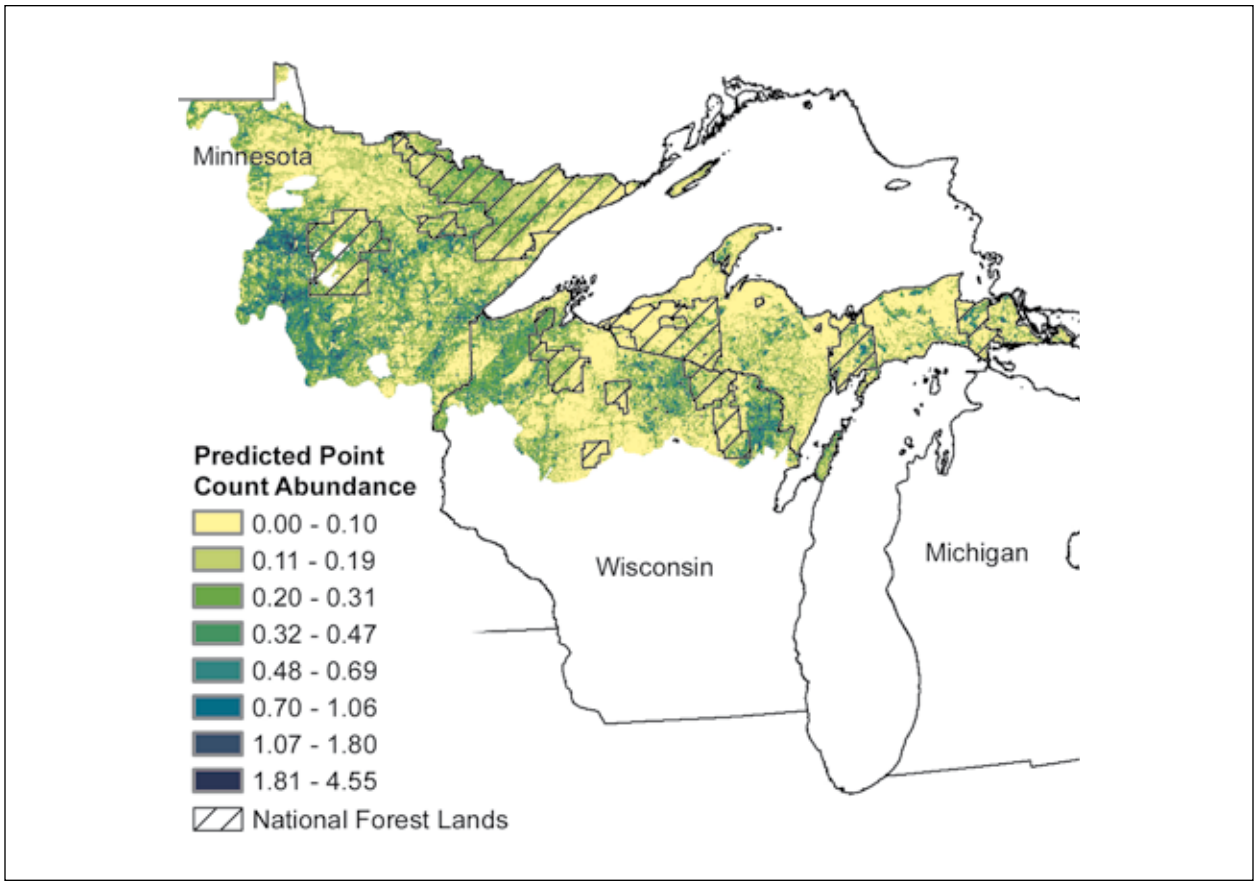
Migration: Short-distance



Trends for chipping sparrow in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for chipping sparrow where at least one bird was observed once during the decade (2001–2010; n=3,182 at 749 points)



Predicted relative abundance (number of birds per 10-minute count) of chipping sparrow for the western Great Lakes region

Clay-colored Sparrow CCSP

Spizella pallida



Photo by Larry Sirvio, used with permission.

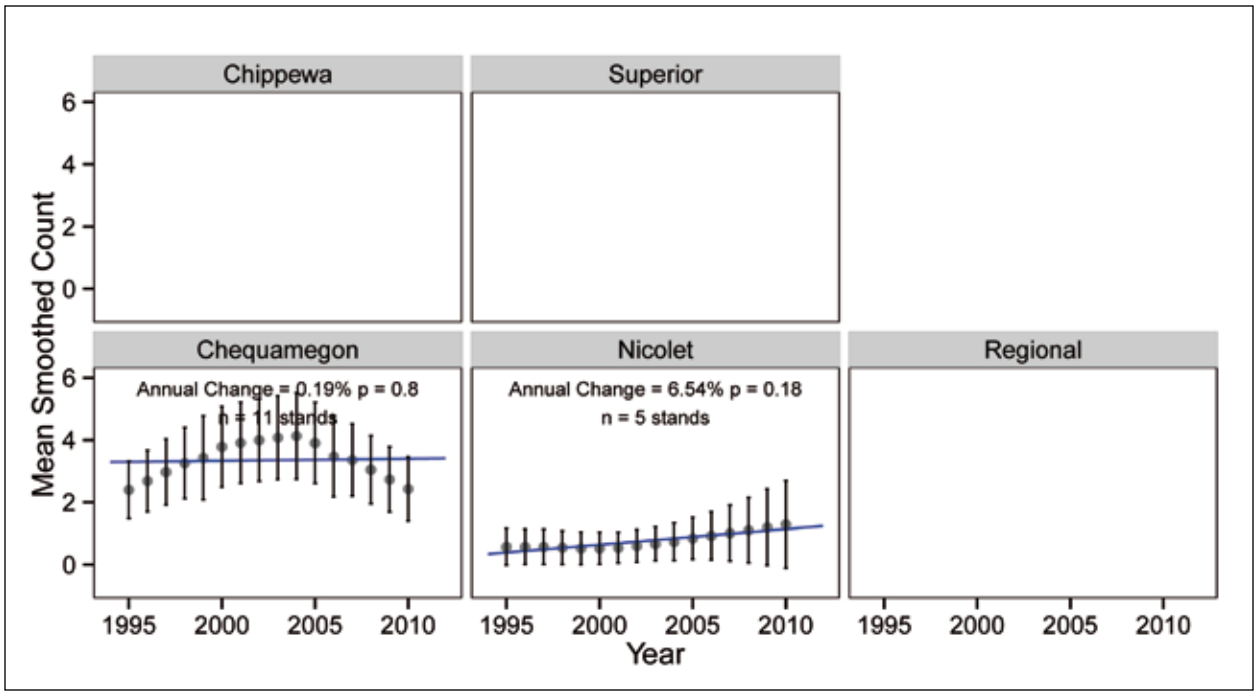
Guild Information

Habitat: Open dry shrubby areas

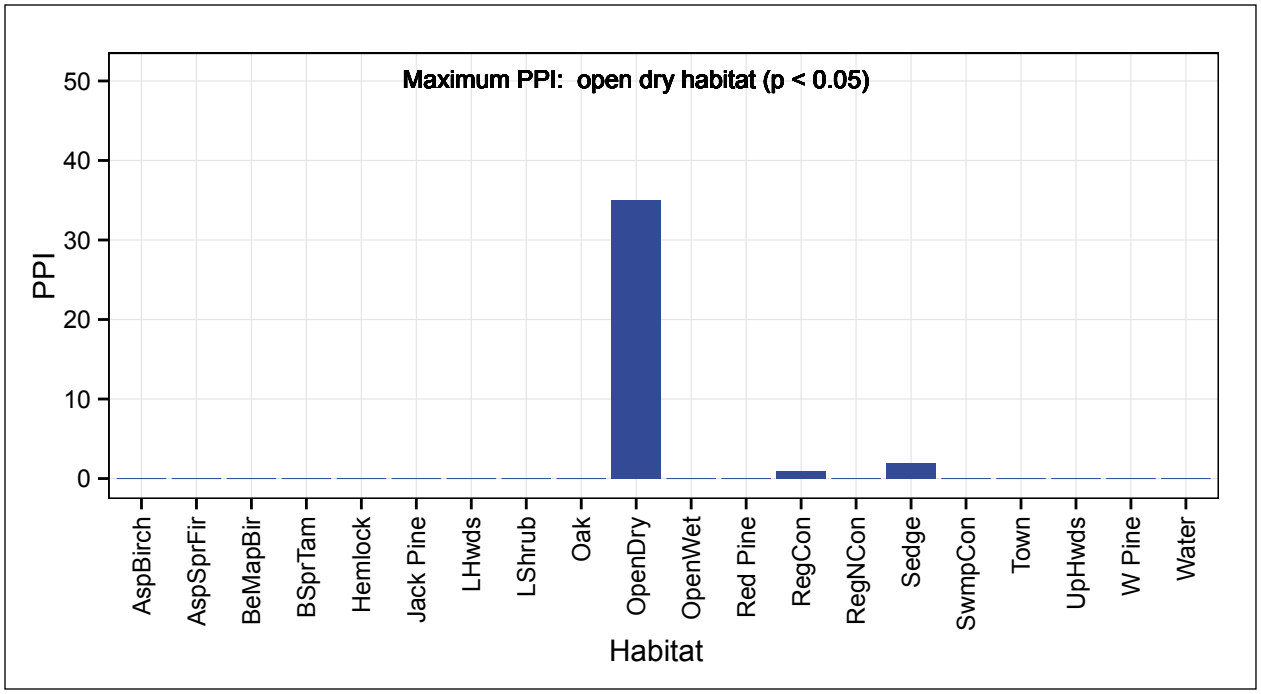
Foraging type: Omnivore—seeds, invertebrates

Nest site: Ground

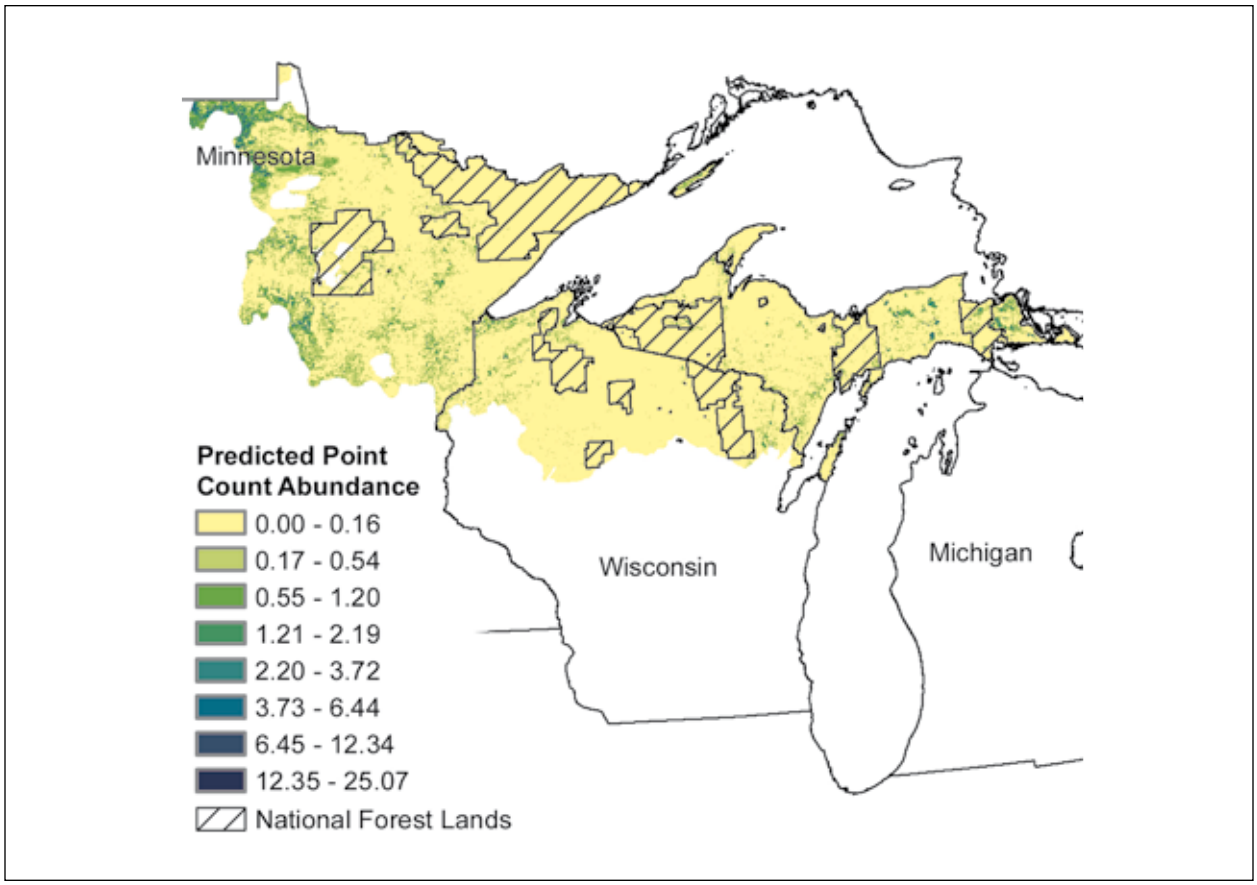
Migration: Short-distance



Trends for clay-colored sparrow in two national forests, 1995–2010



Percent perfect indication of habitat association for clay-colored sparrow where at least one bird was observed once during the decade (2001–2010; n=850 at 88 points)



Predicted relative abundance (number of birds per 10-minute count) of clay-colored sparrow for the western Great Lakes region

Common Loon COLO

Gavia immer



Photo by Jon Swanson, used with permission.

Guild Information

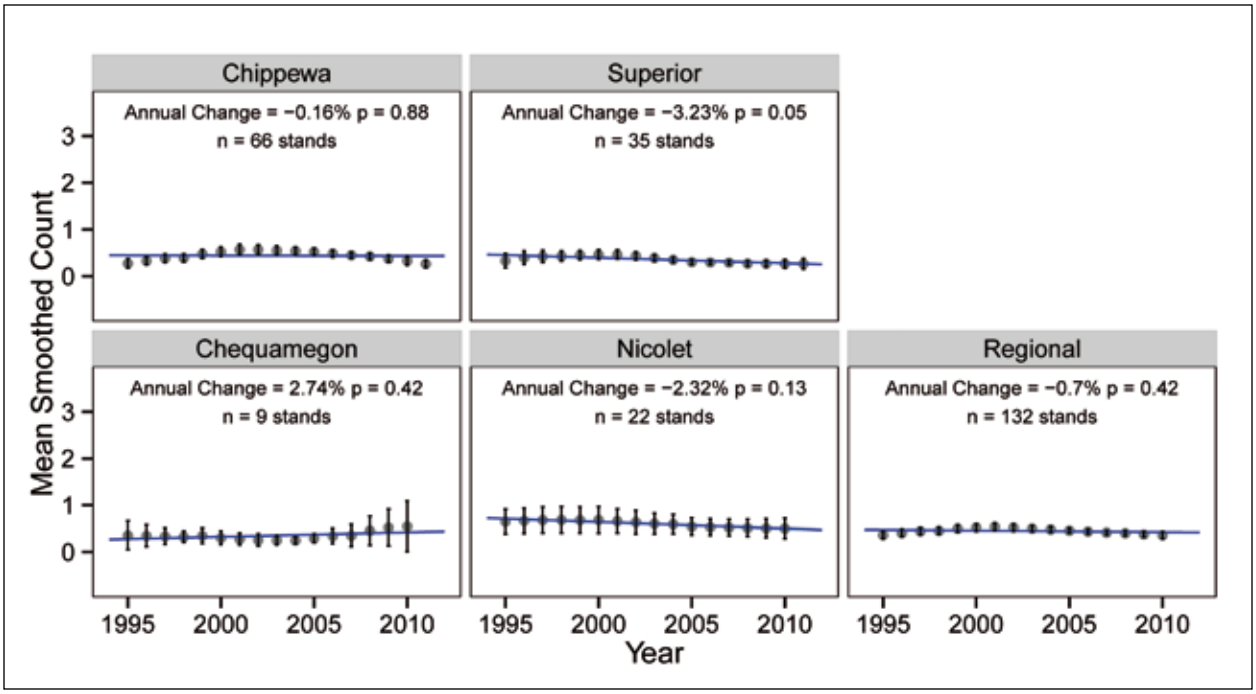
Habitat: Lakes, large ponds

Foraging type: Predator—aquatic invertebrates, fish

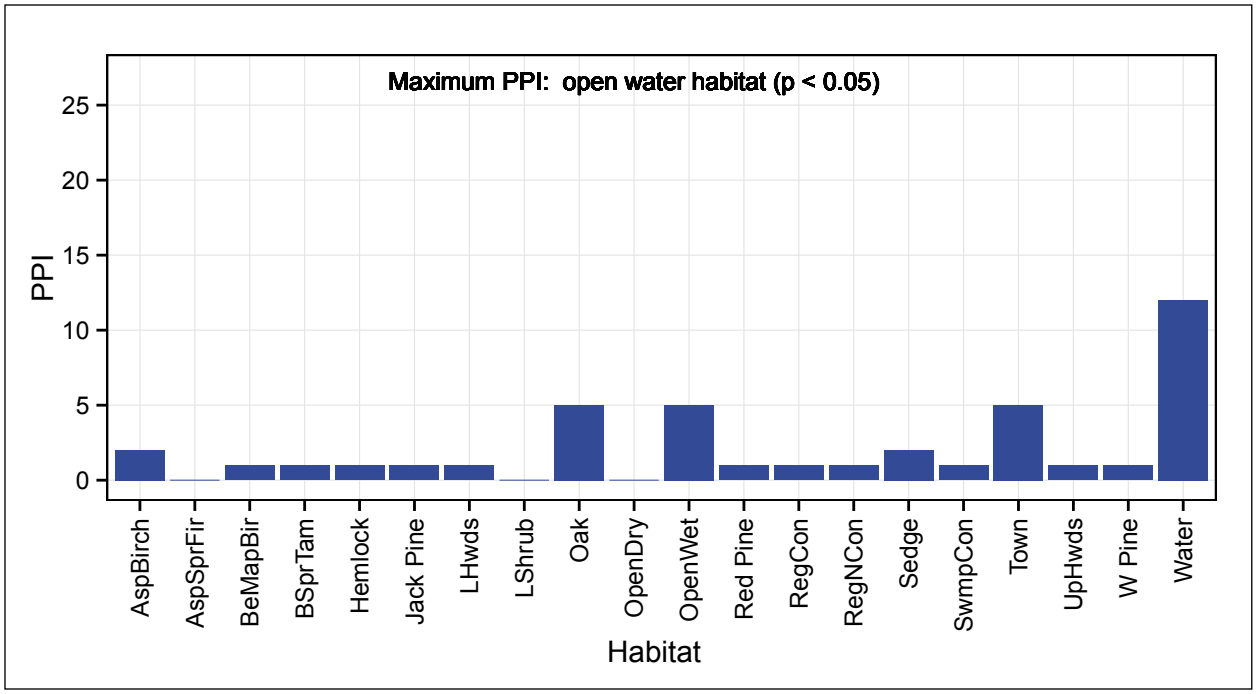
Nest site: Ground

Migration: Short-distance

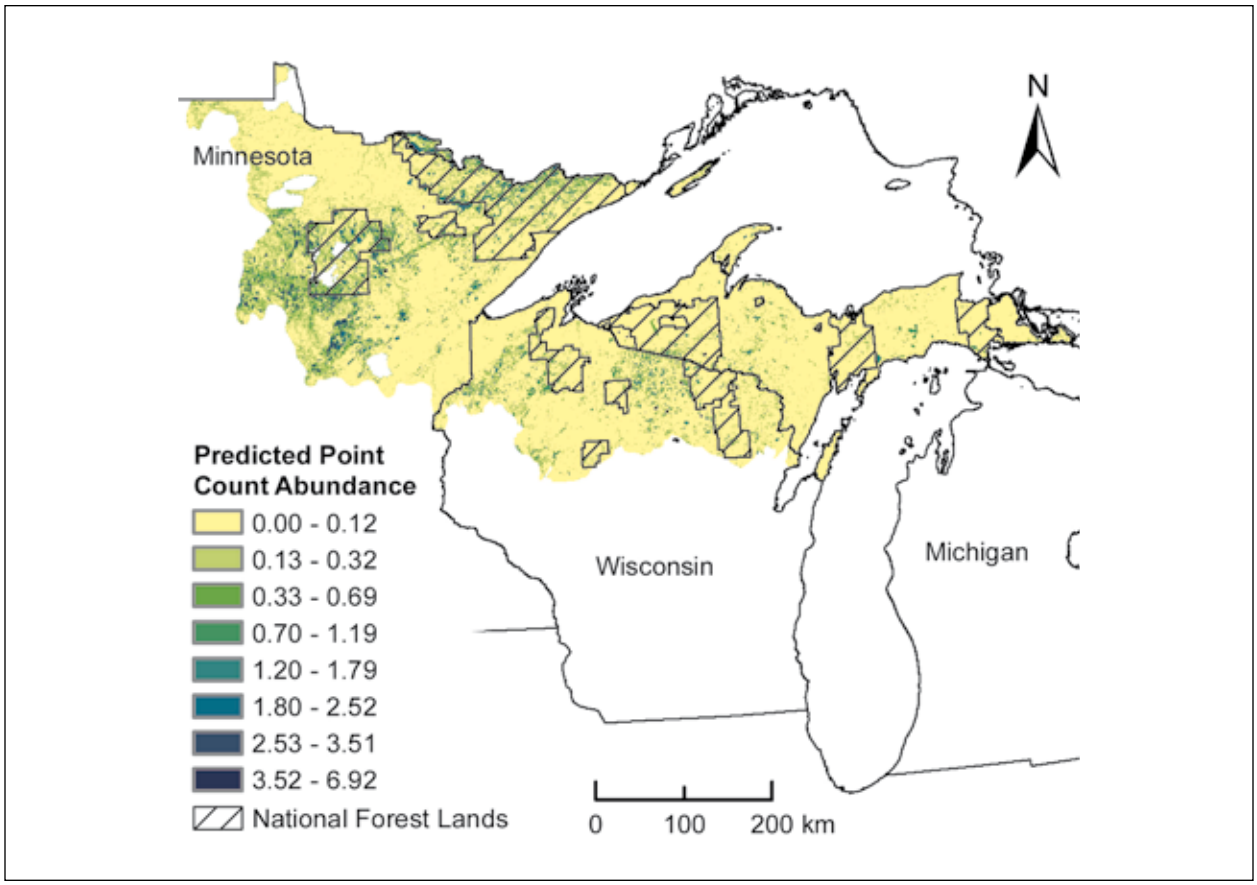
Notes: Loons were frequently heard or observed flying overhead during point counts in a wide variety of habitats. Individuals recorded at forest and other upland points were transients (flyovers) or birds from nearby aquatic habitats.



Trends for common loon in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for common loon where at least one bird was observed once during the decade (2001–2010; n=1,379 at 570 points)



Predicted relative abundance (number of birds per 10-minute count) of common loon for the western Great Lakes region

Common Raven CORA
Corvus corax



Photo by Larry Sirvio, used with permission.

Guild Information

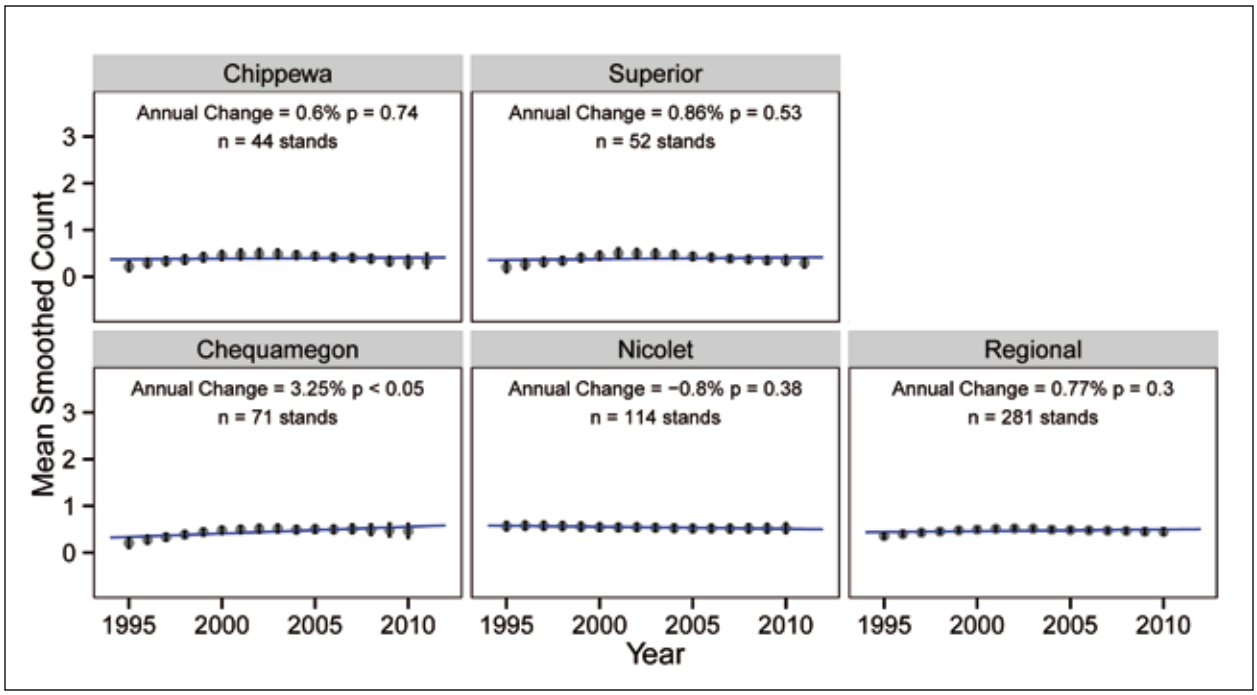
Habitat: Highly variable

Foraging type: Omnivore

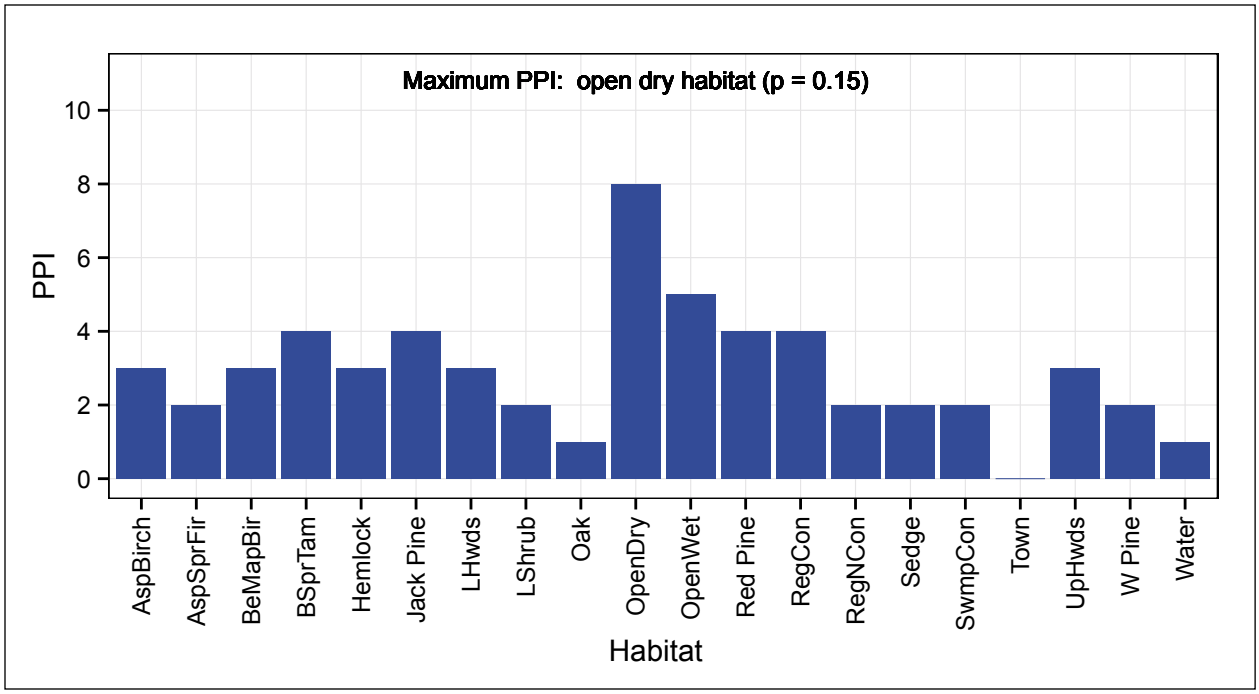
Nest site: Canopy

Migration: Permanent resident

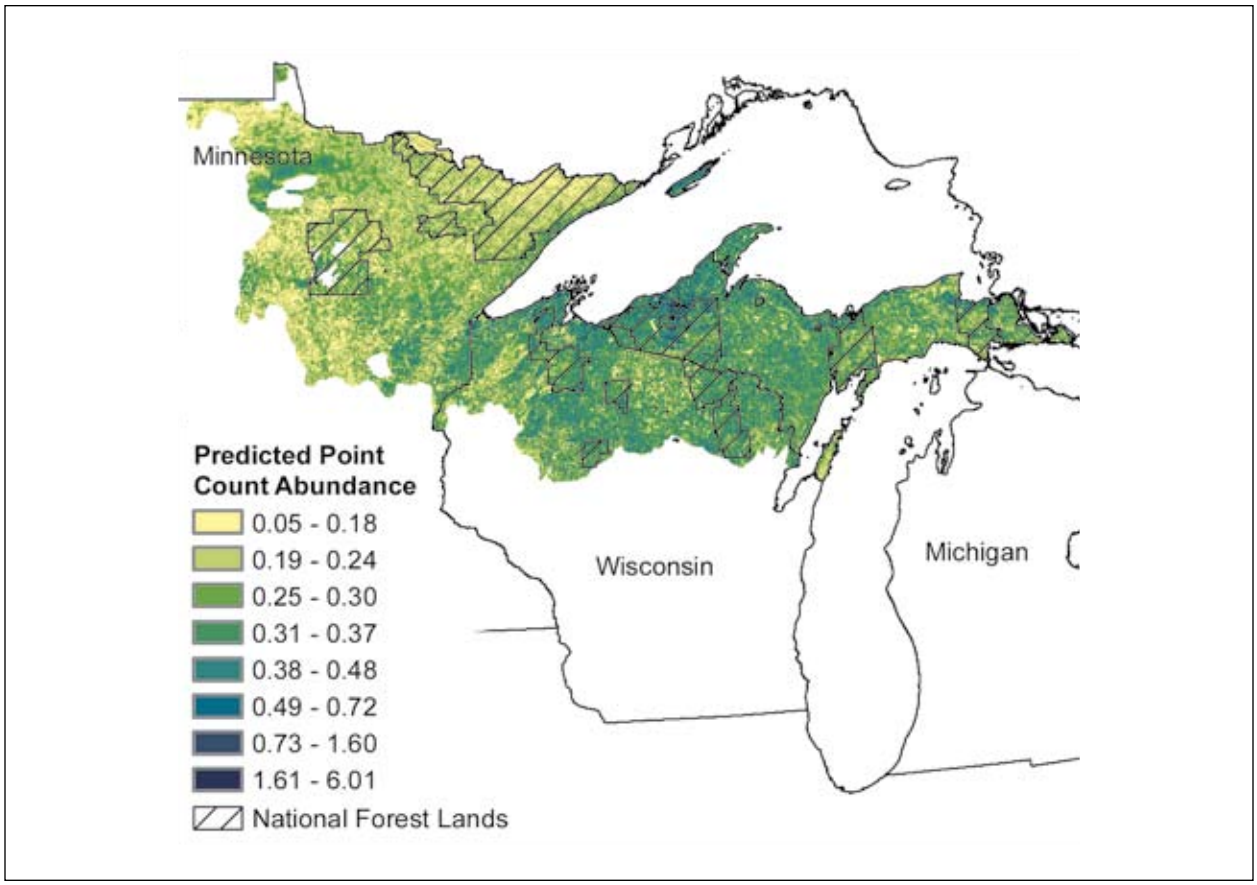
Notes: PPI analysis was not statistically significant for this species, which can be heard or seen from a great distance. Individuals recorded at many points were transients (flyovers) or birds from nearby habitats.



Trends for common raven in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for common raven where at least one bird was observed once during the decade (2001–2010; n=2,902 at 990 points)



Predicted relative abundance (number of birds per 10-minute count) of common raven for the western Great Lakes region

Common Yellowthroat COYE

Geothlypis trichas



Photo by Jon Swanson, used with permission.

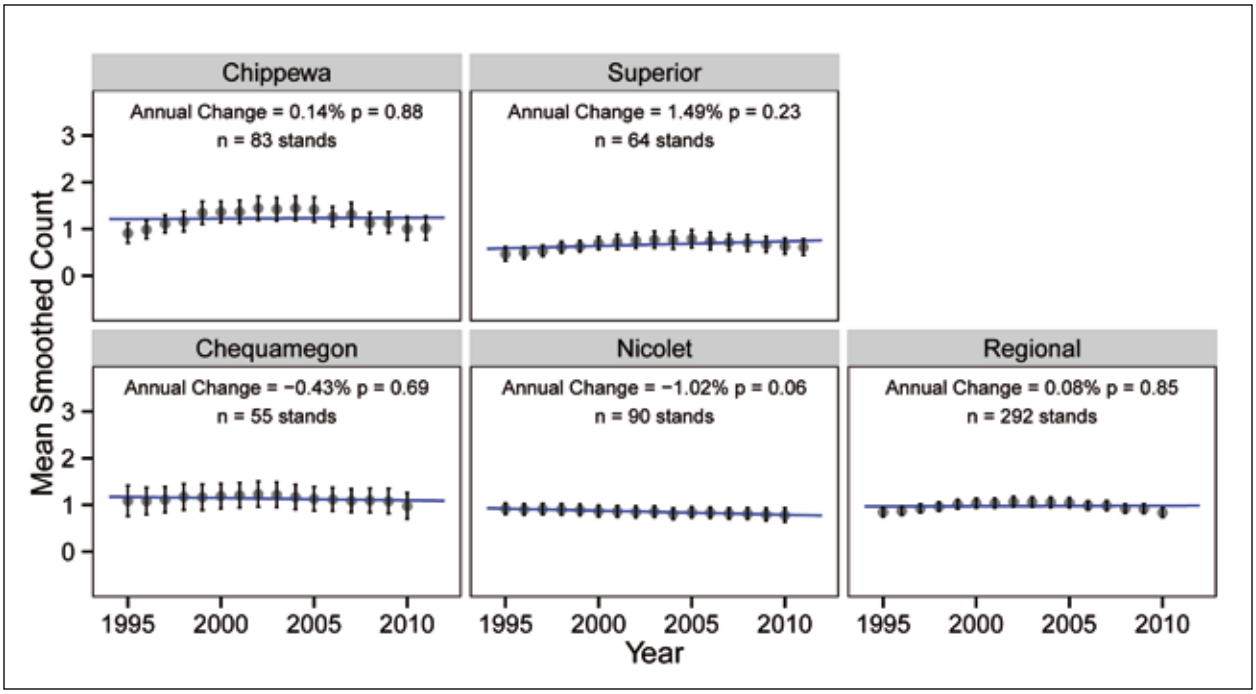
Guild Information

Habitat: Lowland shrubs, wetlands

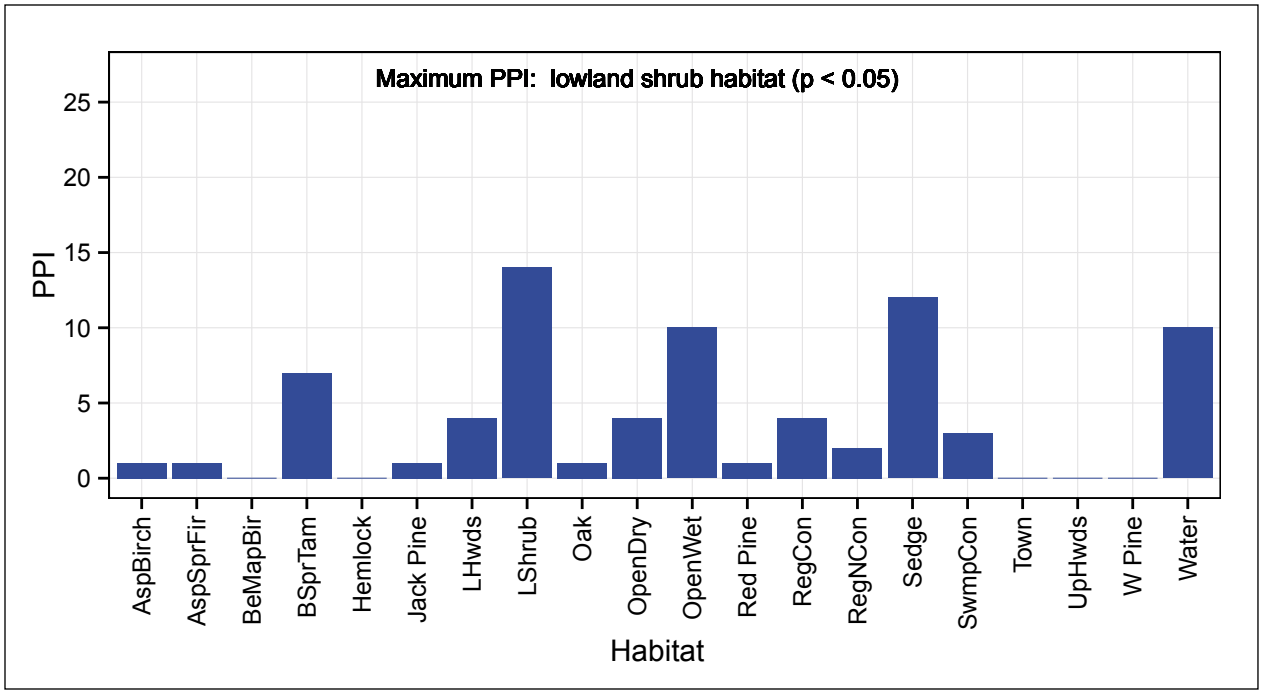
Foraging type: Foliage gleaner

Nest site: Ground, low shrub

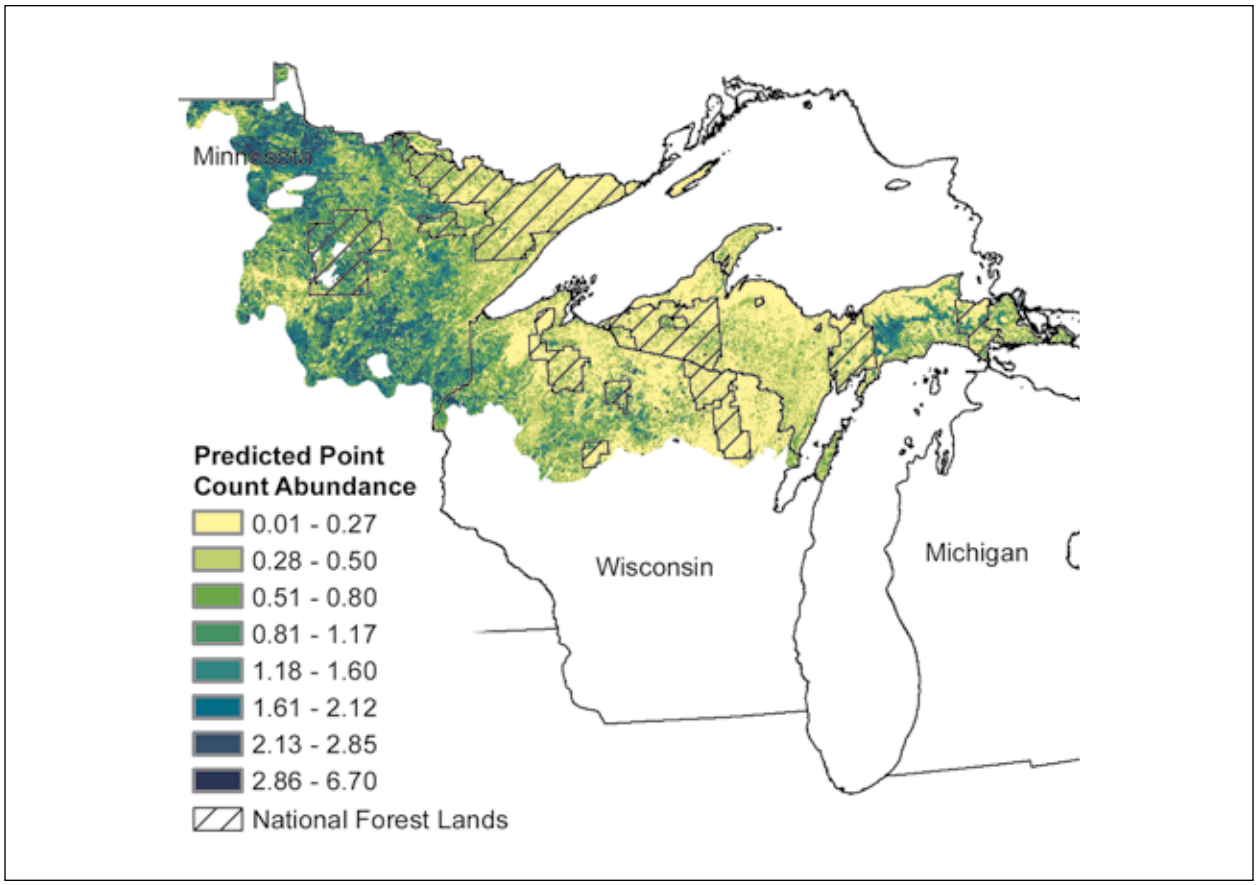
Migration: Short-distance



Trends for common yellowthroat in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for common yellowthroat where at least one bird was observed once during the decade (2001–2010; n=5,064 at 806 points)



Predicted relative abundance (number of birds per 10-minute count) of common yellowthroat for the western Great Lakes region

Connecticut Warbler CONW

Oporornis agilis



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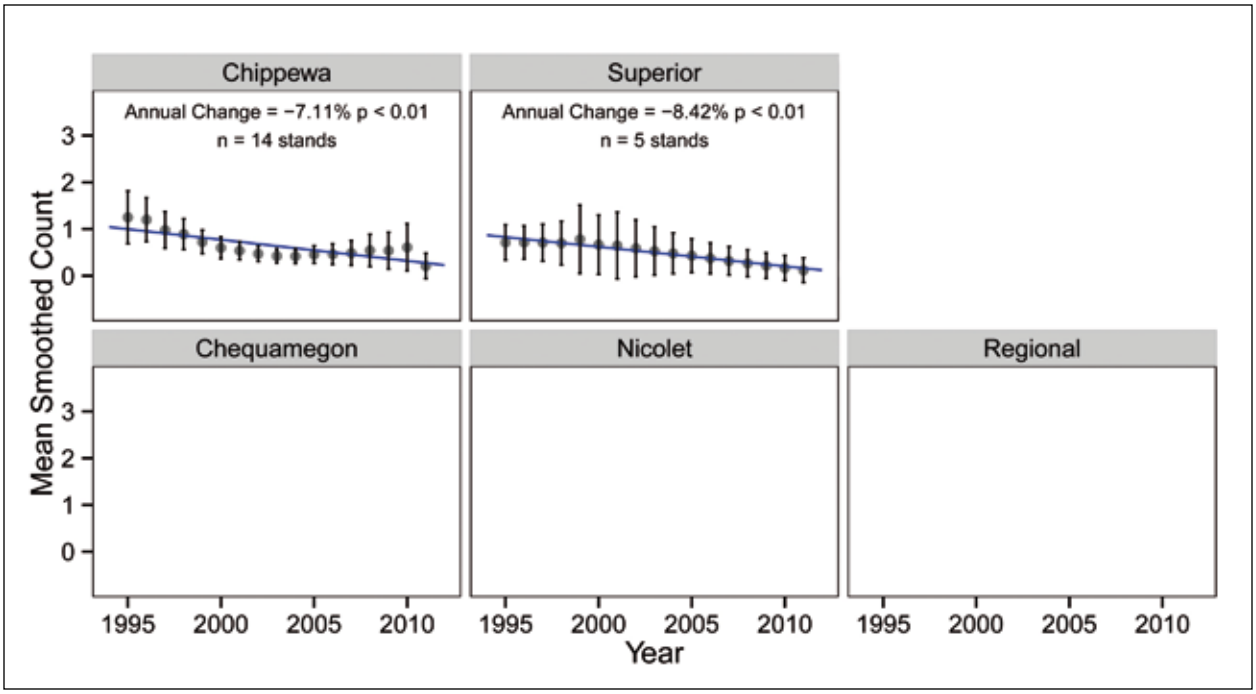
Guild Information

Habitat: Black spruce-tamarack forests, occasionally jack pine forests

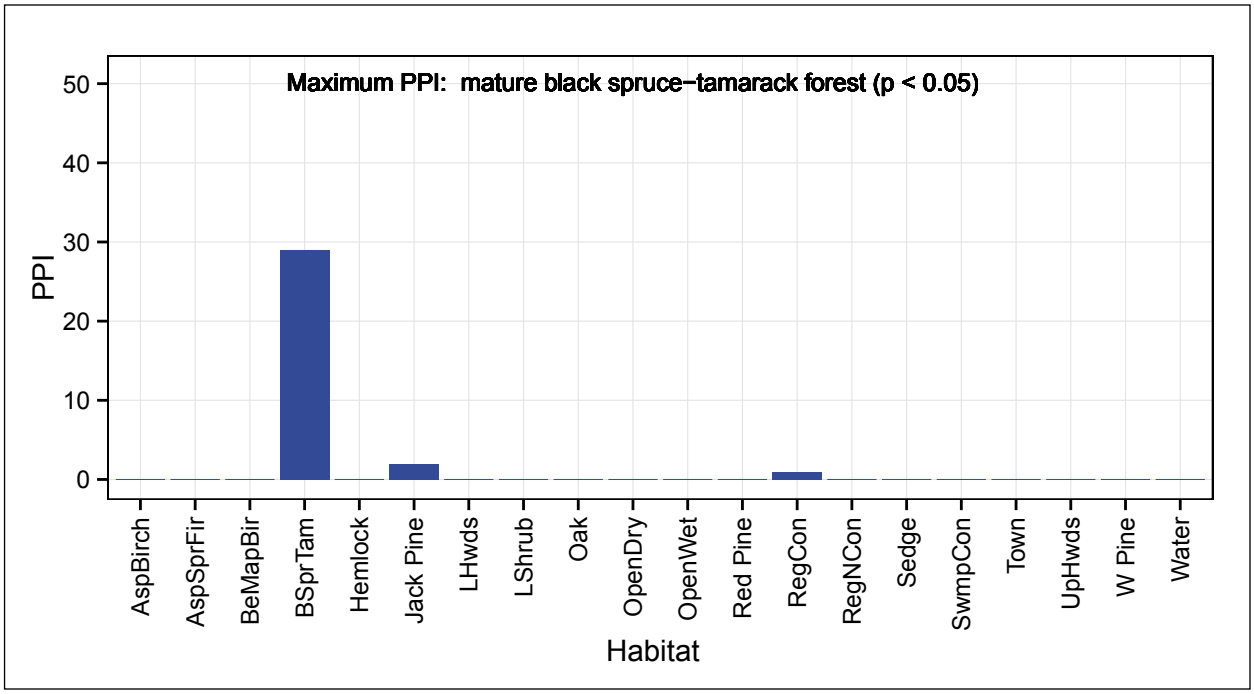
Foraging type: Foliage gleaner

Nest site: Ground, low shrub

Migration: Long-distance



Trends for Connecticut warbler in two national forests, 1995–2010



Percent perfect indication of habitat association for Connecticut warbler where at least one bird was observed once during the decade (2001–2010; n=251 at 89 points)

Downy Woodpecker DOWO

Picoides pubescens



Photo by Jon Swanson, used with permission.

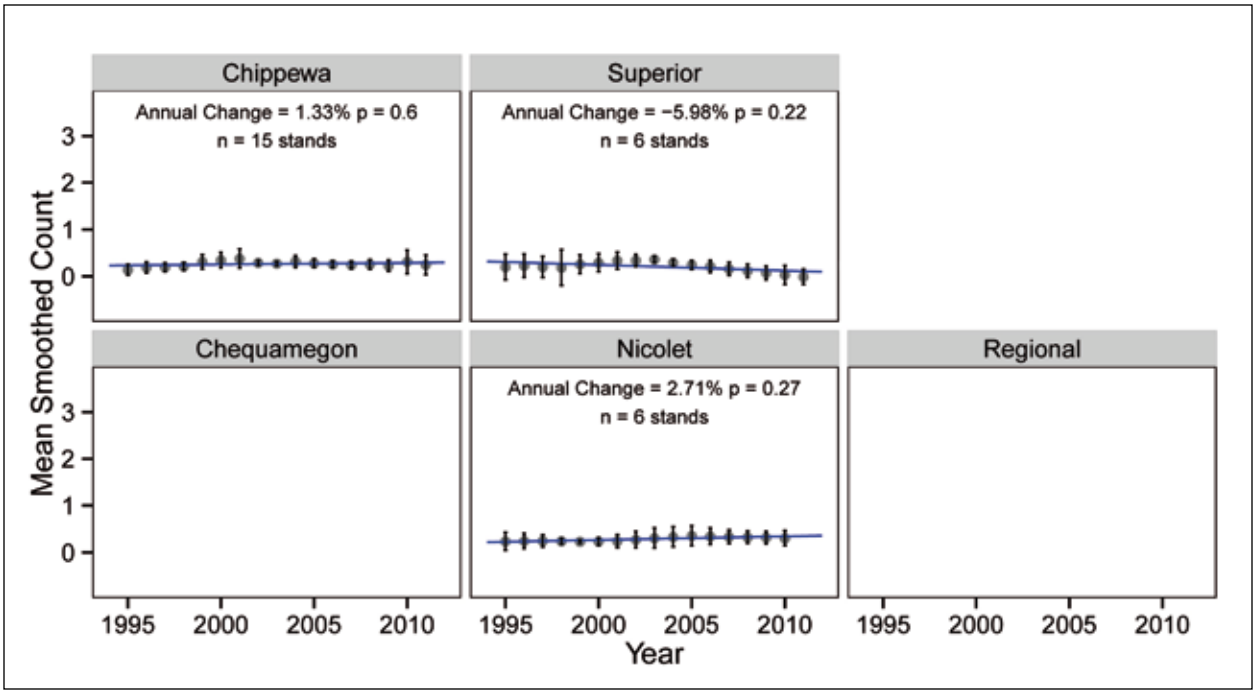
Guild Information

Habitat: Forests, especially oak and northern hardwoods

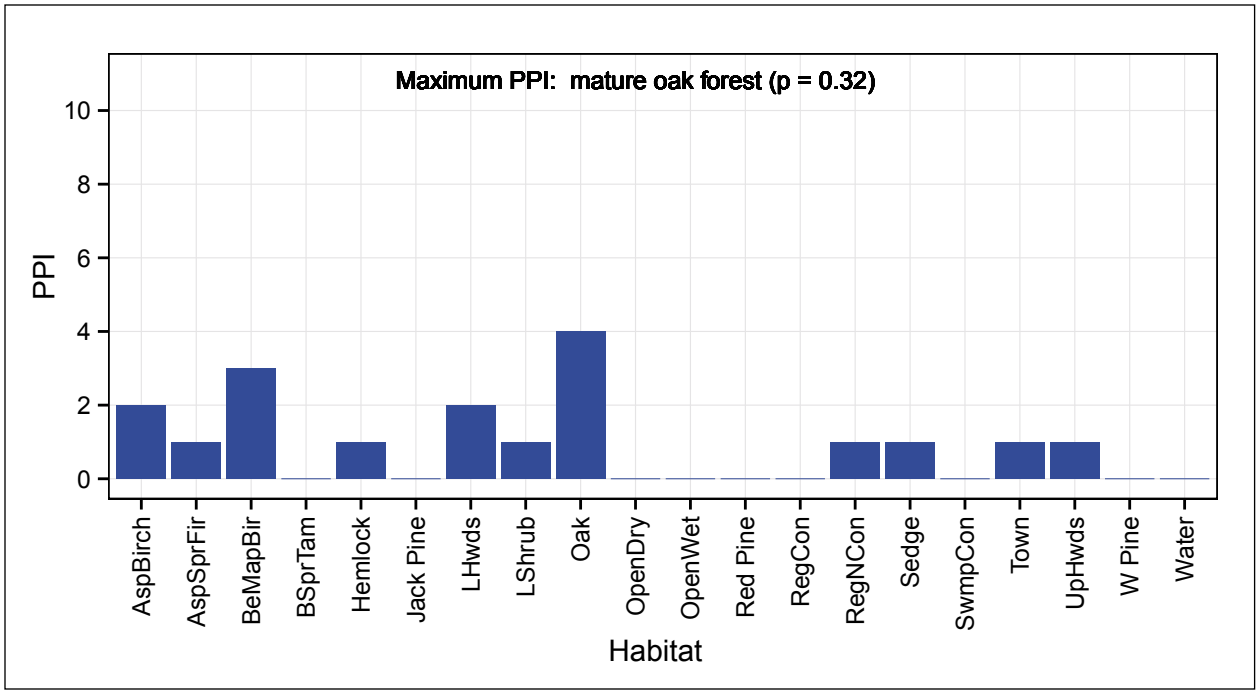
Foraging type: Bark driller and gleaner

Nest site: Cavity

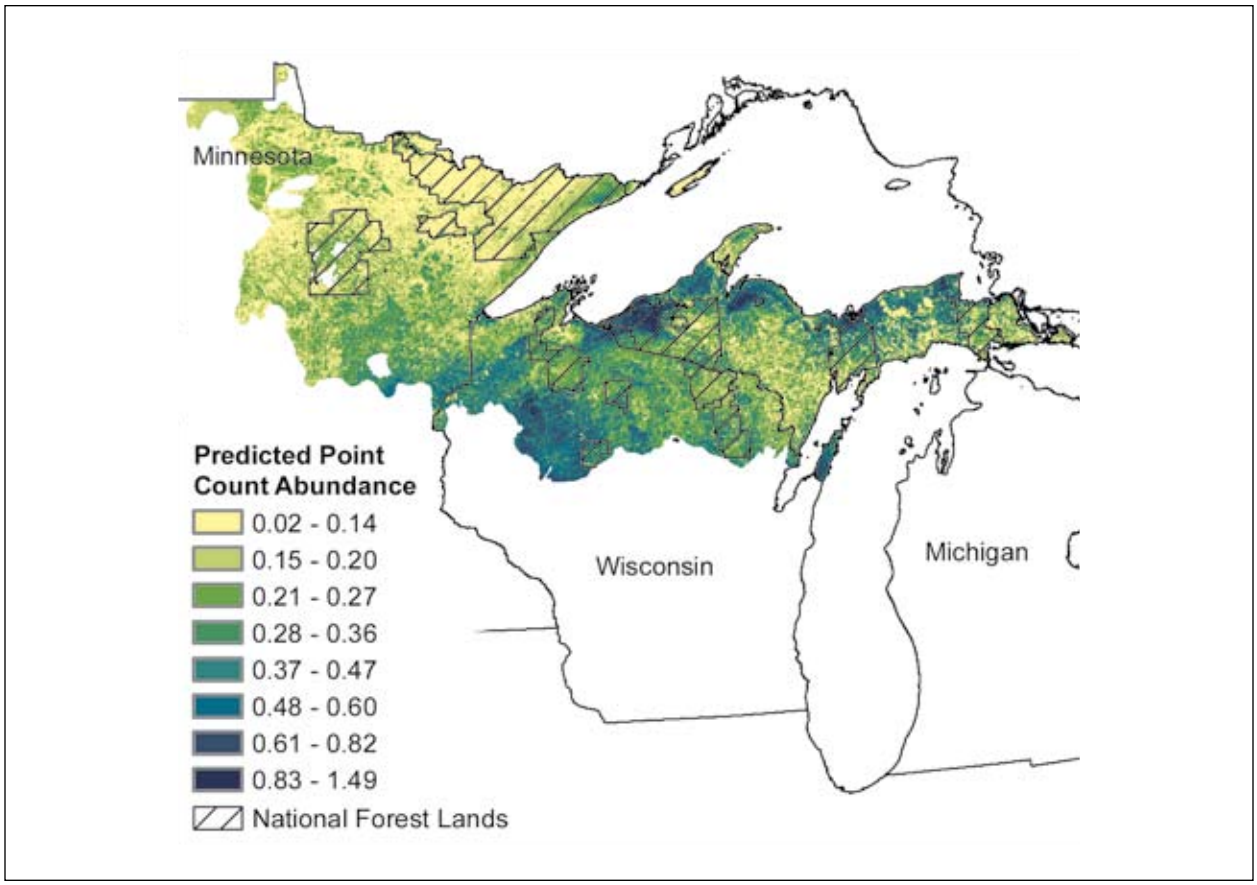
Migration: Permanent resident



Trends for downy woodpecker in three national forests, 1995–2010



Percent perfect indication of habitat association for downy woodpecker where at least one bird was observed once during the decade (2001–2010; n=473 at 301 points)



Predicted relative abundance (number of birds per 10-minute count) of downy woodpecker for the western Great Lakes region

Eastern Bluebird EABL

Sialia sialis



Photo by Deanne Endrizzi, used with permission.

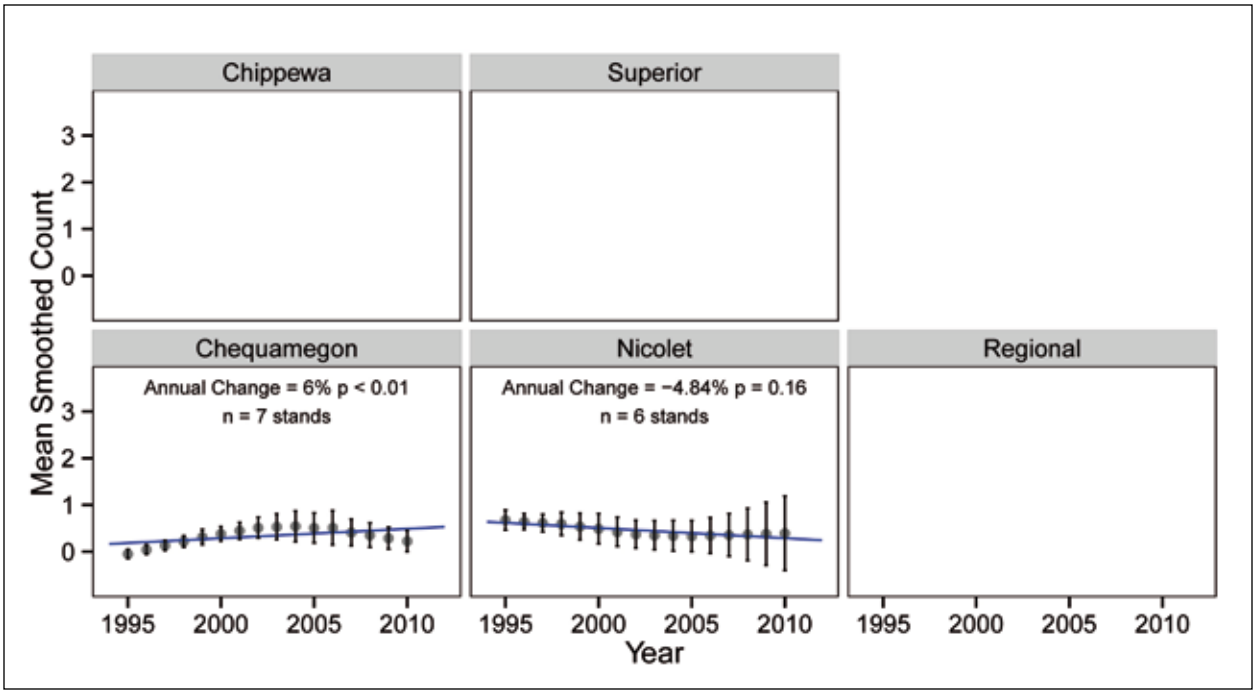
Guild Information

Habitat: Open dry areas

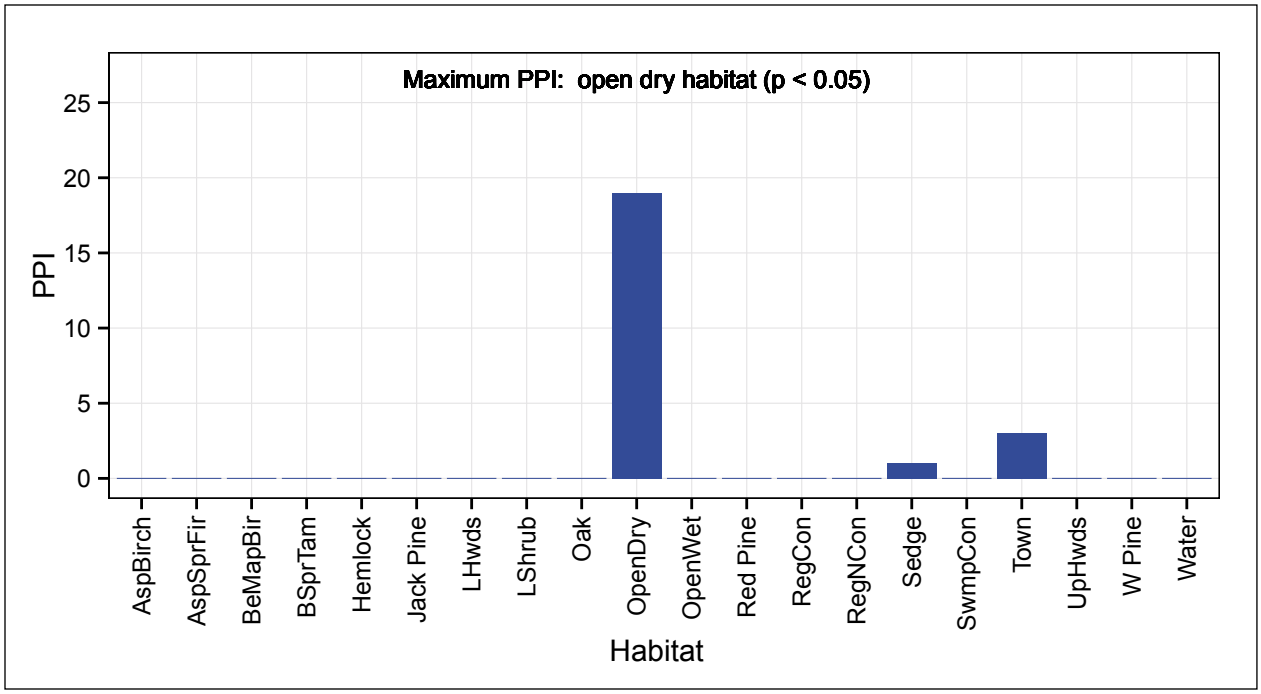
Foraging type: Flycatcher, ground invertebrates

Nest site: Cavity

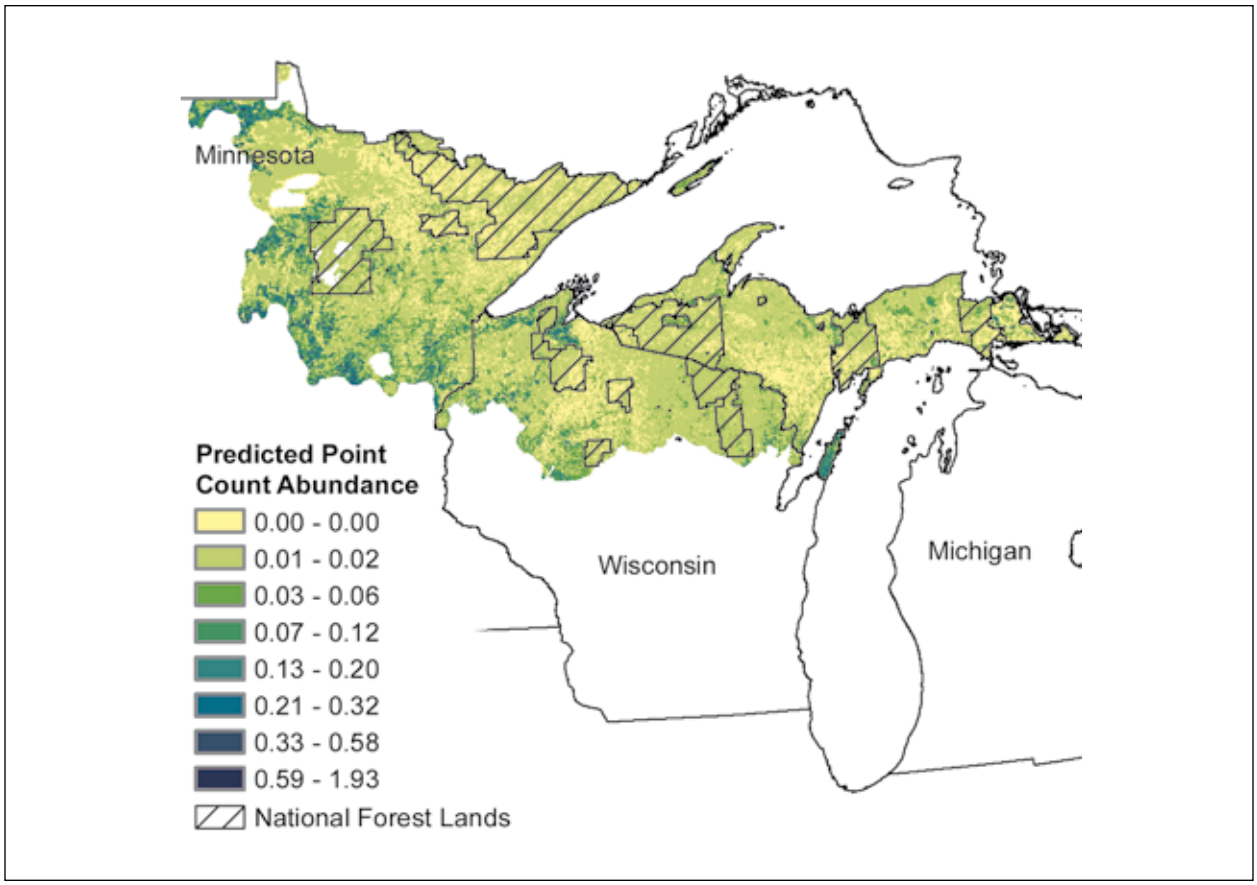
Migration: Short-distance



Trends for eastern bluebird in two national forests, 1995–2010



Percent perfect indication of habitat association for eastern bluebird where at least one bird was observed once during the decade (2001–2010, n=130 at 63 points)



Predicted relative abundance (number of birds per 10-minute count) of eastern bluebird for the western Great Lakes region

Eastern Kingbird EAKI

Tyrannus tyrannus



Photo by Jon Swanson, used with permission.

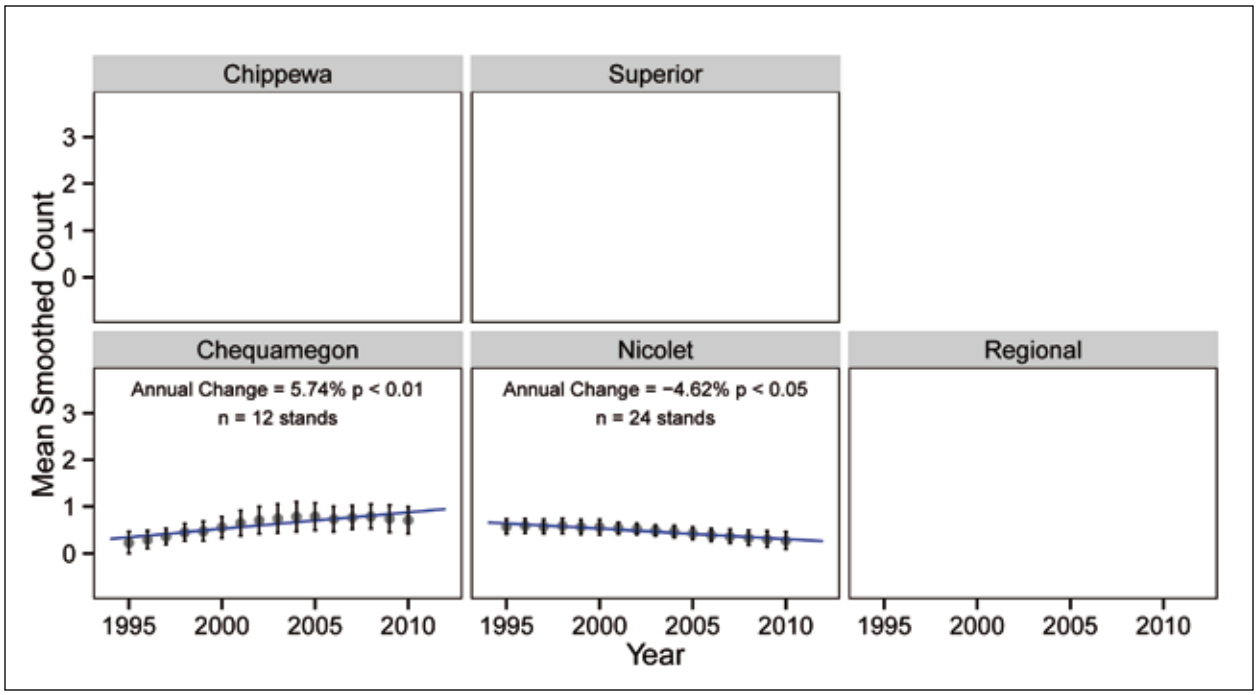
Guild Information

Habitat: Shrubs, forest and water edges

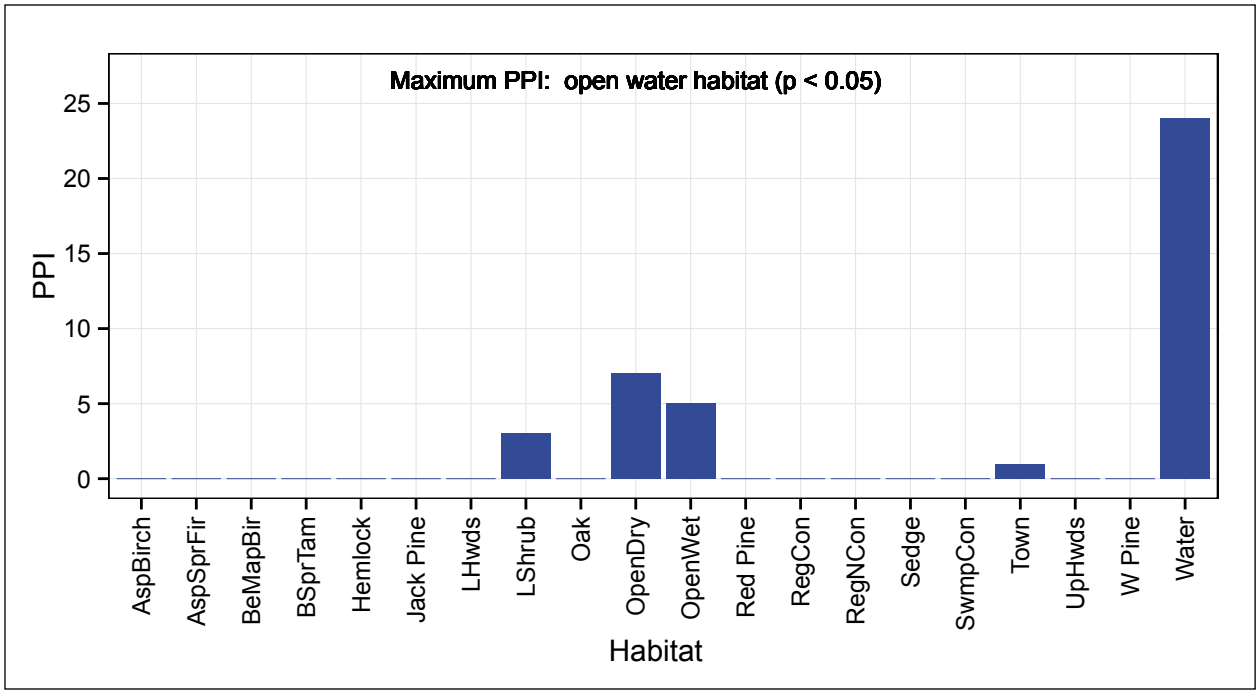
Foraging type: Flycatcher

Nest site: Shrub or subcanopy

Migration: Long-distance



Trends for eastern kingbird in two national forests, 1995–2010



Percent perfect indication of habitat association for eastern kingbird where at least one bird was observed once during the decade (2001–2010; n=373 at 108 points)

Eastern Towhee EATO

Pipilo erythrophthalmus



Photo by Larry Sirvio, used with permission.

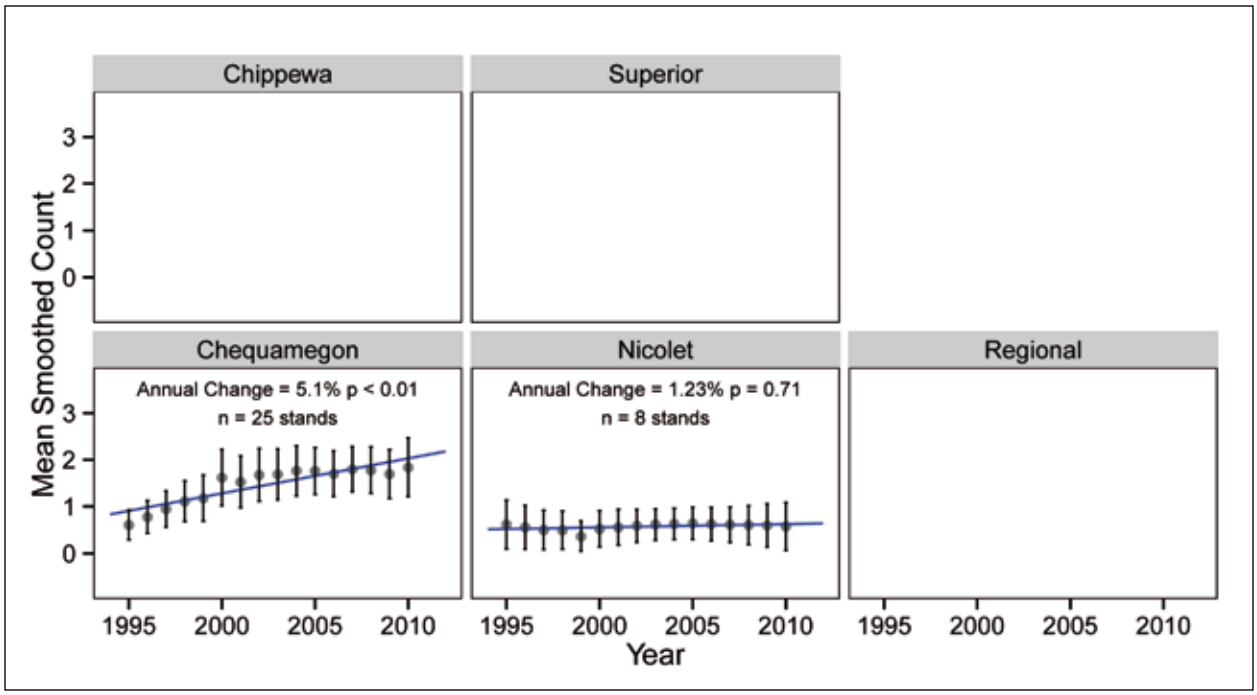
Guild Information

Habitat: Open dry shrubby areas

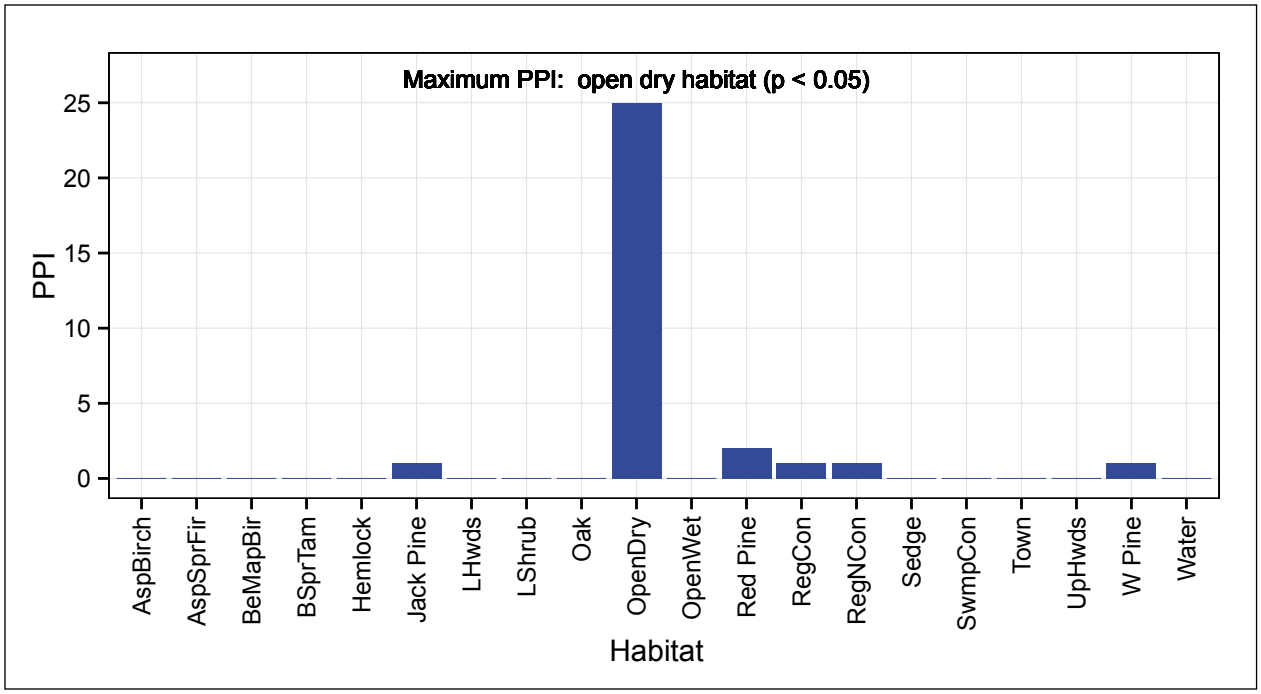
Foraging type: Omnivore—seeds, invertebrates

Nest site: Ground

Migration: Short-distance



Trends for eastern towhee in two national forests, 1995–2010



Percent perfect indication of habitat association for eastern towhee where at least one bird was observed once during the decade (2001–2010, n=868 at 121 points)

Eastern Wood-Pewee EAWP

Contopus virens



Photo by Jon Swanson, used with permission.

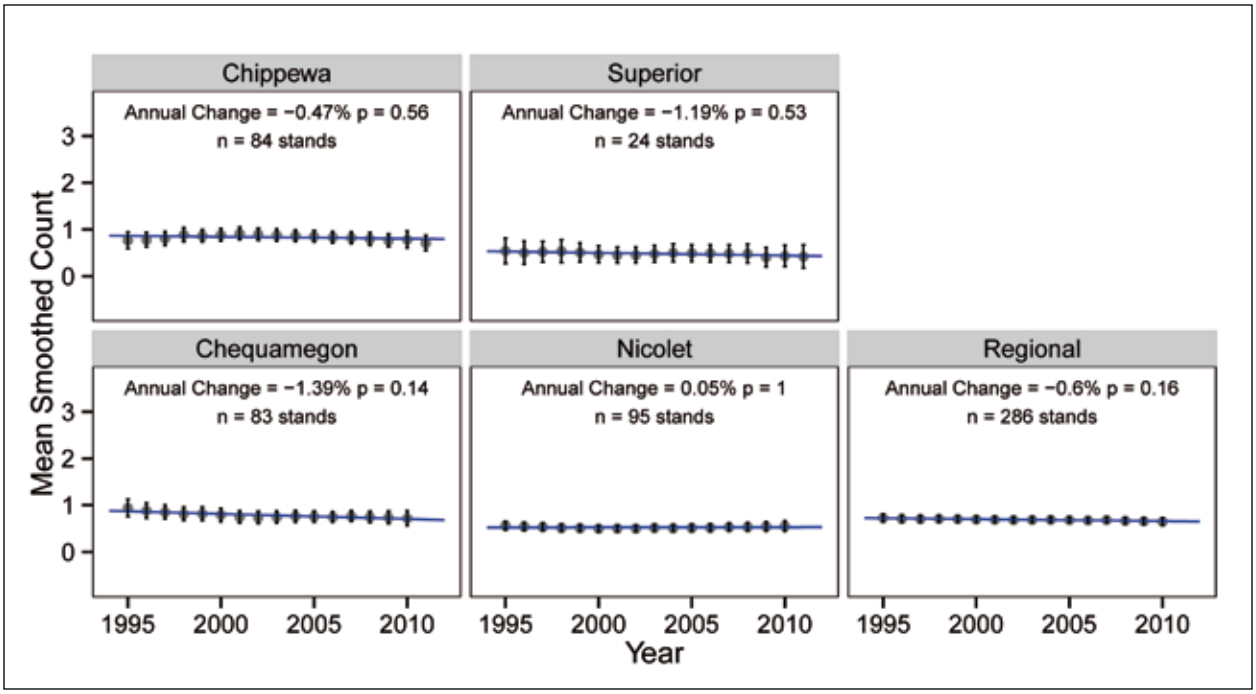
Guild Information

Habitat: Forests—especially oak, open pine, and northern hardwoods

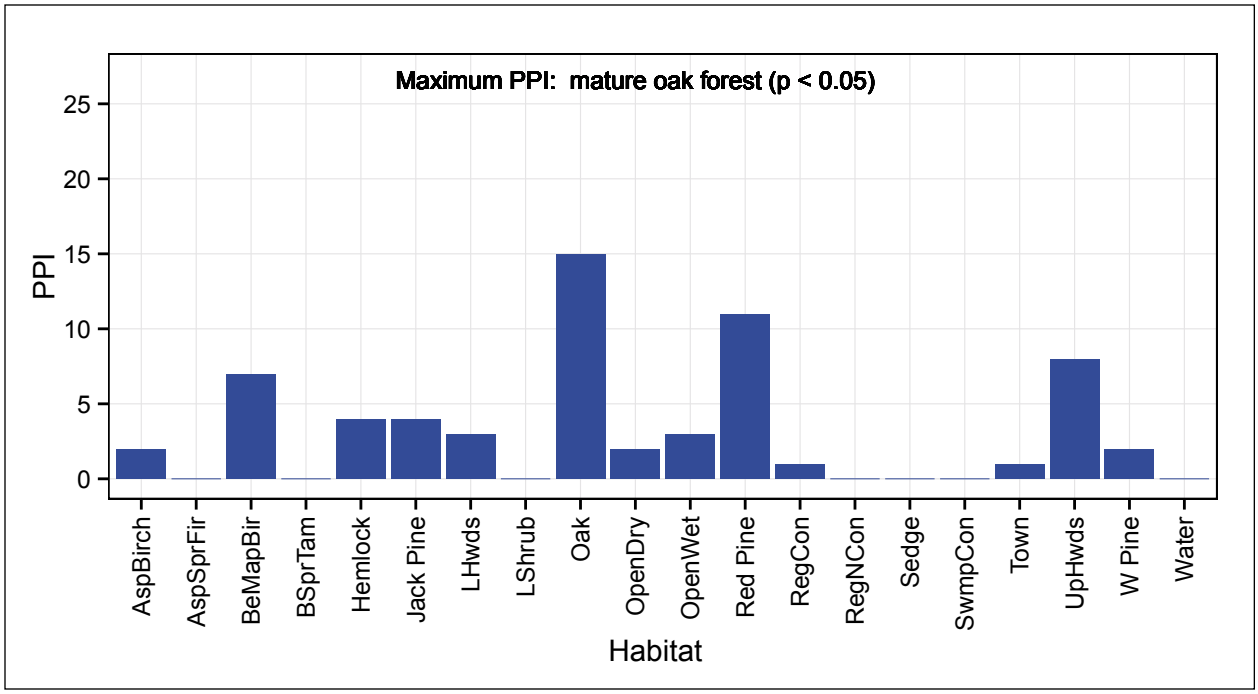
Foraging type: Flycatcher

Nest site: Canopy

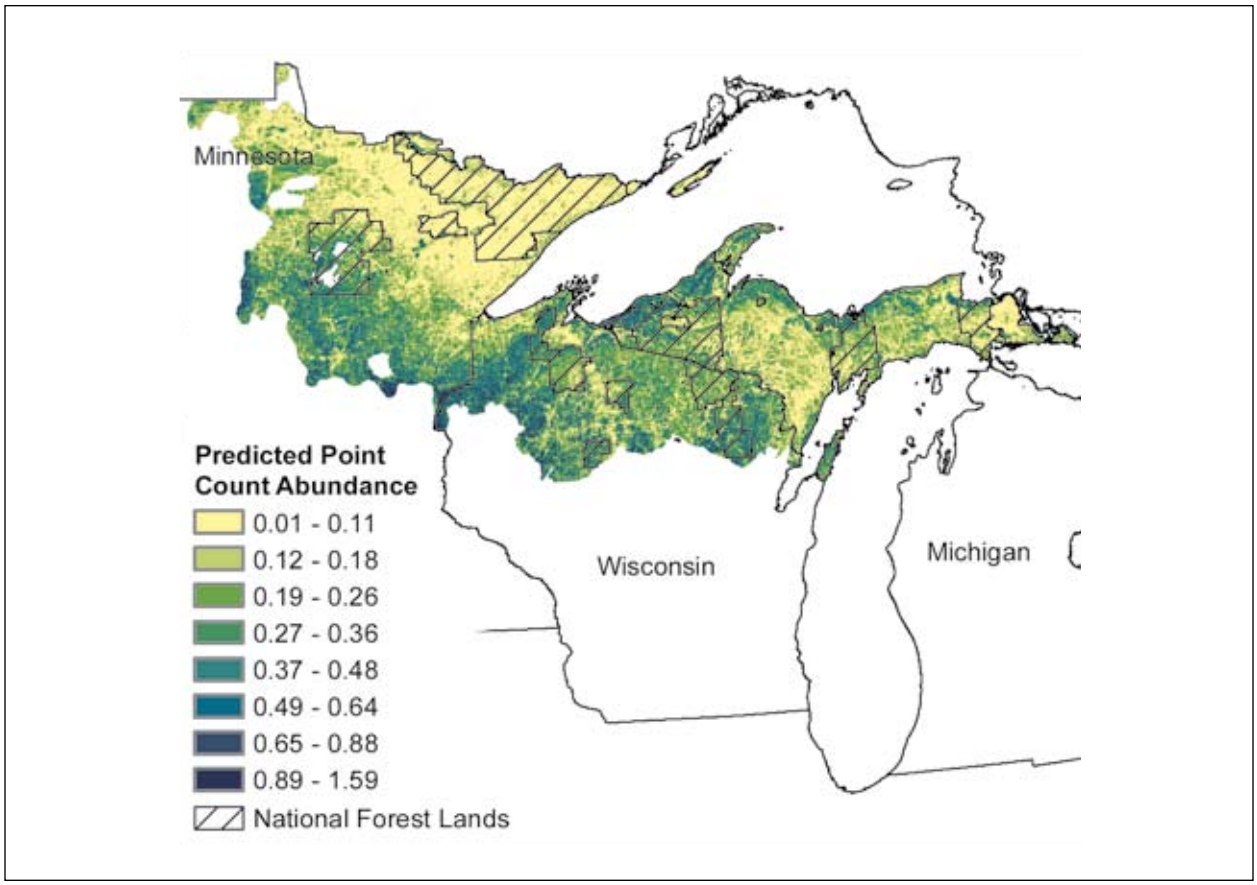
Migration: Long-distance



Trends for eastern wood-pewee in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for eastern wood-pewee where at least one bird was observed once during the decade (2001–2010; n=3,207 at 826 points)



Predicted relative abundance (number of birds per 10-minute count) of eastern wood-pewee for the western Great Lakes region

European Starling
Sturnus vulgaris

EUST



Photo by Lee Karney, U.S. Fish and Wildlife Service, Bugwood.org.

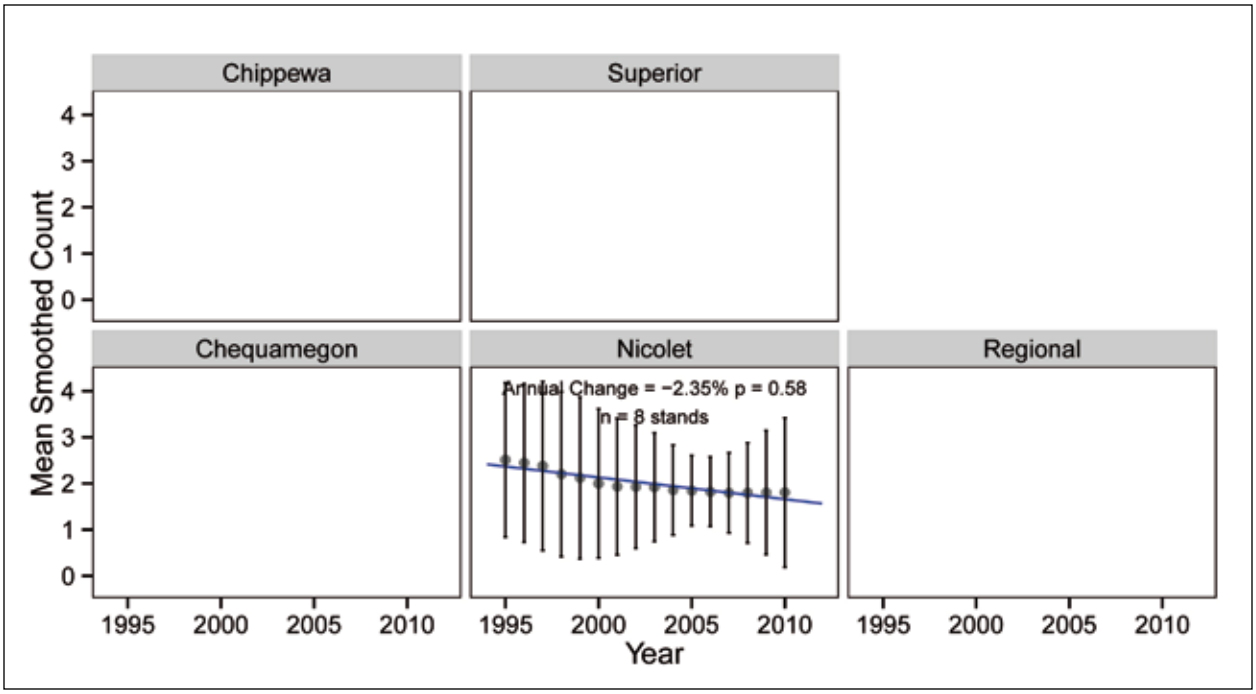
Guild Information

Habitat: Human settlements

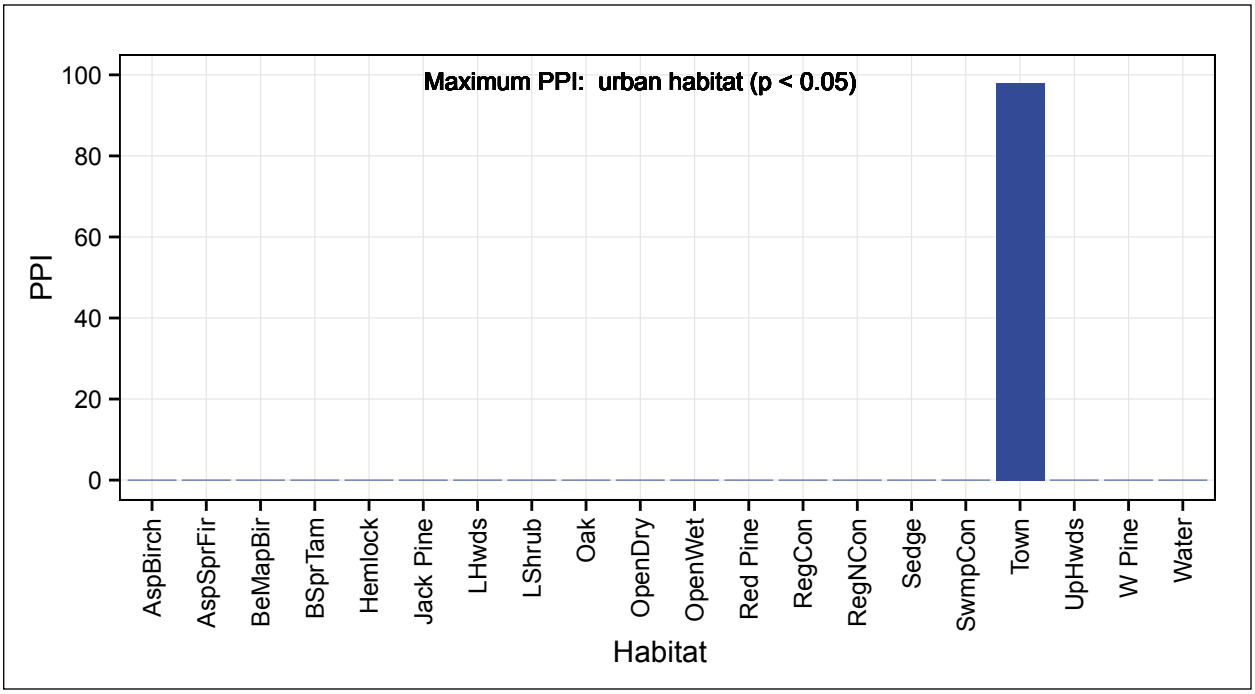
Foraging type: Omnivore

Nest site: Cavity

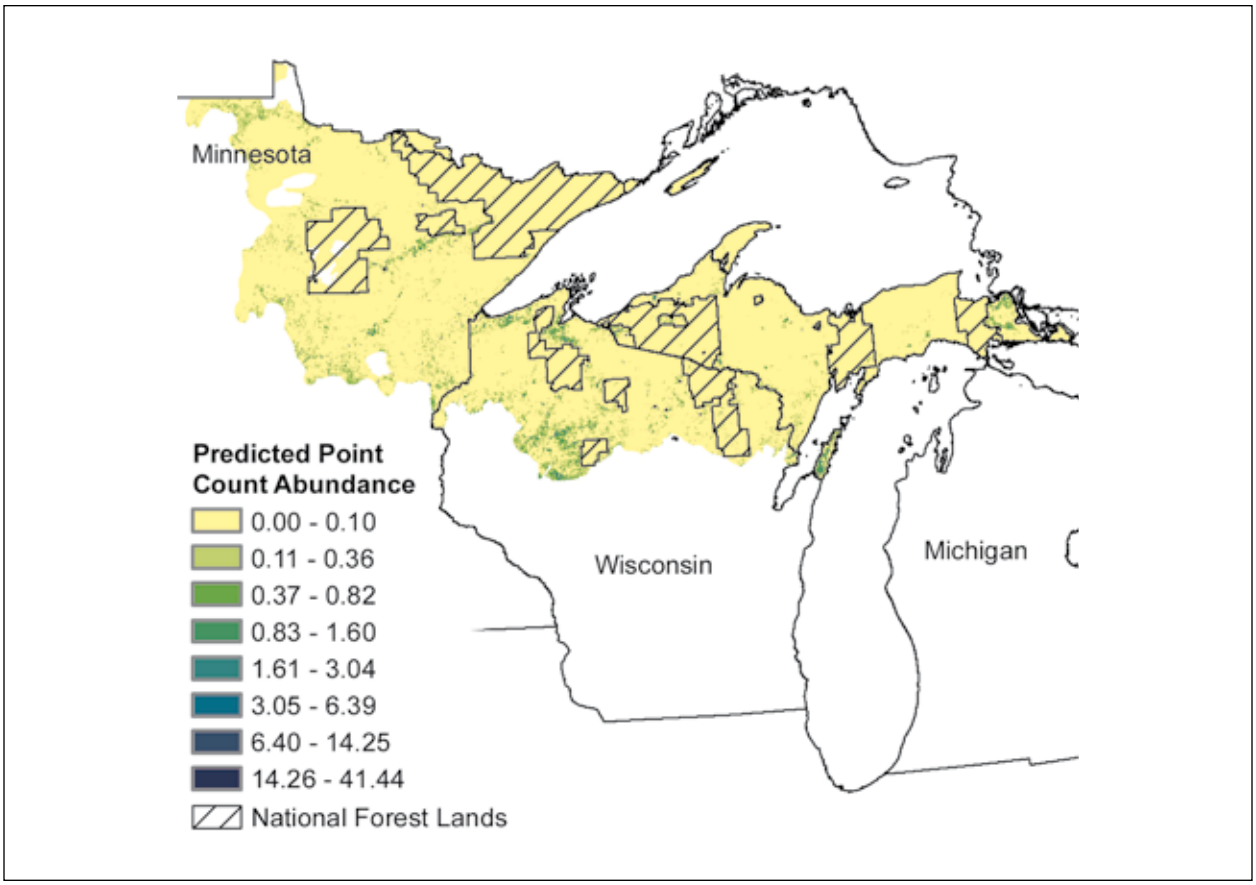
Migration: Permanent resident



Trend for European starling in one national forest, 1995–2010



Percent perfect indication of habitat association for European starling where at least one bird was observed once during the decade (2001–2010; n=164 at 12 points)



Predicted relative abundance (number of birds per 10-minute count) of European starling for the western Great Lakes region

Evening Grosbeak EVGR

Coccothraustes vespertinus



Photo by Jon Swanson, used with permission.

Guild Information

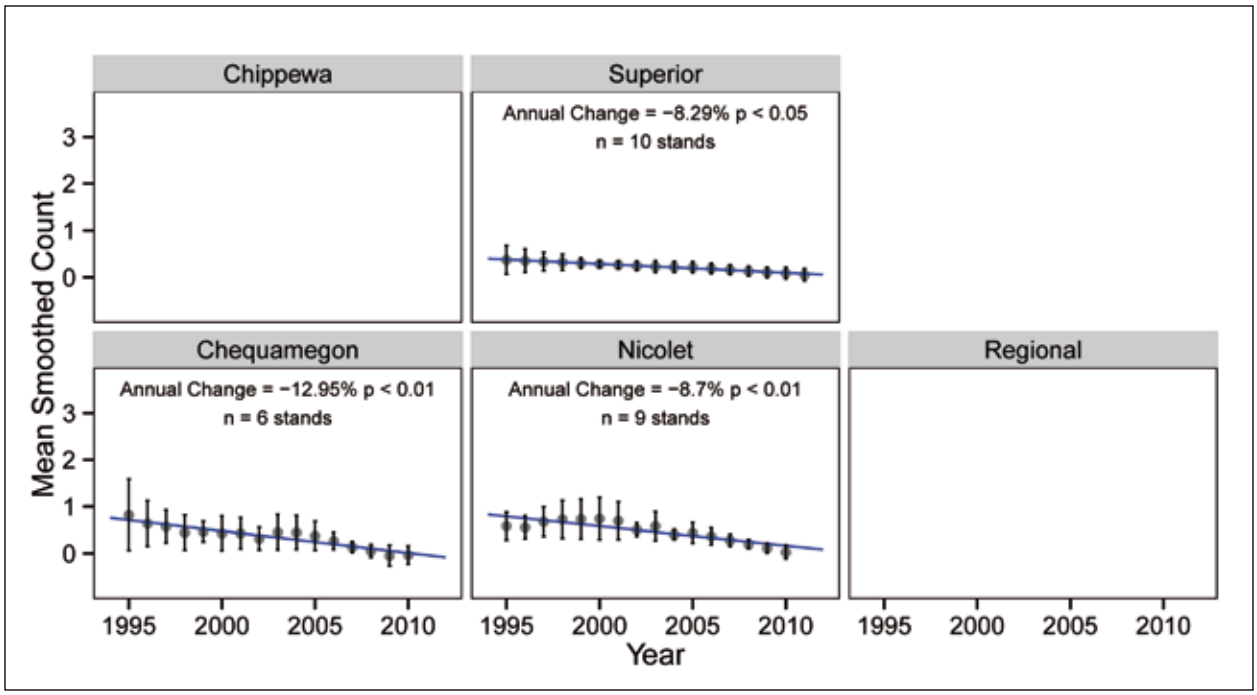
Habitat: Towns, highly variable

Foraging type: Omnivore—seeds, invertebrates

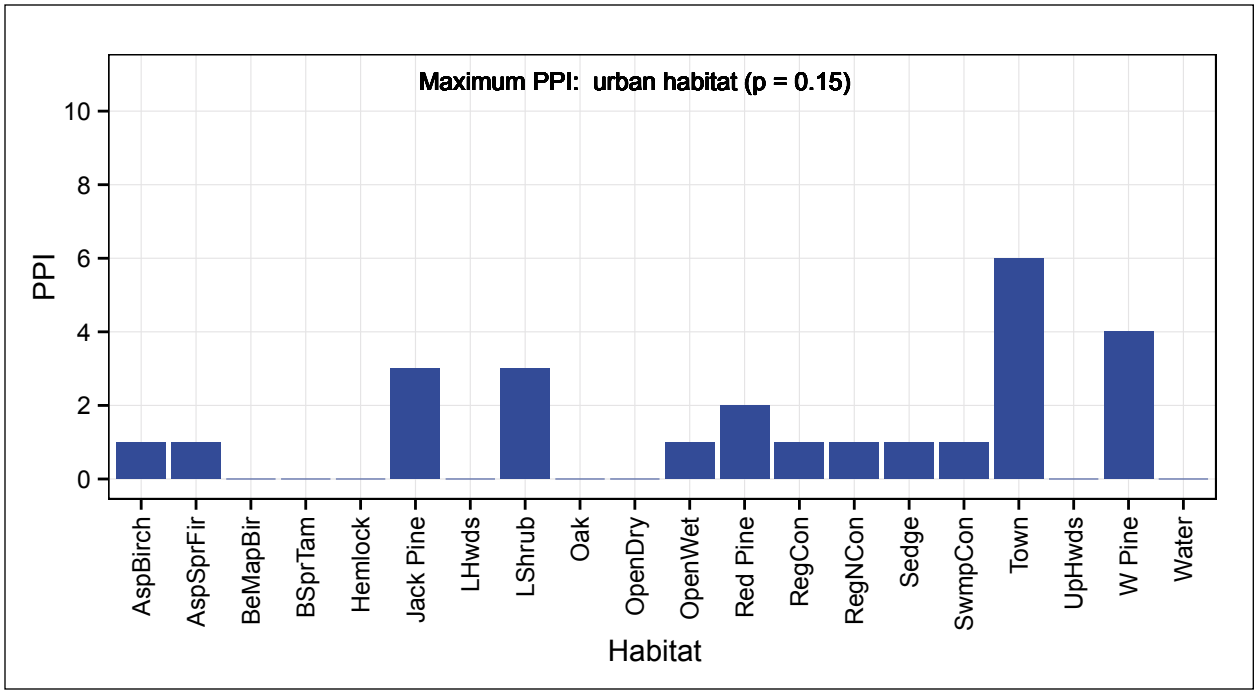
Nest site: Canopy

Migration: Permanent resident

Notes: PPI analysis was not statistically significant for this uncommon, nomadic northern finch. Observations in many habitats probably were transients (flyovers) or residents of adjacent habitat.



Trends for evening grosbeak in three national forests, 1995–2010



Percent perfect indication of habitat association for evening grosbeak where at least one bird was observed once during the decade (2001–2010; n=695 at 315 points)

Field Sparrow FISP

Spizella pusilla



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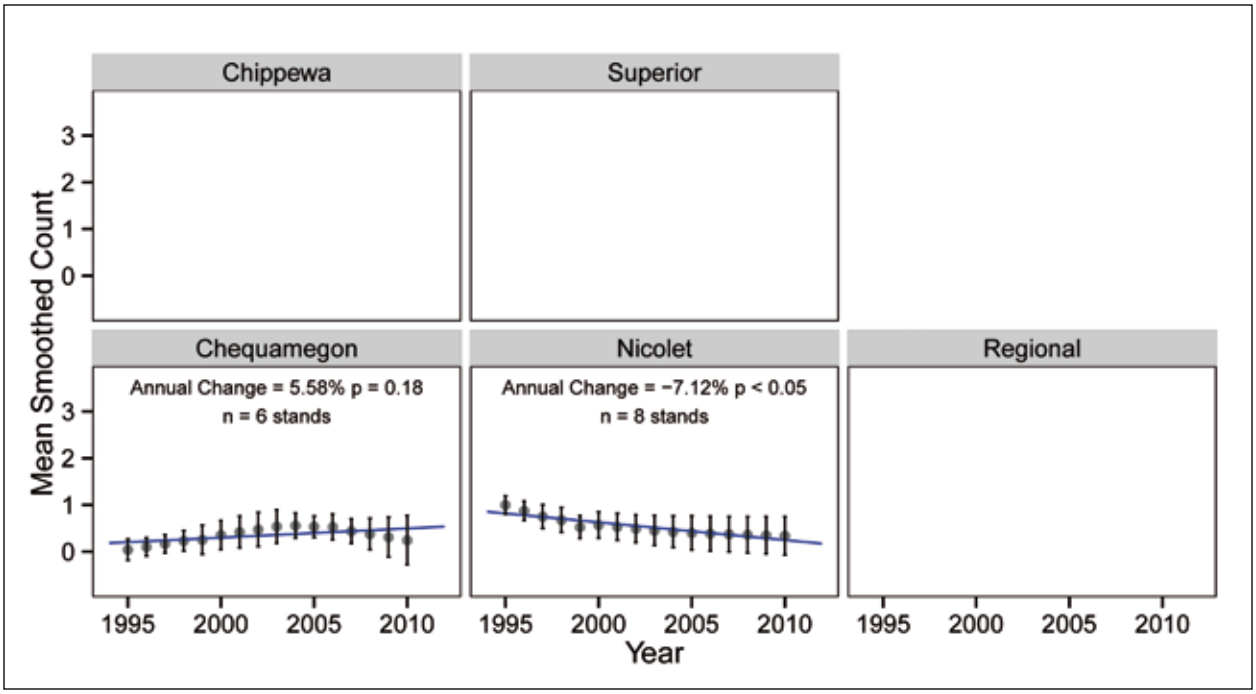
Guild Information

Habitat: Open dry areas

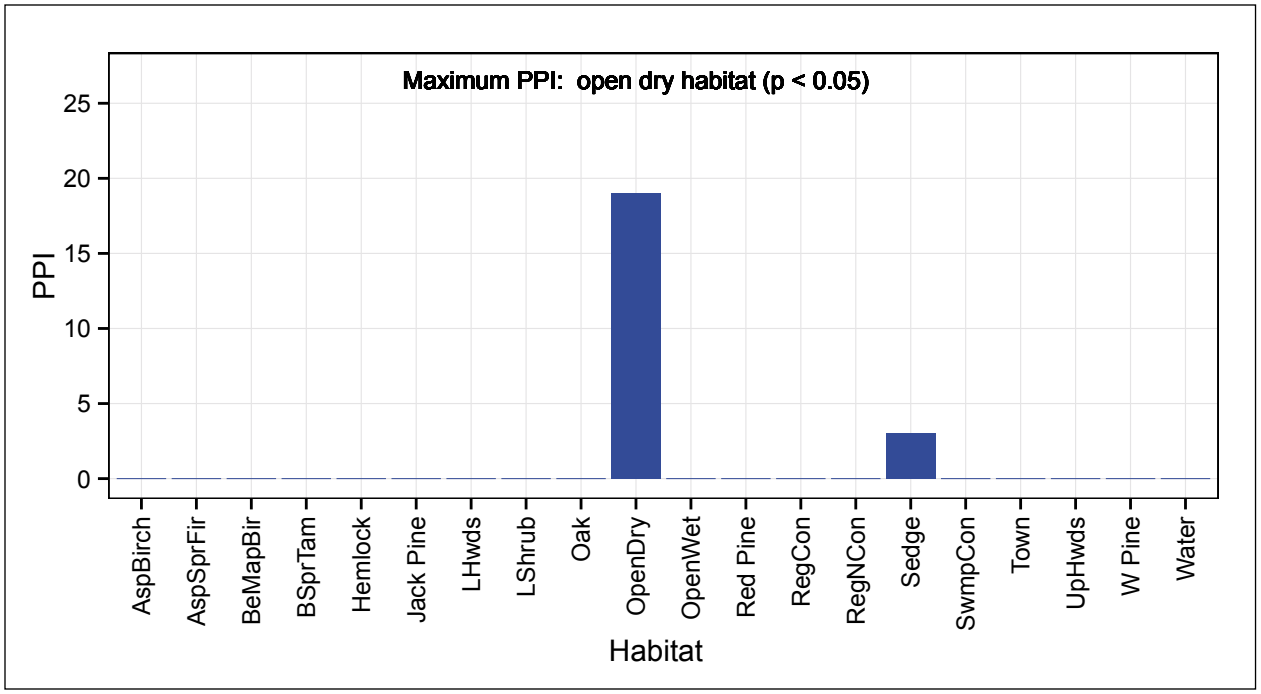
Foraging type: Omnivore—seeds, invertebrates

Nest site: Ground

Migration: Short-distance



Trends for field sparrow in two national forests, 1995–2010



Percent perfect indication of habitat association for field sparrow where at least one bird was observed once during the decade (2001–2010; n=94 at 30 points)

Golden-crowned Kinglet GCKI

Regulus satrapa



Photo by Casey Sanders, Bugwood.org.

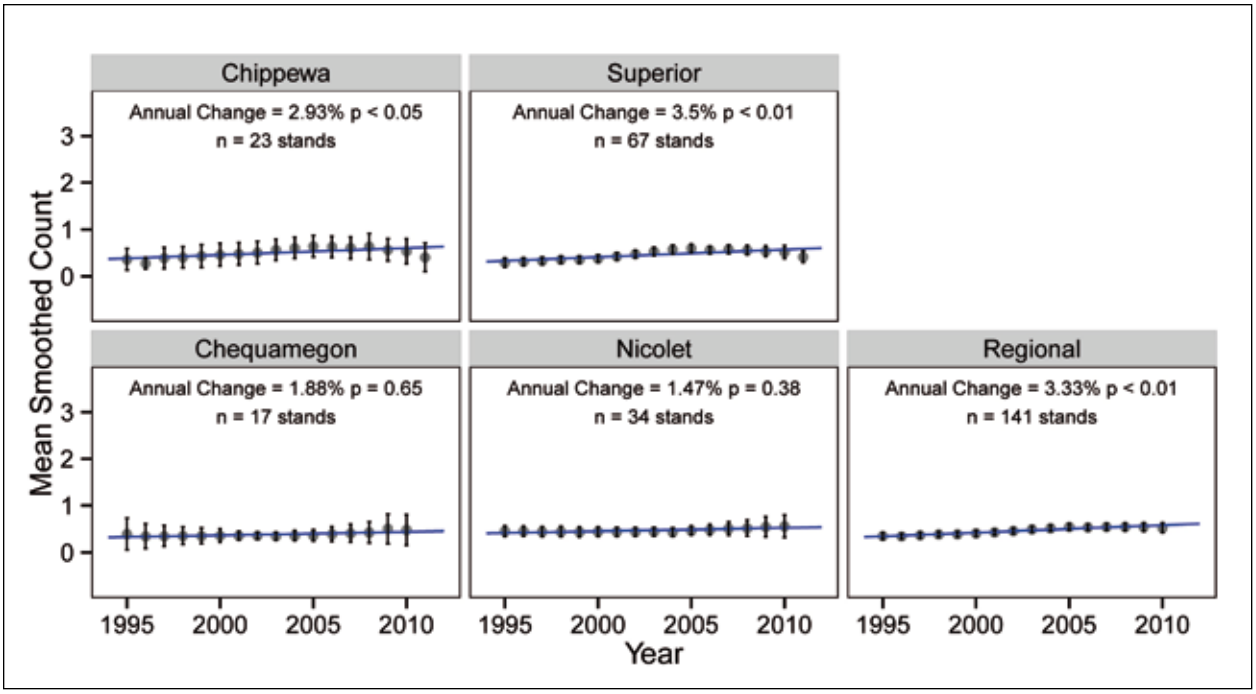
Guild Information

Habitat: Conifer forests

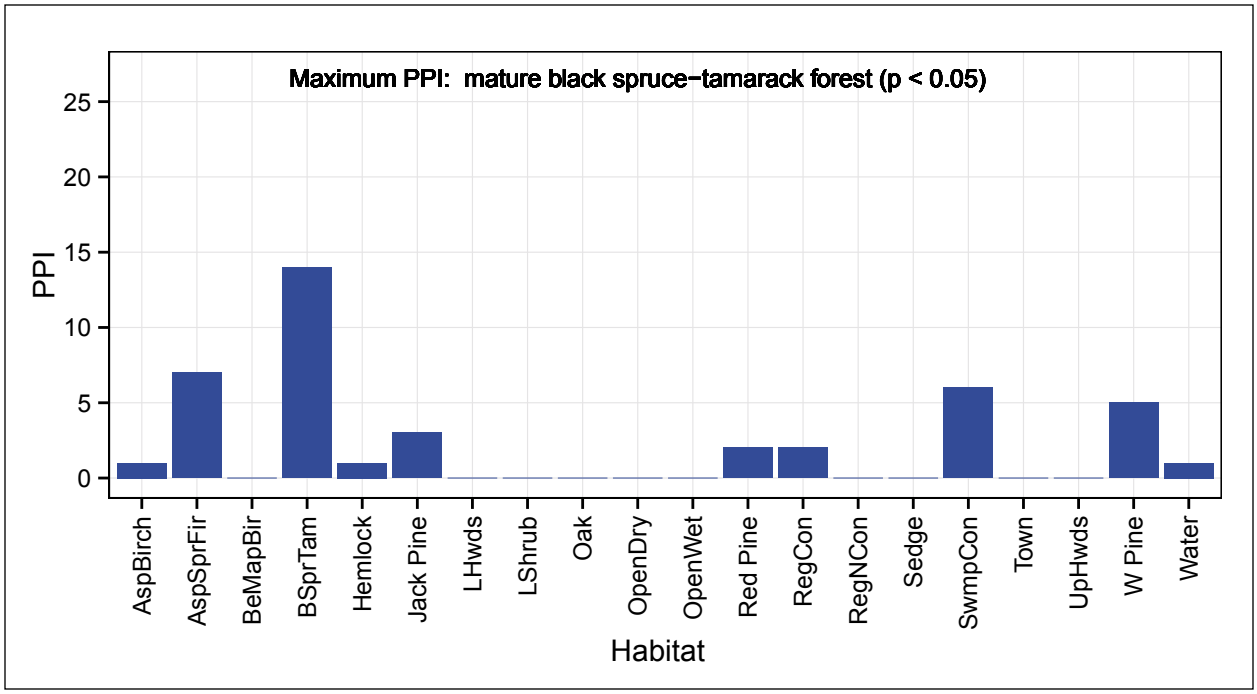
Foraging type: Foliage gleaner

Nest site: Canopy

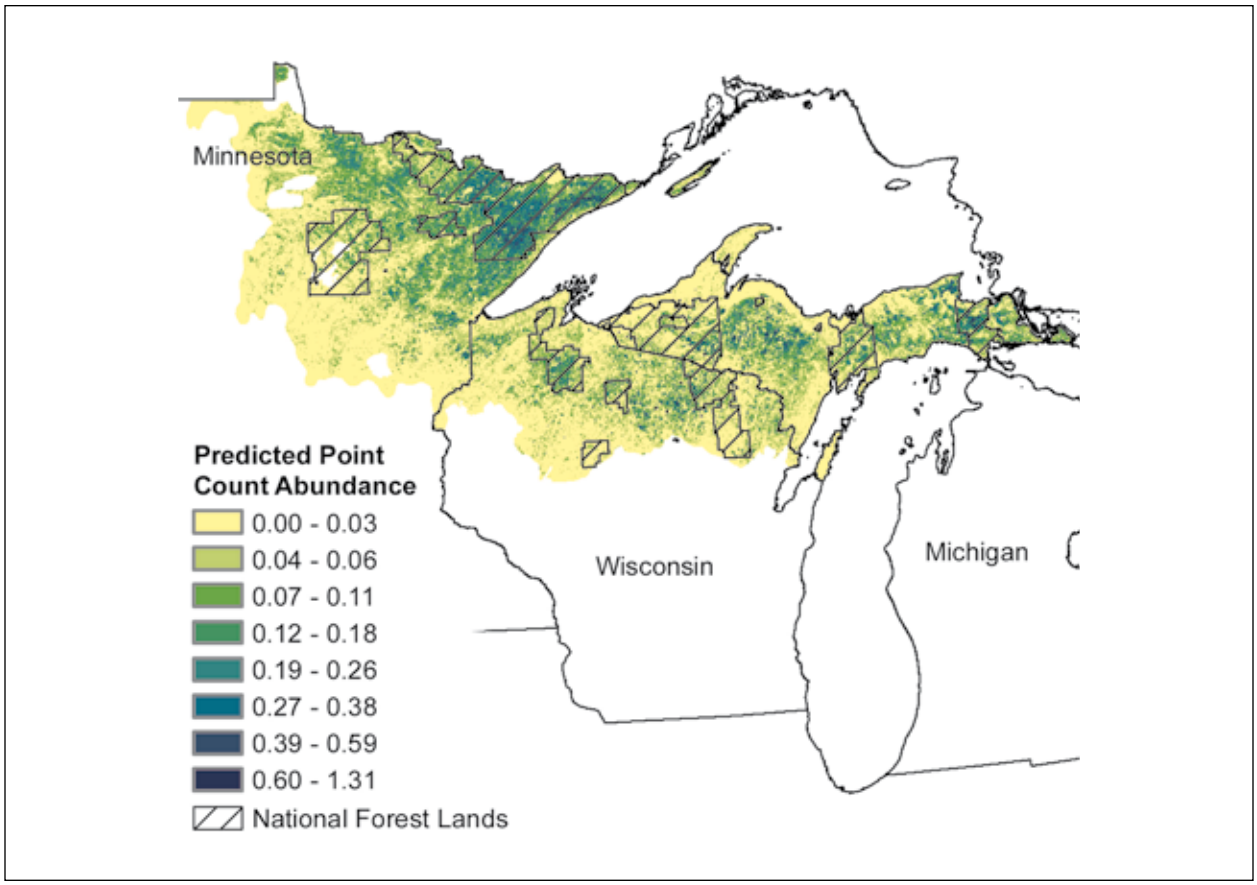
Migration: Short-distance



Trends for golden-crowned kinglet in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for golden-crowned kinglet where at least one bird was observed once during the decade (2001–2010; n=1,469 at 509 points)



Predicted relative abundance (number of birds per 10-minute count) of golden-crowned kinglet for the western Great Lakes region

Golden-winged Warbler GWWA

Vermivora chrysoptera



©Robert Royse, used with permission.

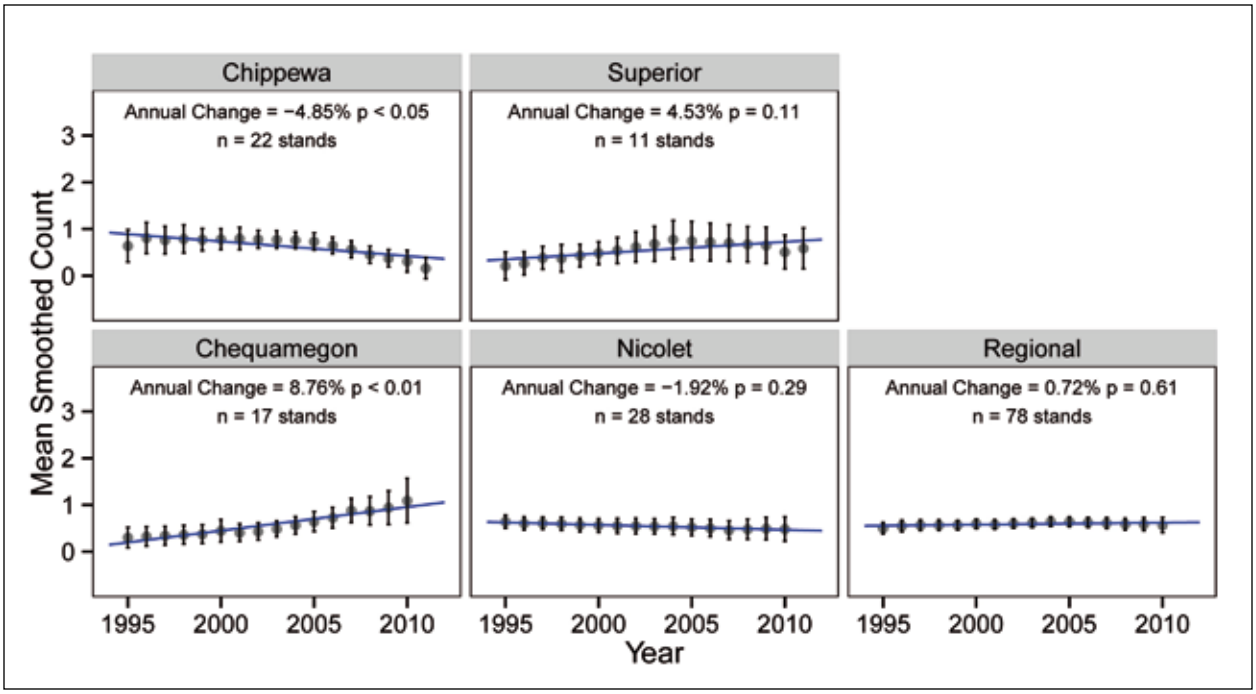
Guild Information

Habitat: Shrubby areas, especially wet

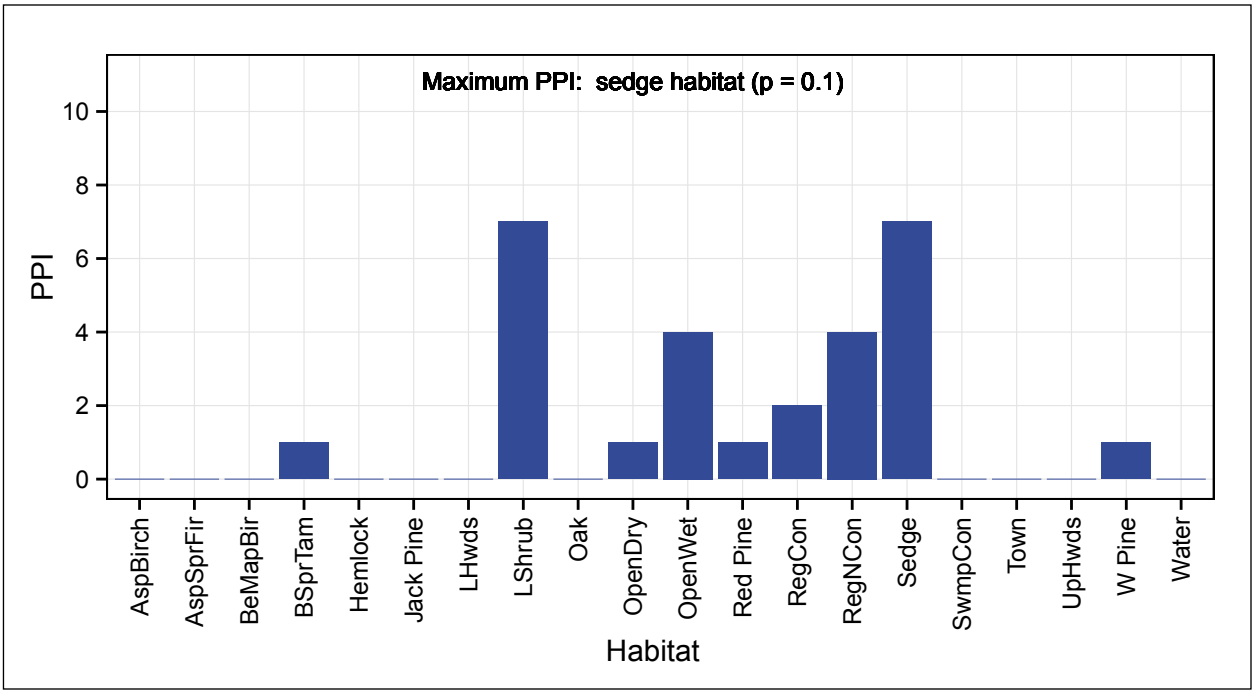
Foraging type: Foliage gleaner

Nest site: Ground

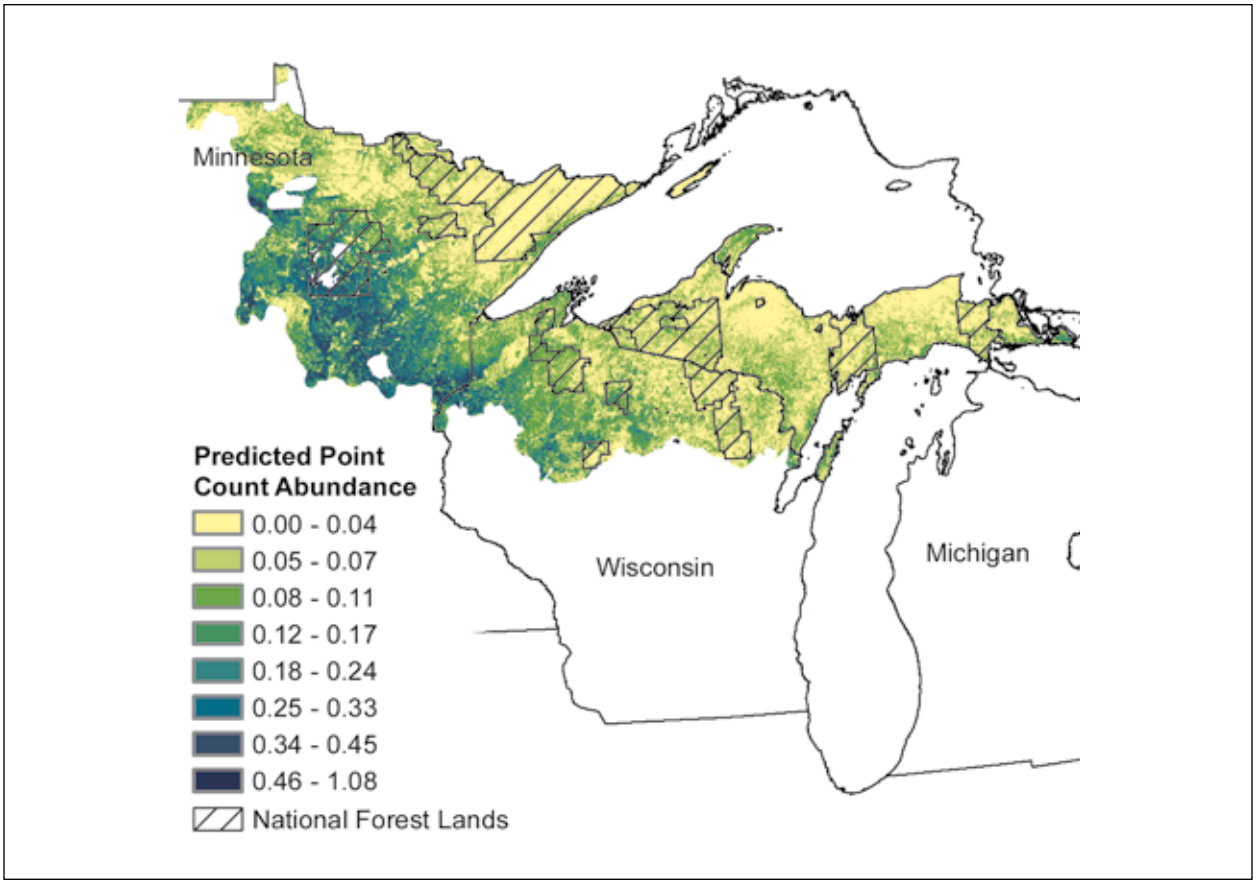
Migration: Long-distance



Trends for golden-winged warbler in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for golden-winged warbler where at least one bird was observed once during the decade (2001–2010; n=885 at 257 points)



Predicted relative abundance (number of birds per 10-minute count) of golden-winged warbler for the western Great Lakes region

Gray Catbird GRCA
Dumetella carolinensis



Photo by Jon Swanson, used with permission.

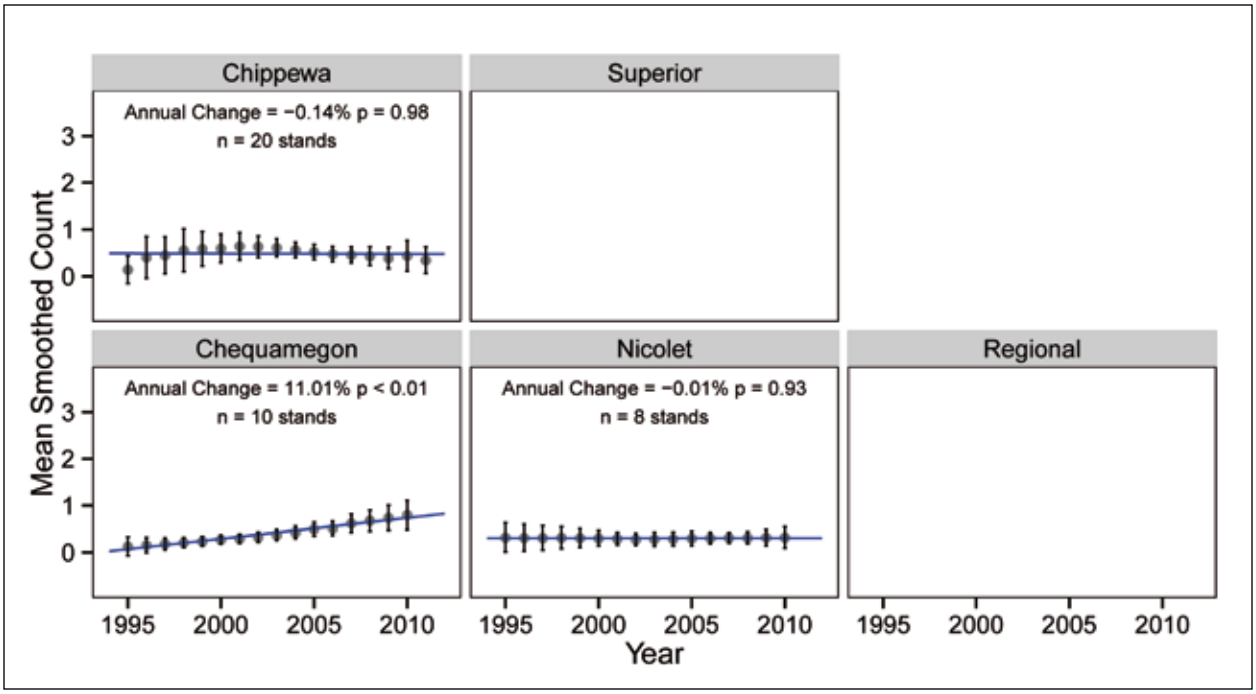
Guild Information

Habitat: Human settlements, shrubby areas, edges

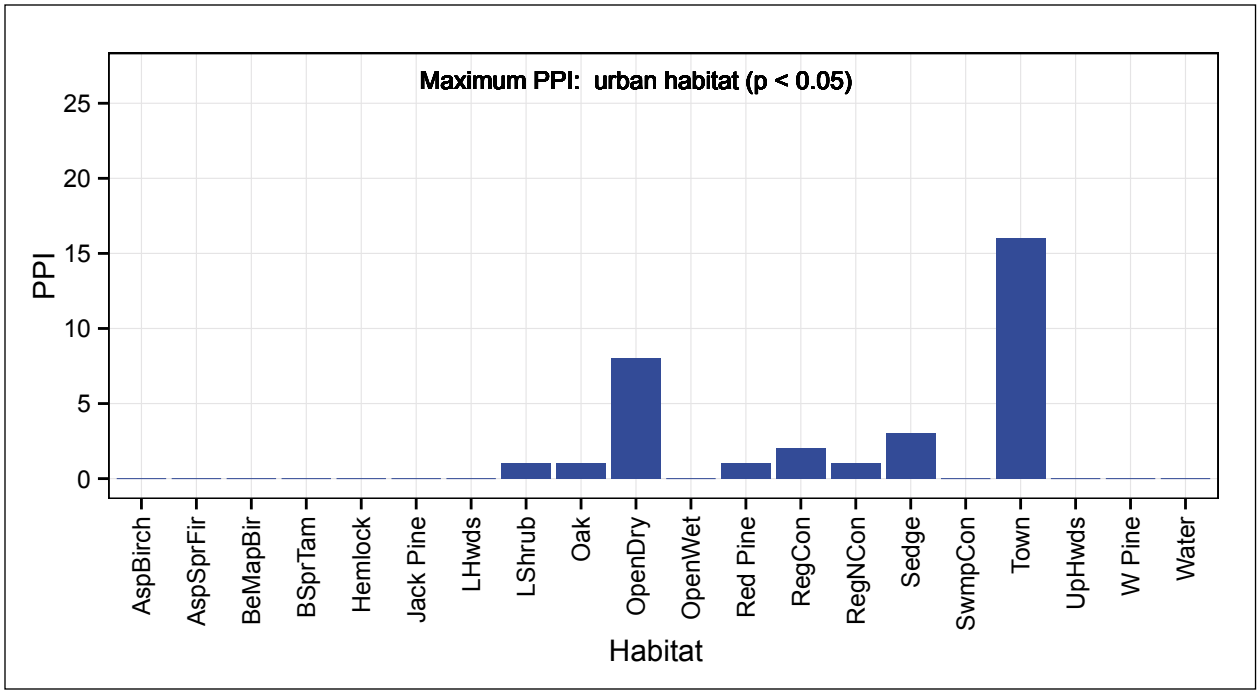
Foraging type: Omnivore—fruit, invertebrates

Nest site: Shrub or subcanopy

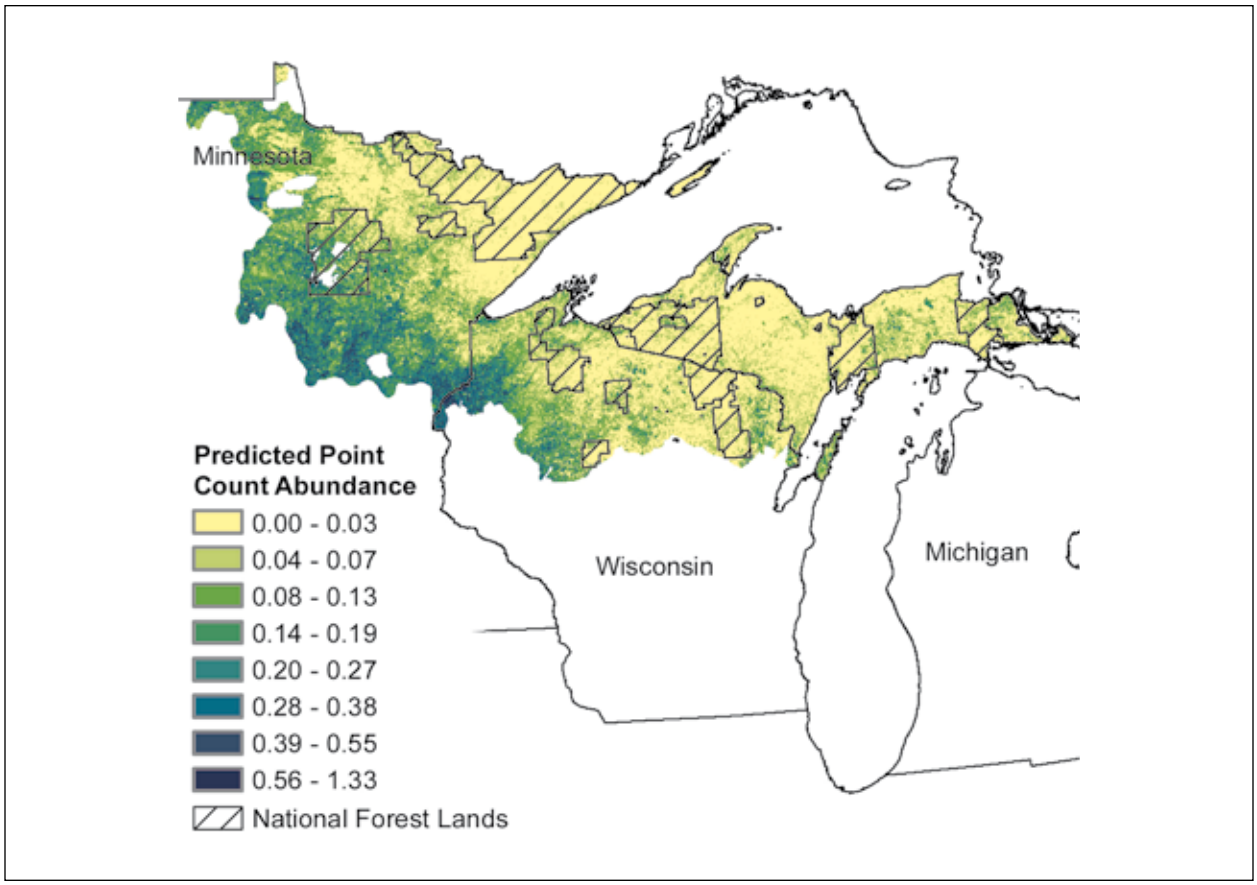
Migration: Long-distance



Trends for gray catbird in three national forests, 1995–2010



Percent perfect indication of habitat association for gray catbird where at least one bird was observed once during the decade (2001–2010; n=442 at 169 points)



Predicted relative abundance (number of birds per 10-minute count) of gray catbird for the western Great Lakes region

Gray Jay GRAJ

Perisoreus canadensis



Photo by Larry Sirvio, used with permission.

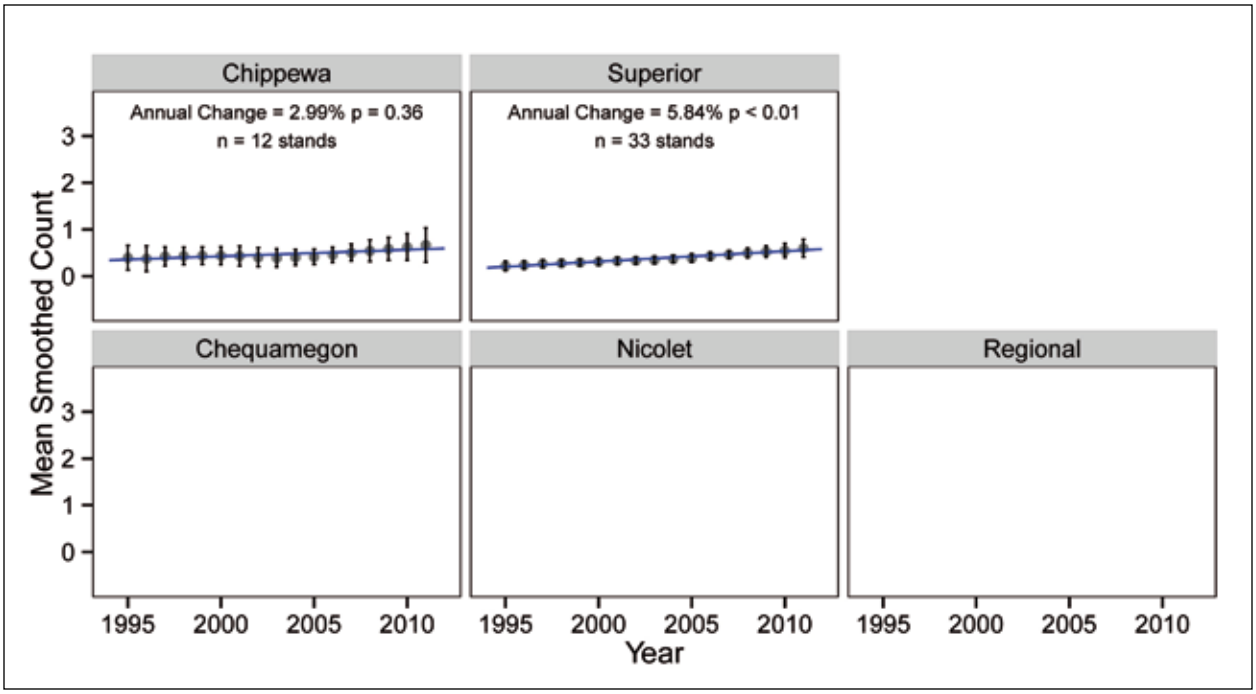
Guild Information

Habitat: Conifer forests

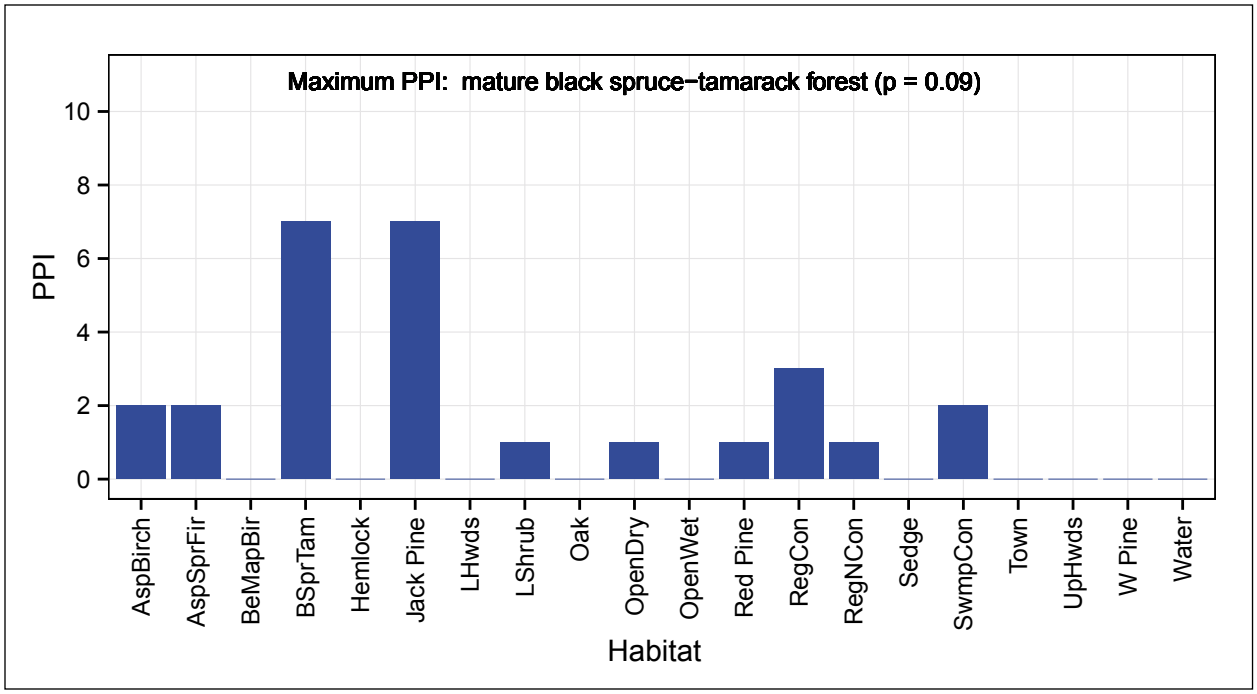
Foraging type: Omnivore

Nest site: Shrub or subcanopy

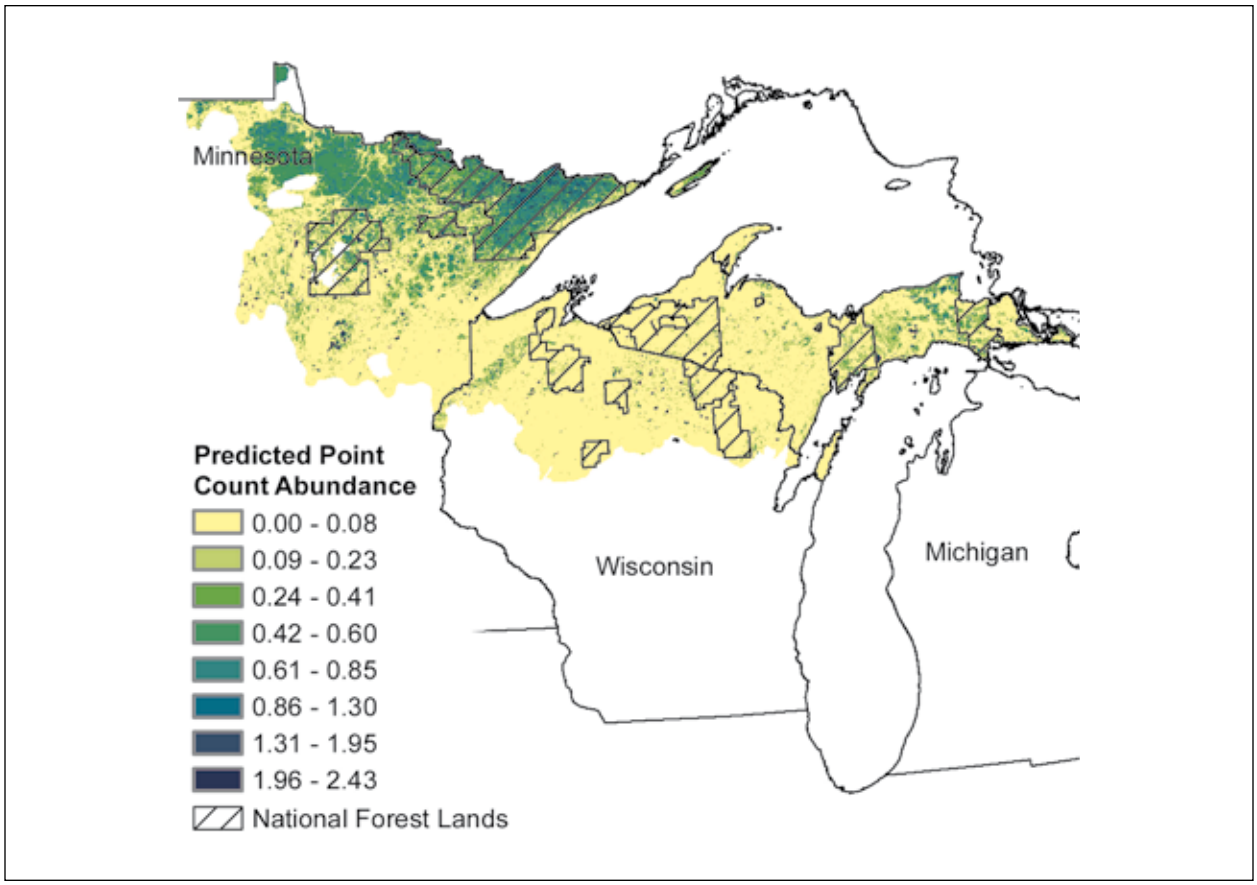
Migration: Permanent resident



Trends for gray jay in two national forests, 1995–2010



Percent perfect indication of habitat association for gray jay where at least one bird was observed once during the decade (2001–2010, n=687 at 309 points)



Predicted relative abundance (number of birds per 10-minute count) of gray jay for the western Great Lakes region

Great Crested Flycatcher GCFL

Myiarchus crinitus



Photo by Bruce Lees, used with permission.

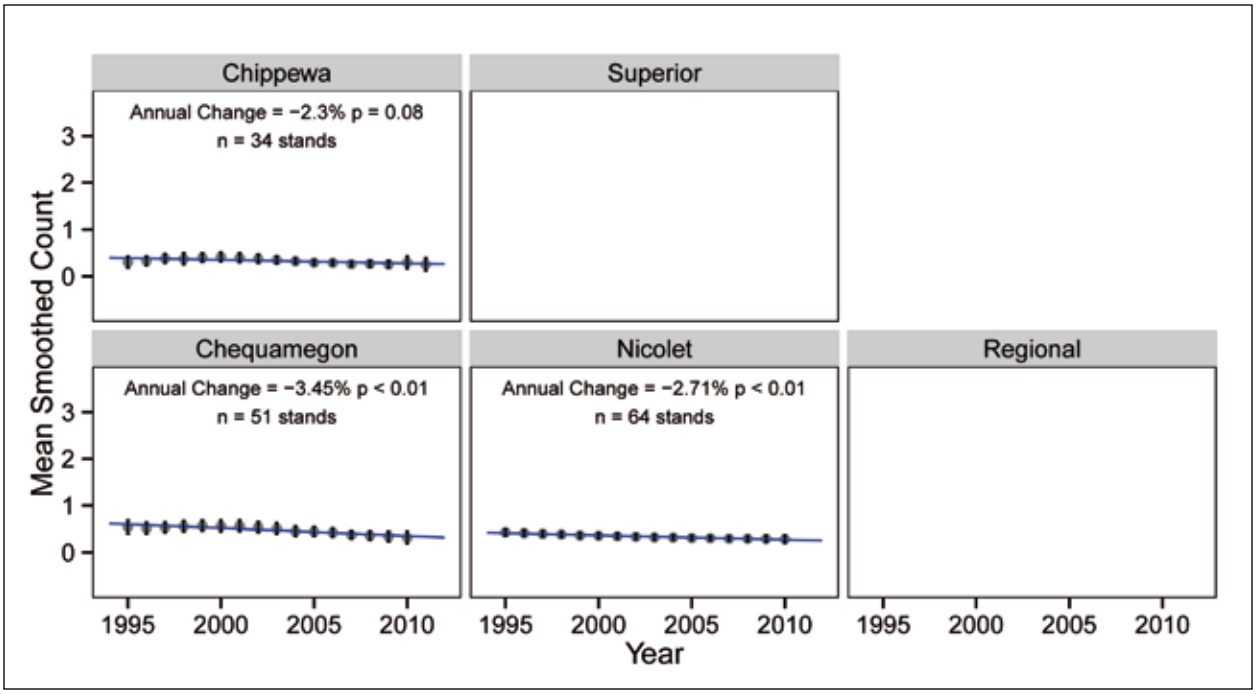
Guild Information

Habitat: Mature lowland hardwood forests

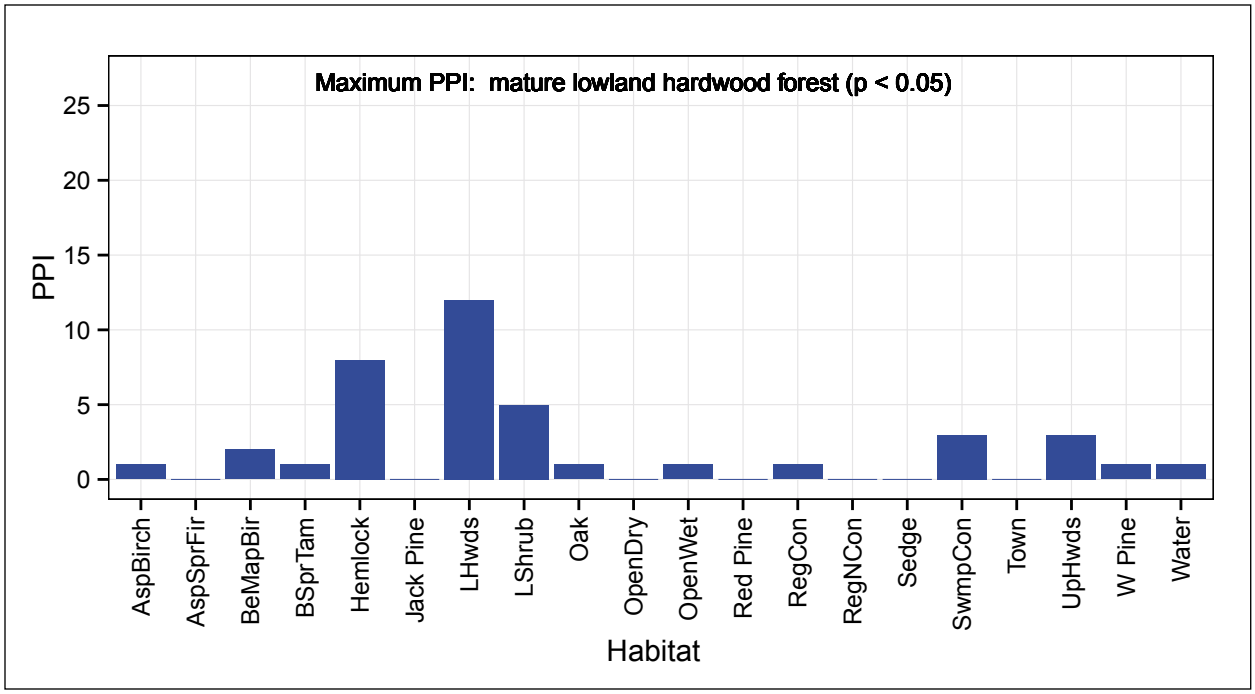
Foraging type: Flycatcher

Nest site: Cavity

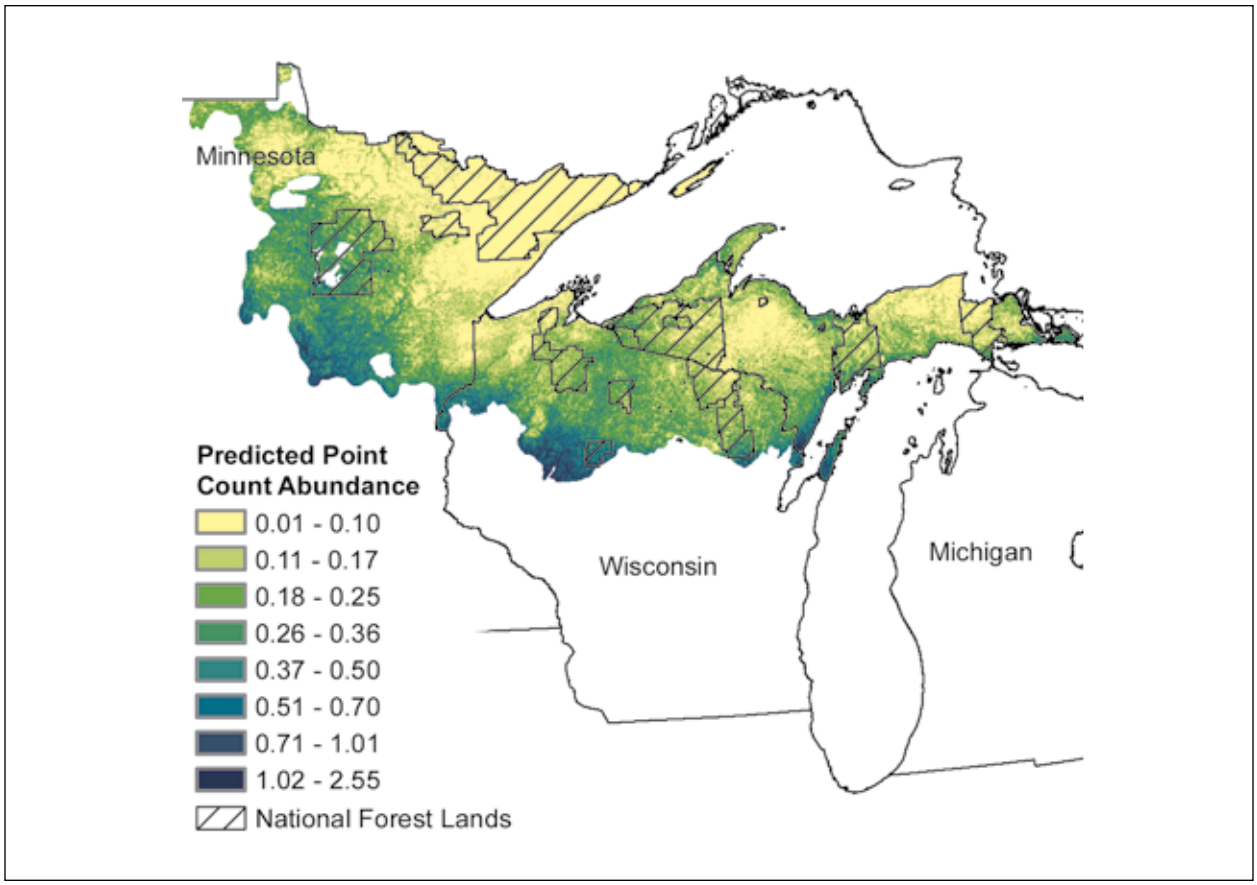
Migration: Long-distance



Trends for great crested flycatcher in three national forests, 1995–2010



Percent perfect indication of habitat association for great crested flycatcher where at least one bird was observed once during the decade (2001–2010; n=1,094 at 497 points)



Predicted relative abundance (number of birds per 10-minute count) of great crested flycatcher for the western Great Lakes region

Hairy Woodpecker HAWO

Picoides villosus



Photo by Jon Swanson, used with permission.

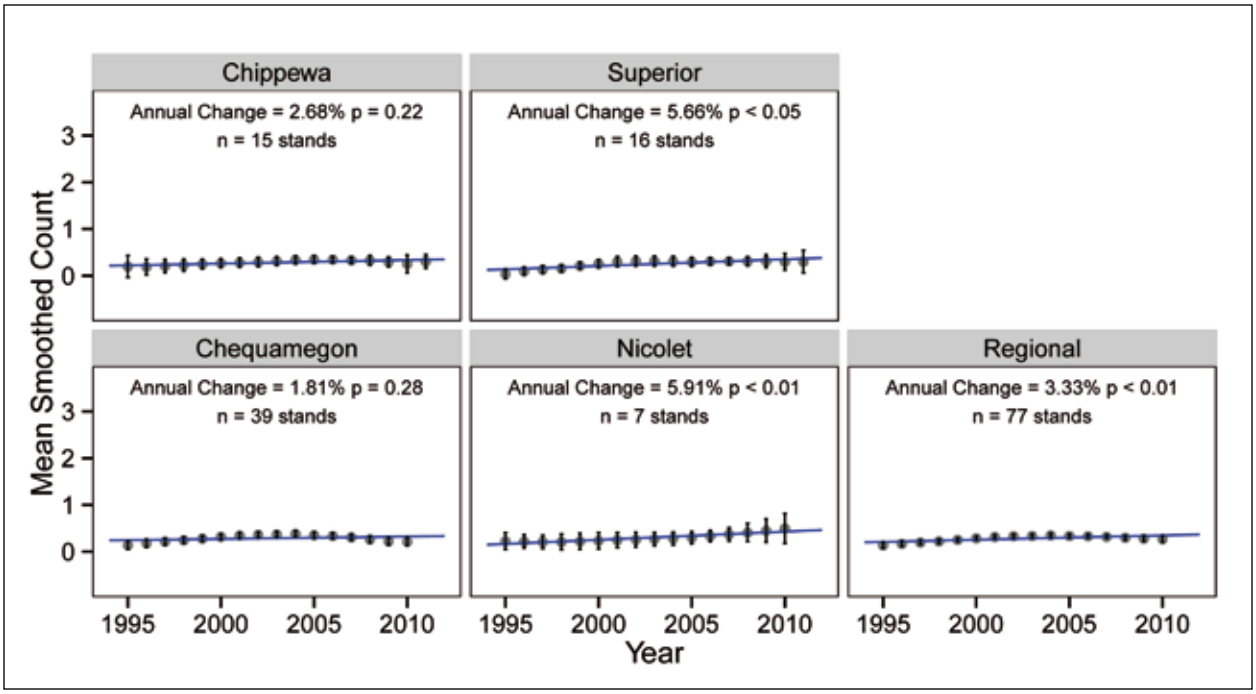
Guild Information

Habitat: Forests, highly variable

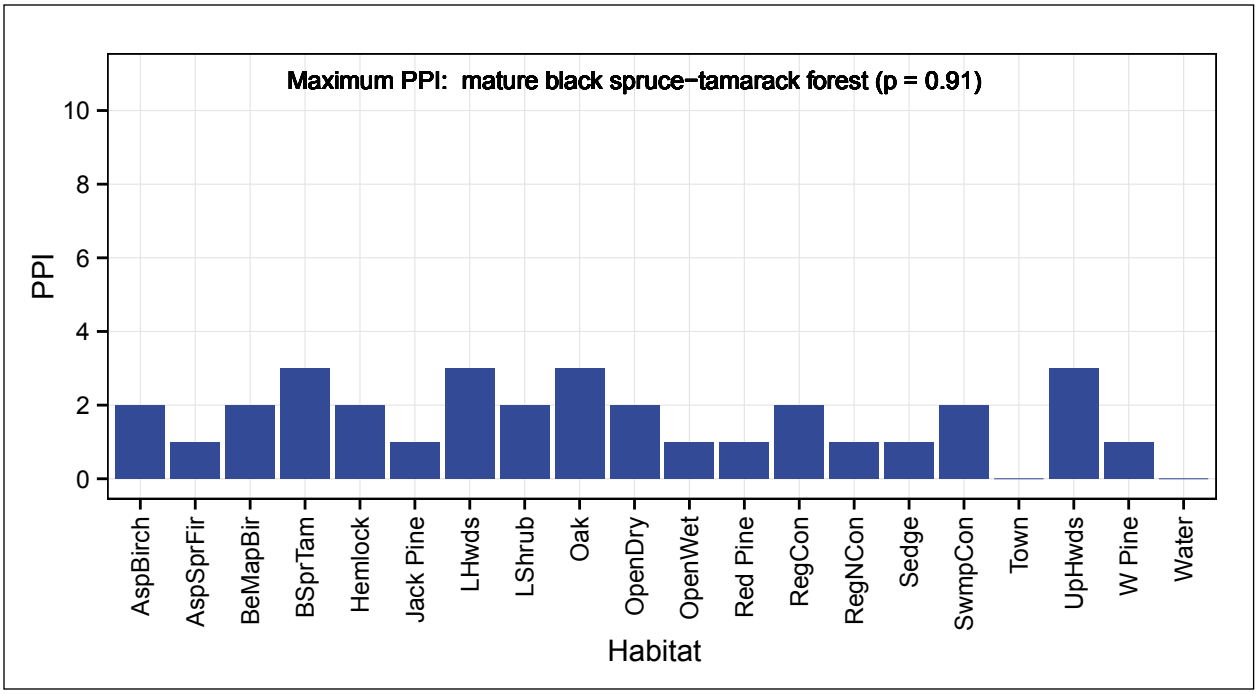
Foraging type: Bark driller and gleaner

Nest site: Cavity

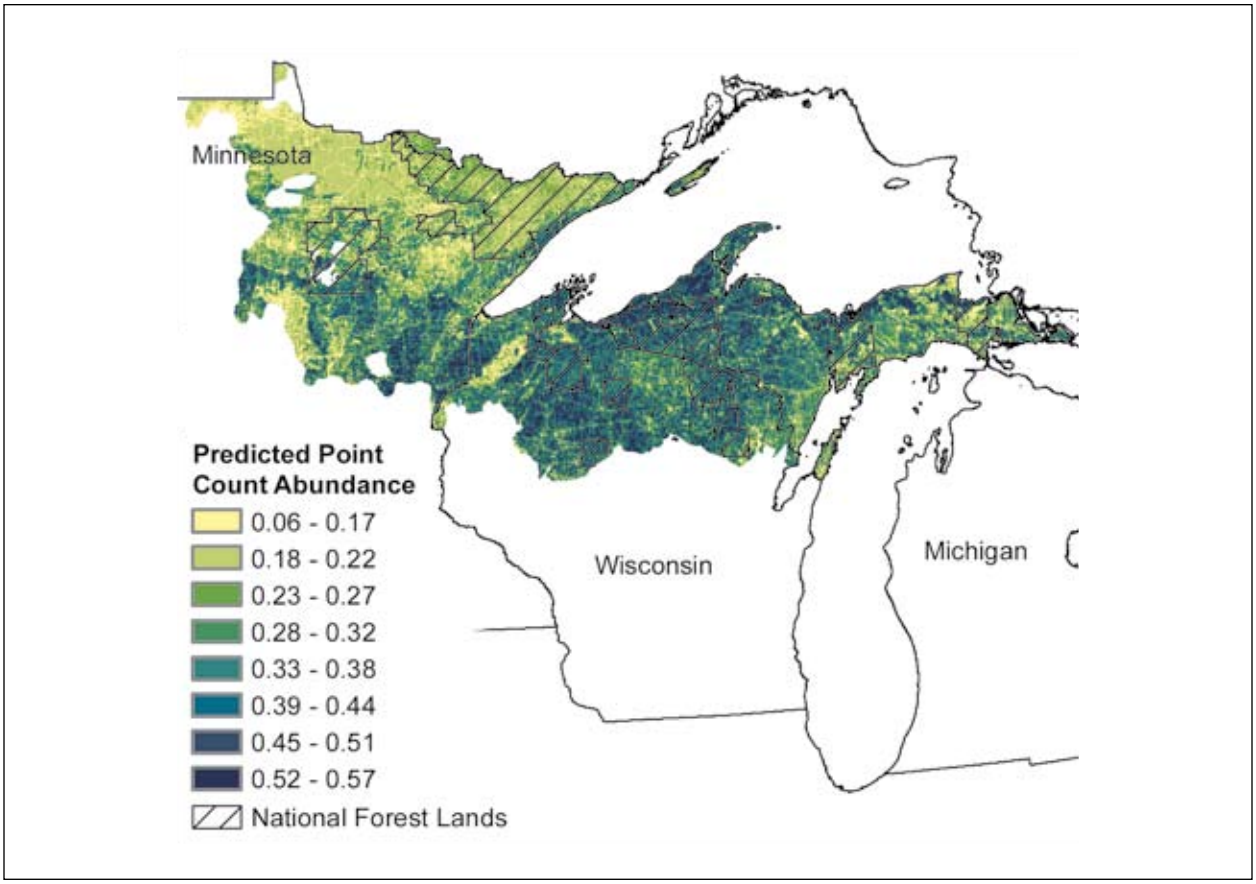
Migration: Permanent resident



Trends for hairy woodpecker in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for hairy woodpecker where at least one bird was observed once during the decade (2001–2010; n=1,029 at 560 points)



Predicted relative abundance (number of birds per 10-minute count) of hairy woodpecker for the western Great Lakes region

Hermit Thrush HETH

Catharus guttatus



Photo by Larry Sirvio, used with permission.

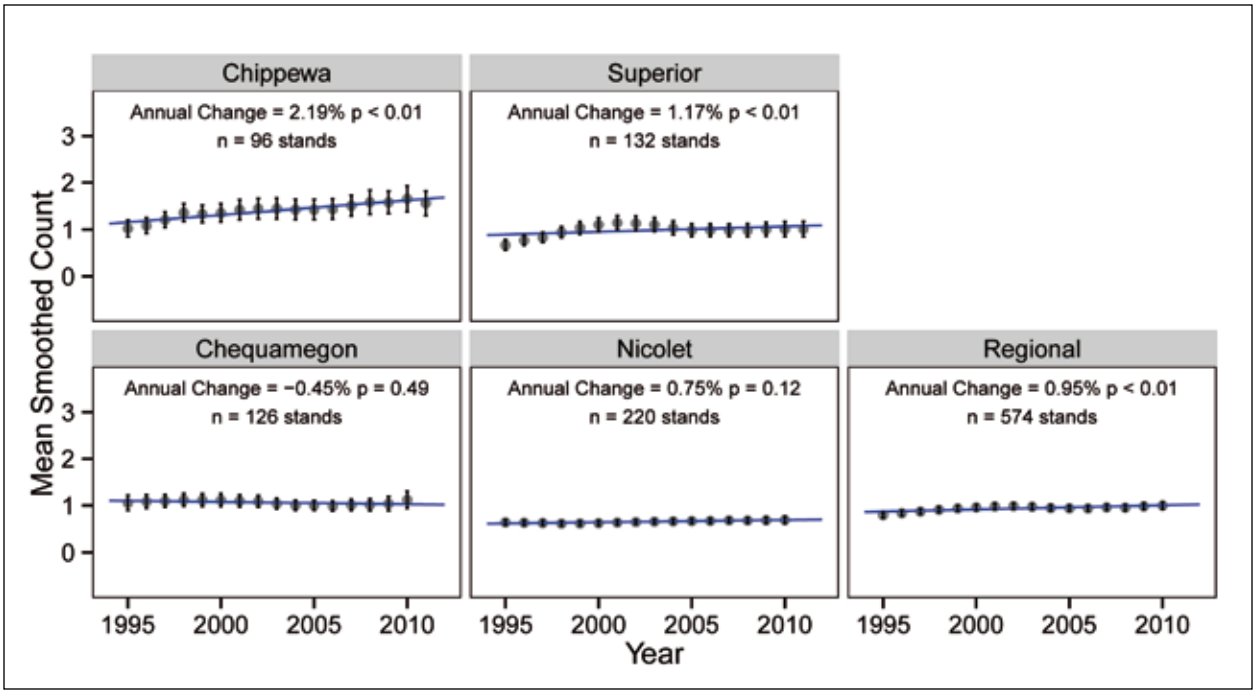
Guild Information

Habitat: Forests, especially conifers

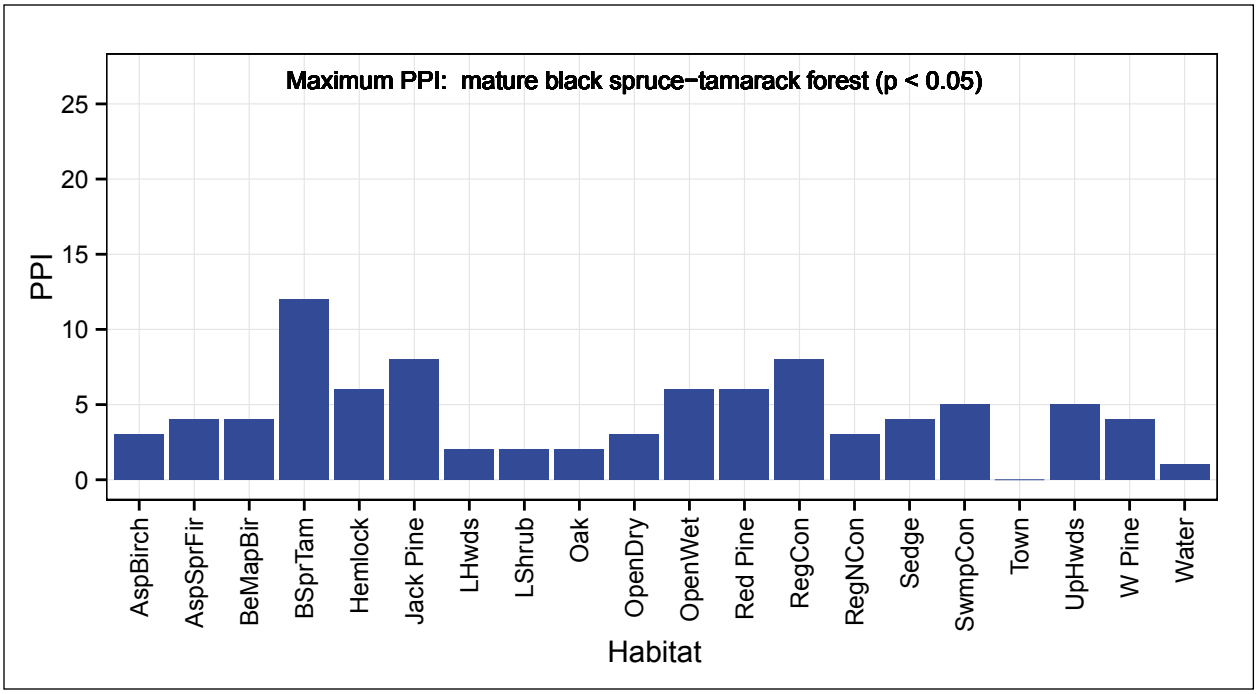
Foraging type: Omnivore—fruit, invertebrates

Nest site: Ground

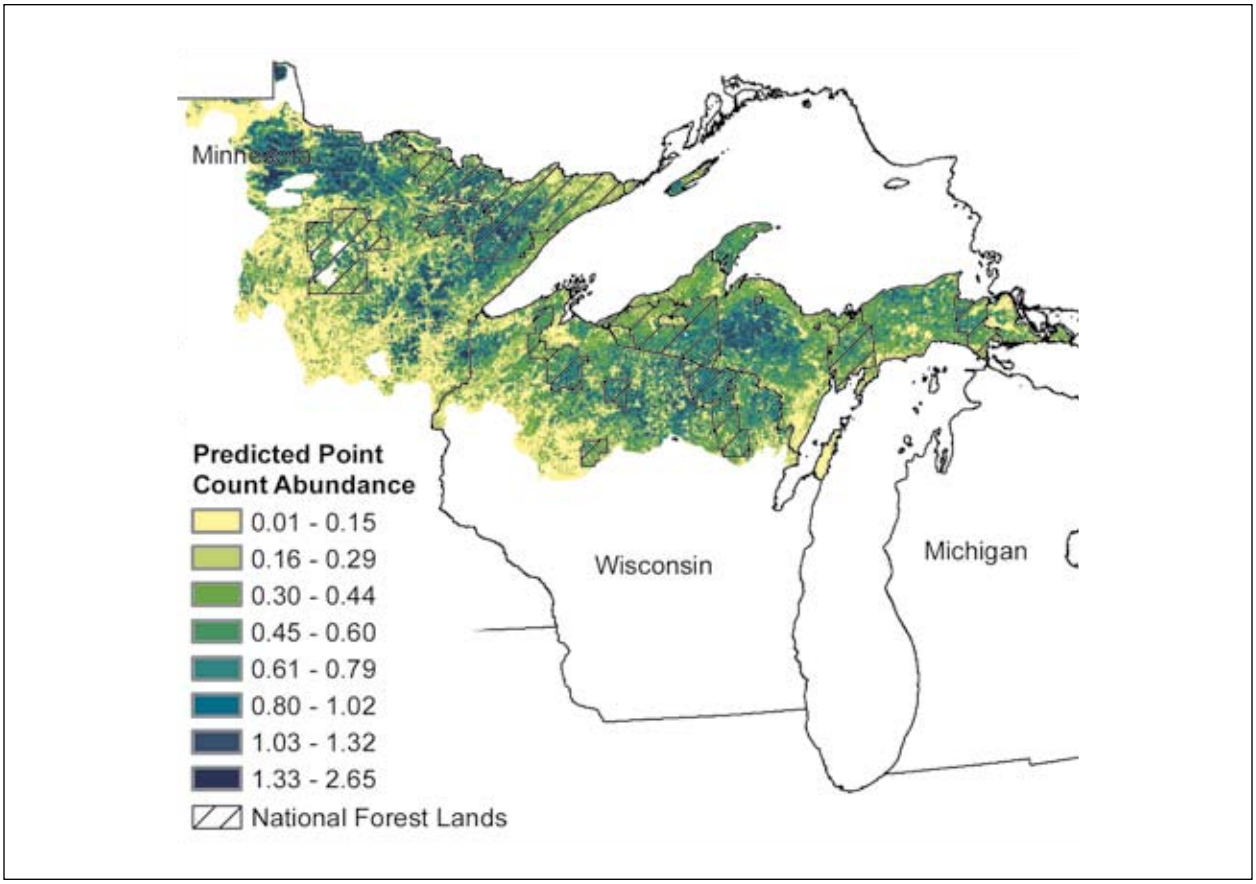
Migration: Short-distance



Trends for hermit thrush in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for hermit thrush where at least one bird was observed once during the decade (2001–2010; n=8,882 at 1,446 points)



Predicted relative abundance (number of birds per 10-minute count) of hermit thrush for the western Great Lakes region

House Wren HOWR

Troglodytes aedon



Photo by Larry Sirvio, used with permission.

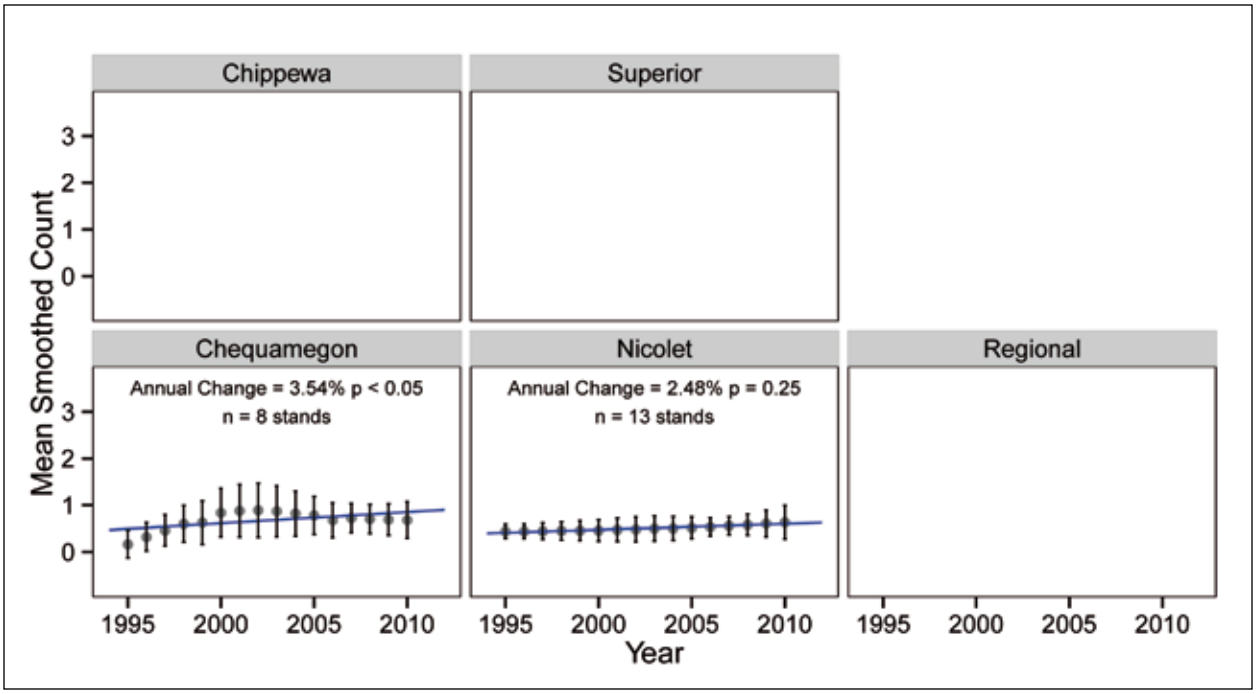
Guild Information

Habitat: Human settlements, recent burns

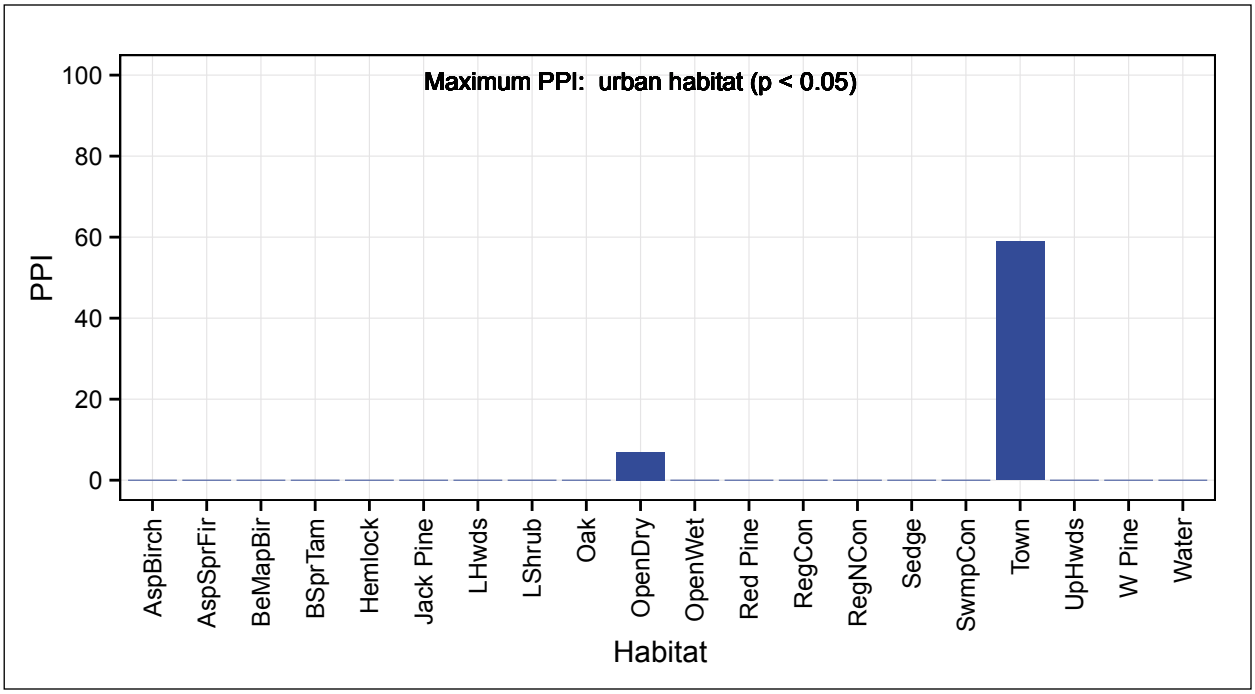
Foraging type: Foliage gleaner

Nest site: Cavity

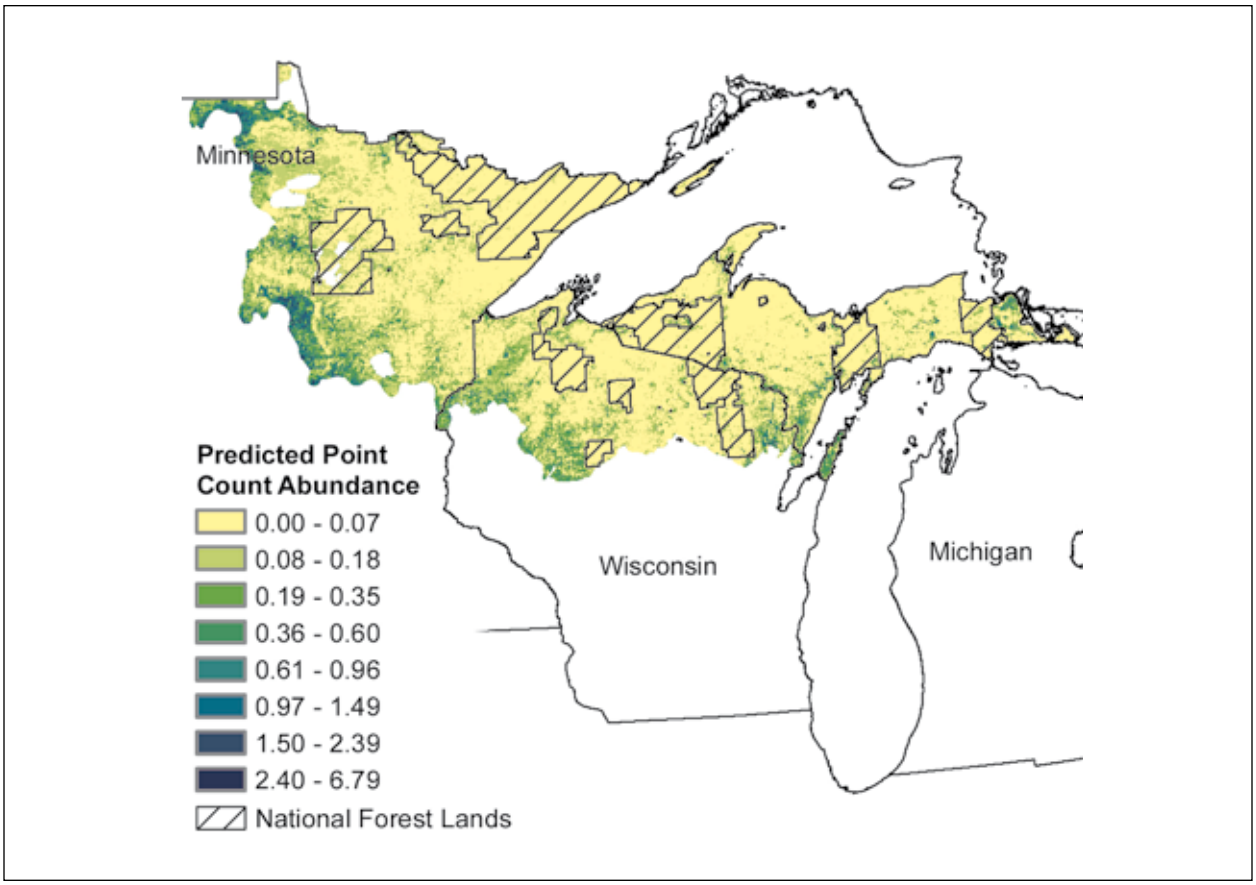
Migration: Short-distance



Trends for house wren in two national forests, 1995–2010



Percent perfect indication of habitat association for house wren where at least one bird was observed once during the decade (2001–2010; n=266 at 90 points)



Predicted relative abundance (number of birds per 10-minute count) of house wren for the western Great Lakes region

Indigo Bunting INBU

Passerina cyanea



Photo by Dewitt @Thinkstockphotos.com.

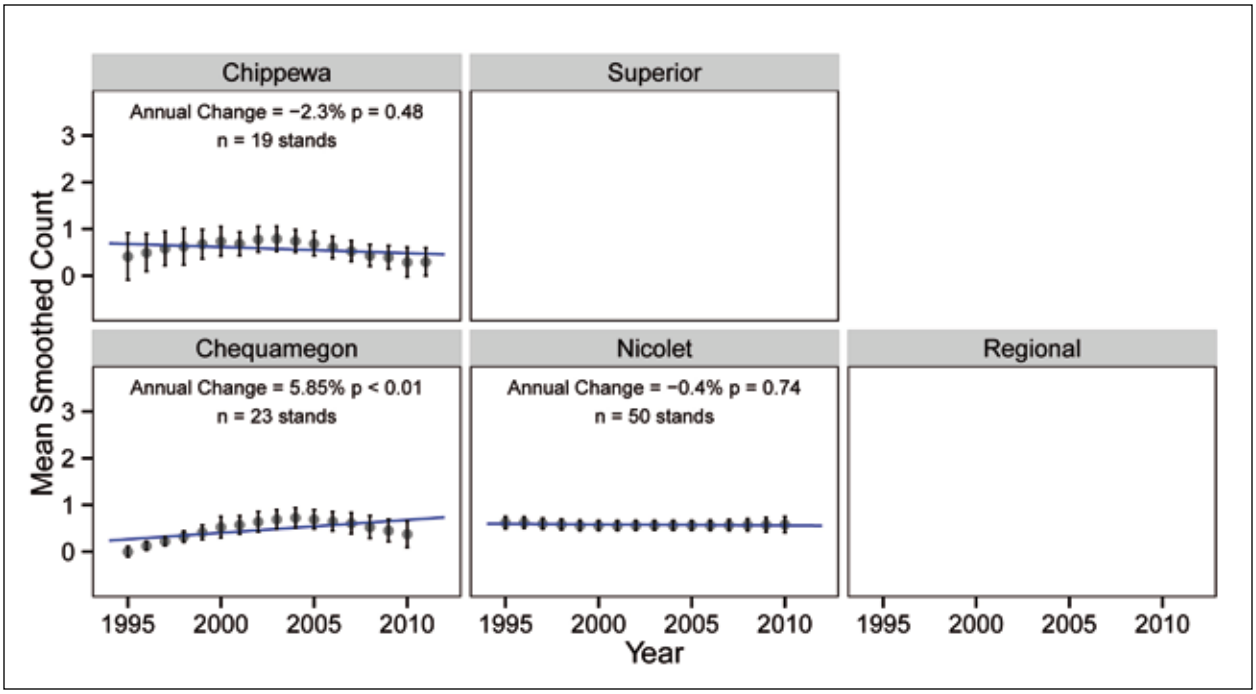
Guild Information

Habitat: Open dry shrubby areas, edges

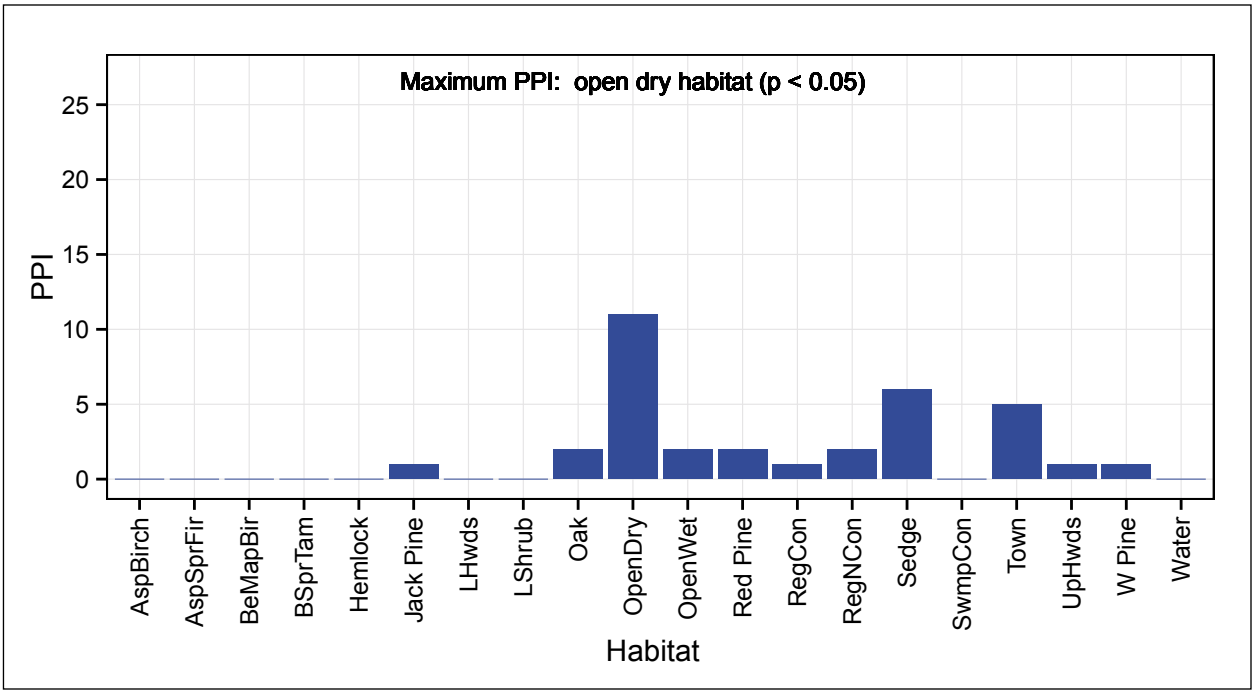
Foraging type: Omnivore

Nest site: Shrub or subcanopy

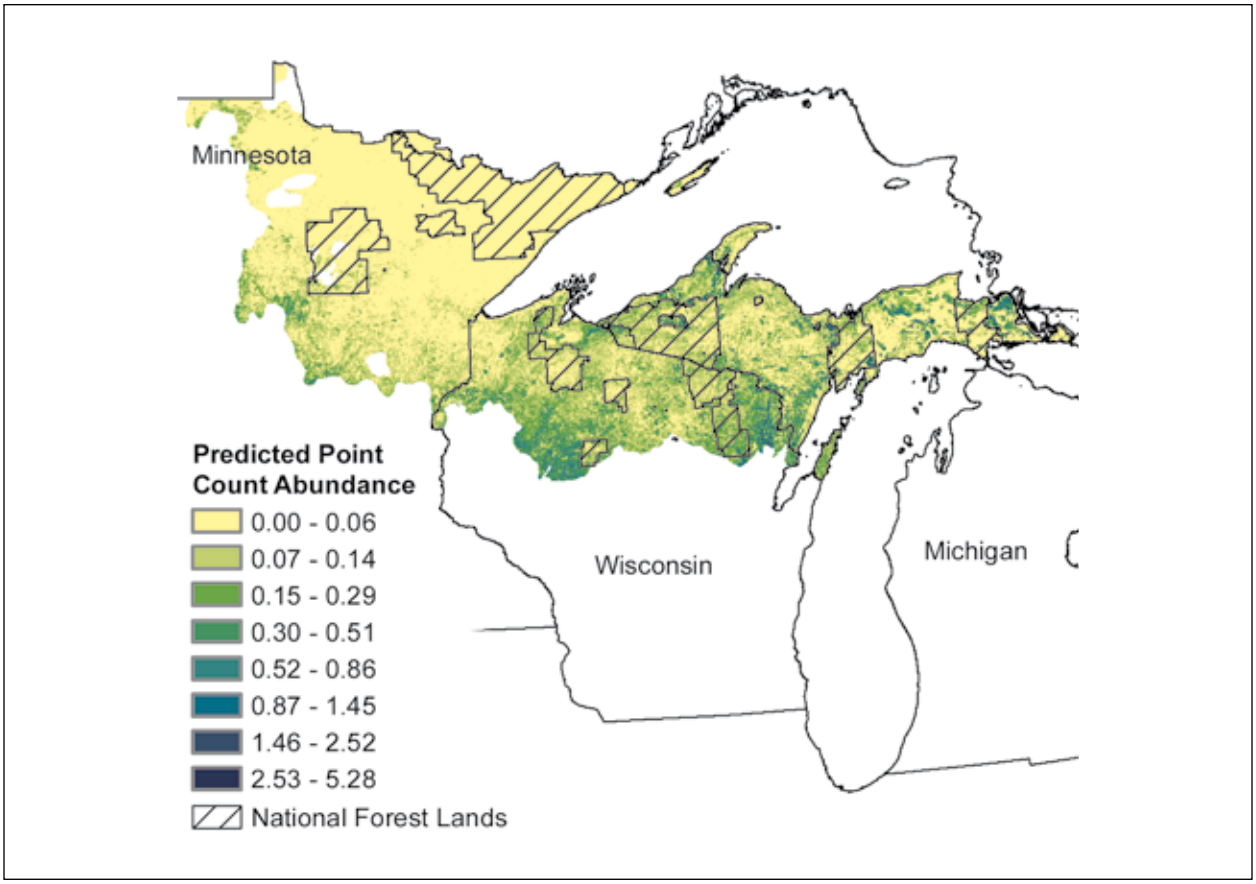
Migration: Long-distance



Trends for indigo bunting in three national forests, 1995–2010



Percent perfect indication of habitat association for indigo bunting where at least one bird was observed once during the decade (2001–2010; n=1,174 at 332 points)



Predicted relative abundance (number of birds per 10-minute count) of indigo bunting for the western Great Lakes region

Least Flycatcher LEFL
Empidonax minimus



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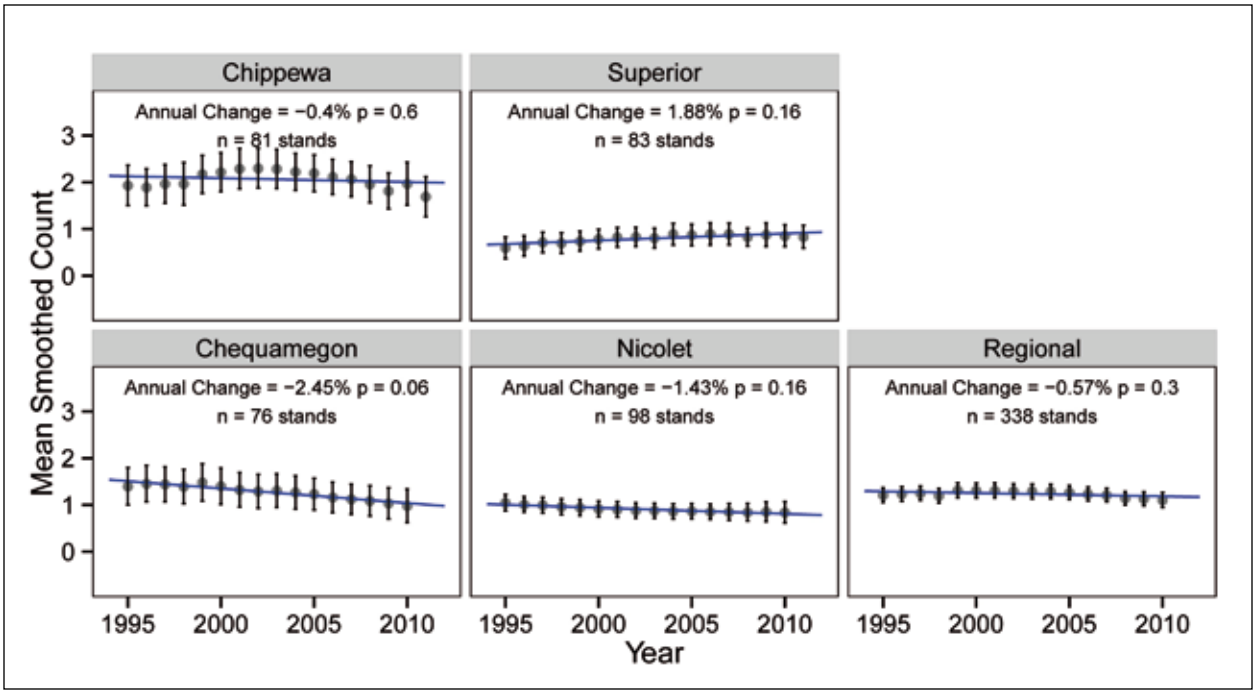
Guild Information

Habitat: Forests, especially oak and northern hardwoods

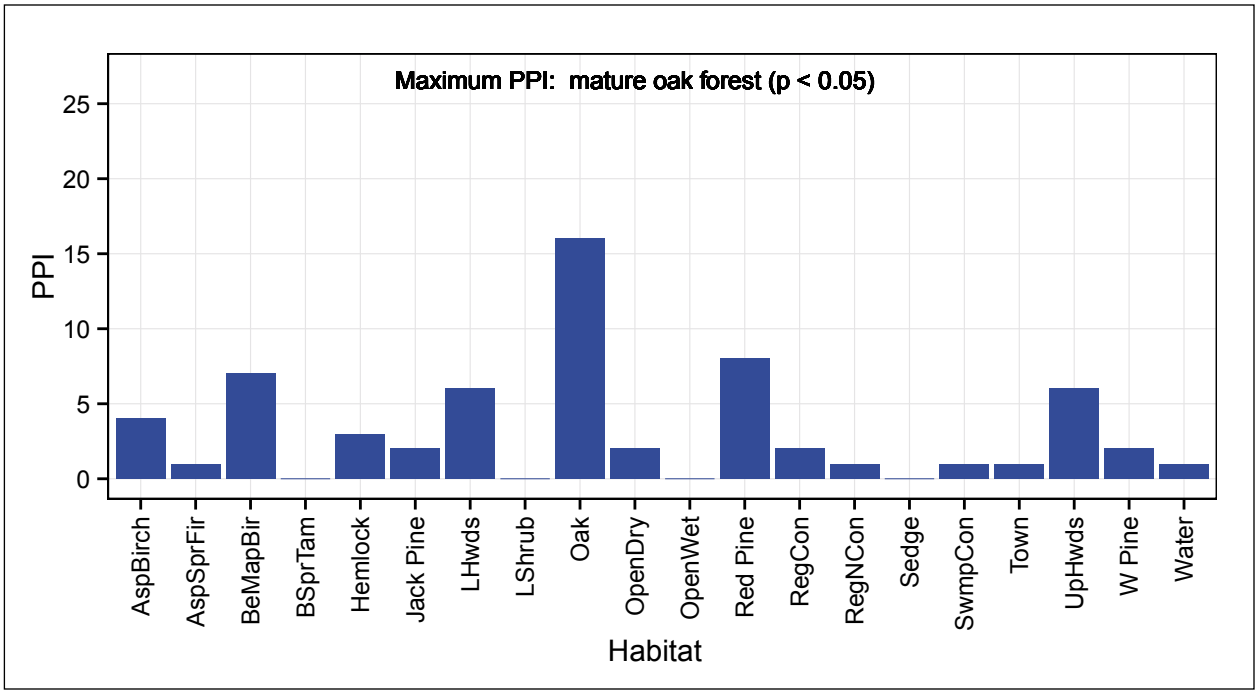
Foraging type: Flycatcher

Nest site: Shrub or subcanopy

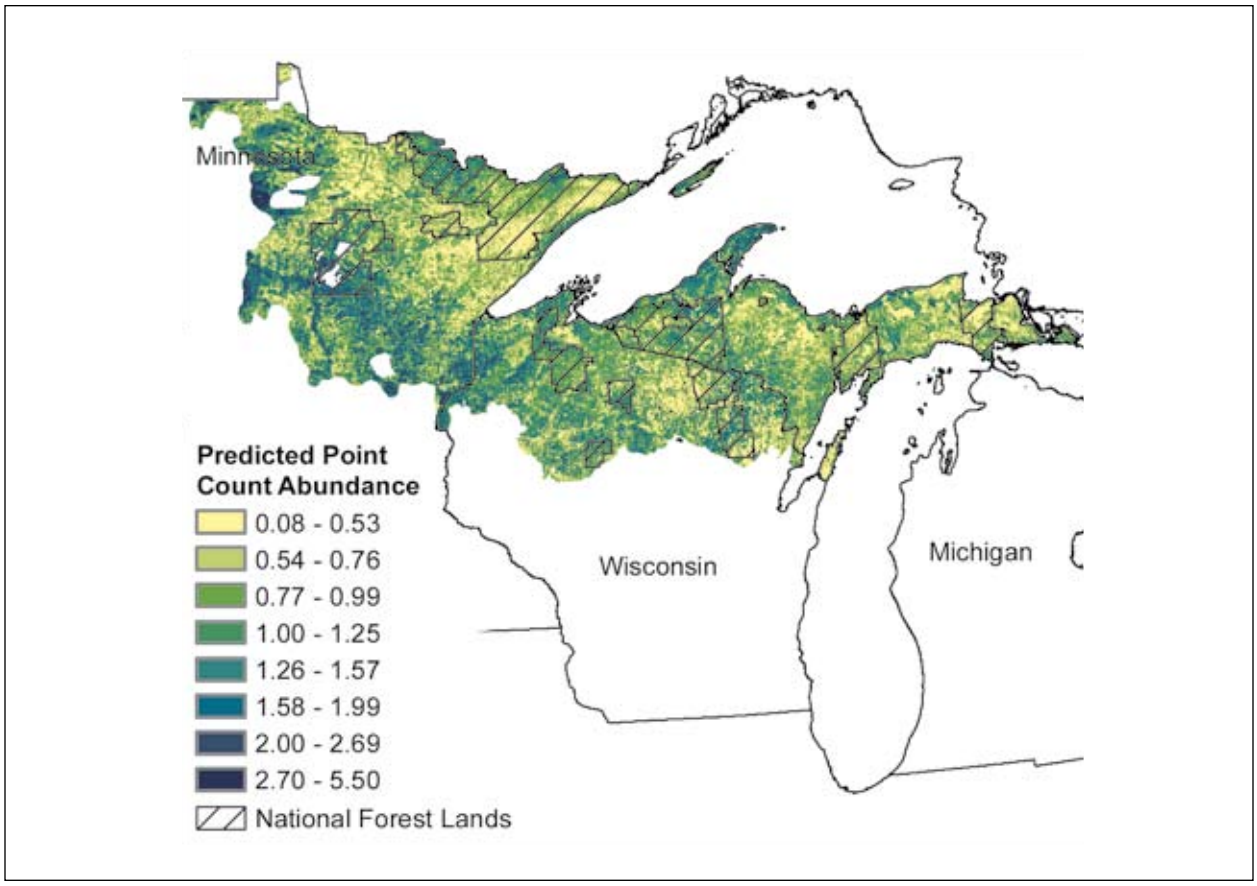
Migration: Long-distance



Trends for least flycatcher in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for least flycatcher where at least one bird was observed once during the decade (2001–2010; n=6,987 at 963 points)



Predicted relative abundance (number of birds per 10-minute count) of least flycatcher for the western Great Lakes region

Lincoln's Sparrow LISP

Melospiza lincolnii



Photo by Larry Sirvio, used with permission.

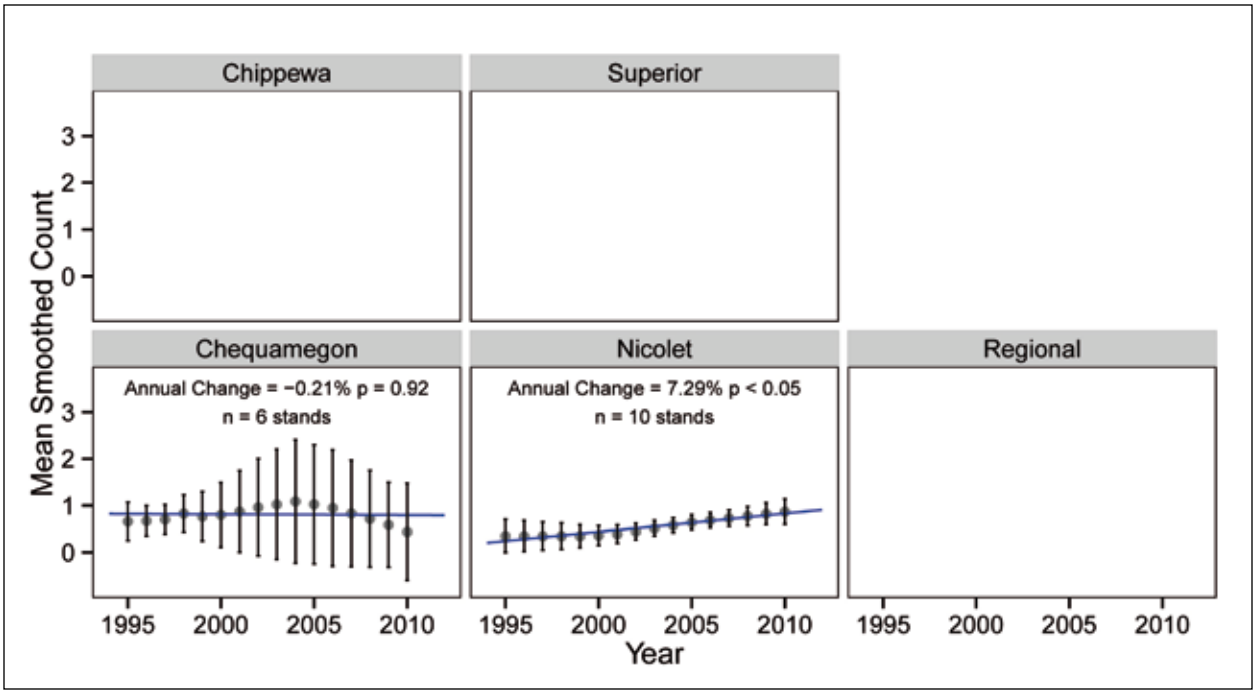
Guild Information

Habitat: Sedge meadows, bogs, open shrubby wetlands

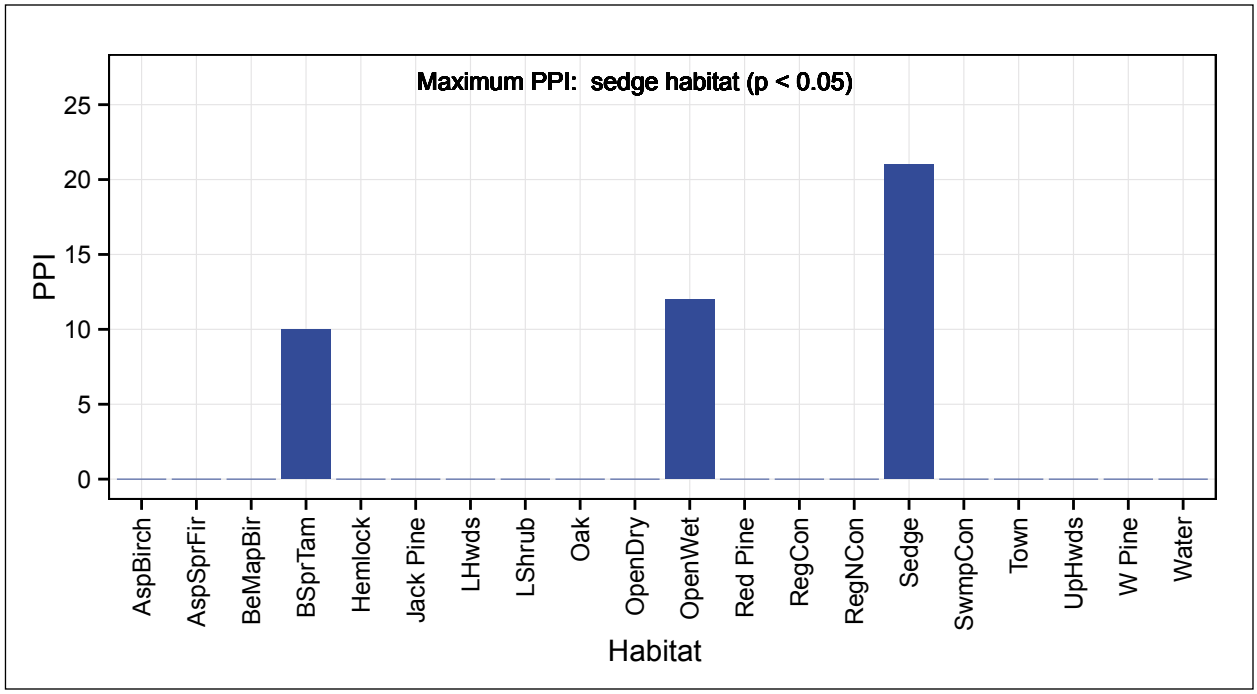
Foraging type: Omnivore—seeds, invertebrates

Nest site: Ground

Migration: Long-distance



Trends for Lincoln's sparrow in two national forests, 1995–2010



Percent perfect indication of habitat association for Lincoln's sparrow where at least one bird was observed once during the decade (2001–2010; n=346 at 130 points)

Magnolia Warbler MAWA

Setophaga magnolia



Photo by Jon Swanson, used with permission.

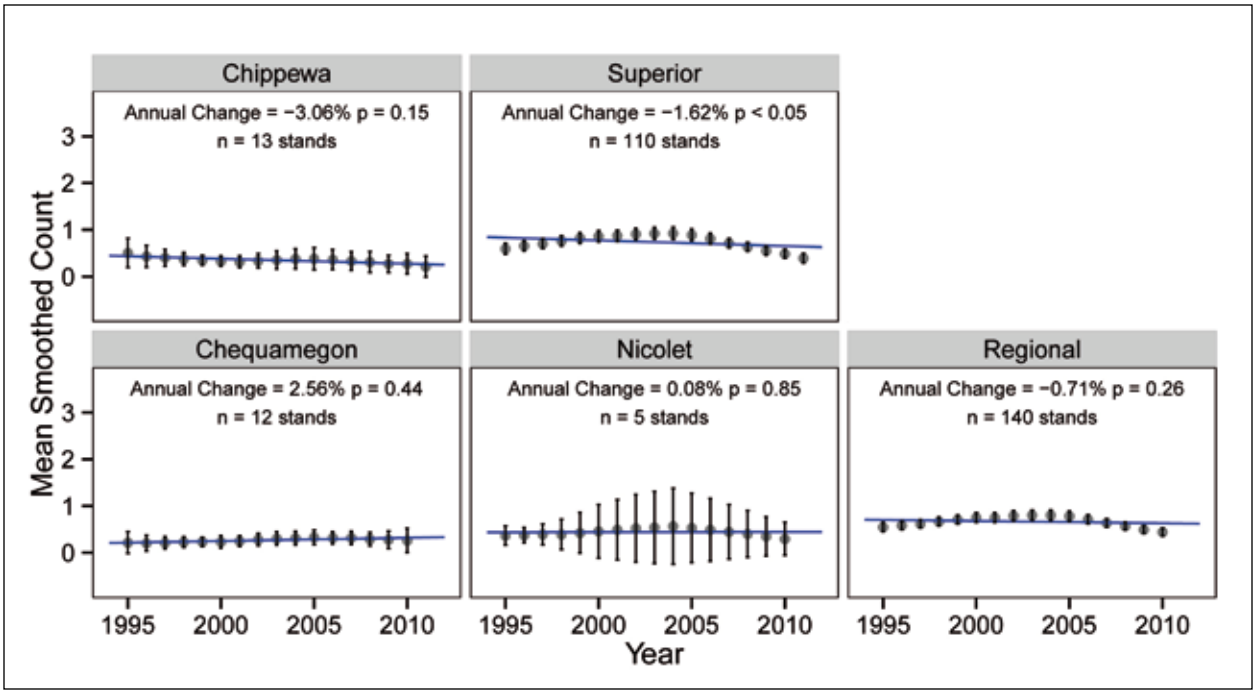
Guild Information

Habitat: Aspen-spruce-fir forests, mostly in the Superior NF

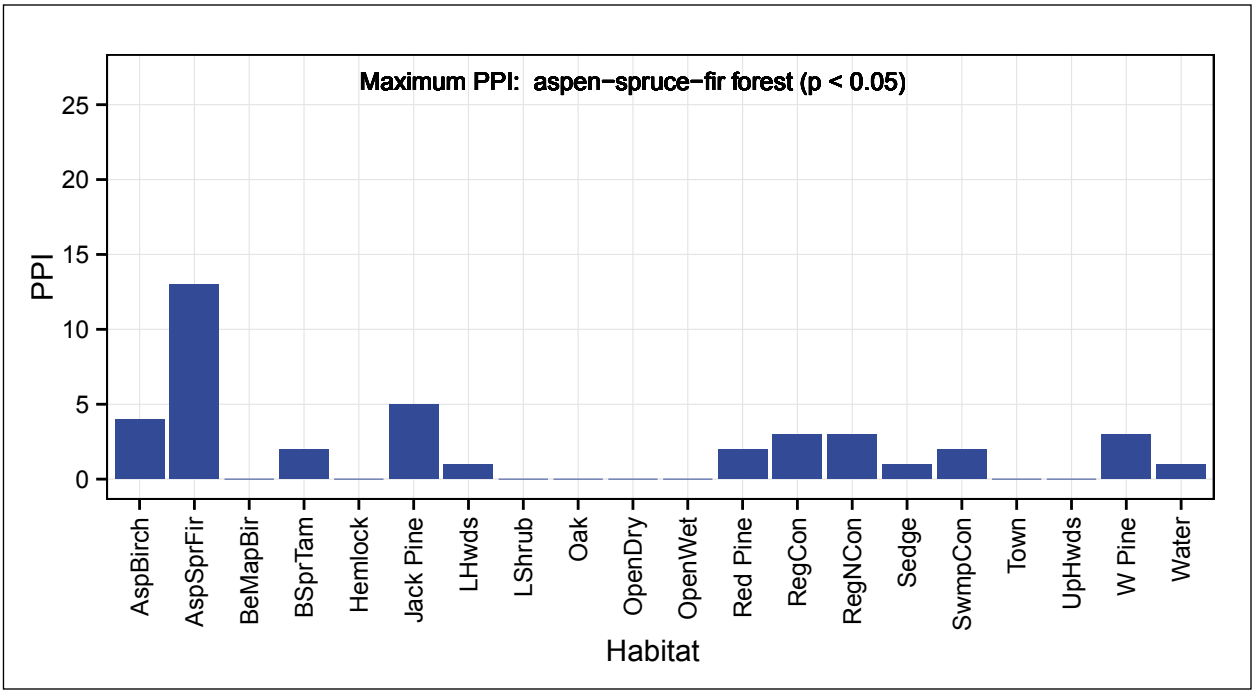
Foraging type: Foliage gleaner

Nest site: Shrub or subcanopy

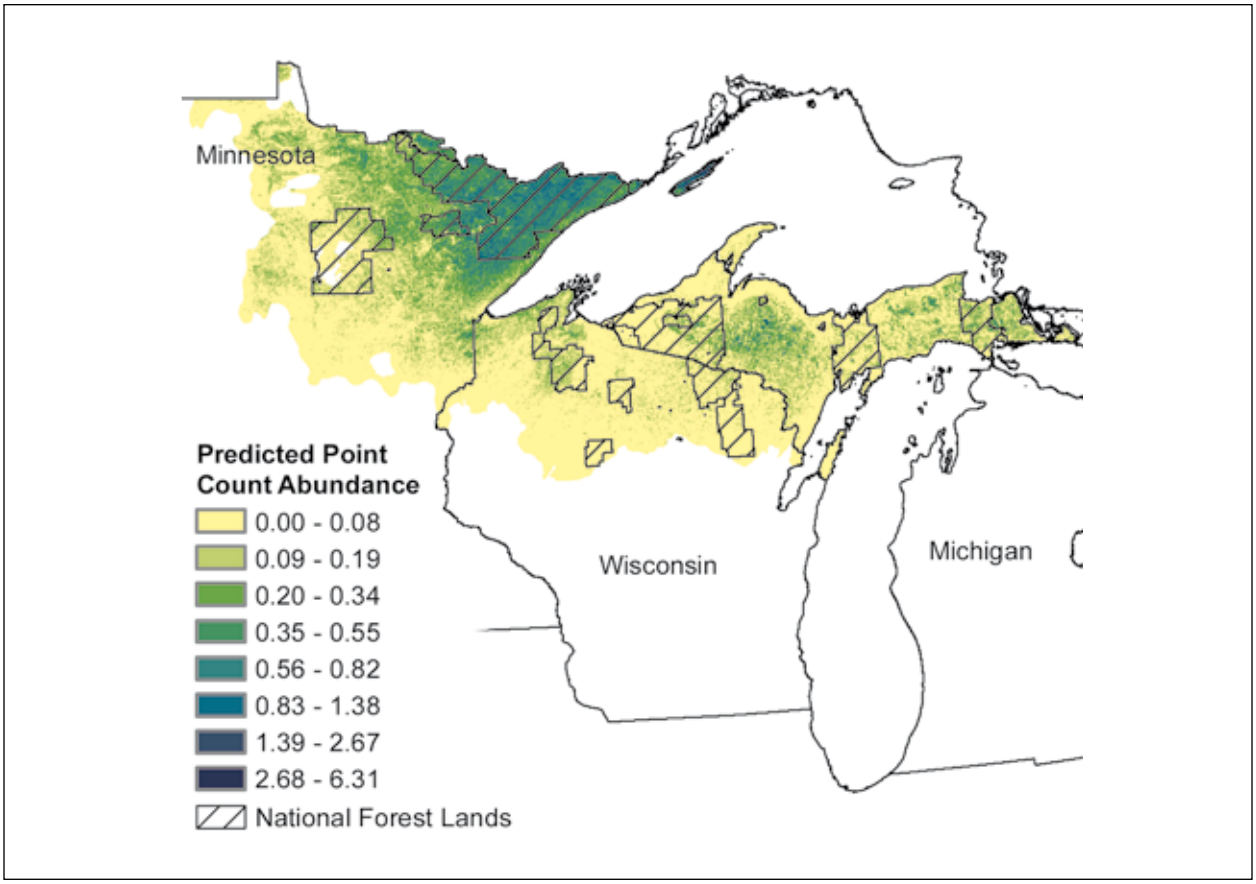
Migration: Long-distance



Trends for magnolia warbler in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for magnolia warbler where at least one bird was observed once during the decade (2001–2010; n=2,287 at 612 points)



Predicted relative abundance (number of birds per 10-minute count) of magnolia warbler for the western Great Lakes region

Mourning Dove MODO

Zenaida macroura



Photo by Joseph Berger, Bugwood.org.

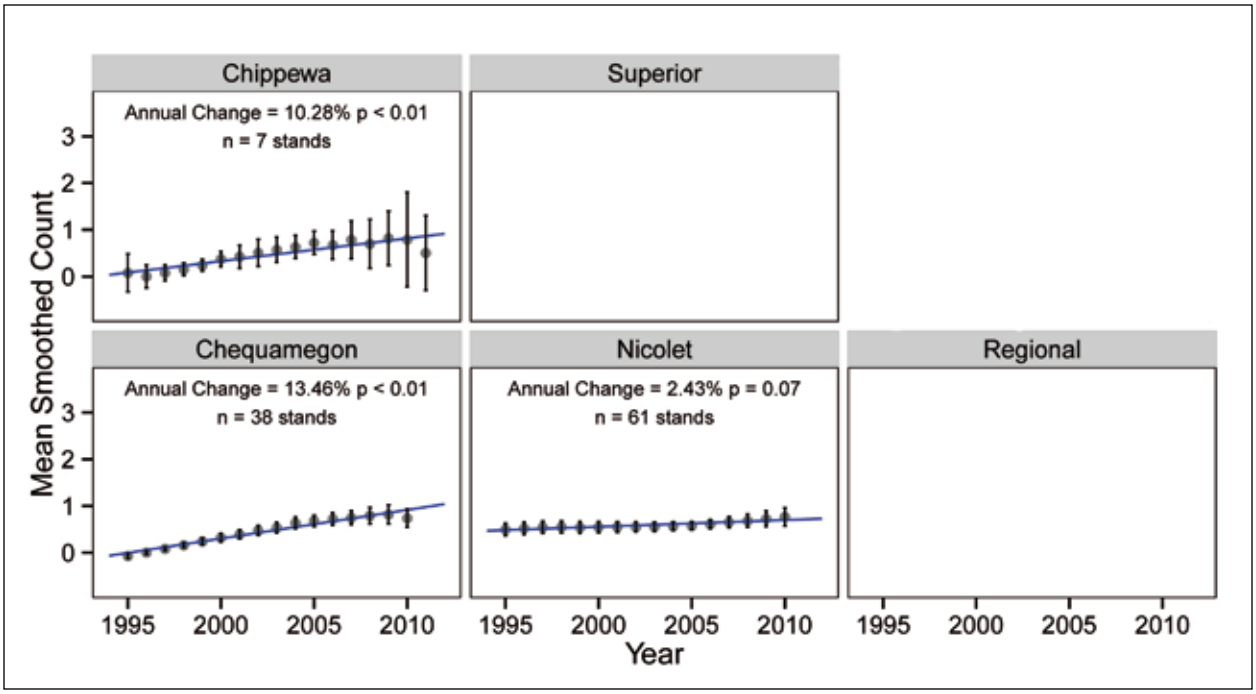
Guild Information

Habitat: Human settlements, open areas

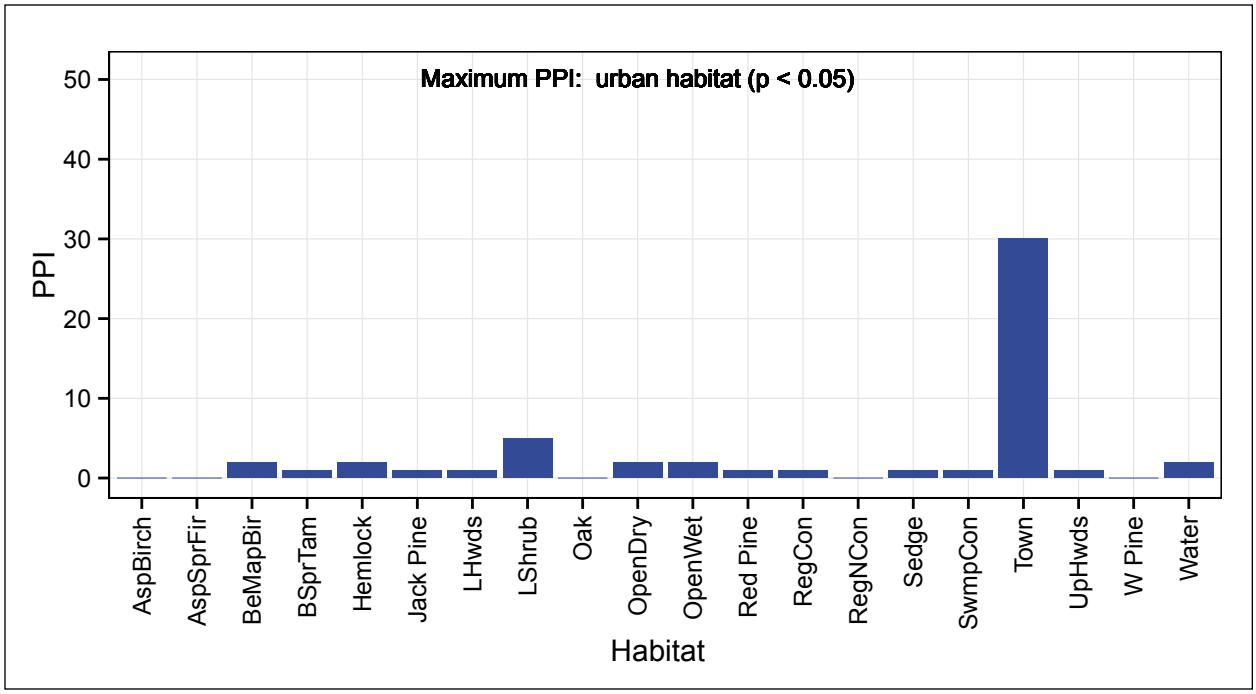
Foraging type: Omnivore

Nest site: Canopy

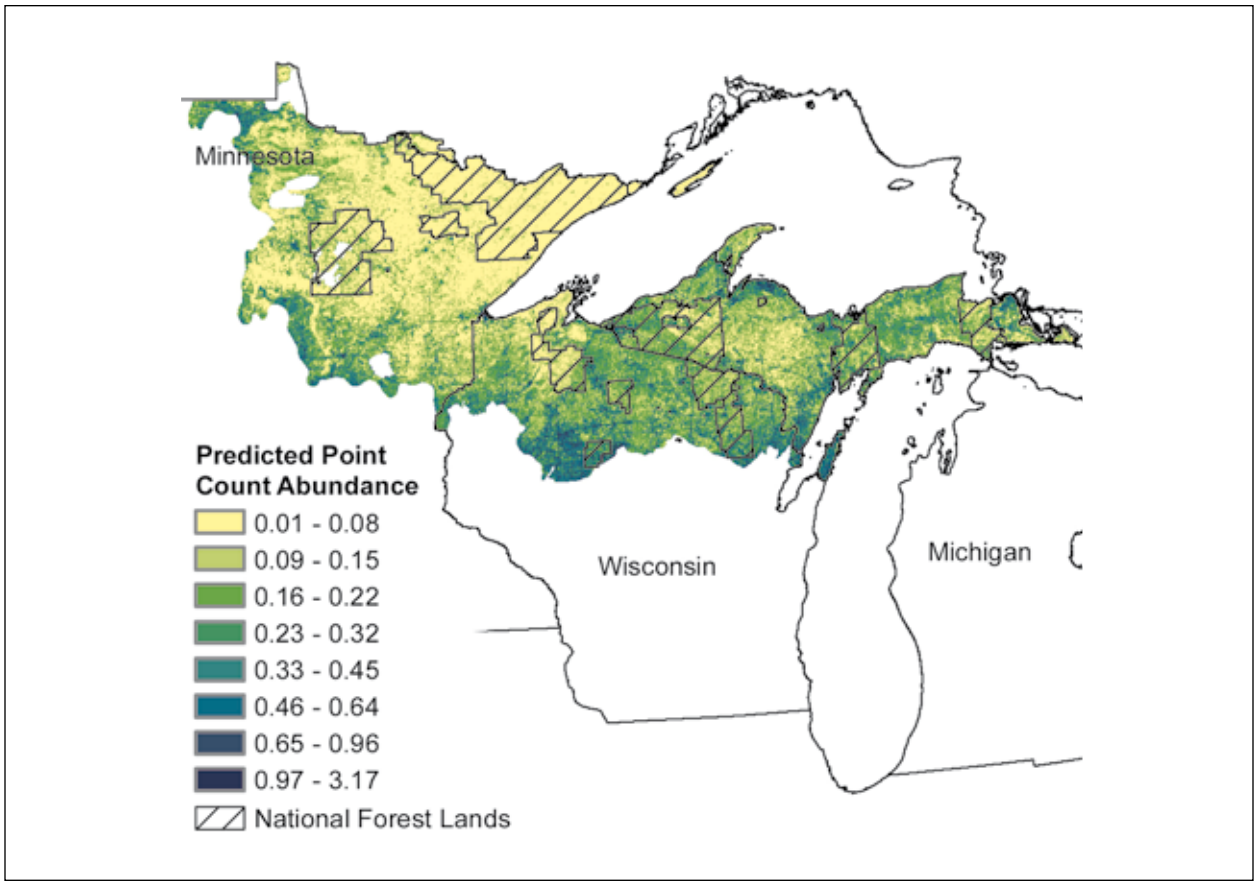
Migration: Short-distance



Trends for mourning dove in three national forests, 1995–2010



Percent perfect indication of habitat association for mourning dove where at least one bird was observed once during the decade (2001–2010; n=1,457 at 471 points)



Predicted relative abundance (number of birds per 10-minute count) of mourning dove for the western Great Lakes region

Mourning Warbler MOWA

Geothlypis philadelphia



Photo by Bruce Lees, used with permission.

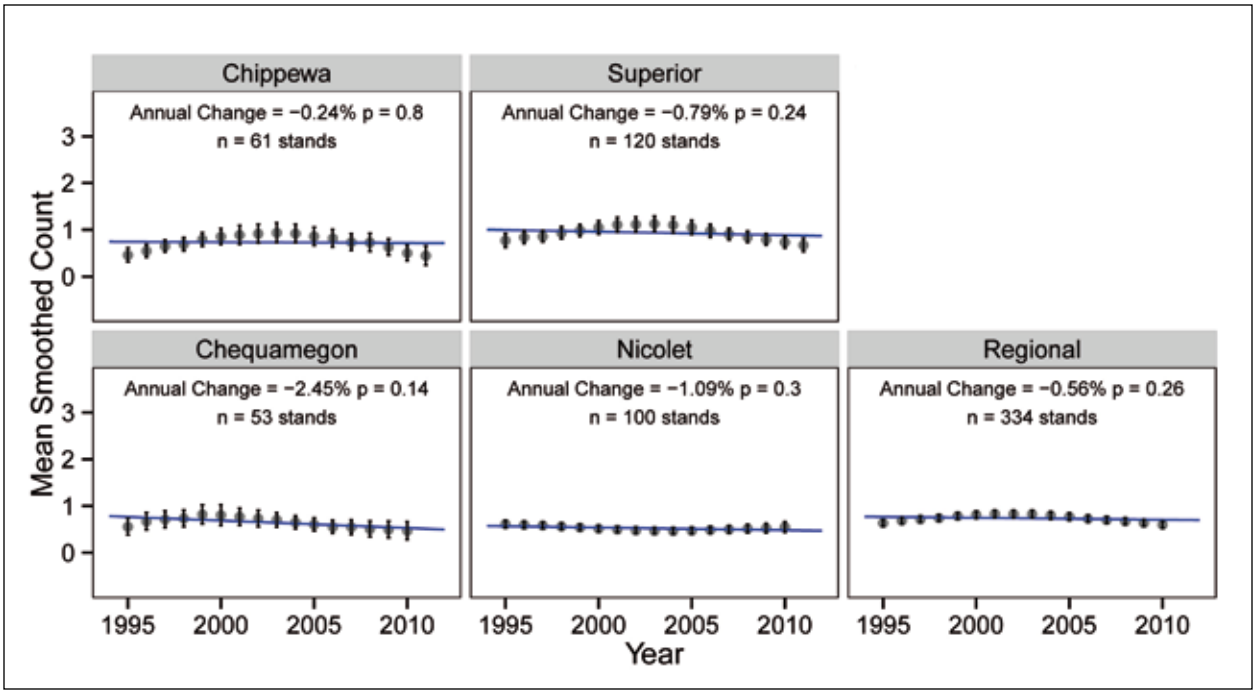
Guild Information

Habitat: Shrubby areas, young forests

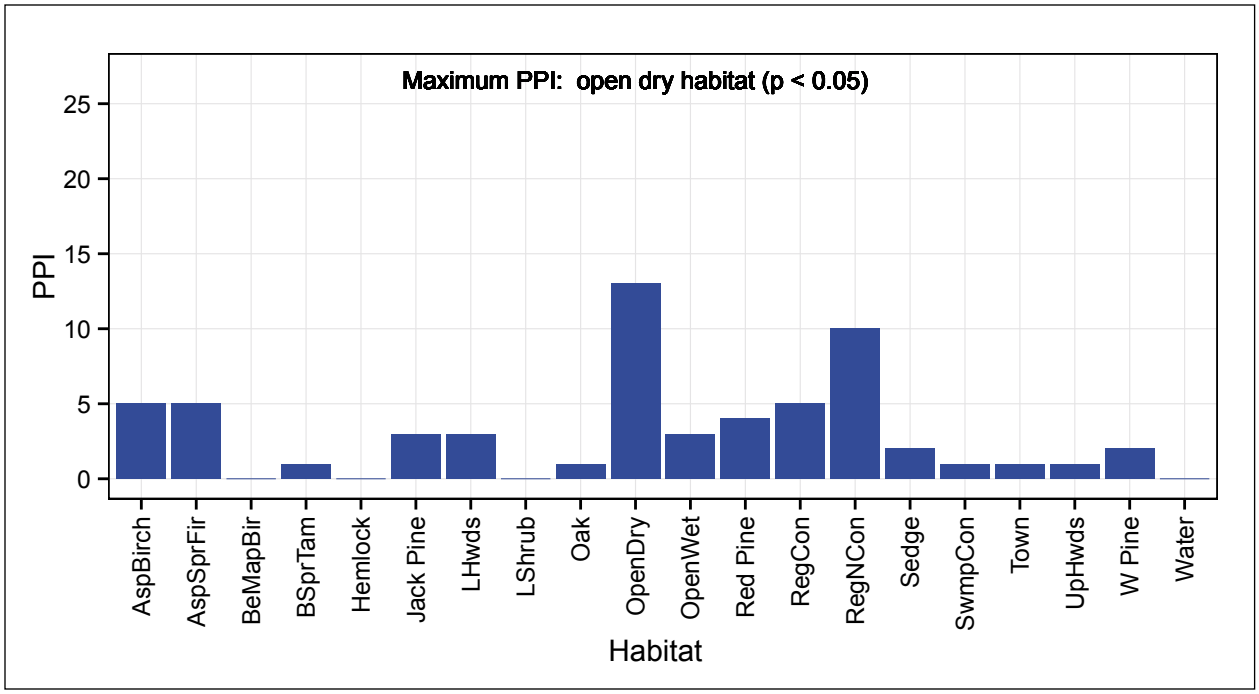
Foraging type: Foliage gleaner

Nest site: Ground

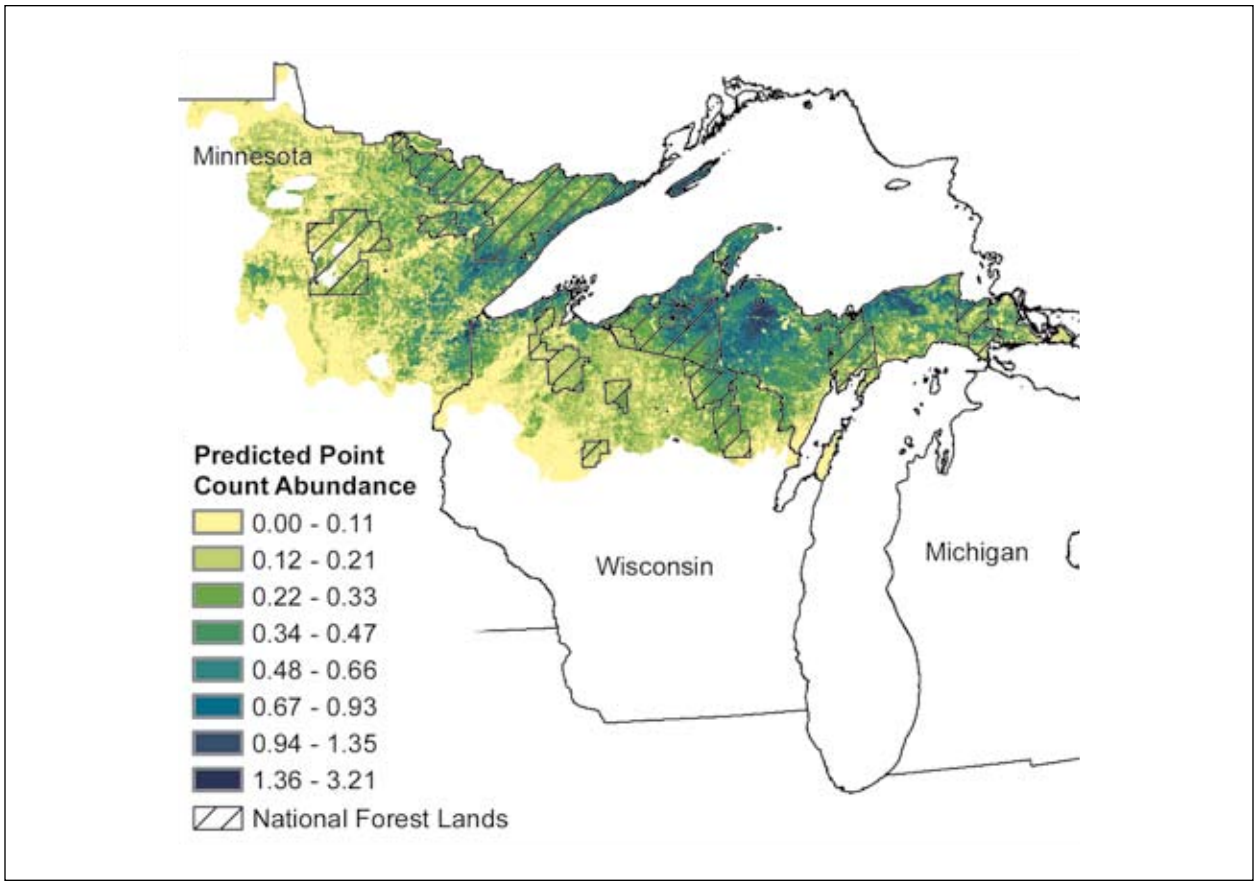
Migration: Long-distance



Trends for mourning warbler in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for mourning warbler where at least one bird was observed once during the decade (2001–2010; n=4,723 at 938 points)



Predicted relative abundance (number of birds per 10-minute count) of mourning warbler for the western Great Lakes region

Nashville Warbler NAWA

Oreothlypis ruficapilla



Photo by Edmund Zlonis, Natural Resources Research Institute, used with permission.

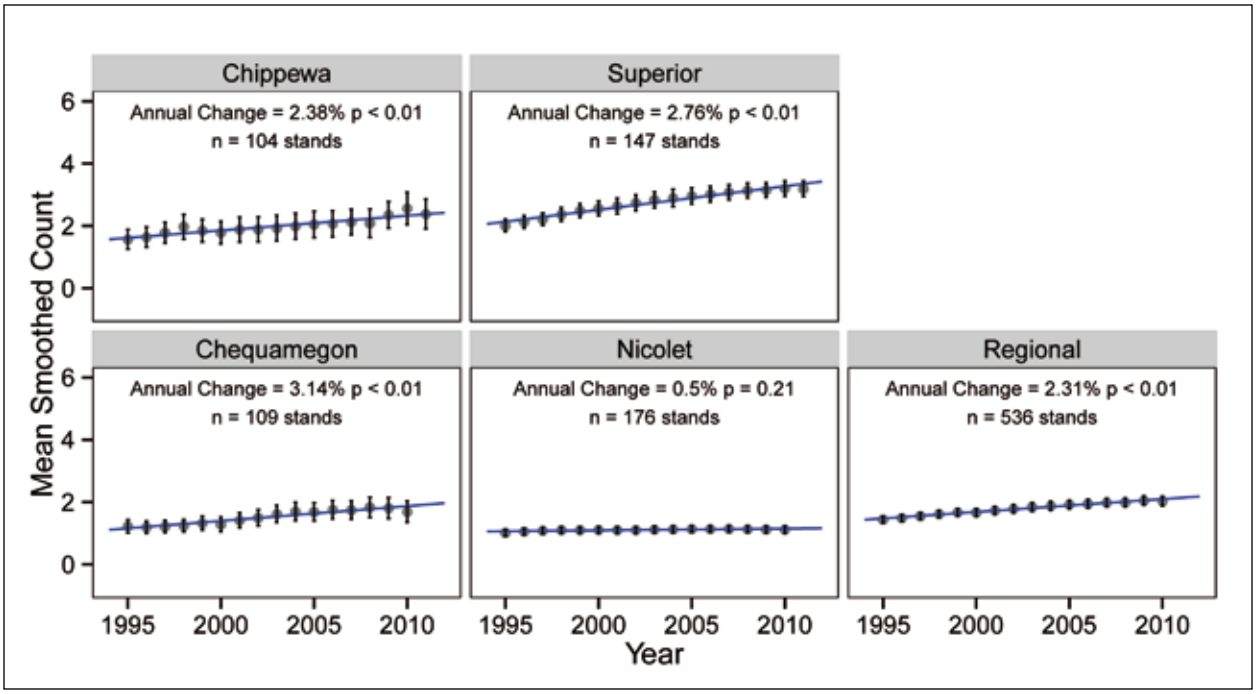
Guild Information

Habitat: Forests with shrubby understory

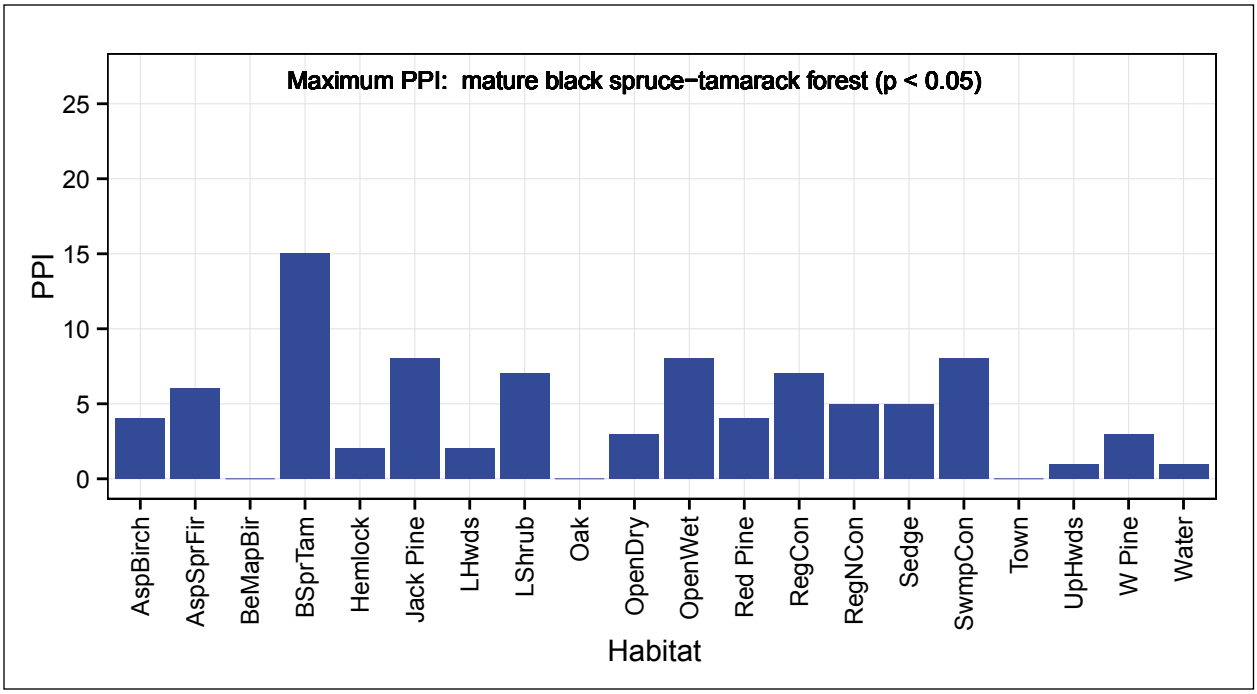
Foraging type: Foliage gleaner

Nest site: Ground

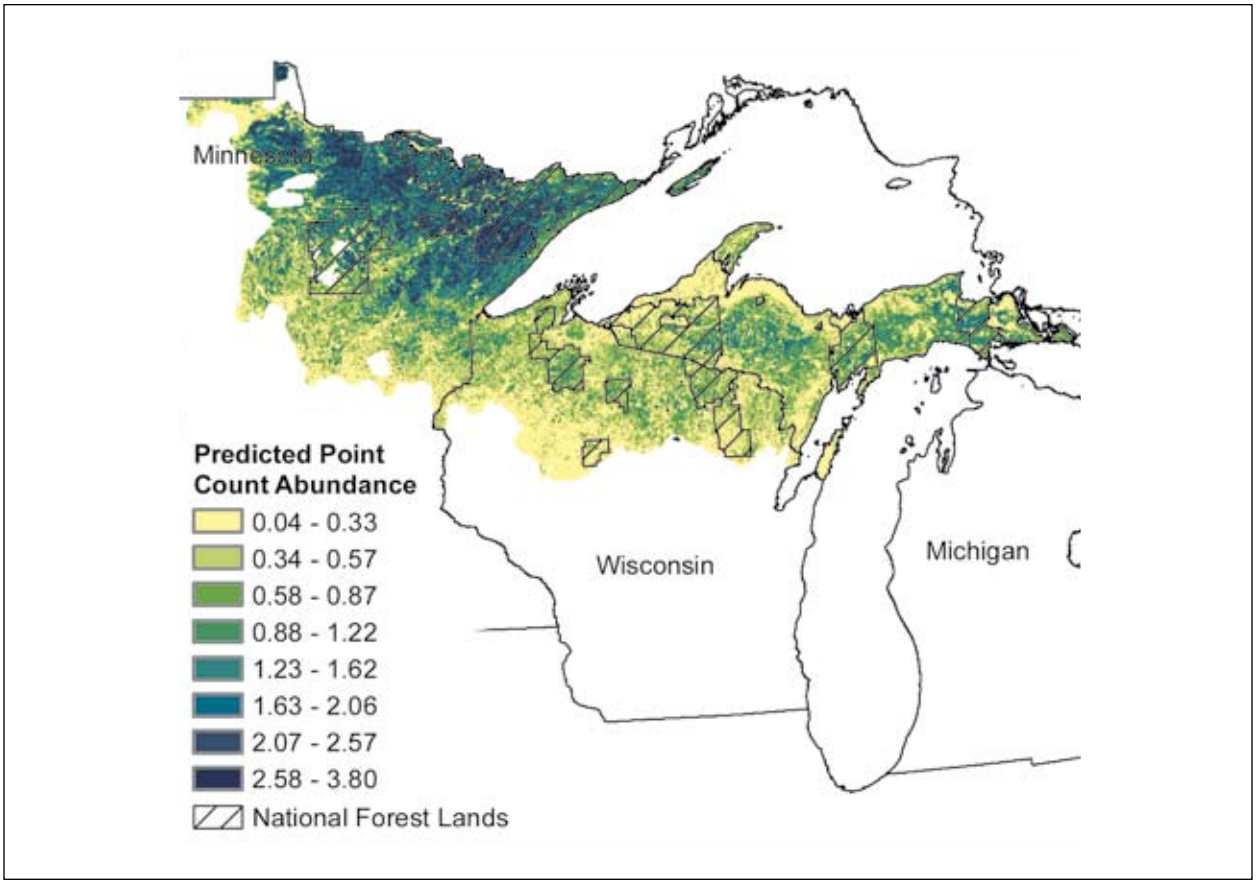
Migration: Long-distance



Trends for Nashville warbler in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for Nashville warbler where at least one bird was observed once during the decade (2001–2010; n=17,221 at 1,449 points)



Predicted relative abundance (number of birds per 10-minute count) of Nashville warbler for the western Great Lakes region

Northern Flicker NOFL

Colaptes auratus



Photo by Bruce Lees, used with permission.

Guild Information

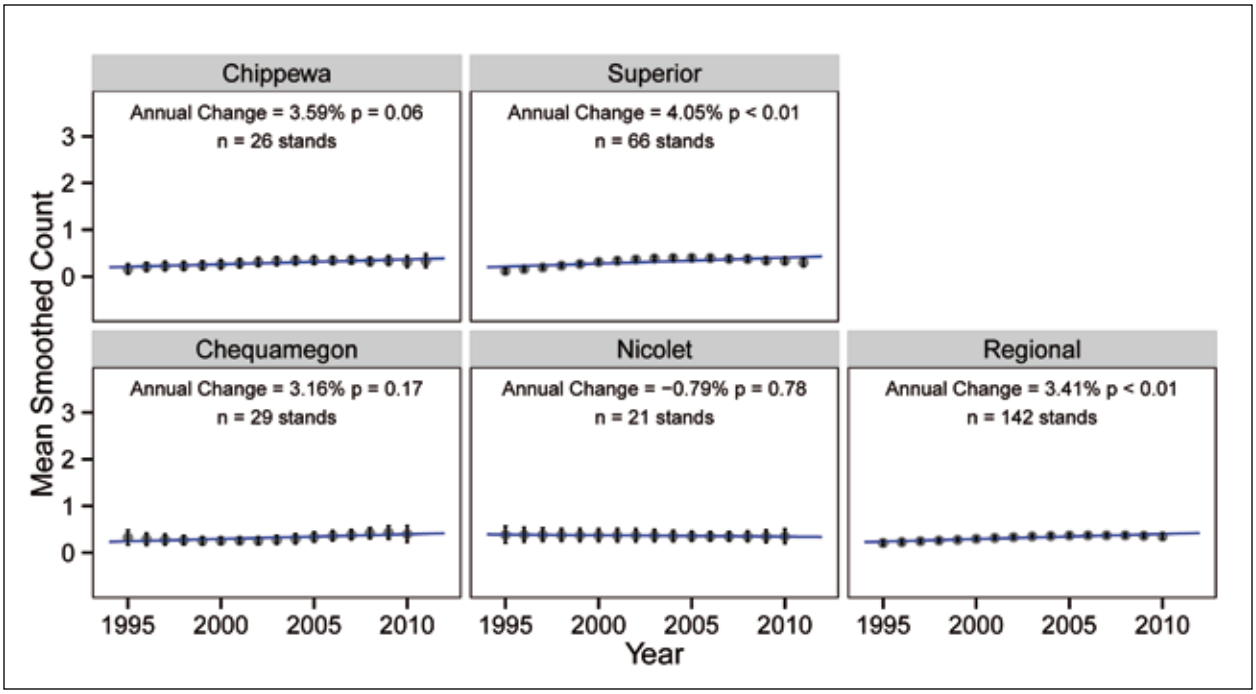
Habitat: Open areas with trees

Foraging type: Ground invertebrates, especially ants

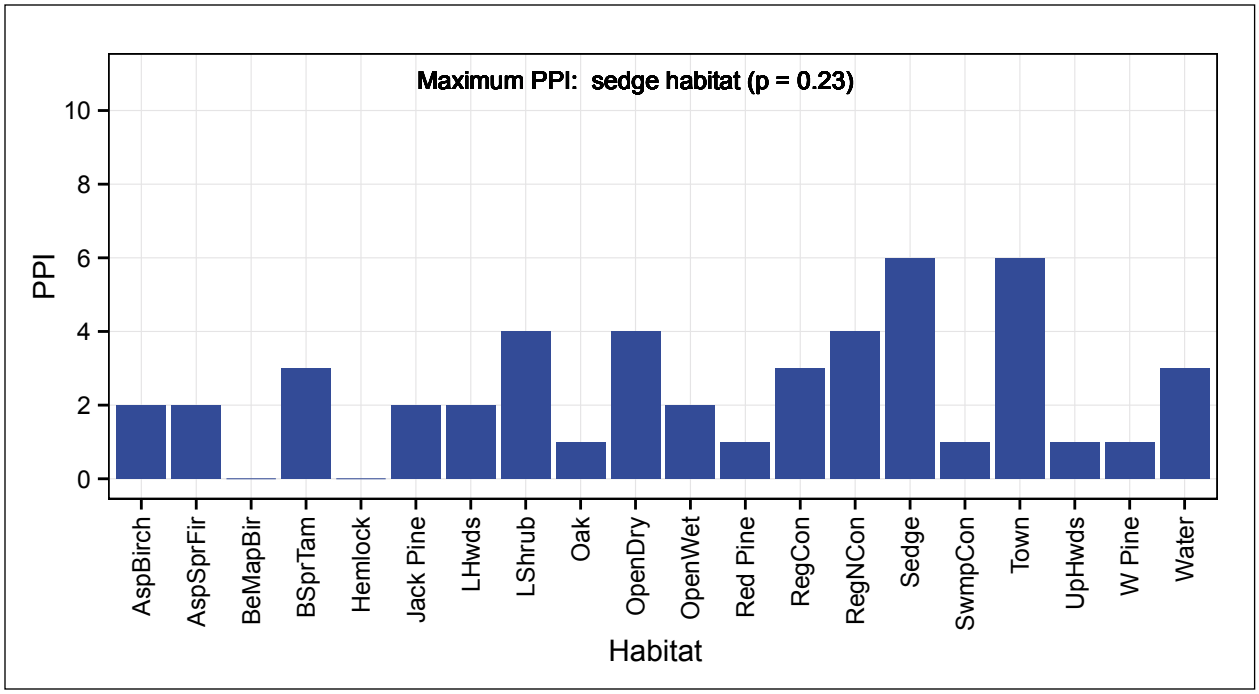
Nest site: Cavity

Migration: Short-distance

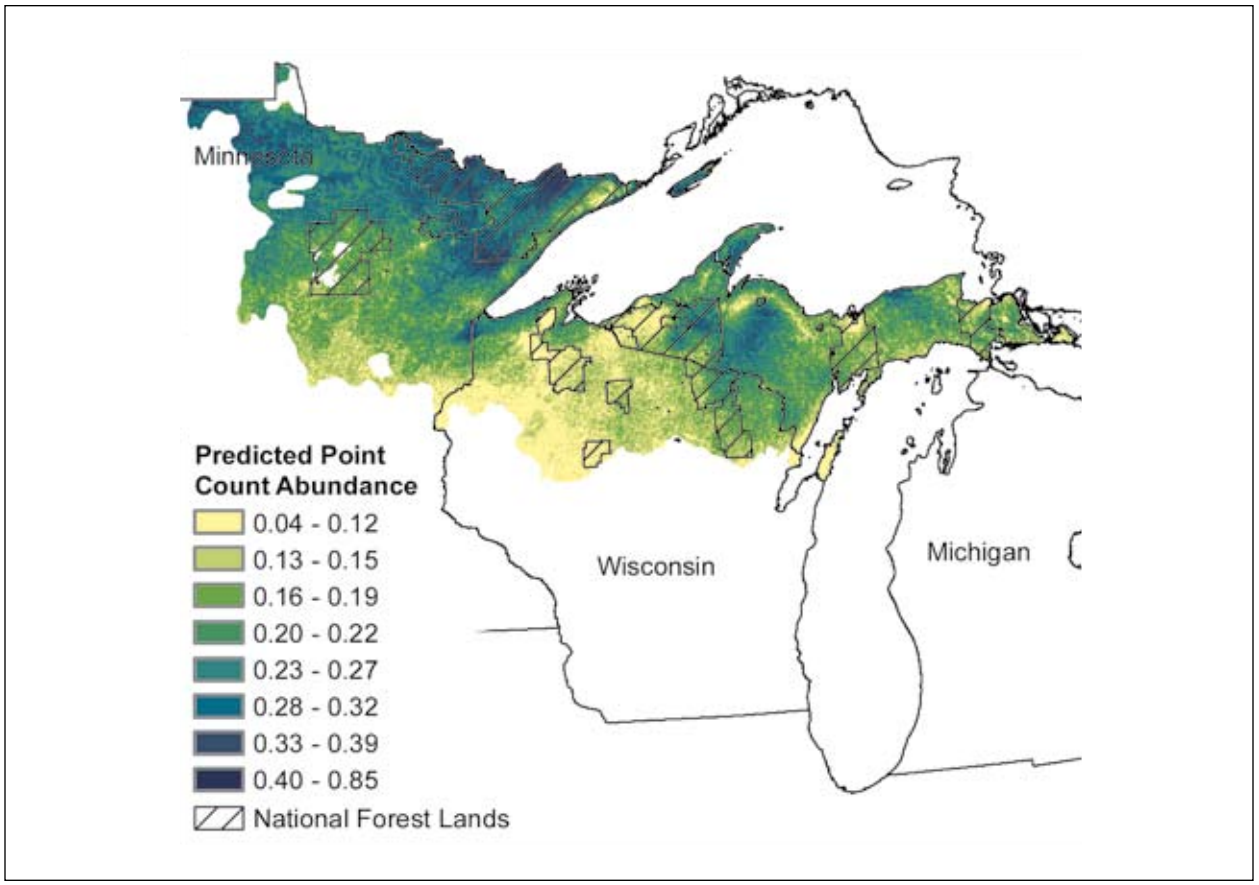
Notes: PPI analysis was not statistically significant for this wide-ranging resident of open woodlands. Individuals can be heard or seen from a great distance, so records at many points were transients (flyovers) or birds from nearby habitats.



Trends for northern flicker in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for northern flicker where at least one bird was observed once during the decade (2001–2010; n=1,558 at 740 points)



Predicted relative abundance (number of birds per 10-minute count) of northern flicker for the western Great Lakes region

Northern Parula NOPA

Setophaga americana



Photo by Jon Swanson, used with permission.

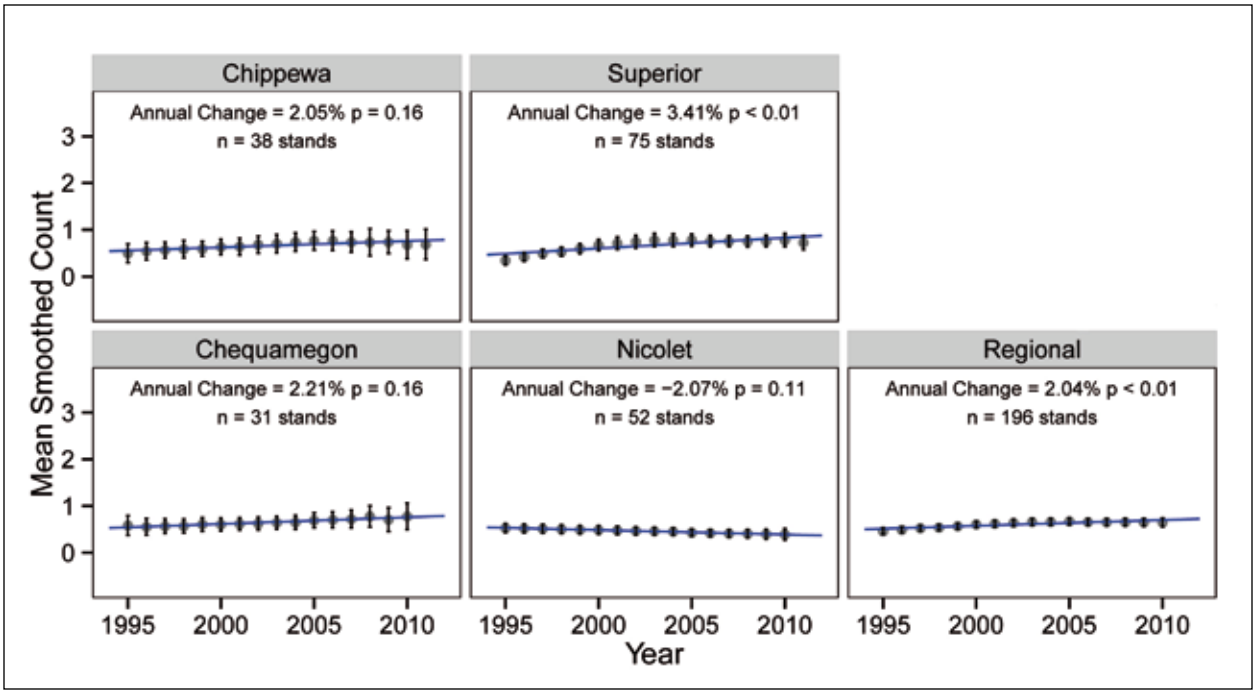
Guild Information

Habitat: Mixed forests, often wet

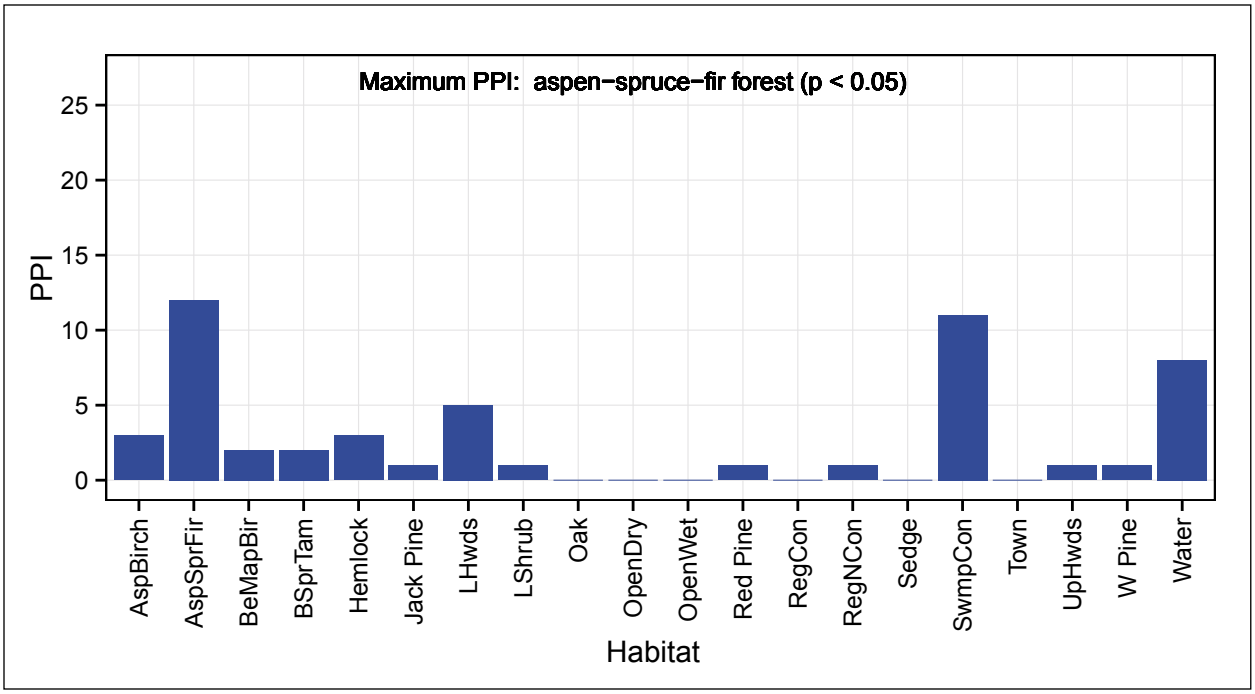
Foraging type: Foliage gleaner

Nest site: Canopy

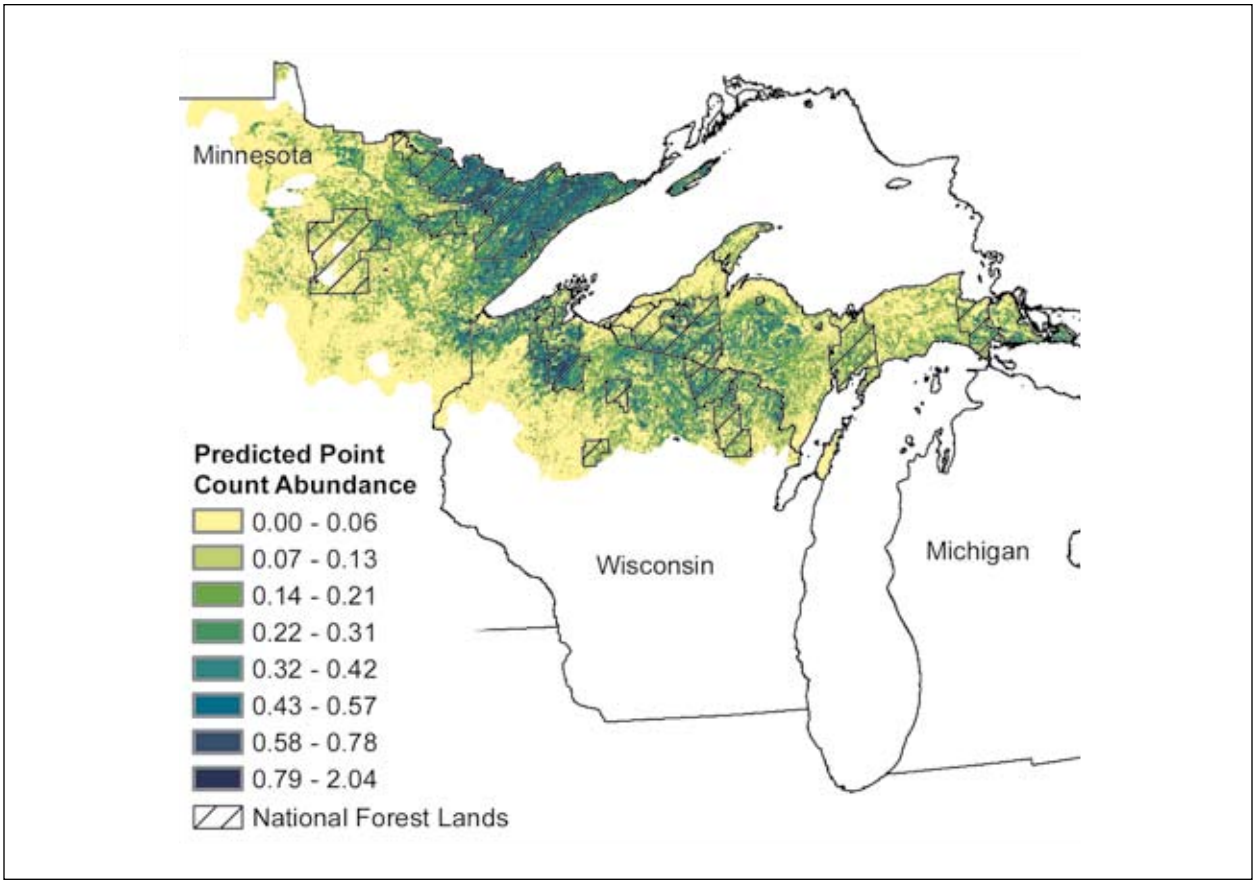
Migration: Long-distance



Trends for northern parula in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for northern parula where at least one bird was observed once during the decade (2001–2010; n=2,413 at 656 points)



Predicted relative abundance (number of birds per 10-minute count) of northern parula for the western Great Lakes region

Northern Waterthrush NOWA

Parkesia noveboracensis



Photo by Bruce Lees, used with permission.

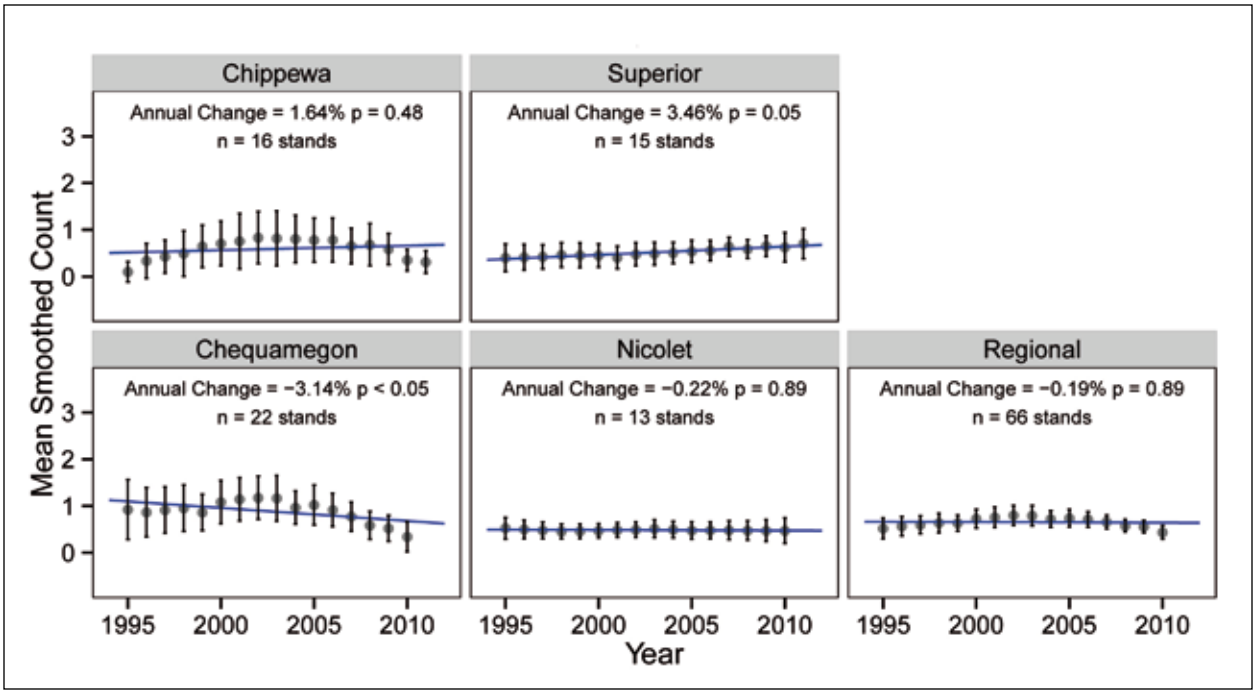
Guild Information

Habitat: Lowland hardwoods, swamp conifer forests, water edges

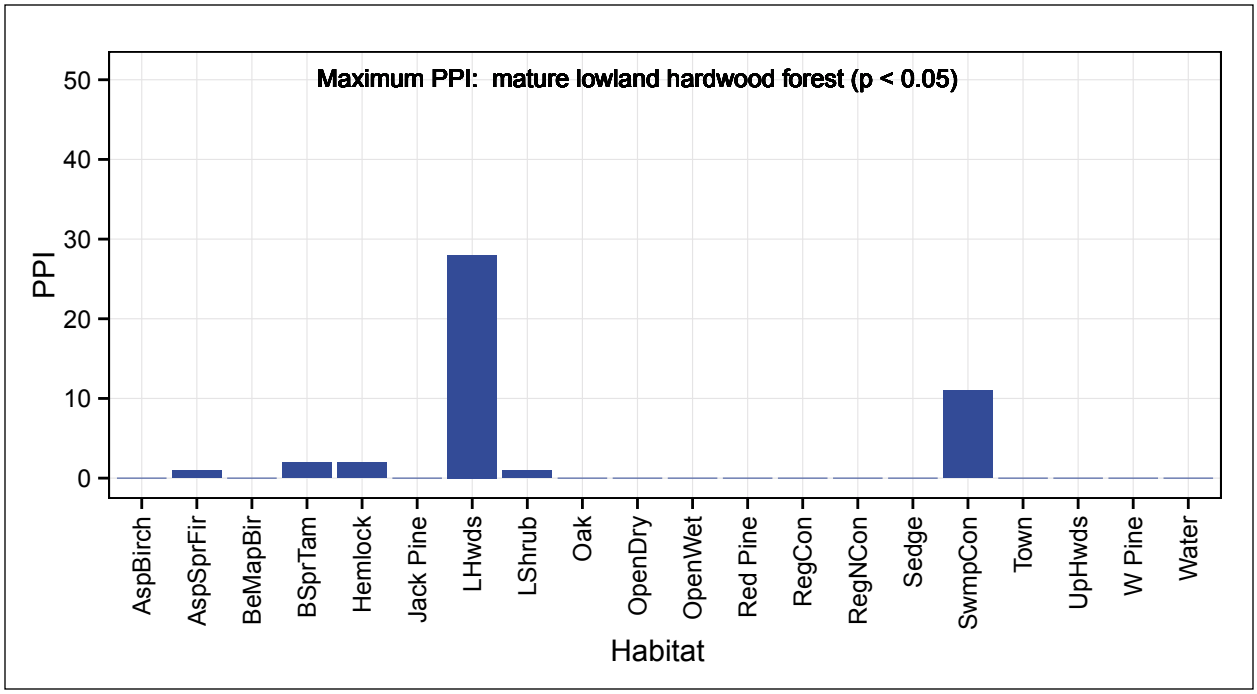
Foraging type: Foliage and ground gleaner

Nest site: Ground

Migration: Long-distance



Trends for northern waterthrush in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for northern waterthrush where at least one bird was observed once during the decade (2001–2010; n=1,101 at 371 points)

Olive-sided Flycatcher OSFL

Contopus cooperi



©Robert Royse, used with permission.

Guild Information

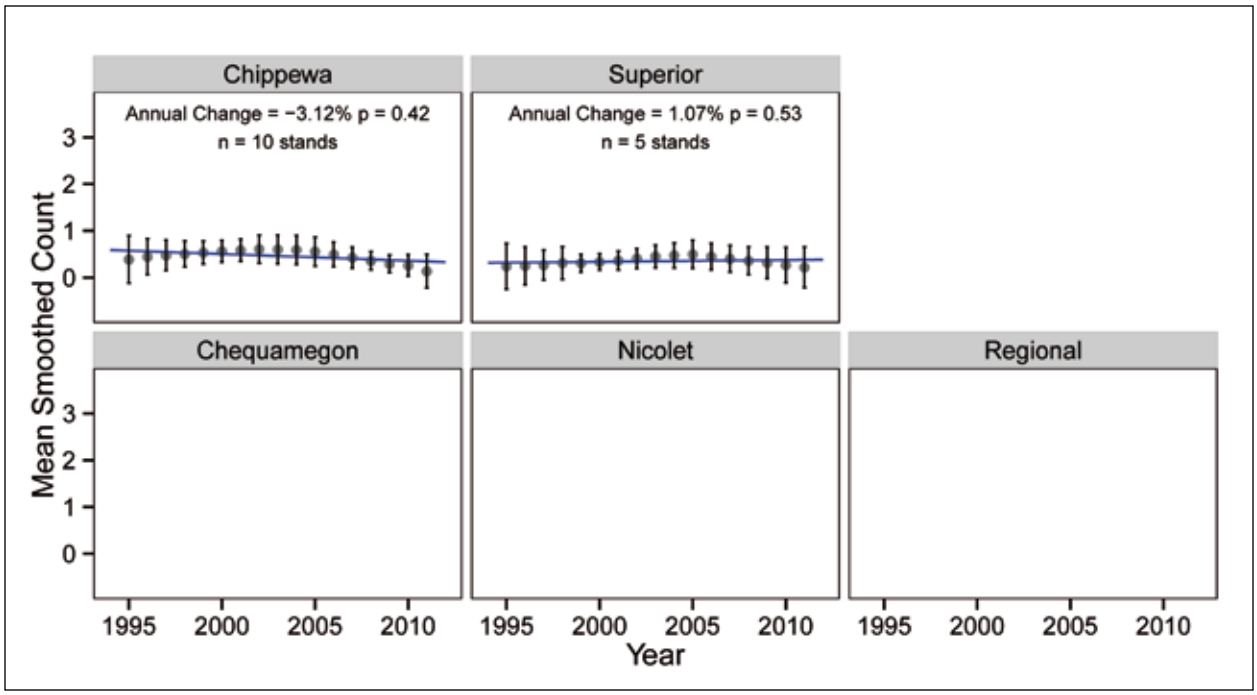
Habitat: Sedge meadows, openings with large trees

Foraging type: Flycatcher

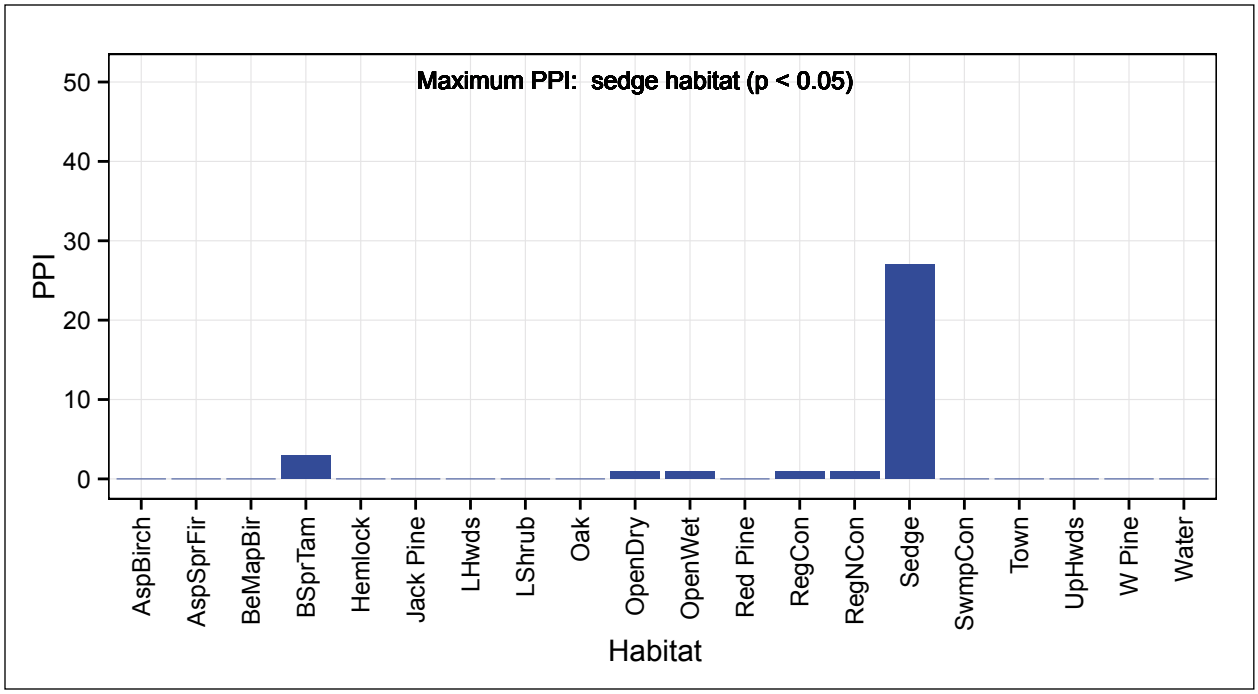
Nest site: Canopy

Migration: Long-distance

Notes: This uncommon species was recorded at a wide variety of open or semi-open habitats, especially recently logged sites and open conifer habitats (both lowland and upland). Individuals were observed at 5 of the 7 Sedge points, but the sample size for this habitat was small.



Trends for olive-sided flycatcher in two national forests, 1995–2010



Percent perfect indication of habitat association for olive-sided flycatcher where at least one bird was observed once during the decade (2001–2010; n=279 at 127 points)

Ovenbird OVEN
Seiurus aurocapilla



Photo by Jon Swanson, used with permission.

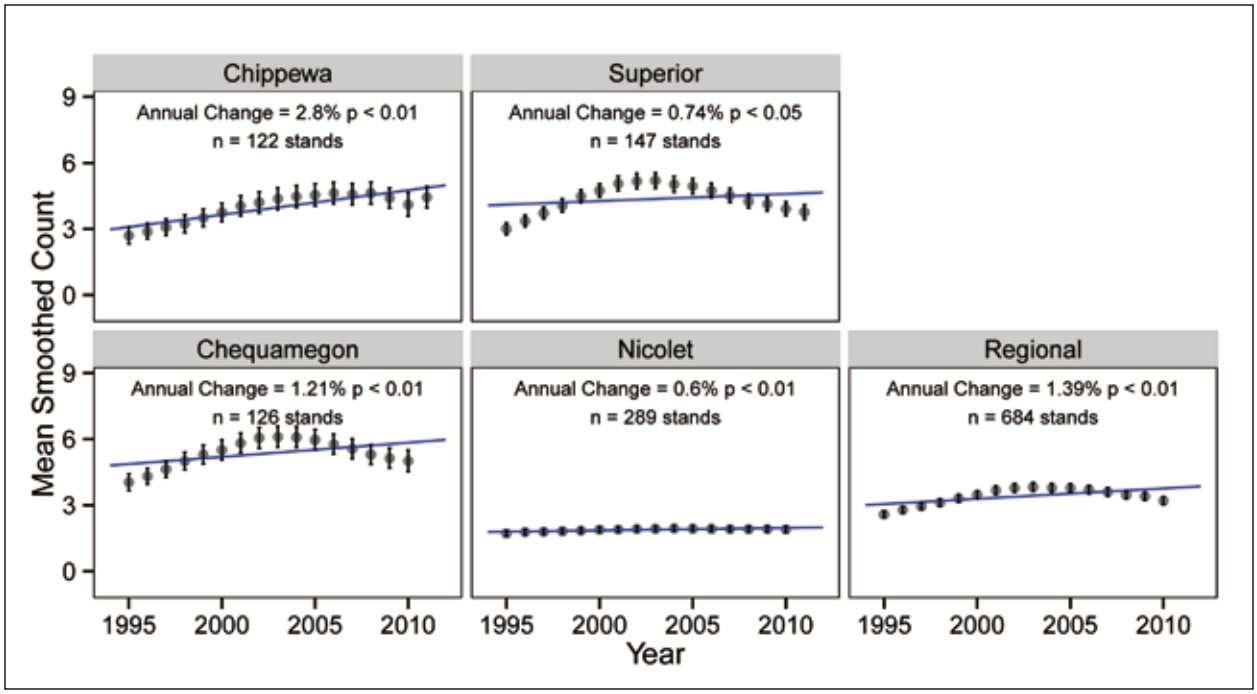
Guild Information

Habitat: All forest types, especially upland

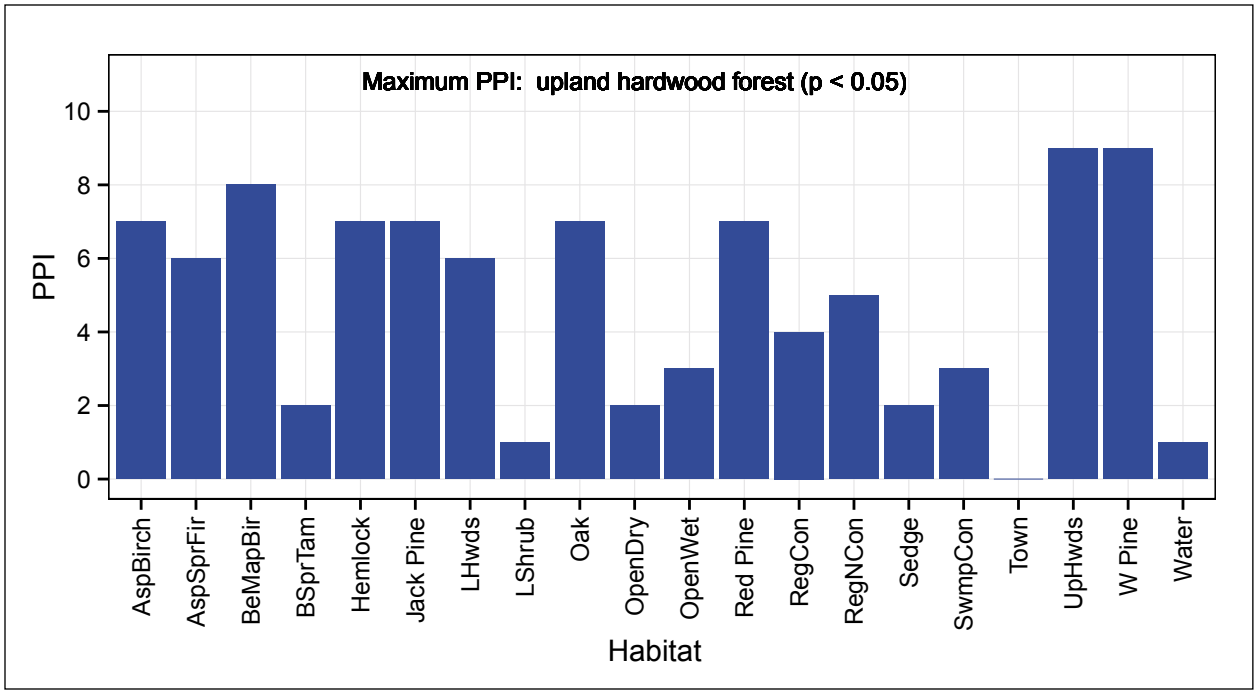
Foraging type: Ground gleaner

Nest site: Ground

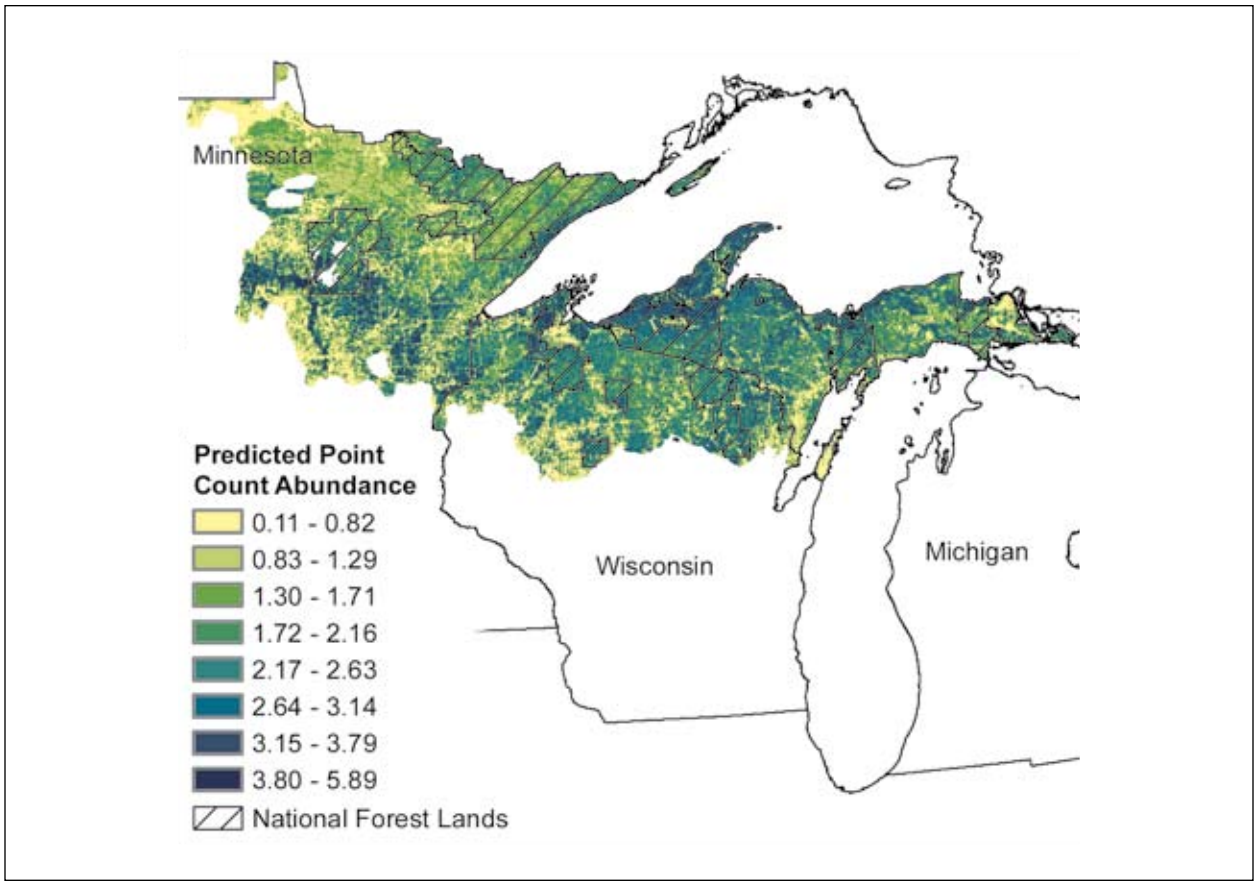
Migration: Long-distance



Trends for ovenbird in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for ovenbird where at least one bird was observed once during the decade (2001–2010; n=40,055 at 1,663 points)



Predicted relative abundance (number of birds per 10-minute count) of ovenbird for the western Great Lakes region

Palm Warbler PAWA

Setophaga palmarum



Photo by Bruce Lees, used with permission.

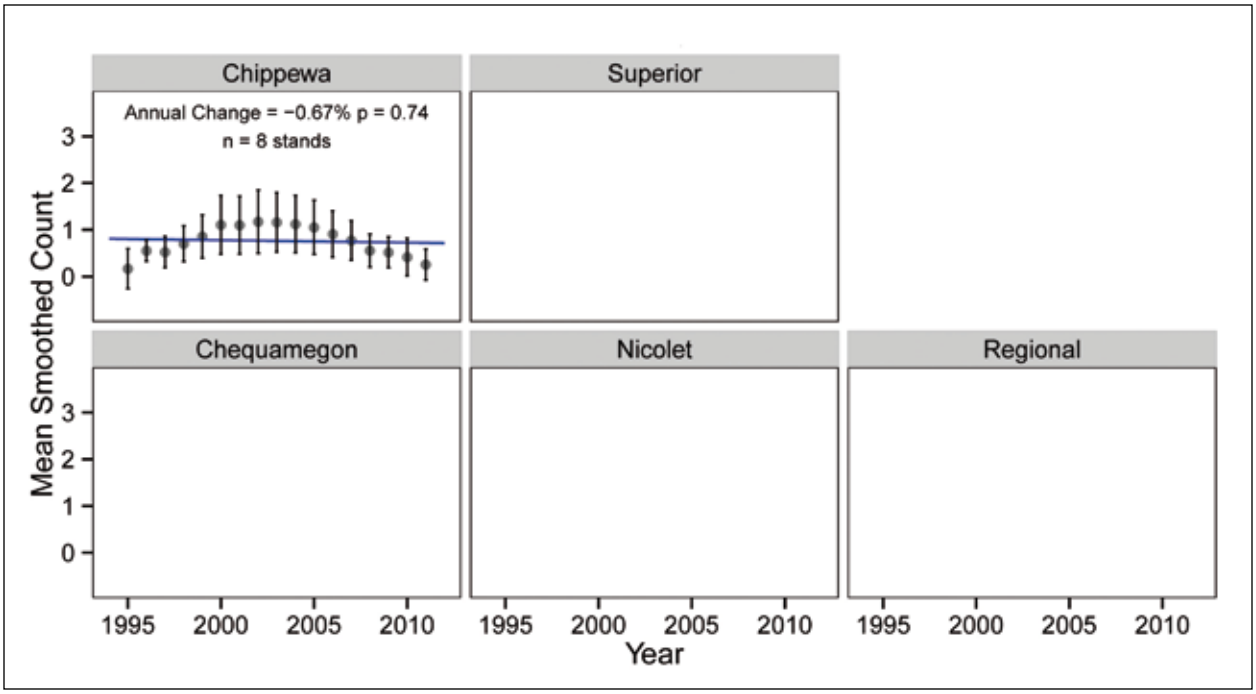
Guild Information

Habitat: Open black spruce-tamarack forests (muskegs)

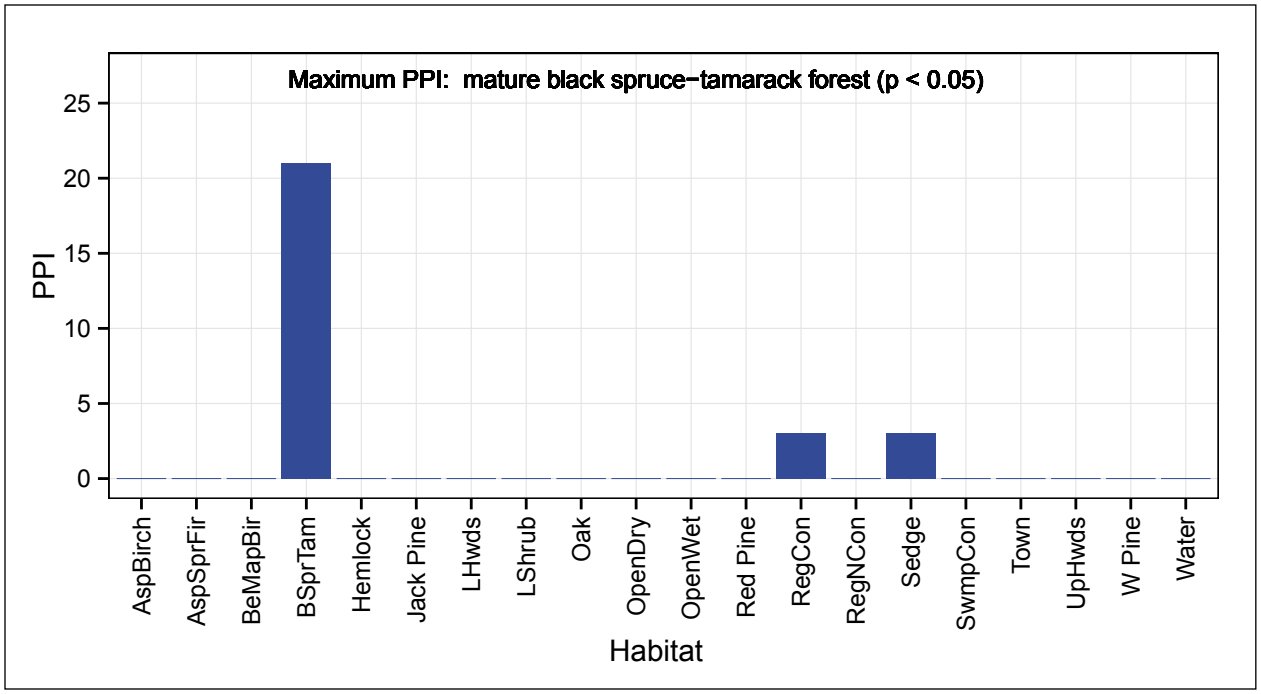
Foraging type: Foliage gleaner

Nest site: Ground

Migration: Long-distance



Trend for palm warbler in one national forest, 1995–2010



Percent perfect indication of habitat association for palm warbler where at least one bird was observed once during the decade (2001–2010; n=310 at 72 points)

Pileated Woodpecker PIWO

Dryocopus pileatus



Photo by Jon Swanson, used with permission.

Guild Information

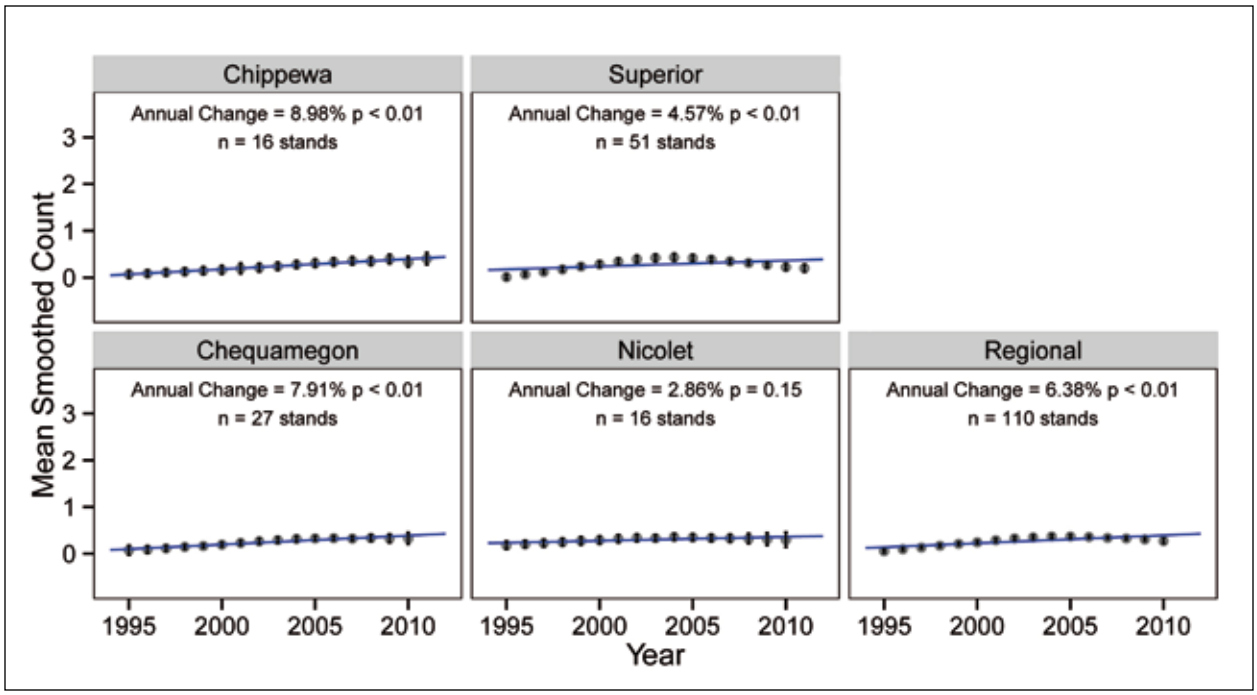
Habitat: Forests; species is highly mobile

Foraging type: Bark driller and gleaner

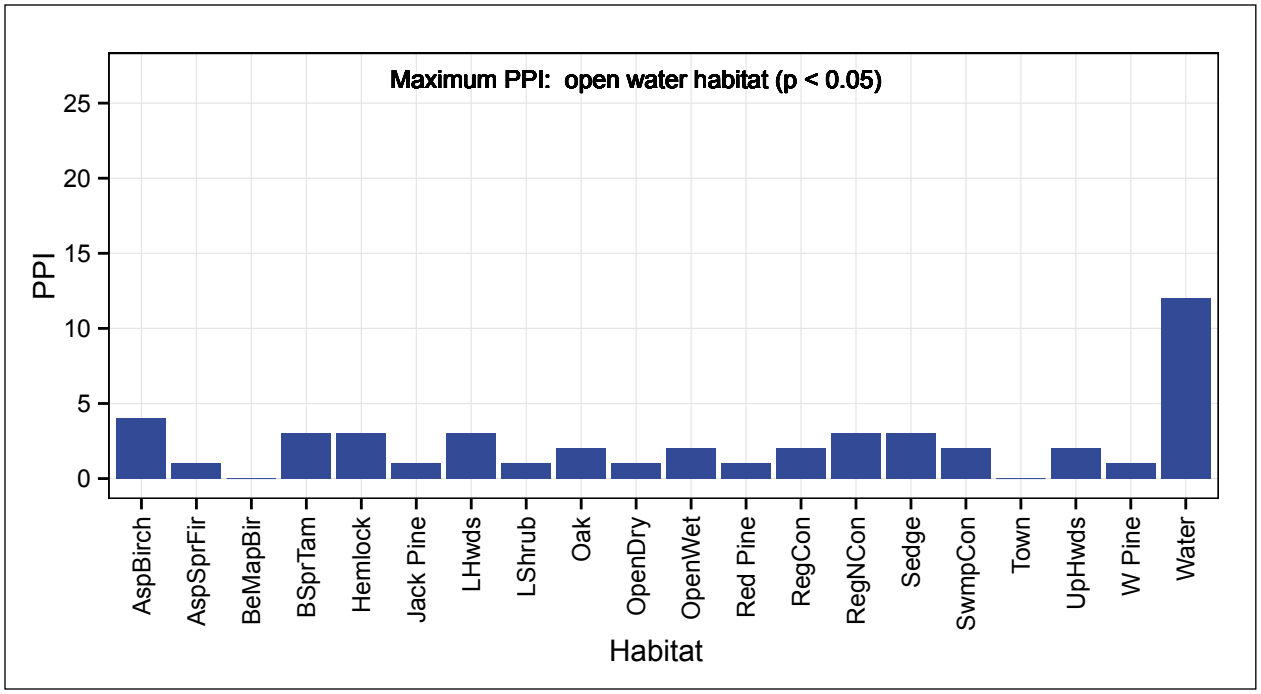
Nest site: Cavity

Migration: Permanent resident

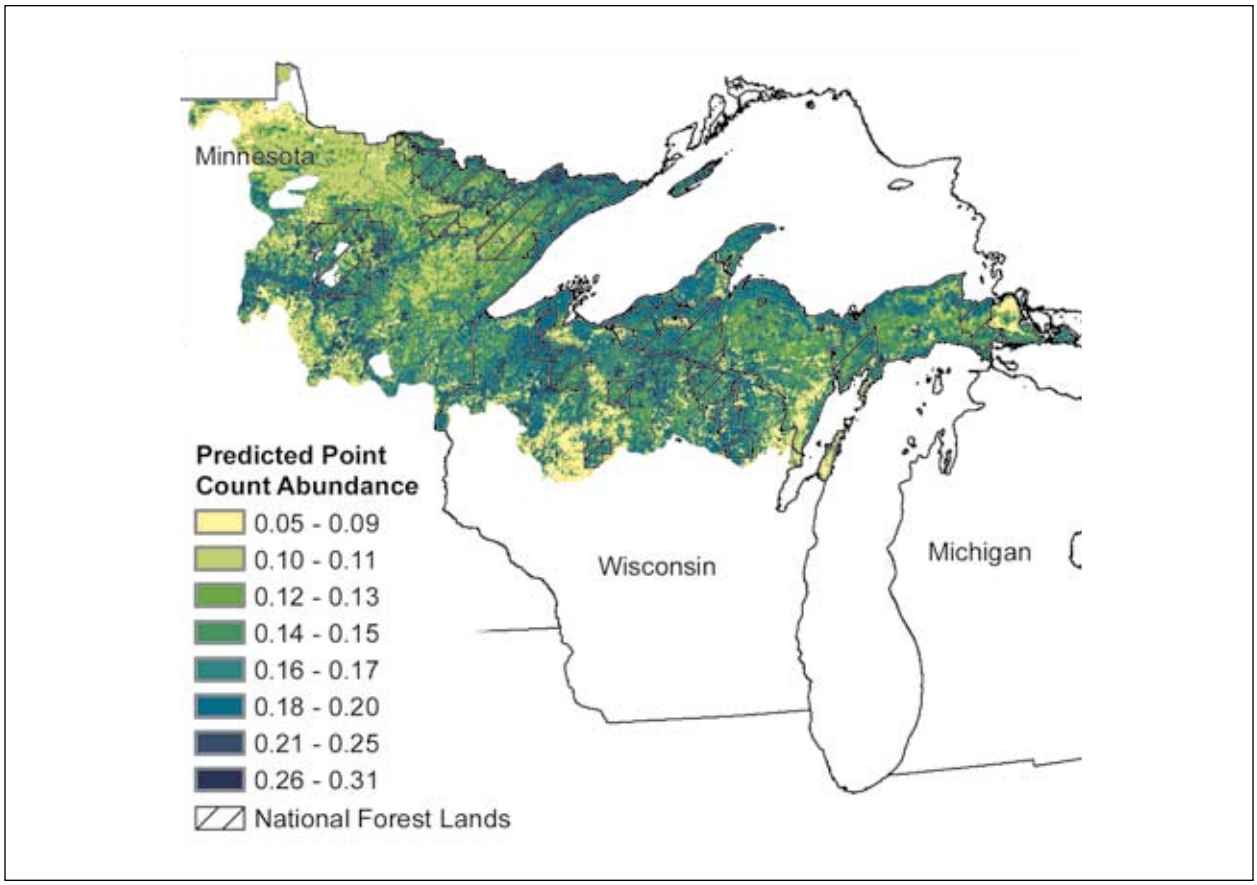
Notes: This wide-ranging forest species can be heard or seen from a great distance, so records at many points were transients (flyovers) or birds from nearby habitats. PPI values for open habitats (OpenWet, Sedge, and Water) reflect the small number of sample points for these habitats and probably represent observations of transients.



Trends for pileated woodpecker in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for pileated woodpecker where at least one bird was observed once during the decade (2001–2010; n=1,371 at 709 points)



Predicted relative abundance (number of birds per 10-minute count) of pileated woodpecker for the western Great Lakes region

Pine Warbler PIWA

Setophaga pinus



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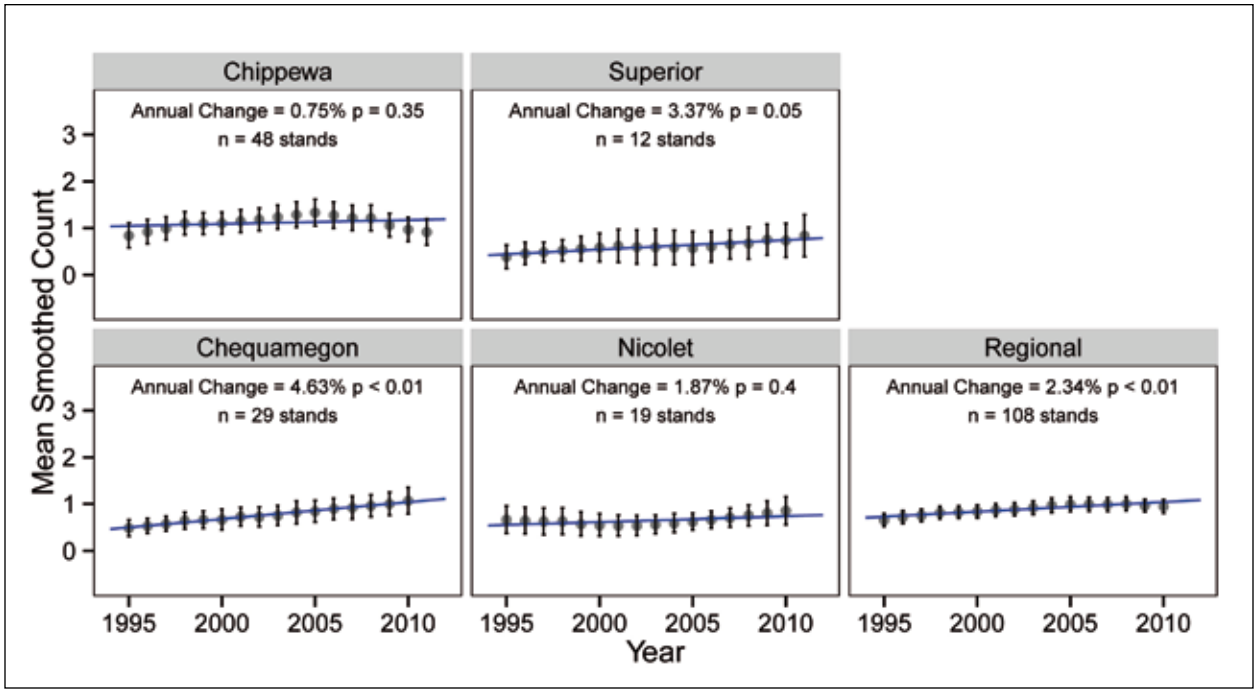
Guild Information

Habitat: Mature pine forests

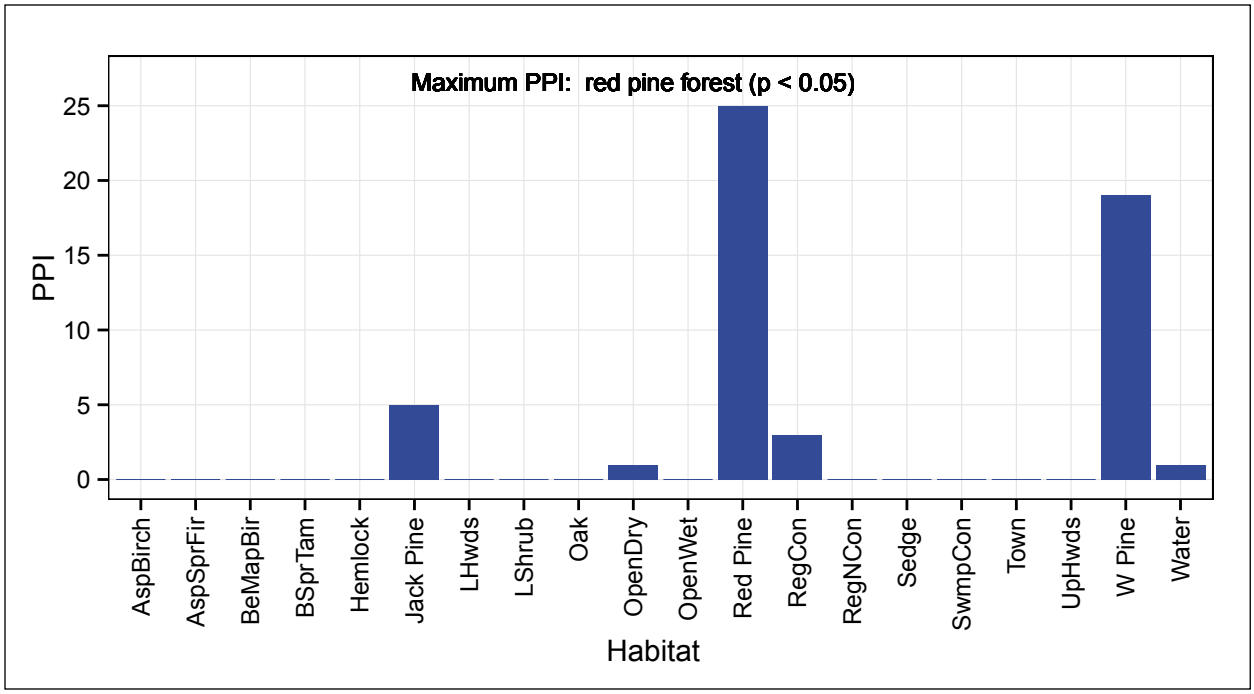
Foraging type: Foliage gleaner

Nest site: Canopy

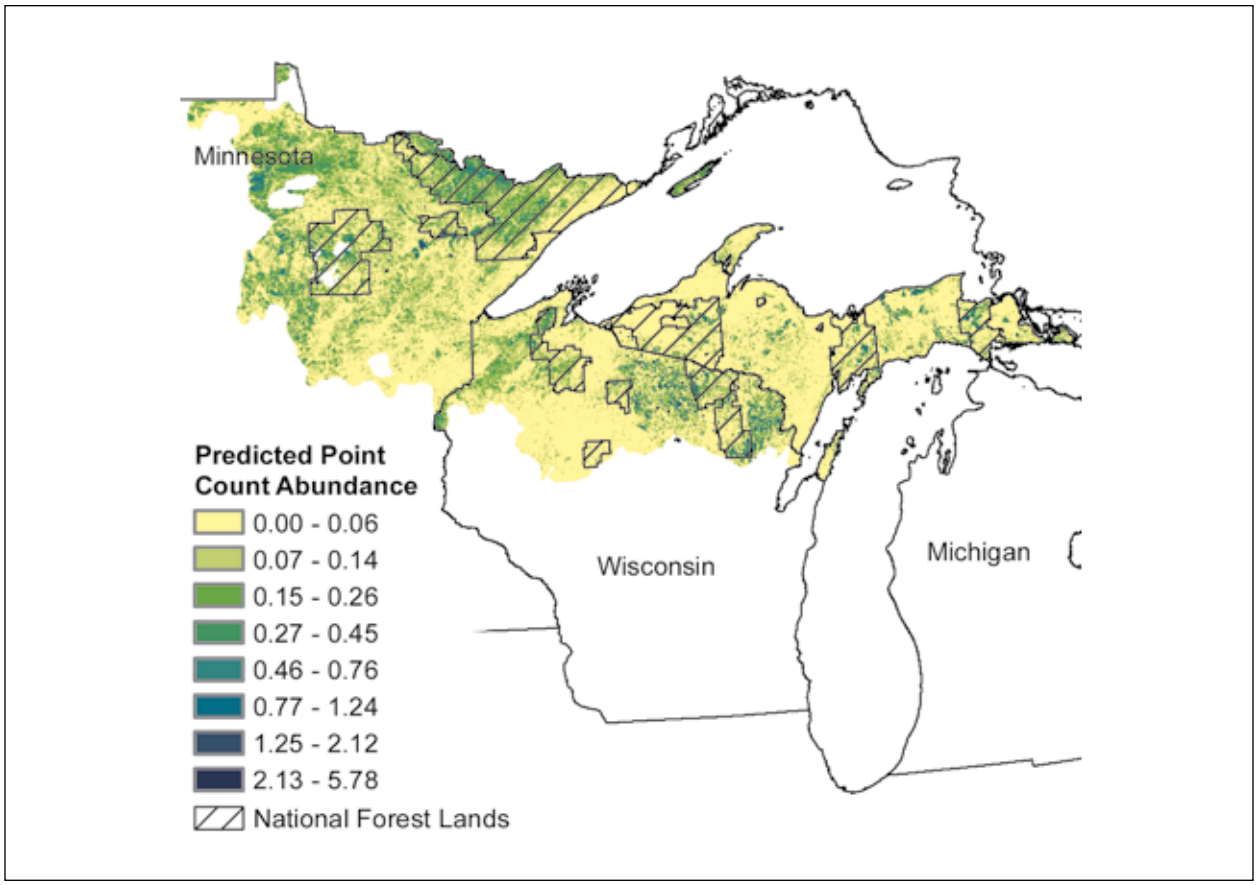
Migration: Short-distance



Trends for pine warbler in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for pine warbler where at least one bird was observed once during the decade (2001–2010; n=1,950 at 430 points)



Predicted relative abundance (number of birds per 10-minute count) of pine warbler for the western Great Lakes region

Purple Finch PUFI

Haemorhous purpureus



Photo by Bruce Lees, used with permission.

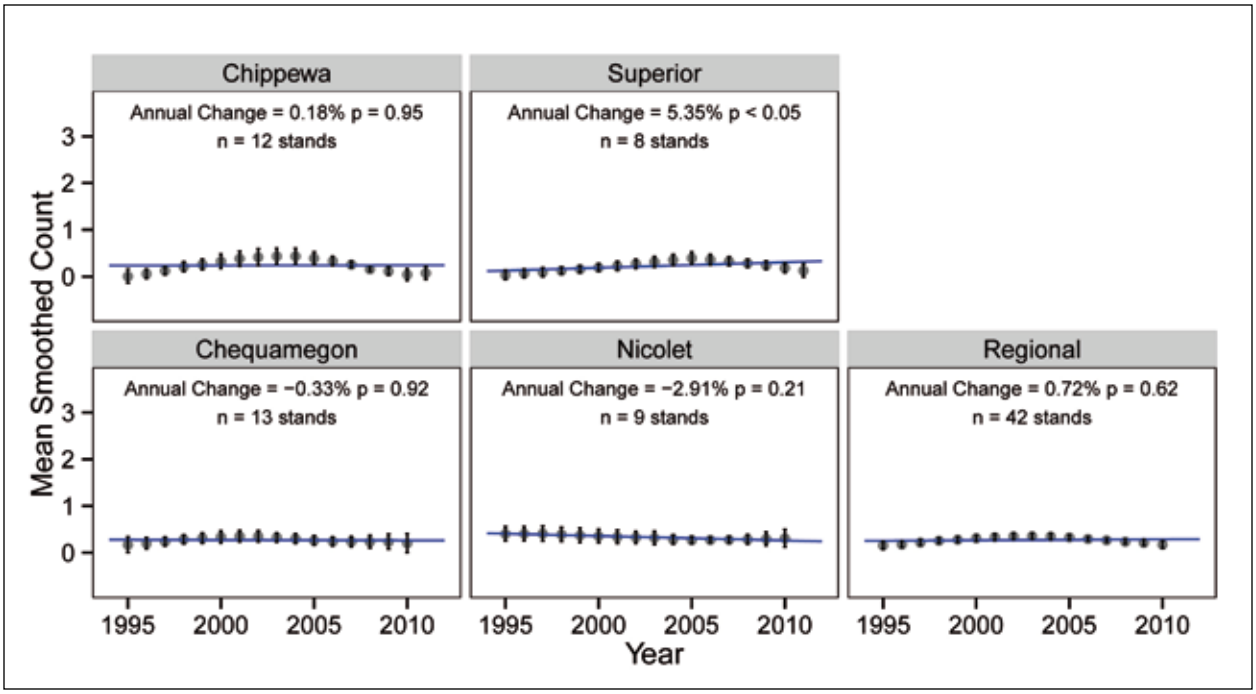
Guild Information

Habitat: Wide variety of habitats, including towns

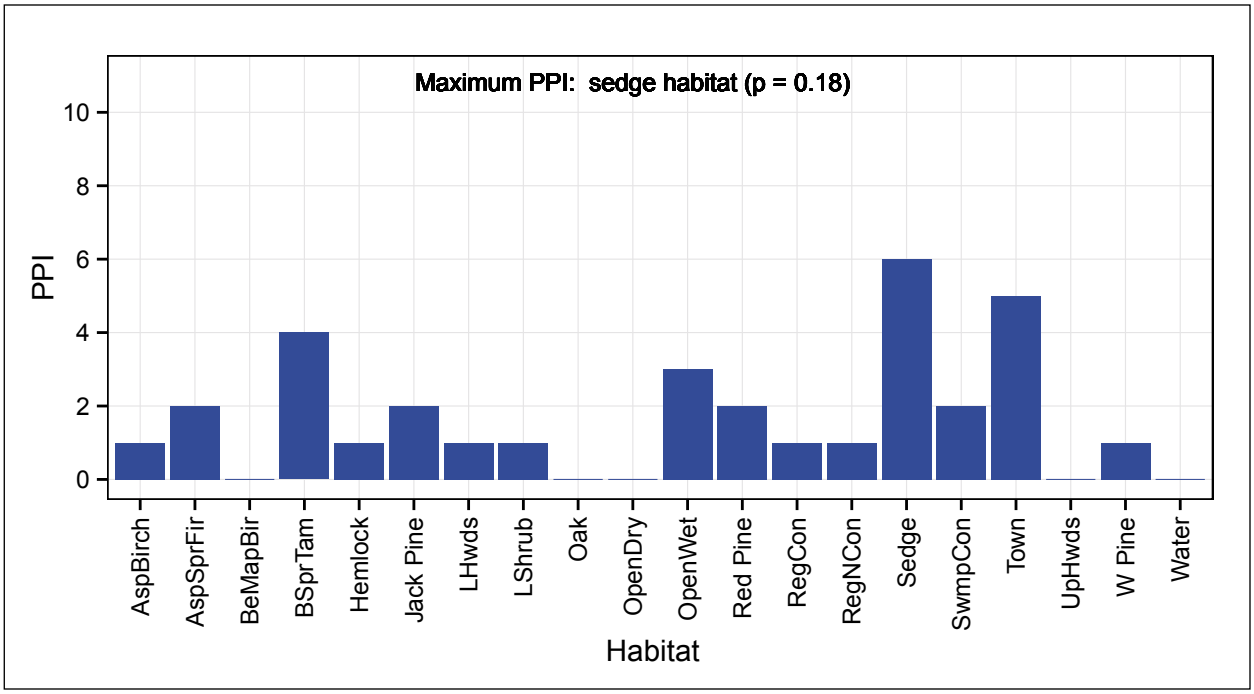
Foraging type: Omnivore

Nest site: Canopy

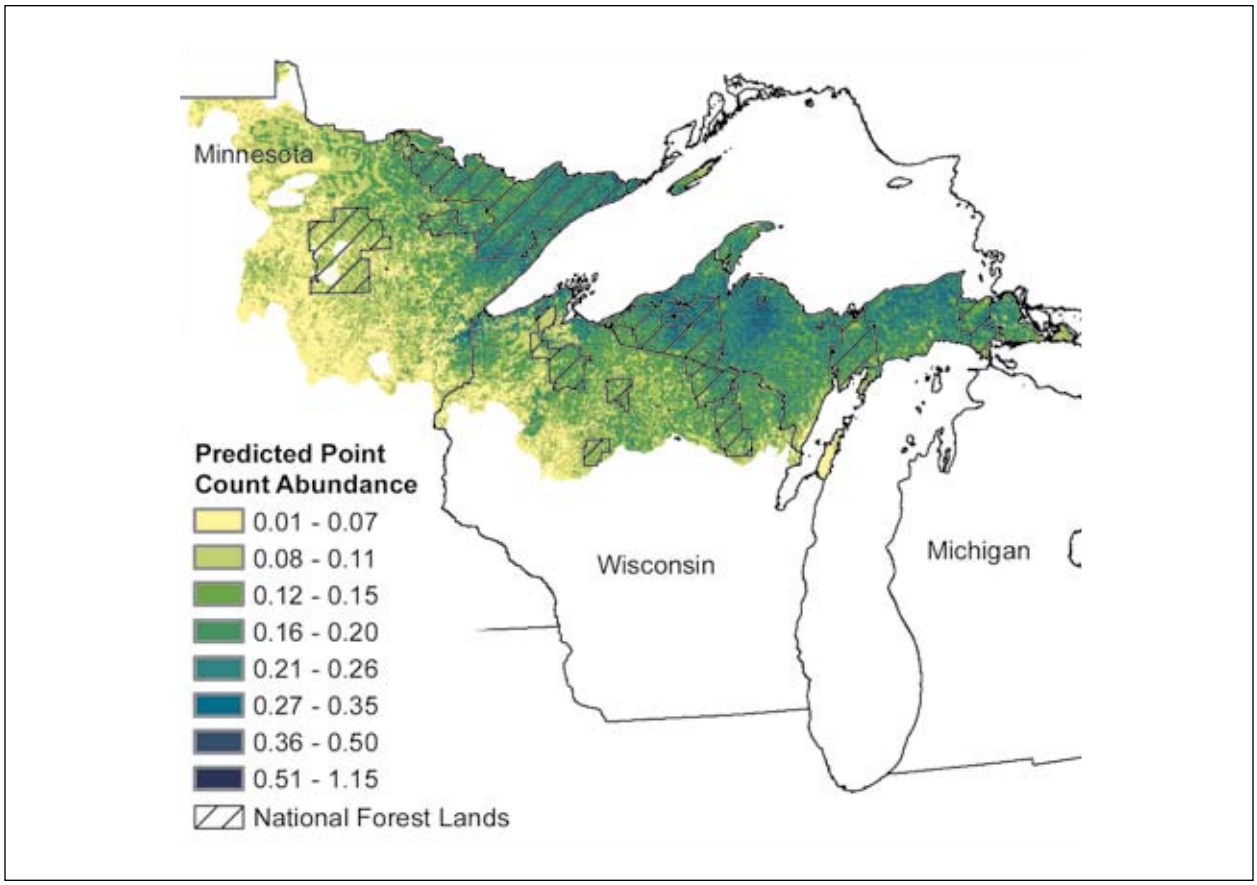
Migration: Short-distance



Trends for purple finch in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for purple finch where at least one bird was observed once during the decade (2001–2010; n=786 at 472 points)



Predicted relative abundance (number of birds per 10-minute count) of purple finch for the western Great Lakes region

Red-breasted Nuthatch RBNU

Sitta canadensis



Photo by Gary Garton, used with permission.

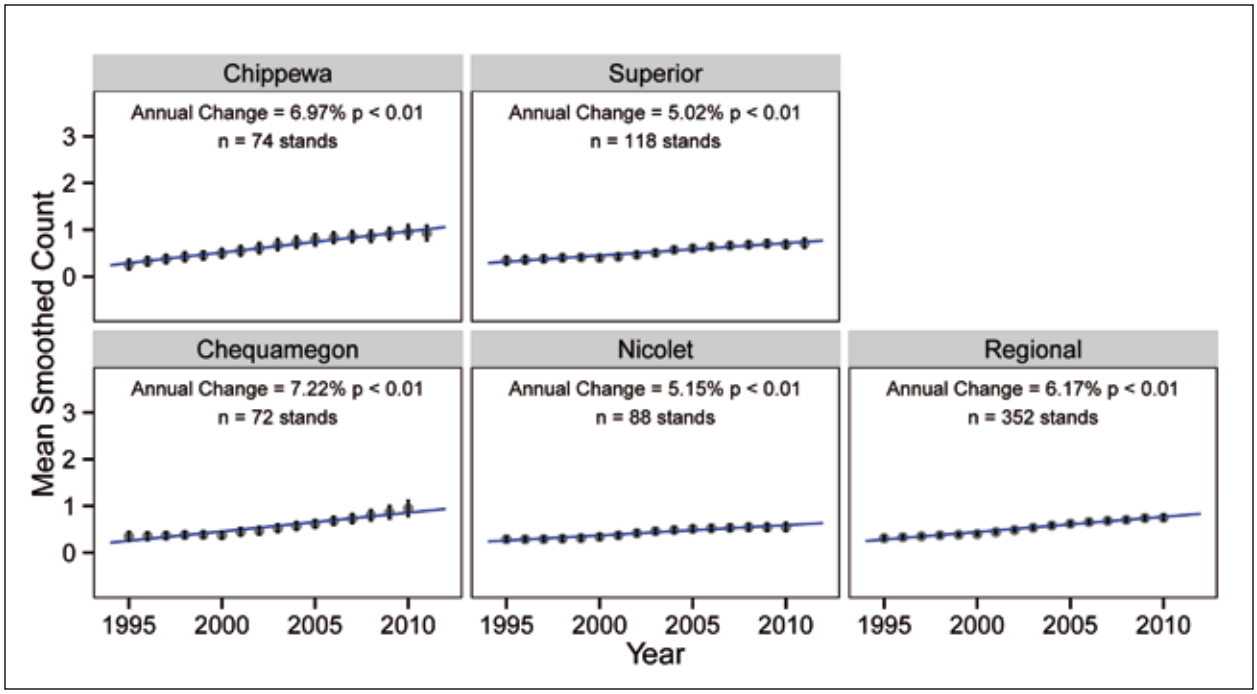
Guild Information

Habitat: Conifer forests

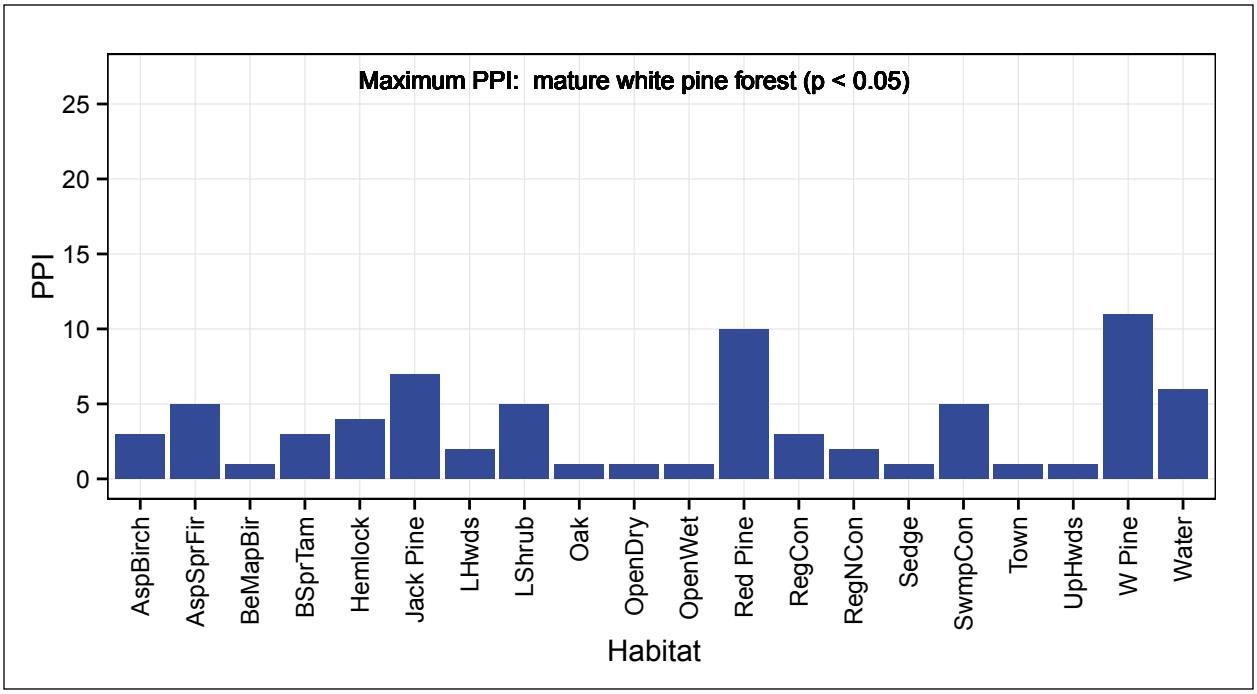
Foraging type: Bark gleaner

Nest site: Cavity

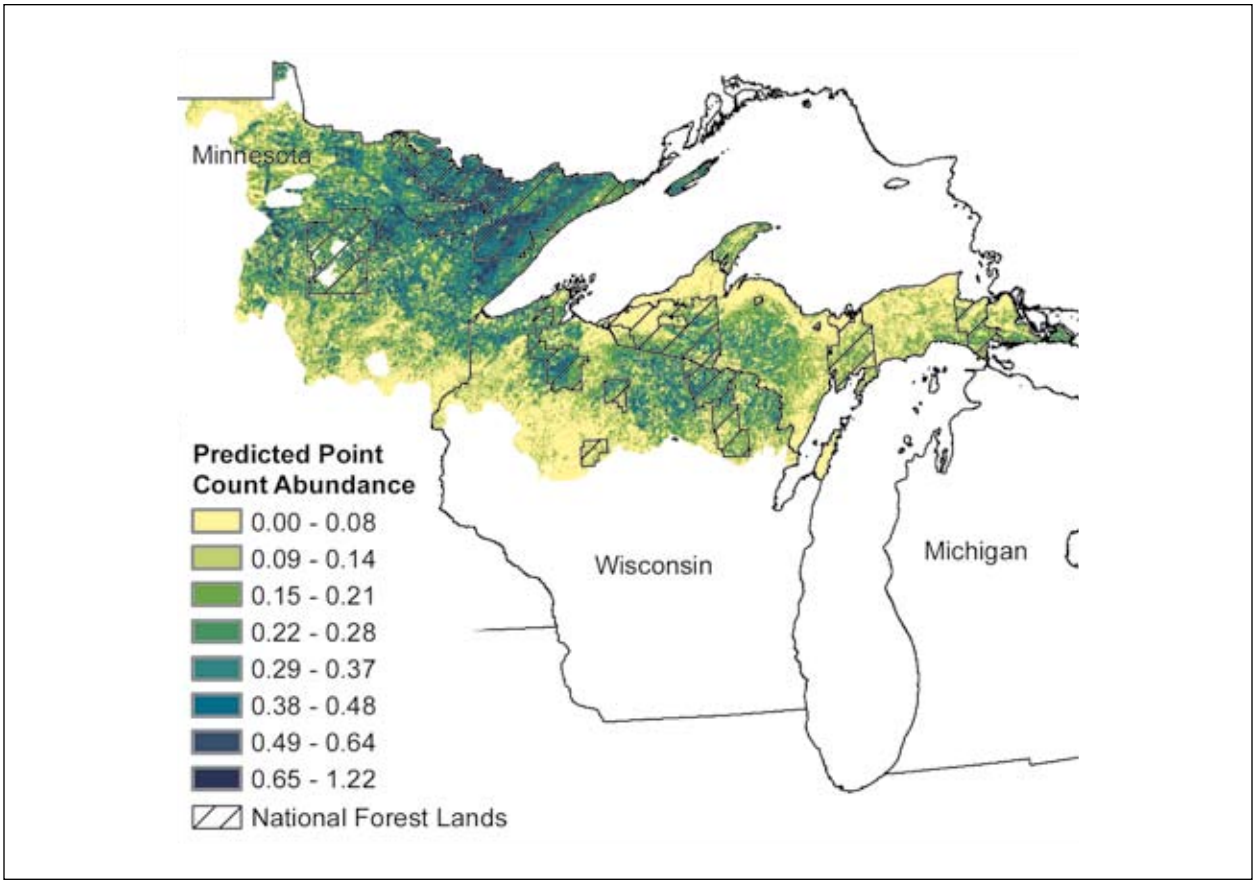
Migration: Permanent resident



Trends for red-breasted nuthatch in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for red-breasted nuthatch where at least one bird was observed once during the decade (2001–2010; n=3,996 at 1,172 points)



Predicted relative abundance (number of birds per 10-minute count) of red-breasted nuthatch for the western Great Lakes region

Red-eyed Vireo REVI

Vireo olivaceus



Photo by Jon Swanson, used with permission.

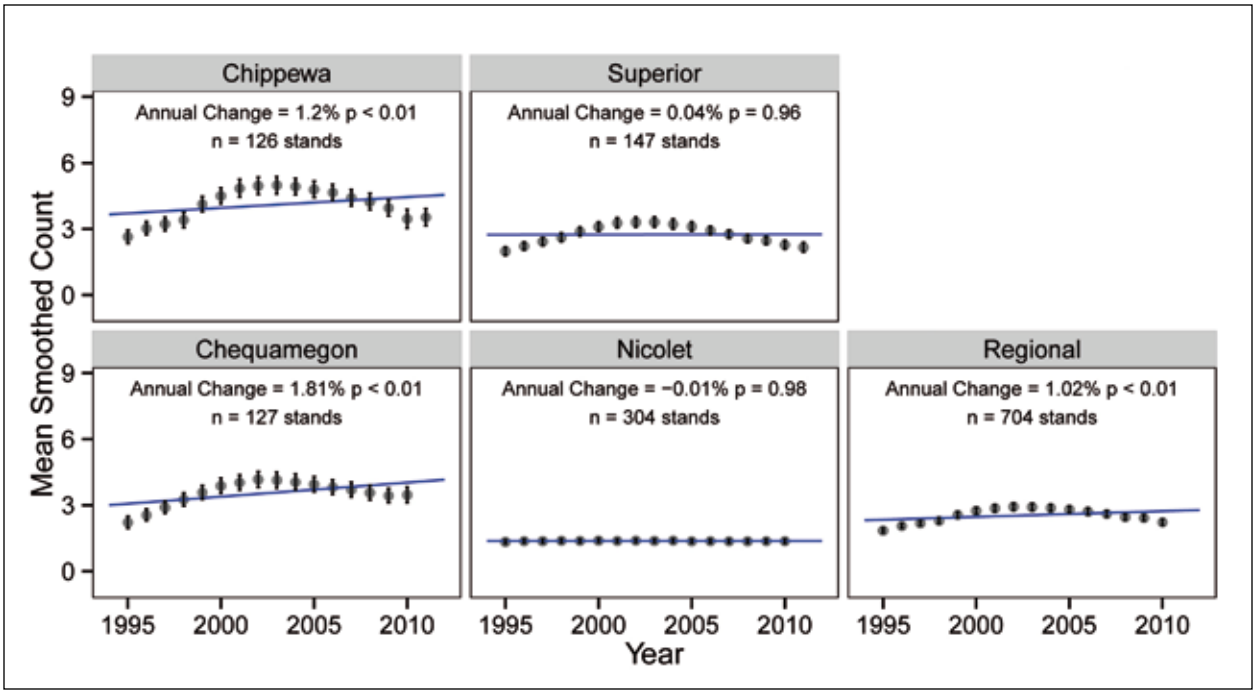
Guild Information

Habitat: All forest types, especially upland

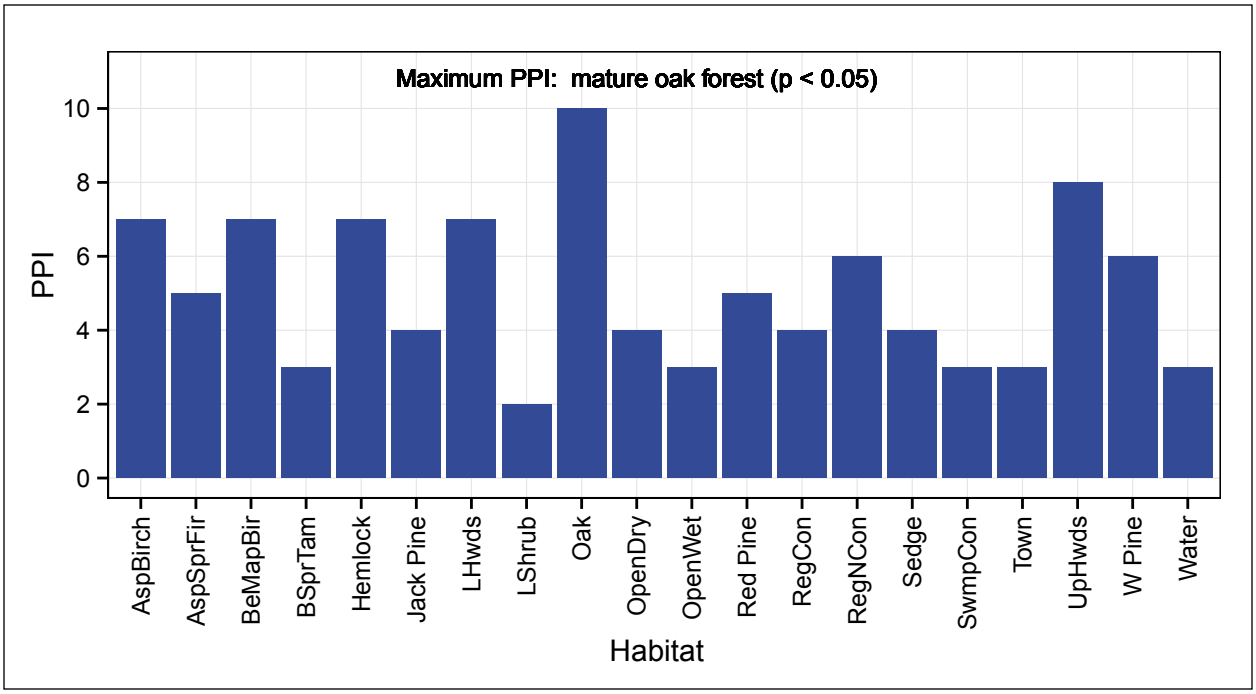
Foraging type: Foliage gleaner

Nest site: Shrub or subcanopy

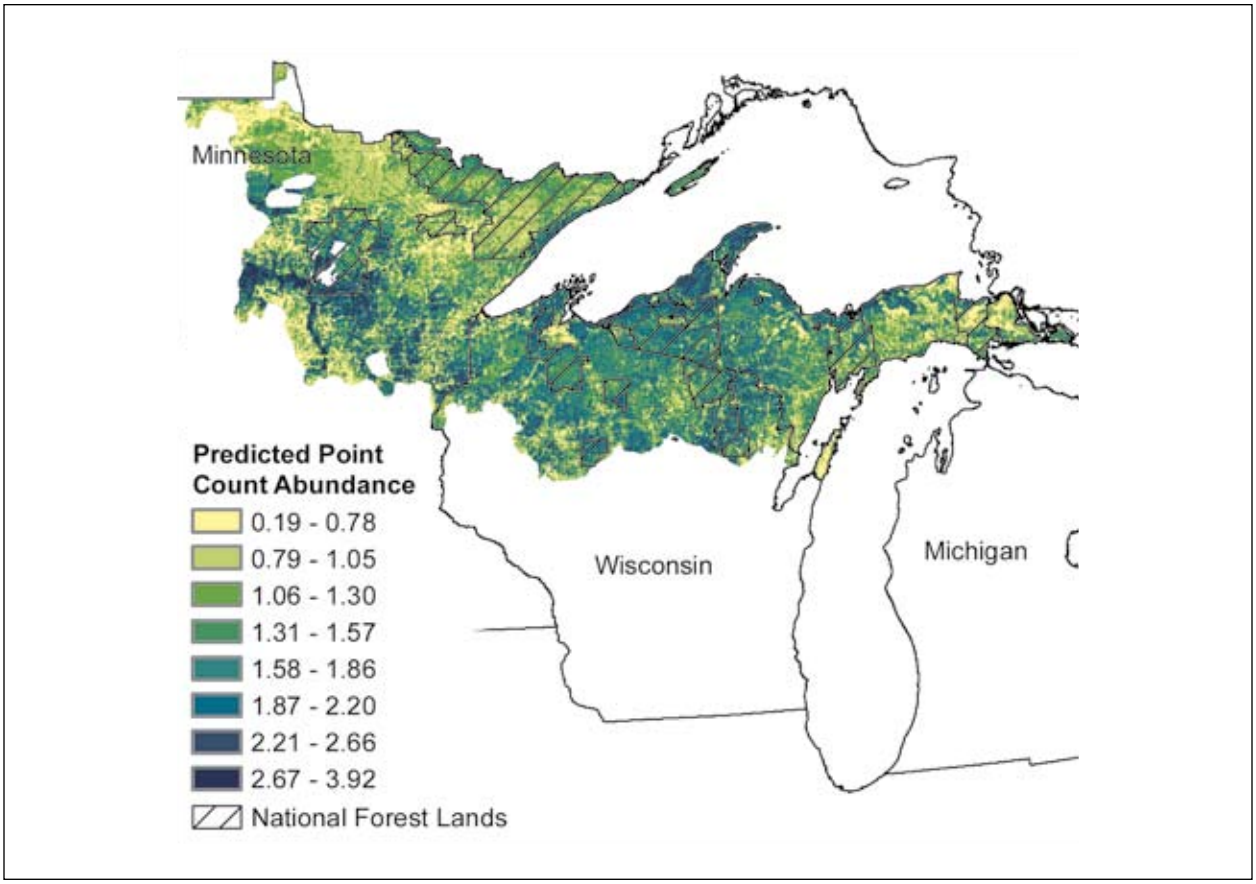
Migration: Long-distance



Trends for red-eyed vireo in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for red-eyed vireo where at least one bird was observed once during the decade (2001–2010; n=30,524 at 1,693 points)



Predicted relative abundance (number of birds per 10-minute count) of red-eyed vireo for the western Great Lakes region

Red-winged Blackbird RWBL

Agelaius phoeniceus



Photo by Larry Sirvio, used with permission.

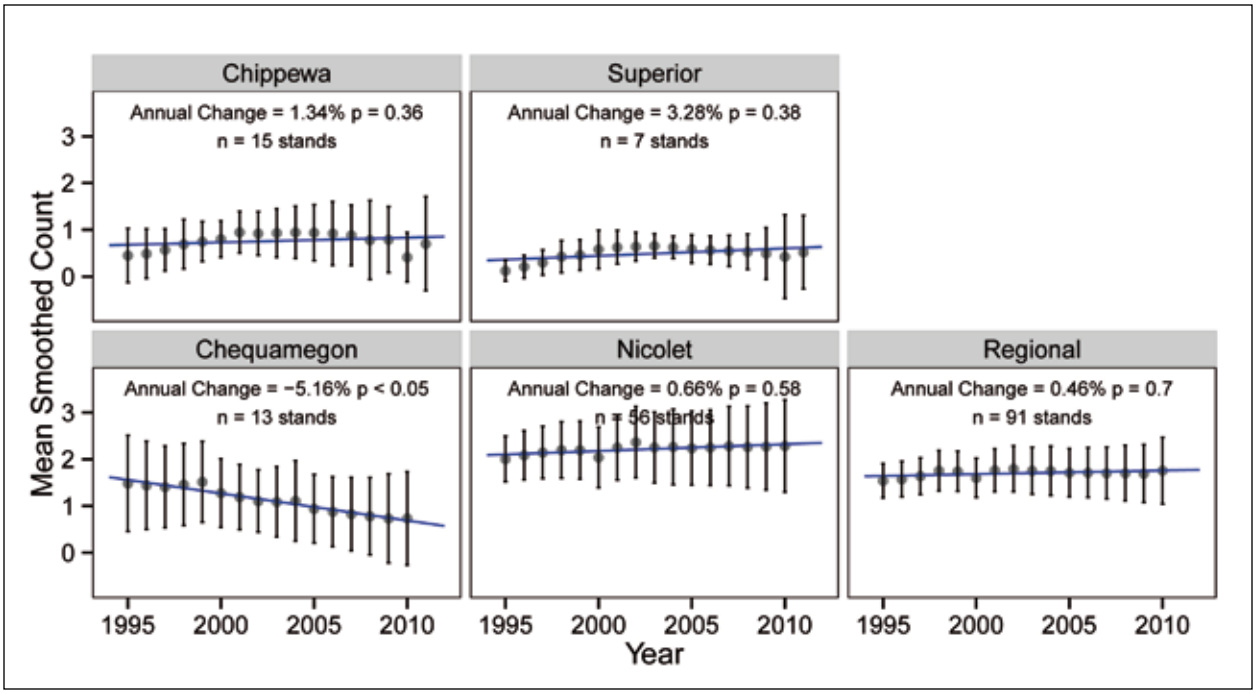
Guild Information

Habitat: Wetlands, shrubby areas

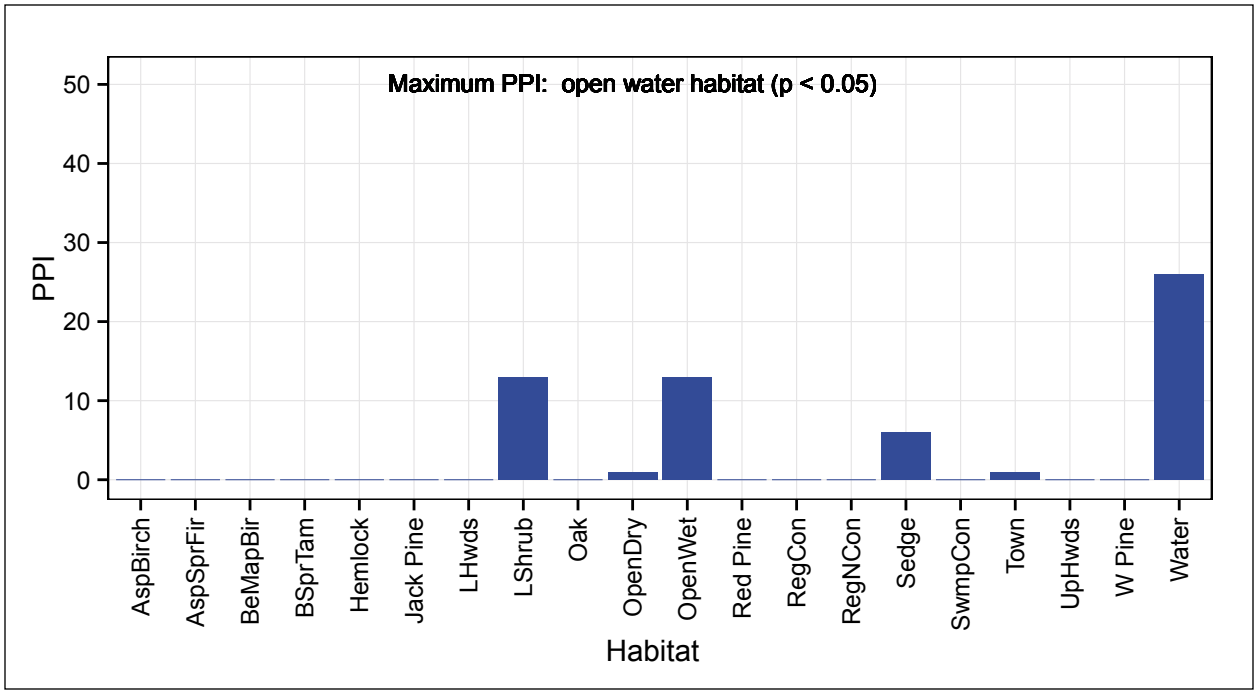
Foraging type: Omnivore

Nest site: Shrub or subcanopy

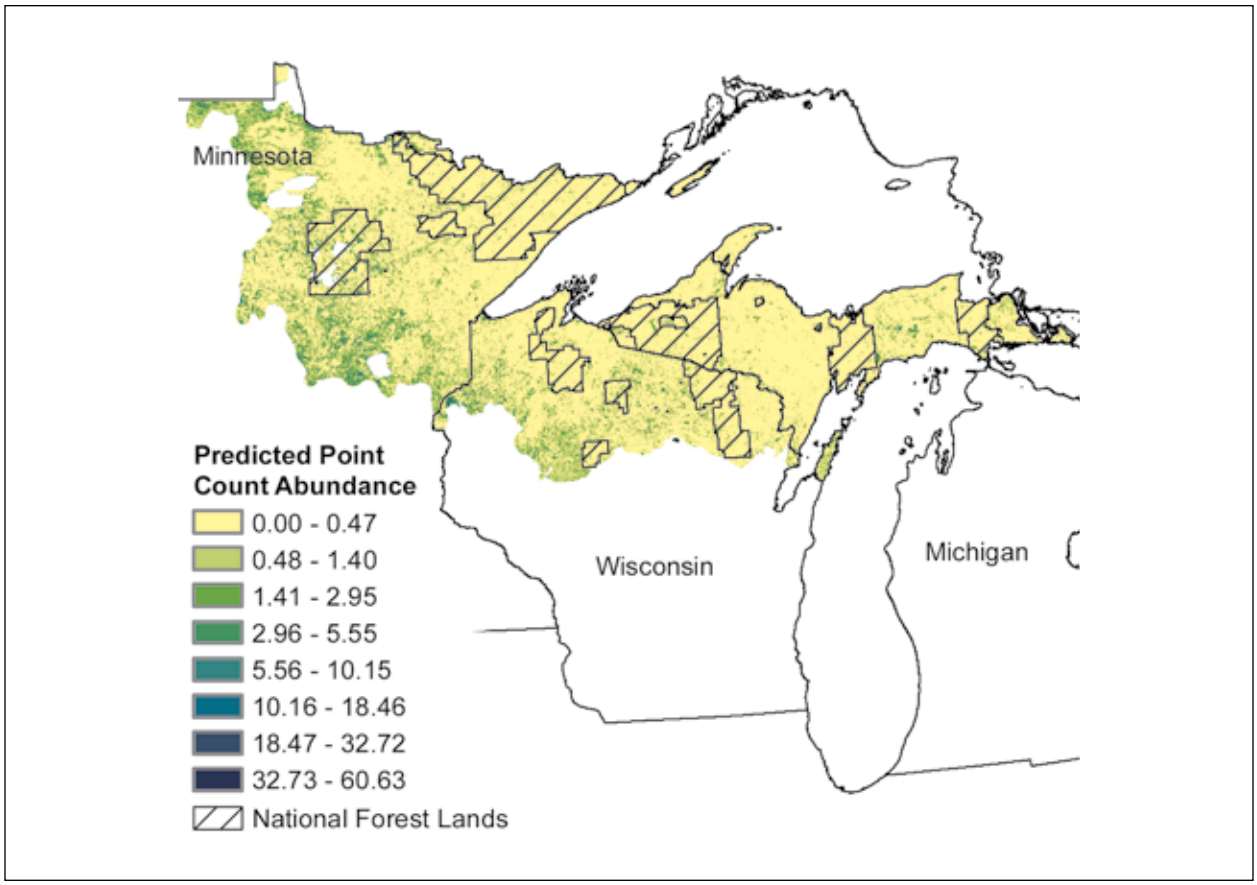
Migration: Short-distance



Trends for red-winged blackbird in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for red-winged blackbird where at least one bird was observed once during the decade (2001–2010; n=1,957 at 277 points)



Predicted relative abundance (number of birds per 10-minute count) of red-winged blackbird for the western Great Lakes region

Rose-breasted Grosbeak RBGR

Pheucticus ludovicianus



Photo by Bruce Lees, used with permission.

Guild Information

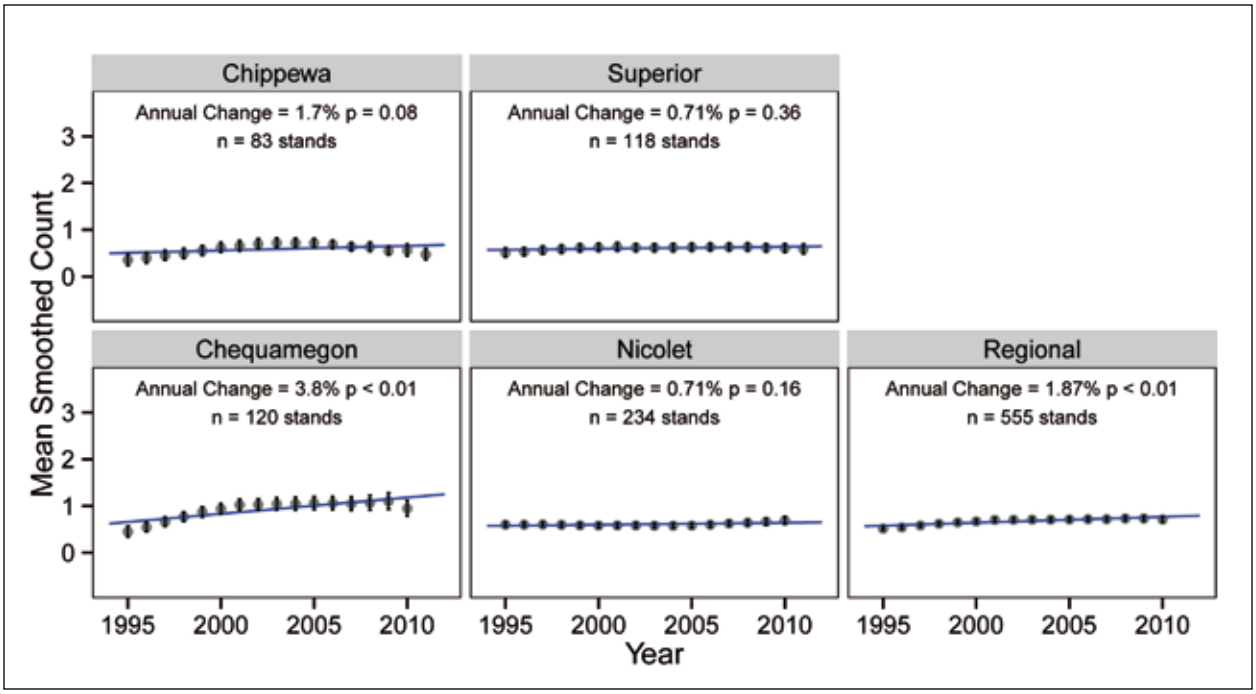
Habitat: Forests, especially young

Foraging type: Omnivore—fruit, invertebrates

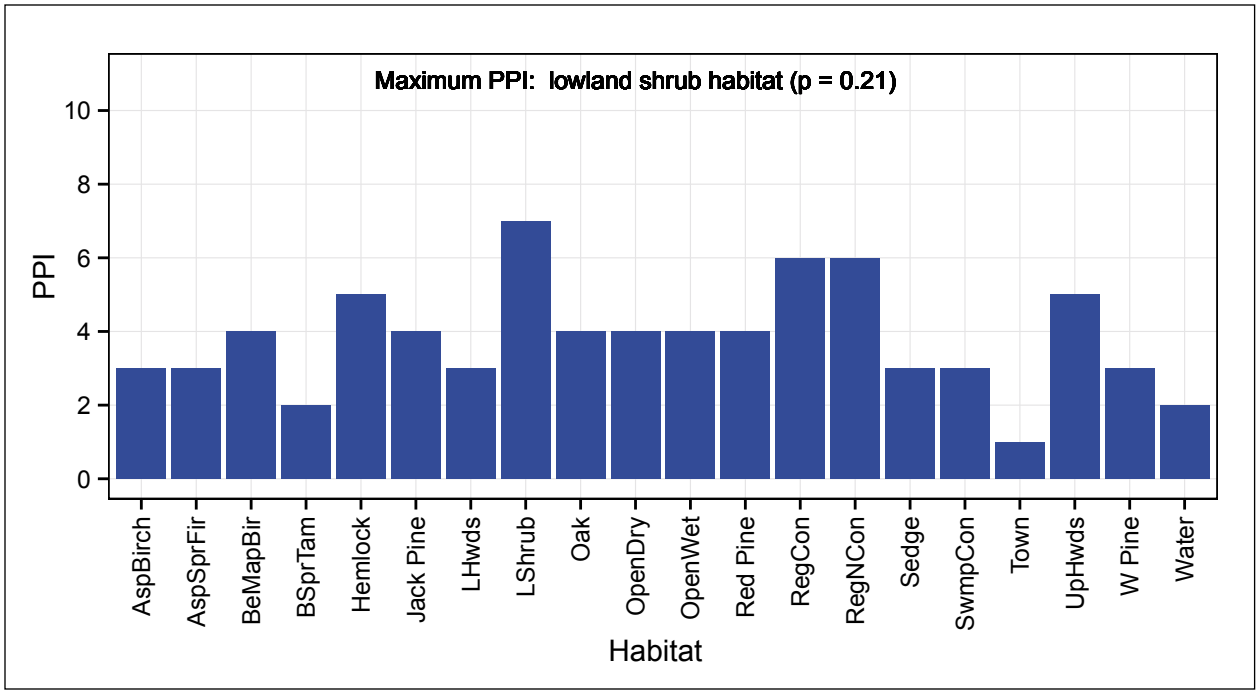
Nest site: Shrub or subcanopy

Migration: Long-distance

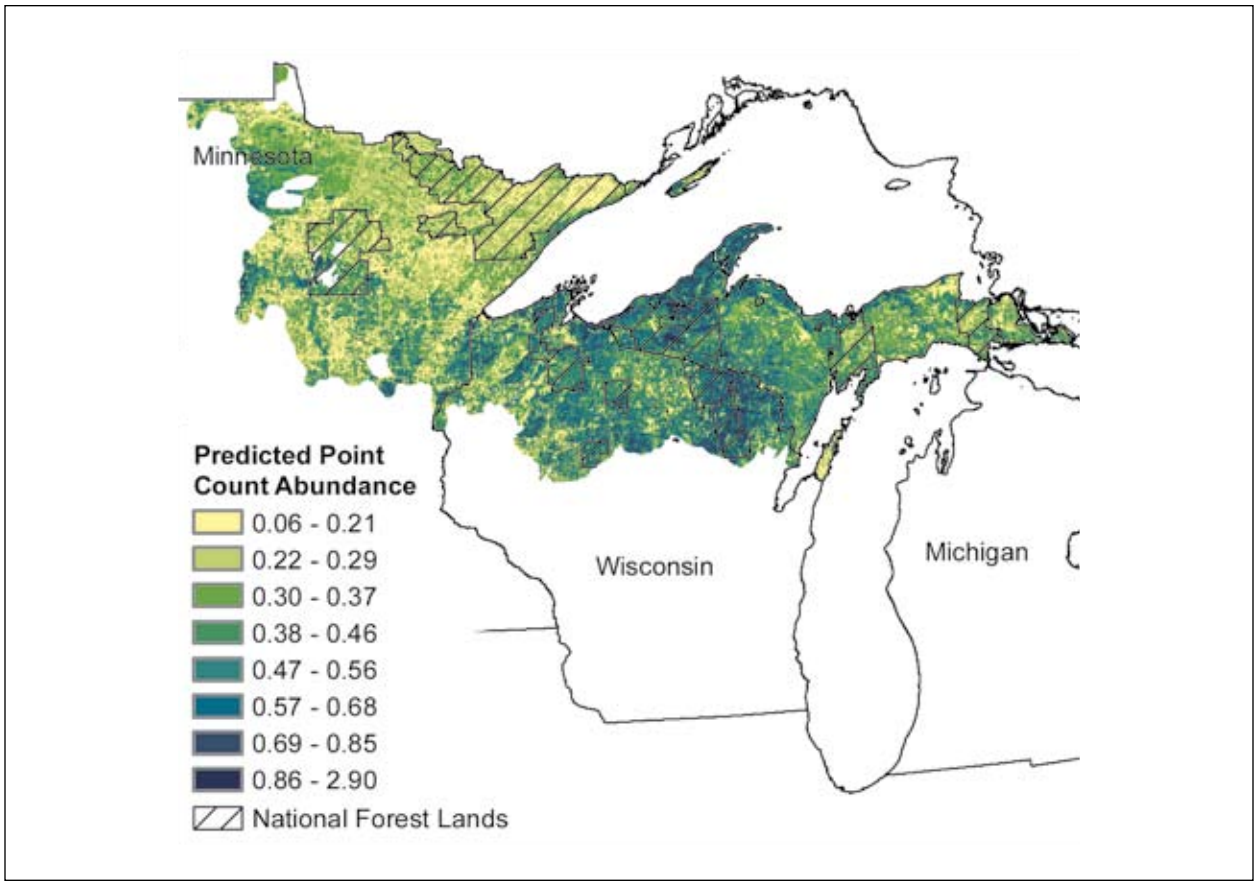
Notes: PPI analysis was not statistically significant for this widespread, conspicuous forest species. Observations in open habitats often were transients or residents of adjacent habitat.



Trends for rose-breasted grosbeak in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for rose-breasted grosbeak where at least one bird was observed once during the decade (2001–2010; n=6,155 at 1,369 points)



Predicted relative abundance (number of birds per 10-minute count) of rose-breasted grosbeak for the western Great Lakes region

Ruby-crowned Kinglet RCKI

Regulus calendula



Photo by Jon Swanson, used with permission.

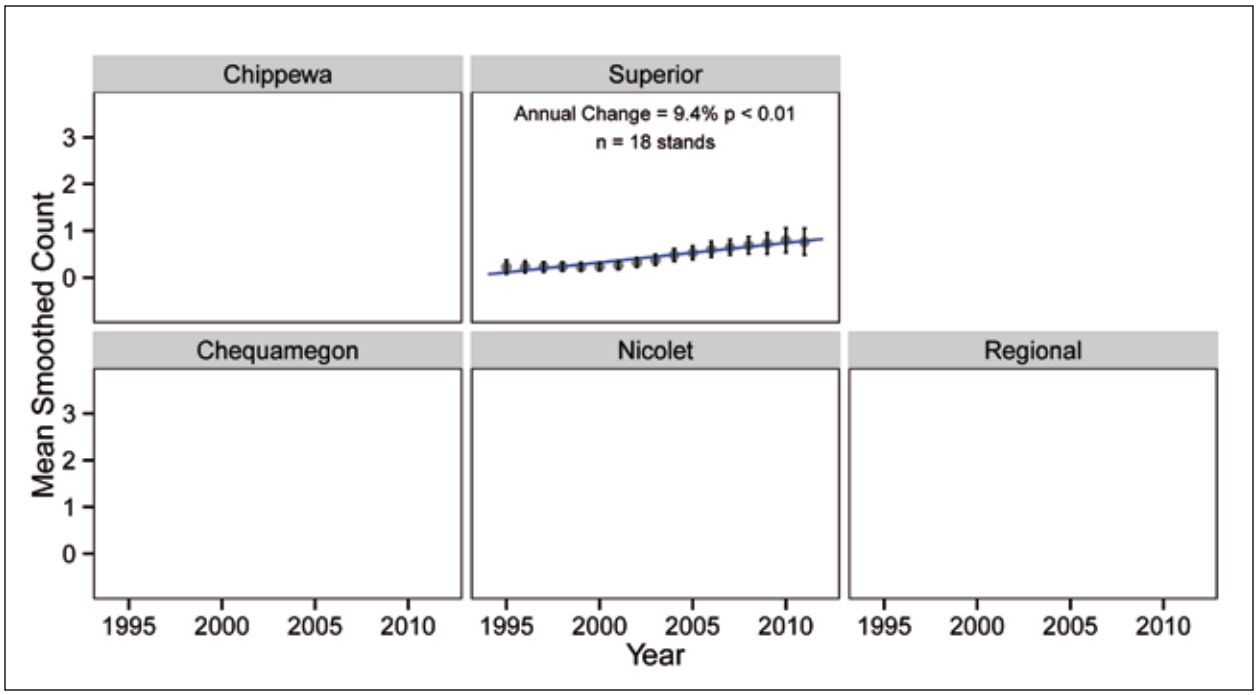
Guild Information

Habitat: Black spruce-tamarack forests, jack pine forests

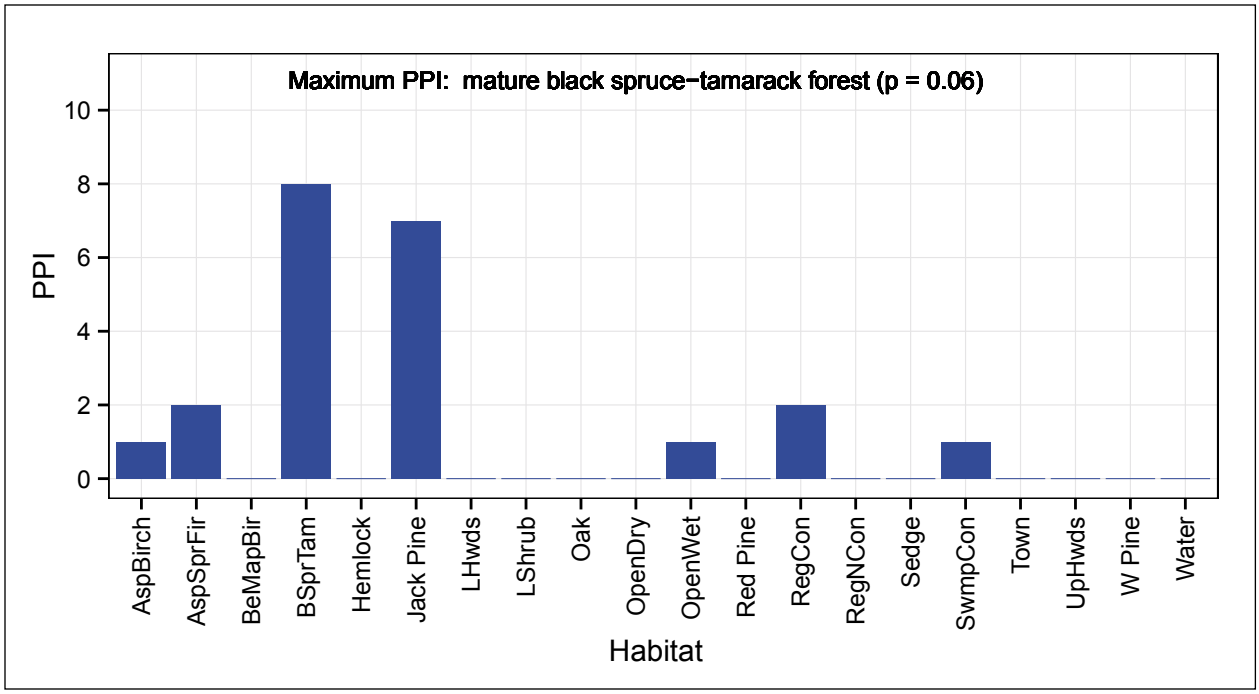
Foraging type: Foliage gleaner

Nest site: Canopy

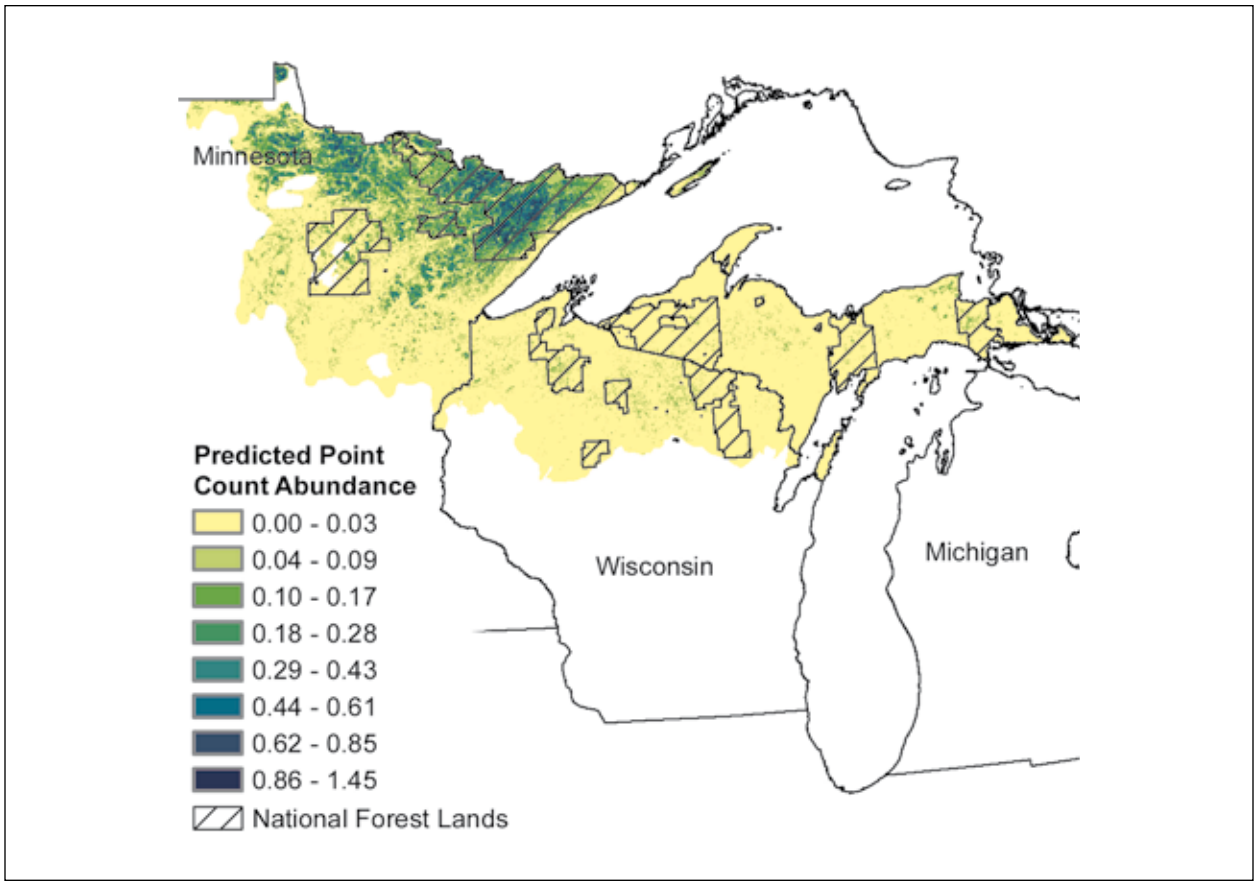
Migration: Short-distance



Trend for ruby-crowned kinglet in one national forest, 1995–2010



Percent perfect indication of habitat association for ruby-crowned kinglet where at least one bird was observed once during the decade (2001–2010; n=358 at 181 points)



Predicted relative abundance (number of birds per 10-minute count) of ruby-crowned kinglet for the western Great Lakes region

Ruby-throated Hummingbird RTHU

Archilochus colubris



Photo by Bruce Lees, used with permission.

Guild Information

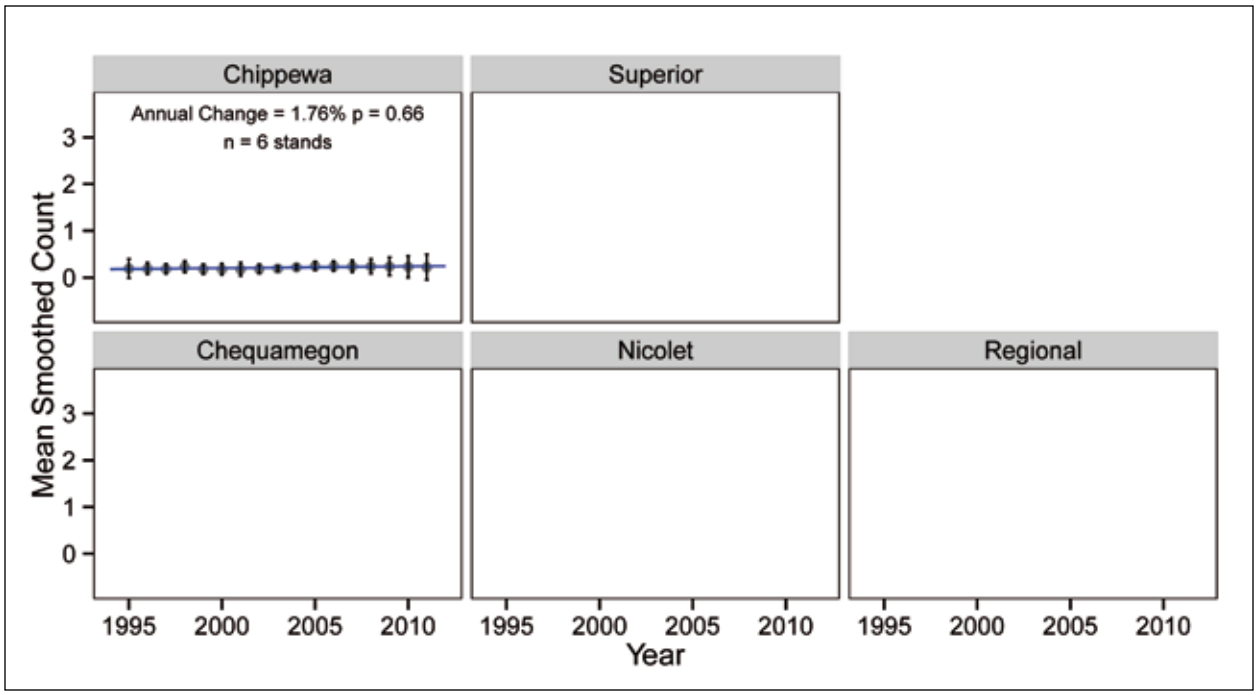
Habitat: Wide variety of habitats, including towns

Foraging type: Hover and glean—nectar, sap

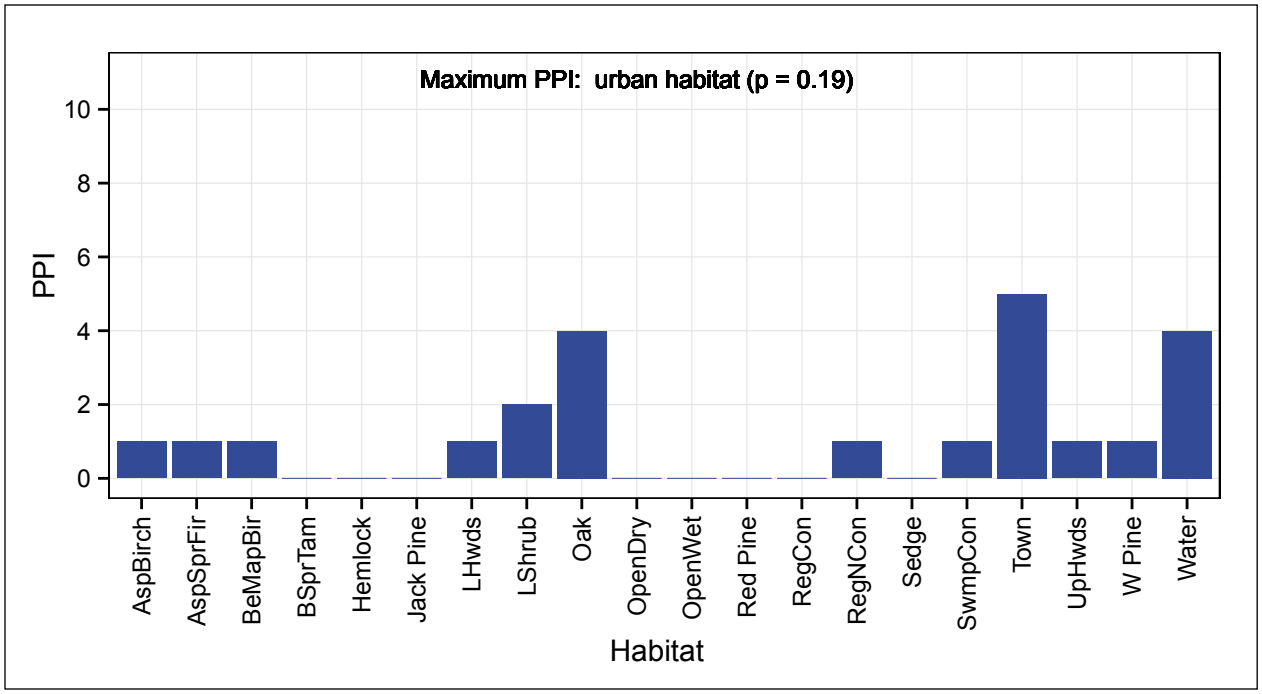
Nest site: Canopy

Migration: Long-distance

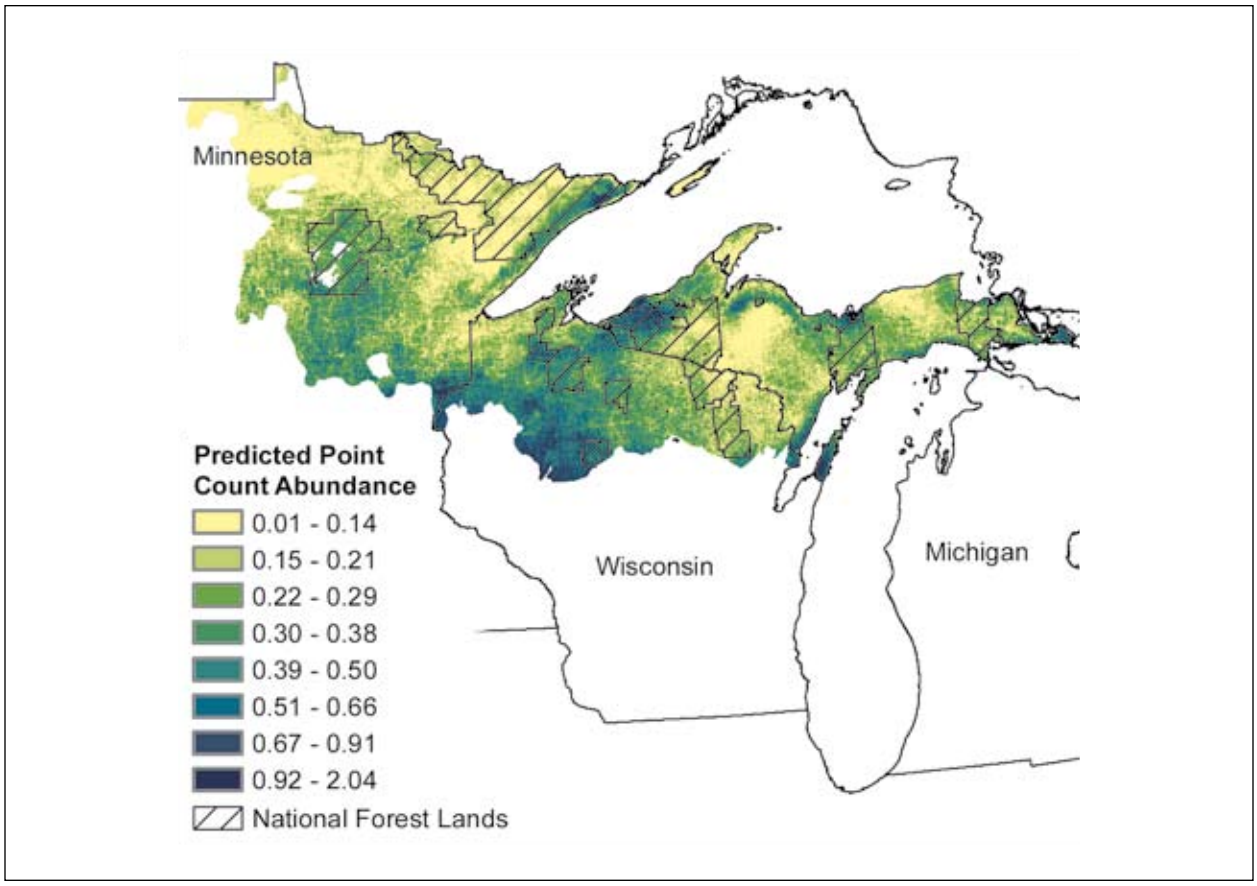
Notes: PPI analysis was not statistically significant for this widespread and wide-ranging species. Distribution is influenced by presence of feeders at towns and rural homes.



Trend for ruby-throated hummingbird in one national forest, 1995–2010



Percent perfect indication of habitat association for ruby-throated hummingbird where at least one bird was observed once during the decade (2001–2010; n=447 at 288 points)



Predicted relative abundance (number of birds per 10-minute count) of ruby-throated hummingbird for the western Great Lakes region

Ruffed Grouse RUGR

Bonasa umbellus



Photo by John Anderson, used with permission.

Guild Information

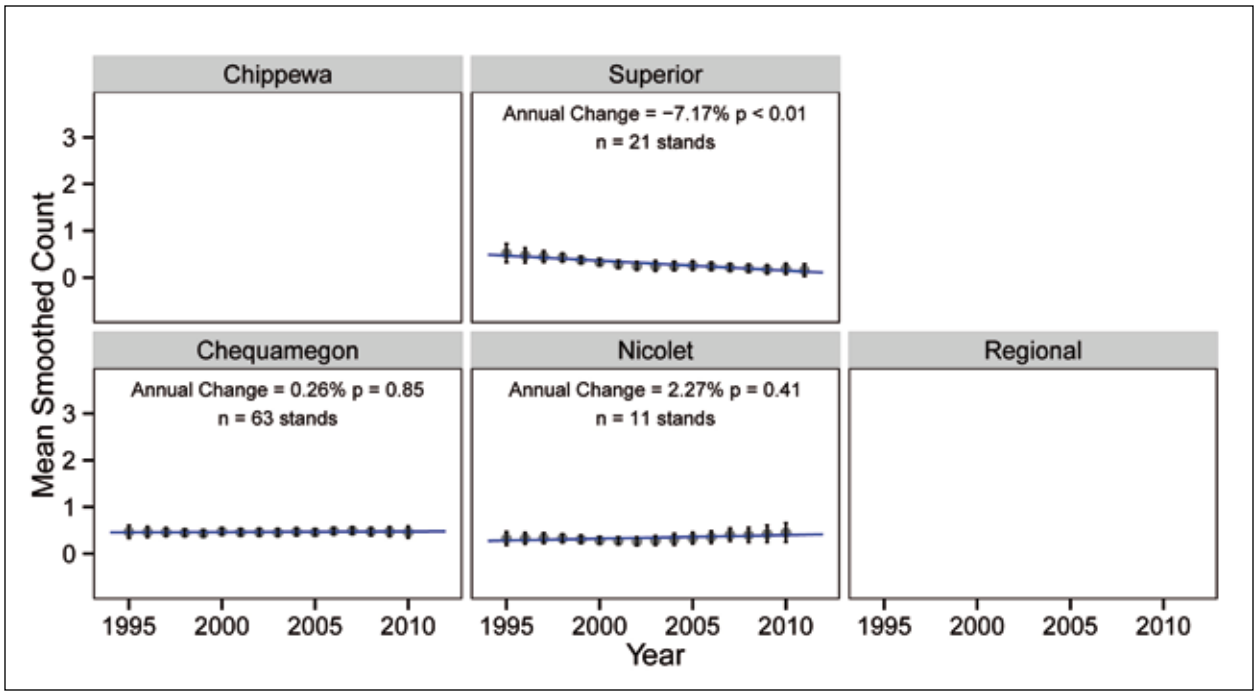
Habitat: Lowland forests, aspen forests, forest edges

Foraging type: Omnivore

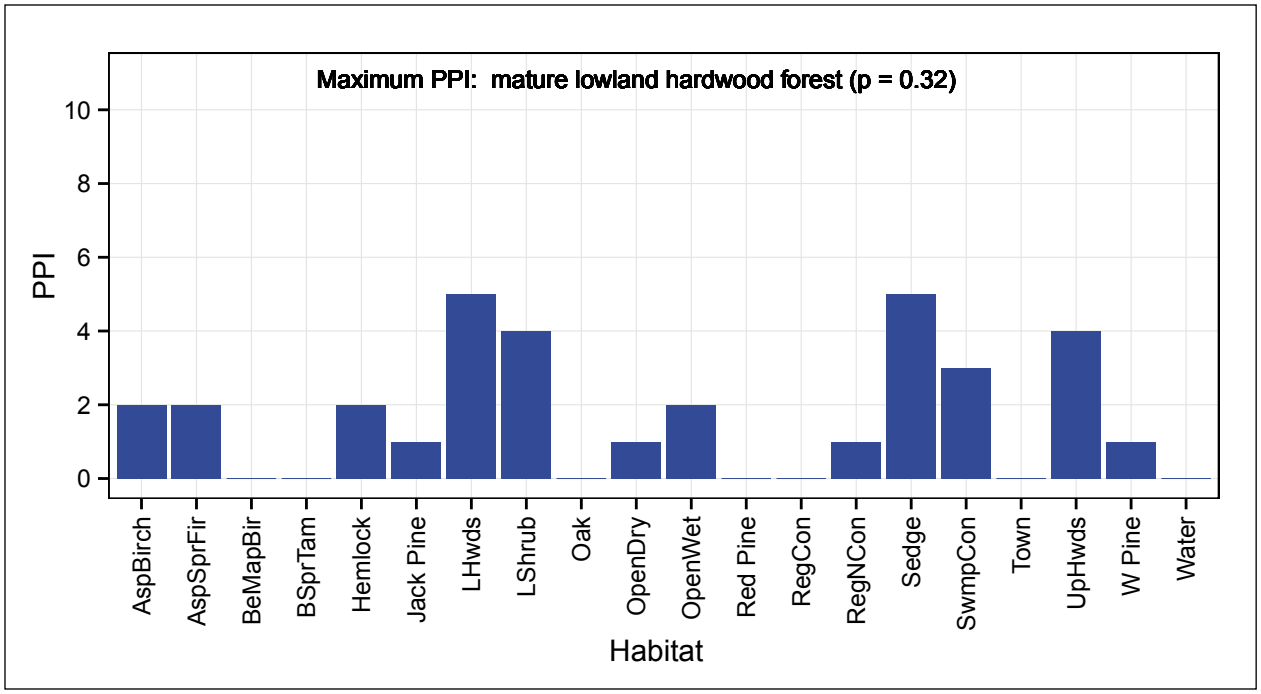
Nest site: Ground

Migration: Permanent resident

Notes: PPI analysis was not statistically significant for this species. Courtship "drumming" could be heard from a great distance, so records at many points represent birds from nearby habitats. PPI value for Sedge reflects the small number of sample points for that habitat (RUGR was observed at 4 of the 7 Sedge points).



Trends for ruffed grouse in three national forests, 1995–2010



Percent perfect indication of habitat association for ruffed grouse where at least one bird was observed once during the decade (2001–2010; n=1,128 at 486 points)

Sandhill Crane SACR

Grus canadensis



Photo by Bruce Lees, used with permission.

Guild Information

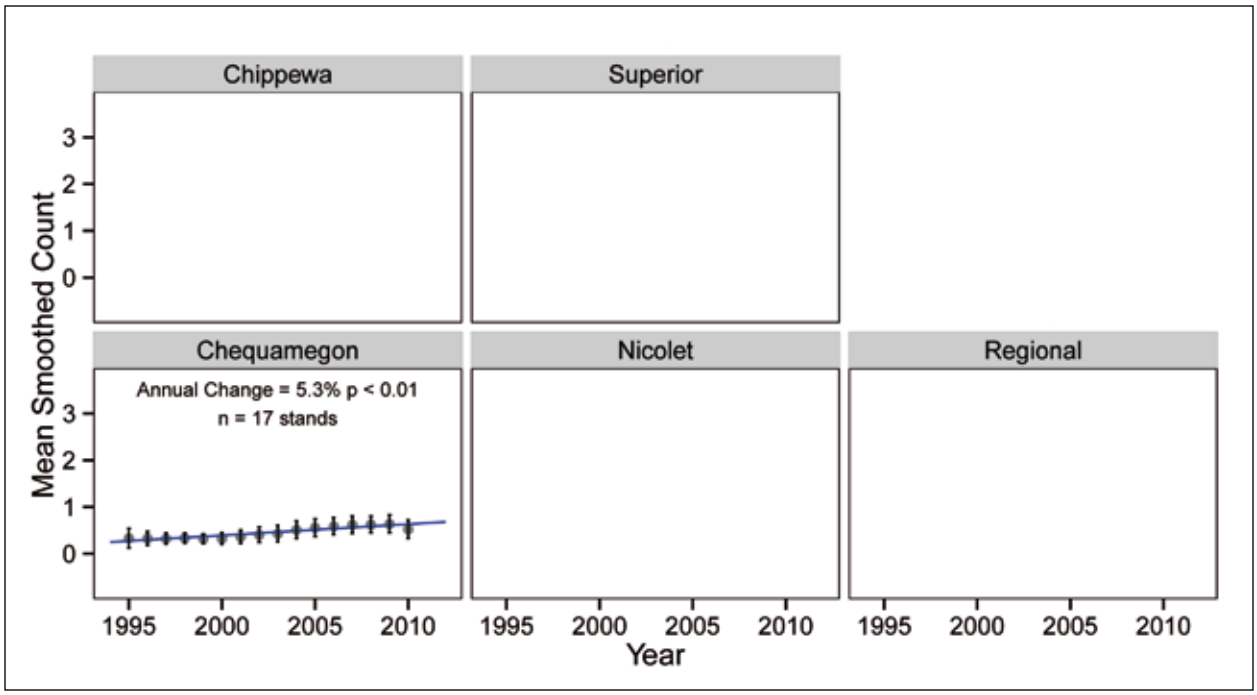
Habitat: Large open wetlands, especially sedge meadows

Foraging type: Omnivore

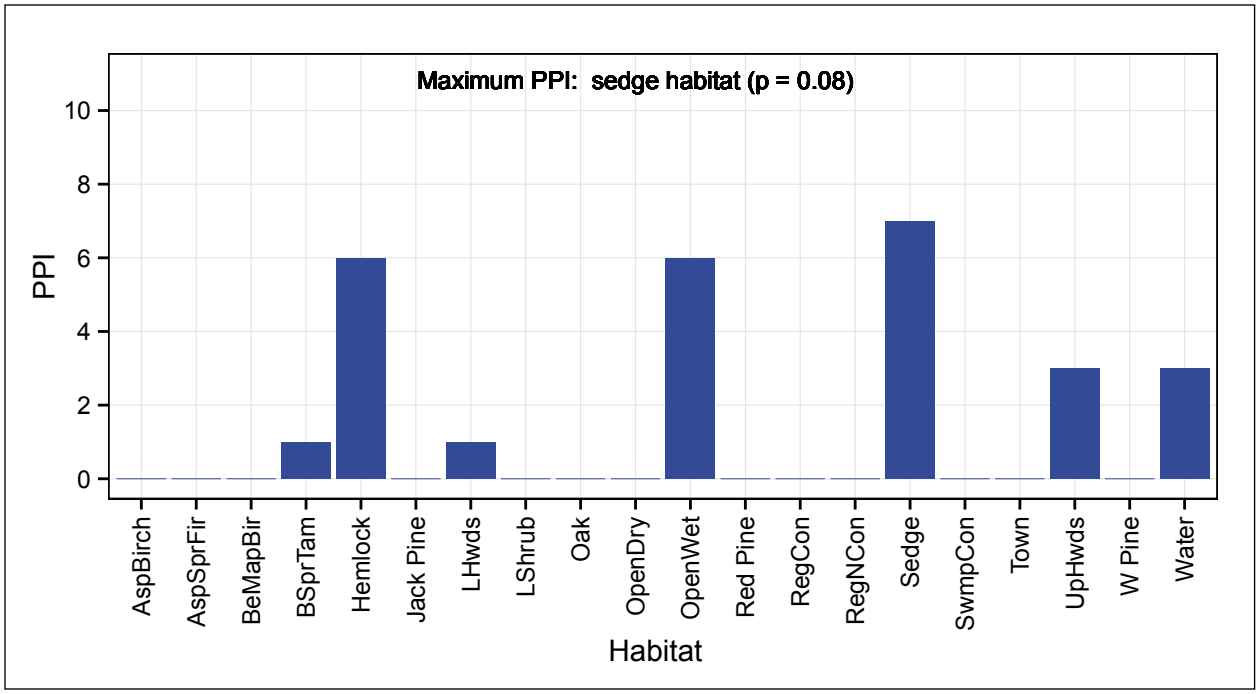
Nest site: Ground

Migration: Short-distance

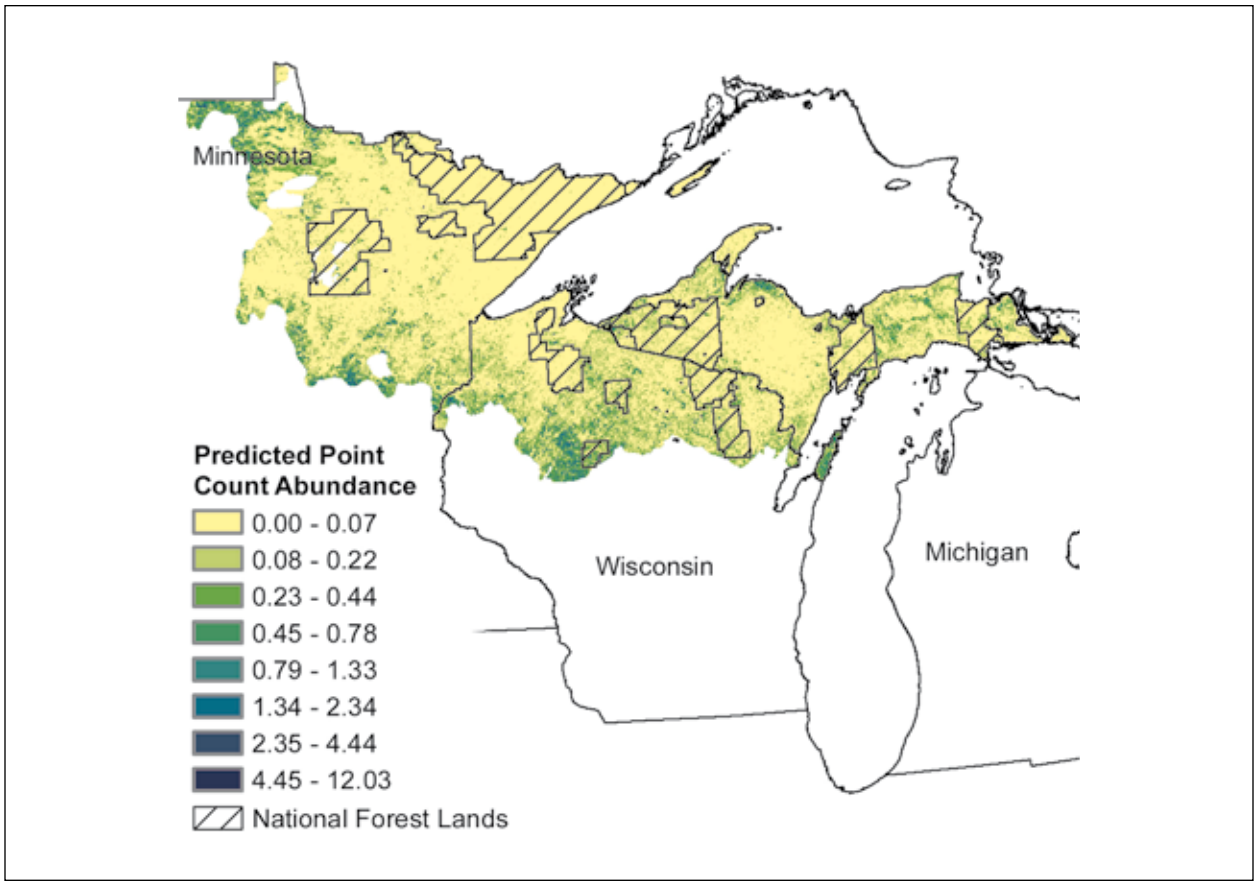
Notes: PPI analysis was marginally significant for this increasing species, whose vocalizations can be heard from a great distance. Individuals recorded at forest and other upland points were transients (flyovers) or birds heard from nearby open habitats.



Trend for sandhill crane in one national forest, 1995–2010



Percent perfect indication of habitat association for sandhill crane where at least one bird was observed once during the decade (2001–2010; n=416 at 163 points)



Predicted relative abundance (number of birds per 10-minute count) of sandhill crane for the western Great Lakes region

Scarlet Tanager SCTA

Piranga olivacea



Photo by Bruce Lees, used with permission.

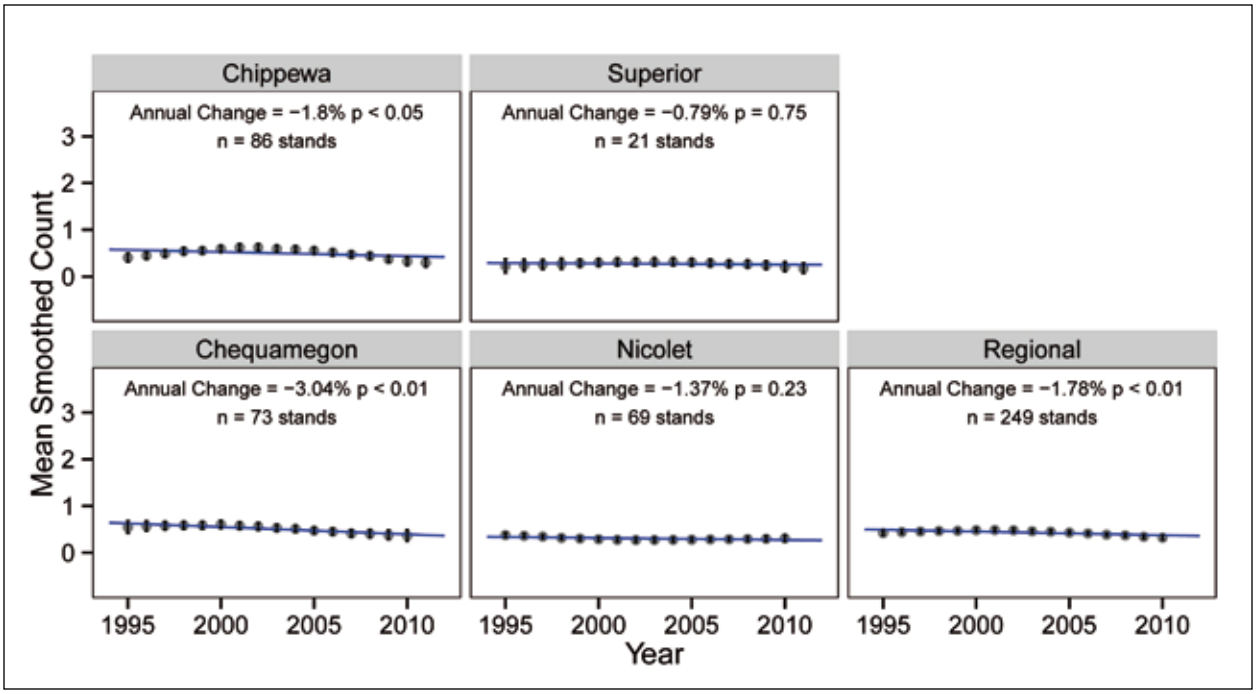
Guild Information

Habitat: Forests, especially oak and beech-maple-birch

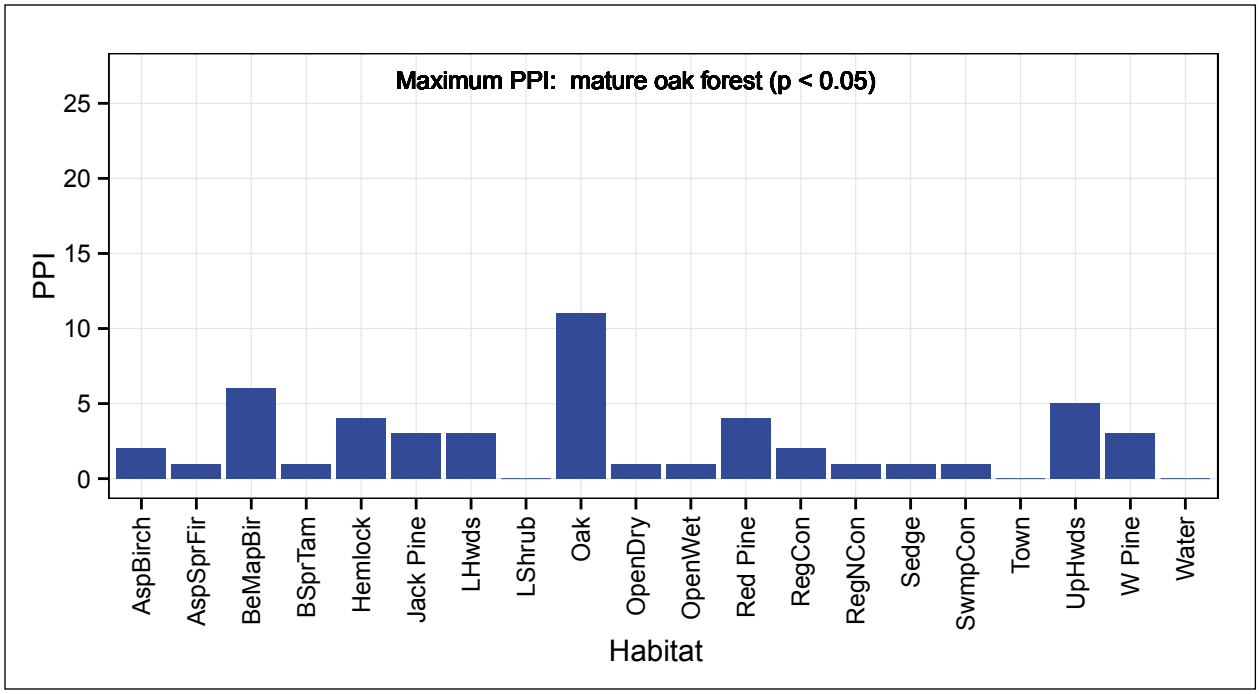
Foraging type: Omnivore—fruit, insects

Nest site: Canopy

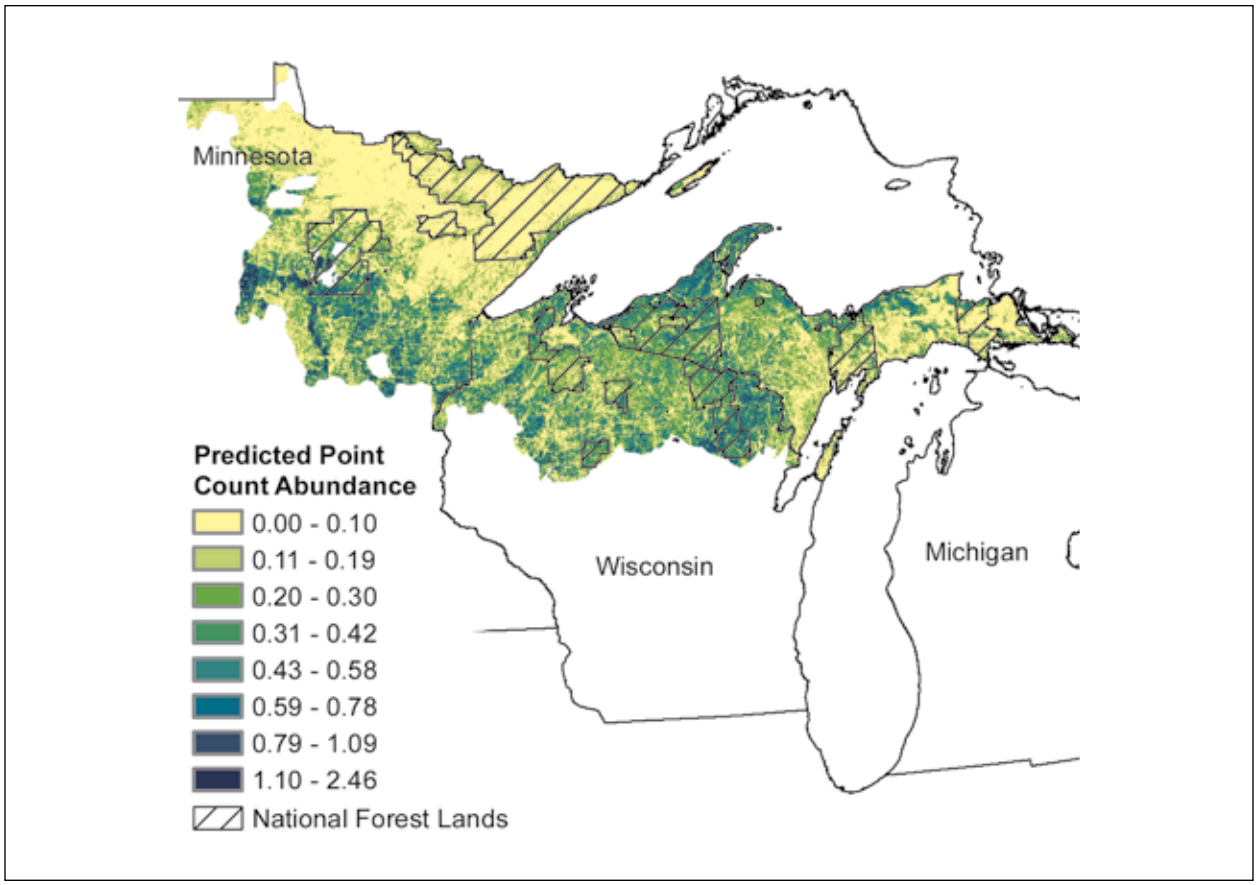
Migration: Long-distance



Trends for scarlet tanager in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for scarlet tanager where at least one bird was observed once during the decade (2001–2010; n=2,032 at 774 points)



Predicted relative abundance (number of birds per 10-minute count) of scarlet tanager for the western Great Lakes region

Sedge Wren SEWR

Cistothorus platensis



Photo by Jon Swanson, used with permission.

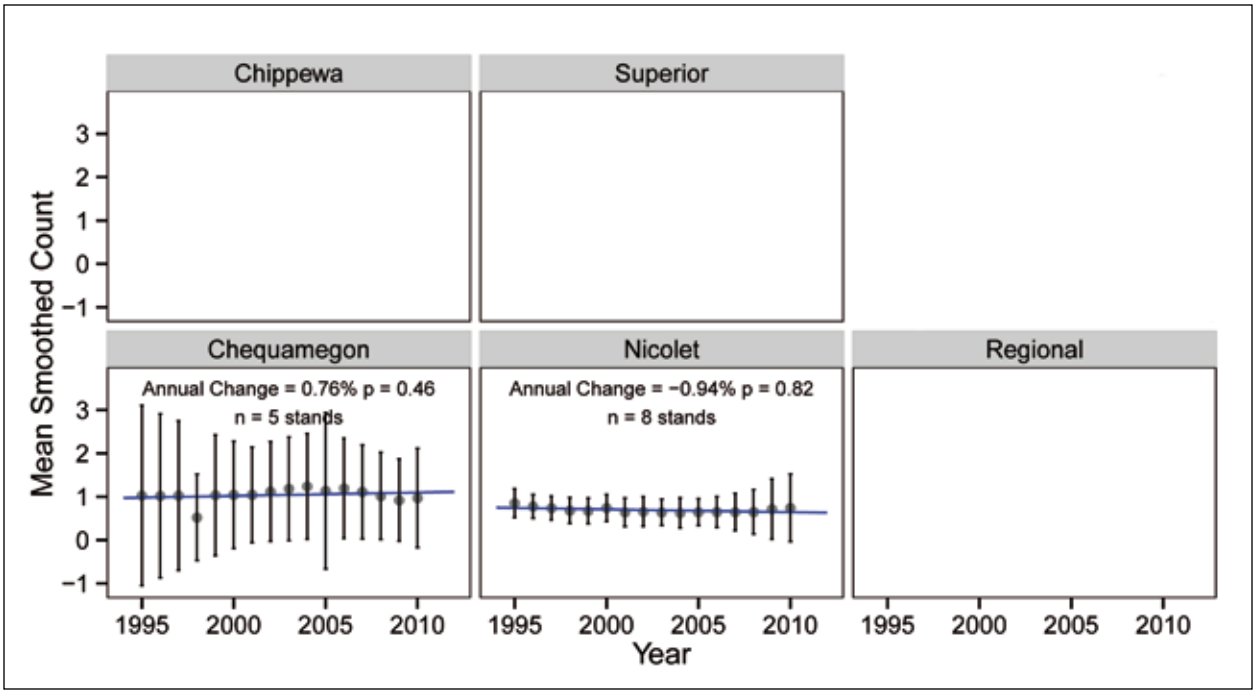
Guild Information

Habitat: Sedge meadows, low shrubs

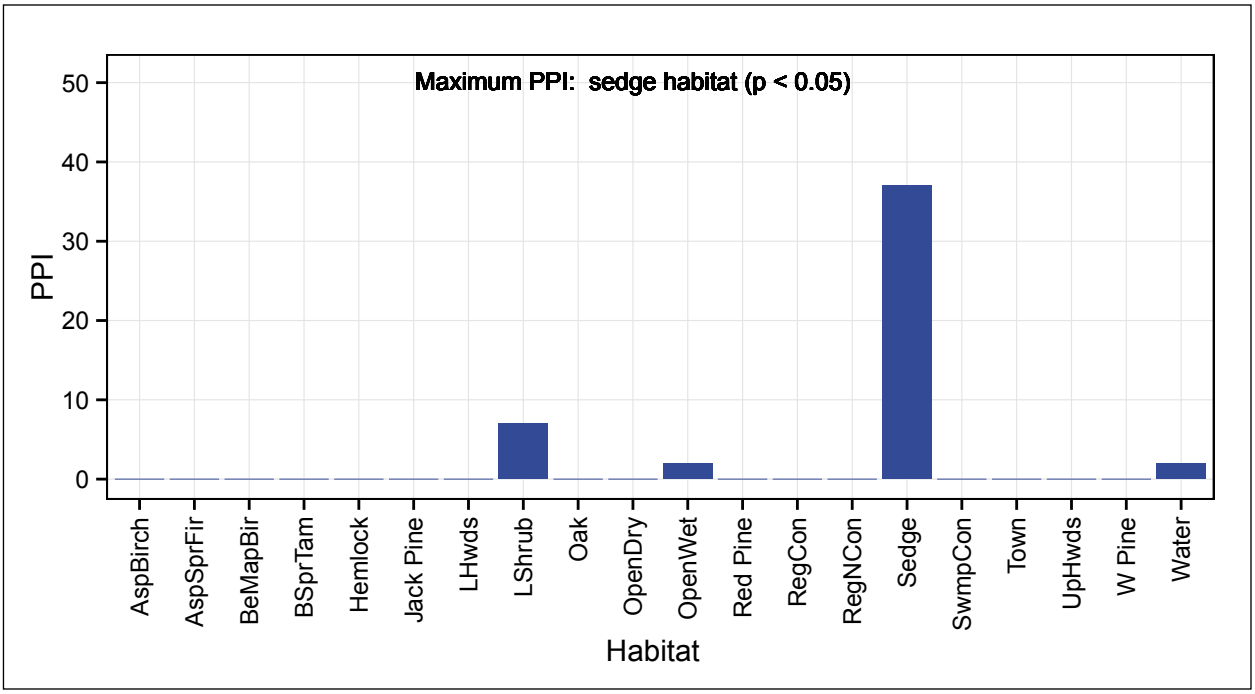
Foraging type: Foliage gleaner

Nest site: Shrub or subcanopy

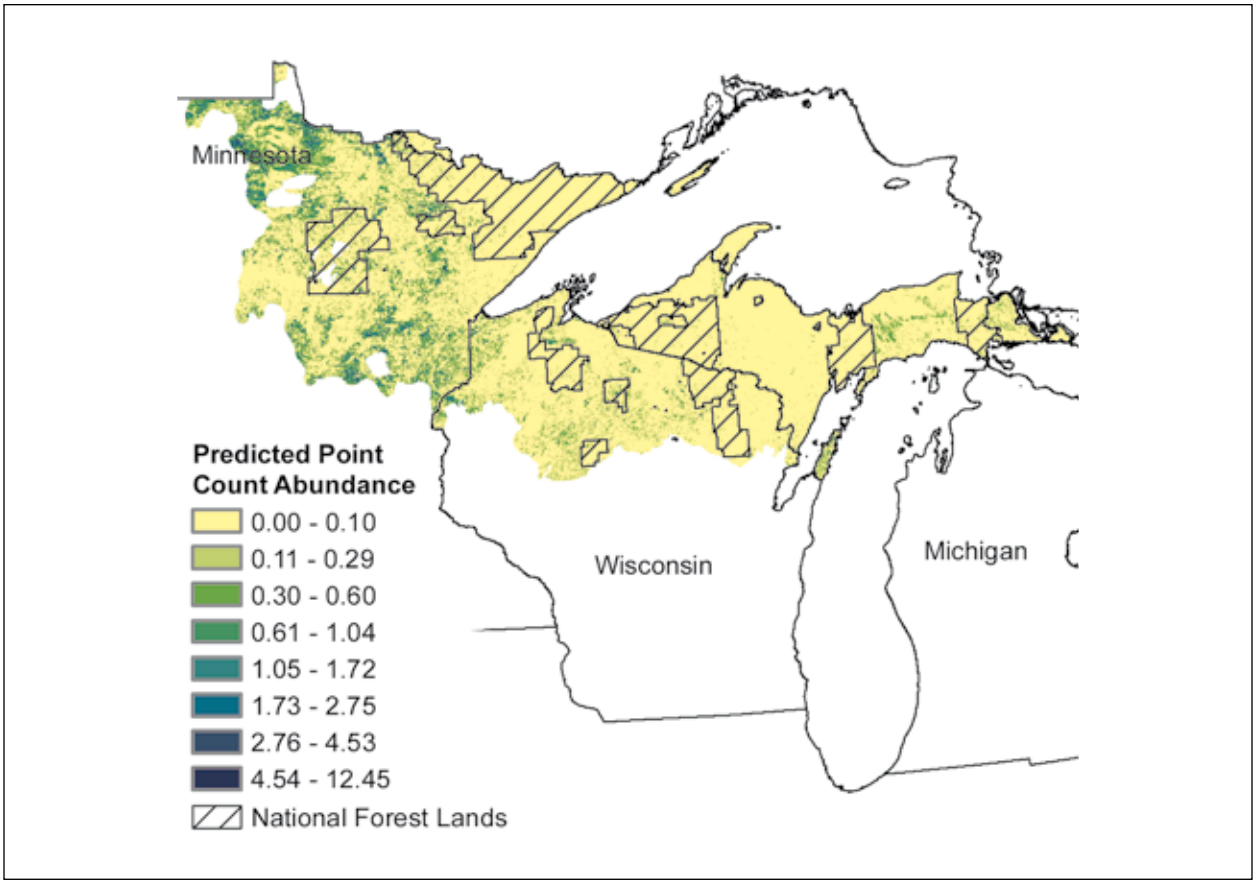
Migration: Short-distance



Trends for sedge wren in two national forests, 1995–2010



Percent perfect indication of habitat association for sedge wren where at least one bird was observed once during the decade (2001–2010; n=257 at 83 points)



Predicted relative abundance (number of birds per 10-minute count) of sedge wren for the western Great Lakes region

Song Sparrow SOSP
Melospiza melodia



Photo by Art Overcott, used with permission.

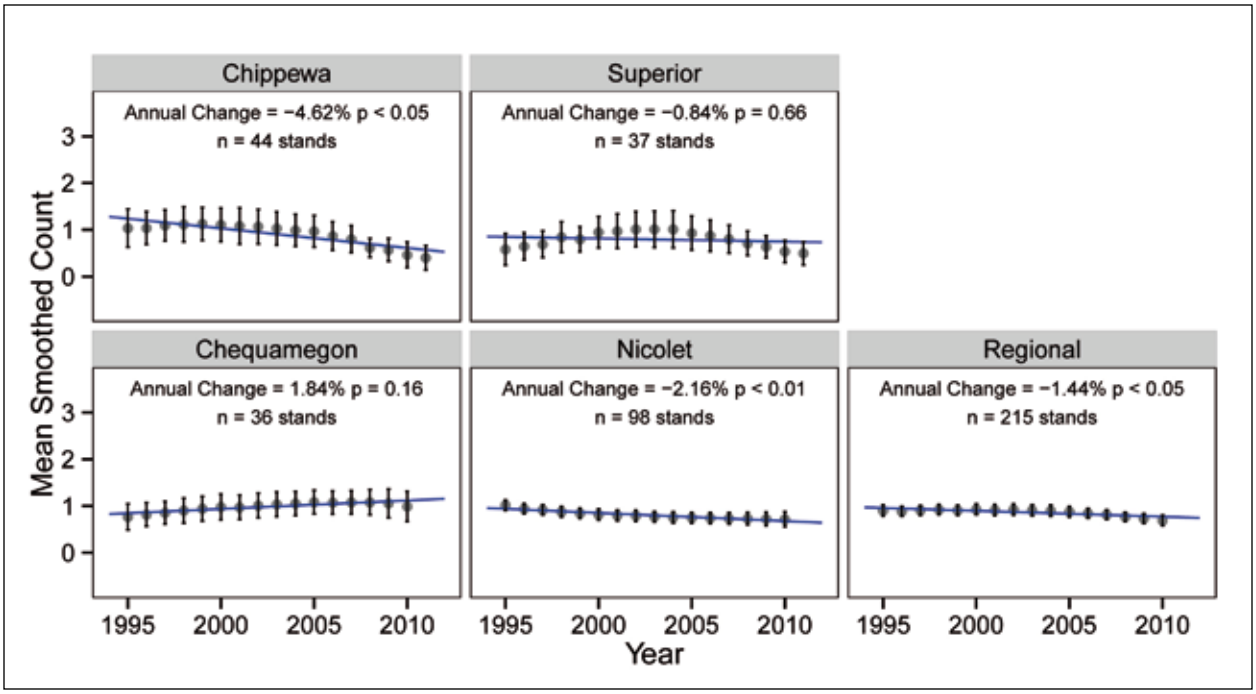
Guild Information

Habitat: Shrub and grassy edges, human settlements

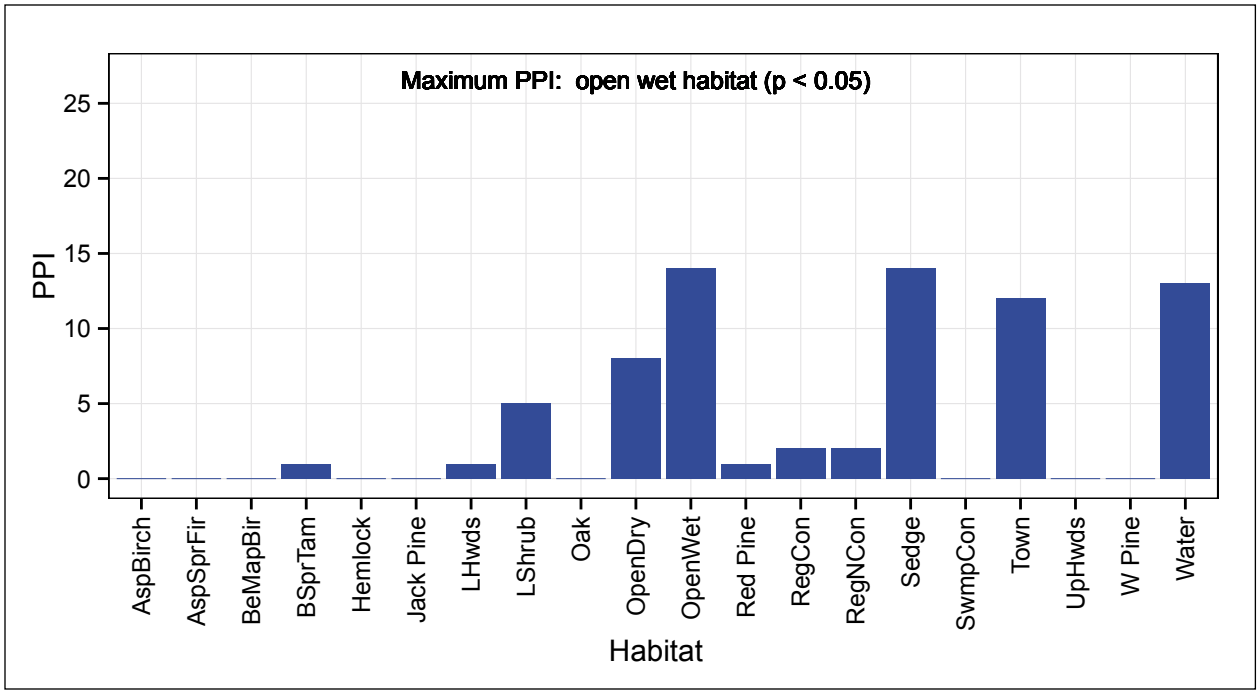
Foraging type: Omnivore—seeds, invertebrates

Nest site: Ground

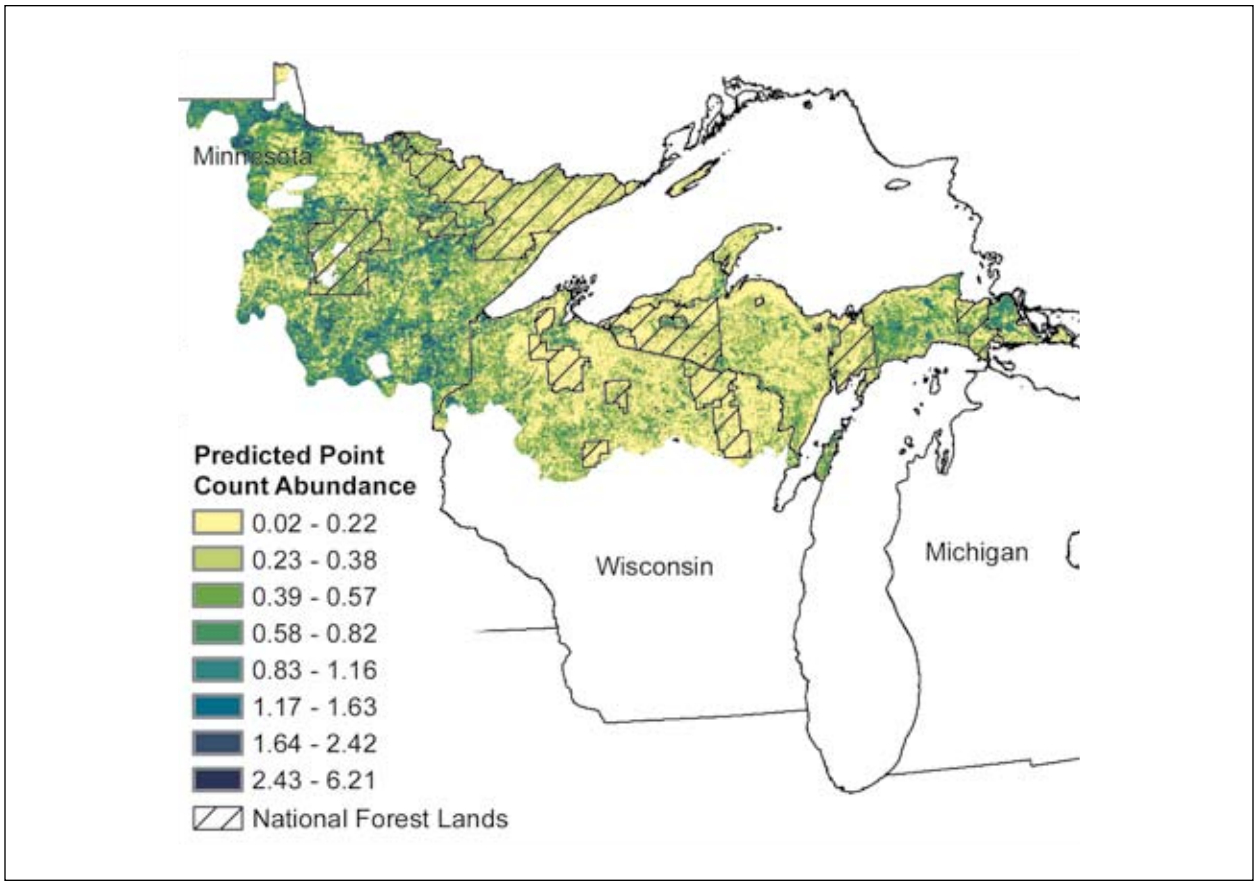
Migration: Short-distance



Trends for song sparrow in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for song sparrow where at least one bird was observed once during the decade (2001–2010; n=3,194 at 523 points)



Predicted relative abundance (number of birds per 10-minute count) of song sparrow for the western Great Lakes region

Swainson's Thrush SWTH

Catharus ustulatus



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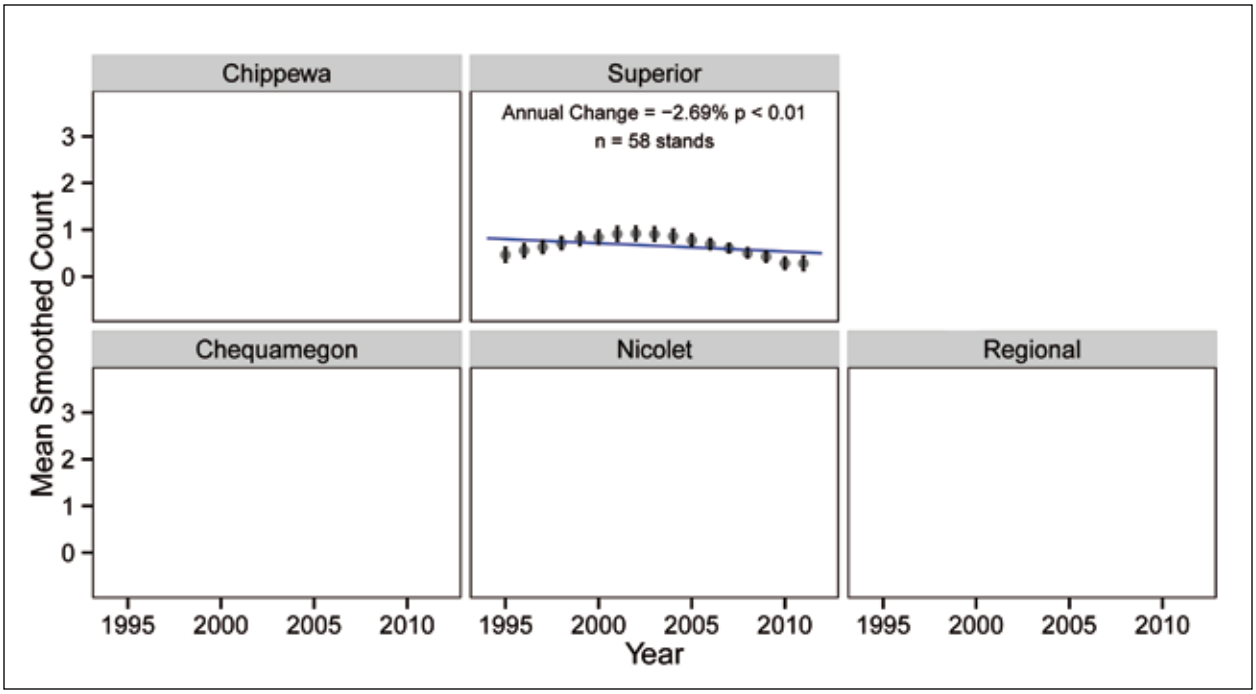
Guild Information

Habitat: Aspen-spruce-fir forests, swamp conifer forests, jack pine forests, and other forest types

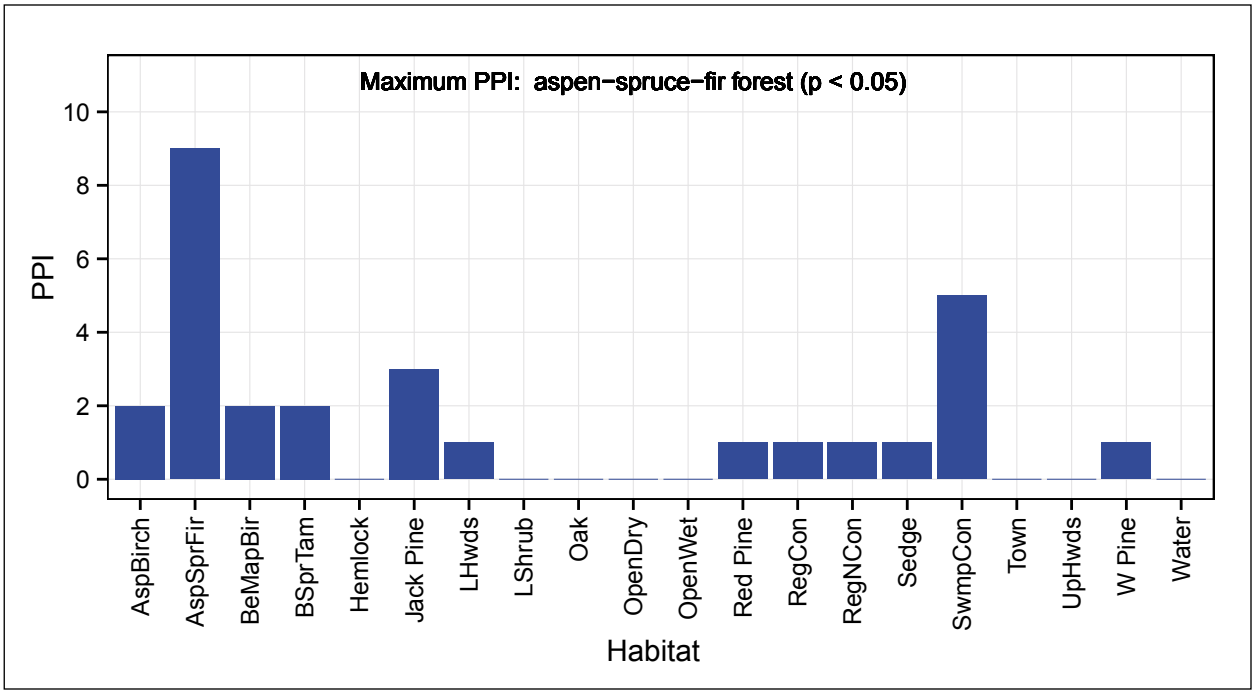
Foraging type: Omnivore—fruit, invertebrates

Nest site: Shrub or subcanopy

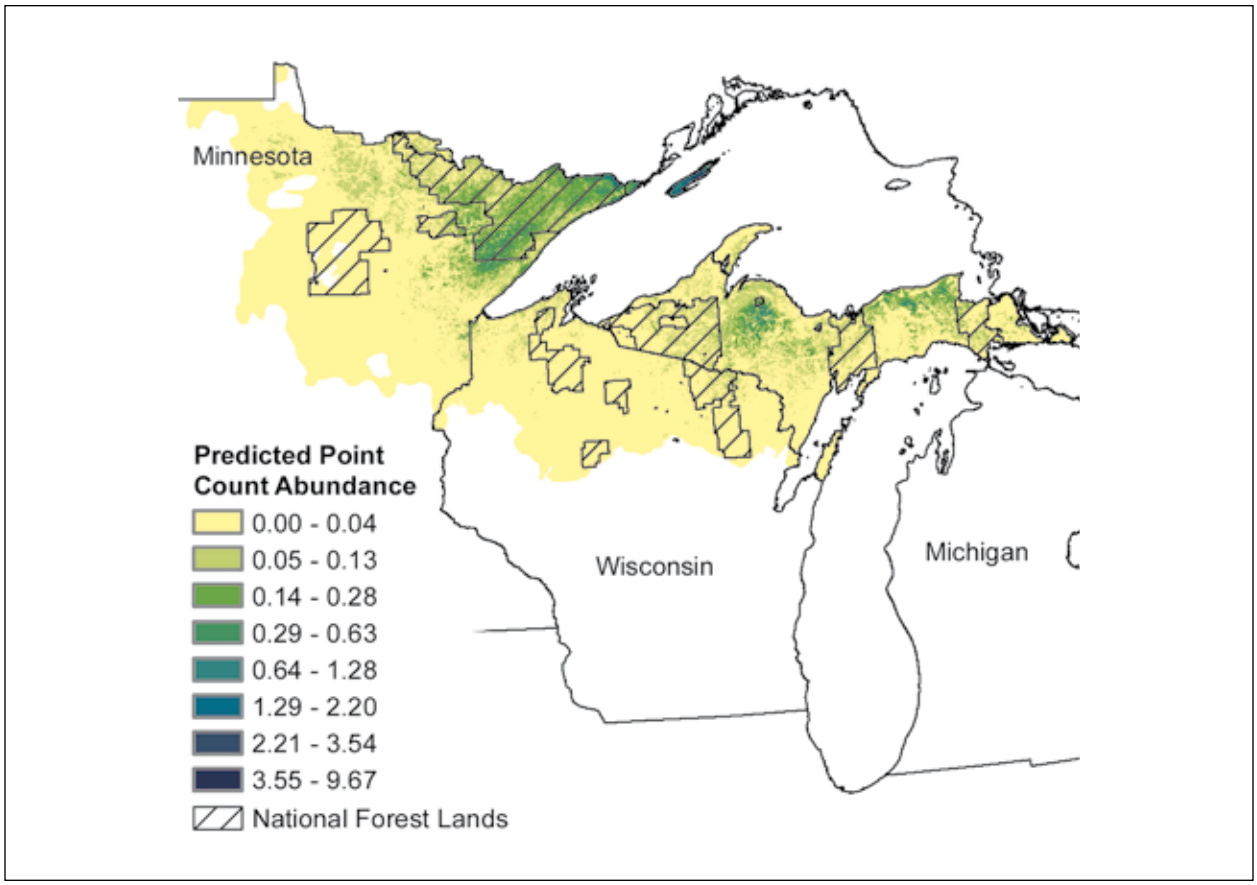
Migration: Long-distance



Trend for Swainson's thrush in one national forest, 1995–2010



Percent perfect indication of habitat association for Swainson's thrush where at least one bird was observed once during the decade (2001–2010; n=927 at 314 points)



Predicted relative abundance (number of birds per 10-minute count) of Swainson's thrush for the western Great Lakes region

Swamp Sparrow SWSP

Melospiza georgiana



Photo by Jon Swanson, used with permission.

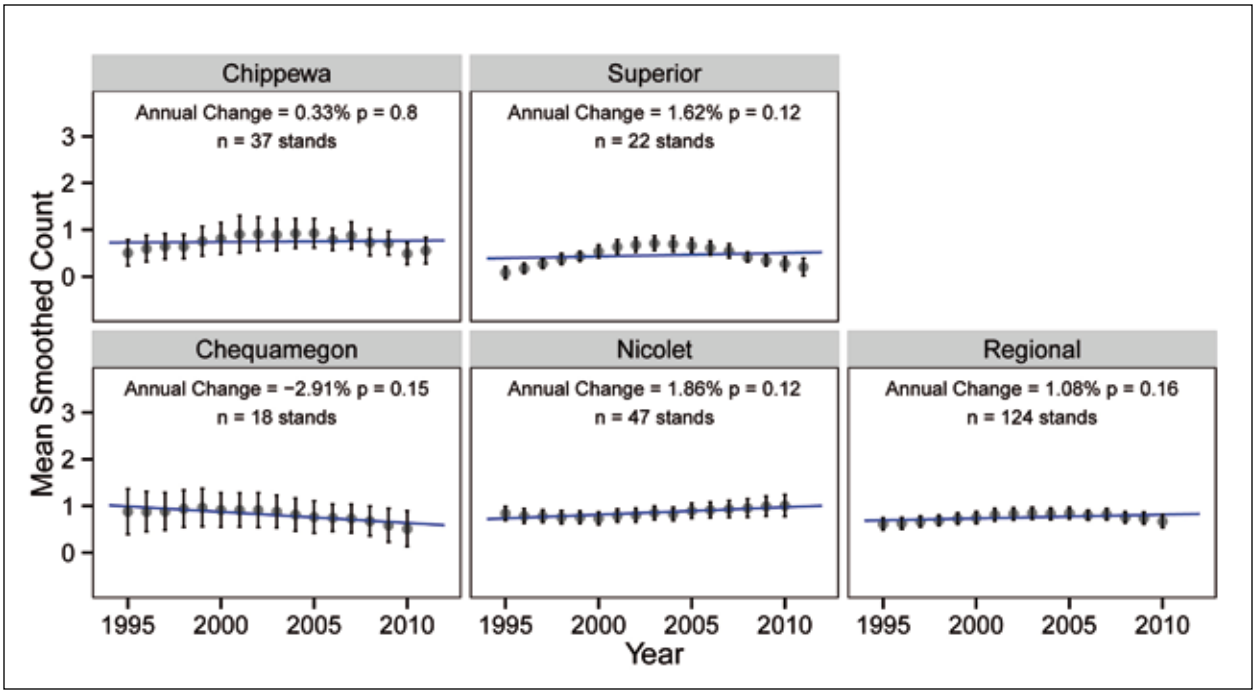
Guild Information

Habitat: Open wetlands, especially with shrubs

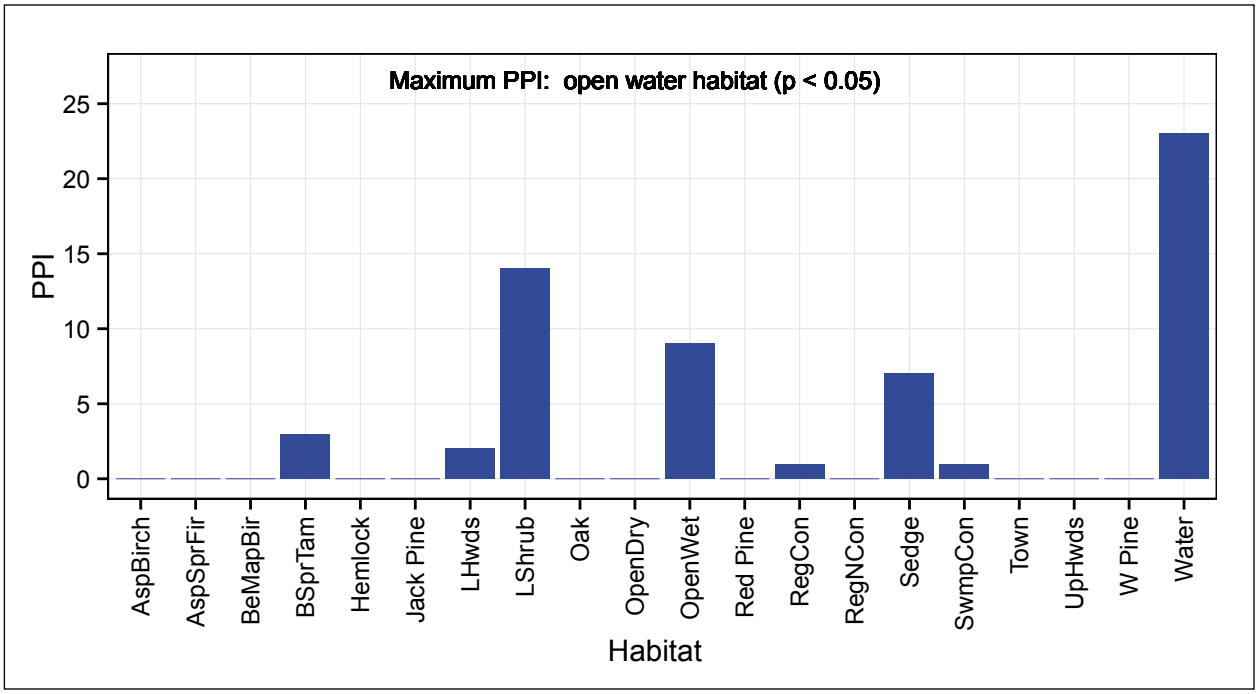
Foraging type: Omnivore—seeds, invertebrates

Nest site: Ground

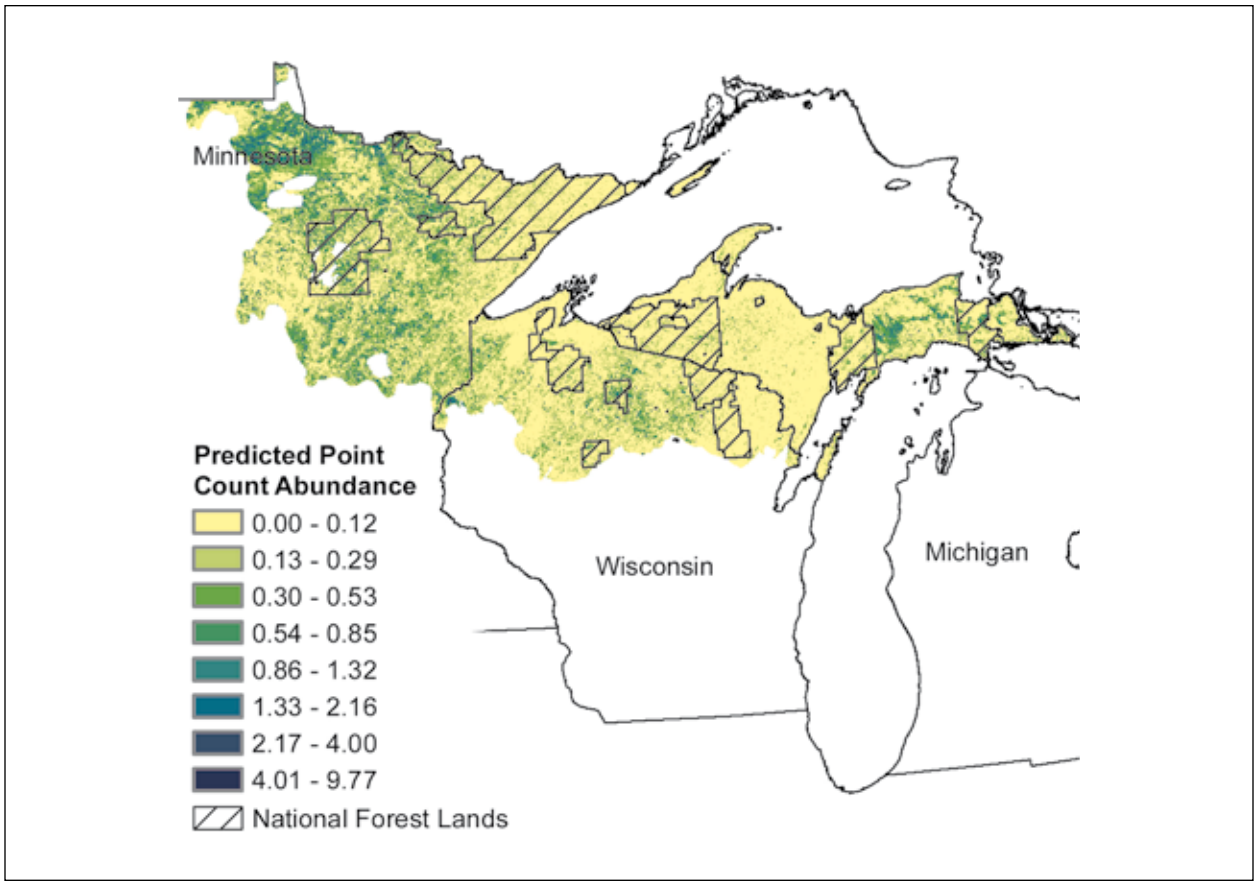
Migration: Short-distance



Trends for swamp sparrow in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for swamp sparrow where at least one bird was observed once during the decade (2001–2010, n=1,723 at 359 points)



Predicted relative abundance (number of birds per 10-minute count) of swamp sparrow for the western Great Lakes region

Tennessee Warbler TEWA

Oreothlypis peregrina



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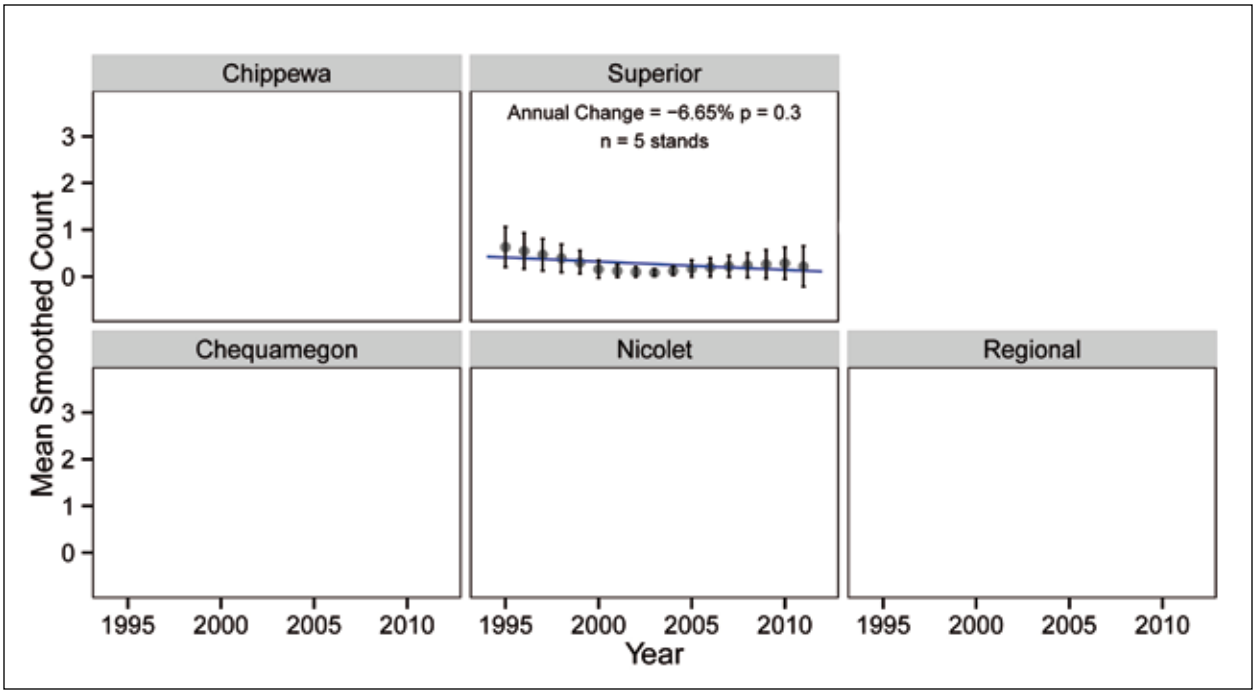
Guild Information

Habitat: Forests, especially regenerating

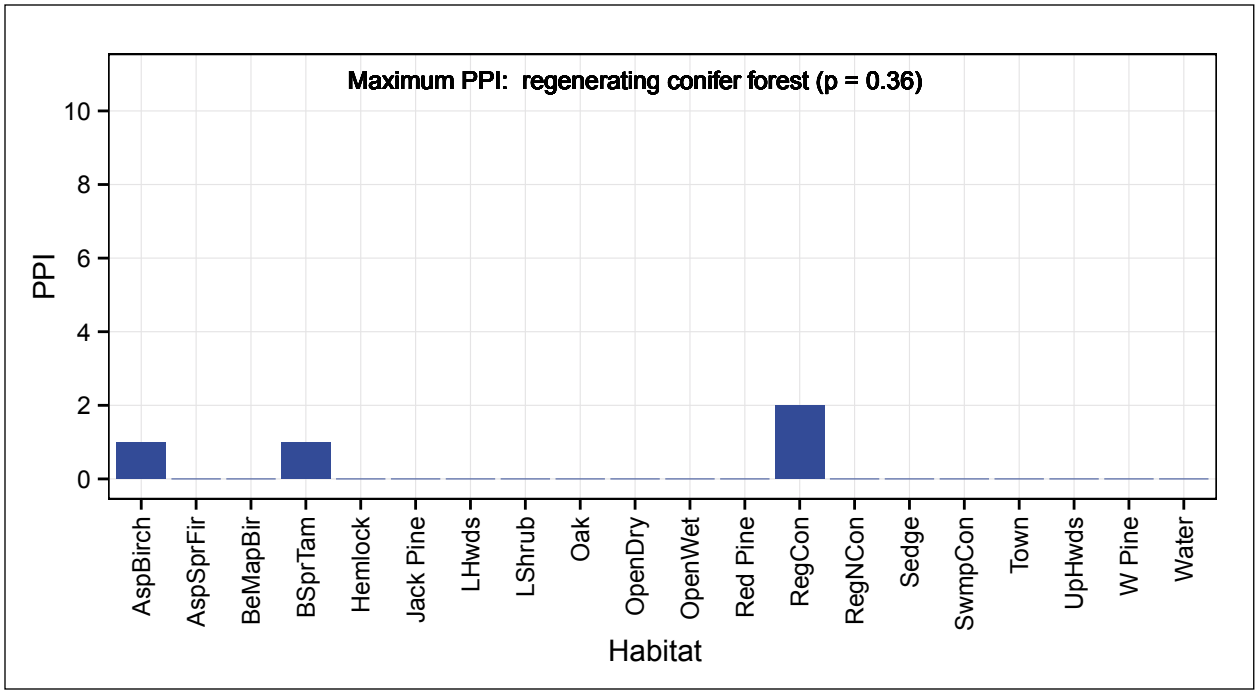
Foraging type: Foliage gleaner, especially spruce budworm

Nest site: Ground

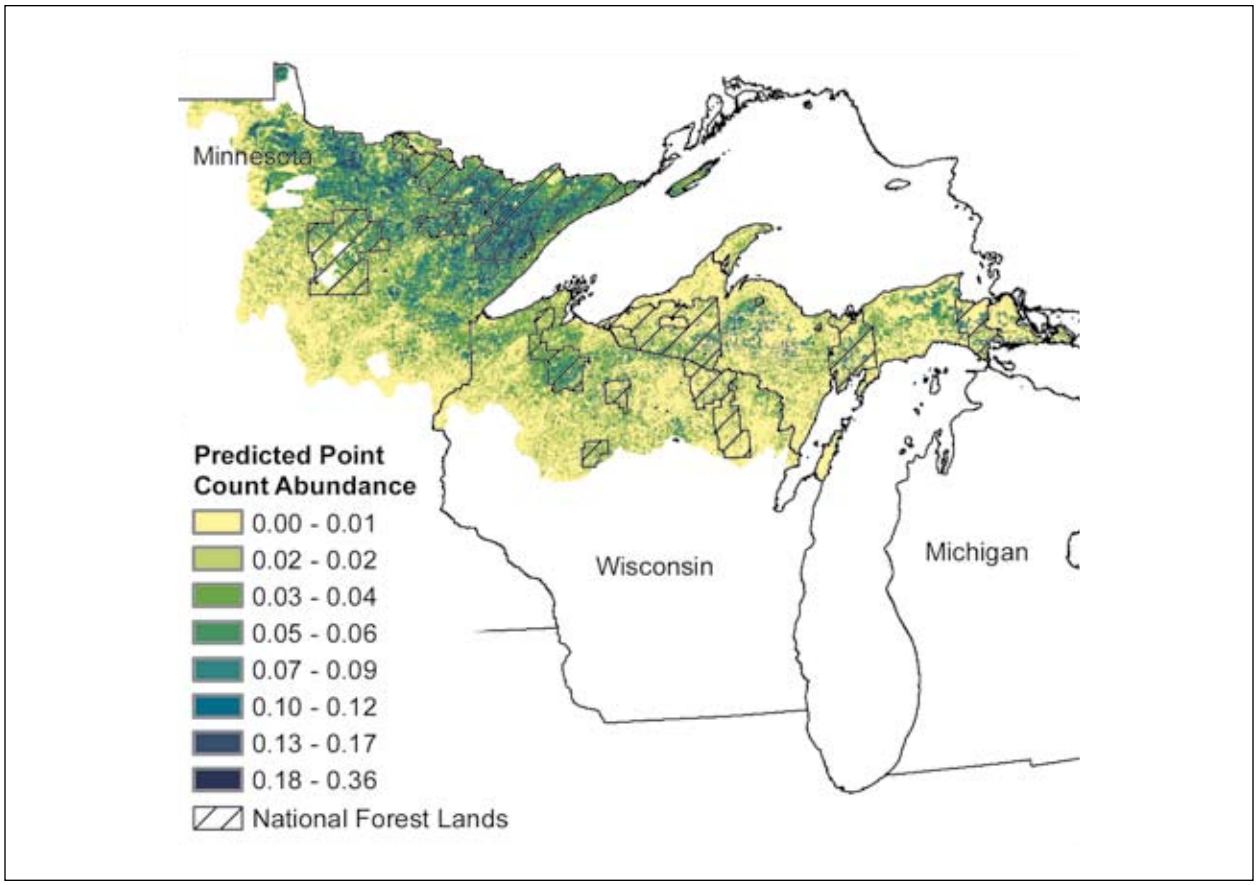
Migration: Long-distance



Trend for Tennessee warbler in one national forest, 1995–2010



Percent perfect indication of habitat association for Tennessee warbler where at least one bird was observed once during the decade (2001–2010; n=111 at 80 points)



Predicted relative abundance (number of birds per 10-minute count) of Tennessee warbler for the western Great Lakes region

Tree Swallow TRES
Tachycineta bicolor



Photo by Chris Evans, Illinois Wildlife Action Plan, Bugwood.org.

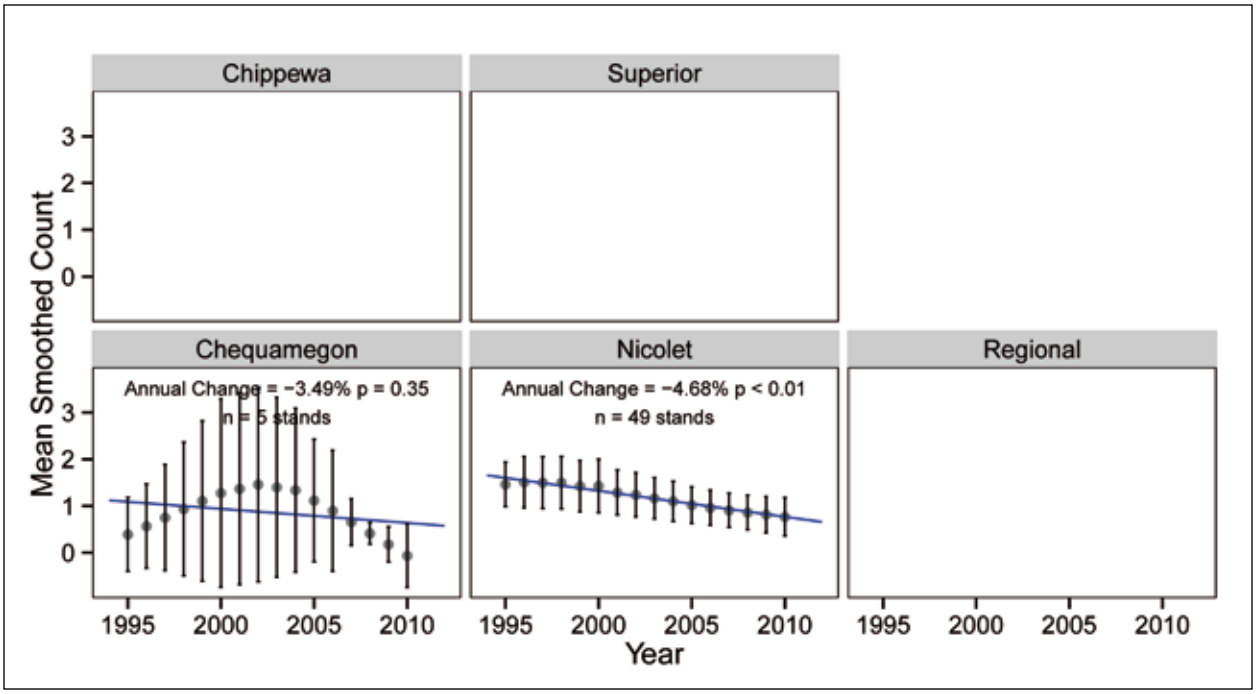
Guild Information

Habitat: Human settlements, open areas, water edges

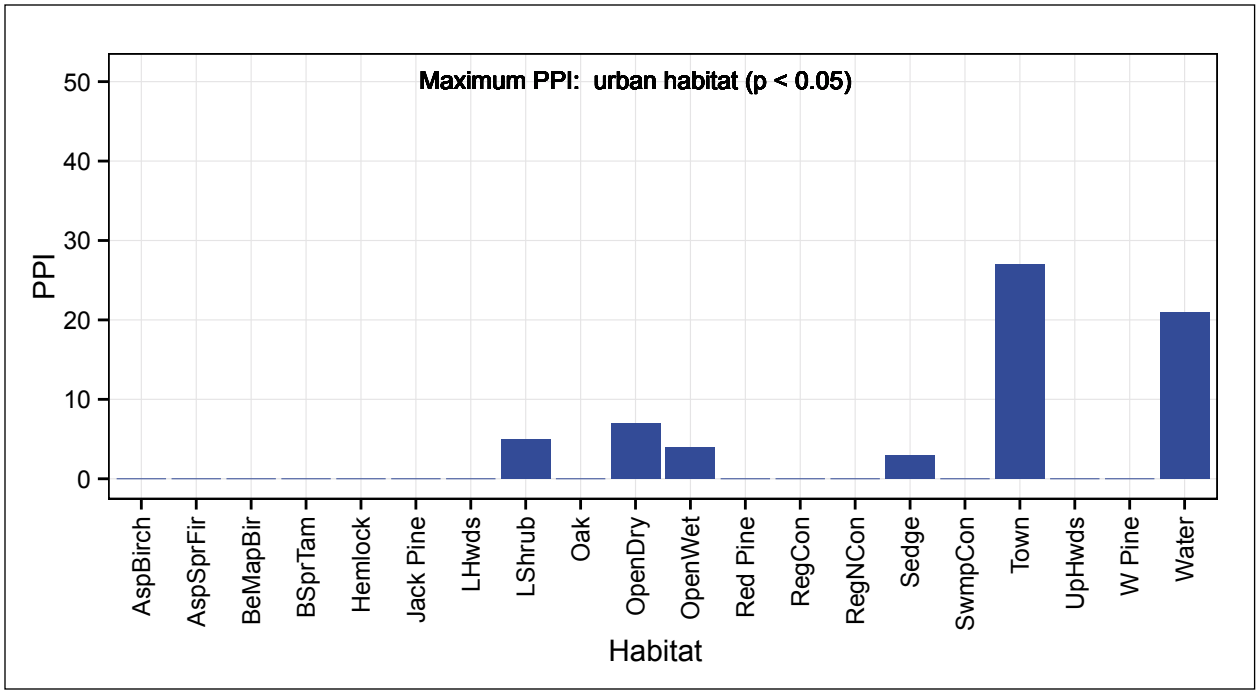
Foraging type: Aerial insectivore

Nest site: Cavity

Migration: Long-distance



Trends for tree swallow in two national forests, 1995–2010



Percent perfect indication of habitat association for tree swallow where at least one bird was observed once during the decade (2001–2010; n=805 at 128 points)

Upland Sandpiper UPSA
Bartramia longicauda



Photo by Patrick Beauzay, used with permission.

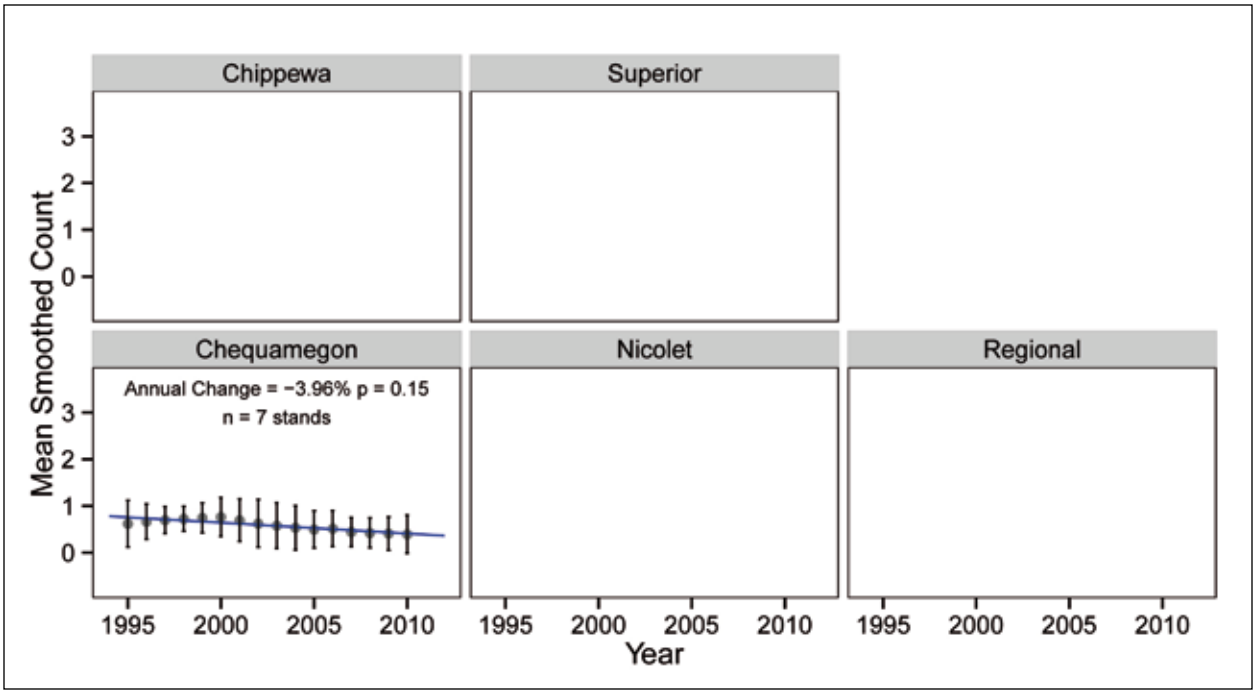
Guild Information

Habitat: Open dry grasslands and meadows

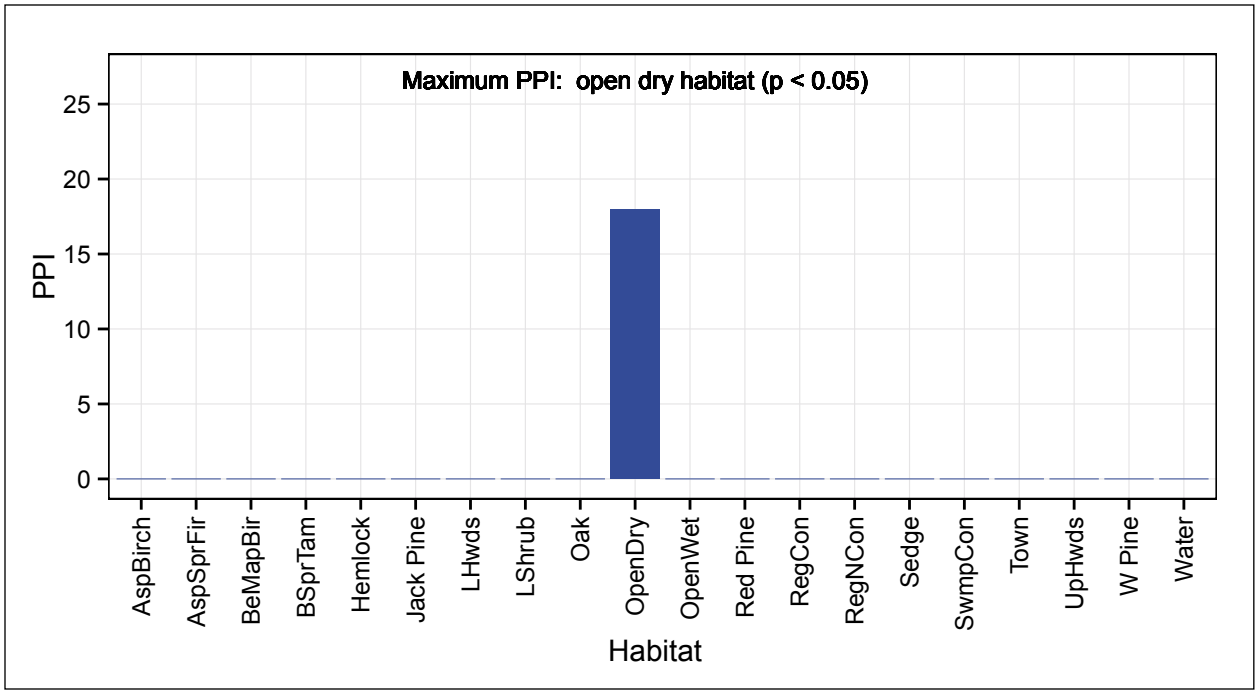
Foraging type: Omnivore

Nest site: Ground

Migration: Long-distance



Trend for upland sandpiper in one national forest, 1995–2010



Percent perfect indication of habitat association for upland sandpiper where at least one bird was observed once during the decade (2001–2010; n=63 at 19 points)

Veery VEER

Catharus fuscescens



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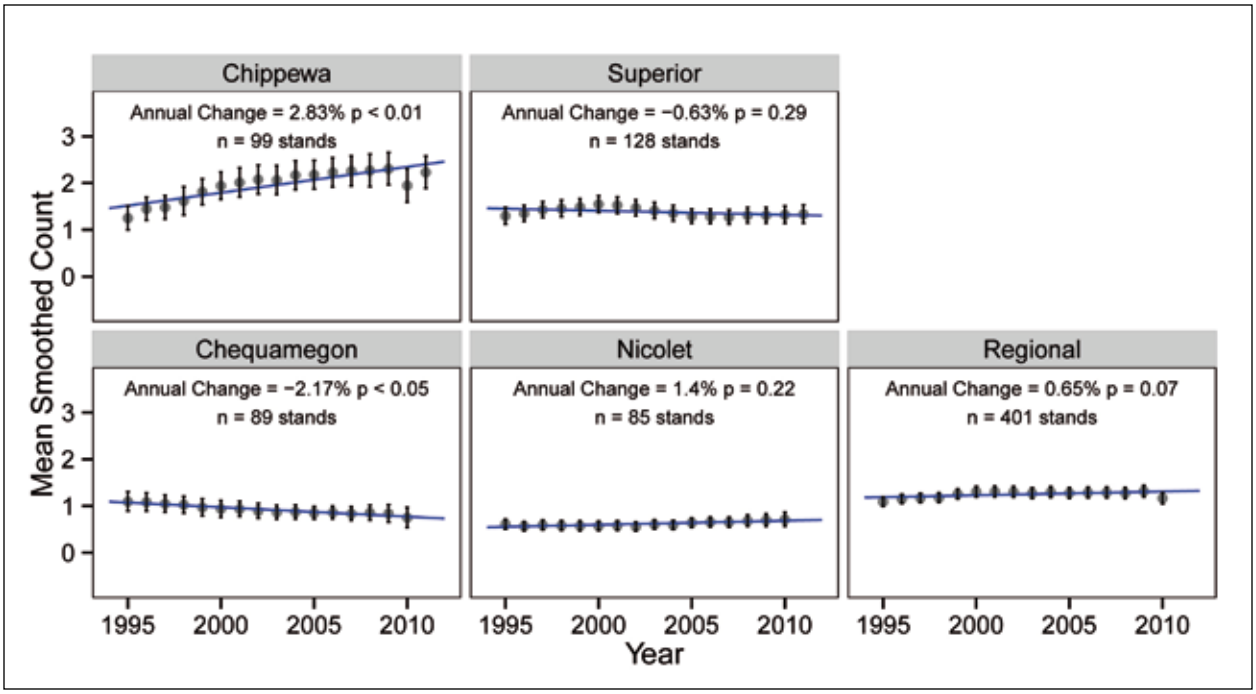
Guild Information

Habitat: Young forests, forests with shrubby understory, lowland hardwoods

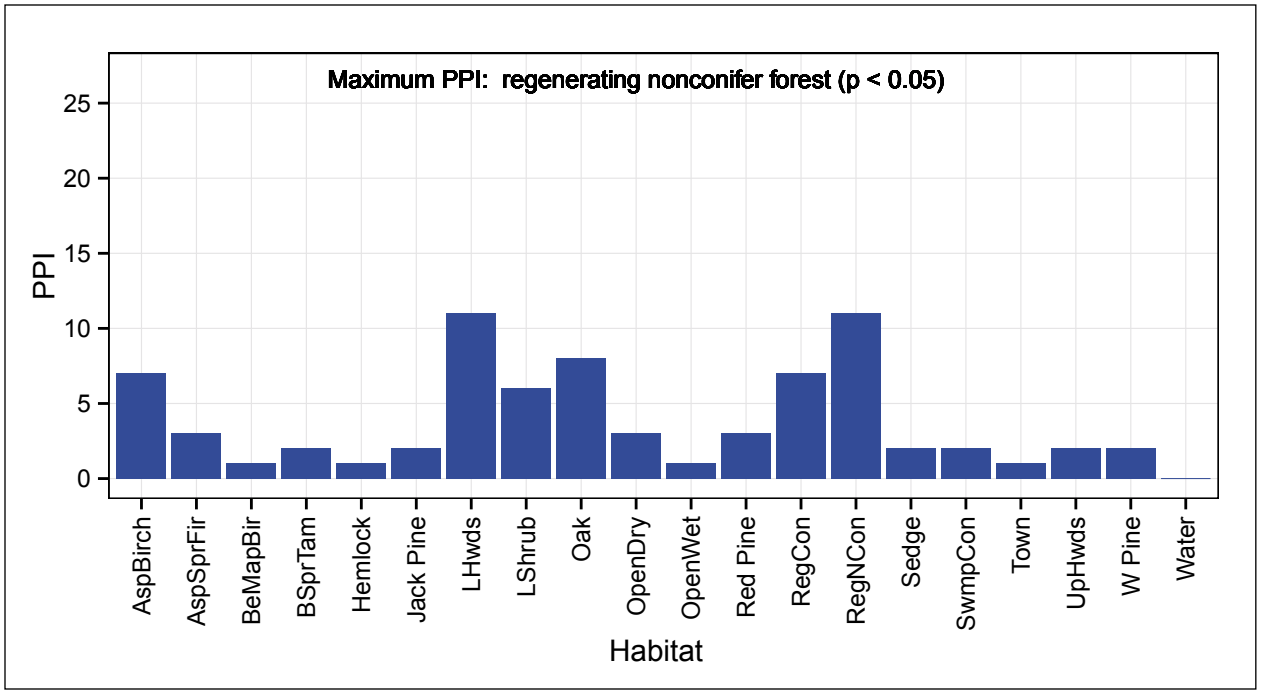
Foraging type: Omnivore—invertebrates, fruit

Nest site: Ground

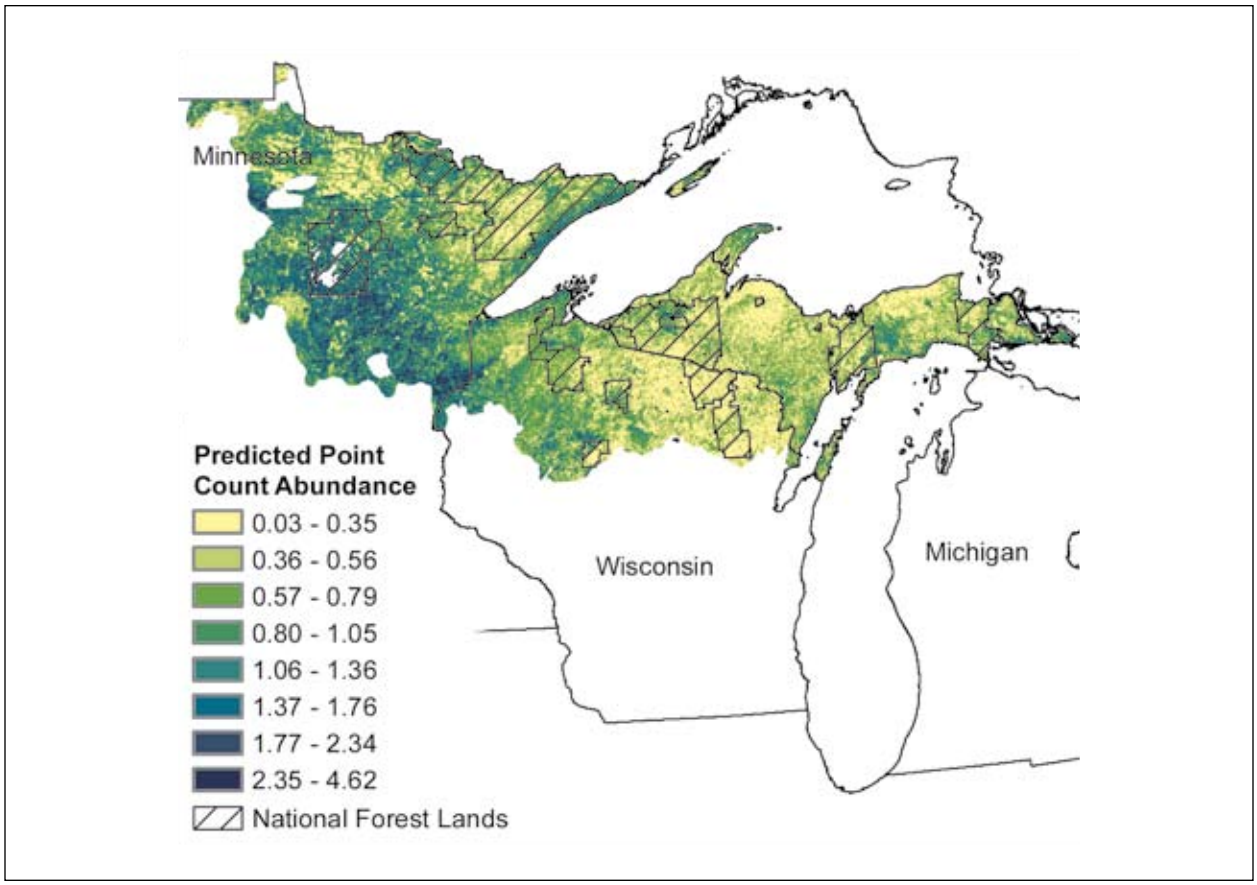
Migration: Long-distance



Trends for veery in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for veery where at least one bird was observed once during the decade (2001–2010; n=9,218 at 1,245 points)



Predicted relative abundance (number of birds per 10-minute count) of veery for the western Great Lakes region

Vesper Sparrow VESP

Pooecetes gramineus



Photo by Larry Sirvio, used with permission.

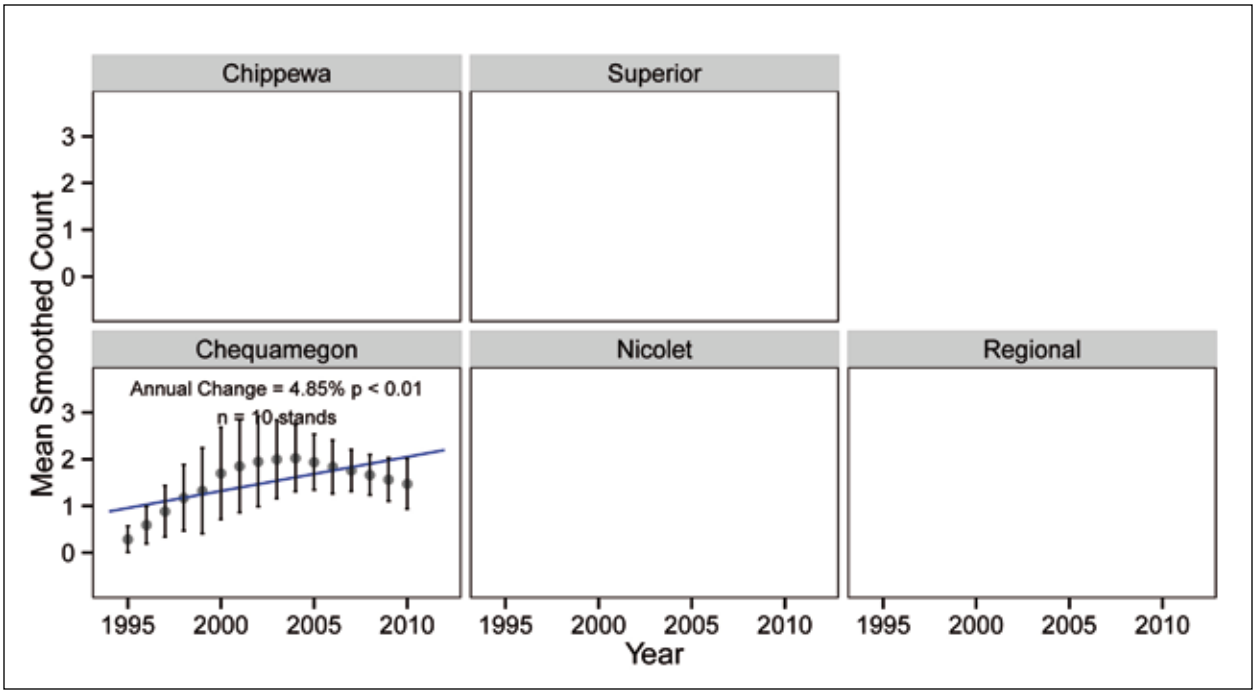
Guild Information

Habitat: Open dry areas

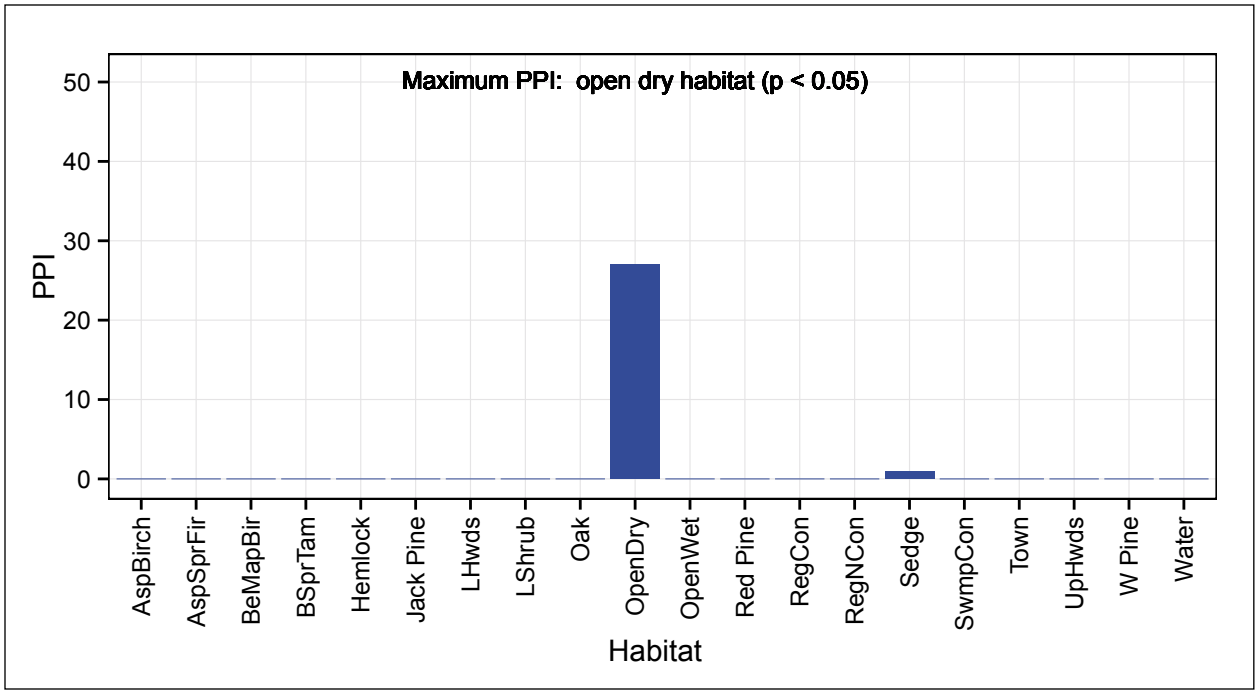
Foraging type: Omnivore—seeds, invertebrates

Nest site: Ground

Migration: Short-distance



Trend for vesper sparrow in one national forest, 1995–2010



Percent perfect indication of habitat association for vesper sparrow where at least one bird was observed once during the decade (2001–2010; n=333 at 42 points)

White-breasted Nuthatch WBNU
Sitta carolinensis



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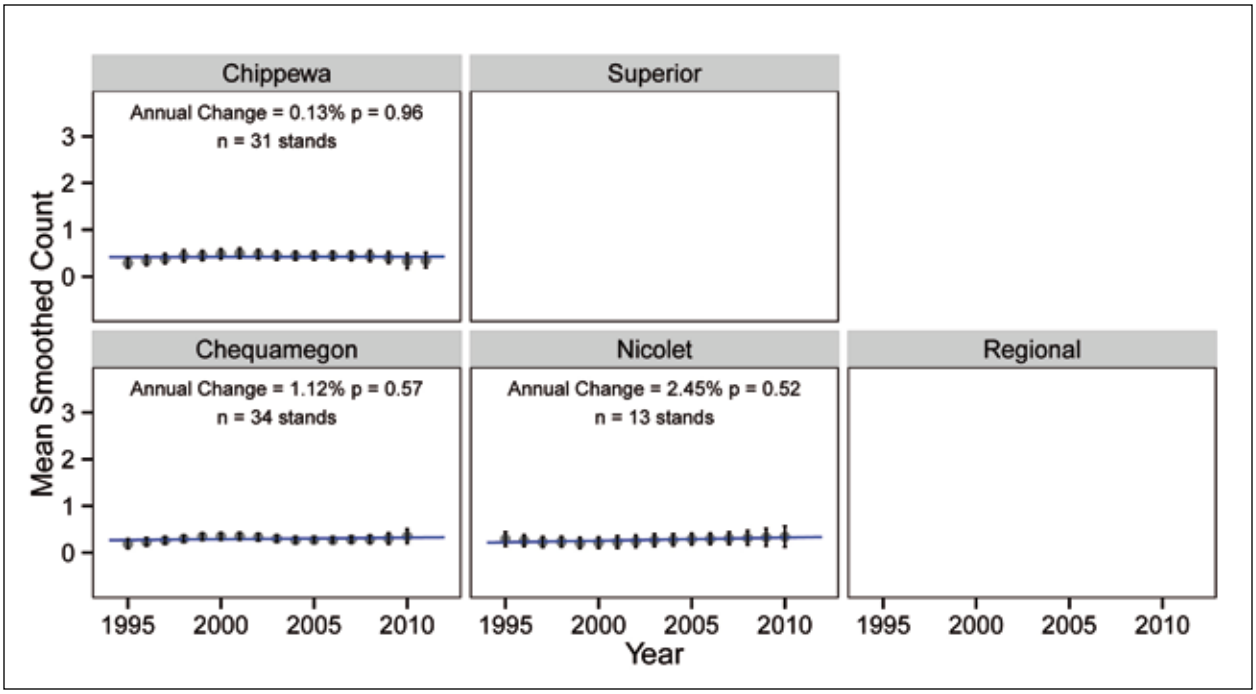
Guild Information

Habitat: Forests, especially oak

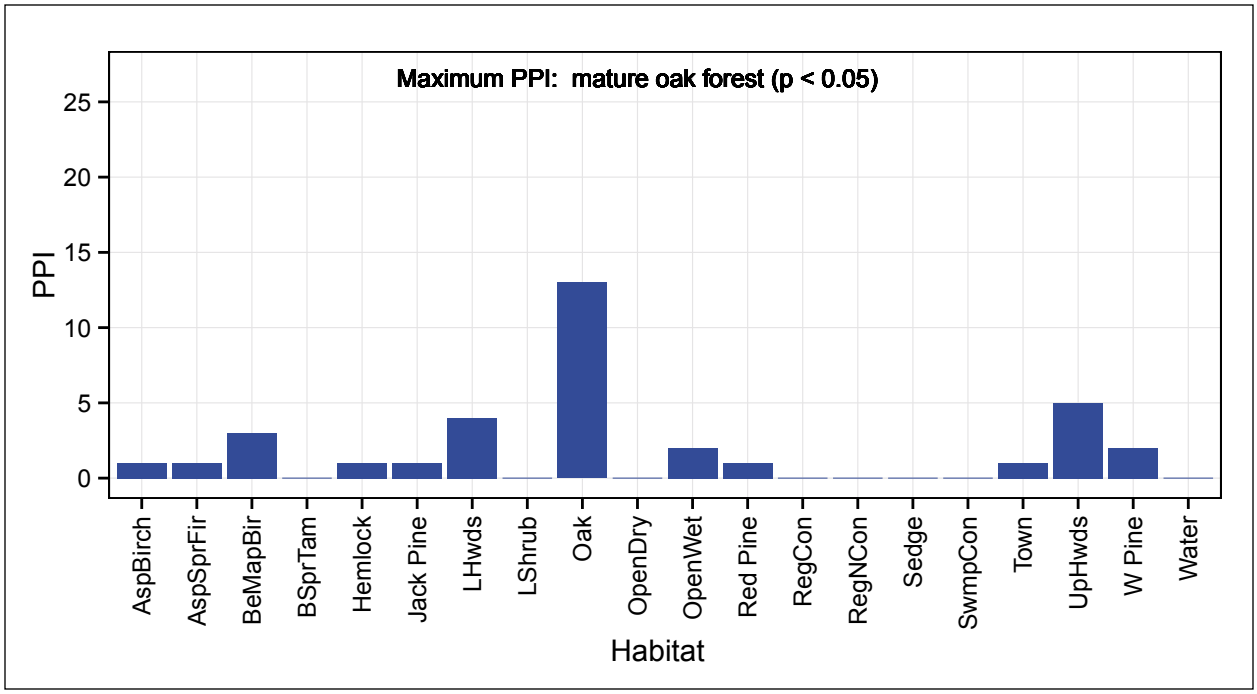
Foraging type: Bark gleaner

Nest site: Cavity

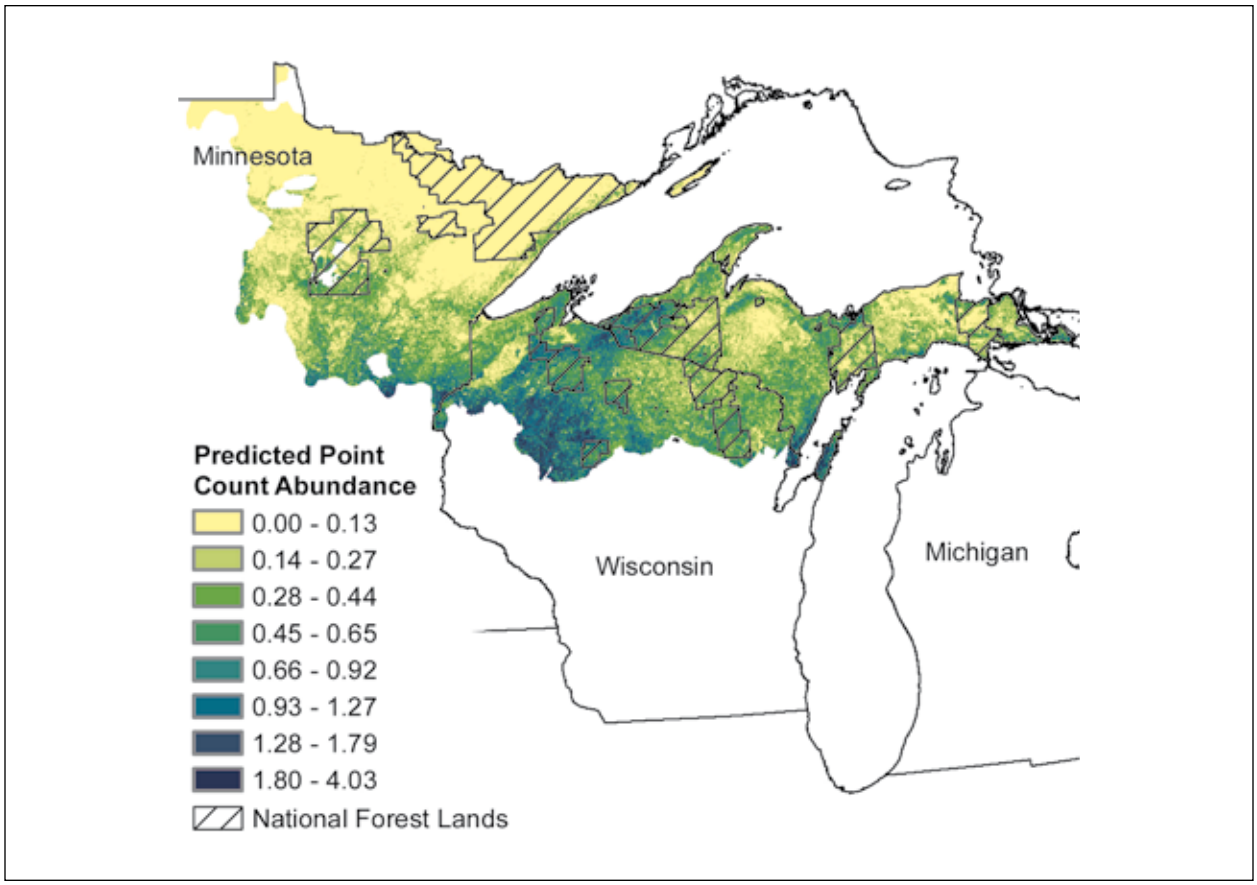
Migration: Permanent resident



Trends for white-breasted nuthatch in three national forests, 1995–2010



Percent perfect indication of habitat association for white-breasted nuthatch where at least one bird was observed once during the decade (2001–2010; n=851 at 436 points)



Predicted relative abundance (number of birds per 10-minute count) of white-breasted nuthatch for the western Great Lakes region

White-throated Sparrow WTSP
Zonotrichia albicollis


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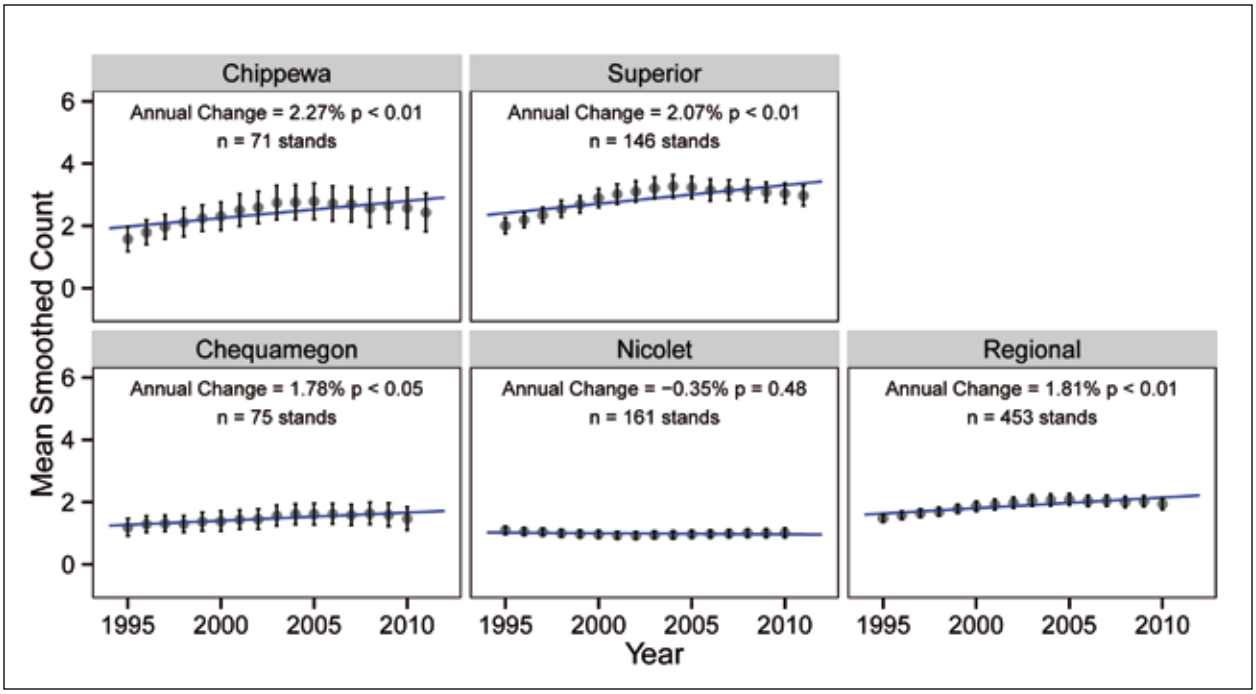
Guild Information

Habitat: Shrubby lowlands, variety of open forest types

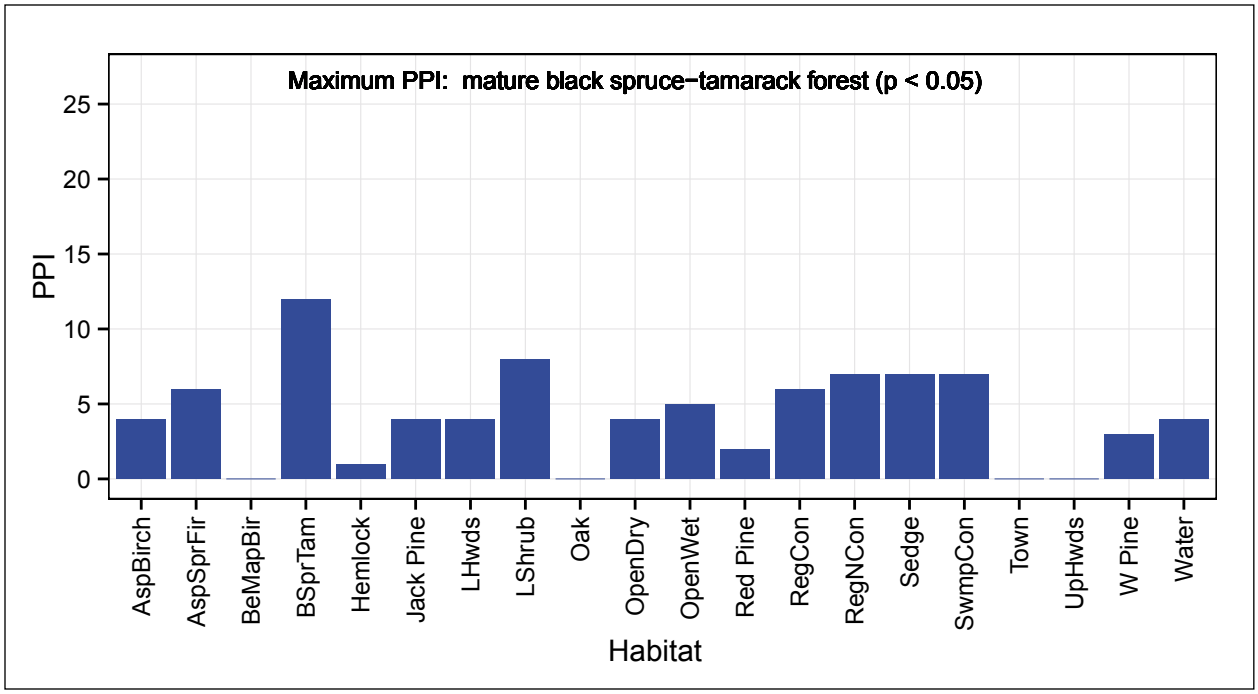
Foraging type: Ground gleaner

Nest site: Ground

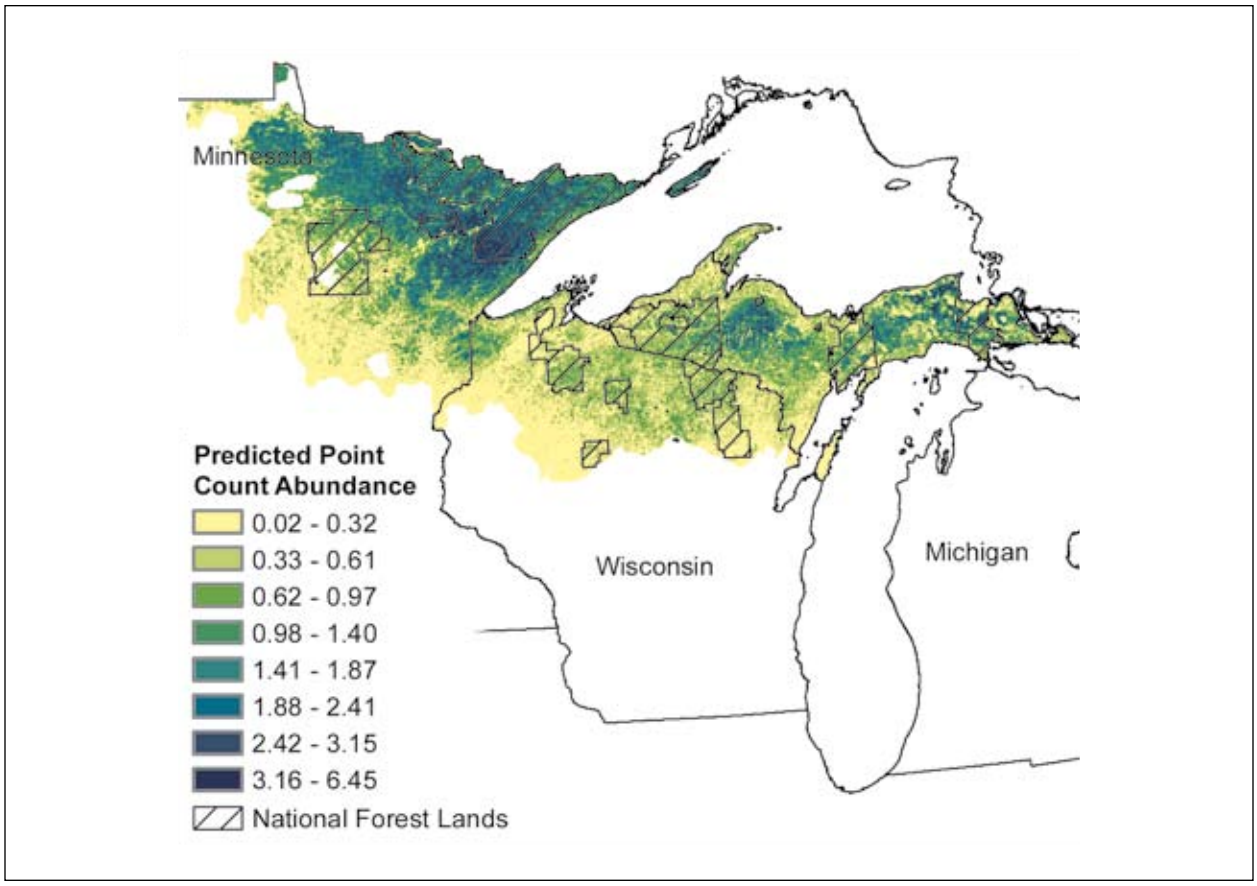
Migration: Short-distance



Trends for white-throated sparrow in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for white-throated sparrow where at least one bird was observed once during the decade (2001–2010; n=16,043 at 1,199 points)



Predicted relative abundance (number of birds per 10-minute count) of white-throated sparrow for the western Great Lakes region

Wild Turkey WITU

Meleagris gallopavo



Photo by Robert Howe.

Guild Information

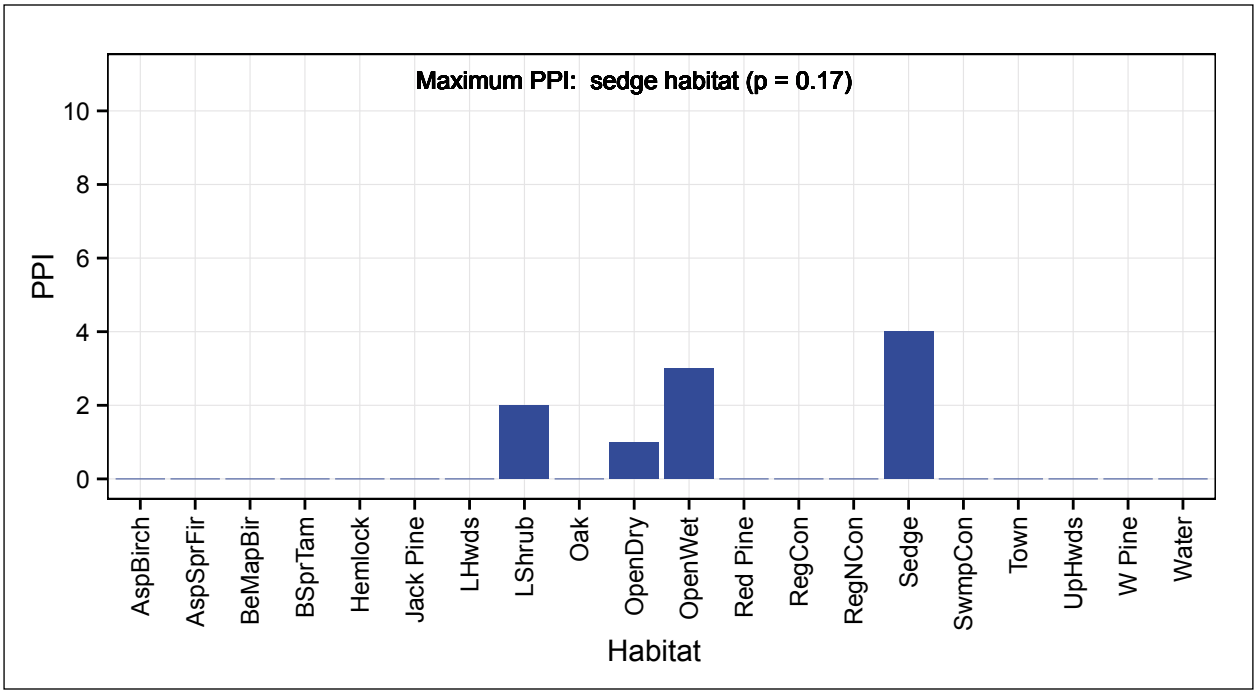
Habitat: Deciduous forests

Foraging type: Omnivore

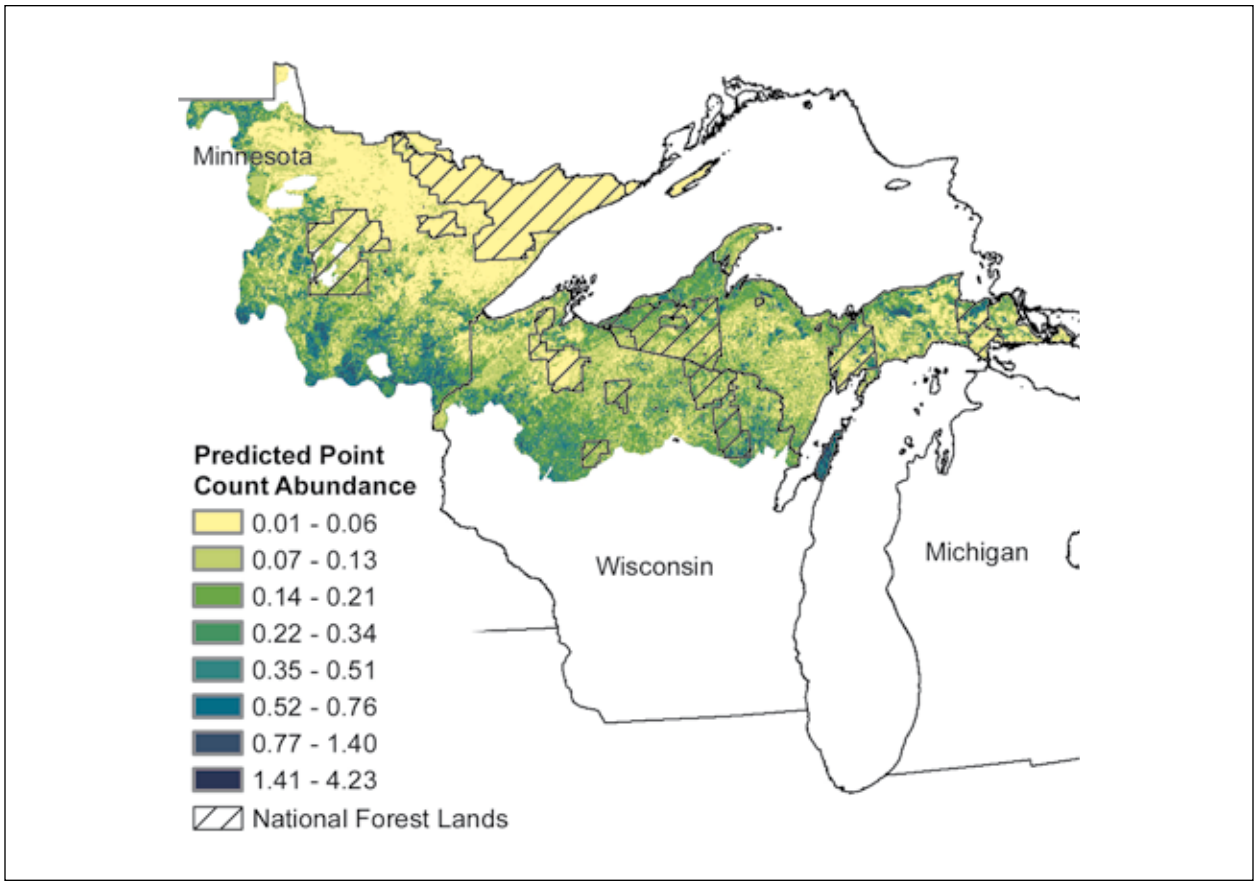
Nest site: Ground

Migration: Permanent resident

Notes: PPI analysis was not statistically significant for this increasing species, whose vocalizations can be heard from a great distance. PPI values for OpenWet and Sedge habitats reflect the small number of sample points for these habitats (WITU was recorded at 2 of the 7 Sedge points and 1 of the 9 OpenWet points) and probably represent birds heard from adjacent forest or woodland habitats.



Percent perfect indication of habitat association for wild turkey where at least one bird was observed once during the decade (2001–2010; n=126 at 59 points)



Predicted relative abundance (number of birds per 10-minute count) of wild turkey for the western Great Lakes region

Wilson's Snipe WISN

Gallinago delicata



Photo by Larry Sirvio, used with permission.

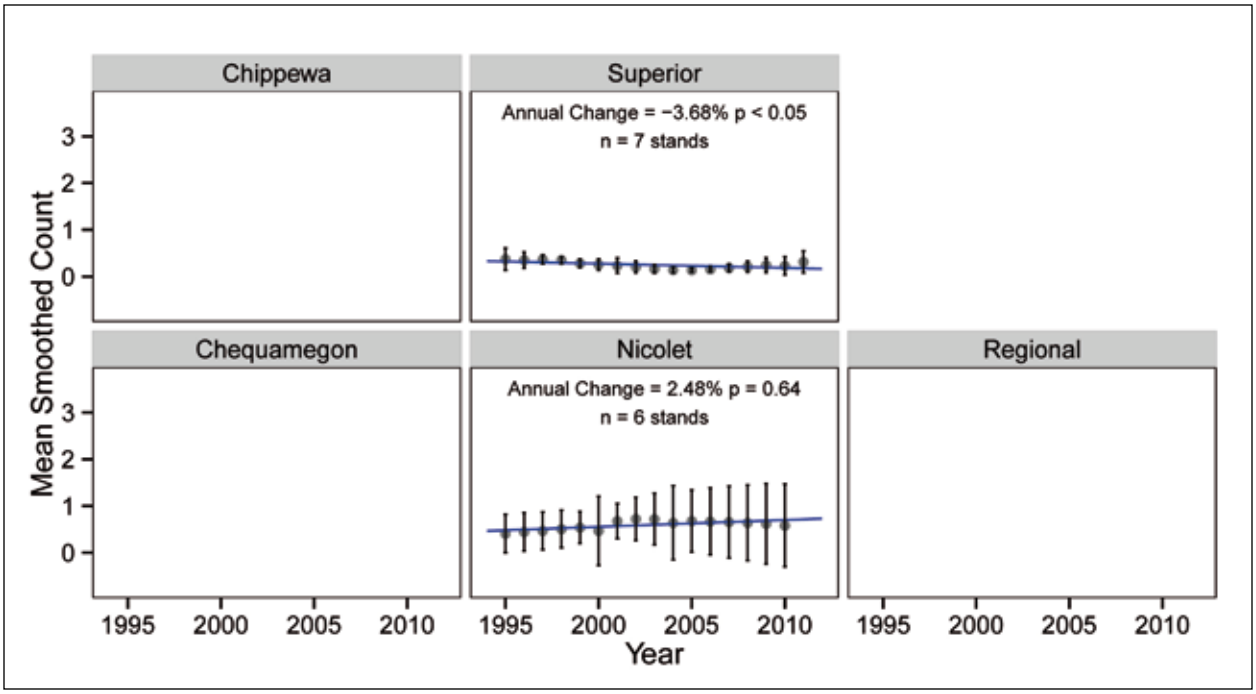
Guild Information

Habitat: Open wetlands

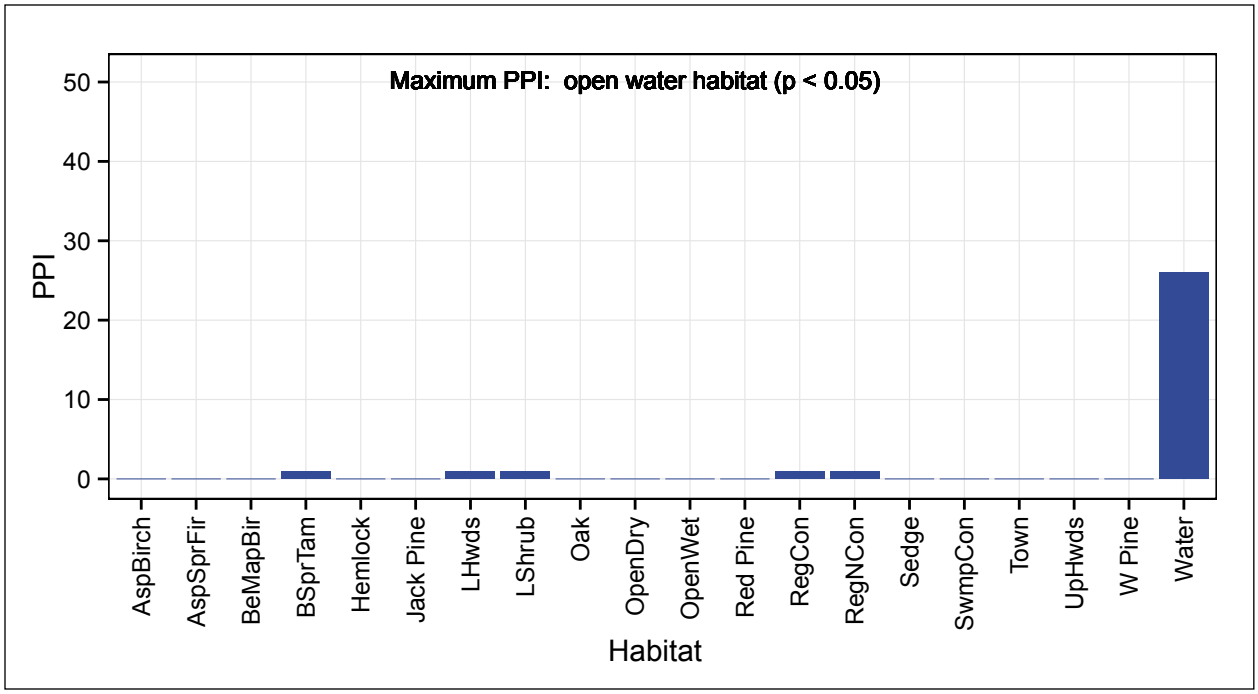
Foraging type: Prober—invertebrates

Nest site: Ground

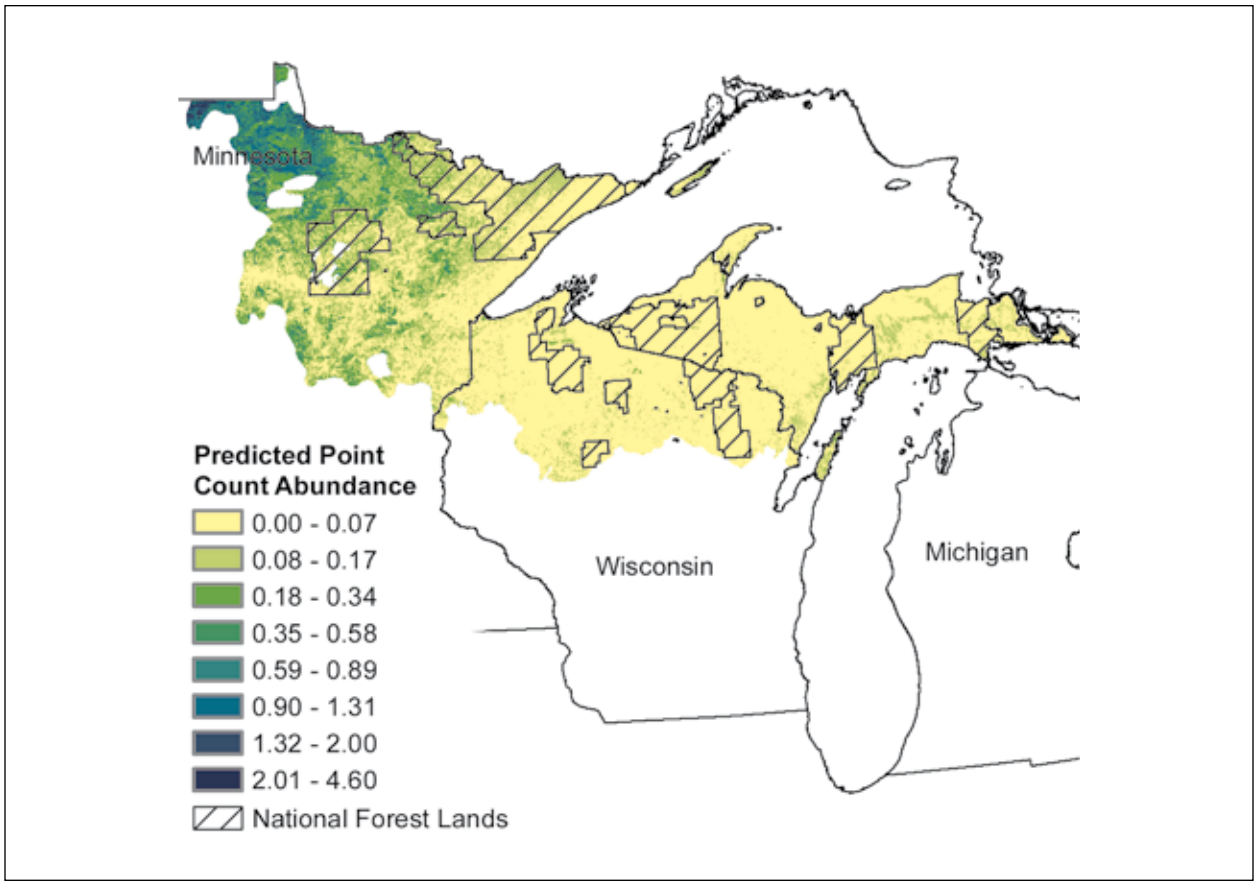
Migration: Short-distance



Trends for Wilson's snipe in two national forests, 1995–2010



Percent perfect indication of habitat association for Wilson's snipe where at least one bird was observed once during the decade (2001–2010; n=280 at 162 points)



Predicted relative abundance (number of birds per 10-minute count) of Wilson's snipe for the western Great Lakes region

Winter Wren WIWR

Troglodytes hiemalis



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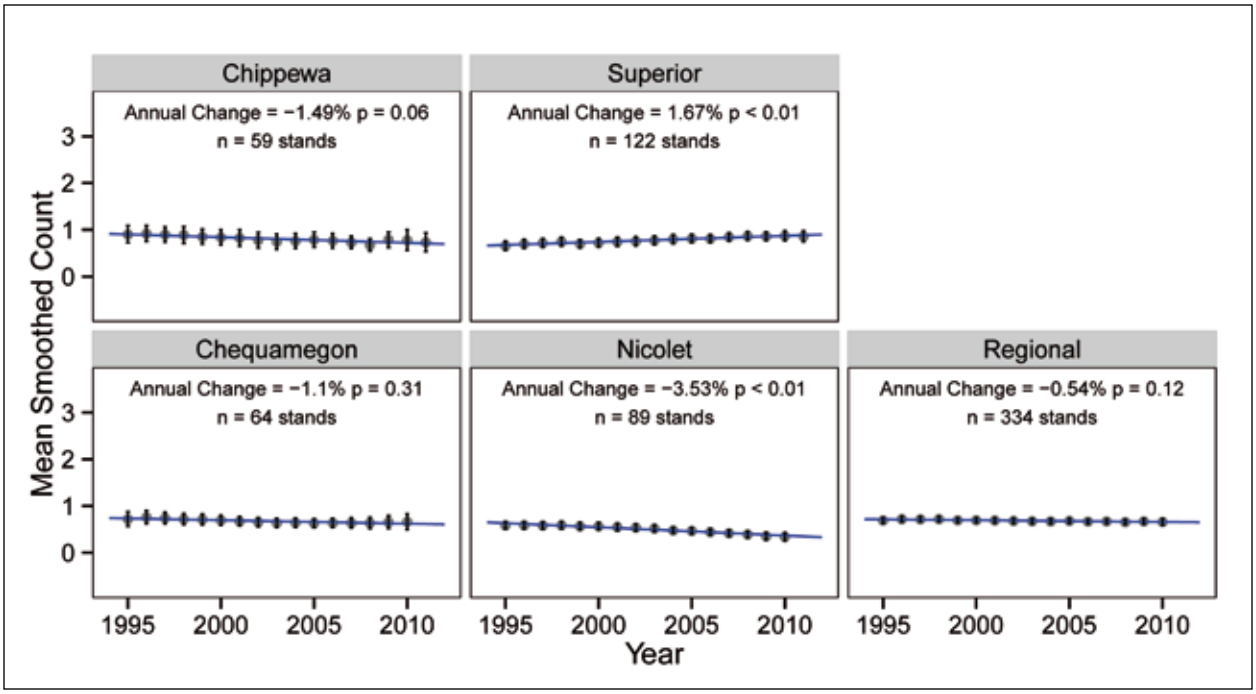
Guild Information

Habitat: Forests, especially lowland and coniferous

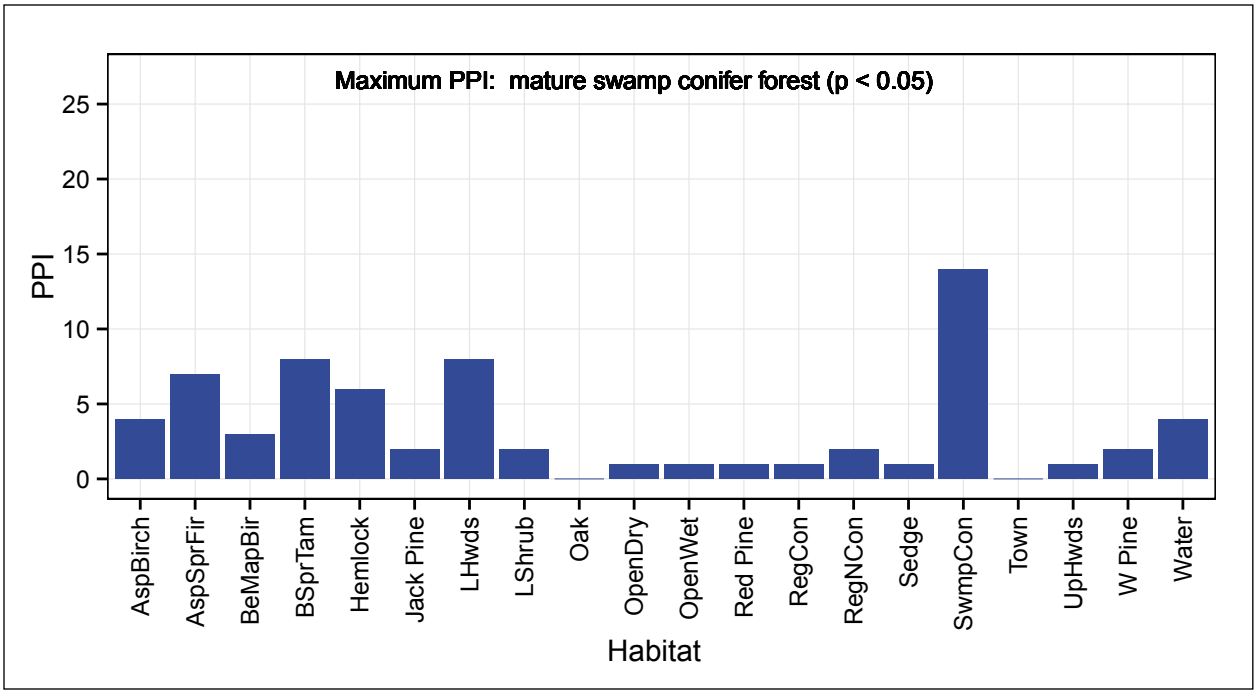
Foraging type: Foliage gleaner

Nest site: Ground

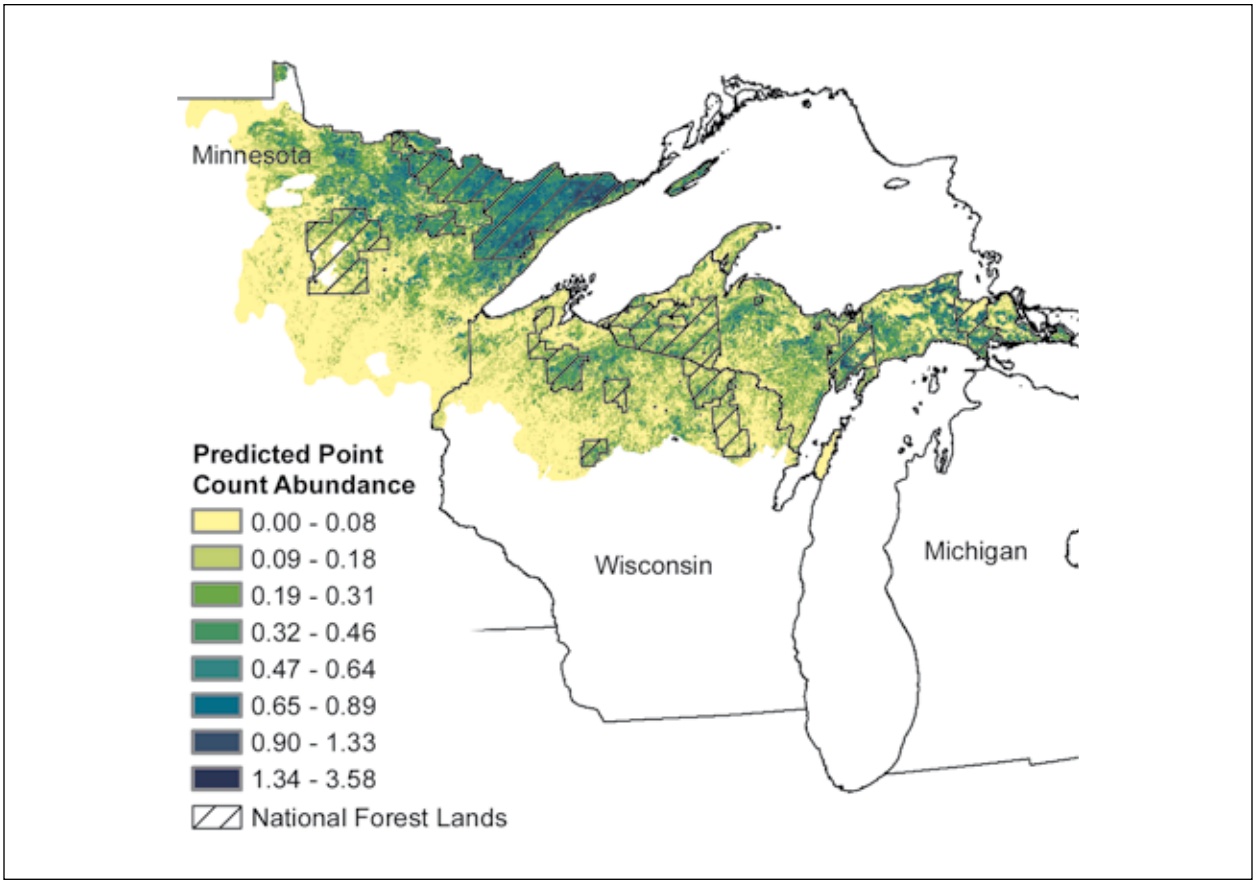
Migration: Short-distance



Trends for winter wren in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for winter wren where at least one bird was observed once during the decade (2001–2010; n=3,918 at 971 points)



Predicted relative abundance (number of birds per 10-minute count) of winter wren for the western Great Lakes region

Wood Thrush WOTH

Hylocichla mustelina



Photo by Jon Swanson, used with permission.

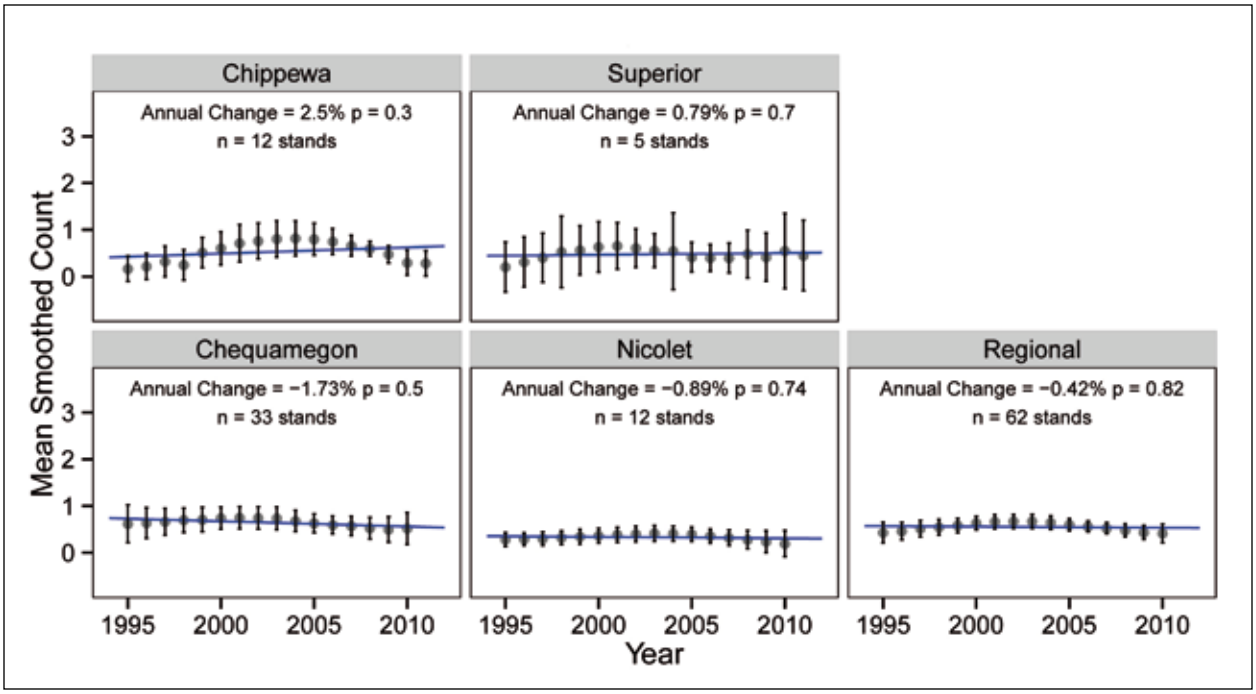
Guild Information

Habitat: Mature hardwood forests, especially upland

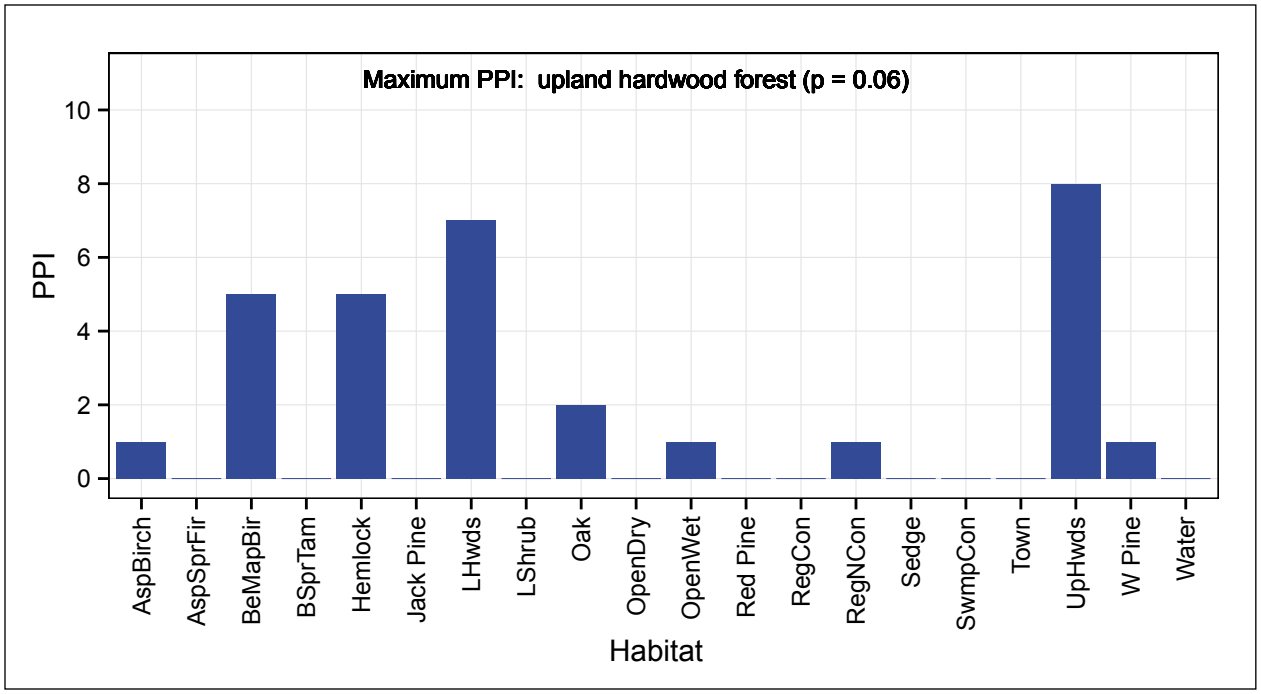
Foraging type: Omnivore—invertebrates, fruit

Nest site: Shrub or subcanopy

Migration: Long-distance



Trends for wood thrush in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for wood thrush where at least one bird was observed once during the decade (2001–2010; n=818 at 322 points)

Yellow Warbler YEWA

Setophaga petechia



Photo by Bruce Lees, used with permission.

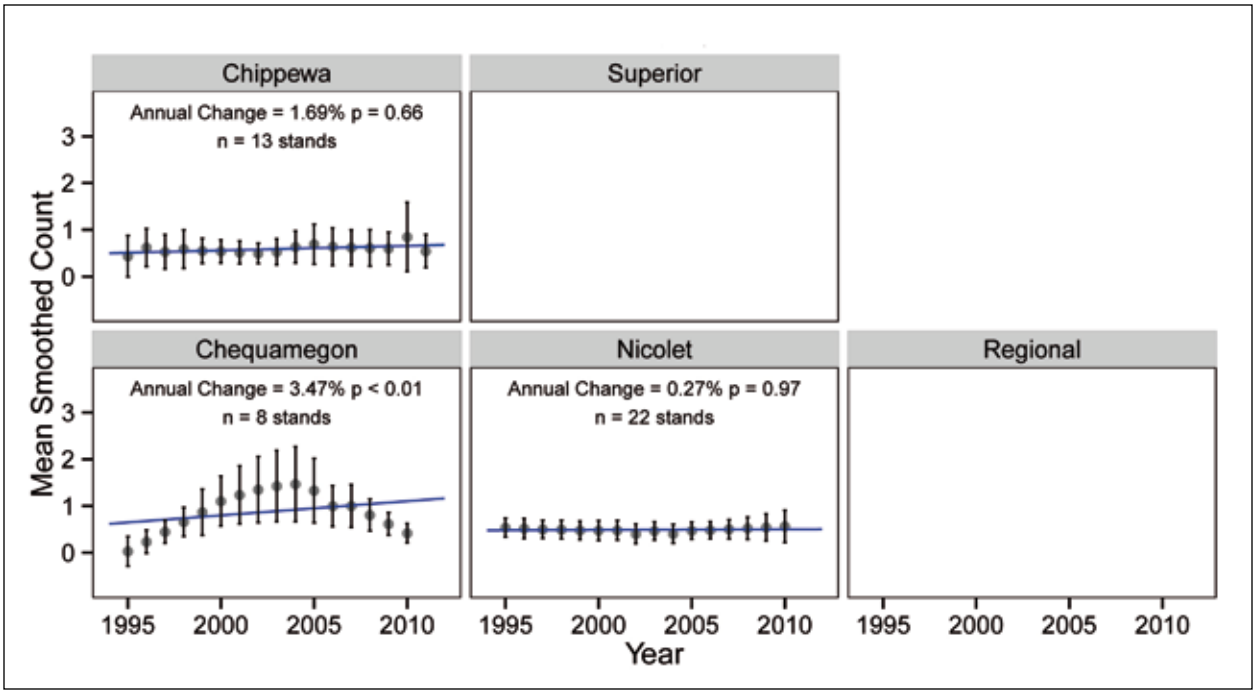
Guild Information

Habitat: Lowland shrubs, open areas with shrubs

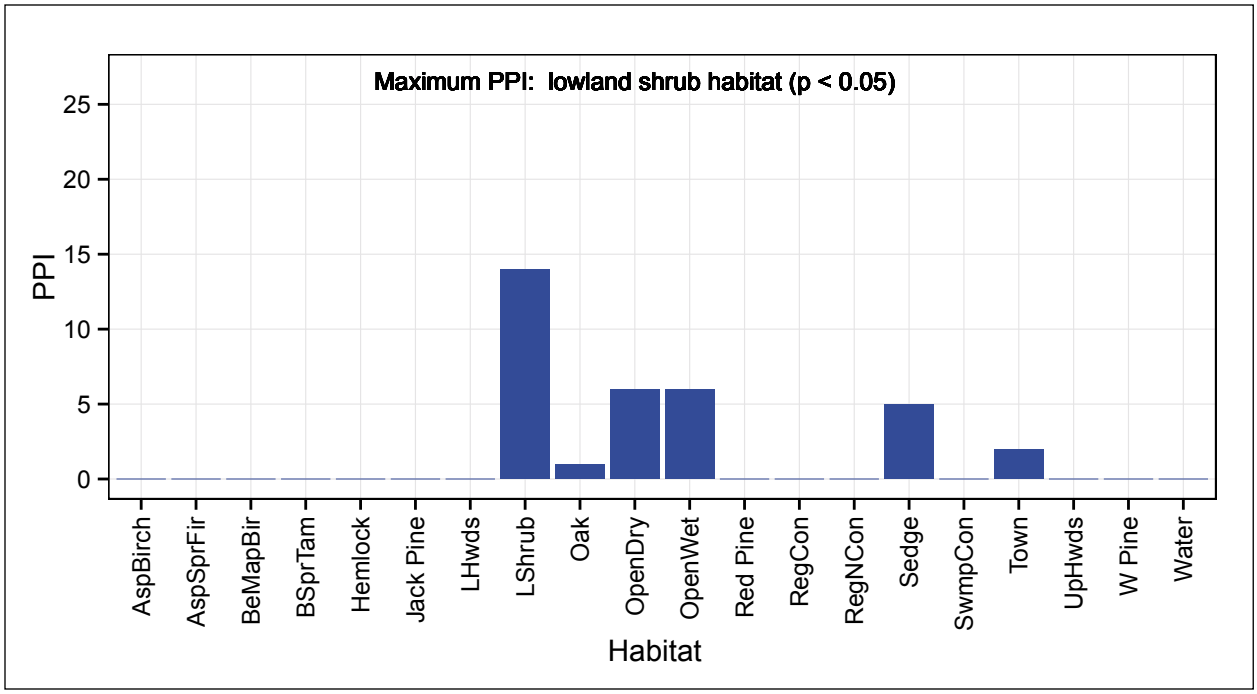
Foraging type: Foliage gleaner

Nest site: Shrub or subcanopy

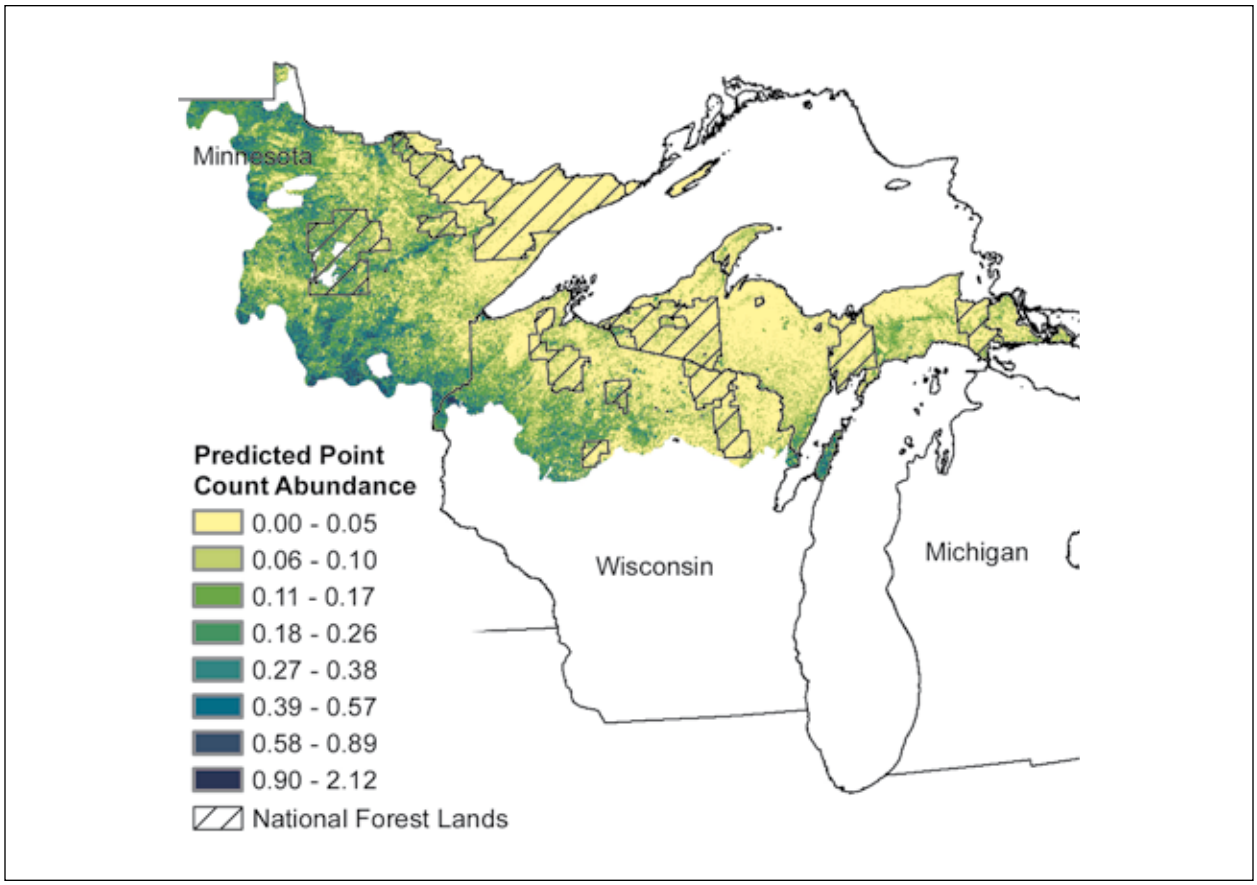
Migration: Long-distance



Trends for yellow warbler in three national forests, 1995–2010



Percent perfect indication of habitat association for yellow warbler where at least one bird was observed once during the decade (2001–2010; n=601 at 178 points)



Predicted relative abundance (number of birds per 10-minute count) of yellow warbler for the western Great Lakes region

Yellow-bellied Flycatcher YBFL

Empidonax flaviventris



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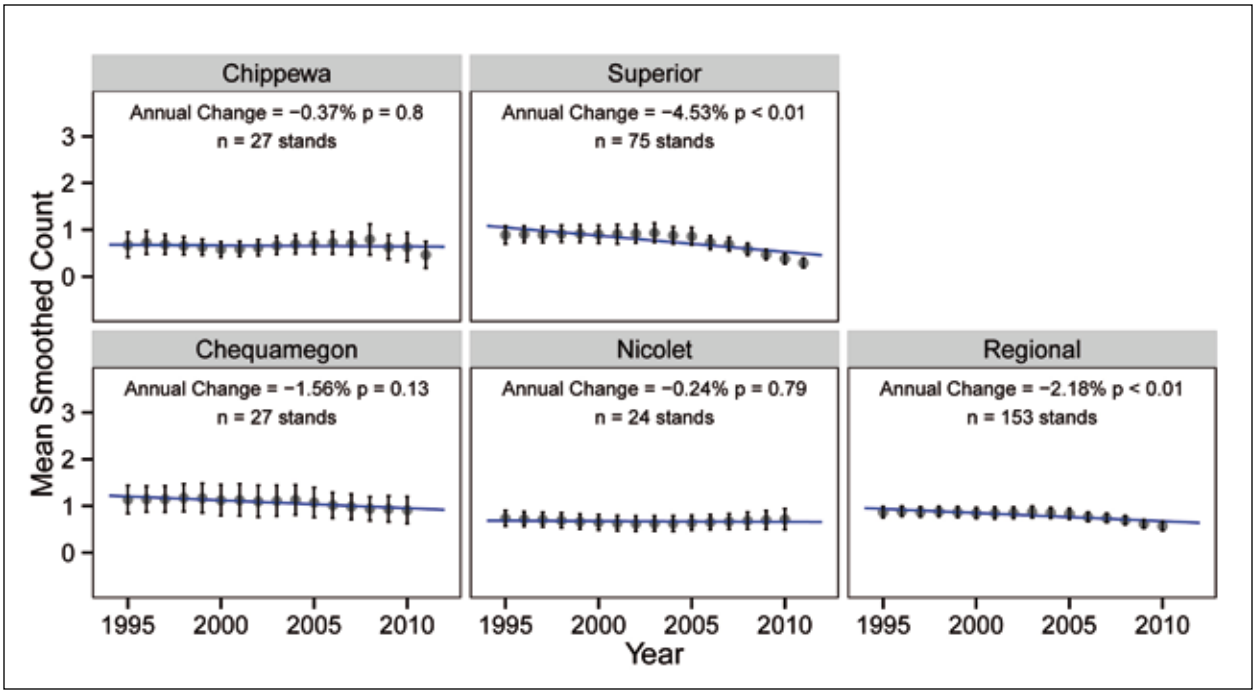
Guild Information

Habitat: Lowland conifer forests

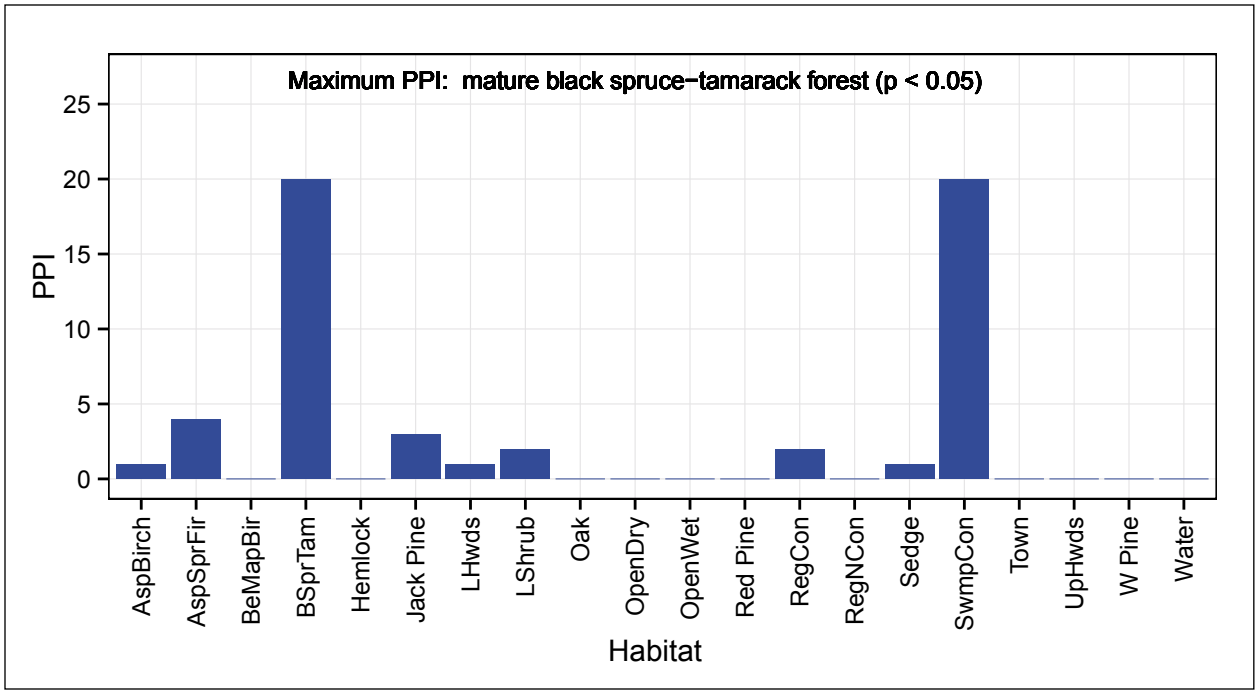
Foraging type: Flycatcher

Nest site: Ground

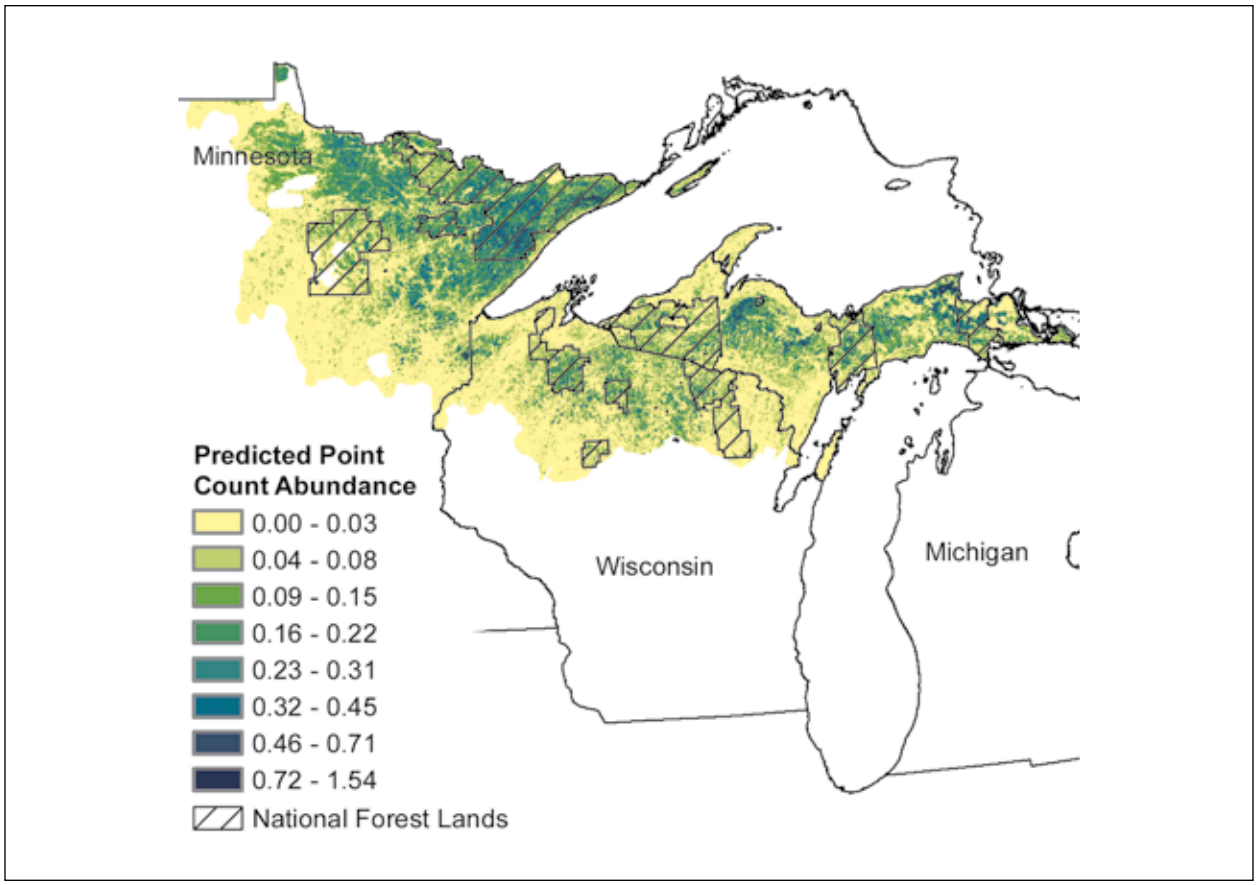
Migration: Long-distance



Trends for yellow-bellied flycatcher in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for yellow-bellied flycatcher where at least one bird was observed once during the decade (2001–2010; n=2,178 at 532 points)



Predicted relative abundance (number of birds per 10-minute count) of yellow-bellied flycatcher for the western Great Lakes region

Yellow-bellied Sapsucker YBSA
Sphyrapicus varius



Photo by Jon Swanson, used with permission.

Guild Information

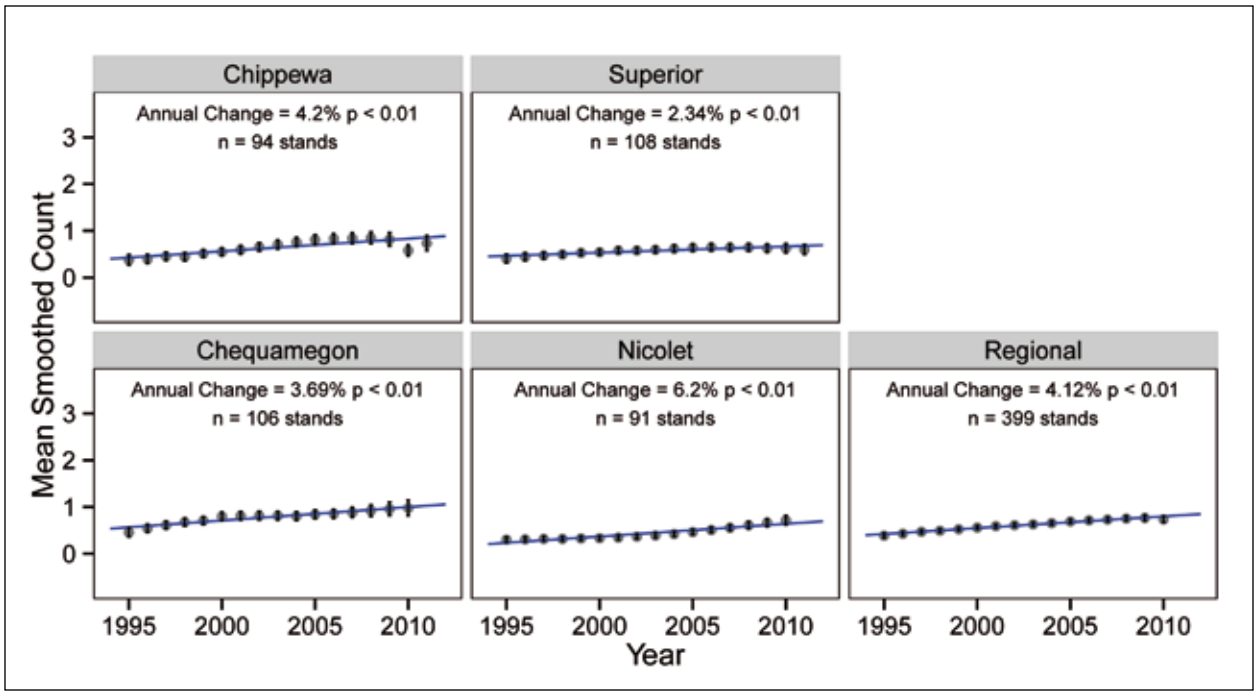
Habitat: Hardwood forests, variety of other forest types

Foraging type: Bark gleaner

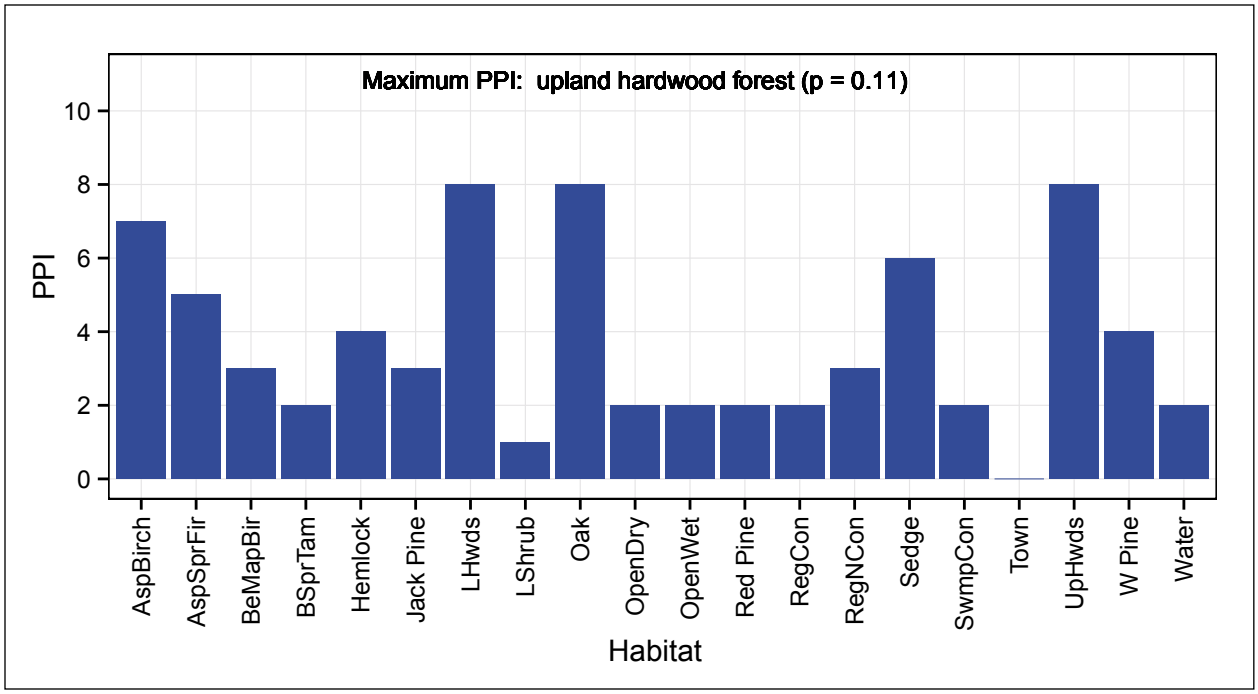
Nest site: Cavity

Migration: Short-distance

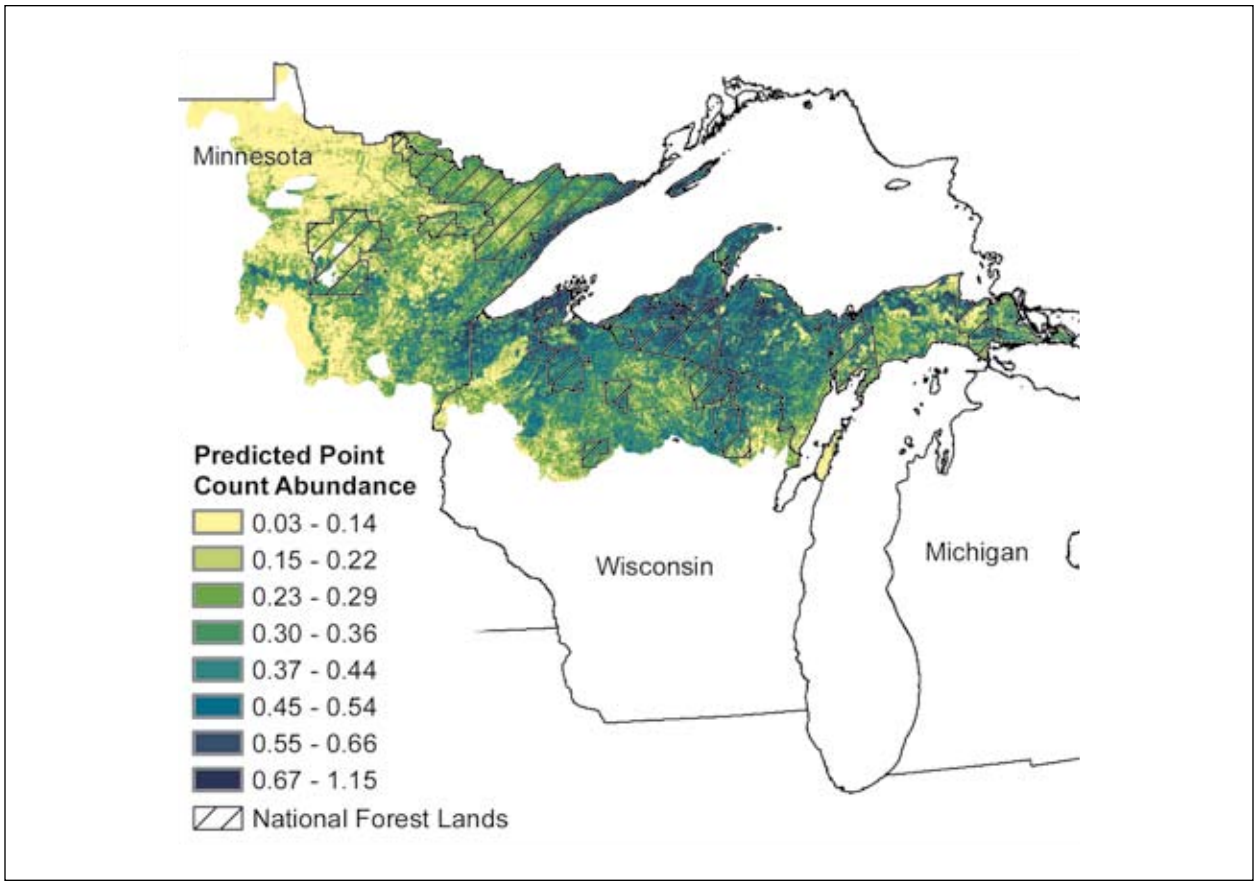
Notes: PPI analysis was not significant for this species, which is predominantly a resident of deciduous forests. Its irregular wood-drilling pattern is conspicuous and audible from a fairly long distance. Individuals recorded at open habitat (OpenWet, Sedge, and Water) points probably were transients (flyovers) or birds heard from nearby forest habitats.



Trends for yellow-bellied sapsucker in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for yellow-bellied sapsucker where at least one bird was observed once during the decade (2001–2010; n=4,834 at 1,282 points)



Predicted relative abundance (number of birds per 10-minute count) of yellow-bellied sapsucker for the western Great Lakes region

Yellow-rumped Warbler YRWA

Setophaga coronata



Photo by Art Overcott, used with permission.

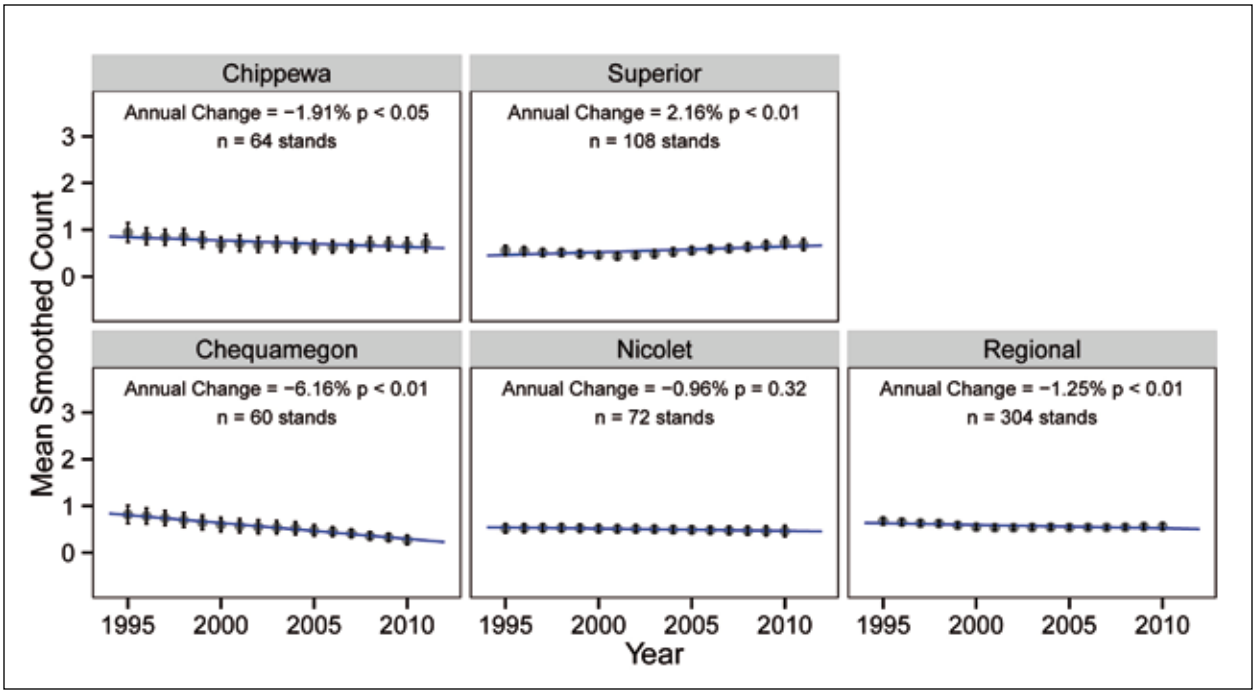
Guild Information

Habitat: Forests, especially black spruce-tamarack and other conifer forest types

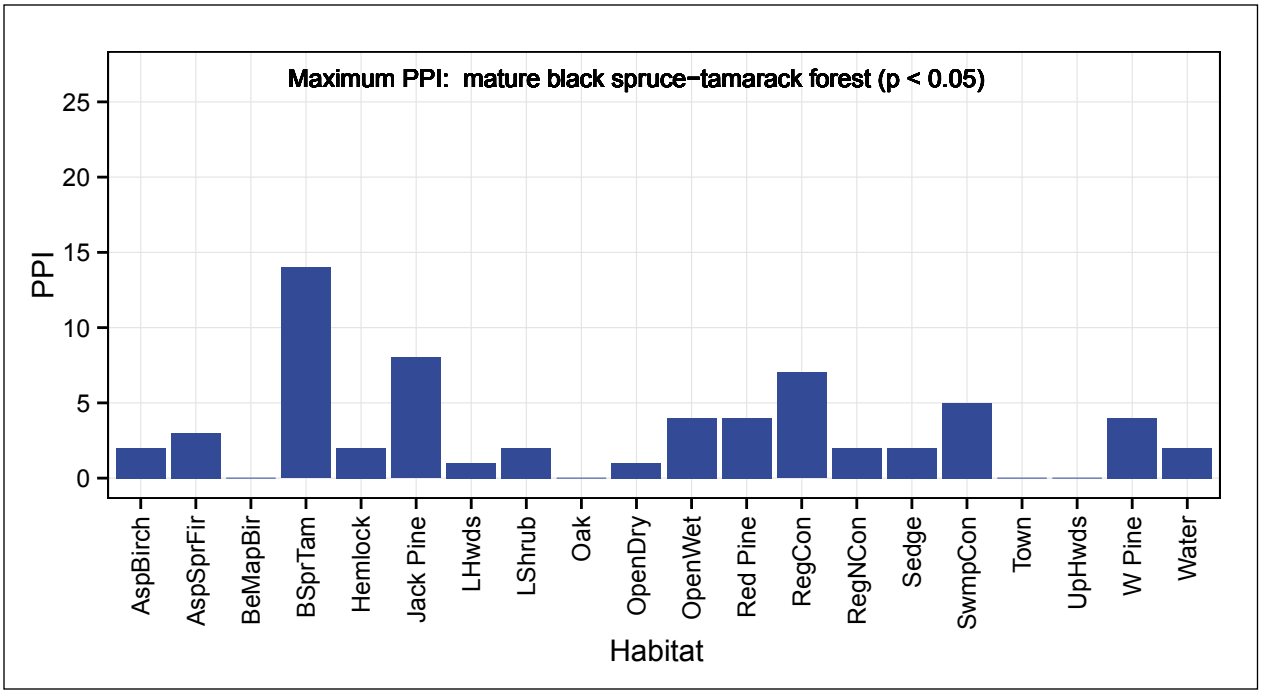
Foraging type: Foliage gleaner

Nest site: Canopy

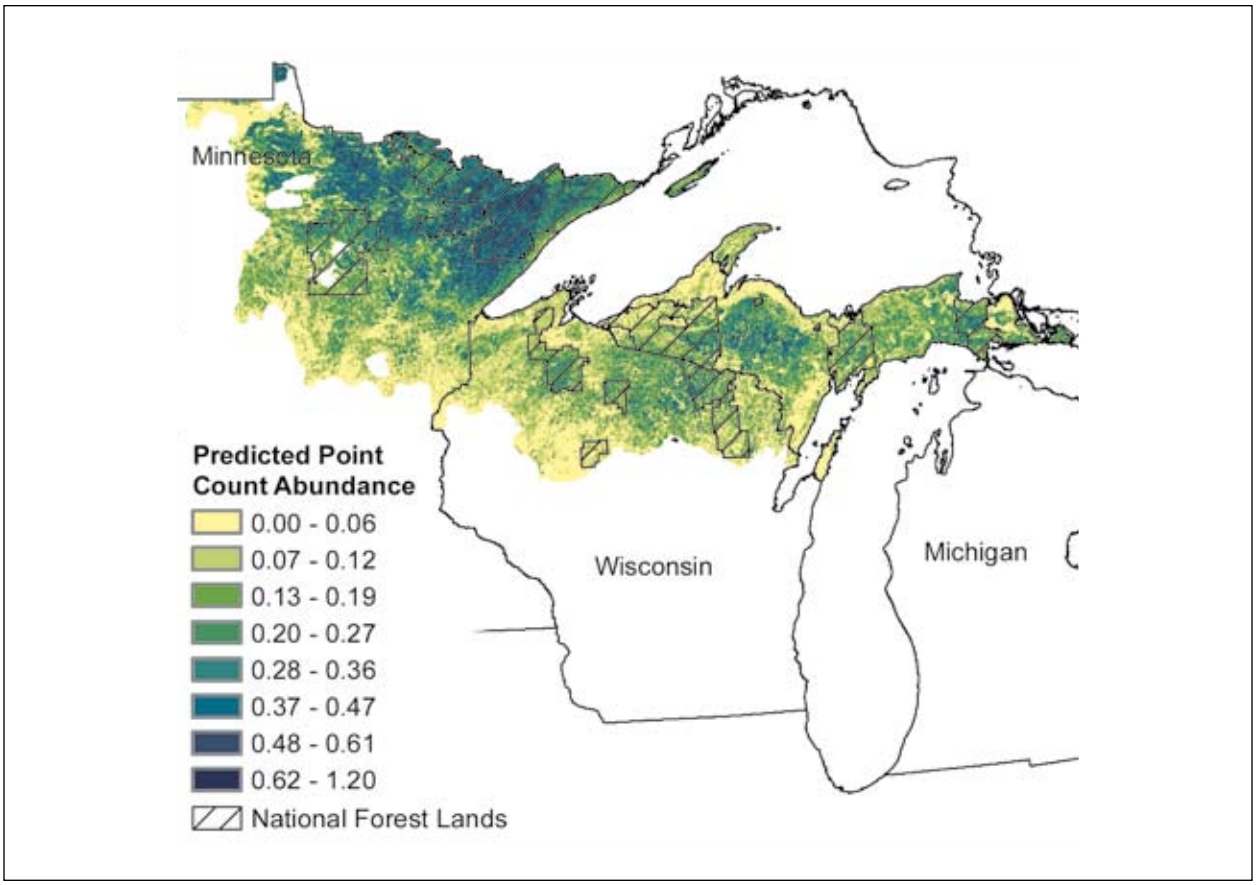
Migration: Short-distance



Trends for yellow-rumped warbler in four national forests individually and combined (regional), 1995–2010



Percent perfect indication of habitat association for yellow-rumped warbler where at least one bird was observed once during the decade (2001–2010; n=2,964 at 944 points)



Predicted relative abundance (number of birds per 10-minute count) of yellow-rumped warbler for the western Great Lakes region

Yellow-throated Vireo YTVI

Vireo flavifrons



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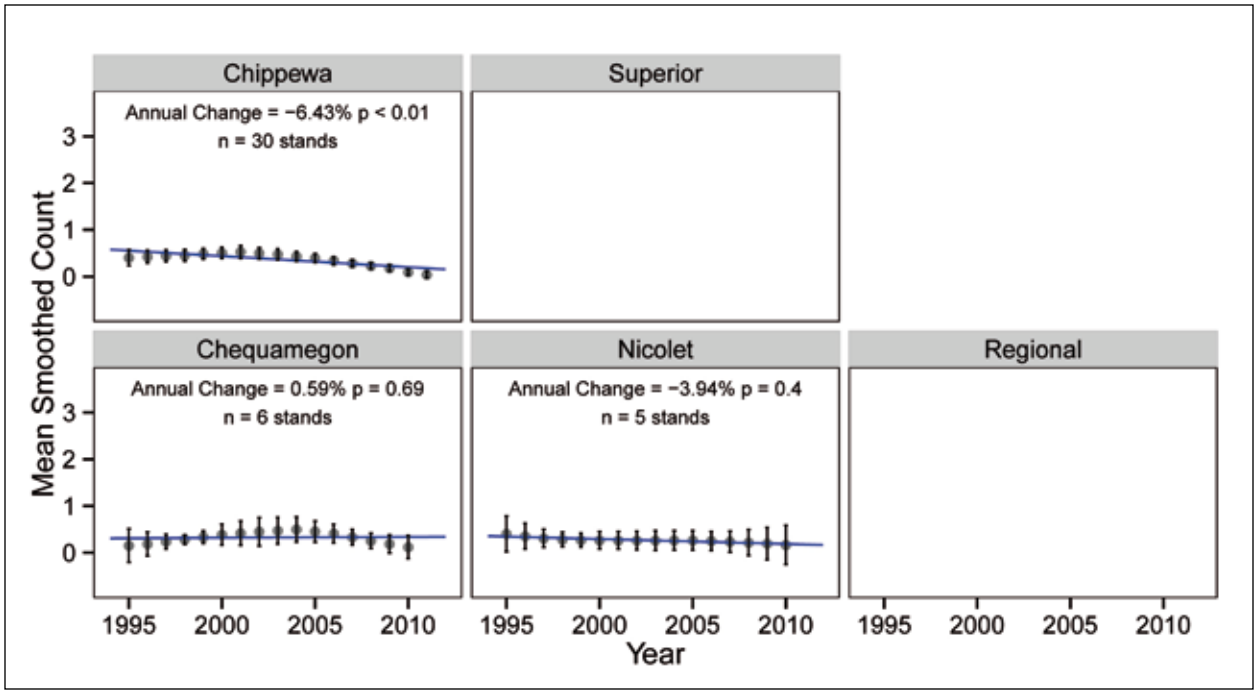
Guild Information

Habitat: Oak forests

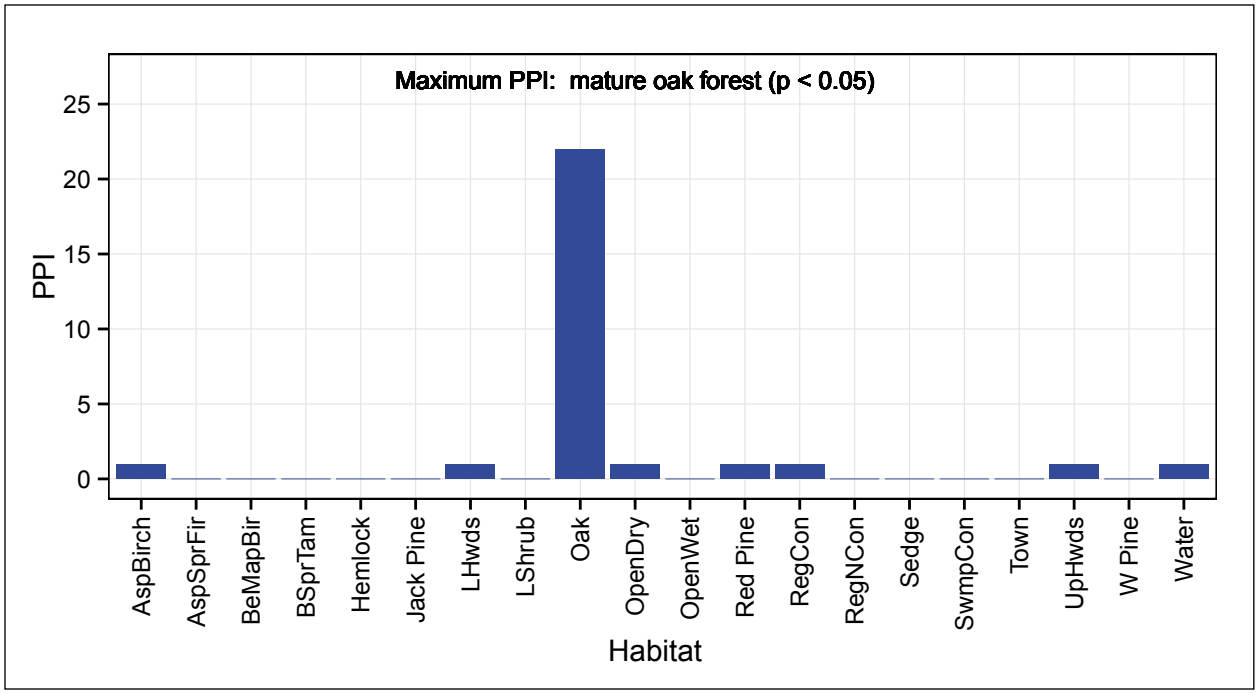
Foraging type: Foliage gleaner

Nest site: Canopy

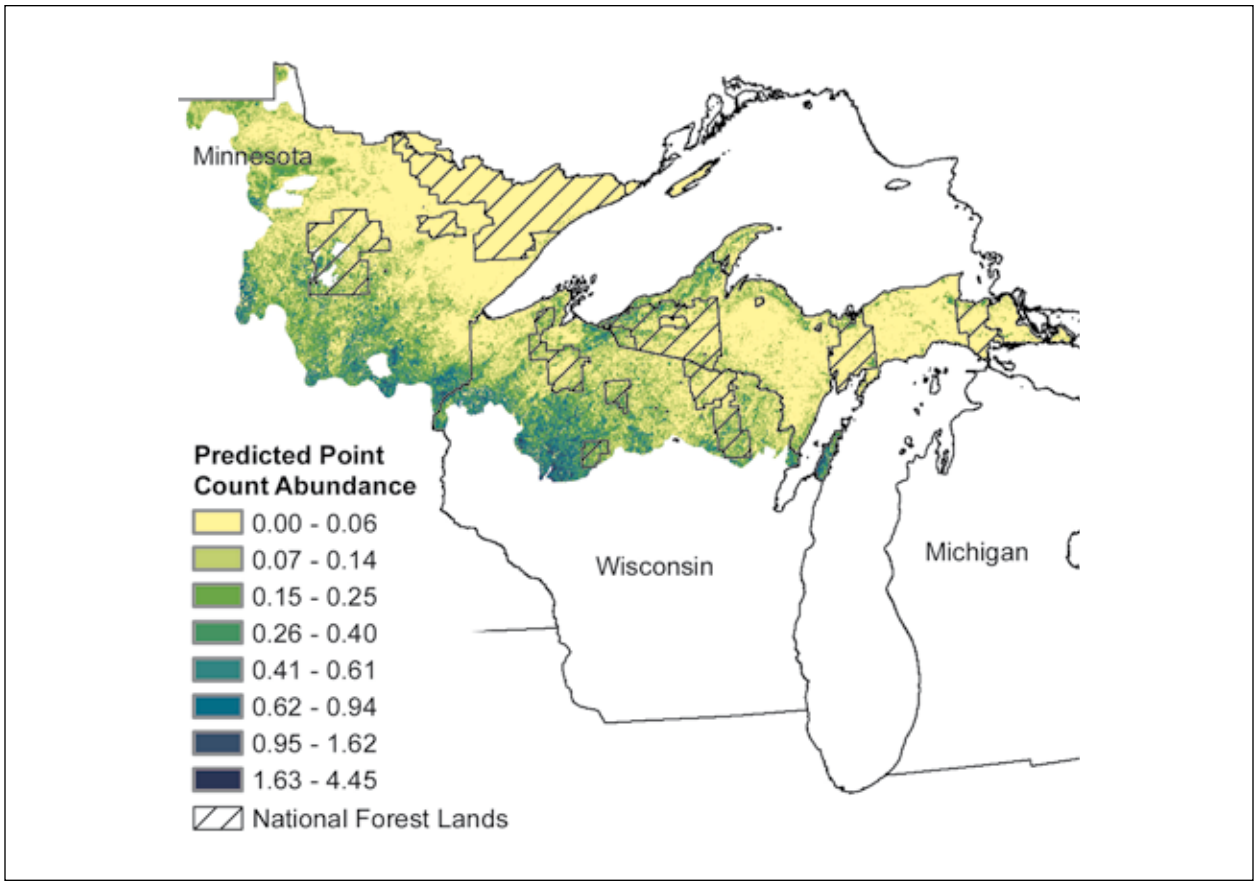
Migration: Long-distance



Trends for yellow-throated vireo in three national forests, 1995–2010



Percent perfect indication of habitat association for yellow-throated vireo where at least one bird was observed once during the decade (2001–2010; n=443 at 222 points)



Predicted relative abundance (number of birds per 10-minute count) of yellow-throated vireo for the western Great Lakes region

APPENDIX 6

Participants in Bird Counts in the Cheqamegon, Chippewa, Superior, and Nicolet National Forests, 1988–2011

Chequamegon, Chippewa, and Superior National Forests

Josh Bednar	Tony Eucolono	Jason Lange	Tom Ruffo
Lars Benson	Tim Fenske	Carly Lapin	Jenny Rukavina
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Brad Bolduan	Craig Fosdick	Jim Lind	Karen Schitek
Chris Brown	David Grosshuesch	Daniel Lipp	Lisa Schulte
Chris Butler	Michelle Grzenda	Angelo Losito	Heidi Seeland
James Cameron	Mary Hammer	Nathan McNett	Trina Stauff
Nate Carle	Terry Hams	Brandon Martinson	Tiffany Thornhill
Carol Carter (Pearson)	Nate Hanke	Tammie Martinson	Jim Tietz
Bret Chapel	JoAnn Hanowski	Chris Merkord	Mike VanSteppen
Jessica Chatterton	Cal Harth	Ryan Merrill	Debbie Waters
Daren Cohen	Rita Hawrot	Chuck Meyer	Katie Weakland
Gaea Crozier	David Hedeen	Jen Milan	John Wharton
Lynette Dagenais	Lars Higdon	Don Mitchell	Heather Wilson
Dawn Doering	Dale Kane	Kent Montgomery	Katie Winkler
Paul Dolan-Linne	Courtney Kerns	Michael North	Fred Wong
Kara Donohue	Wendy Jess	Diane Ostrowski	
Matt Dufort	Andy Jones	Kelly Perkins	
Joan Elias	Tom Jones	Doug Powless	

Nicolet National Forest

Tara Abfalter	Tim Anderson	Sylvia Barbarich	Jeffery Baughman*
Lynn Ackley*	Herbert Arndt	Maria Barlow	Jim Baughman*
Ron Ackley*	Ryan Atwater*	Amanda Barnes	Matt Baumann
Jean Adams	Tom Babcock	Dave Barnhill	Peter Beairl
Kathleen Adams	Carolina Bacelis	Dan Barr	Richard Beier
Susanne Adams*	Bruce Bacon	Betsy Bartelt	Stephanie Beilke*
Carol Anderson*	Cindy Baeirl	Mary Basche	Jeff Bell*
Mike Anderson	Peter Baeirl	Adam Baucknecht	Kris Belling*
Scott Anderson*	Quan Banh	Angela Bauer-Dantoin	Lindsey Bender

*group leader/bird expert

(continued on next page)

Nicolet National Forest (continued)

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Lynne Carpenter*
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Andrea Szymczak
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Chris Tucci
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Nick Walton*
Chloe Warpinski
Todd Warren
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Brian Wehausen
Edward Weidner*
Norman Weiland
Jesse Weinzinger

*group leader/bird expert

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Kurt Westebrook	Mark Wolf	Robert Yaeger	Maria Zimmer
Jim Weyers*	Peter Wolter	Roger Yaeger	Olivia Zimmer
Jake Wickman	Chris Wood*	Mike Younkle	Elizabeth Zimmerman*
Katie Wieselman	Tyler Wood	Ron Zabel	Libby Zimmerman
Virginia Wiggen	John Woodcock	Gary Zimmer*	Andrew Zovnic*
Colleen Wisinki	Julie Woodcock	Heather Zimmer	John Zovnic

*group leader/bird expert

Niemi, Gerald J.; Howe, Robert W.; Sturtevant, Brian R.; Parker, Linda R.; Grinde, Alexis R.; Danz, Nicholas P.; Nelson, Mark D.; Zlonis, Edmund J.; Walton, Nicholas G.; Gnass Giese, Erin E.; Lietz, Sue M. 2016. **Analysis of long-term forest bird monitoring data from national forests of the western Great Lakes Region.** Gen. Tech. Rep. NRS-159. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 322 p.

Breeding bird communities in forests of the western Great Lakes region are among the most diverse in North America, but the forest environment in this region has changed dramatically during the past 150 years. To address concerns about loss of biodiversity due to ongoing forest harvesting and to better inform forest planning, researchers have systematically monitored forest birds in the region for more than two decades. This report summarizes forest bird data collected from 1995 through 2011 in four national forests of the western Great Lakes region (the Chequamegon and Nicolet in Wisconsin and the Chippewa and Superior in Minnesota). Of 187 bird species detected, 127 nest in forest or woodland habitats. Population trends were evaluated by national forest for 98 of the forest bird species, and across all 4 national forests for 49 species. Numbers of most species were stable or increased within and across the national forests during these 17 years. Habitat analyses are presented for 123 forest bird species and are discussed in the context of concurrent trends in climate, land cover, disturbance, and forest structure. Results suggest that different migratory guilds showed different responses to the regional warming during this period. Eight species that were in decline or otherwise of special concern were selected to demonstrate how knowledge gained from analysis of their populations, habitat, and life history could supplement current literature to inform regional conservation management. Ways to improve or optimize the bird monitoring methods are suggested. This report is the most comprehensive compilation to date of quantitative information on the population trends, habitat use, and community assemblages of forest breeding birds of this region.

KEY WORDS: Breeding bird, bird assemblage, Laurentian forest, population trend, habitat affinity, forest management, conservation, disturbance

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