Sixteen Years of Habitat-based Bird Monitoring in the Nicolet National Forest[1]

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Abstract

The 16-year-old Nicolet National Forest Bird Survey is the longest-running volunteer monitoring program on any U.S. national forest. Every year, teams of volunteer observers led by at least one expert with proven field experience sample more than 250 permanent points during the second weekend in June. Altogether 512 points are monitored, approximately half during a given year. Observers use a standard 10-minute point count, separated into three time intervals (0-3 min, 3-5 min, 5-10 min) and three bird-to-observer distance categories (<50 m, 50-100 m, >100m). Since 1989, 75-100 volunteers have participated annually. The initial objective was to quantify the relative abundances, patterns of habitat use, and geographic distributions of breeding birds in the 661,400-acre national forest. The longevity of the survey now permits analyses of regional population trends and more detailed modeling of bird-habitat associations. Results are used with GIS data to predict bird distributions across the region. Data from the survey are available at http://www.uwgb.edu/birds/nnf/. Important findings include: 1) species assemblages sampled by the Nicolet National Forest Bird Survey are different from those monitored by the North American Breeding Bird Survey; 2) an alarmingly large number of species (45) have shown significant declines, compared with only seven species that have shown significant increases; 3) data from the point counts can be used to identify species-specific habitat associations and geographic distribution patterns; and 4) GIS tools can be used to effectively model the distribution of many species across the entire forest. Production of a custom CD of local bird songs has provided an incentive for participation and has helped cultivate a sustained base of expertise among volunteer observers in this regional bird monitoring program.

Key words: bird habitat associations, Breeding Bird Survey, GIS landscape analysis, Nicolet National Forest, population trends, Wisconsin.

Introduction

The North American Breeding Bird Survey (BBS) provides a foundation for large scale analyses of bird population trends in the United States, but the program is not designed to answer spatially explicit questions about local bird distributions or bird-habitat associations (Robbins et al. 1986). Maps presented on the U.S.G.S. Breeding Bird Survey web site (Sauer et al. 2001) and maps derived by Price et al. (1995) provide a coarse image of bird distributions in North America, with little meaningful information at scales of 100 km^2 or perhaps even 10,000 km^2. Nevertheless, bird distributions at these local scales are of great interest to land managers who must determine the impacts of resource extraction, habitat management and other human activities.

In this paper we describe a local bird monitoring program consisting of annual counts at more than 500 permanent points in the eastern unit of the Chequamegon-Nicolet National Forest. Our objectives are 1) to determine how such a program differs from the larger scale BBS, and 2) to illustrate some applied research that can be derived from the results.

Study Area

The Nicolet National Forest is the eastern administrative unit of the Chequamegon-Nicolet National Forest, covering nearly 661,400 acres in Florence, Forest, Langlade, Oconto, Oneida, and Vilas Counties of northeastern Wisconsin. The landscape consists of a complex, glacially-derived mosaic of moraines, drumlins, outwash plains, depressions, and scoured bedrock ridges (Albert 1995). More than 1100 lakes, 400 spring-fed ponds, and extensive lowlands add significant diversity to the predominantly forested uplands. Because of its value as breeding habitat for neotropical migratory birds, the forest is recognized as an Important Bird Area by the American Bird Conservancy (http://www.abcbirds.org/iba/aboutiba.htm).

The presettlement vegetation of the Nicolet National Forest consisted mainly of old growth northern hardwoods forest dominated by sugar maple (*Acer saccharum*), eastern hemlock (*Tsuga canadensis*), basswood (*Tilia americana*), yellow birch (*Betula alleghaniensis*), and white pine (*Pinus strobus*), dissected by several other important vegetation types including lowland conifer forests dominated by black spruce (*Picea mar-*

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[1]A version of this paper was presented at the **Third International Partners in Flight Conference, March 20-24, 2002, Asilomar Conference Grounds, California.**

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iana), balsam fir (*Abies balsamea*), tamarack (*Larix laricina*), or northern white cedar (*Thuja occidentalis*); lowland hardwoods of black ash (*Fraxinus nigra*) and American elm (*Ulmus americana*); dry upland forests with oaks (*Quercus* spp.), jack pine (*Pinus banksiana*), and red pine (*Pinus resinosa*); and successional forests with aspen (*Populus* spp.) and white birch (*Betula papyrifera*). Aspen and birch forests cover a much larger area today (approximately 25 percent of the forest) than they did prior to logging in the 1800's and early 1900's (Frelich 1995); today, only northern hardwoods and mixed northern hardwoods/conifers (approximately 39 percent of the forest area) are more extensive than aspen/ birch forest. Lowland conifers cover an additional 18 percent of the forest area (Great Lakes Ecological Assessment 1997). Like other national forests in the western Great Lakes region, a significant amount of land within the proclamation boundary of the Nicolet National Forest is privately owned, much of it consisting of non-forested agricultural uplands.

Nicolet National Forest Bird Survey

In June 1987, U.S. Forest Service biologists, scientists from the University of Wisconsin-Green Bay, and members of the Northeastern Wisconsin Audubon Society established 65 points in the southern two districts (Lakewood and Laona) of the Nicolet National Forest, and the following year 116 points were established in the northern districts (Eagle River and Florence). Additional points were added during 1989 and 1990, yielding the current array of 151 points in the southern half of the forest and 161 points in the northern half. These "habitat-based points" represent 19 major vegetation or landform types that are prominent in the forest and recognized by the U.S. Forest Service land classification database (*fig. 1*). Points were selected according to two critera: 1) continuous area of the target habitat and 2) accessibility (Howe et al. 1994). Large continuous areas that could be reached within about 200 m from a road were selected whenever possible. The selection process also took into account sampling logistics; points were clustered into groups of 5-7 to minimize travel time. In all cases points were located at least 500 m from any other point. Although the selection process was not random, it provides a reasonably extensive distribution of sites across the forest. These "habitat points" are located off roads, typically 100 - 200 m within the target habitat. A permanent marker (wooden post) was established at each point and at the road access point from which explicit directions are given. Global positioning system (GPS) coordinates have been documented for all of these points.

Beginning in 1992, additional survey points were selected from randomly determined locations across the forest. A straight line was projected from randomly selected coordinates to the nearest road. This constrained random selection process yielded 200 "roadside points," 100 in the southern half of the forest and 100 in the northern half.

Between 1992 and 2001 the 512 points (312 “habitat-based” points and 200 roadside points) were visited during alternate years; approximately half were sampled in the southern half of the forest during one year, while the other half were sampled in the northern half of the forest during the following year.

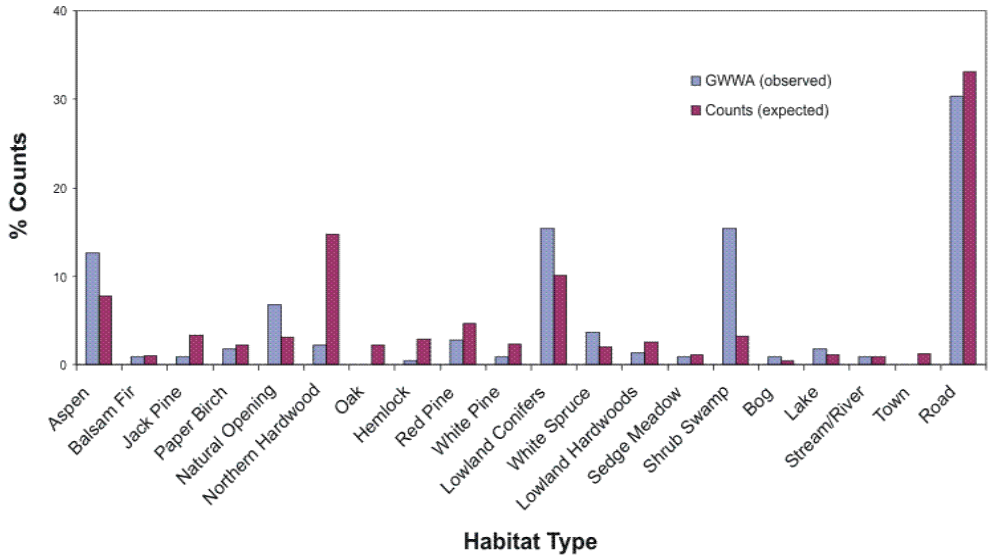

Figure 1— Habitat associations of Golden-winged Warbler from 1987-2001 in the Nicolet National Forest using 19 habitat categories, in addition to random road points. Dark bars represent expected frequency of occurrence based on the number of points sampled in each category (i.e., assuming random distribution among habitats). Light bars represent observed frequency of Golden-winged Warbler in that category.

Six North American Breeding Bird Survey (BBS) routes are located in or near the boundaries of the Nicolet National Forest (Sauer et al. 2001): Amberg, Crandon, Eagle River, Hollister, LandOLakes, and Popple River. Each route consists of 50 roadside points located ½ mi apart. In all but one case at least some part of the 24.5 mi route falls within the boundary of the Nicolet National Forest.

Methods

The Nicolet National Forest Bird Survey (NNFBS) is conducted during a single weekend in early June. Standard, 10-minute point counts (Ralph et al. 1995, Howe et al. 1997) are conducted at each point by teams of observers led by at least one "expert" who is experienced in the auditory identification of birds in northern Wisconsin forests. The bird survey has attracted many of Wisconsin's most skilled birders, and the team approach helps ensure high quality field data and, at the same time, helps groom expertise among less skilled participants. A custom CD with recordings of Nicolet National Forest bird species was prepared by the Cornell Laboratory of Ornithology (funded by the U.S. Forest Service) to help participants learn and practice bird identifications.

Point counts are conducted between sunrise and 9:00 a.m. All birds seen or heard are recorded on standardized forms, with separate fields for distance from observer (0-50 m, 50-100 m, >100 m) and for time intervals when the bird was first observed (0-3 min, 3-5 min, 5-10 min). Birds flying over the habitat but not landing are distinguished by a standard code. In contrast, BBS routes are sampled with 3-min point counts at each of the 50 stops. For both the NNFBS and the BBS, all birds seen or heard at each stop are recorded on standardized forms. In order to compare the species composition of BBS samples with the species composition from the NNFBS, we transformed the count data to relative abundance among all species in the respective samples. BBS data included all available counts between 1966 and 2001 (*table 1*).

Ten groups of bird samples (northern NNFBS habitat-based sites, northern roadside points, southern habitat-based points, southern roadside points, and data from the six BBS routes) were compared using a nonparametric ordination technique known as nonmetric multidimensional scaling (McCune and Grace 2002). This iterative procedure maps the groups of samples in two or three dimensional shape based on their similarity in bird species composition. The algorithm optimizes the configuration so that groups with the most similar bird species compositions are located nearest one another. The software package PC-Ord was used to perform the calculations (McCune and Mefford 1999).

We used another nonparametric technique, Spearman rank correlation (Conover 1999), to test for significance of species abundance trends in the NNFBS between 1989 and 2001. Like nonmetric multidimensional scaling, this test requires fewer assumptions than standard methods (i.e., linear regression analyses and their analogs) and the results are simpler to understand. The trend analyses based on rank correlation are presumably more conservative than the route regression method used to identify trends in the BBS data (Sauer et al. 2001). Systat Version 10 was used for the statistical calculations.

Predictive models for mapping expected bird distributions in the Nicolet National Forest are described in detail by Roberts (2001). He used logistic regression (Systat, Version 10) to predict species presence/absence given two sets of independent variables: local variables measured directly at the point (e.g., mean canopy height, shrub density, etc.); and landscape variables derived from the U.S. Forest Service GIS data-

Table 1— *Number of counts (3-minute unlimited-radius point counts for BBS, 10-minute unlimited-radius counts for NNF) and number of geographic points used in comparison of bird surveys from the North American Breeding Bird Survey (BBS) and Nicolet National Forest Bird Survey (NNF).*

Dataset	No. years*	No. points (max.)**	Total no. counts
NNF Habitat Sites North	7	164	1096
NNF Habitat Sites South	8	152	1125
NNF Road Sites North	5	100	586
NNF Road Sites South	5	100	507
BBS (Amberg)	22	50	1100
BBS (Crandon)	28	50	1400
BBS (Eagle River)	34	50	1700
BBS (Hollister)	31	50	1550
BBS (LandOLakes)	29	50	1450
BBS (Popple River)	33	50	1650

*NNF points are sampled every other year; some road sites were sampled annually during the 1990's.
**several sites were dropped due to access problems or presence of Northern Goshawk nest.

base of the Nicolet National Forest, augmented by published land cover data from non-federal lands (WISCLAND 1998). "Presence" of a species was defined as the occurrence of at least one individual in two or more years during the five point counts at each site between 1992 and 2001. The local variables were further divided into a structure subset (e.g., average basal area of canopy trees, total shrub cover, etc.), and a species composition subset (percent cover of each tree species in the canopy and four subcanopy layers), and finally all variables were combined to examine the relative utility of the different scales of habitat characterization.

Results

Observers have recorded 178 bird species during the first 15 years of the NNFBS, compared with 142 species on the six nearby BBS routes over a much longer time period (1966-2001). The BBS data include a larger number of point counts, but the total observation time (26,250 min) is somewhat less than in the NNF Bird Survey (33,140 min) because the duration of BBS counts (3 minutes per stop) is shorter than the 10-min counts in the NNF.

The greater number of species in the NNF Bird Survey can be traced to the broader geographic and ecological coverage. Of the 36 species observed in the NNFBS but not on the BBS routes, 19 (e.g., American Black Duck, *Anas rubripes*; American Coot, *Fulica atra*; Marsh Wren, *Cistothorus palustris*; Ring-necked Duck, *Aythya collaris*; Virginia Rail, *Rallus limicola*; and Willow Flycatcher, *Empidonax traillii*) are associated with lakes and wetlands, habitats that are not well represented along roads. The NNF Bird Survey includes six sites in or along lakes, plus six in sedge meadows and 16 in shrub swamps. Other species recorded in the NNF Bird Survey but not on the BBS routes include several species of owls (e.g., Eastern Screech-Owl, *Otus asio*; Northern Saw-whet Owl, *Aegolius acadicus*) and species that typically occur in remote habitats such as conifer bogs (e.g., Black-backed Woodpecker, *Picoides arcticus*; Golden-crowned Kinglet, *Regulus satrapa*) and forest interior (e.g., Northern Goshawk, *Accipiter gentilis*). No species was observed on the BBS routes that was not also recorded in the NNF Bird Survey counts between 1987-2001.

The ordination (nonmetric multidimensional scaling) of bird samples from the BBS routes and NNF Bird Survey reveals comprehensive differences in species composition between these two projects and illustrates year-to-year variation in the NNF Bird Survey results (*fig. 2*). Note that the ordination gives results for groups of censuses (habitat-based sites vs. random roadside sites) for each year of the NNF Bird Survey, but combined species assemblages over all years for the BBS routes. The independent variables were relative abundances of each species in all counts combined (i.e., proportions of all individuals belonging to each bird species), thereby standardizing the results among data sets that included different numbers of point counts.

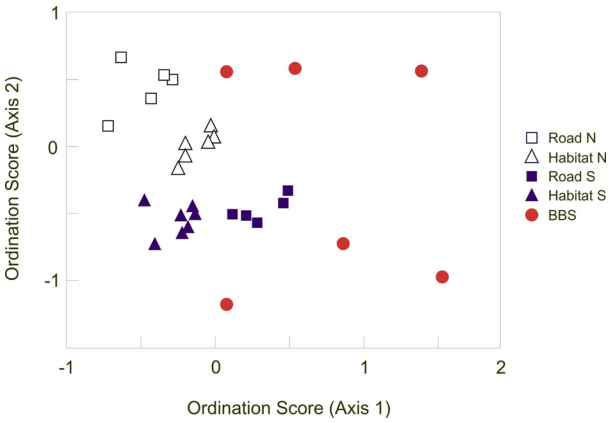

Figure 2— Ordination of bird survey data sets from the Nicolet National Forest and nearby Breeding Bird Survey (BBS) routes. Nicolet National Forest Bird Survey data sets include habitat-based sites in the northern half (Habitat N) and southern half (Habitat S) of the forest and random roadside points in the northern half (Road N) and southern half (Road S). In these cases, cumulative data for all points in a given year were plotted: 1990, 1992, 1994, 1996, 1998, and 2000 for the northern half and 1989, 1991, 1993, 1995, 1997, 1999, and 2001 for the southern half. BBS data sets (see *Table 1*) include all bird records between 1966-2001. For each data set, abundances were relativized as percentages of all birds counted. Ordination was calculated with the method of nonmetric multidimensional scaling using Sorensen's Index as the multivariate distance measure (McCune 2001).

Not only are bird assemblages in the NNF Bird Survey consistently different from those documented by the BBS, but geographic subsets within the NNF Bird Survey (road sites vs. habitat-based sites and northern half of the forest vs. southern half) also are distinct from one another (*fig. 2*). Ovenbird (*Seiurus aurocapillus*) was the most abundant species in all of the NNF data sets, followed in all cases by Red-eyed Vireo (*Vireo olivaceus*). This relationship was reversed in two of the six BBS routes, and in one (Eagle River) Ovenbird was the third most abundant species, after Red-eyed Vireo and American Crow (*Corvus brachyrhynchos*) (*table 2a*).

Table 2a— *Species that were most abundant in the Nicolet National Forest Bird Survey (NNF) between 1987-2001 compared with their relative abundances in six nearby North American Breeding Bird Survey (BBS) routes between 1966-2000. Numbers indicate relative abundance, the proportion of all individuals that belonged to that species.*

Common name	Scientific name	NNF	BBS	Difference
Ovenbird	*Seiurus aurocapillus*	0.108	0.094	0.014
Black-throated Green Warbler	*Dendroica virens*	0.031	0.020	0.011
Great Crested Flycatcher	*Myiarchus crinitus*	0.010	0.0006	0.009
Blue Jay	*Cyanocitta cristata*	0.030	0.021	0.009
Cedar Waxwing	*Bombycilla cedrorum*	0.023	0.015	0.008
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	0.028	0.021	0.007
Nashville Warbler	*Vermivora ruficapilla*	0.033	0.026	0.006
Hermit Thrush	*Catharus guttatus*	0.028	0.023	0.005
Canada Goose	*Branta canadensis*	0.007	0.002	0.005
Common Raven	*Corvus corax*	0.015	0.010	0.005
Red-winged Blackbird	*Agelaius phoeniceus*	0.017	0.013	0.004
Northern Parula	*Parula americana*	0.006	0.002	0.004
Blackburnian Warbler	*Dendroica fusca*	0.007	0.004	0.004
Scarlet Tanager	*Piranga olivacea*	0.009	0.006	0.004
Golden-crowned Kinglet	*Regulus satrapa*	0.004	0.000	0.004
Common Yellowthroat	*Geothlypis trichas*	0.014	0.011	0.003
Brown Creeper	*Certhia americana*	0.005	0.001	0.003
Eastern Wood Pewee	*Contopus virens*	0.013	0.010	0.003
Least Flycatcher	*Empidonax minimus*	0.025	0.022	0.003
Winter Wren	*Troglodytes troglodytes*	0.013	0.010	0.003

Table 2b— *Species that were most abundant in the North American Breeding Bird Survey (BBS) routes between 1966-2000 compared with their relative abundances in the Nicolet National Forest Bird Survey (NNF) between 1987-2001. Numbers indicate relative abundance, the proportion of all individuals that belonged to that species.*

Common name	Scientific name	NNF	BBS	Difference
Chipping Sparrow	*Spizella passerina*	0.015	0.033	-0.018
American Robin	*Turdus migratorius*	0.043	0.058	-0.015
European Starling	*Sturnus vulgaris*	0.004	0.017	-0.013
Red-eyed Vireo	*Vireo olivaceus*	0.081	0.093	-0.012
American Crow	*Corvus brachyrhynchos*	0.031	0.042	-0.011
Cliff Swallow	*Hirundo pyrrhonota*	0.002	0.012	-0.010
Chestnut-sided Warbler	*Dendroica pensylvanica*	0.028	0.037	-0.008
Song Sparrow	*Melospiza melodia*	0.018	0.025	-0.007
Common Grackle	*Quiscalus quiscula*	0.005	0.010	-0.006
Barn Swallow	*Hirundo rustica*	0.001	0.006	-0.005
Brewer's Blackbird	*Euphagus cyanocephalus*	0.0003	0.005	-0.005
Indigo Bunting	*Passerina cyanea*	0.014	0.018	-0.004
Yellow-rumped Warbler	*Dendroica coronata*	0.011	0.014	-0.003
Brown-headed Cowbird	*Molothrus ater*	0.006	0.009	-0.003
House Sparrow	*Passer domesticus*	0.001	0.004	-0.003
Savanna Sparrow	*Passerculus sandwichensis*	0.001	0.004	-0.003
Bobolink	*Dolichonyx oryzivorus*	0.001	0.004	-0.003
Veery	*Catharus fuscescens*	0.012	0.015	-0.003
Pine Warbler	*Dendroica pinus*	0.004	0.006	-0.003
Eastern Phoebe	*Sayornis phoebe*	0.003	0.005	-0.003

Birds of open country and disturbed habitats tend to be more common in the BBS than in the NNF Bird Survey (*table 2b*). Chipping Sparrow, American Robin, European Starling, American Crow, and Common Grackle are among the species that are relatively more abundant in the BBS than in the NNF Bird Survey. Species with the opposite relationship (i.e., relatively more common in the NNF Bird Survey) include Ovenbird, Black-throated Green Warbler, Great Crested Flycatcher, Rose-breasted Grosbeak, Hermit Thrush, Blackburnian Warbler, Scarlet Tanager and other species that are characteristically found in extensive or mature forests. Within the NNFBS, north-south differences were caused by known geographic gradients in species abundances (e.g., Great Crested Flycatcher, House Wren, Baltimore Oriole, and others more common in south; Golden-crowned Kinglet, Black-throated Green Warbler, Black-throated Blue Warbler, and others more common in north). Roadside vs. habitat-based points were distinguished by differences in abundances of Chestnut-sided Warbler, American Crow, Mourning Warbler, and Indigo Bunting (more common at road points) and Brown Creeper (more common at habitat-based sites), among others.

Besides providing a broader coverage of habitat types, the NNF Bird Survey creates opportunities for geographically explicit analyses of bird-habitat associations. In most cases, these analyses are not possible or not as easily derived from BBS data. Observed species' frequencies in different habitat types can be compared with the expected frequencies (based on a neutral hypothesis of random habitat use) to help identify habitat associations (*fig. 1*). If site descriptions are elaborated to include management histories, stand ages, etc., the NNFBS results can help predict the impacts of future land management activities on bird populations.

Davis et al. (2000) used the spatially explicit point data to identify geographic patterns of distribution for many species in the Nicolet National Forest. The majority of species showed patterns of aggregation (clumping), implying that conservation efforts might be targeted effectively toward specific areas. A more detailed analysis of bird-habitat associations is possible by evaluating the habitat characteristics at the geo-referenced NNFBS points. Roberts (2001) acquired local vegetation data (e.g., tree density, canopy species composition, shrub density, etc.) at each habitat-based point and more extensive landscape scale data through analysis of the U.S. Forest Service GIS (geographic information system) data layers. He concluded that both datasets are effective in predicting species occurrences, and the combination of landscape and local variables is most effective. Although local variables performed better than landscape variables, the success of landscape variables is particularly significant because GIS data are available for the entire forest. Predictive models can be used to map the expected distributions of species that show significant landscape associations. We calculated landscape variables for a grid of overlapping 500m circles covering the forest area. Expected probabilities of occurrence based on logistic regression models can be superimposed on this grid. A model for the Black-and-white Warbler (*fig. 3*) predicts a pattern of distribution that is consistent with known habitat associations of this species. Regions of extensive mixed lowland deciduous-conifer forest, known to be a favored habitat of this species (Kricher 1995), are predicted to have the highest numbers of Black-and-white Warblers. Similar maps can be drawn for all species that yield acceptably significant logistic regression models of occurrence.

The NNFBS was not designed to provide information about population trends because that role is well served by the BBS. Nevertheless, the program has been in existence long enough for at least preliminary analyses of changes in species' abundances. We used Spearman rank correlation to identify changes in the average number of individuals per count between 1989-2002. (The 1987 and 1988 survey years were excluded because they did not include the full complements of sites.) Northern and southern halves of the forest and habitat-based and roadside points were treated separately.

Rank correlations of the NNF Bird Survey results yield an alarming result. Among 147 species for which sufficient numbers are available for at least one portion of the forest (northern habitat-based sites, northern road sites, etc.) 45 species declined significantly during this period, compared with only seven species that increased significantly (*table 3*). Of these 52 species, 24 showed similarly significant ($P < 0.05$) or marginally significant ($0.05 < P < 0.10$) BBS trends in Wisconsin over the same period (1989-200), while only one species (House Wren) showed the opposite trend (Sauer et al. 2001). In addition to species showing significant change at the $P < 0.05$ level, six species showed marginally significant increases ($0.05 < P < 0.10$ or similar change in all four sets of data, *table 3*) and 18 species showed marginally significant decreases (*table 4*).

BBS data identify another 15 species that showed significant or marginally significant increases and 10 species that showed significant or marginally significant decreases in Wisconsin between 1989-2000 (*table 5*). None of these 25 species showed significant change in the NNFBS, but in most cases the direction of change was consistent with the BBS trend.

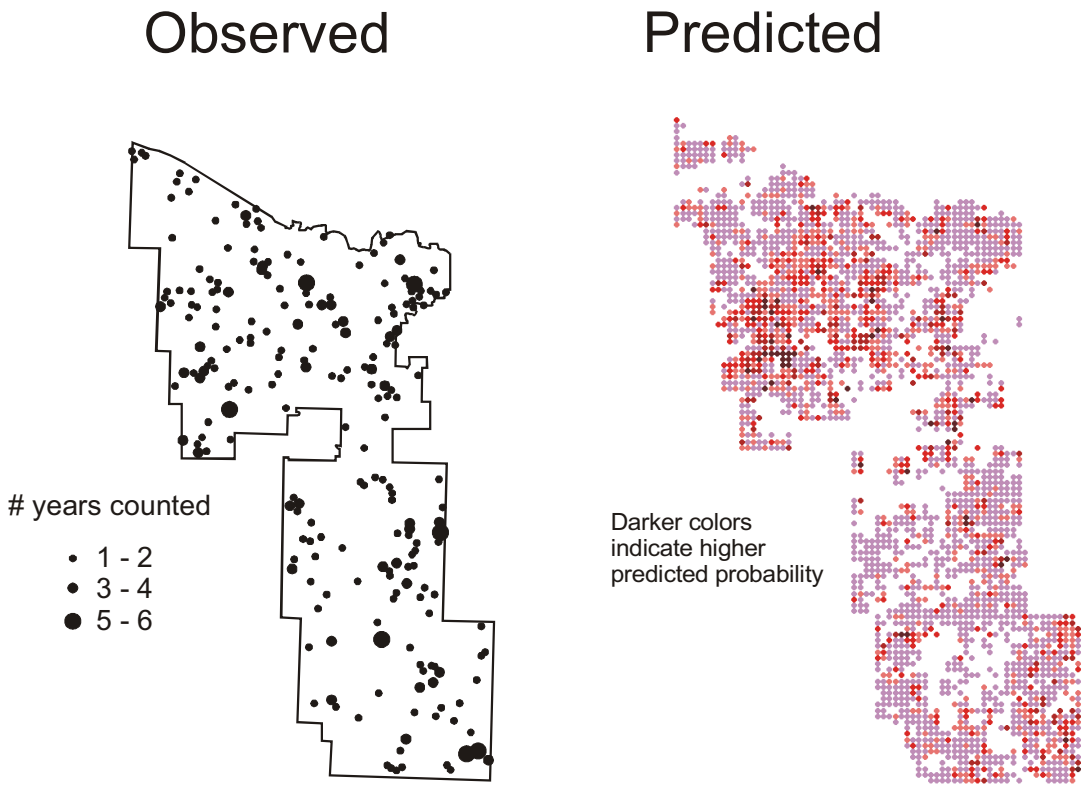

Figure 3— Observed distribution of Black-and-white Warblers in the Nicolet National Forest Bird Survey (on left) and predicted distribution (on right) based on a logistic regression model of local and landscape level habitat variables. Model details are given in Roberts (2001).

Table 3— *Species that showed statistically significant (P < 0.05) or marginally significant (0.05 < P < 0.10) population increases between 1989 – 2002 according to Spearman Rank Correlation of average abundance per point count in the Nicolet National Forest (NNF) Bird Survey and North American Breeding Bird Survey (BBS). NNF Bird Survey points are grouped into 4 categories: habitat-based sites in the northern half (NH) and southern half (SH) of the forest; and roadside sites in the northern half (NR) and southern half (SR) of the forest. Data in the table indicate whether the observed numbers were increasing (+) or decreasing (-) between 1989-2002 for the NNF Bird Survey and 1989-2000 for the BBS.*

Species	Scientific name	NH	NR	SH	SR	BBS
Mourning Dove	*Zenaida macroura*	+**	-	+*	+**	-
American Goldfinch	*Carduelis tristis*	-	+**	+	+**	+**
Wild Turkey	*Meleagris gallopavo*			+	+**	+**
Bald Eagle	*Haliaeetus leucocephalus*	-	+*	-	+**	+**
Chipping Sparrow	*Spizella passerina*	-	+**	-	+	+**
Common Grackle	*Quiscalus quiscula*	+	-	+**	-	-**
Common Loon	*Gavia immer*	-	-	-	+**	+**
American Crow	*Corvus brachyrhynchos*	+	0	+	+*	+**
Palm Warbler	*Dendroica palmarum*	+	+*			+
Northern Parula	*Parula americana*	-	+*	-	-	+*
Cape May Warbler	*Dendroica tigrina*	+	+	+	+	+*
Ovenbird	*Seiurus aurocapillus*	+	+	+	+	-
Red-eyed Vireo	*Vireo olivaceus*	+	+	+	+	+**

*0.05 < P < 0.10
**P < 0.05

Table 4— *Species that showed statistically significant (P < 0.05) or marginally significant (0.05 < P < 0.10) population decreases between 1989 – 2002 according to Spearman Rank Correlation of average abundance per point count in the Nicolet National Forest (NNF) Bird Survey and North American Breeding Bird Survey (BBS). NNF Bird Survey points are grouped into the same categories as in table 3. Data in the table indicate whether the observed numbers were increasing (+) or decreasing (-) between 1989-2002 for the NNF Bird Survey and 1989-2000 for the BBS.*

Species	Scientific name	NH	NR	SH	SR	BBS
Barn Swallow	*Hirundo rustica*	-**	-	-**	-	-
Mourning Warbler	*Oporornis philadelphia*	-**	-	-**	-	-*
White-throated Sparrow	*Zonotrichia albicollis*	-**	-	-**	-	+
Song Sparrow	*Melospiza melodia*	-**	-	-**	-	-
Osprey	*Pandion haliaetus*	-	-**	-**	+	+
Great Crested Flycatcher	*Myiarchus crinitus*	-**	+	-**	-	-**
Eastern Kingbird	*Tyrannus tyrannus*	-**	-	-*	-	-**
Golden-winged Warbler	*Vermivora chrysoptera*	-*	-	-**	-	-*
Baltimore Oriole	*Icterus galbula*	-**	-	-*	-*	-**
Gray Jay	*Perisoreus canadensis*	-*	-	-**		+
Great Blue Heron	*Ardea herodias*	-**	-	-	-	-**
Olive-sided Flycatcher	*Contopus cooperi*	-**	-	-	-	-
Tree Swallow	*Tachycineta bicolor*	-**	-**	+	+	+
Gray Catbird	*Dumetella carolinensis*	-**	-	-	-	-
Eastern Bluebird	*Sialia sialis*	-	-	-**	-	-*
Field Sparrow	*Spizella pusilla*	-	-	-**	-	-**
Eastern Towhee	*Pipilo erythrophthalmus*	-	-	-**	-	+
Brown-headed Cowbird	*Molothrus ater*	-	-	-**	-	-
Northern Flicker	*Colaptes auratus*	-**	+	-*	-	-**
Eastern Wood Pewee	*Contopus virens*	-**	+	-*	-	-
Chestnut-sided Warbler	*Dendroica pensylvanica*	-**	-*	-	+	+
Black-throated Blue Warbler	*Dendroica caerulescens*	-**	-*	-	+	+
Common Nighthawk	*Chordeiles minor*	-	0	-**	-	-
White-breasted Nuthatch	*Sitta carolinensis*	-*	-	-*	-	+**
Pied-billed Grebe	*Podilymbus podiceps*	-**		-		-**
Turkey Vulture	*Cathartes aura*			-**	-	+
Blue-winged Teal	*Anas discors*	-**		-		-**
American Woodcock	*Scolopax minor*	-**		-		ns
Barred Owl	*Strix varia*	-**	-	+	-	-*
Downy Woodpecker	*Picoides pubescens*	-**	-	-	+	+
Yellow-billed Cuckoo	*Coccyzus americanus*	-		-**		-
Black-and-white Warbler	*Mniotilta varia*	-	-	-**	+	-
Connecticut Warbler	*Oporornis agilis*	-**		-		-**
Yellow-throated Vireo	*Vireo flavifrons*	-	-	-**	+	+
Scarlet Tanager	*Piranga olivacea*	-	-	-**	+	+
House Sparrow	*Passer domesticus*	-		-**		-**
Veery	*Catharus fuscescens*	-**	+	-*	+	-
Magnolia Warbler	*Dendroica magnolia*	+	+	-**	-*	+
Killdeer	*Charadrius vociferous*	-		-**	+	-**
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	-**				+
Vesper Sparrow	*Pooecetes gramineus*			-**		-**
American Bittern	*Botaurus lentiginosus*	-	-	+*	-**	-**
European Starling	*Sturnus vulgaris*	-*	-	-	0	-
Hairy Woodpecker	*Picoides villosus*	+	+	-**	-	-
Cliff Swallow	*Riparia riparia*	+	-	+	-**	+
Cedar Waxwing	*Bombycilla cedrorum*	-	+	-**	+	-*
House Wren	*Troglodytes aedon*	-**	+	0	+	+**
Black-capped Chickadee	*Poecile atricapilla*	-	+	-*	-	+**
Brown Creeper	*Certhia Americana*	-	+	-*	-	+

Table 4 *(continued).*

Species	Scientific name	NH	NR	SH	SR	BBS
Golden-crowned Kinglet	*Regulus satrapa*	-	+	-*	-	+
Yellow Warbler	*Dendroica petechia*	-*	-	-	+	+
Brewer's Blackbird	*Euphagus cyanocephalus*	-			-*	-*
Indigo Bunting	*Passerina cyanea*	-	-	-*	+	-**
Blue-headed Vireo	*Vireo solitarius*	-	0	-*	+	+
Common Yellowthroat	*Geothlypis trichas*	-*	+	-	+	+
Blue-winged Warbler	*Vermivora pinus*	+	+	-*	+	+
Broad-winged Hawk	*Buteo platypterus*	-	-	-	-	-
Least Flycatcher	*Empidonax minimus*	-	-	-	-	-
Swainson's Thrush	*Catharus ustulatus*	-	-	-	-	+
Brown Thrasher	*Toxostoma rufum*	-	-	-	-	-**
Northern Waterthrush	*Seiurus noveboracensis*	-	-	-	-	+**
Bobolink	*Dolichonyx oryzivorus*	-	-	-	-	-
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	-	-	-	-	+

*0.05 < P < 0.10
**P < 0.05

Table 5— *Species that showed statistically significant (P < 0.05) or marginally significant (0.05 < P < 0.10) population increases or decreases between 1989 – 2000 in all Wisconsin Breeding Bird Survey routes but not in the Nicolet National Forest (NNF) Bird Survey. NNF Bird Survey points are grouped into the same 4 categories as in table 3. Data in the table indicate whether the observed numbers were increasing (+) or decreasing (-) between 1989-2002 for the NNF Bird Survey and 1989-2000 for the BBS.*

Species	Scientific name	NH	NR	SH	SR	BBS
Canada Goose	*Branta canadensis*	+		+	+	+**
Red-tailed Hawk	*Buteo jamaicensis*	-		-	+	+**
Sandhill Crane	*Grus canadensis*					+**
Ruby-throated Hummingbird	*Archilochus colubris*	-	+	+	+	+**
Eastern Phoebe	*Sayornis phoebe*	-	+	-	+	+**
Warbling Vireo	*Vireo gilvus*	+	+	+	-	+*
Common Raven	*Corvus corax*	-	+	+	+	+**
Red-breasted Nuthatch	*Sitta canadensis*	-	+	-	+	+**
Yellow-rumped Warbler	*Dendroica coronata*	-	-	+	+	+**
Black-throated Green Warbler	*Dendroica virens*	-	+	+	+	+**
Blackburnian Warbler	*Dendroica fusca*	+	-	-	+	+**
Pine Warbler	*Dendroica pinus*	-	+	+	+	+**
American Redstart	*Setophaga ruticilla*	-	-	+	-	+**
Swamp Sparrow	*Melospiza Georgiana*	-	0	-	+	+*
House Finch	*Carpodacus mexicanus*	-		-		+**
American Kestrel	*Falco sparverius*	-				-**
Sora	*Porzana Carolina*					-**
Wilson's Snipe	*Gallinago delicata*					-**
Black Tern	*Chlidonias niger*	-		+		-*
Black-billed Cuckoo	*Coccyzus erythropthalmus*	-	-	-	+	-**
Red-headed Woodpecker	*Melanerpes erythrocephalus*	+		-	+	-**
Purple Martin	*Progne subis*	-		-		-**
Savannah Sparrow	*Passerculus sandwichensis*	0			+	-**
Red-winged Blackbird	*Agelaius phoeniceus*	-	+	-	+	-**
Eastern Meadowlark	*Sturnella magna*			-	-	-**

*0.05 < P < 0.10
**P < 0.05

Discussion

Both the Nicolet National Forest Bird Survey (NNFBS) and North American Breeding Bird Survey (BBS) provide snapshot views of bird species assemblages in northeastern Wisconsin. Considerable variation characterizes the results at any individual census point, but when combined with other points a meaningful picture of the regional avifauna emerges. The BBS data are important because they can be compared with results from across North America as early as 1966. Our analysis, however, shows that local, habitat-based programs like the NNFBS can provide complementary information and opportunities to understand bird populations in specific management areas. Because each habitat-based point is geo-referenced and classified according to widely recognized vegetation/ physiographic types, results can be used to quantify bird-habitat associations at finer scales. These relationships, in turn, can be used to predict species occurrences across areas that have not been sampled for birds. Although still in the early stages, GIS-based models of bird populations (e.g., Flather and Sauer 1996, Pearson and Niemi 2000, Gutzwiller and Barrow 2001, Gustafson et al. 2002) hold considerable promise for conservation planning.

Land managers can use these predictive models to identify critical areas, anticipate the consequences of habitat modifications, and prescribe changes that might benefit priority species. As current models are tested with field observations, new iterations of the predictive models may provide increasingly reliable guidance for management activities. Habitat-based point counts are particularly valuable for developing these predictive models.

Our comparisons of bird assemblages suggest that the habitat-based point counts of the NNFBS assess qualitatively different aspects of the avifauna than does the BBS. In general, the NNF Bird Survey yields higher relative abundances of wetland/aquatic species and species that occur largely in extensive forest. Birds of open country are better represented in BBS database. These differences are not surprising given the differences in site selection; BBS routes were established randomly along roadsides (Robbins et al. 1986), whereas habitat-based points from the NNF Bird Survey were selected to represent specific vegetation types, including wetlands and interior forest.

Trends in species abundances derived from the NNF Bird Survey do not always mirror trends reported from Wisconsin's BBS routes, although results from the two monitoring programs are similar more often than they are different. Differences should not be surprising, however, given the geographically variable population trends that have long been documented by the North American Breeding Bird Survey (Robbins et al. 1986, Sauer et al. 2001). Even widely declining species like Red-headed Woodpecker (*Melanerpes erythrocephalus*) are increasing in parts of their ranges, in marked contrast to the precipitous decline that has occurred elsewhere (Sauer et. al. 1997, 2001). Nevertheless, the fact that so many species (45) in the Nicolet National Forest are declining significantly (compared with only seven species that are increasing significantly) is cause for genuine concern. Declining species include neotropical migrants, short-distance migrants, permanent residents, forest interior species, wetland species, early successional species, old-growth forest species, and birds of open country, so a single explanation for the declines is unlikely. Especially troubling are species like Eastern Kingbird, Golden-winged Warbler, Baltimore Oriole, and several others that have shown consistent declines in all parts of the Nicolet National Forest as well as in the Breeding Bird Survey. Continued monitoring will help determine whether these trends reflect temporary declines in bird numbers or whether they represent widespread and ongoing deterioration of environmental conditions. The possibility certainly exists that Terborgh's (1990) controversial warning about the decline of North American birds is correct and deserves increasing attention by land managers and conservationists.

In summary, regional surveys like the NNFBS provide information that complements the more comprehensive North American Breeding Bird Survey. Results of geo-referenced surveys can be used for analysis of bird-habitat associations and GIS models can be derived from the spatially explicit point counts. In addition, bird species that are not well represented in the BBS database (e.g., wetland birds, species of remote habitats) can be specifically targeted, providing a more complete representation of the regional avifauna.

Like the BBS, the NNFBS relies on volunteer observers for all of the field work. Quality control is improved by using teams of observers and by providing these teams with reference tools like a custom CD of bird songs. Reliability of the data can be evaluated by implementing a rigorous observer certification program, an initiative that is currently being explored. Other measures that might improve the quality and applicability of the results include expanded coverage of habitats, better coordination with management activities on the forest, and estimation of variance associated with the point counts. Despite the shortcomings of the point count method (Dettmers et al. 1999, Drapeau et al. 1999, Nichols et al. 2000, Bart and Earnst 2002, Thompson 2002), databases generated by the NNFBS provide meaningful results that will grow in importance as these consistent annual surveys are continued.

Acknowledgments

We acknowledge the work of hundreds of volunteer observers in the NNF Bird Survey and BBS and institutional support from the U.S. Forest Service, Northeastern Wisconsin Audubon Society, Wisconsin Society for Ornithology, University of Wisconsin-Green Bay, and U.S. Fish and Wildlife Service/U.S. Geological Survey. We are particularly grateful for contributions to the Bird Survey or this paper by T. Rinaldi, L. Parker, G. Zimmer, M. Peczynski, T. Matthiae, J. Kastenholz, B. Reardon, S. Anderson, J. Nieland, M. Grimm, A. Wolf, J. Davis, A. Paulios, and R. Hutto.

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