1999 Annual Update Report:

Breeding bird monitoring in Great Lakes National Forests: 1991-1999

Report to: Chequamegon/Nicolet, Chippewa and Superior National Forests

By: Jim Lind, Nick Danz, Malcolm T. Jones, JoAnn M. Hanowski, and Gerald J. Niemi

Natural Resources Research Institute
5013 Miller Trunk Highway
Duluth, MN 55811

This is NRRI Technical Report:
NRRI/TR-2000/04

SUMMARY

- A total of 135, 168, and 133 stands (1,268 survey points) were surveyed for breeding birds in the Chippewa, Superior, and Chequamegon National Forests, respectively. Surveys have been completed for nine years in the Chippewa and Superior, and for eight years in the Chequamegon NF.

- Breeding bird surveys in the St. Croix region of Minnesota have been conducted over the last eight years at 171 points. Surveys in Southeast Minnesota have been conducted over the last five years at 211 points.

- We were able to examine trends in abundance for 79 bird species in at least one of the five study areas. Fifty-two species in the Chequamegon NF, 48 species in the Superior NF, 53 species in the Chippewa NF, 33 species in the St. Croix region, and 35 species in Southeast Minnesota were tested.

- Sixteen species showed a significant increase in at least one of the five study areas, and 13 species showed a significant decrease. Of the 16 increasing species, the American Robin, Yellow-rumped Warbler, and American Redstart showed significant increases in more than one study area. Of the 13 decreasing species, six declined significantly in more than one study area. The Eastern Wood-Pewee, Black-and-white Warbler, Ovenbird, Mourning Warbler, and Brown-headed Cowbird declined in two study areas and the White-throated Sparrow declined in three study areas.

- The number of species detected per sampling unit has shown significant changes between years in all study areas, with the St. Croix and Southeast each showing a significant decline.

- Nine (17%) of the species tested in the Chequamegon NF had increasing trends and two (4%) had decreasing trends. Conversely, one (2%) of the species tested in the Chippewa NF had increased significantly and seven (13%) decreased. Six (13%) of the species tested in the Superior NF also had significant decreasing trends, and five (10%) had increasing trends. Along with the Superior NF, the St. Croix and Southeast study areas had fairly even proportions of increasing and decreasing species. In the St. Croix, two (6%) of the species tested increased significantly, and two (6%) decreased. In the Southeast, two (6%) species increased significantly and three (9%) decreased.

- The regional analysis of the three National Forests combined revealed four species with significant increases: Blue Jay, Black-capped Chickadee, White-breasted Nuthatch, and Northern Waterthrush. Seven species had significant decreases: Eastern Wood-Pewee, Connecticut Warbler, Mourning Warbler, White-throated Sparrow, Veery, Ovenbird, and Canada Warbler.

- Of the 16 species that increased significantly in at least one study area, two were permanent residents, seven were short-distance migrants, and seven were long-distance migrants. Of the 13 species that decreased significantly in at least one study area, none were permanent residents, four were short-distance migrants, and nine were long-distance migrants.

- Of the 16 species that increased significantly in at least one study area, one species nests on the ground, two nest in cavities, and the remaining 13 species nest in shrubs or trees. Of the 13 species that decreased significantly in at least one study area, two nest in trees, one is a brood parasite, and the remaining ten species nest on the ground.

- The abundance of many species, as well as the number of species and individuals per sampling unit, varied significantly over the survey period but did not show significant increases or decreases. However, among the four northern study areas, the number of species detected per sampling unit has followed a consistent pattern. Each area showed a decline in this variable between 1994 and 1996, with an increase from 1996 to 1998. The reason for this pattern is unclear, but it may be related to winter and spring weather.

- The majority of decreasing species (10 of 13) were ground-nesters. Ground-nesting species that declined in multiple study areas, such as the White-throated Sparrow, Black-and-white Warbler, Ovenbird, and Mourning Warbler, warrant close attention in the future.

INTRODUCTION

Concerns about the status of continental forest bird populations have been raised in recent years for a variety of reasons (Lynch and Whigham 1984, Terborgh 1989, Hagen and Johnston 1992, Finch and Stangel 1993, Martin and Finch 1995). Declines in abundance of several species have been noted in some regions of North America, possibly due to forest fragmentation on the breeding grounds, deforestation on wintering grounds in the tropics, or other factors (Robbins et al. 1989, Robinson et al. 1995). Large-scale population monitoring programs such as the U.S. Geological Survey's Breeding Bird Survey (BBS) provide important information on trends at a continental scale, however, detection of population trends in smaller geographic areas is problematic. Also, continental trends have the potential to mask regional population trends (Holmes and Sherry 1988), thus there is a need for regional monitoring programs that provide more specific information (Green 1995, Howe et al. 1997).

In response to the need for regional data, a long-term forest breeding bird monitoring program was established on the Chippewa and Superior National Forests in 1991, the Chequamegon National Forest and the St. Croix region of east-central Minnesota in 1992, and in Southeast Minnesota in 1995. Currently, 1,650 points within the five study areas are monitored during each breeding season.

The primary objective of this report is to update the Forests on results of the forest bird monitoring program. We will focus on abundance trends of individual species, as well as assemblages of species, over the five to nine year time frame of the monitoring. Our intent is to summarize the most important results and provide detailed information in appendix form for

those who need more specific results. Other objectives, including bird/habitat and bird/landscape relationships, development of management recommendations for birds, and development and monitoring of the forest plan, are being met through ongoing work as part of Minnesota's Forest Bird Diversity Initiative.

We have continued the development and updating of our world wide web site (http://www.nrri.umn.edu/mnbirds/) that was made publicly available in mid-October of 1999. Currently, our web site consists of 511 pages that are divided among 12 top-level sections (see site map in Appendix A). Eight of these 12 sections contain the majority of the information we are presenting while the remainder are devoted to acknowledging our funding sources, highlighting our project staff or providing links to other relevant web sites. We have added species accounts in a web compatible format and have updated each species' maps based on the data collected during the 1999 field season. We are also providing interactive querying of our database via the web site. We have completed only one set of queries to date since this involved learning a new programming technique. Along these lines we met and identified several additional queries that are currently being developed.

DESIGN AND METHODS

Experimental Design

Experimental design and point count sampling used in our program follow national standards (Ralph et al. 1993, 1995). The monitoring program also was designed so that it would integrate with each National Forest's method of describing vegetation cover types (Hanowski and Niemi 1995). The sampling unit in our design is a forest stand that is ≥ 40 acres (16 ha), the minimum size needed for three non-overlapping point counts. Stands within each of the National Forests are stratified by forest type so that our sample of stands is representative of the area available in each Forest. Four to five stands (12 to 15 points) is the maximum amount that can be sampled by one person in a single morning. Thus, stands were selected in a restricted random manner to accommodate access and travel time between stands. A total of 135, 168, and 133 stands (1,268 survey points) were established in the Chippewa, Superior, and Chequamegon National Forests, respectively.

The difference in the design between the three National Forests and the St. Croix and Southeast Minnesota study areas is the sampling unit. Because forest patches in the St. Croix region and Southeast Minnesota are generally small (< 40 acres), only one survey point could be placed in each stand. For these study areas, a stand had to be at least 10 acres (4 ha) in size. Points were stratified in a similar fashion as stands in the National Forests with restrictions based on access and travel time. A total of 171 and 211 sampling points were established in St. Croix and Southeast study areas, respectively (Figure 1).

Sampling

Ten-minute point counts were conducted at each point during June and early July (Reynolds et al. 1980). This method is appropriate for determining the relative abundance of most singing passerine species, but is inadequate for waterfowl and most raptors. In addition, because only one survey is conducted in June or early July, this method probably underestimates the relative

Figure 1. General locations of breeding bird point counts in five regions of Minnesota and Wisconsin.

abundance of early nesting species (e.g., many permanent residents that begin breeding in April, including woodpeckers and chickadees).

Point counts were conducted by trained observers (see observer training section below) from approximately 0.5 hour before to 4 hours after sunrise on days with little wind (< 15 km/hr) and little or no precipitation. All birds heard or seen from the center point were recorded with estimates of their distance from that point. From 1991 to 1994, all birds heard or seen within 100 m of the point count center were recorded. In 1995, we changed our methods to include all birds heard or seen from the census point so that our results could be compared with other monitoring programs in this region (see Howe et al. 1997). The number of individuals observed for each species was summed for 3, 5, and 10-minute periods so that regional comparisons could be made with data gathered using 3 or 5-minute point counts.

We attempted to have each observer sample a similar number of stands of each forest cover type. This is to minimize bias caused by observer differences in sampling different forest cover types. Weather data (cloud cover, temperature, and wind speed) and time of day was recorded before each count. Counts that had rain throughout the entire census or excessive winds (> 15 km/hr) were dropped from the analyses for that particular year.

Observer training

Prior to the field season, tapes of bird songs were provided as a learning tool and all observers were required to pass an identification test of 75 bird songs made by Cornell University's Laboratory of Ornithology. A standard for number of correct responses was established by giving the test to observers who were trained in identifying birds by sound, and who had four to five years of field experience. This was done to identify songs on the tape that were not good representations of songs heard in northern Minnesota and Wisconsin. Based on results of trained observers, the standard for passing was set at 85% correct responses. Songs on the tape were grouped by habitat (e.g., upland deciduous, lowland coniferous) to simulate field cues that would aid in song identification.

Observer field training was conducted during the last week of May in the Superior National Forest. Observers conducted simultaneous practice counts at several points used in the monitoring program. Data were compiled for each observer, and species lists and numbers of individuals recorded on the count by each observer were compared to that of experienced observers. Deviations from the average or species missed were noted on the field sheets and returned. In addition to field training and testing, all observers were required to have a hearing test to ensure that their hearing was within normal ranges for all frequencies (125 to 8000 hertz). Normal ranges were standards established by audiologists.

Analysis

Because the sampling unit varies between forest regions, yearly relative abundance was calculated using methods specific to each region. For the three National Forests and the St. Croix region, we used only birds detected within 100 m of the sampling point. This was done to avoid confounding population trends with the expected increase in species observations due to the change to an unlimited radius in 1995. Relative abundance for species from the three National Forests was calculated by summing the number of individuals of each species across the three points per stand. For the St. Croix region, where the point is the sampling unit, relative abundance is the count of individuals of each species at each point. Points in Southeast MN have been sampled using an unlimited radius in all years, and at each point we used the count from the unlimited radius as the measure of relative abundance. We also calculated species abundance at a regional scale using data pooled from the three National Forests.

To ensure that our analysis provided reliable information about population trends, we used species only if they were observed on a minimum of 5 stands per study area and in at least three years on each stand. Stands were used only if they had been sampled in at least six years for the four northern study areas, and at least four years in Southeast MN. For the region-wide analysis, the criteria required a species to be present on a minimum of 10 stands combined from the three National Forests.

For several reasons, we decided to change our statistical methods for trend analysis. In previous years, we used repeated measures ANOVA to test for differences in relative bird abundance between years. To deal with the difficulty of zero counts and to stabilize the variance, past analyses were carried out after first adding a small positive constant (0.5) and then taking the logarithm of the counts. However, Link and Sauer (1994) have recently shown that the addition of a small constant can bias the analysis of trends. In addition, we now have at least eight years

of abundance data in the northern forest regions and we feel that our data set is sufficiently large to use statistical techniques better suited to analyze long-term population trends. Although there is a lack of consensus in the literature on the most appropriate method with which to analyze breeding bird population trends, there are several alternatives to choose from (Thomas 1996).

The method we used is similar to non-parametric route regression described by James et al. (1996). Our technique does not assume a specific pattern of change in bird populations, and it enables us to use untransformed data (counts) because it does not depend on the assumption of a normal distribution. For each stand (or point), a non-linear estimate of trend is calculated for each species by using locally-weighted regression (loess) to model species abundance as a smooth function of year. This procedure yields smoothed (fitted) values for each year. An overall mean for each species in each study area is then calculated by averaging fitted abundance across all stands in each year. The individual fitted values are used in a bootstrap procedure to estimate a 95% confidence interval around each year's mean. Finally, we calculate mean percent annual change in overall mean abundance, and use this statistic as a simple description of each trend. All statistical analyses were conducted in S-Plus (MathSoft, Inc. 1999)

In addition to single-species trends, we calculated trends for the total number of individuals, the total number of species, and the total number of individuals in each of three migration strategies (permanent resident, short-distance migrant, long-distance migrant). These trends were calculated both for individual forests and for the northern region.

To test for significant trends, we checked whether confidence intervals for a species from the first year of sampling in a forest overlapped with the confidence interval from 1999. If there was no overlap, the species was described as having either a significant increase or decrease. However, we did not assign an increase or decrease to a species if its smoothed mean was less than zero for any year, regardless of the pattern of confidence intervals (e.g., Ruffed Grouse); we suspect this is a mathematical artifact of the loess regression. If there were non-overlapping confidence intervals in other years within the time series, but not between the first and last years, the species was described as having a "mixed" significant change in abundance. When all confidence intervals overlapped in a trend, the trend was described as non-significant.

There are a few issues that should be noted when interpreting the results of our trend analyses. First, reducing changes in abundance across years to a unidirectional trend can be misleading, because it gives only a limited view of the pattern of change. For example, there were certain species that met our criteria for a significant increase or decrease, but visual observation of the graphs led us to believe the patterns were not significant. For example, neither the Eastern Wood-Pewee or the Evening Grosbeak show a statistically significant trend in the Chequamegon NF, but visual observation of the graphs (Figure 2) shows that both species have demonstrated consistent declines since 1994. Conversely, there are examples where a species met the criteria for a significant trend, but the trend was inconsistent across years. The American Goldfinch in the Chequamegon NF and the Blackburnian Warbler in the Chippewa NF both met the criteria for significant trends, but the trends were inconsistent across most years (Figure 3). In order to point these instances out, we have marked them with superscripts in the trend summary tables (Tables 1 and 2).

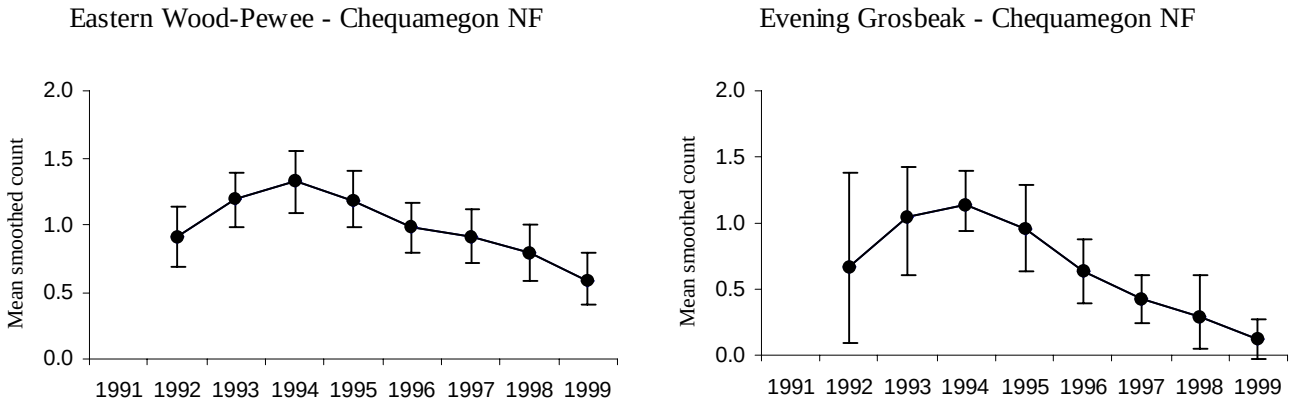


Figure 2. Examples of potentially important trends that did not meet significance criteria.

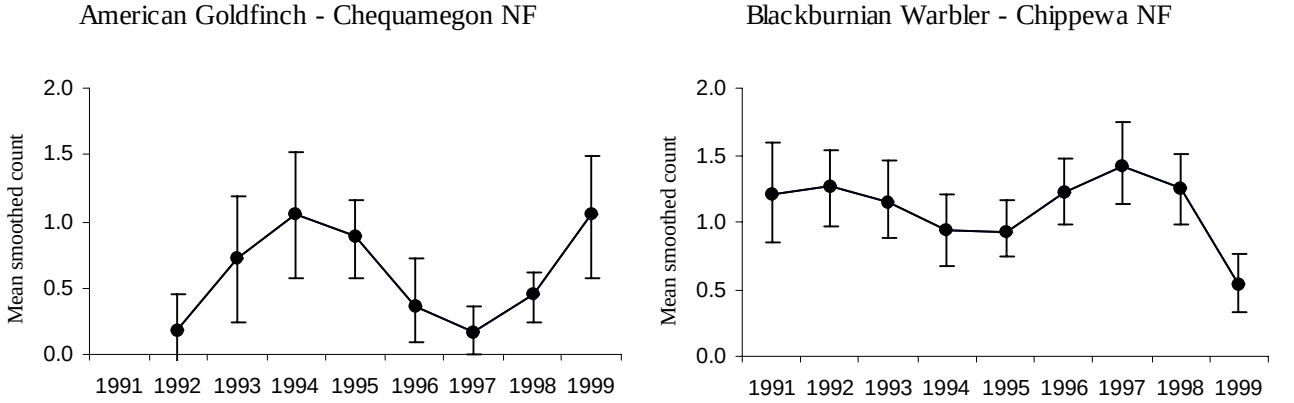


Figure 3. Examples of trends that met significance criteria, but were inconsistent across years.

In 1991 to 1994, when only birds within a 100-m radius were recorded, there may have been a tendency for observers to include rather than exclude individuals near the 100-m border, thus inflating the number of individuals detected. This tendency would probably have been more pronounced when dealing with loud species (e.g. Ovenbird, Hermit Thrush) than with quieter species that are difficult to hear past 100 m (e.g. Blackburnian Warbler, Golden-crowned Kinglet). Although this is a legitimate concern, it is impossible to quantify the extent to which it occurred. Finally, because the sampling unit is different across the five forest regions, trends may be compared across forests, but relative abundance should not.

RESULTS

We were able to examine trends for 79 species in at least one of the five study areas (Table 1). Graphs of these species with the study areas in which they were tested can be found in Appendix B. We also examined a regional trend (the three National Forests combined) for 55 species (Table 2). Many of the trends listed in Tables 1 and 2 were given superscripts based on visual

Table 1. Summary of trends by species and study area, with % annual change and number of sample units (n). I = significant increase between first and last year of monitoring, D = significant decrease between first and last year of monitoring, M = no significant change between first and last year, but mixed significant changes exist between years, ns = no significant changes between any years. Superscript symbols follow the same notation and are used when a trend is significant but inconsistent across years (used only on I or D trends) or, conversely, when a trend is consistent across years but not significant (used only on M or ns trends). See Appendix B for individual species graphs.

	Chequamegon NF			**Chippewa NF**			**Superior NF**			**St. Croix**			**Southeast**		
	Trend	% annual	*n*	**Trend**	% annual	*n*	**Trend**	% annual	*n*	**Trend**	% annual	*n*	**Trend**	% annual	*n*
Total # of Species	**M**	0.6	129	**M**	-0.6	130	**M**	-0.3	157	**D^{M}**	-2.0	143	**D**	-7.8	193
Total # of Individuals	**I^{M}**	2.1	129	**D^{M}**	-1.0	130	**M**	-0.6	157	**M**	-0.1	143	**D^{M}**	-4.9	193
Ring-necked Pheasant													**ns^{D}**	-16.6	6
Ruffed Grouse							**M**	16.2	9						
Mourning Dove													**ns**	9.9	11
Red-bellied Woodpecker													**M**	-3.6	21
Yellow-bellied Sapsucker	**I**	15.4	44	**ns**	-3.9	53	**ns**	0.7	55	**M**	-1.1	10	**ns**	8.0	14
Downy Woodpecker													**ns**	-7.9	6
Hairy Woodpecker	**ns**	-0.7	8	**M**	5.0	5									
Northern Flicker							**M**	31.3	6						
Olive-sided Flycatcher				**ns**	-2.1	6									
Eastern Wood-Pewee	**M^{D}**	-4.8	55	**D**	-4.8	64	**D**	-17.9	18	**ns**	-1.2	33	**ns**	0.2	150
Yellow-bellied Flycatcher	**M**	5.1	25	**M**	13.9	22	**M**	9.6	55	**ns**	7.0	9			
Alder Flycatcher	**I**	25.9	16	**ns**	-0.6	13	**ns**	3.6	19	**ns**	0.5	5			
Least Flycatcher	**ns**	1.0	60	**ns**	3.7	71	**ns**	1.7	48	**I**	13.1	48			
Great Crested Flycatcher	**ns**	-3.4	23	**M**	-2.4	21				**M^{D}**	2.7	9	**ns**	-4.5	48
Eastern Kingbird	**M**	16.9	5												
Yellow-throated Vireo				**ns**	-0.8	19				**I^{M}**	17.9	6	**ns**	-3.3	19
Blue-headed Vireo	**M**	10.0	9	**ns**	5.5	18	**ns**	6.0	7						
Warbling Vireo													**ns**	6.3	8
Red-eyed Vireo	**I^{M}**	5.3	110	**M**	-1.0	115	**M**	3.0	154	**M**	3.9	122	**ns**	0.7	113
Gray Jay				**M**	7.5	6	**ns**	22.0	8						
Blue Jay	**M**	9.5	57	**M**	2.4	50	**I**	16.7	58	**M**	3.4	8	**ns**	4.9	50

	Chequamegon NF			Chippewa NF			Superior NF			St. Croix			Southeast		
	Trend	% annual	*n*	**Trend**	% annual	*n*	**Trend**	% annual	*n*	**Trend**	% annual	*n*	**Trend**	% annual	*n*
American Crow				**M**	3.4	6							**I**	11.7	121
Black-capped Chickadee	**ns**	0.6	67	**ns**	3.1	55	**M**	19.3	19	**M**	5.6	15	**M**	9.9	49
Red-breasted Nuthatch	**ns**	2.4	23	**ns**	7.4	31	**ns**	8.3	46						
White-breasted Nuthatch	**ns**	4.0	12	**I**	72.7	12				**M**[I]	11.1	11	**ns**	1.5	47
Brown Creeper	**M**	-5.1	37	**ns**	-5.1	33	**ns**	5.1	24						
House Wren													**ns**	3.0	47
Winter Wren	**D**	-7.3	46	**M**	1.7	43	**M**	2.8	82	**ns**	7.7	7			
Golden-crowned Kinglet	**ns**	5.2	8	**M**	-0.4	17	**M**	6.9	34	**ns**	-9.7	5			
Ruby-crowned Kinglet							**ns**	18.2	6						
Blue-gray Gnatcatcher													**ns**	5.3	60
Veery	**ns**	0.4	57	**M**	-1.7	86	**M**	-2.4	114	**M**	0.6	97			
Swainson's Thrush							**M**	3.9	32						
Hermit Thrush	**ns**	-1.3	85	**M**	3.6	71	**I**	12.5	65	**ns**	9.5	24			
Wood Thrush	**ns**	16.4	11										**ns**	12.2	16
American Robin	**I**	10.7	77	**M**[I]	6.0	56	**M**	2.4	93	**ns**	6.8	11	**I**	17.8	41
Gray Catbird				**ns**	21.3	6				**M**	19.4	6	**ns**	-7.6	9
Brown Thrasher	**ns**	15.5	10												
Cedar Waxwing				**ns**	2.7	9	**I**	28.6	13						
Blue-winged Warbler													**D**	-14.5	7
Golden-winged Warbler	**ns**[I]	15.3	10	**ns**	-1.1	21	**D**	-21.2	10	**M**	-235.1	8			
Tennessee Warbler							**M**	-73.9	9						
Nashville Warbler	**ns**	-2.7	90	**M**	5.7	86	**M**	0.9	153	**M**[D]	-5.5	49			
Northern Parula	**ns**	-5.5	25	**ns**	0.1	30	**M**	2.9	56						
Yellow Warbler				**ns**	-4.2	10							**ns**	-5.1	10
Chestnut-sided Warbler	**ns**	1.3	66	**ns**	1.3	93	**M**	-1.6	128	**M**	-1.1	72			
Magnolia Warbler				**M**	111.7	7	**M**	6.4	92						
Cape May Warbler							**M**	6.9	6						
Black-throated Blue Warbler							**ns**	16.1	5						
Yellow-rumped Warbler	**I**[M]	43.7	48	**M**	4.2	45	**I**[M]	18.0	69	**ns**[I]	19.4	11			
Black-throated Green Warbler	**ns**	1.0	89	**ns**	-0.7	39	**M**	-1.8	66	**ns**	0.9	17			

	Chequamegon NF			Chippewa NF			Superior NF			St. Croix			Southeast		
	Trend	% annual	*n*	**Trend**	% annual	*n*	**Trend**	% annual	*n*	**Trend**	% annual	*n*	**Trend**	% annual	*n*
Blackburnian Warbler	**I**^{M}	15.9	53	**D**^{M}	-5.6	42	**M**	-0.4	102						
Pine Warbler	**M**	9.6	19	**ns**	-2.8	40	**ns**	-6.2	6						
Palm Warbler				**M**	8.2	7									
Black-and-white Warbler	**ns**	-2.9	50	**M**^{I}	5.6	45	**D**	-4.6	120	**D**^{M}	-13.4	18			
American Redstart	**I**	35.5	11	**ns**	2.5	49	**I**^{M}	22.6	41	**ns**	9.0	21	**M**	1.1	71
Ovenbird	**M**	0.8	114	**D**	-6.3	113	**M**	-0.4	152	**D**^{M}	-2.6	118	**ns**	0.0	119
Northern Waterthrush	**ns**	10.2	7	**M**	26.8	6	**M**^{I}	-101.8	8						
Connecticut Warbler				**D**	-13.2	15									
Mourning Warbler	**M**	3.2	34	**D**	-10.7	51	**D**	-6.6	109	**ns**	-5.8	29			
Common Yellowthroat	**ns**	-5.0	44	**ns**	0.1	69	**M**^{D}	-8.4	36	**ns**	-2.3	67	**ns**	-3.0	27
Canada Warbler	**ns**	-2.2	26	**ns**	5.8	11	**D**	-7.1	80						
Scarlet Tanager	**ns**	-2.3	40	**M**	0.8	60	**M**	-253.7	10	**O**	6.4	10	**ns**	1.9	30
Eastern Towhee	**ns**	2.3	11										**ns**	10.1	19
Chipping Sparrow	**ns**	-4.0	21	**M**	7.9	48	**ns**	-3.4	49				**ns**	-13.3	8
Clay-colored Sparrow	**ns**	-5.4	12												
Field Sparrow													**ns**^{D}	-16.2	8
Vesper Sparrow	**M**	3.1	7												
Song Sparrow	**ns**	-2.1	20	**M**	-5.9	41	**ns**	0.0	29	**ns**	-1.8	22	**D**	-15.0	35
Lincoln's Sparrow	**ns**^{D}	-8.1	5												
Swamp Sparrow	**ns**	-5.5	12	**ns**	6.7	22	**M**	18.5	9	**M**	-0.4	11			
White-throated Sparrow	**D**	-11.6	46	**D**	-8.2	54	**D**	-6.7	136	**M**	-5.0	21			
Northern Cardinal													**ns**	-0.2	77
Rose-breasted Grosbeak	**I**	12.9	49	**M**	-1.0	29	**M**	3.4	64				**ns**	-9.4	38
Indigo Bunting	**M**^{D}	-12.4	6	**ns**	16.5	7				**M**	-0.2	9	**ns**	6.2	53
Red-winged Blackbird	**M**	-11.4	5	**ns**	7.1	5							**ns**	5.1	21
Brown-headed Cowbird	**ns**	-0.2	23	**D**	-22.1	24				**M**	-5.6	12	**D**	-21.5	69
American Goldfinch	**I**^{M}	76.1	6										**M**^{D}	-21.6	5
Evening Grosbeak	**M**^{D}	-15.7	7				**ns**	22.2	5						

Table 2. Summary of regional trends (three National Forests combined) by species and study area, with % annual change and number of stands sampled. I = significant increase between first and last year of monitoring, D = significant decrease between first and last year of monitoring, M = no significant change between first and last year, but mixed significant changes exist between years, ns = no significant changes between any years. Superscript symbols follow the same notation and are used when a trend is significant but inconsistent across years (used only on I or D trends) or, conversely, when a trend is consistent across years but not significant (used only on M or ns trends). See Appendix B for individual species graphs.

			# of stands		
	Trend	% annual change	Chequamegon NF	Chippewa NF	Superior NF
Total # Species	**M**	-0.54	129	130	157
Total # Individuals	**D^M**	-0.96	129	130	157
Ruffed Grouse	**M**	9.81	4		9
Yellow-bellied Sapsucker	**ns**	0.41	44	53	55
Hairy Woodpecker	**ns**	-3.17	8	5	4
Northern Flicker	**ns**	9.91	4	4	6
Eastern Wood-Pewee	**D**	-8.72	55	64	18
Yellow-bellied Flycatcher	**M**	10.03	25	22	55
Alder Flycatcher	**M**	7.05	16	13	19
Least Flycatcher	**ns**	1.85	60	71	48
Great Crested Flycatcher	**ns**	-5.67	23	21	1
Yellow-throated Vireo	**ns**	-3.51	4	19	
Blue-headed Vireo	**M**	7.43	9	18	7
Red-eyed Vireo	**M**	1.43	110	115	154
Gray Jay	**M**	7.15		6	8
Blue Jay	**I^M**	10.39	57	50	58
Black-capped Chickadee	**I^M**	8.57	67	55	19
Red-breasted Nuthatch	**M**	8.31	23	31	46
White-breasted Nuthatch	**I^M**	59.33	12	12	
Brown Creeper	**ns**	-2.43	37	33	24
Winter Wren	**M**	0.40	46	43	82
Golden-crowned Kinglet	**ns**	2.30	8	17	34
Veery	**D^M**	-3.23	57	86	114
Hermit Thrush	**M**	2.56	85	71	65
Wood Thrush	**ns**	19.01	11	1	3
American Robin	**M**	4.64	77	56	93
Cedar Waxwing	**M**	16.25	1	9	13
Golden-winged Warbler	**ns**	-4.85	10	21	10
Nashville Warbler	**M**	0.47	90	86	153
Northern Parula	**ns**	0.28	25	30	56
Yellow Warbler	**ns**	-4.72	1	10	
Chestnut-sided Warbler	**M**	-1.66	66	93	128
Magnolia Warbler	**M**	6.27	3	7	92
Black-throated Blue Warbler	**ns**	26.13	4	1	5

Table 2 (cont.)

	Trend	% annual change	# of stands Chequamegon NF	Chippewa NF	Superior NF
Yellow-rumped Warbler	**M**	10.93	48	45	69
Black-throated Green Warbler	**ns**	0.59	89	39	66
Blackburnian Warbler	**M**	-1.19	53	42	102
Pine Warbler	**M**	-1.41	19	40	6
Palm Warbler	**M**	11.06	3	7	
Black-and-white Warbler	**ns**	-2.35	50	45	120
American Redstart	**M**	4.02	11	49	41
Ovenbird	**D^{M}**	-1.47	114	113	152
Northern Waterthrush	**I^{M}**	121.40	7	6	8
Connecticut Warbler	**D**	-15.06	3	15	4
Mourning Warbler	**D**	-6.91	34	51	109
Common Yellowthroat	**ns**	-2.46	44	69	36
Canada Warbler	**D^{M}**	-6.07	26	11	80
Scarlet Tanager	**M**	-0.70	40	60	10
Chipping Sparrow	**M**	2.55	21	48	49
Song Sparrow	**ns**	-3.61	20	41	29
Swamp Sparrow	**M**	6.81	12	22	9
White-throated Sparrow	**D**	-8.83	46	54	136
Rose-breasted Grosbeak	**M**	2.69	49	29	64
Indigo Bunting	**ns**	16.51	6	7	
Red-winged Blackbird	**ns**	-2.45	5	5	4
Brown-headed Cowbird	**ns^{D}**	-6.79	23	24	2
Evening Grosbeak	**M^{D}**	12.44	7		5

examination of the graphs for each species. Although superscripts were assigned subjectively, we believe they may be helpful in pointing out biologically important trends that might otherwise be missed. Beyond this, we will focus our results and discussion mainly on species that met our criteria for statistical significance. The scientific name, migration strategy, and typical nest site of each species tested is listed in Appendix C.

During the time frame of our study, slightly more species demonstrated significant increases in abundance than decreases. A total of 16 species showed a significant increase in at least one of the five study areas, and 13 species showed a significant decrease (Table 3). Of the 16 increasing species, only the American Robin, Yellow-rumped Warbler, and American Redstart showed significant increases in more than one study area. Of the 13 decreasing species, six declined significantly in more than one study area. The Eastern Wood-Pewee, Black-and-white Warbler, Ovenbird, Mourning Warbler, and Brown-headed Cowbird declined in two study areas and the White-throated Sparrow declined in three study areas. A list of species with significant trends for each study area is presented in Table 4. The total number of species detected per sampling unit has shown significant changes between years in all study areas, with the St. Croix

and Southeast each showing a significant decline (Table 1). The total number of individuals detected per sampling unit has also shown significant changes between years in all study areas,

Table 3. Summary of species with significant increasing or decreasing trends.

Increasing Species		
1 study area	2 study areas	3 study areas
Yellow-bellied Sapsucker	American Robin	
Alder Flycatcher	Yellow-rumped Warbler	
Least Flycatcher	American Redstart	
Yellow-throated Vireo		
Red-eyed Vireo		
Blue Jay		
American Crow		
White-breasted Nuthatch		
Hermit Thrush		
Cedar Waxwing		
Blackburnian Warbler		
Rose-breasted Grosbeak		
American Goldfinch		
Decreasing Species		
1 study area	2 study areas	3 study areas
Winter Wren	Eastern Wood-Pewee	White-throated Sparrow
Blue-winged Warbler	Black-and-white Warbler	
Golden-winged Warbler	Ovenbird	
Blackburnian Warbler	Mourning Warbler	
Connecticut Warbler	Brown-headed Cowbird	
Canada Warbler		
Song Sparrow		

Table 4. Increasing and decreasing species by study area.

		Increasing Species		
Chequamegon	Chippewa	Superior	St. Croix	Southeast
Yellow-bellied Sapsucker	White-breasted Nuthatch	Blue Jay	Least Flycatcher	American Crow
Alder Flycatcher		Hermit Thrush	Yellow-throated Vireo	American Robin
Red-eyed Vireo		Cedar Waxwing		
American Robin		Yellow-rumped Warbler		
Yellow-rumped Warbler		American Redstart		
Blackburnian Warbler				
American Redstart				
Rose-breasted Grosbeak				
American Goldfinch				

		Decreasing Species		
Chequamegon	Chippewa	Superior	St. Croix	Southeast
Winter Wren	Eastern Wood-Pewee	Eastern Wood-Pewee	Black-and-white Warbler	Blue-winged Warbler
White-throated Sparrow	Blackburnian Warbler	Golden-winged Warbler	Ovenbird	Song Sparrow
	Ovenbird	Black-and-white Warbler		Brown-headed Cowbird
	Connecticut Warbler	Mourning Warbler		
	Mourning Warbler	Canada Warbler		
	White-throated Sparrow	White-throated Sparrow		
	Brown-headed Cowbird			

with the Chequamegon showing a significant increase and the St. Croix and Southeast each showing a significant decrease.

The numbers of increasing and decreasing species varied across the five study areas (Figure 4). Nine (17%) of the species tested in the Chequamegon NF had increasing trends and two (4%) had decreasing trends. Conversely, one (2%) of the species tested in the Chippewa NF had increased significantly and seven (13%) decreased. Six (13%) of the species tested in the Superior NF also had significant decreasing trends, and five (10%) had increasing trends. Along with the Superior NF, the St. Croix and Southeast study areas had fairly even proportions of increasing and decreasing species. In the St. Croix, two (6%) of the species tested increased significantly, and two (6%) decreased. In the Southeast, two (6%) species increased significantly and three (9%) decreased.

Permanent resident species did not show significant declines in any study areas (Figure 5). Two short-distance migrants increased in more than one study area (American Robin, Yellow-rumped Warbler) and two short-distance migrants (Brown-headed Cowbird, White-throated Sparrow) decreased in more than one study area (Table 3). The American Redstart is the only long-distance migrant to increase significantly in multiple study areas (Table 3). Long-distance migrants that decreased significantly in multiple study areas include the Eastern-Wood-Pewee, Black-and-white Warbler, Ovenbird, and Mourning Warbler.

Of the 16 species that increased significantly in at least one study area, one species nests on the ground (Hermit Thrush), two nest in cavities (Yellow-bellied Sapsucker, White-breasted Nuthatch), and the remaining 13 species nest in shrubs or trees (Figure 6). Of the 13 species that decreased significantly in at least one study area, two nest in trees (Eastern Wood-Pewee, Blackburnian Warbler), one is a brood parasite (Brown-headed Cowbird), and the remaining ten species nest on the ground. Of the five non-parasitic species declining in multiple study areas, only the Eastern Wood-Pewee does not nest on the ground.

The regional analysis of the three National Forests combined revealed four species with significant increases and seven species with significant decreases (Table 2). The Blue Jay, Black-capped Chickadee, White-breasted Nuthatch, and Northern Waterthrush showed a significant region increase, but only the White-breasted Nuthatch demonstrated a significant increase in one of the National Forests. The Eastern Wood-Pewee, Connecticut Warbler, Mourning Warbler, White-throated Sparrow, Ovenbird, Veery, and Canada Warbler showed a significant regional decrease. All of these species showed a corresponding significant decrease in at least one National Forest, except the Veery and Canada Warbler.

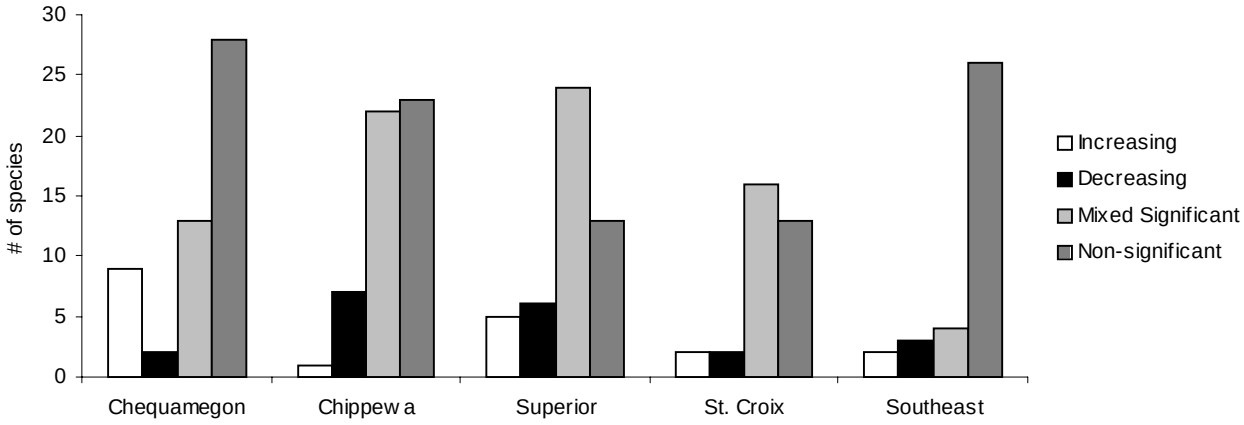


Figure 4. Trends by study area.

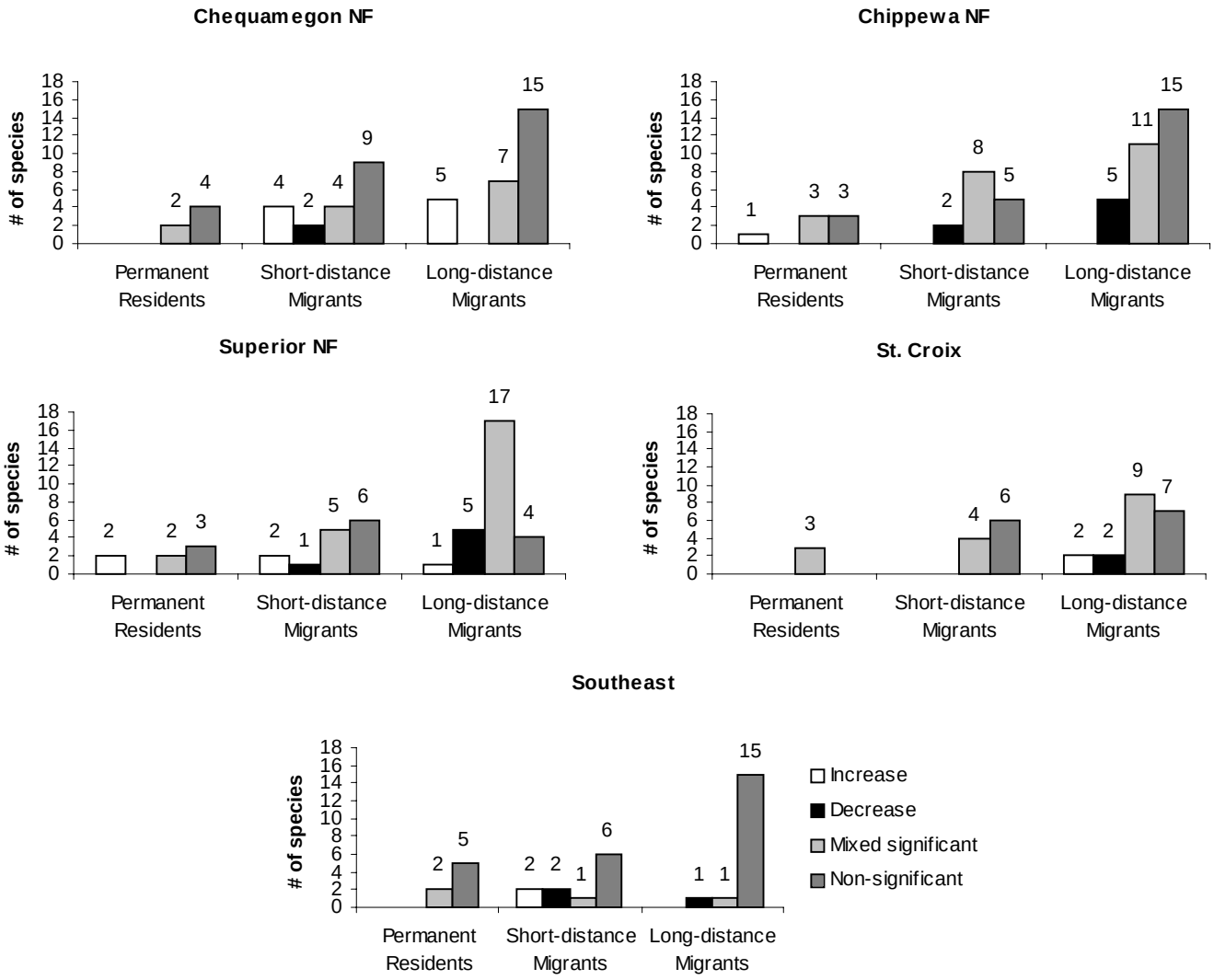
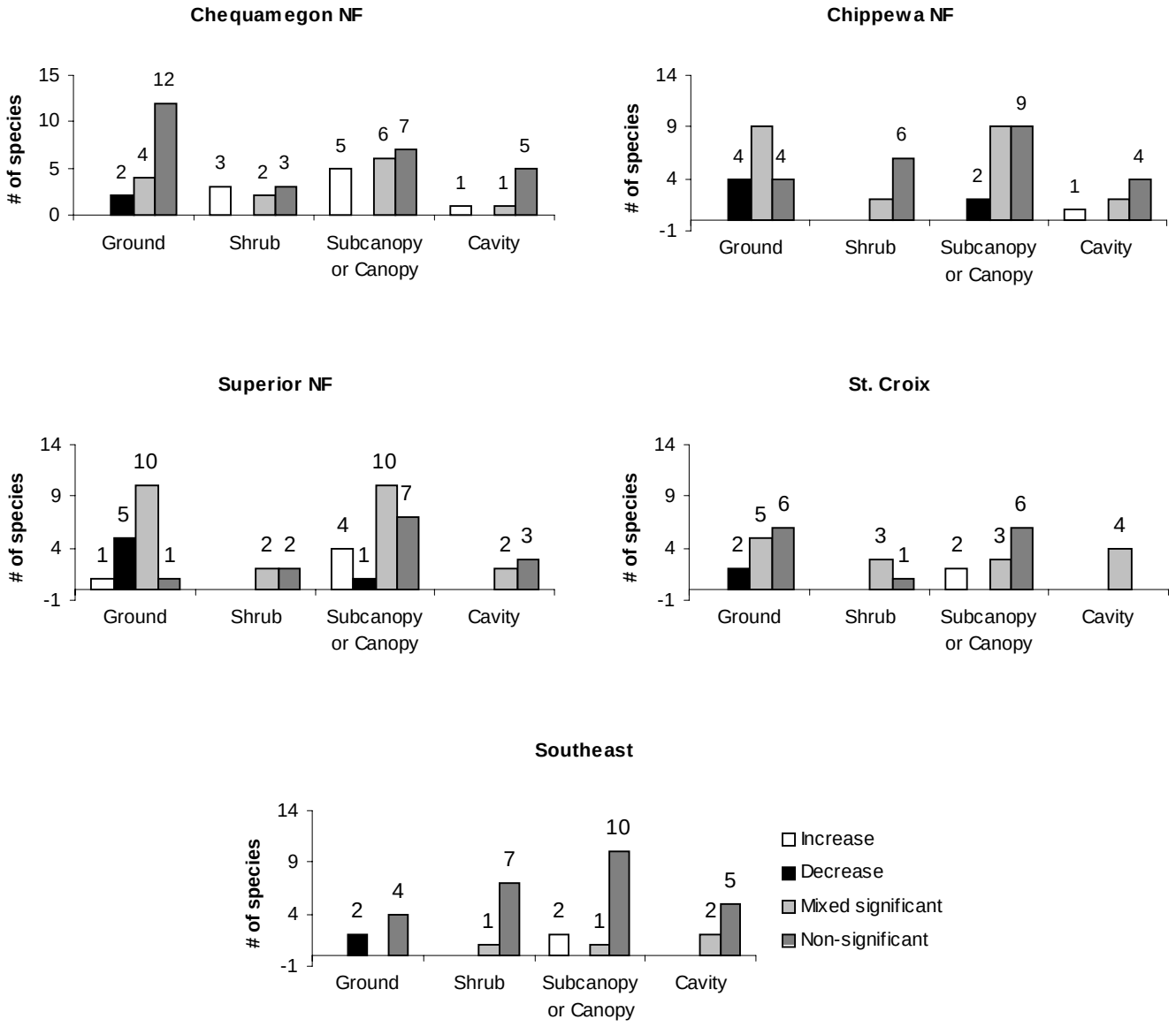


Figure 5. Trends by migration strategy and study area.



DISCUSSION

Caveats

As mentioned in the Methods section, reducing changes in abundance across years to a unidirectional trend can be misleading. It is likely that there are biologically important trends that did not meet our criteria for statistical significance (e.g., Eastern Wood-Pewee in Chequamegon NF) as well as instances where a species met the significance criteria, but the trend was inconsistent across years (e.g., Blackburnian Warbler in Chippewa NF). We feel that it is important to examine the graph for each individual species in each forest, especially those with superscripts in Tables 1 and 2. It is also important to note that a significant trend for a geographically restricted species (e.g., Blue-winged Warbler, Connecticut Warbler) in just one of our five study areas could be as meaningful as trends in multiple areas for widespread species (e.g., American Robin, Ovenbird).

Because we have only five years of data from the Southeast study sites, trends from this area should be viewed with caution. A brief examination of the abundance graphs of many of the species with nine years of data demonstrates that a species' trend from a five-year segment can be different from its overall trend. For example, the Hermit Thrush and Red-eyed Vireo both demonstrated significant declines between 1991 and 1996 in the Chippewa NF, but both species increased significantly between 1996 and 1999. Obviously trends will continue to change through time, and the data from this study will become increasingly useful with each additional year.

Population Trends

The majority (65%) of the 79 bird species tested showed no significant increase or decrease between the first and last year of monitoring. Although trends vary widely among individual species and study areas, the trend across years in the number of species detected per sampling unit has been fairly similar among the four northern study areas (Appendix B). Each area shows a decline in this variable between 1994 and 1996, with an increase from 1996 to 1998. The reason for this pattern is unclear, but it may be related to winter and spring weather. The winter of 1995-1996 was among the most severe on record and the winter of 1997-1998 was among the most mild. Also, the abundance of migrant breeding birds could be affected through heterospecific attraction (Monkkonen et al. 1996, 1997). This hypothesis states that migrants may make decisions on where to breed based on the abundance and distribution of local populations of resident birds with similar life-history traits. A late spring could result in fewer numbers of residents being present when migrants arrive from the south, causing some migrant birds to select different areas for breeding, and causing others to forgo breeding, especially those with marginal territories. Manipulation experiments conducted in northern Minnesota and Finland have supported this hypothesis (Monkkonen et al. 1997).

The number of species detected per sampling unit has declined significantly in the St. Croix and Southeast study areas, although the trend in the St. Croix has not been consistent (Appendix B), and the Southeast represents only five years of data. The Southeast and the St. Croix have a higher amount of forest fragmentation than the other study areas, and several studies have demonstrated that forest fragmentation negatively affects the abundance and breeding productivity of several forest bird species (Lynch and Whigam 1984, Robbins et al. 1989, Robinson et. al 1995).

The total number of individuals detected per sampling unit has also decreased significantly in the Southeast, as well as the Chippewa NF, but this parameter is strongly influenced by changes in a few of the most abundant species. Examination of trends by individual species is much more instructive.

Increasing Species

The American Robin increased significantly in the Southeast and Chequamegon NF, and showed a consistent, but non-significant, increasing trend in the Chippewa NF (Appendix B). This species occurs in a wide variety of habitats including suburban areas and semi-open forests. The Yellow-rumped Warbler increased significantly in the Chequamegon and Superior National Forests. However, visual examination of the graphs (Appendix B) shows that the abundance of this species is highly variable, and it has actually declined since 1995 in the Chequamegon and

Chippewa NF. The coniferous habitats this species uses for nesting and foraging can be impacted by periodic spruce budworm invasions, which could possibly account for some of the variation in abundance between years (Crawford and Jennings 1989). The American Redstart also increased significantly in the Chequamegon and Superior National Forests, however, the increase in the Superior NF has been rather inconsistent (Appendix B). This species is associated with early successional forests as well as openings within older forests.

Of the 13 species that increased in at least one of the three National Forests, only the White-breasted Nuthatch and Blue Jay showed a corresponding significant regional increase. These two species, in addition to the Black-capped Chickadee, are permanent residents and all declined regionally in 1996 and have since increased. The mild winters of 1997-1998 and 1998-1999 may have helped facilitate this rebound. The Northern Waterthrush has shown a significant regional increase, but the trend appears to be strongly influenced by low abundance in the first year of sampling (Appendix B).

It is often informative to try to identify shared life-history traits among species with similar population trends. Long-distance migrant birds are often thought to be more specific in their habitat use, and possibly more vulnerable to habitat changes, than short-distance and permanent residents (Lynch and Whigham 1984, O'Connor et al. 1992). In this study, the proportion of long-distance, short-distance, and permanent residents in the 16 species that increased is similar to the pool of species that were tested, although three of the four regionally increasing species are permanent residents. Nest location can a have significant effect on nest success rates, thus affecting the number of young recruited into a population (Martin 1992). Only one ground-nesting species demonstrated a significant increase, which is fewer than would be expected. However, three other ground-nesting species (Golden-winged Warbler, Black-and-white Warbler, and Northern Waterthrush) showed consistent but non-significant increases in at least one study area (Appendix B), so it is difficult to determine the consistency of this pattern among increasing species.

Decreasing Species

The White-throated Sparrow, Eastern Wood-Pewee, Black-and-white Warbler, Ovenbird, Mourning Warbler, and Brown-headed Cowbird decreased significantly in more than one study area. The White-throated Sparrow decreased in all three National Forests and has shown a non-significant decrease in the St. Croix study area (Appendix B). This species breeds in a variety of shrubby habitats, from forests to clearcuts. The Eastern Wood-Pewee decreased significantly in the Chippewa and Superior National Forests and has shown a consistent decline since 1994 in the Chequamegon NF. This species is typically found in contiguous mature forests, but can also be found around forest edges. The Black-and-white Warbler has decreased significantly in the Superior NF and the St. Croix, although the St. Croix trend appears to be strongly influenced by low abundance in 1999. It breeds in a variety of forest types, which typically have a well-developed shrub layer. The Ovenbird decreased in the Chippewa NF and St. Croix and dipped to its lowest level in all four northern study areas in 1996, the same year that the number of species per sampling unit reached its lowest level. Ovenbirds breed in a variety of forested habitats, particularly those with open understories. Mourning Warblers decreased significantly in the Chippewa and Superior National Forests and have shown a non-significant but consistent decline in the St. Croix. This species breeds in brushy open areas within forests and along forest edges.

The Brown-headed Cowbird has declined in the Chippewa NF and the Southeast. It is a brood parasite that is closely associated with agricultural feedlots that are used for foraging.

Of the 13 species that decreased significantly in at least one study area, nine are long-distance migrants and four (White-throated Sparrow, Brown-headed Cowbird, Winter Wren, and Song Sparrow) are short-distance migrants (Table 3). Many long-distance migrants are thought to be experiencing continental population declines, although almost half of the increasing species from this study are long-distance migrants. Ten of the 13 declining species nest on the ground, two nest in trees (Eastern Wood-Pewee, Blackburnian Warbler), and the Brown-headed Cowbird is a brood parasite. The prevalence of ground-nesting habits in declining species (77%; Table 3) is apparent when compared to the proportion of ground-nesters in all the species tested (32%; Appendix C).

Some studies have shown that generalist nest predators, particularly in fragmented landscapes, can significantly reduce nesting success (Robinson et al. 1995, Donovan et al. 1997). In the forested landscapes of the Upper Midwest, some studies have found higher nest predation rates near forest edges (Fenske-Crawford and Niemi 1997, Flaspohler 1999), while others have not (Hanski et al. 1996). Data from the Minnesota DNR winter track survey (Berg 1999) between 1991 and 1998 indicate a peak in track indices in 1995 for potential ground nest predators such as fisher (*Martes pennati*) and pine marten (*Martes martes*). Nonetheless, the effects of nest predation on population trends in this study are unknown.

Of the 11 species that decreased in at least one of the three National Forests, five species (White-throated Sparrow, Eastern Wood-Pewee, Ovenbird, Connecticut Warbler, and Mourning Warbler) showed a corresponding significant regional decline (Table 2). The Veery and Canada Warbler also declined regionally, but did not show a significant decline in any of the individual study areas. All species that showed a significant regional decline are long-distance migrants (except the White-throated Sparrow) that nest on the ground (except the Eastern Wood-Pewee).

A decline in the Brown-headed Cowbird population may be beneficial to many forest birds vulnerable to brood parasitism. Although Brown-headed Cowbird parasitism continues to be a problem in many areas (Robinson et al. 1995), and the species is still abundant in parts of the region (Green 1995), the declines in our study are encouraging.

The Blackburnian Warbler is the only species to decrease significantly in one study area and increase significantly in another. This species is dependent on conifers for nesting and foraging, and trends may be associated with local changes in spruce budworm populations (Morris et al. 1958, Crawford and Jennings 1989).

LITERATURE CITED

Berg, B. 1999. Winter track survey summary, 1998. Forest Wildlife Populations and Research Group, Minnesota Department of Natural Resources. Grand Rapids, MN.

Crawford, H. S., and D. T. Jennings. 1989. Predation by birds on spruce budworm *Choristoneura fumiferana*: functional, numerical, and total responses. Ecology 70:152-163.

Donovan, T. M., P. J. Jones, E. M. Annand, and F. R. Thompson, III. 1997. Variation in local-scale edge effects: mechanisms and landscape context. Ecology 78:2064-2075.

Fenske-Crawford, T. J., and G. J. Niemi. 1997. Predation of artificial ground nests at two types of edges in a forest-dominated landscape. Condor 99: 14-24.

Finch, D. M., and P. W. Stangel. 1993. Status and management of neotropical migratory birds. Gen. Tech. Rep. RM-229, Rocky Mountain Research Station, Forest Service, U.S. Department of Agriculture, Fort Collins, CO. 422 pp.

Flaspohler, D. J. 1999. Songbird breeding response to clearcuts in northern forests. Newsletter of the Wisconsin Working Group of Partners in Flight: 3(1): 1-2.

Green, J. C. 1995. Birds and forests: A management and conservation guide. Minnesota Department of Natural Resources. St. Paul, MN. 182 pp.

Hagan, J. M., and D. W. Johnston. 1992. Ecology and conservation of neotropical migrant landbirds. Smithsonian Institution Press, Washington, D.C. 609 pp.

Hanski, I. K., T. Fenske, and G. J. Niemi. 1996. Lack of edge effect in nesting success of breeding birds in managed forest landscapes. Auk 113:578-585.

Hanowski, J. M., and G. J. Niemi. 1995. Experimental design considerations for establishing an off-road, habitat specific bird monitoring program using point counts. *In:* Monitoring bird populations by point counts. Gen. Tech. Rep. PSW-GTR-149. Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture, Albany, CA.

Holmes, R. T., and T. W. Sherry. 1988. Assessing population trends of New Hampshire forest birds: Local vs. regional trends. Auk 105:756-768.

Howe, R. W., G. J. Niemi, G. J. Lewis, and D. A. Welsh. 1997. A standard method for monitoring songbird populations in the Great Lakes region. Passenger Pigeon 59:182-194.

James, F. C., C. E. McCulloch, and D. A. Wiedenfeld. 1996. New approaches to the analysis of population trends in land birds. Ecology 77(1):13-27.

Link, W.A., and J. R. Sauer. 1994. Estimating equations estimates of trends. Bird Populations 2:23-32.

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

Martin, T. E. 1992. Breeding season productivity: what are the appropriate habitat features for management? Pages 455-473 in Ecology and conservation of neotropical landbirds (J. M. Hagan, and D. W. Johnston, eds.). Smithsonian Institute Press, Washington D.C.

Martin, T. E., and D. M. Finch (eds.). 1995. Ecology and management of neotropical migratory birds: A synthesis and overview of critical issues. Oxford University Press, New York, NY. 489 pp.

MathSoft, Inc. 1999. S-Plus User's Guide, Data Analysis Products Division, MathSoft, Seattle, WA. 634 pp.

Monkonnen, M., J. T. Forsman, and P. Helle. 1996. Mixed-species foraging aggregations and heterospecific attraction in boreal bird communities. Oikos 77:127-136.

Monkonnen, M., P. Helle, G. J. Niemi, and K. Montgomery. 1997. Heterospecific attraction affects community structure and migrant abundances in northern breeding bird communities.

Morris, R. F., W. F. Cheshire, C. A. Miller, and D. G. Mott. 1958. The numerical response of avian and mammalian predators during a gradation of the spruce budworm. Ecology 39:487-494.

O'Connor, R. J. 1992. Population variation in relation to migrancy status in some North American birds. Pages 455-473 in Ecology and conservation of neotropical landbirds (J. M. Hagan, and D. W. Johnston, eds.). Smithsonian Institute Press, Washington D.C.

Ralph, C. J., G. R. Geupel, P. Pyle, T. E. Martin, and D. F. DeSante. 1993. Handbook of field methods for monitoring landbirds. Gen. Tech. Rep. PSW-GTR-144. Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture, Albany, CA. 41 pp.

Ralph, C. J., J. R. Sauer, and S. Droege. 1995. Monitoring bird populations by point counts. Gen. Tech. Rep. PSW-GTR-149. Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture, Albany, CA. 181 pp.

Reynolds, R. T., J. M. Scott, and R. A. Nussbaum. 1980. A variable circular-plot method for estimating bird numbers. Condor 82:309-313.

Robbins, C. S., J. R. Sauer, R. S. Greenburg, and S. Droege. 1989. Population declines in North American birds that migrate to the neotropics. Proceedings of the National Academy of Sciences, USA 86:7658-7662.

Robinson, S. K., F. R. Thompson III, T. M. Donovan, D. R. Whitehead, and J. Faaborg. 1995. Regional forest fragmentation and the nesting success of migratory birds. Science 267:1987-1990.

Terborgh, J. W. 1989. Where have all the birds gone? Princeton University Press, Princeton, New Jersey. 207 pp.

Thomas, L. 1996. Monitoring long-term population change: why are there so many analysis methods? Ecology 77(1):49-58.