Breeding Bird Monitoring in Western Great Lakes National Forests 1991-2008

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

- A total of 425 existing stands were surveyed for breeding birds including 131, 126, and 168 stands (1,298 survey points) in the Chequamegon, Chippewa, and Superior National Forests (NFs), respectively in 2008. Annual surveys have been conducted since 1991 in the Chippewa and Superior NF, and since 1992 in the Chequamegon NF.
- A total of 75 new points in lowland conifer and research natural areas (RNAs) in the Superior NF were also sampled this past year.
- Trends in relative abundance were calculated for 73 bird species, including 60 species in the Chequamegon NF, 58 in the Chippewa NF, and 49 in the Superior NF, for an overall total of 167 species*NF trends. A total of 42 species were also tested for a pooled trend by combining data from the three national forests.
- Of the 167 species*NF trends, 68 (43%) were significant ($P \leq 0.05$). A total of 23 species increased significantly ($P \leq 0.05$) in at least one national forest and 25 species decreased. Only two species, White-breasted Nuthatch and Rose-breasted Grosbeak, had conflicting increasing and decreasing trends in two national forests.
- Fifteen species had significant increasing pooled trends across all of the NFs and 11 had decreasing trends.
- Of the 166 species trends calculated in 2007, 27 (16%) changed in 2008. Three of the changes were positive and 9 were new significant decreases. The majority were changes that were increasing in 2007 but no longer were significant in 2008. Most of the changes observed were in the Chequamegon and Chippewa NFs.
- The Red-eyed Vireo, one of the most abundant birds in the region, had been increasing in the Chequamegon and Superior NFs since the early 1990s but its decreasing trend that began in 2002 no longer indicates an increasing trend in those two NFs. The overall trend in the Chippewa NF still indicates an increasing trend but also a slight decline since 2002.
- Ovenbird, our most abundant regional species, continued to show significant negative trends on all three NFs, although it has been steadily increasing in the Chippewa NF since 2000.
- The percentage of increasing species on each national forest ranged from 13% in the Chequamegon NF to 22% in the Superior NF. The percentage of decreasing species ranged from 21% in the Superior NF to 26% in the Chequamegon NF.
- The short-distance migrant guild continued to show highly significant declines in the Chequamegon NF only and for the pooled NFs. This guild, however, continued to show the pattern of increase in the Chippewa and Superior NFs since 2000.
- Long-distance migrants now show a significant declining trend in both the Chequamegon and Superior NFs and in the pooled data set in 2008. Permanent residents continued to increase in the Chippewa and Superior NF and in the pooled NFs. They continue to be stable in the Chequamegon NF.
- The ground nesting guild continued to show highly significant declines on all national forests. The Chippewa NF is the only NF that shows a hint of increasing or at least stabilization of this trend since 1999. Shrub/sub-canopy nesters continued to increase in the Chippewa NF and in the pooled NFs. Canopy nesting species showed a mixed pattern; decreasing in the Chequamegon NF but incrasing in the Superior NF. Cavity nesting species continued to show a strong increase in the Chippewa and Superior NFs which strongly influenced the increase in the pooled NFs.

- The coniferous forest-associated species continued to increase in the Chippewa, Superior, and pooled NFs, while those associated with deciduous forests decreased in the Chequamegon and Superior NFs and for the pooled NFs. Bird species of mixed deciduous-coniferous forests continued to decrease in the Chequamegon and pooled NFs. Those species associated with lowland coniferous forest habitats continued to decline on both Chippewa and pooled NFs, while those species associated with early successional habitats continued to increase in the Chippewa NF only.
- The greatest common denominator for those species that are declining appears to be their ground nesting life history – Hermit Thrush, Ovenbird, Winter Wren, and Veery are among those that have declined in two or more NFs. There also is a slight trend toward species associated with more mature forested habitats such as the Great Crested Flycatcher, Yellow-rumped Warbler, Eastern Wood-Pewee, Hermit Thrush, Ovenbird, and Scarlet Tanager. Recent reversals of previous negative trends in species such as the White-throated Sparrow are encouraging.
- Of the 1,274 survey sites in the three national forests, approximately 16% have been at least partially harvested since the beginning of monitoring, which is about 1% a year. This harvest rate is comparable to the documented 4.8% change from mature forest to early-successional types on federally managed forest lands in northeastern Minnesota between 1990 and 1995 (i.e. ~1% annual change). Thus, it appears that management activities on our sample sites are representative of the national forests as a whole, and that the trends we are documenting are probably occurring across the regional landscape.
- In 2008 we submitted a paper on "Estimating the effects of detection heterogeneity and overdispersion on trends estimated from avian point counts" to the journal *Ecological Applications.* The paper received favorable reviews, but required revision. Those revisions have been made and the paper was resubmitted to the journal. The underlying question of our analysis was "do differences in the ability to detect species in the bird counts affect the estimates of trends?" For instance, Ovenbirds are easy to detect, while Brown Creepers are more difficult because of differences in their singing intensity. Overdispersion is a bit more esoteric, but is a fundamental issue related to the mean and variance of the bird counts for each species. Both issues are hotly debated in the current ornithological and animal sampling literature. Our results suggest that analysis of raw counts that we have been using in our trend estimates throughout this project will give reliable estimates of trends if 1) detection probability does not show a temporal trend and 2) the time series of counts is long (preferably more than ten years). We have no reason to suspect that there is a systematic change in our detection of species over time and because we have greater than ten years of data, our confidence in the trends improves every year.

INTRODUCTION

The national forests of the western Great Lakes have among the richest diversity of breeding bird species in North America (Green 1995, Rich et al. 2004). An increased appreciation of this diversity, along with concerns about potential declines of some species, has led to a strong interest in monitoring forest bird populations in the region. The relatively heavily forested landscapes of northern Minnesota and Wisconsin are considered to be population "sources" for many forest bird species and may be supplementing population "sinks" in the agricultural landscapes of the lower Midwest (Robinson et al. 1995, Temple and Flaspohler 1998), highlighting the importance of monitoring trends in forest bird populations in the Upper Midwest.

Agencies such as the USDA Forest Service have a need for population trend data at the scale of an individual national forest to identify when and where population changes are occurring and to identify potential conservation problems. 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, limited coverage in some areas can make it difficult to use BBS data to characterize population trends at smaller geographic scales (Peterjohn et al. 1995). Continental trends also have the potential to mask regional population trends (Holmes and Sherry 1988), thus there is a need for regional monitoring programs that can provide more localized information (Green 1995, Howe et al. 1997).

In response to the need for regional population data, a long-term forest breeding bird monitoring program was established in 1991 in the Chippewa and Superior NFs, and in 1992 in the Chequamegon NF and the St. Croix region of east-central Minnesota. The Forest Service is mandated to monitor certain management indicator species (Manley 1993), and our monitoring program expands beyond indicator species to include all forest songbird species that we can adequately sample. Currently, approximately 420 stands (1,271 points) within the three national forests are surveyed once during each breeding season (June 1 to July 10). From 1995 to 2001 we surveyed an additional 211 points in southeast Minnesota, however, counts were discontinued due to a lack of funding (Lind et al. 2001b) for 1995-2001 results from southeast Minnesota. Surveys in the St. Croix region of east-central Minnesota were also discontinued after 2003 due to lack of funding, with 1992-2003 results available in our 2003 annual report (Lind et al. 2003). Results from the Nicolet NF bird monitoring program in northeastern Wisconsin were included in the 2005 analysis and a comparison with that forest is available in the 2005 annual report (Lind et al. 2005). In addition, species' RNV (Hanowski and Danz 2003) have been calculated and compared to trends in 2004 and 2005 (Lind et al. 2004, 2005).

The primary objective of this report is to update U.S. Forest Service personnel on results of the forest bird monitoring program. We focus on relative abundance trends of individual species, as well as assemblages of species, over the 17 to 18 year time frame of the monitoring. Our intent is to summarize the most important results and to provide detailed information in appendix form for those who need more specific results. This report, as well as annual update reports from 1998 to 2007, can be found on the internet at: http://www.nrri.umn.edu/mnbirds/reports.htm. Other objectives, including bird/habitat and bird/landscape relationships, development of management recommendations for birds, and development and monitoring of the forest plan, were met through Minnesota's Forest Bird Diversity Initiative (Niemi et al. 2003). Additional information on these objectives will be available as time and monetary resources become available. It is our intent next year to produce a document, coupled with the monitoring being completed in the Nicolet NF and other areas in the western Great Lakes region (e.g. Apostle Islands National Lakeshore) with some similarities with that produced by La Sorte et al. (2007) for the Southern NFs. This report closely follows reports from the previous two years (Etterson et al. 2007, Danz et al. 2008).

DESIGN AND METHODS

Sample Design

The monitoring program was designed to provide an accurate estimate of population change for forest bird species on three national forests in northern Minnesota and Wisconsin (Figure 1). The spatial extent of each national forest is large, on the order of hundreds of thousands of hectares, and each area includes a mosaic of forest stand types. We distributed sampling locations across the forest mosaic in a stratified random manner. A list of forest stands was created for each study area, and stands with the same stand type according to dominant tree species and stocking density were grouped into strata. Stands were ≥ 16 ha (40 acres) and were identified from the individual national forest inventories. For each national forest, a number of stands were selected from each stratum so that the final proportion of stands of each stand type was equal to the proportion of forested land area of each stand type (Hanowski and Niemi 1995). Our sample of stands is therefore representative of the forest cover in each national forest. A total of 133, 135, and 169 stands were established in the Chequamegon, Chippewa, and Superior National Forests, respectively.

Stands were large enough to accommodate three sampling points a minimum of 220 meters apart. Changes to forest cover through natural and anthropogenic disturbance have occurred on sampling locations since the beginning of the study and may have caused concomitant changes in bird populations. Because sampling locations are permanently marked, we are able to incorporate such changes into our descriptions of bird population patterns through time.

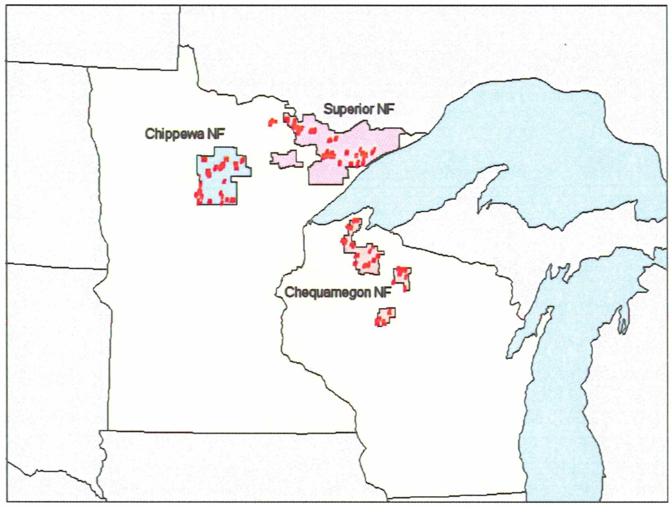

Figure 1. Locations of forest breeding bird point counts in northern Minnesota and Wisconsin 1991-2008.

Sampling

Point count sampling used in our program follow national and regional standards (Ralph et al. 1993, 1995, Howe et al. 1997). Ten-minute point counts were conducted at each point between June and early July (Reynolds et al. 1980). Point counts are appropriate for determining the relative abundance of most singing passerine species, but are inadequate for waterfowl, grouse, woodpeckers, and most raptors. In addition, because our surveys are conducted during the summer months, we may underestimate the relative abundance of early-nesting species (e.g. permanent residents that begin breeding in April, such as 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 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 were recorded. From 1995-2006, we included all birds heard or seen from the point regardless of distance 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 can be summed for 3, 5, and 10-minute periods so that regional comparisons are possible 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 was done to minimize bias due to observer differences in sampling different forest cover types. Weather data (cloud cover, temperature, and wind speed) and time of day were recorded before each count.

Observer Training

Prior to the field season, tapes of 120+ bird songs were provided as a learning tool, and all observers were required to pass an identification test of 75 bird songs made by the Cornell Lab 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, as established by audiologists, for all frequencies (125 to 8000 hertz).

Analysis

The pattern of population change through time can be viewed in two distinct ways: 1) as *population trajectory*, the path of a population through time, including its ups and downs, and 2) as *population trend*, the overall pattern of increase or decrease over the course of the study, presented as a positive or negative number. We built statistical models of species relative abundance as a function of time to describe these features of bird populations.

Relative abundance

For each species, yearly relative abundance was calculated using birds detected within 100 m of each point. Relative abundance for species from the three national forests was calculated by summing the number of individuals of each species across two points per stand. In order to avoid double-counting of individuals, data from the two farthest separated points within a stand were summed and analyzed.

We used a set of criteria to ensure that our analyses provided reliable population information. Stands were included in the analysis only if they had been sampled in at least six years. Data were included for a species if it was observed on a minimum of five stands per study area and in at least three years on each stand. For species that were observed on a minimum of five stands in each of the three national forests, we pooled all stands and carried out an additional (three national forest combined) analysis. Although this pooled analysis does not include lands in non-federal ownerships, it should give an indication of population trends at a larger scale than the individual national forest.

Population trajectory

Population trajectory can be thought of simply as the size of a population across time. Because we do not record every individual bird present in our study areas, we cannot know true population size. Instead, we must rely on our sample design to give an index of population size in each year. Central to our analytical process is how we scaled up bird abundance recorded at the stand level to an annual index of population size for the study areas. We used a non-parametric route regression procedure similar to that described by James et al. (1996), in which observed abundances on each stand are smoothed and then combined to give a region-wide index of population size.

We used locally-weighted (LOESS) regression to smooth the time series of species relative abundance for each stand. In LOESS-regression, fitted values (points along the curve) for years are calculated by giving a small amount of weight to neighboring years, for example, a year with high raw abundance for a species would tend to bring up the fitted values for the year before and the year after. We then computed the arithmetic mean and 95% confidence intervals using the fitted values from the within-stand regressions for each species in each year. The mean fitted value represents the annual index of population size. By plotting the mean fitted values and confidence intervals in a time series, we get a graphic depiction of the population trajectory (Appendix A). With every new year of sampling, we can expect the modeled abundance of a species in a given year to vary slightly from previous years' results, due to the way fitted abundance values are calculated in the LOESS-regression.

Population trend

Population trend can be thought of as a statement of the direction and magnitude of population change over a given time period (Link and Sauer 1997). Because a significant trend implies a unidirectional change, linear methods can be used to detect trend without asserting that the population trajectory is linear (Urquhart and Kincaid 1999). To assess trend, we modeled the relationship between the annual index of population size for a study area (described in *Population Trajectory* above) and time using simple linear regression. We used the slope coefficient to characterize direction and magnitude of the trend. To facilitate comparison, slopes were converted to units of percent annual change by dividing annual population indexes by the predicted value of the index at the midpoint of the survey period prior to regressing the index against time (Bart et al. 2003). We assessed the significance of the regressions using a bootstrap procedure (Manly 1991) in which trends were computed for 500 bootstrap resamples of the stands used to calculate the annual population index. For each bootstrap resample, trend was calculated using the same steps as for the original trend. For each original trend, an exact p-value was calculated as the percentile at which zero occurred in the distribution of 500 bootstrapped slopes. For example, $p = 0.01$ would be equivalent to 99% of bootstrapped slopes being greater than zero, which would give us a high degree of confidence that the true population slope was different from zero.

Guild analyses

We examined trends for three types of guilds: migration strategy, nesting substrate, and vegetation-type preference (Appendix C). Guild analyses followed similar procedures as the individual species analyses, except that each species was assigned a guild category and all species within that category (e.g. long-distance migrants) were combined and analyzed as a group. All non-flyover individuals of all species within the 100 m radius were included, regardless of whether the species met the inclusion criteria described above for individual species. Guild categories were taken from Ehrlich et al. (1988) and Freemark and Collins (1992), with modifications based on personal experience and data from the region.

Note that some species use different migration strategies, nesting substrates, and vegetation types in different portions of their geographic range. Guild analyses also can be complicated by a lack of agreement on how to categorize guilds, and there will always be species that use multiple guilds. Species guilds are not mutually exclusive and the species pool in a migration guild, for example, can be very similar to the species pool in a nesting guild (Sauer et al. 1996). Directional trends in abundant species can strongly affect all the guilds that those species are categorized in. Given these limitations, we still feel it is important to look for underlying similarities among groups of increasing and decreasing species.

Vegetation sampling

Since the beginning of the monitoring program in 1991, we have carried out vegetation surveys on bird point count locations using ocular estimates of overstory, shrub, and understory characteristics. We used a protocol designed to maximize time-efficiency; each survey taking fewer than 5 minutes to carry out. Every point was surveyed at least once in the early-mid 1990s and again in 2005-2006. It has always been our goal to obtain more comprehensive, standardized measurements of vegetation on the point count locations for the purpose of developing bird/habitat relationships. In 2006, we developed a more detailed vegetation sampling protocol based on measured variables that would be useful to forest managers instead of ocular estimates alone. In 2007, we surveyed 220 points and an additional 13 were surveyed by the Superior NF monitoring personnel.

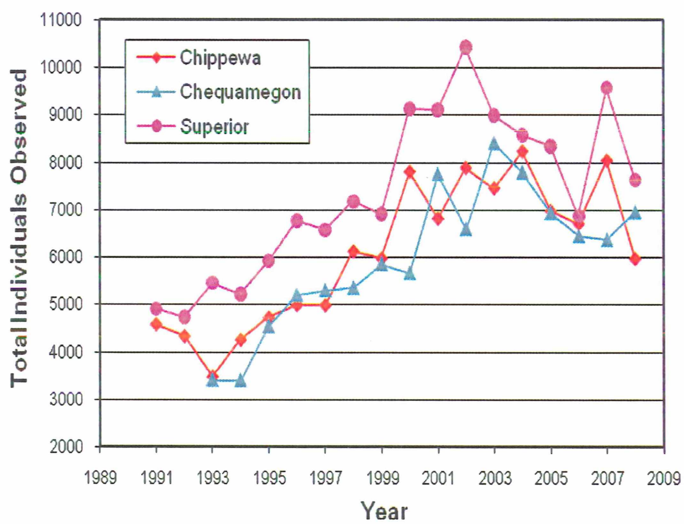

Figure 2. Total number of individuals detected annually (1991-2008) based on raw data before applying analysis criteria (e.g. includes flyovers, etc.). In 1995, the monitoring protocol changed from recording only individuals within 100m to recording all individuals regardless of distance from observer.

RESULTS AND DISCUSSION

Over the course of 18 field seasons we have detected over 350,000 individual birds of 173 species on more than 22,200 ten-minute point counts (almost 3,700 hours of sampling) in the three national forests (Figure 2). In 2008, we sampled 131 stands in the Chequamegon NF, 126 stands in the Chippewa NF, and 168 in the Superior NF.

Seventy-three species were tested for trends in at least one national forest, including 60 in the Chequamegon NF, 58 in the Chippewa NF, and 49 in the Superior NF (Table 1). Additionally, 42 species were tested for a "pooled" (three national forests combined) trend. As monitoring has proceeded through the years, new species have met our criteria for inclusion in trend analyses on each national forest. The number of tested species has increased steadily from 36 in 2000, when the criteria were first applied, to 73 in 2008. See Appendix A for graphs of individual species trajectories and Appendix B for test statistics and sample sizes used in the trend analyses.

Overview of Population Trends

A total of 167 species/national forest trends were calculated (not including pooled trends), 69 (44%) of which were significant ($P \leq 0.05$). Twenty-three species increased in at least one national forest, including six (Yellow-bellied Flycatcher, Black-capped Chickadee, Red-breasted Nuthatch, Cedar Waxwing, Rose-breasted Grosbeak, and American Redstart) that increased in multiple national forests (Tables 2 and 3). Twenty-five species decreased in at least one national forest, including eight (Eastern Wood-Pewee, Great-crested Flycatcher, Winter Wren, Veery, Hermit Thrush, Yellow-rumped Warbler, Ovenbird, and Scarlet Tanager) that decreased in multiple national forests (Tables 4 and 5).

Of the 166 species/national forest trends calculated in 2007 (i.e. excluding pooled trends, Danz et al. 2008), 27 (16%) changed in 2008 (Table 6). Three of the changes were positive and 9 were decreasing trends. The remaining changes were from species that were increasing up to 2007 and now those trends are stable.

Many of the species we monitor exhibit large annual fluctuations in abundance, a phenomenon which has been documented on several other long-term studies (Virkkala 1991, Blake et al. 1994, Weslowski and Tomialojc 1997, Holmes and Sherry 2001). Long-term monitoring studies are important for differentiating between these short-term fluctuations and actual long-term trends. In previous years' results, we often observed species with opposite trends in different study areas (e.g. five species in 2000 results; Lind et al. 2001a). This year there were two species, White- breasted Nuthatch and Rose-breasted Grosbeak, with inconsistent trends. The White-breasted Nuthatch was significantly decreasing in the Chequamegon NF, but increasing in the Chippewa NF. The Rose-breasted Grosbeak was increasing in both the Chequamegon and Chippewa NFs, but decreasing in the Superior NF. After 18 years of sampling, there have been consistently increasing species (e.g. Red-eyed Vireo, Black-capped Chickadee, American Redstart) and decreasing species (e.g. Eastern Wood-Pewee, Winter Wren, Veery, Hermit Thrush, and Ovenbird).

Chequamegon National Forest

We observed 6,134 individuals of 106 species overall in the Chequamegon NF in 2008. Forty-six species did not meet the criteria to be included in trend analysis (Appendix D). Notable among these were twelve species with all-time high observation totals (in parentheses), including Pied-billed Grebe (3), Ruffed Grouse (98), Wild Turkey (10 – tie with 2007), Sandhill Crane (41), Northern Harrier (3- tie 2003), Mourning Dove (79), Whip-poor-will (2 – tie with 1996), Eastern Phoebe (13), Sedge Wren (25), Gray Catbird (26), Tennessee Warbler (11), and Blackpoll Warbler (1 – undoubtedly a late migrant).

Number of observations in Chequamegon NF for ten most abundant species in 2008.

Species	*Count*
Ovenbird	*865*
Red-eyed Vireo	*590*
Nashville Warbler	*271*
Blue Jay	*249*
Black-throated Green Warbler	*221*
Chestnut-sided Warbler	*211*
Rose-breasted Grosbeak	*211*
White-throated Sparrow	*199*
American Robin	*199*
Hermit Thrush	*175*

Of the 60 species tested for trends in the Chequamegon NF, 8 species (13%) increased significantly and 16 (26%) have decreased (Figure 3). Compared to 2007, there was only one new increasing species (Yellow-bellied Sapsucker) and five new decreasing species (Table 6). Six species that were increasing in 2007 now have non-significant, stable trends. Indigo Bunting (7.5%), Yellow Warbler (6.8%), and American Redstart (4.7%) had the greatest rates of increase.

The Eastern Wood-Pewee, Winter Wren, and Hermit Thrush were well-represented in the Chequamegon NF, but continued to have some of the greatest declines (5-9% annually; Appendix B). Great-crested Flycatcher and Blue-headed Vireo were less widespread in the forest (28 and 23 stands, respectively) and also continued to have approximately 5% declines. The Red-winged Blackbird (-8.8%) and Evening Grosbeak (-17.5%) had the highest rates of decrease, but they were each tested on just six stands. The trend for Red-winged Blackbird is suspect because we do not sample primary habitat for this species, but both species have been decreasing over a substantial part of their range (Sauer et al. 2004). Other common species in Chequamegon NF that are declining, though at a lesser rate, include White-breasted Nuthatch, Veery, Brown Thrasher, Yellow-rumped Warbler, Black-throated Green Warbler, Common Yellowthroat, Ovenbird, and Scarlet Tanager. The decline detected for the Brewer's Blackbird is also a new trend, but this species is also rare on the habitats sampled (n=6) in the Chequamegon NF. The negative trend should be interpreted with caution.

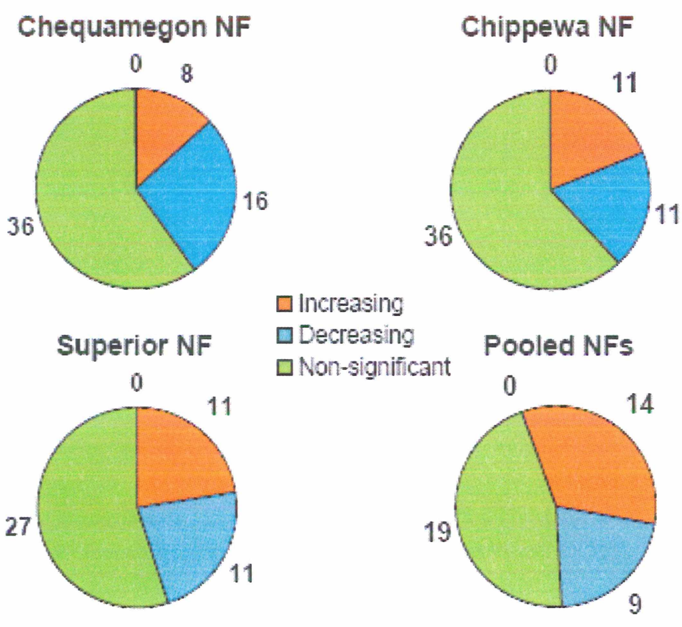

Figure 3. Summary of significant trends (P<) by national forest (1991-2008). Pooled trends include three national forests combined. See Table 1 for species trends.

Chippewa National Forest

We observed 5,969 individuals of 101 species overall in the Chippewa NF in 2008. Ovenbird and Red-eyed Vireo continue to be two most abundant species. Forty-three species did not meet the inclusion criteria for trend analysis. Notable among these species were American White Pelican (7), Red-shouldered Hawk (1 – tie with 1996 and 2001), Ring-billed Gull (3-tie with 2000), Chimney Swift (3 – tie with 2002), Ruby-throated Hummingbird (15 – tie with 2007), Red-bellied Woodpecker (2), Ruby-crowned Kinglet (5), Brown Thrasher (2 – tie with 2005), Tennessee Warbler (8), Cape May Warbler (4 – tie with 1994 and 1999), Bay-breasted Warbler (3-tie with 1994), Blackpoll Warbler (1-tie with 1995 but also undoubtedly a late migrant), and White-winged Crossbill (81!). Several species were observed for the first time including the Lesser Scaup (1), Wild Turkey (1), and Bank Swallow (2) (Appendix E).

Number of observations in Chippewa NF for ten most abundant species in 2008.

Species	*Count*
Ovenbird	*749*
Red-eyed Vireo	*670*
Nashville Warbler	*334*
Veery	*278*
White-throated Sparrow	*268*
Least Flycatcher	*233*
Chestnut-sided Warbler	*230*
Blue Jay	*172*
Hermit Thrush	*148*
Common Yellowthroat	*134*

Of the 58 species tested in the Chippewa NF, 11 species (19%) continued to increase significantly and 11 (19%) continue to decrease (Figure 3). Canada Warbler (9.3%) and American Goldfinch (9.3%) continue to have the greatest rates of increase, but are relatively rare in the Chippewa NF found on 16 or fewer stands. Black-capped Chickadee, Red-breasted Nuthatch, Cedar Waxwing and Black-and-White Warbler had increasing rates of 5% or greater, while Yellow-bellied Flycatcher, Red-eyed Vireo, White-breasted Nuthatch, Chestnut-sided Warbler, Black-and-white Warbler, American Redstart, and Rose-breasted Grosbeak had moderate annual increases between 1-5 %. The only species to show a new increase in 2008 was the Rose-breasted Grosbeak. In contrast, several species that were increasing up until 2007, no longer showed increasing trends. They include the Least Flycatcher, Veery, Wood Thrush, Black-throated Green Warbler, Canada Warbler, and Chipping Sparrow (Table 6).

The greatest rate of annual decrease in the Chippewa NF continued to be the Connecticut Warbler (-11%); but the species was only sampled on 15 stands. In addition, its recent rate of decease has stabilized since 2002 (Appendix A). Well-represented species (detected on >= 40 stands) that showed annual rates of decline of 4% or more include the Eastern Wood-Pewee, Winter Wren, Hermit Thrush, Scarlet Tanager, and Song Sparrow. Great Crested Flycatcher (-7.6%) also continued to decline although it is less widespread and only found on 25 stands (Appendix B). Similarly, large declines were observed in the American Crow (-8.5%) but it was only found on six stands. Moderate annual declines continued to be observed for the Nashville Warbler (-1.2%), Ovenbird (-2.1%), and a new decrease in 2008 for the Yellow-rumped Warbler (-1.7%) (Tables 4, 5, and 6, Appendix B).

Superior National Forest

We observed 7,639 individuals and 97 species in the Superior NF in 2008. Forty-eight species were observed that did not meet the minimum abundance criteria for trends. Notable among these species were American Woodcock (2 – tie with 2004), Mourning Dove (5), Eastern Phoebe (8), Wood Thrush (13), Blackpoll Warbler (2-late migrant), Eastern Towhee (1-also observed in 1995 and 2001), Savannah Sparrow (2), White-winged Crossbill (21), and American Goldfinch (40) , all of which had all-time high observation records (in parentheses) (Appendix F). In addition, this is the first year that a Bobolink was observed on one of the stands.

Number of observations in Superior NF for ten most abundant species in 2008.

Species	*Count*
Ovenbird	*931*
Nashville Warbler	*641*
White-throated Sparrow	*639*
Red-eyed Vireo	*545*
Chestnut-sided Warbler	*364*
Blue Jay	*343*
Veery	*222*
Winter Wren	*210*
Blackburnian Warbler	*209*
Black-and-White Warbler	*203*

Of the 49 species tested in the Superior NF, 11 species (22%) were increasing and 11 (22%) were decreasing (Figure 3). Black-throated Blue Warbler, Tennessee Warbler, and Hairy Woodpecker all had rates of increase >5%, but they were tested on 11 or fewer stands and their trends may be more susceptible to site-specific influences than other species. Northern Flicker, Black-capped Chickadee, Red-breasted Nuthatch, Brown Creeper, and Cedar Waxwing are more widespread species increasing at >3% annually (Tables 2 and 3, Appendix B). The only new species that increased in 2008 was the Cape May Warbler (+8.8%), but it was also a relatively rare species found on only 9 stands (Table 6). Two species, the Red-eyed Vireo and Nashville Warbler, were increasing until 2007 but those increases are no longer significant (Table 6). The trend for the Red-eyed Vireo in the Superior NF has been steadily decreasing since 2002, while the Nashville Warbler has shown a steady increase, albeit currently non-significant, since 1998 (Appendix A).

Ruffed Grouse (-12.3%), Tennessee Warbler (-16.2%), Scarlet Tanager (-9.7%), and Eastern Wood-Pewee (-6.9%) had the greatest rates of decrease, but were not widespread species or in the case of the Ruffed Grouse not sampled effectively in Superior NF (Tables 4 and 5). Rose-breasted Grosbeak, Winter Wren, and Veery, were declining at >3% annually, and were widely distributed in the forest. Ovenbird, the most abundant species in the Superior NF, Mourning Warbler, American Robin, and Hermit Thrush continued to show about a 1-2% population decline (Tables 4 and 5, Appendix B). The Ruffed Grouse and Hermit Thrush were the two species with new negative trends this year not detected in 2007 (Table 6).

Pooled National Forests

Of the 42 species tested for a pooled national forests trend, 15 species (33%) increased significantly and 11 (23%) decreased (Figure 3). The strongest increases (>3%/year) across all national forests occurred in Hairy Woodpecker, Black-capped Chickadee, Red-breasted Nuthatch, Golden-crowned Kinglet, and Cedar Waxwing. Other widespread species that increased include Yellow-bellied Sapsucker, Yellow-bellied Flycatcher, Red-eyed Vireo, Blue Jay, Northern Parula, Chestnut-sided Warbler, Magnolia Warbler, Blackburnian Warbler, Black-and-white Warbler, and American Redstart (Table 1 and 2, Appendix B).

The strongest decreases across all national forests continued to be the Eastern Wood-Pewee, Winter Wren, Hermit Thrush, and Scarlet Tanager (>3%/year) (Table 1 and 4, Appendix B). Other widespread species that continue to show declines through 2008 include Veery, Yellow-rumped Warbler, Ovenbird, Mourning Warbler, Common Yellowthroat, Song Sparrow, and White-throated Sparrow. Four of these species, the Yellow-rumped Warbler, Mourning Warbler, Song Sparrow, and White-throated Sparrow – indicated stable trends in 2007 after the trends showed significant declines through 2006. However, these decreases are once again significant in 2008 (Table 4, Appendix B).

Management Activities on Study Areas

Of the 1,274 survey sites in the three national forests, 16% have been at least partially harvested since the beginning of monitoring, which is about 1% a year. A small number of our monitoring points have also had prescribed burns since the start of monitoring, but this is usually done after harvest. This harvest rate is comparable to the 4.8% change from mature forest to early-successional types on federally managed forest lands in northeastern Minnesota between 1990 and 1995 (i.e. ~1% annual change; Wolter and White 2002). Thus, it appears that management activities on our sample sites are representative of the national forests as a whole, and that the trends we are documenting are probably occurring across the regional landscape.

Guild Analyses

Short-distance migrants (species that winter primarily north of Mexico) showed highly significant declines in the Chequamegon NF in 2008 and in the pooled NF data set (Table 7). The most abundant short-distance migrants in our analyses include White-throated Sparrow, American Robin, Hermit Thrush, and Yellow-rumped Warbler, all species that indicated some decreases in counts in 2008. Long-distance migrants (species that winter primarily south of the U.S./Mexico border) signficantly declined in the Chequamegon and Superior NFs in 2008 and overall in the combined NF data set. Permanent residents continued to show significant increases in all forests except the Chequamegon NF, where they showed no change through 2008. Black-capped Chickadee, Blue Jay, and Red-breasted and White-breasted Nuthatches were the most abundant permanent residents. Their overall pattern of increasing abundance in the 3 NFs contributed to this increasing trend.

Ground nesting birds continued to show highly significant declines in all study areas, while shrub/sub-canopy nesters significantly increased in the Chippewa NF and in the pooled NF data set (Table 7). Abundant ground-nesters include Ovenbird, Nashville Warbler, Veery, and White-throated Sparrow. The most common shrub and subcanopy-nesting species include Red-eyed Vireo, Chestnut-sided Warbler, and American Redstart. These patterns of increase and decrease were likely strongly influenced by these relatively abundant species. Canopy nesting species continued to increase in the Superior NF but showed a significant decline in the Chequamegon NF (Table 7). Cavity nesters showed highly significant increases in the Chippewa and Superior NFs and for the pooled analysis (Table 7). Most primary cavity excavators (e.g. woodpeckers) have had stable trends or increasing trends, while many secondary excavators (e.g. chickadees and nuthatches) have had increasing trends. An exception is the Great Crested Flycatcher (a secondary excavator) which continued to decline in the Chequamegon and Chippewa NF.

The habitat guilds had varying patterns of increase and decrease. The coniferous forest guild continued to increase in the Chippewa, Superior, and pooled NFs, while deciduous forest-associated species decreased in the Chequamegon and Superior NFs and in the pooled data set (Table 7). Bird species associated with mixed deciduous-coniferous forest continued to decrease in the Chequamegon and pooled NFs through 2008. Species associated with lowland coniferous forests decreased on both Chippewa and pooled NFs, while the early successional guild continued to increase in the Chippewa NF only.

CONCLUSIONS

In 2007 we had a marked increase in the number of species that had significant increases in their counts since the start of sampling in 1991 or 1992; however, many of these trends were again non-significant ($P > 0.05$) in 2008. We emphasize that these are based on the long-term trends, but many of the species are now showing complex patterns of change over the 18 years of sampling, while others have consistent increasing or decreasing patterns over the entire period. For instance, the Red-eyed Vireo was increasing steadily in the Chequamegon and Superior NF from 1992 and 1991 (respectively) until 2000 and since that time the species has been in a steady decline. Hence, the overall trend is stable or slightly increasing, yet the recent trend shows a strong negative pattern (Appendix A). In contrast, the Ovenbird has shown a very strong negative trend in both the Chequamegon and Superior NF from 1992 and 1991 to the present (Appendix A). For both the Red-eyed Vireo and Ovenbird, the patterns in the Chippewa NF are quite different. The Red-eyed Vireo has shown a steady increase from 1991 to 2008, but some inconsistent trends. From 1991 to 1998, the counts were relatively stable, then increased substantially from 1998 to 2002 and have declined slightly between 2002 and 2008. Similarly, the Ovenbird in the Chippewa NF declined sharply from 1991 to 1998, while from 1998 to 2008 the species has been steadily increasing. We are clearly approaching the maturity of the monitoring program where a more detailed time-series analysis is merited.

Two of the major issues regarding trends that we will need to consider include 1) adjustments to detectability (Etterson et al. 2009) and 2) whether we should consider beginning the analyses using unlimited radius counts that began in 1995. Etterson et al. (2009) examined 16 species in our bird monitoring program with different detectability and habitat association. Among the species included were highly detectable species such as the Ovenbird and Winter Wren to species that are more difficult to detect such as the Brown Creeper and Golden-crowned Kinglet. This detailed analysis revealed that indeed using the raw counts do provide consistent trend estimates without adjustments for detectability. Among the positive reasons for this result is the long time series of observations that we have plus the large sample size being gathered as part of this monitoring program. We do, however, want to evaluate the detectability of all species that we are testing for trends to insure no additional adjustments need to be made in order to have confidence in the trend estimates. In 2008 we also added more information to the data gathering process by more precisely identifying when a species was first detected. Observations are now recorded in intervals of the first two minutes and each minute thereafter. Previously we were recording observations in 3, 5, and 10-minute intervals.

The second issue on using unlimited radius counts concerns the substantial number of observations we make in the field that are excluded when they are beyond 100 m. Etterson et al. (2009) suggest that there was a slight "heaping" effect during the years that counts were restricted to a 100 m radius circle (1991-1994). This is due to the censusers, although well aware of the caution in not placing species within the 100 m radius circle doing so probably sub-consciously. We still use the 100 m radius circle and will continue to do so in the future, especially for more detailed habitat analysis, but the unlimited radius counts minimizes the error associated with distance estimation from the point. Both of these issues raise major concerns with many monitoring programs across the country, especially since many programs restrict their observations to 25 and 50 m radius circles. Presumably heaping will be a much greater concern with these sampling programs.

In general, many of the species with widespread increasing trends are either forest habitat generalists (e.g. Red-eyed Vireo, Black-capped Chickadee and Blue Jay) or early successional species (e.g. Cedar Waxwing, Chestnut-sided Warbler and American Redstart). Many of these increasing species are currently at or above their estimated population size RNV values (Lind et al. 2005). Recent increases in the amount of edge and early-successional habitat on the regional landscape (Wolter and White 2002) is likely benefiting these species. Black-capped Chickadee, Red-breasted Nuthatch, and Hairy Woodpecker are year-round residents that may also be responding to increased food availability from bird feeding activities, especially considering their increasing numbers on Minnesota Christmas Bird Counts in the past decade (Niemi et al. 1996, National Audubon Society 2004).

The White-throated Sparrow was experiencing alarming declines on all three NFs as of 2000, but this species recently has been on the rise throughout the region and has converted to a stable trend in all individual NFs as of 2008. However, the overall trend in the pooled NFs is negative and highly significant. This is largely due to the large sample size (e.g. n= 232 stands across all three NFs) and the ability to detect change in this species. This trend, however, may be influenced by the higher counts during the first three years of the study and, therefore, it may have been one of the species affected by a heaping effect. The White-throated Sparrow is a species that is highly detectable, but its song may be difficult to estimate distance.

Species with widespread declines on our study sites are mainly found in mature forest habitats, with the possible exception of the Veery. The Eastern Wood-Pewee, Winter Wren, and Veery, have each shown significant declines on our surveys as well as USGS Breeding Bird Survey routes over much of their range (Sauer et al. 2004). Increases in edge and early-successional habitats may be having negative effects on these species, although there are examples of increases in mature forest species on individual national forests (e.g. Red-eyed Vireo, Blackburnian Warbler, and Golden-crowned Kinglet). There are also examples of decreases in shrub/early successional species (Mourning Warbler, Common Yellowthroat, and Song Sparrow). Connecticut Warbler, a species with a high affinity for lowland conifer, continued its consistent decline in the Chippewa NF, with the population down over 200% (-11% annual change) since the survey began. This species is stable on regional trends estimated from the U.S. Breeding Bird Survey, but is not sampled very well on those surveys.

The declines in ground nesters and increases in shrub nesters in our study seem to occur irrespective of migration strategy and habitat. It is possible that declines in ground-nesting populations are being influenced by recent changes in the landscapes of the Upper Midwest. Although the landscape surrounding the three national forests is primarily forested, average forest stand sizes and ages have changed in recent years. Wolter and White (2002) demonstrated a substantial decrease in patch size and interior forest area and a significant increase in edge density in early successional forest types in northeastern Minnesota between 1990 and 1995. Studies have shown that nesting success is reduced in landscapes with reduced patch sizes and high amounts of edge habitat, probably due to an increase in generalist nest predators (Robinson et al. 1995, Hanski et al. 1996, Donovan et al. 1997, Mattsson and Niemi 2006, 2008. In the forested landscapes of the Upper Midwest, recent studies have found higher predation rates on ground nests near forest/clearcut edges than in interior areas (Fenske-Crawford and Niemi 1997, Manolis et al. 2000, Flaspohler et al. 2001). Data from the Minnesota DNR winter track survey (Berg 2001) between 1991 and 2000 indicate a peak in track indices in 1995 for potential ground nest predators such as fisher (*Martes pennati*) and pine marten (*Martes martes*), which loosely follows the declines between 1994 and 1996 in many of the species we monitor. Nonetheless, the effects of nest predation on population trends in this study are unknown.

One of the main goals of this monitoring program is to identify consistent long-term declines of forest bird species. This is especially true for species of conservation concern such as the Eastern Wood-Pewee, Winter Wren, Hermit Thrush, Connecticut Warbler, and Scarlet Tanager. The declining trends for these species have been consistent across years and special management consideration may be considered for these species. Additionally, several species are currently well below their estimated RNV values (Lind et al. 2005) and they may not remain common if their declining trends continue. For the past several years, we have been especially concerned about the widespread regional population declines of Ovenbird (Mattsson and Niemi 2008), a species that is both the most abundant species across our region and has been experiencing widespread population declines. Being able to identify and distinguish between consistent population declines (e.g. > ten years) and shorter-term fluctuations or cycles in abundance is a critically important benefit of our long-term monitoring data.

Many of the declining species breed in mature forests, and many are ground-nesters. Some of these population declines may be linked to recent reductions in forest patch size and stand age on the landscape, especially in light of regional studies showing high nest predation on ground-nests near forest edges (Mattsson and Niemi 2006, 2008). Although the factors responsible for population declines are not definitively known, the prominence of declining ground-nesting species suggests that it would be prudent to curb further reductions in average forest patch sizes and age on the landscape. Several of these declining species have high PIF conservation values (e.g. Veery, Mourning Warbler, Eastern Wood-Pewee, and Connecticut Warbler) (Rich 2004), and the extensive forests of northern Minnesota and Wisconsin represent excellent opportunities to provide "source" populations for many species.

As detailed place-based information for this monitoring program increases over time, we are beginning to see some interesting observations emerge. For instance, this year was a banner year for the White-winged Crossbill with record numbers recorded in both the Chippewa and Superior NFs (81 and 21 respectively). This was likely a very high reproductive year for the species and its relationship with fluctuations in the spruce cone crop across northern Minnesota would provide an interesting analysis. Additional noteworthy new observations or record number of individuals reported include the Mourning Dove, Eastern Phoebe, Wood Thrush, and Eastern Towhee. Each of these species has their major distribution south or east of the NF region, especially for the Wood Thrush and Eastern Towhee. This longer, place-based data set could also prove useful for examining distribution patterns associated with climate change.

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