Summary of Breeding Bird Trends in the Chippewa and Superior National Forests of Minnesota - 1995-2015

Report to Chippewa National Forest and Superior National Forest, November 2015

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SUMMARY

- A total of 326 existing forest stands were surveyed for breeding birds including 135 and 191 stands (953 survey points) in the Chippewa and Superior National Forests (NFs), respectively in 2015.
- Trends in relative abundance were calculated for 74 bird species, including 65 species in the Chippewa NF and 63 in the Superior NF for 21 years from 1995 to 2015. All trends are reported as significant when $P < 0.05$.
- The Chippewa NF had 17 species that increased, 7 species that significantly decreased, and 41 species that were relatively stable from 1995 to 2015. Hence, 89 % of the species (58/65 species) with adequate trend information are estimated to be stable or increasing over the past 21 years in the Chippewa NF.
- The Superior NF had 17 species that increased, 11 that decreased, and 35 species that were relatively stable from 1995 to 2015. Hence, 83 % of the species (52/63 species) with adequate trend information are estimated to be stable or increasing over the past 21 years in the Superior NF.
- Seven species increased in both the Chippewa and Superior NFs, including Black-and-White Warbler, Black-throated Green Warbler, Blue Jay, Cedar Waxwing, Nashville Warbler, Pine Warbler, and Red-breasted Nuthatch.
- The Connecticut Warbler and Chipping Sparrow were the only species with significantly declining trends in both the Chippewa and Superior NFs. However, nine species had significantly declining regional trends when the two National Forests were combined, Chipping Sparrow, Common Loon, Connecticut Warbler, Eastern Wood-Pewee, Mourning Warbler, Red-eyed Vireo, Song Sparrow, Winter Wren, and Yellow-bellied Flycatcher.
- Most of the guild analyses showed signficant increases during the 1995-2015 period in each NF and regionally except for non-significant trends for bird species associated with early-successional forests and shrub/sub-canopy nesting species. In addition, non-significant trends were detected for short-distance migrants in the Chippewa NF, and both deciduous forest breeding and ground nesting species in the Superior NF. The guild trends are primarily influenced by the large number of species that have positive trends relative to the number of negative trends.
- The overall trend information indicates that most breeding bird species within these NFs that we are capable of monitoring and detecting trends are either increasing or stable in populations, while several species such as the Connecticut Warbler and Yellow-bellied Flycatcher continue to have trends that remain a concern. Both species are commonly found in conifer-dominated forests, especially lowland coniferous forests.
- A broader regional analysis of trends that includes the Chequamegon (1995-2010), Chippewa (1995-2011), Superior (1995-2011) and Nicolet (1995-2011) NF's of northern Minnesota and Wisconsin will be available soon in a USFS General Technical Report (Niemi et al. 2015).

INTRODUCTION

The breeding bird communities of the western Great Lakes region have among the richest diversity of breeding bird species in North America (Green 1995, Howe et al. 1997, Rich et al. 2004). The importance of this diversity and past concerns with 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). Analysis of population trends is used as an 'early-warning system' of potential problems in a species population and serves as a measure of the ecological condition of the environment (Niemi and McDonald 2004a).

Recently, a draft of a general technical report on a summary of the twenty-plus year data that have been gathered in the Chequamegon, Chippewa, Nicolet, and Superior NFs from the late 1980s through 2011 has been completed (Niemi et al. 2015). This report has gone through several iterations of peer-review and is currently in press. It summarizes a substantial amount of information that has been gathered on population trends, habitat relationships, bird community assemblages, factors potentially affecting population trends, and considerations for bird species of concern.

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 (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. The Forest Service is mandated to monitor certain management indicator species (Manley et al. 1993), and our monitoring program expands beyond indicator species to include all forest songbird species that we can adequately sample. Although recent changes to the USFS Planning Rule are in the process of being implemented (USDA Forest Service 2012), we are confident that this program is an effective way of monitoring the characteristics and conditions of an important component of the ecological communities present in these NFs. Currently, more than 300 stands (> 900 points) within the two NFs are surveyed during the breeding season (June 1 to July 10).

The primary objective of this report is to update U.S. Forest Service personnel on results of the forest bird monitoring program. Here we focus on relative abundance trends of individual species during the period from 1995-2015 (21 years) and summarize the most important recent results.

DESIGN AND METHODS

Sample Design

Bird monitoring programs within NFs in northern Minnesota and Wisconsin were designed 1) to establish a baseline inventory of local breeding bird assemblages, 2) to monitor population changes of forest bird species over time, and 3) to identify bird-habitat associations, particularly those relevant to forest management activities. Originally, the monitoring program was designed for the Chequamegon NF (WI), Chippewa NF (MN), and Superior NF (MN). After the 2010 field season, the Chequamegon NF was unable to continue to fund the program. Results from the Chequamegon NF 1995-2010 and the Chippewa and Superior NFs 1995-2011 were included in the general technical report (Niemi et al. 2015)

Verner (1985) in a classic paper on bird counting techniques concluded that greater care in planning and executing counts of birds should include prior consultation with biometricians, training of personnel, and testing the bird identification skills and sensory capabilities (e.g., hearing) of field observers. Our design in the Chippewa and Superior NFs adhered to these recommendations, and has been peer-reviewed as part of national breeding bird monitoring meetings (Hanowski et al. 1995, 2002a, and 2005a) and in several peer-reviewed publications (e.g., Niemi et al. 2004, Etterson et al. 2009, and Lapin et al. 2013).

We distributed sampling locations across the forest mosaic in a proportionally stratified random manner. For each NF, stands ≥ 16 ha were grouped from their respective compartment inventories into strata defined by dominant tree species (i.e., forest cover type) and stocking density. Because the Superior NF was large, we randomly selected three of the six districts to sample (Tofte, Kawishiwi, and LaCroix). We also excluded the Boundary Waters Canoe Area Wilderness because there is no timber management and logistically the area is difficult to access. For each NF, stands were randomly selected from each stratum so the final proportion of stands was equal to the proportion of forested land area of each cover type and stocking density for each of the NFs (Hanowski and Niemi 1995a). A total of 135 and 169 stands were originally selected in the Chippewa, and Superior NFs, respectively (Figure 1). A total of 13 habitat types were sampled in the Chippewa NF and 12 in the Superior NF (Niemi et al. 2015). Due to potential interest in logging lowland-conifer forests, 25 stands primarily composed of productive black spruce forest were added to the Superior NF in 2008.

Breeding Bird Counts

In 1991 we established three point locations within each stand using the guidance for point counts available at the time (Reynolds et al. 1980, Ralph and Scott 1981). Point count locations were initially located a minimum of 220 m apart and at least 100 m from the edge of the forest stand using a combination of forest inventory maps and pacing (Hanowski et al. 1990, 1996; Blake et al. 1992). Sample points were subsequently recorded using a recreation-grade GPS when the technology became available. Point counts were designed to be 10 minutes in length, conducted by trained observers (see observer training below), and completed between 0.5 hours before to 4 hours after sunrise on days with low wind (< 15 km/hr) and light or no precipitation. All counts were conducted between early to mid-June in the Superior NF, and late June to early July in the Chippewa NF. Prior to 1995, only birds recorded up to 100 m from the sample point were recorded. In 1995 we changed the protocol to include unlimited distance sampling, but continued to estimate distances within 10 m, 25 m, 50 m, 100 m, and beyond 100 m following a series of coordination workshops (Howe et al. 1997b). The number of individuals observed for each species was recorded at 0-3, 3-5, and 5-10-minute intervals. In 2010 we began to gather data at one-minute intervals after the first two minutes of sampling to gain a better understanding of bird detectability (Etterson et al. 2009). Bird counters were randomly assigned to forest stands so each counter sampled approximately the same number of stands of each forest cover type. Weather data (cloud cover, temperature, and wind speed) and time of day were recorded before each count.

Observer Training

Testing and training of counters has been an important component of the monitoring program. Prior to the field season, tapes or compact disks of 120+ bird songs were provided to all potential counters. Each counter was tested on their ability to pass an identification test of 86 bird songs. Songs on the tape were grouped by habitat (e.g., upland deciduous, lowland coniferous) to simulate field cues that would aid in song identification. A standard for number of correct responses was established by giving the test to observers who had four to five years of field experience. Based on their results, the standard for passing was set at 85% correct responses. In late May of each monitoring year observer field training was conducted over a three or four day period in either the Superior NF or in the vicinity of Duluth, Minnesota, USA. Observers conducted simultaneous practice counts at several points used in the monitoring program. Data were compiled for each observer and compared with experienced observers. In addition to field training and testing, all observers were required to have a hearing test to ensure their hearing was within normal ranges, as established by audiologists, for all frequencies (125 to 8,000 hertz).

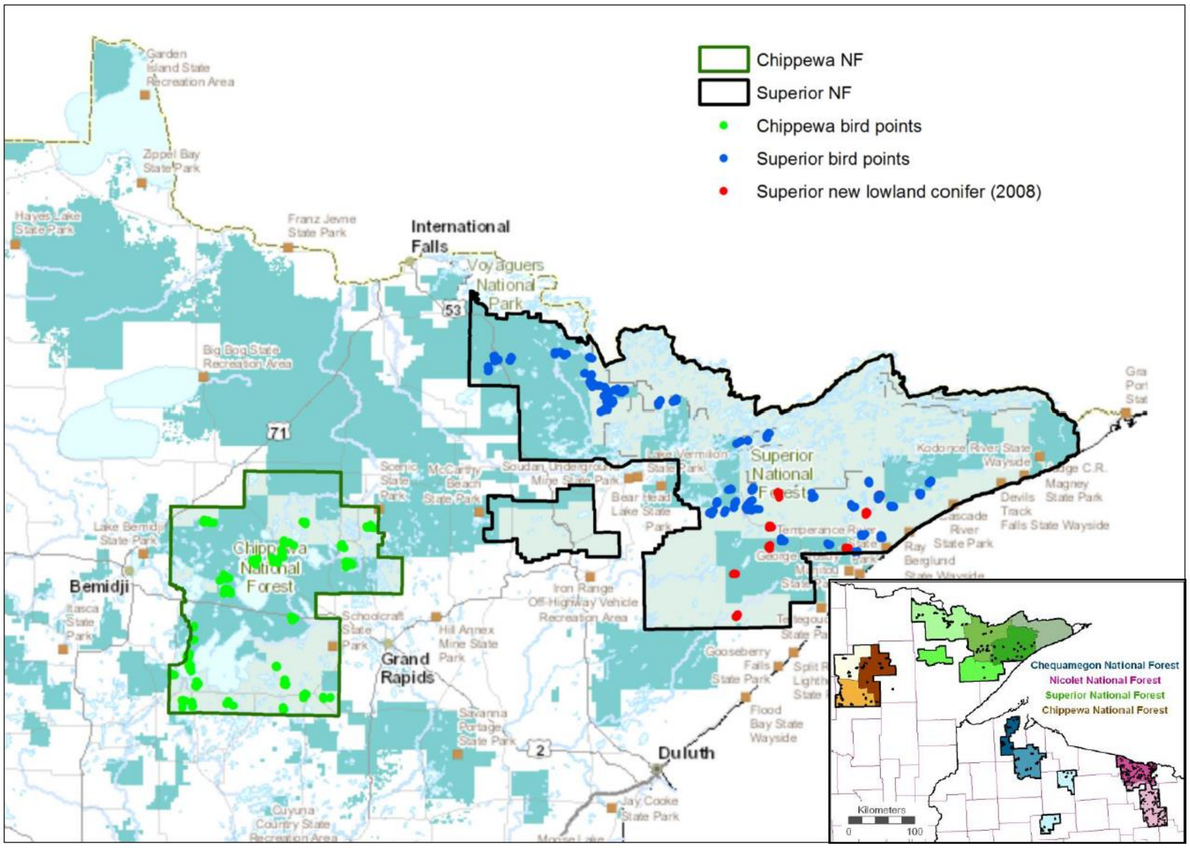

Figure 1. General locations of forest breeding bird point counts in northern Minnesota's Chippewa and Superior National Forests. Approximately 950 individual points are annually sampled between the Chippewa and Superior NFs. Inset shows the regional scope of National Forests included in Niemi et al. 2015.

Analysis

Population/abundance estimates

Bird population estimates are defined here as the annual mean number of observations of a species in a 10-minute point count for each NF and for the NFs combined. Stand-level abundance estimates for species trend analyses in the Chippewa and Superior NFs were calculated by summing the numbers of individuals across the two furthest points per stand. The middle point in each stand was excluded because an unlimited radius count from the center of the middle point sometimes overlapped areas counted on the other points. In addition, Hanowski et al. (1995) analyzed these data and determined that two points per stand were nearly equivalent in power to detect change as the use of three points per stand. The mid-point of the stand has been recorded regardless because 1) it may be used as a test point for habitat prediction modeling, 2) little time is saved by skipping the point, 3) occupancy models require a minimum of three replications in a stand (MacKenzie et al. 2006), and 4) data collected annually from the point still can be used to estimate population change. During training sessions there was an emphasis to use best judgment to avoid double counting of individual birds while sampling within a stand. Because of the change to unlimited distances, all of the trend analyses (below) were based on unlimited distance counts and were restricted to the period from 1995-2015.

We used the following criteria to help ensure that our trend analyses provided reliable population information. Stands were included in the analysis only if they had been sampled during at least six years.

Data were included for a species if it was observed at a minimum of five stands per NF and during at least three years at each stand. For species that were observed at a minimum of five stands in each of the NFs, we pooled results and carried out an additional, regional, analysis.

The implicit assumption underlying the use of point count data to estimate species-level relative abundance was that the bird species monitored have equivalent detectability within the surveys. Detectability analysis attempts to correct for species-level biases in detectability, and has been applied to bird point count data recently (e.g. Farnsworth 2002, Thompson 2002, Royale et al. 2005, MacKenzie et al. 2006, Etterson et al. 2009, Nichols et al. 2009, Sólymos et al., 2013). We applied detectability analysis to explore how our counts compared with detectability-adjusted counts for sixteen species with varying detectability using the methods of Etterson et al. (2009). Results for sixteen species that spanned the range for low-detectable species (e.g., Golden-crowned Kinglet) to highly detectable species (e.g., Ovenbird) showed that trends calculated from detectability-adjusted counts were similar to trends calculated from counts of individuals, but the most appropriate method was not apparent for cases where the two methods yielded conflicting trends. For instance, differences between methods were greatest for species with relatively small sample sizes (e.g., Brown Creeper). The primary conclusion from these detectability comparisons was that large within-year sample sizes from the same points, standardization of data gathering, and a relatively long time series resulted in trends that were similar regardless of whether counts or detectability-adjusted counts were used. Using counts unadjusted for detectability has also been supported in a critical review by Johnson (2007). For these reasons, and for the sake of simplicity, we report results using indices estimated from annual counts and have assumed that detection probabilities are constant among habitat types.

Population trajectories

A population trajectory is defined as the relative change in size of a population across years. Because we do not detect every individual bird present in our study areas, we cannot know true population size. Instead, we must assume that our sample design gives a representative index of population size for each year. We used locally weighted (LOESS) regression to smooth the time series of species relative abundance for each stand (James et al.1996). In LOESS-regression, fitted values (points along the curve) for years are calculated by giving a small amount of weight to neighboring years, for example, a year with high raw abundance for a species would tend to bring up the fitted values for the year before and the year after. We then computed the arithmetic mean and 95% 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 and the respective confidence intervals represent the uncertainty in the estimated index. The time series of the fitted mean population index and confidence intervals graphically define a species' population trajectory.

Population trend

A population trend defines the direction and magnitude of population change over a given time period (Link and Sauer 1997). Non-linear trends notwithstanding, we view a significant trend as a unidirectional change, therefore linear methods can be used to detect a trend without asserting that the population trajectory is linear (Urquhart and Kincaid 1999). Population trends were assessed using simple linear regression applied to an annual index of population size for a study area (described above) and time. 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 entire survey period (1995 to 2015) prior to regressing the index with 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. Future analyses of trends will explore the recent approach by Sauer and Link (2011) using a hierarchical modeling approach for trend detection in the BBS.

Guild analyses

Each species was categorized within three different guild types: migration, nesting, and habitat preference (Appendix C). Information for categorizing species was obtained primarily from Ehrlich et al. (1988), Freemark and Collins (1992). Given that some species use different migration strategies, nesting substrates, and vegetation types in different portions of their geographic range, we further modified guild assignments based on personal experience with forest birds within the western Great Lakes region. All individuals of a species that were assigned to each guild were included in the same analysis described above for individual species.

Species guilds are not mutually exclusive, so the species pool in a migration guild, for example, can include many of the same species that were assigned to a nesting guild (Sauer et al. 1996). Directional trends in abundant species (e.g., Ovenbird or Red-eyed Vireo) can strongly influence the trend of the guilds in which it is a member. Given these limitations, we believe it is important to examine common patterns of change among species within a guild. If all or many species within a guild show similar trends in relative abundance, then a more thorough examination of potential stressors affecting this portion of their life histories may reveal causes of observed trends. For instance, a severe drought in the late 1980s was correlated with a decline in the population levels of many breeding bird species found in the habitat guild of aspen forests of northern Wisconsin (Blake et al. 1992).

RESULTS AND DISCUSSION

Over the course of 21 field seasons we have detected nearly 315,000 individual birds of 164 species on approximately 19,000 ten-minute point counts (over 3,000 hours of sampling) in the Chippewa and Superior NFs. In 2015, we sampled 135 stands in the Chippewa NF and 191 in the Superior NF. Seventy-four species were tested for trends in at least one national forest, including 65 in the Chippewa NF and 63 in the Superior NF (Table 1). 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 74 in 2015. Regional trends were calculated for 53 species between the Chippewa and Superior NFs.

Overview of Population Trends

Twenty-seven species (36%) had population trends that were significantly increasing in at least one national forest and 17 species (23%) had population trends that were significantly decreasing in at least one national forest (Table 1). Therefore, 30 species (41%) had stable or non-significant population trends among those in which we could detect a trend. There were three conflicting trends between the Chippewa and Superior NFs in 2015; Hermit Thrush and Veery were found to be increasing in the Chippewa and decreasing in the Superior, while American Robin was decreasing in the Chippewa and increasing in the Superior. Both NFs had 17 species that were significantly increasing. Of these, seven species increased in both NFs. These included the Black-and-White Warbler, Black-throated Green Warbler, Blue Jay, Cedar Waxwing, Nashville Warbler, Pine Warbler, and Red-breasted Nuthatch (Tables 2 and 3). In contrast, seven species decreased in the Chippewa NF and 11 species decreased in the Superior NF (Table 4). Two species, Chipping Sparrow and Connecticut Warbler, decreased in both NFs. Fifteen species had marginally significant trends ($0.05 < p < 0.10$), either increasing or decreasing, in either NF or regionally (Table 5). When compared to 2014, 22 species had changes in the significance of trends in either NF or regionally (Table 6).

Appendix A includes trend graphs of individual species trajectories within the Chippewa and Superior NFs. Appendix B is a complete statistical summary of the trend analysis including species, its four alphabet code, its trend within each NF, a regional trend (if possible), the significance of the trend (*P*), the explained variation of the trend (R^2), and the number of stands (N) in which the species was detected sufficiently to include in the trend calculation. The combination of the p-value and the explained variation indicate the strength of the trend for each species within each NF. Appendix C describes the common name, scientific name, four-letter code used in field identification, and a summary of the three major guilds included here: migration strategy, nest site, and vegetation type primarily used by the species. Appendices D and E identify the number individuals observed for species not included in the trend calculations from 1995 to 2015 in the Chippewa and Superior NFs, respectively. Appendix F is discussed in more detail below and includes results of trend analysis for lowland-conifer forests in the Superior NF, 2008-2015.

Chippewa National Forest

Of the 65 species tested in the Chippewa NF, 17 species (26 %) had significantly increasing trends (Table 2), seven species (11%) had significantly declining trends (Table 4), and 41 species had non-significant trend indices. Three species have shown significantly decreasing trends for at least four years through 2015; Connecticut Warbler, Song Sparrow, and Yellow-throated Vireo. Chipping Sparrow, Least Flycatcher, and Winter Wren have had declining trends for two years and American Robin had a new declining trend in 2015 (Appendix A).

The Connecticut Warbler has shown one of the most consistent declines for any species in the monitoring project and is discussed in more detail below as well as in Niemi et al. (2015). The Yellow-throated Vireo is a relatively uncommon species in the Chippewa NF; however, 41 forest stands were included in the analysis of its trend, potentially indicating a spatially and temporally patchy distribution in the forest (Appendix A). A declining pattern since the early 2000's is also evident for Song Sparrow, which coincides with detected declines on the BBS routes within these National Forests (Niemi et al. 2015) as well as across the boreal-hardwood transition and entire eastern United States (Sauer et al. 2014).

Superior National Forest

Of the 63 species tested in the Superior NF, 17 species (27%) had significantly increasing trends (Table 2), 11 species (17%) had significantly decreasing trends (Table 4), and 35 species had non-significant trend indices. Common Loon, Connecticut Warbler, Swainson's Thrush, and Yellow-bellied Flycatcher have shown declining trends for at least three years through 2015. American Crow, Chipping Sparrow, Downy Woodpecker, Mourning Warbler and Red-eyed Vireo have been declining for two years, while Hermit Thrush and Veery had new declining trends in 2015 (Appendix A; Table1). Notably, the long-term decline observed in Evening Grosbeak was no longer significant in the Superior NF.

The declining trends in the Connecticut Warbler and Swainson's Thrush are discussed in detail in Niemi et al. (2015). These species as well as the Yellow-bellied Flycatcher and Hermit Thrush are primarily found in conifer, and often lowland-conifer forests on the Superior NF. Twenty-five stands in lowland conifer forests were added to the Superior NF in 2008 and have been consistently sampled for eight years (Figure 1). We performed a comprehensive analysis of how the inclusion of these new stands affects forest bird trends in 2014 (see Appendix F in Zlonis et al. 2014). The effects of including the new stands on trend analysis were most apparent in species that either utilize lowland conifer habitat (e.g. Ruby-crowned Kinglet) or avoid lowland conifer habitat (e.g. deciduous-forest species). Species that breed in lowland conifer had an increase in annual indices starting in 2008 because a higher proportion of the stands available for trend analysis were of their preferred habitat. We expect this effect to become diluted as additional sampling years are included in analysis; though for the current report and the foreseeable future we report a separate trend analysis for lowland conifer forests in the Superior NF (see below).

The Evening Grosbeak has been declining over a large area of the northern U.S. and Canada (Sauer et al. 2014, Niemi et al. 2015). Through 2014, this species had one of the most consistent declines recorded in the Superior NF. Local population trends have been shown to track spruce budworm outbreaks (Gillihan and Byers 2001). A budworm outbreak starting around 2010 in and around the Superior NF (Sturtevant et al. 2013) is likely associated with the dramatic population increases seen in spruce-budworm specialists Cape May Warbler and Tennessee Warbler and possibly related to a lessening in the Evening Grosbeak decline (Appendix A). An average of 15 Cape May Warblers and 20 Tennessee Warblers were detected per year through 2010 in the Superior NF, while an average of 43 and 41 were detected per year since 2011. The declining trends of Common Loon and Downy Woodpecker should be viewed with caution unless substantiated with other data. The point count methodology may not be the best survey technique for these species, plus the sample sizes are small for Downy woodpecker.

Lowland-conifer Superior NF

We completed a separate trend analysis for lowland conifer stands in the Superior NF, 2008-2015 (Table 7, Appendix F). Forty-two stands primarily composed of black spruce, tamarack or mixed swamp conifer are sampled annually in the Superior NF and were included in the analysis. Mixed swamp conifer is dominated by northern white cedar, balsam fir, and black spruce, though occasionally mixed with tamarack, paper birch and black ash. Twenty-five of the 42 stands were added to the sampling design in 2008 and are primarily productive black spruce forest. Fifteen species that are associated with conifer or lowland-conifer for breeding habitat were included in the analysis. Results varied widely between the shortened time-series and forest type when compared to the standard analysis that included all years and habitats (Table 7, Appendix B). In particular, four of the species had opposite trend interpretation between the analyses; Ruby-crowned Kinglet, Red-breasted Nuthatch, Swainson's Thrush, and Yellow-bellied Flycatcher. The two former species were significantly increasing in the Superior NF 1995-2015 and were significantly decreasing in lowland-conifer forests 2008-2015. The latter two species were significantly decreasing in the Superior NF 1995-2015 and significantly increasing in lowland-conifer forests 2008-2015.

We have two primary hypotheses for the discrepancies in trends results for species related to conifer and lowland conifer forests. First, lowland black spruce and tamarack forest were not included in the initial design of sampling on the Superior NF as these forests were usually not considered for harvest. Thus, the stands selected for sampling in 2008 represent a unique forest type not previously included in trend analysis. The breeding bird community of this forest type is also unique (Niemi et al. 2015). Species like Yellow-bellied Flycatcher that appear to prefer lowland-conifer forests over other types might be displaying source-sink dynamics where they have been declining in non-preferred 'sink' habitats of the Superior NF, but increasing in preferred 'source' habitats (Pulliam 1988). Similar dynamics might be occurring in species like Red-breasted Nuthatch which prefer upland conifer habitats and might be declining in 'sink' lowland-conifer forests.

Second, the complicating factors of differing time-series and starting points might be affecting results. Many of the population trends are non-linear and thus, the starting point and time-series of analysis are particularly important in determining if there is a general increase or decrease in population. For example, opposing results and interpretations would be found if population trends for Ovenbird in the Superior NF were calculated over the time periods 1995-2003 and 2004-2015 (Appendix A). We are actively exploring methods for accounting for these nuisance factors and will update methodology accordingly. Though, for the immediate future, we recommend most attention be given to the longer-term analysis. Most species utilize multiple habitats for breeding and longer time-frames provide more clarity in trends in these inherently variable data.

Pooled National Forests

We calculated a regional trend between the Chippewa and Superior NFs for 53 species in 2015. Seventeen species (32%) were increasing significantly (Table 2) and nine species (17%) were decreasing significantly (Table 4). Song Sparrow and Yellow-bellied Flycatcher showed declining region-wide trends in the Chippewa and Superior as well as across the four NFs included in Niemi et al. (2015) (Chippewa, Superior, Chequamegon and Nicolet). New regional declines were identified in Eastern Wood-Pewee and Winter Wren, while previous declines observed in Scarlet Tanager and Downy Woodpecker were no longer significant in 2015. The additional species that had regional declines included Chipping Sparrow, Common Loon, Connecticut Warbler and Mourning Warbler.

In results from local BBS routes (overlapping the NFs), the Song Sparrow showed a decline, while the Yellow-bellied Flycatcher had an increasing trend (Niemi et al. 2015). This example is indicative of the differences between the two monitoring projects, especially in sample size and the habitat context of on versus off-road counts. The agreement of results for Song Sparrows might relate to this species' use of open and shrubby habitats often characteristic of roadsides in northern Minnesota and hence surveyed by the BBS. Conversely, the Yellow-bellied Flycatcher, along with many other forest-species, is best monitored using off-road, habitat-specific counts (Hanowski and Niemi 1995b). Contrary results between this program and the BBS point to the importance of monitoring bird populations at different landscape scales (Niemi et al. 2015). The primary strengths of the BBS program are its long time-frame (1966-present) and broad geographical context. To better understand conservation needs for Minnesota's breeding birds, it is important to study local e.g. NF-level, as well as regional populations e.g. boreal-hardwood transition; Partners in Flight Bird Conservation Region 12 (BCR 12).

Management Activities on Study Areas

Of the survey sites in the two national forests, 22% have been at least partially harvested since the beginning of monitoring in 1991, which is about 1% per year. Over the first 12 years of monitoring an average of 1.2% of sampled sites were harvested each year, whereas in the most recent 12 years of monitoring 0.7% of sampled sites were harvested per year. The overall 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). Additionally, the trend towards lower harvest levels in recent years is compatible with NF-wide trends (Niemi et al. 2015). Thus, it appears that management activities on our sample sites have continued to be representative of these two national forests.

Guild Analyses

At both the NF-level and regional scale, nearly all migratory, nesting, and habitat association guilds showed significant increases from 1995-2015 (Table 8). Notable exceptions were species associated with early-successional forests and shrub/sub-canopy nesting species within both NFs and regionally. This parallels the reduction in logging that has occurred in these two NFs over the past 10 years as documented in Niemi et al. (2015). Among the guilds included in the analysis, one would expect that breeding bird species associated with early-successional forests would be those most affected by a reduction in logging activity. Several species associated with open areas and early-successional habitats had apparent declines including the Chipping Sparrow, Mourning Warbler, and Song Sparrow. These species also had widespread declines across BCR 12 (Sauer et al. 2014) and the two former species were recently found to be most indicative of managed habitats in the Superior NF (Zlonis and Niemi 2014). Maturation of forests across the region in conjunction with an increase in forested lands (MFRC 2013) might contribute to these declines due to loss of breeding habitat. Still, many early-successional species had stable or increasing trends over the period 1995-2015.

There were no guilds that had significantly decreasing trends. A continued noteworthy pattern; however, are the trends among the migratory guilds. Permanent residents continue to show the greatest overall percentage increase over the past 21 years with an increase of 1.7% per year within both the Chippewa and Superior NFs (Table 8). Note that a 1.7% per year increase over a 21-year period represents an over 40% increase in the number of permanent resident individuals within these two NFs in 2015 compared with 1995. Short-distance and long-distance migrants, though both increasing significantly at the regional scale, have more modest population trends, having increased approximately 6-7% over the same time-period.

The possible hypotheses why permanent residents may be increasing at a greater rate than the short and long distance migrants include the following. (1) Over-winter survival has increased for permanent residents because the climate is warming and winters are less severe in terms of temperature. (2) Nest success has increased due to increased access to snags and cavities present from decreased logging and changing silvicultural practices. (3) Winter feeding of birds has been increasing over the past 20 years and supplemental food aids in over-winter survival. (4) Climatic warming results in earlier emergence of food (insects, berries, buds, etc.) and, hence, the earlier nesting species such as permanent residents would gain the greatest benefit from this shift in phenology. These hypotheses are not mutually exclusive, but some of the data presented in the recent general technical report on climate patterns over the period 1995-2011 suggests some support for hypotheses 1 and 4 (Niemi et al. 2015). However, it is noteworthy that recent cold winters and springs in 2012-2013 and 2013-2014 may have an effect on permanent residents because they have declined especially in the past three years (Appendix A).

CONCLUSIONS

The delayed springs in 2013 and 2014 likely contributed to poor nesting success for many forest birds, as indicated by the decrease in total abundance of breeding birds counted since 2013 (Figure 2) and lower abundance estimates for all migratory guilds, especially short-distance migrants (Appendix A; Table 8). In addition, several new declining trends were identified in 2015 (Table 6). Still, most species for which we can detect trends show a stable or increasing pattern over the period 1995-2015.

There are several possible hypotheses on why so many species seem to be stable or increasing in relative abundance over the past 21 years. First, and most apparent, logging activity has steadily decreased in both the Chippewa and Superior NFs over the past ten years; primarily due to the economic downturn of the recent recession and other factors that have contributed to reduced demand for lumber, paper, and other forest products. This has led to several potentially important changes to the age structure of forests. Over the period 1977-2012, northeastern Minnesota has seen an increase in the proportion of forest that is greater than 60 years old and a concurrent decrease in mid-successional forests of 41-60 years old (MFRC 2013). Therefore, the amount of forest in early successional age-classes (0-20 years) has either remained stable or increased slightly. Because the majority of breeding bird species in these forests relates to either early or late successional forests, it is logical that nearly all species would also be stable or increasing. Older forests, especially those with diverse structural elements, support a much broader range of species including early successional species (Helle and Niemi 1996, Schieck and Song 2006). Aspen forests provide an excellent example of how this structural diversity develops; stands >60 years old have 2-3 times higher natural mortality than those that are 41-60 years old (MFRC 2013), thus providing a variety of habitat elements from snags that increase nest-cavities to tree-fall gaps that create shrubby growth utilized by many species.

Silvicultural practices have also changed over the last two decades. Although about 70% of harvesting is completed through clear-cutting, this has steadily decreased from 1991-2008 with selection harvesting, thinning, and patch clear-cuts being utilized more often (D’Amato et al. 2009). Over the same period, there has been a nearly two-fold increase in the number of clear-cuts (44% in 1991 to 80% in 2008) that incorporate leave trees (D’Amato et al. 2008). With logging being the most significant disturbance on these NFs, changes in practice have a variety of effects on both local and regional populations of birds. This is especially true if modifications (e.g. leaving standing timber and snags in clear-cuts) mimic disturbance features that these species evolved to utilize. Changing age-class structure and silvicultural practices might better represent the natural fire disturbance regime that once dominated these forests (Heinselman 1973; Niemi et al. 1998) and to which most of these bird species certainly respond.

Despite increasing mature forest cover, several of the species that are decreasing breed primarily in mid-to-late-successional forests including the Connecticut Warbler, Hermit Thrush, Swainson's Thrush, and Yellow-bellied Flycatcher. For each, there are potential reasons for these trends. First, these species have mostly boreal distributions and are at or near the edge of their breeding range in these NF's. This is where we might expect initial declines to be most evident, especially if changing climatological factors are influencing these species' populations. Additionally, these species are all associated with coniferous and especially, lowland coniferous forests, which have different logging and management pressures than upland deciduous forests. These species also share similar food types and foraging-space in dense, shrubby growth near the ground (Jones and Donovan 1996; Pitocchelli et al. 1997; Evans-Mack and Yong 2000; Gross and Lowther 2001). There is some evidence that drought conditions and lower food supplies over the past ten years may have affected reproduction for these species that rely on an insectivorous diet to feed their young (Niemi et al. 2015).

Among the major conclusions of the 20-year summary of the national forest bird monitoring program (Niemi et al. 2015) is our inability to definitively pinpoint specific causes of increases or decreases in trends of specific species. Because these species range over relatively wide areas these populations are subject to many potential factors that can affect their population. These factors include climate, weather, diseases, landscape and habitat change due to both natural and anthropogenic disturbances (e.g., forest fire, logging, wind, exurban development and insect defoliation). Hazards of migration (Loss et al. 2014) and over-wintering conditions (Norris et al. 2004) can also influence population levels. We plan to explore two analyses that may shed light on how these factors might be affecting species' populations; an analysis of the important factors influencing trend numbers and a re-examination of the trend analysis with a Bayesian hierarchical framework similar to that conducted for the BBS (Sauer and Link 2011). Nevertheless, given the number of species that we are able to monitor, if there is an influence of a large-scale forest management activity, it is likely that such a signal would be detected by these data. In fact, the clearest signal we may have is reflected in the large number of species that are increasing or are stable; possibly due to the reduction in logging activity in these forests, associated changes in age-class structure across the landscape, as well as the annual changes in ambient weather conditions.

Detailed studies and conservation action are needed for species that have dramatic declines such as the Connecticut Warbler. In the last 21 years, we have detected a more than 80% population decline in Minnesota NFs for this species, which parallels range-wide declines in BBS data (Sauer et al. 2014). It was also acknowledged as part of the 'Yellow Watch List' in the most recent State of the Birds report (Rosenberg et al. 2014). With a large portion of its population in the western part of BCR 12 (Ruth 2006), Minnesota is an important location for both research and conservation of the Connecticut Warbler. Similar at-risk species, such as the Golden-winged Warbler are receiving attention (Pfannmuller 2012, Buehler et al. 2007). Little is known about the Connecticut Warbler, though two recent analyses of habitat associations have provided information on breeding habitat in Minnesota (Lapin et al. 2013, Zlonis et al. *in prep.*). To identify causes for the decline, future study must address detailed demographic information, as well as full life-cycle analysis.

The overall message in this report is positive regarding breeding forest birds in the Chippewa and Superior NFs. Although there is evidence of positive trends in forest-cover across the region (+5.5% in last 35 years; MFRC 2013), from a historical perspective, most of these forest-associated breeding species likely have much lower populations today than in the past due to habitat loss. For example, Minnesota has lost almost half of its forest area from 31 million acres in the mid-1800's to less than 17 million acres today. These rates of forest loss are conservative relative to other U.S. states and in over-wintering habitats of Mexico and in Central and South America. Maintaining adequate forested habitat across these species' ranges and identifying the factors influencing their populations will be major challenges for many generations to come.

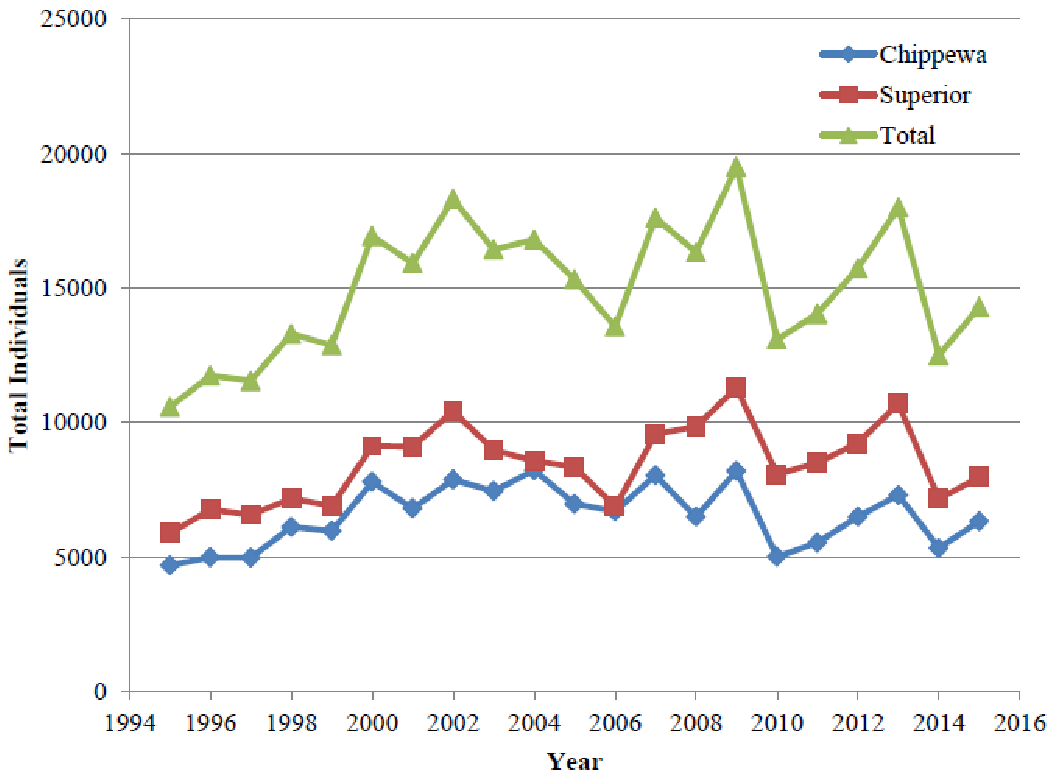

Figure 2. Total number of individual birds detected each year in the Chippewa and Superior NFs. Note that birds detected at 25 stands added to the Superior NF in 2008 are included, causing the slightly increased discrepancy between the two NFs from 2008-2015.

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Tables

Table 1. Trends for two National Forests (NF) and pooled NF's based on linear regression of loess-smoothed annual index of abundance (See Methods) (1995- 2015). I= significantly increasing, D= significantly decreasing. *P < 0.05, ** P < 0.01. See Appendix A for species graphs and Appendix B for test statistics and sample sizes.

Species	**Chippewa NF**	**Superior NF**	**Regional**
Alder Flycatcher	ns	ns	ns
American Crow	ns	D**	ns
American Goldfinch	I**	ns	I*
American Redstart	ns	ns	ns
American Robin	D*	I**	ns
Black-and-white Warbler	I**	I**	I**
Blackburnian Warbler	ns	ns	ns
Black-billed Cuckoo	-	ns	-
Black-capped Chickadee	ns	I*	ns
Black-throated Blue Warbler	-	ns	-
Black-throated Green Warbler	I**	I**	I**
Blue Jay	I**	I**	I**
Blue-headed Vireo	ns	ns	ns
Broad-winged Hawk	-	ns	-
Brown Creeper	ns	ns	ns
Brown-headed Cowbird	ns	-	-
Canada Warbler	I*	ns	I*
Cape May Warbler	-	I**	-
Cedar Waxwing	ns	I**	I**
Chestnut-sided Warbler	ns	ns	ns
Chipping Sparrow	D**	D**	D**
Common Loon	ns	D**	D**

Common Raven		ns		ns		ns
Common Yellowthroat		ns		ns		ns
Connecticut Warbler		D**		D**		D**
Downy Woodpecker		ns		D*		ns
Eastern Towhee		ns		-		-
Eastern Wood-Pewee		ns		ns		D*
Evening Grosbeak		-		ns		-
Golden-crowned Kinglet		ns		I**		I*
Golden-winged Warbler		ns		ns		ns
Gray Catbird		ns		-		-
Gray Jay		ns		ns		ns
Great Crested Flycatcher		ns		-		-
Hairy Woodpecker		ns		I*		ns
Hermit Thrush		I**		D**		ns
Indigo Bunting		ns		-		-
Least Flycatcher		D*		ns		ns
Magnolia Warbler		ns		ns		ns
Mourning Dove		I**		-		-
Mourning Warbler		ns		D**		D*
Nashville Warbler		I**		I**		I**
Northern Flicker (Yellow-shafted)		ns		ns		I*
Northern Parula		I*		I**		I**
Northern Waterthrush		ns		I**		I*
Olive-sided Flycatcher		ns		ns		ns
Ovenbird		I**		ns		I**
Palm Warbler (Western)		ns		-		-
Pileated Woodpecker		I**		ns		I**
Pine Warbler		I**		I**		I**
Purple Finch		ns		ns		ns
Red-breasted Nuthatch		I**		I**		I**

Red-eyed Vireo		ns		D**		D**
Red-winged Blackbird		ns		ns		ns
Rose-breasted Grosbeak		ns		ns		ns
Ruby-crowned Kinglet		-		I**		-
Ruby-throated Hummingbird		ns		-		-
Ruffed Grouse		-		ns		-
Scarlet Tanager		ns		ns		ns
Song Sparrow		D**		ns		D**
Swainson's Thrush		-		D**		-
Swamp Sparrow		ns		ns		ns
Tennessee Warbler		-		I**		-
Veery		I**		D*		ns
White-breasted Nuthatch		ns		-		-
White-throated Sparrow		ns		ns		ns
Wilson's Snipe		I*		ns		ns
Winter Wren		D**		ns		D**
Wood Thrush		I**		ns		ns
Yellow Warbler		ns		-		-
Yellow-bellied Flycatcher		ns		D**		D*
Yellow-bellied Sapsucker		I**		ns		I**
Yellow-rumped Warbler (Myrtle)		ns		I**		I**
Yellow-throated Vireo		D*		-		-

Table 2. Species with significantly increasing trends ($P \leq 0.05$) for two national forests and region-wide (1995-2015), based on regression of loess-smoothed annual index of abundance. **$P \leq 0.01$. Species graphs can be found in Appendix A.

Chippewa NF	Superior NF	Regional
American Goldfinch**	American Robin**	American Goldfinch
Black-and-white Warbler**	Black-and-white Warbler**	Black-and-white Warbler**
Black-throated Green Warbler**	Black-capped Chickadee	Black-throated Green Warbler**
Blue Jay**	Black-throated Green Warbler**	Blue Jay**
Canada Warbler	Blue Jay**	Canada Warbler
Hermit Thrush**	Cape May Warbler**	Cedar Waxwing**
Mourning Dove**	Cedar Waxwing**	Golden-crowned Kinglet
Nashville Warbler**	Golden-crowned Kinglet**	Nashville Warbler**
Northern Parula	Hairy Woodpecker	Northern Flicker (Yellow-shafted)
Ovenbird**	Nashville Warbler**	Northern Parula**
Pileated Woodpecker**	Northern Parula**	Northern Waterthrush
Pine Warbler**	Northern Waterthrush**	Ovenbird**
Red-breasted Nuthatch**	Pine Warbler**	Pileated Woodpecker**
Veery**	Red-breasted Nuthatch**	Pine Warbler**
Wilson's Snipe	Ruby-crowned Kinglet**	Red-breasted Nuthatch**
Wood Thrush**	Tennessee Warbler**	Yellow-bellied Sapsucker**
Yellow-bellied Sapsucker**	Yellow-rumped Warbler (Myrtle)**	Yellow-rumped Warbler (Myrtle)**

Table 3. Summary of species with increasing trends ($P \leq 0.05$) on two national forests (1995-2015). Individual species graphs can be found in Appendix A.

Increased in one NF	Increased in both NFs
American Goldfinch	Black-and-white Warbler
American Robin	Black-throated Green Warbler
Black-capped Chickadee	Blue Jay
Canada Warbler	Nashville Warbler
Cape May Warbler	Northern Parula
Cedar Waxwing	Pine Warbler
Golden-crowned Kinglet	Red-breasted Nuthatch
Hairy Woodpecker	
Hermit Thrush	
Mourning Dove	
Northern Waterthrush	
Ovenbird	
Pileated Woodpecker	
Ruby-crowned Kinglet	
Tennessee Warbler	
Veery	
Wilson's Snipe	
Wood Thrush	
Yellow-bellied Sapsucker	
Yellow-rumped Warbler (Myrtle)	

Table 4. Species with significantly decreasing trends ($P < 0.05$) for two national forests (1995-2015), based on regression of loess-smoothed annual index of abundance. $^{**}P < 0.01$. Species graphs can be found in Appendix A.

Chippewa NF	Superior NF	Regional
American Robin	American Crow**	Chipping Sparrow**
Chipping Sparrow**	Chipping Sparrow**	Common Loon**
Connecticut Warbler**	Common Loon**	Connecticut Warbler**
Least Flycatcher	Connecticut Warbler**	Eastern Wood-Pewee
Song Sparrow**	Downy Woodpecker	Mourning Warbler
Winter Wren**	Hermit Thrush**	Red-eyed Vireo**
Yellow-throated Vireo	Mourning Warbler**	Song Sparrow**
	Red-eyed Vireo**	Winter Wren**
	Swainson's Thrush**	Yellow-bellied Flycatcher
	Veery	
	Yellow-bellied Flycatcher**	

Table 5. Species with marginally significant trends (0.05 < *P* ≤ 0.10) for two national forests and region-wide (1995-2015), based on regression of loess-smoothed annual index of abundance. Direction of trend indicated by either positive (+) or negative-sign (-). Species graphs can be found in Appendix A.

Chippewa NF	Superior NF	Regional
Brown-headed Cowbird (-)	Broad-winged Hawk (-)	American Crow (-)
Cedar Waxwing (+)	Chestnut-sided Warbler (-)	American Robin (+)
Eastern Wood-Pewee (-)	Gray Jay (+)	Black-capped Chickadee (+)
Swamp Sparrow (-)	Olive-sided Flycatcher (-)	Chestnut-sided Warbler (-)
	Song Sparrow (-)	Downy Woodpecker (-)
		Gray Jay (+)
		Olive-sided Flycatcher (-)
		Swamp Sparrow (-)
		White-throated Sparrow (+)
		Wood Thrush (+)

Table 6. Species with changes to significance of trends between 2014 and 2015. Changes were either in a positive direction, from decreasing (2014) to non-significant (2015) or non-significant (2014) to increasing (2015), or in a negative direction, from increasing (2014) to non-significant (2015) or non-significant (2014) to decreasing (2015). The specific National Forest where the change occurred is indicated. Species graphs can be found in Appendix A.

Decreasing to non-significant	Non-significant to increasing	Increasing to non-significant	Non-significant to decreasing
Broad-winged Hawk, Superior	Canada Warbler, Regional	American Robin, Regional	American Robin, Chippewa
Downy Woodpecker, Regional	Hairy Woodpecker, Superior	Black-capped Chickadee, Regional	Eastern Wood-Pewee, Regional
Evening Grosbeak, Superior	Yellow-shafted Flicker, Regional	Cedar Waxwing, Chippewa	Hermit Thrush, Superior
Olive-sided Flycatcher, Superior	Northern Parula, Chippewa	Gray jay, Superior	Red-eyed Vireo, Regional
Scarlet Tanager, Chippewa	Northern Waterthrush, Superior	Pileated Woodpecker, Superior	Veery, Superior
Scarlet Tanager, Regional	Northern Waterthrush, Regional	Red-eyed Vireo, Chippewa	Winter Wren, Regional
	Wilson's Snipe, Chippewa	White-throated Sparrow, Superior	
		White-throated Sparrow, Regional	

Table 7. Population trend estimates (% annual change) and associated test statistics for lowland-conifer forests in the Superior National Forest (2008-2015). Only species in 'conifer' and 'lowland-conifer' habitat guilds were analyzed. Included for each species are its four letter 'alpha' code, its trend within each NF, the significance of the trend (P), the explained variation of the trend (R^2), and the number of stands (N) in which the species was detected sufficiently to include in the trend calculation

		Superior			
Species		**Trend**	**P**	**R^2**	**N**
Blackburnian Warbler	BLBW	-0.80	0.86	0.02	18
Blue-headed Vireo	BHVI	-8.18	0.04	0.52	11
Chipping Sparrow	CHSP	5.05	0.60	0.10	6
Common Raven	CORA	-14.28	<0.01	0.42	7
Golden-crowned Kinglet	GCKI	0.42	0.82	0.03	31
Magnolia Warbler	MAWA	12.22	<0.01	0.80	30
Nashville Warbler	NAWA	-2.44	0.05	0.56	42
Northern Parula	NOPA	-0.15	0.97	0.00	10
Northern Waterthrush	NOWA	-2.75	0.61	0.11	7
Red-breasted Nuthatch	RBNU	-6.69	0.01	0.53	28
Ruby-crowned Kinglet	RCKI	-9.39	<0.01	0.81	21
Swainson's Thrush	SWTH	6.12	0.03	0.66	24
Winter Wren	WIWR	-8.04	<0.01	0.89	41
Yellow-bellied Flycatcher	YBFL	6.94	<0.01	0.87	37
Yellow-rumped Warbler (Myrtle)	MYWA	9.67	<0.01	0.71	29

Table 8. Test statistics and sample sizes for guild trend analyses on two National Forests and a combined regional analysis (1995-2015). All species combined within each guild category and analyzed as a group, regardless of whether a species meets criteria for individual species analyses. Trend= percent annual change in population trend. N= number of stands analyzed. See appendix A for trend graphs.

	Chippewa NF				**Superior NF**				**Regional**			
Guild Category	Trend	*P*	R^2	N	Trend	*P*	R^2	N	Trend	*P*	R^2	N
Coniferous forest	1.05	<0.01	0.34	123	1.61	<0.01	0.85	147	1.37	<0.01	0.67	270
Deciduous forest	0.71	<0.01	0.13	126	-0.12	0.39	0.01	147	0.30	<0.01	0.03	273
Early-successional forest	0.03	0.98	0.00	125	-0.22	0.53	0.01	147	-0.12	0.75	0.00	272
Lowland-coniferous forest	0.81	<0.01	0.55	119	0.77	<0.01	0.35	147	0.79	<0.01	0.51	266
Mixed forest	1.38	<0.01	0.55	126	0.67	<0.01	0.28	147	1.00	<0.01	0.44	273
Long-distance migrants	0.62	<0.01	0.15	126	0.03	0.72	0.00	147	0.30	<0.01	0.04	273
Permanent residents	1.64	<0.01	0.42	126	1.72	<0.01	0.50	147	1.68	<0.01	0.47	273
Short-distance migrants	-0.07	0.74	0.00	126	0.66	<0.01	0.18	147	0.34	<0.01	0.04	273
Canopy nesting	0.56	<0.01	0.15	126	1.60	<0.01	0.87	147	1.07	<0.01	0.54	273
Cavity nesting	1.83	<0.01	0.39	126	1.35	<0.01	0.18	147	1.59	<0.01	0.28	273
Ground nesting	0.84	<0.01	0.33	126	0.16	0.11	0.02	147	0.44	<0.01	0.11	273
Shrub/sub-canopy nesting	-0.15	0.45	0.01	126	-0.28	0.26	0.02	147	-0.22	0.09	0.01	273