Breeding Bird Monitoring in Great Lakes National Forests: 1991-2006

2006 annual report to the
Chequamegon/Nicolet, Chippewa, and Superior National Forests

by

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SUMMARY

- A total of 132, 133, and 164 stands (1,254 survey points) were surveyed for breeding birds in the Chequamegon, Chippewa, and Superior National Forests (NF), respectively in 2006. Annual surveys have been conducted since 1991 in the Chippewa and Superior NF, and since 1992 in the Chequamegon NF.

- Comprehensive surveys of vegetation structure were carried out on 93, 74, and 63 points in the Chequamegon, Chippewa, and Superior NFs, respectively, on over 50 observer-days of sampling. Monitoring personnel on the Chippewa and Superior NFs provided excellent assistance in the coordination and completion of this effort.

- Trends in relative abundance were calculated for 72 bird species, including 57 species in the Chequamegon NF, 57 in the Chippewa NF, and 49 in the Superior NF. Thirty-nine species were also tested for a pooled trend by combining data from the three national forests.

- A total of 163 species/national forest trends were calculated in 2006 (not including pooled trends), 68 (42%) of which were significant ($P \leq 0.05$). Twenty three species increased significantly ($P \leq 0.05$) in at least one national forest and 24 species decreased. Eleven species had significant increasing pooled trends and 11 had decreasing trends. Of the 158 species/national forest trends calculated in 2005, 19 (12%) changed in 2006.

- The percent of increasing species on each national forest ranged from 9% in the Chequamegon NF, to 25% in the Chippewa NF. The percent of decreasing species ranged from 20% in the Superior NF, to 28% in the Chequamegon NF.

- The short-distance migrant guild showed highly significant declines on all national forests. Long-distance migrants also declined on all national forests. Permanent residents increased on the Chippewa and Superior NF and in the pooled NFs, but were stable on the Chequamegon NF.

- The ground nesting guild showed highly significant declines on all national forests. Shrub/sub-canopy nesters increased on Chippewa NF, but were stable in Chequamegon and Superior NFs. Canopy nesters increased in Chquamegon NF and cavity-nesters increased in Chippwa and Superior NFs. All nesting guilds showed significant trends in the pooled NFs with increases in shrub/subcanopy-nesters and cavity-nesters and decreases in ground- and canopy-nesters.

- The deciduous and mixed forest bird guilds declined on the Chequamegon and Superior NFs and the pooled NFs. The lowland coniferous forest bird guild declined on the Chippewa NF and the pooled NFs. The early-successional bird guild increased on the Chippewa NF and the upland coniferous bird guild increased on the Chippewa and Superior NFs as well as in the pooled NFs.

- Evidence from previous regional studies have demonstrated greater nest predation rates on ground nests near forest/clearcut edges, as well as a significant increase in the creation of forest edges in recent years. Increasing amounts of forest edge and nest predation may be having negative effects on declining ground-nesters such as the Winter Wren, Veery, Hermit Thrush, Ovenbird, and White-throated Sparrow.

- Of the 1274 survey sites on the three national forests, 15.5% 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.
- Many of the declining trends that we have detected appear to be consistent across years instead of being due to a few years with very low or high abundance. One of the main goals of this monitoring program is to identify potential declines of forest bird species, especially for species of conservation concern such as the Eastern Wood-Pewee, Winter Wren, Hermit Thrush, Ovenbird, and White-throated Sparrow. The declines observed over the past years for common species such as the Ovenbird and White-throated Sparrow are a continuing concern and special management consideration should be given to these species.

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 on the Chippewa and Superior National Forests, and in 1992 on the Chequamegon National Forest 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, 435 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. See 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 National Forest 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' range of natural variability (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 15 to 16 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 2005, 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.

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 tens 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 m 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.

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).

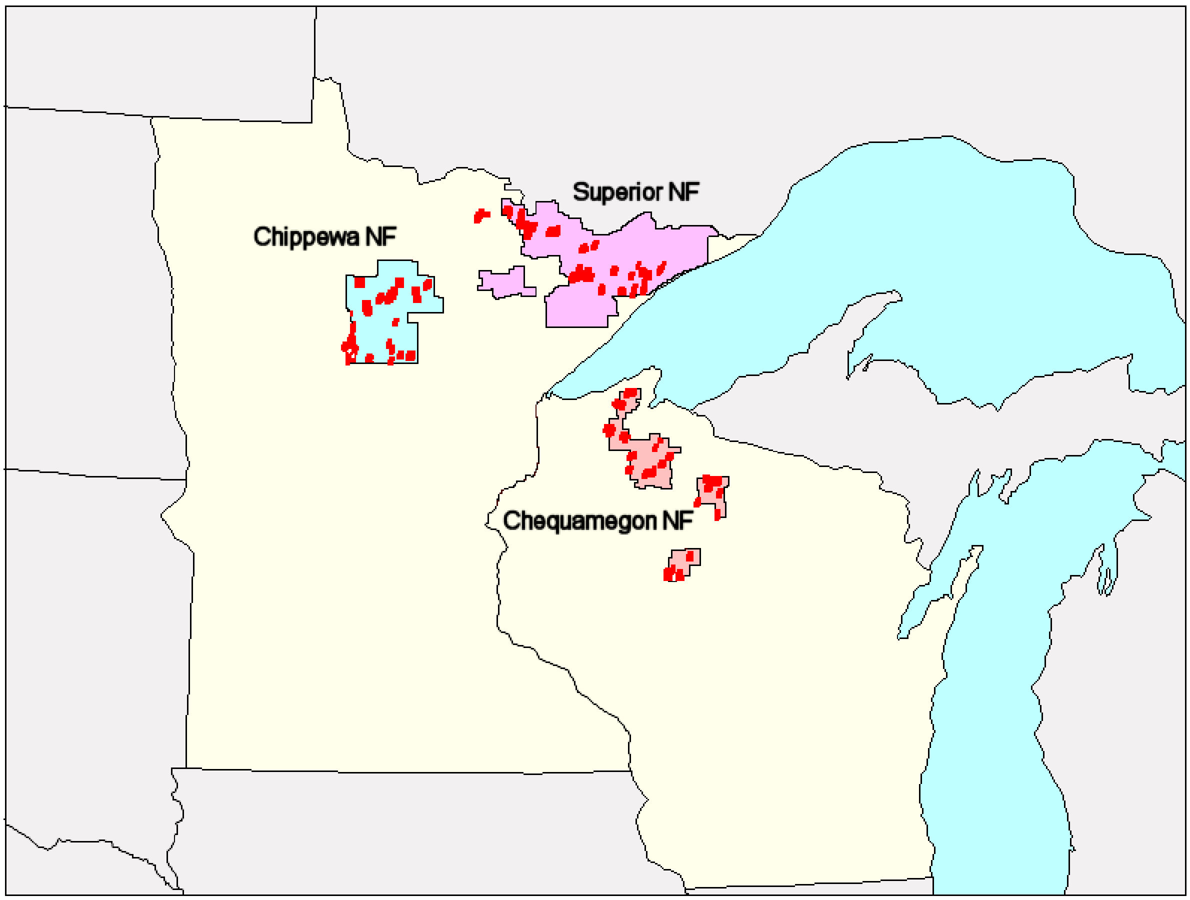

Figure 1. Locations of forest breeding bird point counts in northern Minnesota and Wisconsin (1991-2006).

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 University 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 estimate 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 1990) 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 Erlich 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 have used a protocol designed to maximize time-efficiency, with each survey taking fewer than 5 minutes to carry out. Every point has 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 (Appendix G). Using over 50 person-days of sampling, we surveyed 93, 74, and 63 point locations in the Chequamegon, Chippewa, and Superior NFs, respectively. Points were chosen randomly so that one point was selected per stand and that all forest covertypes were represented in each forest. In the Superior NF, B. Anderson and other monitoring program personnel provided invaluable assistance, surveying about 50 points independently. In the Chippewa NF, G. Swanson provided a GIS analysis of our point locations to assist our selection of sites.

RESULTS AND DISCUSSION

Over the course of 16 field seasons we have detected over 297,000 individual birds of 173 species on more than 19,750 ten-minute point counts (almost 3,300 hours of sampling) in the three national forests (Figure 2). In 2006, we sampled 132 stands in the Chequamegon NF, 133 stands in the Chippewa NF, and 164 in the Superior NF.

Seventy-two species were tested for trends in at least one national forest, including 57 in the Chequamegon NF, 57 in the Chippewa NF, and 49 in the Superior NF (Table 1). Additionally, 39 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 72 in 2006. 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 163 species/national forest trends were calculated (not including pooled trends), 68 (42%) of which were significant ($P \leq 0.05$). Twenty three species increased in at least one national forest, including four (Black-capped Chickadee, Red-breasted Nuthatch, Cedar Waxwing, and American Redstart) that increased in multiple national forests (Tables 2 and 3). Twenty four species decreased in at least one national forest, including nine (Eastern Wood-Pewee, Great-crested Flycatcher, Winter Wren, Veery, Hermit Thrush, Ovenbird, Mourning Warbler, Scarlet Tanager, White-throated Sparrow) that decreased in multiple national forests (Tables 4 and 5). Of the 158 species/national forest trends calculated in 2005 (i.e., excluding pooled trends, Lind et al. 2005), 19 (12%) changed in 2006 (Table 6).

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 saw species with opposite trends in different study areas (e.g. five species in 2000 results; Lind et al. 2001a). After 16 years of sampling, there now appears to be "core" groups of 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, Ovenbird, and White-throated Sparrow).

Chequamegon National Forest

Of the 57 species tested for trends in the Chequamegon NF, five species (9%) increased significantly and 16 (28%) have decreased (Figure 3). Yellow Warbler and American Redstart have the greatest rates of increase (>9%), but Yellow Warbler is not a widespread species in the forest (detected on only 7 stands). The only widespread increasing species is Blackburnian Warbler (detected on 61 stands). One species, Alder Flycatcher, is showing a new increasing trend this year (4.1% annual increase; $P = 0.05$). All other species (four species, Table 2) that exhibited significant increases in Chequamegon NF in 2005 maintained those trends in 2006.

The Eastern Wood-Pewee, Winter Wren, and Hermit Thrush are well-represented on the Chequamegon NF, but have some of the greatest declines (6-9% annually; Appendix B). The Red-winged Blackbird and Evening Grosbeak have the two greatest rates of decrease, but they are tested on just five and six stands, respectively, and their trends may be more susceptible to site-specific influences than other species. Both of these species are, however, showing substantial declines in other parts of their ranges (Sauer 2004). Other widespread species (detected on >= 40 stands) in Chequamegon NF that are declining, though at a lesser rate, include Veery, Common Yellowthroat, Mourning Warbler, Scarlet Tanager, and White-throated Sparrow (declines >= 3% annually,). Brown Thrasher showed a new significant decline in 2006, whereas Ruby-crowned Kinglet, declining in 2005, no longer shows significant decline in Chequamegon NF (Table 6).

Chippewa National Forest

Of the 57 species tested in the Chippewa NF, 14 species (25%) increased significantly and 13 (23%) decreased (Figure 3). Wood Thrush, Canada Warbler, and American Goldfinch had the greatest rates of increase (>10% annually), but are found on ten or fewer stands. Cedar Waxwing continued to increase rapidly (8.7%), though less so than last year (11%). Black-capped Chickadee, Red-breasted Nuthatch, American Robin, Chestnut-sided Warbler, Black-and-white Warbler, and American Redstart are widespread (>=40 stands) species in the forest, with 3-7% annual increases. The Red-eyed Vireo has the lowest rates of increase among the significantly increasing species, but because of its wide distribution, the increase is probably occurring over a large portion of the forest. It has also had a substantial increase since 1998 (Appendix A). Red-breasted Nuthatch, Wood Thrush, and Chipping Sparrow all showed new increases in 2006. Gray Catbird was again increasing in 2006 (as it was in 2004) after not showing increases in 2005. Least Flycatcher was no longer increasing significantly (Table 6)

The greatest rate of annual decrease in the Chippewa NF is that of the Connecticut Warbler (13.5%). Although it is sampled on only 14 stands, the species has declined consistently since 1991 and the stands on which it occurs are spread across most of the forest. Well-represented species (detected on >= 40 stands) that are showing annual rates of decline of 3% or more include the Eastern Wood-Pewee, Winter Wren, Hermit Thrush, Song Sparrow, and Scarlet Tanager. Great Crested Flycatcher, a moderately widespread species (24 stands) continues to decline. Ovenbird is declining at 2.6%/year, but its trend may be especially important given its widespread distribution. American Crow and Purple Finch show new declines in 2006 and Brown-headed Cowbird, again was declining significantly in 2006 (as it was in 2004, Table 6).

Superior National Forest

Of the 49 species tested in the Superior NF, ten species (20%) are increasing and 10 (20%) are decreasing (Figure 3). The Hairy Woodpecker has the highest rate of annual increase (10.9%) of any species in the Superior NF, but it is tested on just five stands and its trend may be more susceptible to site-specific influences than other species. The Black-throated Blue Warbler, Northern Flicker, and Cedar Waxwing all have high (>8%) rates of increase, but were detected on fewer than 20 stands. Black-capped Chickadee, Red-breasted Nuthatch, Golden-crowned Kinglet are widespread species that are increasing at >4% annually. This year's increases in Red-breasted Nuthatch represent a change over last year when the species showed stable trends. Red-eyed Vireo and Nashville warbler, formerly increasing species, did not show increases this year (Table 6).

Tennessee Warbler, Scarlet Tanager and Eastern Wood-Pewee have the greatest rates of decrease (17.7%, 10.9%, and 9% annually), and are not widespread species in Superior NF. Rose-breasted Grosbeak, Winter Wren, and Veery, are declining at >3% annually, and are widely distributed on the forest. American Robin and Mourning Warbler show new significant declines this year and two species that were declining last year, are no longer declining (Black-throated Green Warbler and Northern Waterthrush, Table 6).

Pooled national forests

Of the 39 species tested for a pooled national forests trend, 11 species (28%) increased significantly and 11 (28%) 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 American Redstart. Other widespread species that increased include Red-eyed Vireo, Chestnut-sided Warbler, and Black-and-white Warbler. Of these species, increases in Hairy Woodpecker, Red-breasted

Nuthatch, and Black-and-white Warbler were all new in 2006. All species that were increasing in 2005 in the pooled analysis were again increasing in 2006 (Table 6).

The strongest decreases across all national forests occurred in Eastern Wood-Pewee, Winter Wren, Hermit Thrush, Scarlet Tanager, and Song Sparrow (>3%/year). Other widespread species that declined include Veery, Ovenbird, Mourning Warbler, and White-throated Sparrow. No species show new declining trends in the pooled analysis in 2006 and two formerly declining species (Black-throated Green Warbler and Rose-breasted Grosbeak) did not show declines this year (Table 6).

Management activities on study areas

Of the 1274 survey sites on the three national forests, 15.5% have been at least partially harvested since the beginning of monitoring, which is about 1% a year (Table 8). 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 mainly north of Mexico) showed highly significant declines ($P \leq 0.01$) in each national forest (Table 7). The most abundant short-distance migrants in our analyses include White-throated Sparrow, American Robin, Hermit Thrush, and Yellow-rumped Warbler. Long-distance migrants (species that winter mainly south of the U.S./Mexico border) also declined significantly in each forest. Abundant long-distance migrants included Ovenbird, Red-eyed Vireo, Nashville Warbler, and Chestnut-sided Warbler. Permanent residents increased significantly in all forests except the Chequamegon NF, where they showed non-significant declines. Black-capped Chickadee, Blue Jay, and Red-breasted and White-breasted nuthatches are the most abundant permanet residents.

Ground nesting birds showed highly significant declines in all study areas, while shrub/sub-canopy nesters increased in all study areas (Table 7), though the increases were only significant in Chippewa NF and in the pooled analysis. 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. Canopy nesters declined signficantly in Chequamegon and in the pooled analysis (Table 7) and cavity nesters showed highly significant increases in Chippewa and Superior NFs and in the pooled analysis (Table 7). Most primary cavity excavators (e.g. woodpeckers) have had stable 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 is declining in the Chequamegon and Chippewa NF.

The deciduous and mixed forest bird guilds declined on the Chequamegon and Superior NFs and the pooled NFs. The lowland coniferous forest bird guild declined on the Chippewa NF and the pooled NFs. The early-successional bird guild increased on the Chippewa NF and the upland coniferous bird guild increased in the Chippewa and Superior NFs.

Conclusions

Most 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 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) may be benefiting these species. The Black-capped Chickadee is a year-round resident 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 Blackburnian Warbler is a mature coniferous/mixed forest species that has also shown widespread increases. Population fluctuations in this species are often attributed to changes in spruce budworm (*Choristonuera fumiferana*) abundance. There was an outbreak in early 1990s with a decline since 1998 (Blackford 2001) that seems to correspond to the Blackburnian Warbler's trajectory (Appendix A). However, this is difficult to corroborate with other spruce budworm specialists (e.g. Tennessee, Bay-breasted and Cape May warblers) which are on the southern fringe of their ranges in our study areas. Of the latter three species, Tennessee Warbler shows highly significant declines with a consistent trajectory over the last 16 years in Superior NF. Cape May Warbler met the minimum detection criteria for analysis for the first time this year in Superior NF and showed increasing, though non-significant trends. Our database does not contain enough detections of Bay-breasted Warbler for analysis with our current methods.

Species with widespread declines on our study sites are mainly found in mature forest habitats, with the possible exception of Veery and White-throated Sparrow. While White-throated Sparrow abundance is often higher in clearcuts than in mature forests, reproductive rates have been shown to be up to three times greater in older forests (75-100 years) than in younger forests (Rangen et al. 2000). The Eastern Wood-Pewee, Winter Wren, Veery, and White-throated Sparrow have each shown significant declines on our surveys as well as USGS Breeding Bird Survey routes over much of their range (Sauer 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., White-breasted Nuthatch, Black-throated Blue Warbler, Northern Waterthrush). There are also examples of decreases in shrub/early successional species (Mourning Warbler, Common Yellowthroat, Song Sparrow).

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). 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.

Many of the declining trends that we have detected have been consistent across the years and are not likely due to annual variation. One of the main goals of this monitoring program is to identify potential declines of forest bird species. This is especially true for species of conservation concern such as the Eastern Wood-Pewee, Winter Wren, Hermit Thrush, Ovenbird, and White-throated Sparrow. The declines observed over the past years for common species such as the Ovenbird and White-throated Sparrow are a continuing concern and special management consideration should be given to these species. 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.

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. 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 the extensive forests of northern Minnesota and Wisconsin represent excellent opportunities to provide “source” populations for many species.

Future Directions

The point count methods we use are a common and efficient way to sample avian populations. Nevertheless, a frequent criticism of point counts is that they often cannot be used to estimate true abundance or density because an unknown number of birds are not detected during the course of the survey (Burnham 1981). Our sampling protocol does allow estimation of detectability (Farnsworth et al. 2002) and we have developed a modeling strategy that incorporates detection probabilities directly into the trend analysis using maximum likelihood. This work is currently undergoing peer review. However, preliminary results suggest that detection probability estimates would likely be greatly enhanced by increasing the temporal resolution at which we are currently sampling. Thus in 2007 we will modify the sampling protocol to divide the ten-minute point counts into 10 equal intervals of 1 minute each. The resulting data will be fully retrospectively compatible with data collected under the current protocols (i.e., data could always be lumped into the three current intervals). It will also allow much greater power in parameterizing detectability models, including ability to model within-species heterogeneity in detection. Longer term modeling goals for the future are to incorporate the temporal stratification (removal) model of detection with distance based methods (e.g. Buckland et al. 2004) and we have already adopted distance-based sampling methods to allow such model development.

While we have previously investigated patterns of bird occurrence in relationship to land cover data, forest covertype classifications, and vegetation data from ocular estimates, our new, more intensive dataset of vegetation structure provides the opportunity to develop a fuller understanding of bird/habitat relationships that can inform forest management. Further incorporation of forest-wide vegetation measurements from existing or developing Forest Service programs (e.g. common stand exams or individual tree crown coverages) will provide even more opportunities for research and incentive for collaboration.

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Table 1. Trends for three individual national forests (NF), combined NFs, and Nicolet NF based on linear regression (1991-2006). I = significantly increasing, D = significantly decreasing. * $P \leq 0.05$, ** $P \leq 0.01$. See Appendix A for species graphs and Appendix B for test statistics and sample sizes.

Species	Chequamegon NF	Chippewa NF	Superior NF	Combined Trend
Ruffed Grouse			ns	
Yellow-bellied Sapsucker	ns	ns	ns	ns
Downy Woodpecker		ns		
Hairy Woodpecker	ns	ns	I**	I*
Northern Flicker	ns		I*	
Olive-sided Flycatcher		ns		
Eastern Wood-Pewee	D**	D**	D**	D**
Yellow-bellied Flycatcher	ns	ns	ns	I*
Alder Flycatcher	I*	ns	ns	ns
Least Flycatcher	ns	ns	ns	ns
Great Crested Flycatcher	D**	D**		
Eastern Kingbird	ns			
Yellow-throated Vireo	ns	ns		
Blue-headed Vireo	D*	ns	ns	ns
Red-eyed Vireo	ns	I**	ns	I**
Gray Jay		ns	ns	
Blue Jay	ns	ns	ns	ns
American Crow		D**		
Black-capped Chickadee	ns	I**	I**	I**
Red-breasted Nuthatch	ns	I**	I**	I**
White-breasted Nuthatch	ns	I**		
Brown Creeper	ns	ns	ns	ns
House Wren	ns			
Winter Wren	D**	D**	D**	D**
Golden-crowned Kinglet	ns	ns	I**	I**
Ruby-crowned Kinglet			ns	
Veery	D**	ns	D**	D**
Swainson's Thrush			ns	
Hermit Thrush	D**	D**	ns	D**
Wood Thrush	ns	I**		
American Robin	ns	I*	D*	ns
Gray Catbird		I*		
Brown Thrasher	D*			
Cedar Waxwing		I**	I**	
Golden-winged Warbler	ns	ns	ns	ns

Table 1 (continued)

Species	Chequamegon NF	Chippewa NF	Superior NF	Combined Trend
Tennessee Warbler			D**	
Nashville Warbler	ns	D*	ns	ns
Northern Parula	ns	ns	I**	I**
Yellow Warbler	I**	ns		
Chestnut-sided Warbler	ns	I**	ns	I**
Magnolia Warbler	ns	ns	I*	I*
Cape May Warbler			ns	
Black-throated Blue Warbler			I**	
Yellow-rumped Warbler	D**	ns	ns	D*
Black-throated Green Warbler	D**	ns	ns	ns
Blackburnian Warbler	I**	ns	ns	ns
Pine Warbler	ns	ns	ns	ns
Palm Warbler		ns		
Black-and-white Warbler	ns	I**	ns	I**
American Redstart	I**	I**	I*	I**
Ovenbird	D**	D**	D**	D**
Northern Waterthrush	I*	ns	ns	ns
Connecticut Warbler		D**		
Mourning Warbler	D*	ns	D*	D**
Common Yellowthroat	D*	ns	ns	D**
Canada Warbler	ns	I*	ns	ns
Scarlet Tanager	D*	D**	D**	D**
Eastern Towhee	ns			
Chipping Sparrow	ns	I*	ns	ns
Clay-colored Sparrow	ns			
Vesper Sparrow	ns			
Song Sparrow	ns	D**	ns	D*
Swamp Sparrow	ns	ns	ns	ns
White-throated Sparrow	D*	D**	D**	D**
Rose-breasted Grosbeak	ns	ns	D**	ns
Indigo Bunting	ns	ns		
Red-winged Blackbird	D*	ns		
Brewer's Blackbird	ns			
Brown-headed Cowbird	ns	D*		
Purple Finch		D**	ns	
American Goldfinch	ns	I**		
Evening Grosbeak	D**			

Table 2. Species with significantly increasing trends ($P \leq 0.05$) for three national forests (1991-2006), based on simple linear regression. ** $P \leq 0.01$. Species graphs can be found in Appendix A.

Increasing Species

Chequamegon NF	Chippewa NF	Superior NF	Pooled national forests
Alder Flycatcher	** Red-eyed Vireo	** Hairy Woodpecker	Hairy Woodpecker
** Yellow Warbler	** Black-capped Chickadee	Northern Flicker	Yellow-bellied Flycatcher
** Blackburnian Warbler	** Red-breasted Nuthatch	** Black-capped Chickadee	** Red-eyed Vireo
** American Redstart	** White-breasted Nuthatch	** Red-breasted Nuthatch	** Black-capped Chickadee
Northern Waterthrush	** Wood Thrush	** Golden-crowned Kinglet	** Red-breasted Nuthatch
	American Robin	** Cedar Waxwing	** Golden-crowned Kinglet
	Gray Catbird	** Northern Parula	** Northern Parula
	** Cedar Waxwing	Magnolia Warbler	** Chestnut-sided Warbler
	** Chestnut-sided Warbler	** Black-throated Blue Warbler	Magnolia Warbler
	** Black-and-white Warbler	American Redstart	** Black-and-white Warbler
	** American Redstart		** American Redstart
	Canada Warbler		
	Chipping Sparrow		
	** American Goldfinch		

Table 3. Summary of species with increasing trends ($P \leq 0.05$) on three national forests (1991-2006). Individual species graphs can be found in Appendix A.

Increased in one national forest	**Increased in two national forests**	**Increased in three national forests**
Hairy Woodpecker	Black-capped Chickadee	American Redstart
Northern Flicker	Red-breasted Nuthatch	
Alder Flycatcher	Cedar Waxwing	
Red-eyed Vireo		
White-breasted Nuthatch		
Golden-crowned Kinglet		
Wood Thrush		
Gray Catbird		
Northern Parula		
Yellow Warbler		
Chestnut-sided Warbler		
Magnolia Warbler		
Black-throated Blue Warbler		
Blackburnian Warbler		
Black-and-white Warbler		
Northern Waterthrush		
Canada Warbler		
Chipping Sparrow		
American Goldfinch		

Table 4. Species with significantly decreasing trends ($P \leq 0.05$) for three national forests (1991-2006), based on simple linear regression. ** $P \leq 0.01$. Species graphs can be found in Appendix A.

Decreasing Species

Chequamegon NF	Chippewa NF	Superior NF	Pooled national forests
** Eastern Wood-Pewee	** Eastern Wood-Pewee	** Eastern Wood-Pewee	** Eastern Wood-Pewee
** Great Crested Flycatcher	** Great Crested Flycatcher	** Winter Wren	** Winter Wren
Blue-headed Vireo	** American Crow	** Veery	** Veery
** Winter Wren	** Winter Wren	American Robin	** Hermit Thrush
** Veery	** Hermit Thrush	** Tennessee Warbler	Yellow-rumped Warbler
** Hermit Thrush	Nashville Warbler	** Ovenbird	** Ovenbird
Brown Thrasher	** Ovenbird	Mourning Warbler	** Mourning Warbler
** Yellow-rumped Warbler	** Connecticut Warbler	** Scarlet Tanager	** Common Yellowthroat
** Black-throated Green Warbler	** Scarlet Tanager	** White-throated Sparrow	** Scarlet Tanager
** Ovenbird	** Song Sparrow	** Rose-breasted Grosbeak	Song Sparrow
Mourning Warbler	** White-throated Sparrow		** White-throated Sparrow
** Common Yellowthroat	Brown-headed Cowbird		
Scarlet Tanager	** Purple Finch		
White-throated Sparrow			
Red-winged Blackbird			
** Evening Grosbeak			

Table 5. Summary of species with decreasing trends (*P* ≤ 0.05) on three national forests (1991-2006). Individual species graphs can be found in Appendix A.

Decreased in one national forest	**Decreased in two national forests**	**Decreased in three national forests**
Blue-headed Vireo	Great Crested Flycatcher	Eastern Wood-Pewee
American Crow	Veery	Winter Wren
Brown Thrasher	Hermit Thrush	Ovenbird
Tennessee Warbler	Mourning Warbler	Scarlet Tanager
Nashville Warbler		White-throated Sparrow
Myrtle Warbler		
Black-throated Green Warbler		
Connecticut Warbler		
Common Yellowthroat		
Song Sparrow		
Rose-breasted Grosbeak		
Red-winged Blackbird		
Brown-headed Cowbird		
Purple Finch		
Evening Grosbeak		

Table 6. Summary of changes in trends on three national forests between 2005 and 2006 analyses.

Species with new significant trends (P ≤ 0.05) in 2006			
Increasing		*Decreasing*	
Species	Study area	Species	Study area
Alder Flycatcher	Chequamegon NF	Brown Thrasher	Chequamegon NF
Red-breasted Nuthatch	Chippewa NF	American Crow	Chippewa NF
Wood Thrush	Chippewa NF	Brown-headed Cowbird	Chippewa NF
Gray Catbird	Chippewa NF	Purple Finch	Chippewa NF
Chipping Sparrow	Chippewa NF	American Robin	Superior NF
Red-breasted Nuthatch	Superior NF	Mourning Warbler	Superior NF
Hairy Woodpecker	Pooled NFs		
Red-breasted Nuthatch	Pooled NFs		
Black-and-white Warbler	Pooled NFs		
Species no longer showing significant trends (P > 0.05) in 2006			
Was increasing in 2005		*Was decreasing in 2005*	
Species	Study area	Species	Study area
Least Flycatcher	Chippewa NF	Ruby-crowned Kinglet	Chequamegon NF
Red-eyed Vireo	Superior NF	Yellow Warbler	Chippewa NF
Nashville Warbler	Superior NF	Black-throated Green Warbler	Superior NF
		Northern Waterthrush	Superior NF
		Black-throated Green Warbler	Pooled NFs
		Rose-breasted Grosbeak	Pooled NFs

Table 7. Test statistics and sample sizes for guild trend analyses on three national forests (1991-2006). All species combined within each guild category and analyzed as a group, regardless of whether a species meets criteria for individual species analyses. Change = percent annual change. N = number of stands analyzed. See Appendix A for trend graphs.

Guild Category		Chequamegon NF				Chippewa NF				Superior NF				Pooled National Forests			
		change	*P*	R^2	N	change	*P*	R^2	N	change	*P*	R^2	N	change	*P*	R^2	N
Migration	Short-distance	**-2.4**	**0.00**	**0.96**	**129**	**-0.9**	**0.02**	**0.42**	**126**	**-1.0**	**0.02**	**0.39**	**147**	**-1.4**	**0.00**	**0.82**	**402**
	Long-distance	**-0.7**	**0.00**	**0.92**	**129**	**0.4**	**0.04**	**0.16**	**126**	**-0.7**	**0.00**	**0.75**	**147**	**-0.4**	**0.00**	**0.36**	**402**
	Permanent Resident	-0.5	0.45	0.58	121	**3.2**	**0.00**	**0.91**	**125**	**2.9**	**0.00**	**0.98**	**145**	**2.1**	**0.00**	**0.92**	**391**
Nesting	Ground	**-2.3**	**0.00**	**0.91**	**129**	**-1.6**	**0.00**	**0.49**	**126**	**-1.8**	**0.00**	**0.80**	**147**	**-2.0**	**0.00**	**0.75**	**402**
	Shrub/Sub-canopy	0.5	0.25	0.15	129	**2.4**	**0.00**	**0.91**	**126**	0.4	0.27	0.34	147	**1.1**	**0.00**	**0.73**	**402**
	Canopy	**-1.4**	**0.00**	**0.78**	**124**	-0.5	0.12	0.39	126	0.1	0.89	0.02	147	**-0.5**	**0.02**	**0.84**	**397**
	Cavity	-0.2	0.66	0.61	126	**2.6**	**0.00**	**0.65**	**125**	**3.8**	**0.00**	**0.93**	**147**	**2.1**	**0.00**	**0.85**	**398**
Vegetation Preference	Coniferous forest	-0.2	0.68	0.04	107	**1.2**	**0.02**	**0.77**	**111**	**1.6**	**0.00**	**0.87**	**145**	**0.9**	**0.00**	**0.78**	**363**
	Lowland coniferous	-0.8	0.15	0.22	108	**-1.6**	**0.00**	**0.71**	**101**	-0.3	0.28	0.47	147	**-1.0**	**0.00**	**0.65**	**356**
	Deciduous forest	**-1.4**	**0.00**	**0.88**	**127**	0.1	0.71	0.00	126	**-0.9**	**0.00**	**0.77**	**147**	**-0.6**	**0.00**	**0.69**	**400**
	Early-succession	0.9	0.45	0.70	103	**2.2**	**0.00**	**0.82**	**118**	-0.8	0.30	0.13	145	0.2	0.70	0.01	366
	Mixed forest	**-3.0**	**0.00**	**0.96**	**121**	-0.3	0.44	0.09	124	**-1.3**	**0.00**	**0.61**	**147**	**-1.4**	**0.00**	**0.70**	**392**

Table 8. Number of survey sites harvested in each national forest since the start of monitoring.

Study Area	Total # of sites	# clearcut	# partially or selectively cut*	% harvested
Chequamegon NF	390	15	31	11.8%
Chippewa NF	393	21	49	17.8%
Superior NF	491	42	40	16.7%

* Sites in the partially cut category can include anywhere from 10-90% of the 100 m radius count circle harvested.

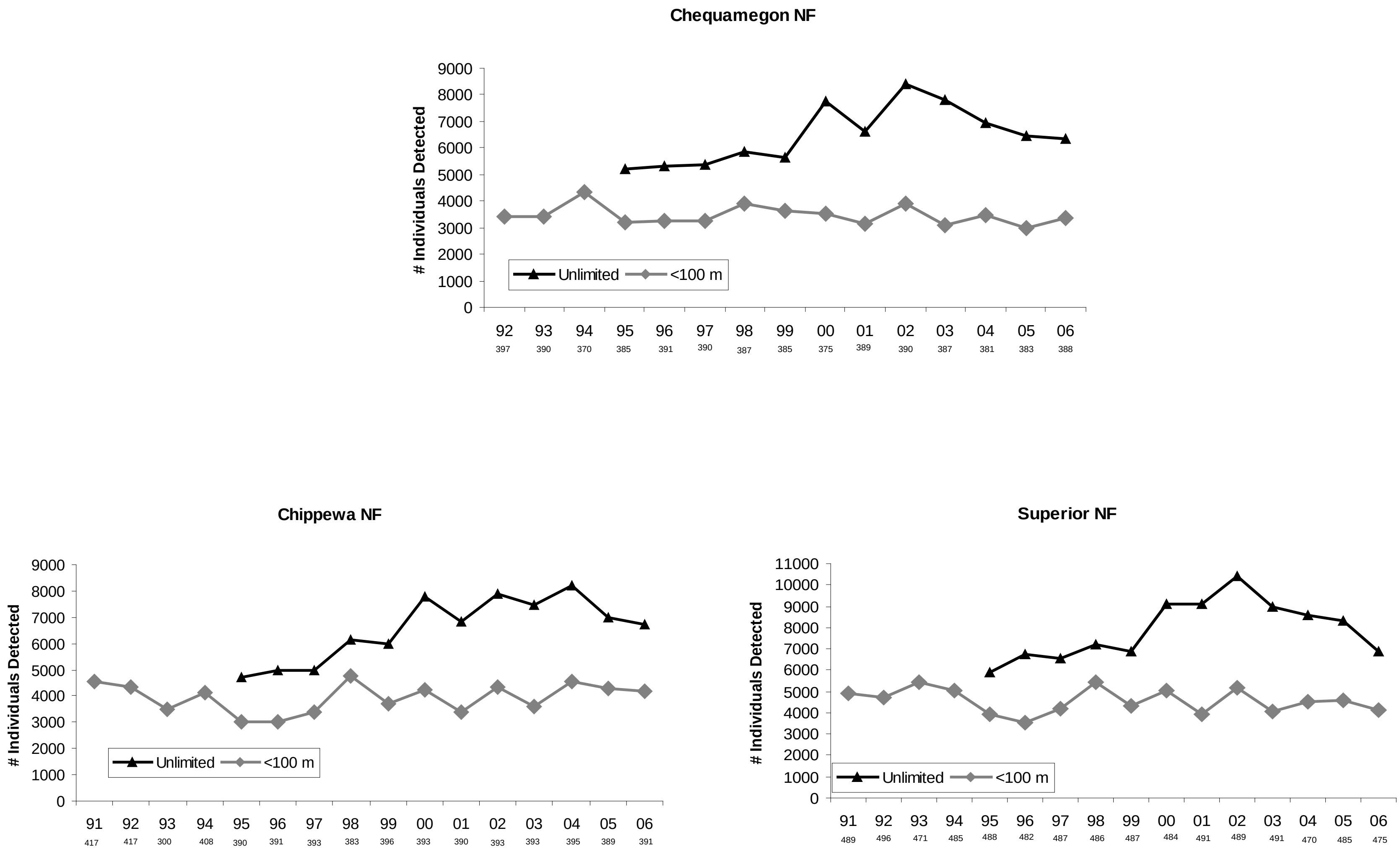

Figure 2. Total number of individuals detected annually (1991-2006) in each national forest based on raw data before applying analysis criteria (e.g. includes flyovers, etc.). The number of sites sampled is presented below each year

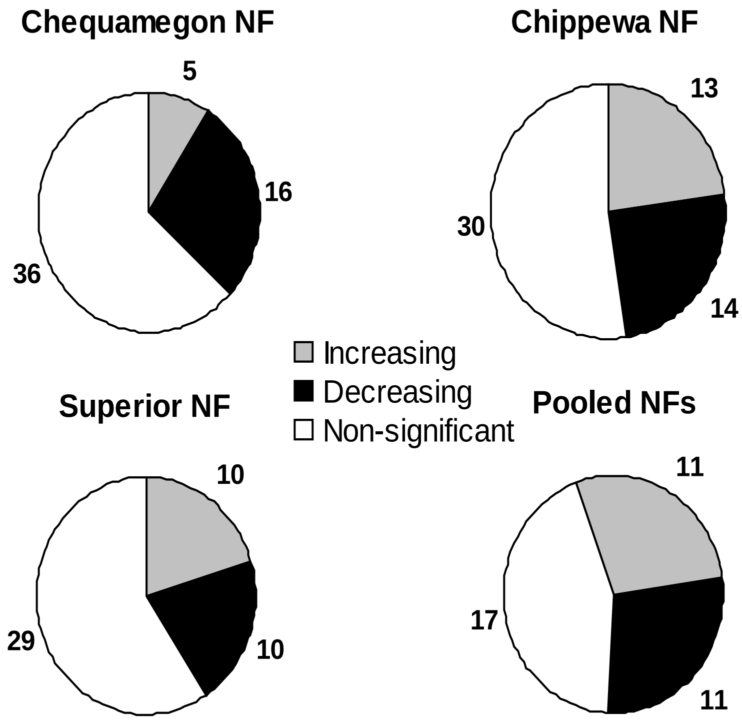

Figure 3. Summary of significant trends ($P \leq 0.05$) by national forest (1991-2005). Pooled trends include three national forests combined. See Table 1 for list of species trends by national forest.

Appendix A

Trends in relative abundance by study area for all species and guilds tested (1991-2006)

Please see the *Analysis* section in the body of the report for details about how the plots were constructed.