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BREEDING BIRD MONITORING IN GREAT LAKES NATIONAL FORESTS: 1991-2003

REPORT TO: CHEQUAMEGON/NICOLET, CHIPPEWA AND SUPERIOR NATIONAL FORESTS

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SUMMARY

- A total of 132, 134, and 169 stands (1,271 survey points) were surveyed for breeding birds in the Chequamegon, Chippewa, and Superior National Forests, respectively in 2003. Annual surveys have been conducted since 1991 in the Chippewa and Superior National Forests, and since 1992 in the Chequamegon National Forest. Breeding bird surveys in the St. Croix region of Minnesota have been conducted since 1992 on 170 stands (170 points).
- We examined trends in relative abundance for 68 bird species in at least one of the four study areas. Fifty-five species in the Chequamegon NF, 52 in the Chippewa NF, 44 in the Superior NF, and 41 in the St. Croix region were tested for population trends. Thirty-six species were also tested for regional trends by combining data from the three national forests.
- A total of 192 species/study area trends were calculated (not including regional trends), 98 (51%) of which were significant ($P < 0.05$). Twenty-five species increased significantly ($P \leq 0.05$) in at least one study area and 31 species decreased.
- Seven species had significant increasing regional trends and 14 had decreasing trends. Six species had highly significant ($P \leq 0.01$) increasing trends in multiple study areas, and nine species had highly significant decreasing trends in multiple study areas.
- The percentage of increasing species in each study area ranged from 13% in the Chequamegon NF, to 29% in the St. Croix study area. The percentage of decreasing species ranged from 25% in the Chequamegon NF study area, to 35% in the Chippewa NF.
- There were 12 instances where a species wasn't increasing in a particular study area in 2002 results but is increasing in 2003, and ten instances where a species showed a significant increase in 2002, and isn't in 2003. Conversely, there were 19 instances where a species wasn't decreasing in 2002 but is decreasing in 2003, and one instance where a species showed a decrease in 2002 but isn't in 2003.
- Short-distance migrants showed highly significant declines in all study areas. Long-distance migrants showed mixed results, including declines in the Chequamegon and Superior NF's, an increase in the St. Croix study area, and a stable trend in the Chippewa NF. Permanent residents increased on all study areas except the Chequamegon NF, where they were stable.
- Ground nesting birds showed highly significant declines in all study areas, with shrub and sub-canopy nesters increasing in all study areas. Canopy and cavity nesters showed mostly stable trends.

- Of the five vegetation-type preference guilds tested, lowland coniferous forest birds, deciduous, and mixed forest bird species showed widespread declines on our study areas, and upland coniferous species increased on all study areas except the Chequamegon NF. The early-successional guild showed an increase in the Chippewa NF and declines in the Superior NF and the regional analysis.
- Evidence from recent 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. Landscape fragmentation and nest predation may be having negative effects on declining ground-nesters such as the Winter Wren, Hermit Thrush, Black-and-white Warbler, Ovenbird, and White-throated Sparrow.
- Of the 1445 survey sites in all four study areas, 13.4% have been at least partially harvested since the beginning of monitoring, which is about 1% a year. 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).
- 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 species of conservation concern, and species such as the Eastern Wood-Pewee, Winter Wren, Hermit Thrush, Mourning Warbler, Ovenbird, and White-throated Sparrow probably need special management consideration by agencies such as the U.S. Forest Service and state Department of Natural Resources. Although most of these are common species, several are currently well below their estimated RNV values and they may not remain common if their declining trends continue.

INTRODUCTION

The national forests of the western Great Lakes have among the richest diversity of breeding bird species in North America (Green 1995). 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, in order to identify when and where population changes are occurring and 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, 605 stands (1,445 points) within the four study areas 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. (2001) for 1995-2001 results from southeast Minnesota.

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 12 to 13 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 2002, 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 species in four study areas (Figure 1). The spatial extent of each study area 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. In the three national forests, stands were ≥ 16 ha (40 acres) and were identified from the individual national forest inventories. For the St. Croix region, stands on state-owned land ≥ 4 ha (10 acres) were identified from a state inventory. For each study area, 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 study area. A total of 133, 135, 169, and 171 stands were established in the Chequamegon, Chippewa, and Superior National Forests, and the St. Croix region respectively.

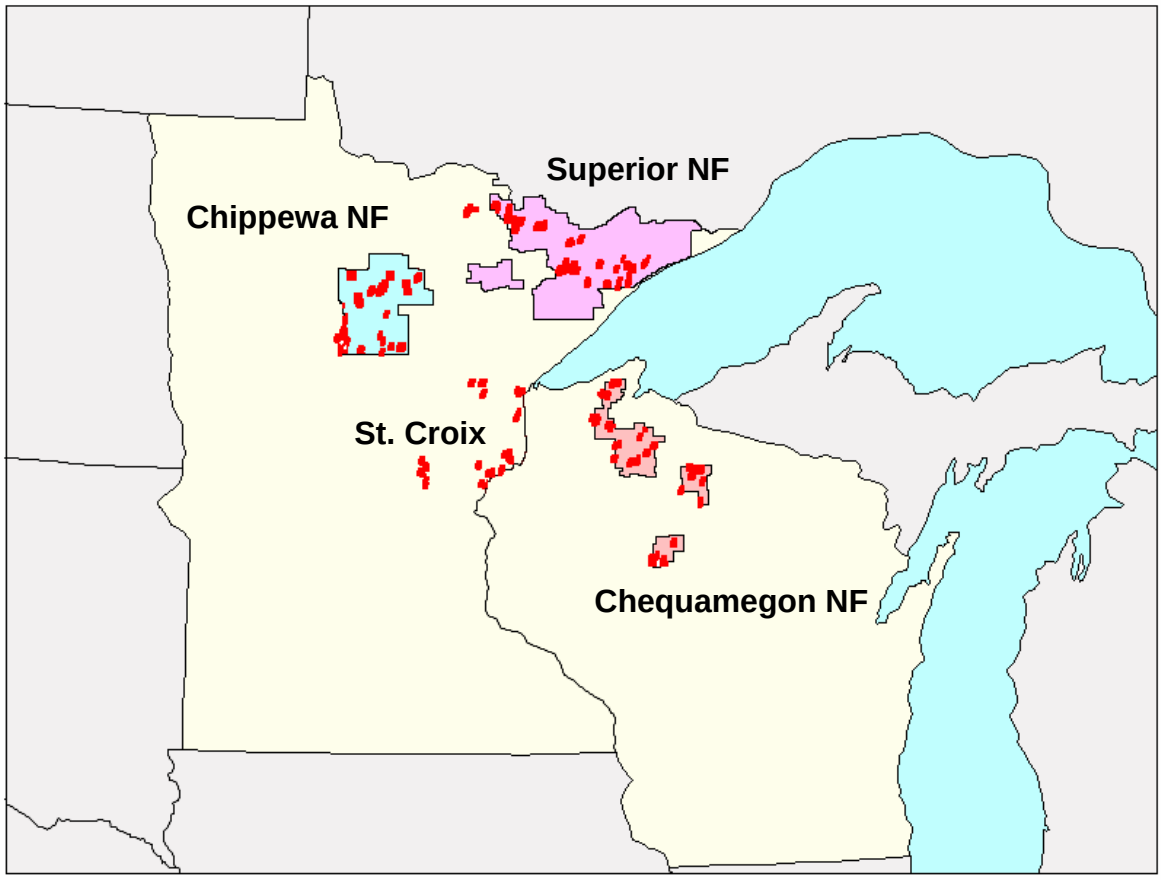

Figure 1. General locations of breeding bird point counts in four regions of Minnesota and Wisconsin.

For the national forests, stands were large enough to accommodate three sampling points a minimum of 220 meters apart. There were several smaller stands in the St. Croix region, and to maximize sample size one survey point was located in each stand. 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).

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 1995-2002, 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 Cornell University's Laboratory of Ornithology. A standard for number of correct responses was established by giving the test to observers who were trained in identifying birds by sound, and who had four to five years of field experience. This was done to identify songs on the tape that were not good representations of songs heard in northern Minnesota and Wisconsin. Based on results of trained observers, the standard for passing was set at 85% correct responses. Songs on the tape were grouped by habitat (e.g., upland deciduous, lowland coniferous) to simulate field cues that would aid in song identification.

Observer field training was conducted during the last week of May in the Superior National Forest. Observers conducted simultaneous practice counts at several points used in the monitoring program. Data were compiled for each observer, and species lists and numbers of individuals recorded on the count by each observer were compared to that of experienced observers. Deviations from the average or species missed were noted on the field sheets and returned. In addition to field training and testing, all observers were required to have a hearing test to ensure that their hearing was within normal ranges, 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. For the St. Croix region, where the point is the sampling unit, relative abundance is the count of individuals of each species within 100 m at each point. This is important to keep in mind when comparing graphs of mean relative abundance on stands in the St. Croix to those on the national forests.

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 regional (three national forest combined) analysis. Although this regional 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 a given time period (Link and Sauer 1997). Because a significant trend implies a unidirectional change, linear methods can be used to detect trend (Urquhart and Kincaid 1999) without asserting that the population trajectory is linear. 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 % 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 250 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 250 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 the potential influence of three guild types on trends: 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 100m radius were included, regardless of whether the species met the inclusion criteria described above for individual species. The distribution of guilds among increasing and decreasing species was also graphed for visual comparison with the pool of species tested, to examine whether certain guilds were more prevalent among trend types. To reduce the number of guild categories in the vegetation-type preference analysis, we only considered those categories with 20 or more category/study area trends. Guild categories were taken from Erlich et al. (1988) and Freemark and Collins (1992), with modifications based on personal experience and data.

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.

Range of Natural Variability

Bird population sizes in the Chippewa and Superior National Forests have been assessed in relation to their range of natural variability (RNV; Hanowski and Danz 2003). In an effort to place the trends from these two national forests into context with their historic and current populations, we have presented the RNV values for each of the species tested in the Chippewa and Superior NF. The RNV calculations are based on estimated historic forest conditions and the habitat affinities of each species, and represent a potential benchmark for evaluating our trends. An underlying assumption of the RNV concept is that a species is considered sustainable if it is currently present on the landscape at the same levels which it occurred historically.

RESULTS AND DISCUSSION

Over the course of 13 field seasons we have detected over 264,000 individual birds of 173 species on more than 18,000 ten-minute point counts in our four study areas (Figures 2 & 3). In 2003, we sampled 132 stands in the Chequamegon NF, 134 stands in the Chippewa NF, 169 in the Superior NF, and 167 stands in the St. Croix region.

Sixty-eight species were tested for trends in at least one study area, including 55 in the Chequamegon NF, 52 in the Chippewa NF, 44 in the Superior NF, and 41 in the St. Croix region (Table 1). Additionally, 36 species were tested for a "regional" (three national forests combined) trend. 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

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. It should also be noted that our trends should be viewed as summaries of change within the specific time frame of our monitoring (Sauer et al. 2003).

A total of 192 species/study area trends were calculated (not including regional trends), 98 (51%) of which were significant ($P < 0.05$). Twenty-five species increased in at least one study area, including three that increased in two study areas, three that increased in three study areas, and two (Red-eyed Vireo and American Redstart) that increased in all four study areas (Tables 2 and 3). Thirty-one species decreased in at least one study area, including eight that decreased in two study areas, two that decreased in three study areas, and five (Eastern Wood-Pewee, Winter Wren, Ovenbird, Common Yellowthroat, and White-throated Sparrow) that decreased in all four study areas. Six species had both increasing and decreasing trends in different study areas. Six species had highly significant ($P \leq 0.01$) increasing trends in multiple study areas, and nine species had highly significant decreasing trends in multiple study areas (Table 4).

Of the 185 species/study area trends calculated in 2002 (Lind et al. 2002), 42 (23%) changed in 2003 (Table 5). There were 12 instances of a species not increasing in 2002, but increasing in 2003 ("new" increases), and ten instances of a species showing a significant increase in a particular study area in 2002 results, but no increase noted in 2003 ("lost" increases). Conversely, there were 19 instances of a species not decreasing in 2001, but decreasing in 2002, and only one instance of a decreasing species from 2002 no longer showing a significant decrease.

Chequamegon National Forest

Of the 55 species tested for trends in the Chequamegon NF, seven species (13%) increased significantly and 14 (25%) have decreased (Figure 4). The Yellow Warbler and American Redstart have the greatest rates of annual increase (>10%/year). The Red-eyed Vireo is the most ubiquitous species on our surveys in the Chequamegon (Appendix B), and while it actually has one of the lower rates of increase, it is substantial given the species' distribution and abundance on the forest. Two species are showing new

increasing trends this year (including the Yellow Warbler), and five formerly increasing species now have non-significant trends (Table 5). Five of these seven species have sample sizes of less than 20 stands (Appendix B).

The Eastern Wood-Pewee, Winter Wren, Veery, Hermit Thrush, and Black-and-white Warbler are well-represented on the Chequamegon NF, but have some of the greatest rates of annual decrease (6-12%/year; Appendix B). The Red-winged Blackbird and Evening Grosbeak have the two highest 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 2002). Three species have new declines in 2003, and all species that were declining in 2002 are still showing significant declines (Table 5).

A Northern Mockingbird was seen on June 7 on a point count in the Moqua Barrens in Bayfield County. This is the first time this species has been detected on any of our surveys. This sighting coincides with several other sightings from around the region during late May and early June (P. Svingen, *pers. comm.*).

Chippewa National Forest

Of the 52 species tested in the Chippewa NF, 12 species (23%) increased significantly and 18 (35%) decreased (Figure 4). The annual rate of increase of the Cedar Waxwing (16%) is nearly twice as much as the next highest species (Appendix B). However, its population trajectory (Appendix A) shows an increase in relative abundance since the mid-1990's with an increase in the variance about the mean. This is probably a result of this species' flocking behavior. The White-breasted Nuthatch, Gray Catbird, Palm Warbler, and Indigo Bunting are the next four species with the greatest rates of annual increase. Each of these has relatively high variance throughout the time period, or in the case of the White-breasted Nuthatch and Gray Catbird, increases from the early to mid-1990's and declines since then. The Black-capped Chickadee, Chestnut-sided Warbler, and American Redstart are well-represented species on the forest, with relatively low variances and 4-6% annual increases. The Red-eyed Vireo has one of the lowest rates of increase among the significantly increasing species, but due to its distribution, the increase is probably occurring over a large portion of the forest.

Two species are showing new increasing trends this year, including the Red-eyed Vireo which is now increasing in all four study areas. Two formerly increasing species are now showing non-significant trends (Table 5).

The highest rate of annual decrease in the Chippewa NF is that of the Connecticut Warbler (15%/year). Although it is sampled on only 13 stands, its consistent decline throughout the time period is alarming. More well-represented species that are showing annual rates of decline of 5% or more include the Yellow-bellied Sapsucker, Eastern Wood-Pewee, Winter Wren, Hermit Thrush, and White-throated Sparrow. The Veery and Nashville Warbler are showing declines of 2-3%/year, but their trends may be especially important given their widespread distribution on the Chippewa NF. Three species have new decreasing trends in 2003, and three formerly decreasing species are no longer showing a significant decline (Table 5).

Eight species are moving toward their historic population levels (RNV). Five species are below their RNV but have increasing trends (including Black-capped Chickadee and Cedar Waxwing), and three species are above their RNV, but declining (Scarlet Tanager, Song Sparrow, and Brown-headed Cowbird; Table 7). Conversely, 11 species are moving away from their historic population levels. Two species are above their RNV and have increasing trends (Gray Catbird and Indigo Bunting), and nine species are below their RNV and decreasing (especially Winter Wren, Hermit Thrush, Nashville Warbler, Blackburnian Warbler, and White-throated Sparrow). Of the 11 species within their RNV, five are increasing and four are decreasing.

Superior National Forest

Of the 44 species tested in the Superior NF, nine species (20%) are increasing and 14 (32%) are decreasing (Figure 4). The Black-capped Chickadee has the highest rate of annual increase (12%) of any species in the Superior NF, with most of its increase occurring since 1997. The Cedar Waxwing, Black-throated Blue Warbler, Swamp Sparrow, and Pine Warbler have the next highest rates of increase (6-11% annually) on the six to seven stands they are tested on. The Northern Parula, Magnolia Warbler, and American Redstart are widespread species showing annual rates of increase of 3-5%. Four species have new increasing trends in 2003, and three formerly increasing species are now showing stable trends (Table 5).

The Tennessee Warbler has the highest rate of decrease (17%) on the Superior NF, however, it was just abundant enough to be tested for trends during its peak in the mid-1990's, and has had only 11 detections since 1999. The Eastern Wood-Pewee, Winter Wren, Rose-breasted Grosbeak, and White-throated Sparrow are declining at 6-12% annually, and unlike the Tennessee Warbler, they are widely distributed on the forest. The decline of the Veery is not as steep (4% annually), but it has shown a marked decrease since 1999 in all four study areas (Appendix A). Five species have new significant declines in 2003, and all species that were declining in the Superior NF in 2002 are still declining (Table 5.)

Eight species are below their RNV on the Superior NF but have increasing trends (including Black-capped Chickadee and American Redstart), and no species are above their RNV (Table 7). Eight species are below their RNV and decreasing (including Northern Waterthrush and Winter Wren). Of the 14 species within their RNV, two are increasing and five are decreasing.

St. Croix Region

Of the 41 species tested for trends in the St. Croix region, 12 species (29%) increased and 12 (29%) decreased (Figure 4). The Red-breasted Nuthatch, Cedar Waxwing, Canada Warbler, Blackburnian Warbler, and Brown Creeper have the highest rates of annual increase, ranging from 9-11% (Appendix B). The Cedar Waxwing and Blackburnian Warbler are both also increasing in two of the national forests (Table 1).

The Least Flycatcher, Red-eyed Vireo and Scarlet Tanager have annual rates of increase of 6-7% and are widely distributed on our sites. The Red-eyed Vireo is the most widely distributed species on our St. Croix sites, and as was the case in the Chequamegon and Chippewa national forests, it has a relatively low rate of annual change (3%) that is

nonetheless impacting a vast area. Three species have new significant increases in the St. Croix region this year, and one formerly increasing species (Wood Thrush) now has a non-significant trend (Table 5).

The Winter Wren has had the greatest rate of decrease (9% annually) in the St. Croix region, especially since the late-1990's (Appendix A). This decline is reflected in the three national forests. Of the remaining 11 declining species in the St. Croix region, nine are declining in at least one of the national forests (Table 3). Five of this year's decreasing trends are new, and all species that were declining in 2002 are still declining (Table 5.)

Regional

Of the 36 species tested for a regional trend (three national forests combined), seven species (19%) increased significantly and 14 (39%) decreased (Figure 4). The American Redstart and Black-capped Chickadee had the highest rates of annual increase (5% and 4%, respectively). The Chestnut-sided Warbler and Red-eyed Vireo have had lower rates of increase (2% annually), but both are well represented in each of the national forests. All four of these species have had consistently increasing trends since the early to mid-1990's (Appendix A). The Black-capped Chickadee and Chestnut-sided Warbler increases are both new this year, and the Alder Flycatcher is no longer showing a significant increase (Table 5).

The Winter Wren had the highest annual rate of decrease (9%), which along with the Eastern Wood-Pewee, Hermit Thrush, Song Sparrow and Common Yellowthroat, has had a consistent downward trajectory since the early 1990's (Appendix A). The White-throated Sparrow and Ovenbird have declined 7% and 4%, respectively, but their trajectories have remained essentially level since 1997. The Veery was relatively stable until 2000 when it began a steep decline. Three species have new declines and species that were declining regionally in 2002 are still declining (Table 5).

Management Activities on Study Areas

Of the 1445 survey sites in all four study areas, 13.4% 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.

Guild Analyses

Short-distance migrants (species that winter mainly north of Mexico) showed highly significant declines ($P \leq 0.01$) in all four study areas and in the regional analysis (Table 6). 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) showed mixed results across our study areas, including declines in the Chequamegon and Superior NF's, an increase in the St. Croix study area, and a stable trend in the Chippewa NF.

Abundant long-distance migrants included Ovenbird, Red-eyed Vireo, Nashville Warbler, and Chestnut-sided Warbler. Permanent residents increased on all study areas except the Chequamegon NF, where they were stable. 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 and sub-canopy nesters increased in all study areas (Table 6). 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, Least Flycatcher, and American Redstart. Canopy and cavity nesters showed stable trends, for the most part.

Of the five vegetation-type preference guilds tested, lowland coniferous forest birds, deciduous, and mixed forest bird species showed widespread declines on our study areas, and upland coniferous species increased on all study areas except the Chequamegon NF. The early-successional guild showed an increase in the Chippewa NF and declines in the Superior NF and the regional analysis.

Conclusions

Short-distance migrants are showing obvious widespread declines on our study areas, but the declines seen in long-distance migrants are less dramatic. It is not known if factors on the wintering grounds in the southern U.S. are affecting our trends, or if the declines are related to some other life-history trait (e.g. nesting strategy). Recent declines in short-distance migrants have been documented from the Midwest, predominantly in grassland species rather than forest species (Sauer et al. 2003, Herkert 1996).

The declines in ground nesters and increases in shrub nesters in our study seem to be occurring 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 our four northern study areas is primarily forested, it has become increasingly fragmented in recent years. Wolter and White (2002) used satellite data from northeastern Minnesota between 1990 and 1995 and demonstrated a substantial decrease in patch size and interior forest area and a significant increase in edge density in early successional forest types. Studies have shown that nesting success is reduced in fragmented landscapes, probably due to an increase in generalist nest predators (Robinson et al. 1995, 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.

Although increasing trends were outnumbered by declining trends, there are still many species showing widespread and substantial increases. The Least Flycatcher, Red-eyed Vireo, Black-capped Chickadee, American Redstart, and Chestnut-sided Warbler have increased in multiple study areas since the early 1990's and may be benefiting from current and past management practices, including the creation of early- to mid-successional

deciduous forest types. Indeed, many of these increasing species are currently at or above their estimated RNV values. However, several increasing species have relatively high conservation values in our region (e.g. Least Flycatcher, Chestnut-sided Warbler), according to the Partners in Flight (PIF) prioritization scheme (Carter et al. 2000). It is also encouraging to see that many species with declines in past years are no longer showing significant declines (e.g. Golden-winged Warbler, Canada Warbler).

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 species of conservation concern, and species such as the Eastern Wood-Pewee, Winter Wren, Hermit Thrush, Mourning Warbler, Ovenbird, and White-throated Sparrow probably need special management consideration by agencies such as the U.S. Forest Service and state Department of Natural Resources. Although most of these are common species, several are currently well below their estimated RNV values 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 fragmentation 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 across different habitats and migration strategies suggests that a prudent course of action may be to attempt to reduce the amount of habitat fragmentation on the northern Minnesota 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 an excellent opportunity to provide “source” populations for many species.

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Table 1. Trends for four study areas and regional analysis (three national forests combined) based on linear regression. 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	Chequam. NF	Chippewa NF	Superior NF	St. Croix, Minn.	Regional
Yellow-bellied Sapsucker	ns	D**	ns	ns	D**
Downy Woodpecker		ns			
Hairy Woodpecker	ns	D*			
Olive-sided Flycatcher		ns			
Eastern Wood-Pewee	D**	D**	D**	D**	D**
Yellow-bellied Flycatcher	ns	ns	ns	ns	I*
Alder Flycatcher	I*	ns	ns	ns	ns
Least Flycatcher	ns	I**	ns	I**	I*
Great Crested Flycatcher	ns	D*		D*	
Eastern Kingbird	I*				
Yellow-throated Vireo	ns	ns		ns	
Blue-headed Vireo	ns	I*	ns		ns
Red-eyed Vireo	I**	I**	I**	I**	I**
Gray Jay		ns	ns		
Blue Jay	ns	ns	ns	ns	ns
Black-capped Chickadee	ns	I**	I**	I*	I**
Red-breasted Nuthatch	ns	ns	ns	I**	ns
White-breasted Nuthatch	ns	I**		I*	
Brown Creeper	D*	D*	ns	I**	D**
House Wren	ns				
Winter Wren	D**	D**	D**	D**	D**
Golden-crowned Kinglet	D*	ns	ns	ns	ns
Ruby-crowned Kinglet			D*		
Veery	D**	D*	D**	ns	D**
Swainson's Thrush			ns		
Hermit Thrush	D**	D**	ns	ns	D**
Wood Thrush	ns			ns	
American Robin	ns	ns	ns	D*	ns
Gray Catbird		I**		ns	
Brown Thrasher	ns				
Cedar Waxwing		I**	I**	I*	
Golden-winged Warbler	ns	ns	ns	ns	ns
Tennessee Warbler			D**		
Nashville Warbler	D*	D**	ns	D**	D**
Northern Parula	ns	ns	I**		I*
Yellow Warbler	I**	D**			
Chestnut-sided Warbler	ns	I**	ns	I*	I**

Table 1 (continued)

Species	Chequam. NF	Chippewa NF	Superior NF	St. Croix, Minn.	Regional
Magnolia Warbler		ns	I**		
Black-throated Blue Warbler			I*		
Yellow-rumped Warbler	ns	ns	ns	ns	ns
Black-throated Green Warbler	ns	ns	D**	ns	ns
Blackburnian Warbler	I**	D*	I*	I**	ns
Pine Warbler	ns	ns	I*		ns
Palm Warbler		I*			
Black-and-white Warbler	D**	I**	ns	D**	ns
American Redstart	I**	I**	I**	I**	I**
Ovenbird	D**	D**	D**	D**	D**
Northern Waterthrush	I**		D**		
Connecticut Warbler		D**			
Mourning Warbler	ns	ns	D*	D**	D**
Common Yellowthroat	D**	D*	D*	D**	D**
Canada Warbler	ns	ns	ns	I*	ns
Scarlet Tanager	ns	D*	D*	I**	D**
Eastern Towhee	ns				
Chipping Sparrow	ns	ns	D*	ns	ns
Clay-colored Sparrow	ns				
Vesper Sparrow	ns				
Song Sparrow	D*	D*	ns	ns	D*
Swamp Sparrow	ns	ns	ns	D*	ns
White-throated Sparrow	D*	D**	D**	D*	D**
Rose-breasted Grosbeak	ns	ns	D**	ns	D**
Indigo Bunting	ns	I*		ns	
Red-winged Blackbird	D**				
Brewer's Blackbird	ns				
Brown-headed Cowbird	ns	D*		D**	
Purple Finch		ns			
American Goldfinch	ns				
Evening Grosbeak	D**				

Table 2. Species trends ($P \leq 0.05$) by study area, 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	St Croix, MN	Regional
Alder Flycatcher	** Least Flycatcher	** Red-eyed Vireo	** Least Flycatcher	Yellow-bellied Flycatcher
Eastern Kingbird	Blue-headed Vireo	** Black-capped Chickadee	** Red-eyed Vireo	Least Flycatcher
** Red-eyed Vireo	** Red-eyed Vireo	** Cedar Waxwing	Black-capped Chickadee	** Red-eyed Vireo
** Yellow Warbler	** Black-capped Chickadee	** Northern Parula	** Red-breasted Nuthatch	** Black-capped Chickadee
** Blackburnian Warbler	** White-breasted Nuthatch	** Magnolia Warbler	White-breasted Nuthatch	Northern Parula
** American Redstart	** Gray Catbird	Black-throated Blue Warbler	** Brown Creeper	** Chestnut-sided Warbler
** Northern Waterthrush	** Cedar Waxwing	Blackburnian Warbler	Cedar Waxwing	** American Redstart
	** Chestnut-sided Warbler	Pine Warbler	Chestnut-sided Warbler	
	Palm Warbler	** American Redstart	** Blackburnian Warbler	
	** Black-and-white Warbler		** American Redstart	
	** American Redstart		Canada Warbler	
	Indigo Bunting		** Scarlet Tanager	

Decreasing Species

Chequamegon NF	Chippewa NF	Superior NF	St Croix, MN	Regional
** Eastern Wood-Pewee	** Yellow-bellied Sapsucker	** Eastern Wood-Pewee	** Eastern Wood-Pewee	** Yellow-bellied Sapsucker
Brown Creeper	Hairy Woodpecker	** Winter Wren	Great Crested Flycatcher	** Eastern Wood-Pewee
** Winter Wren	** Eastern Wood-Pewee	Ruby-crowned Kinglet	** Winter Wren	** Brown Creeper
Golden-crowned Kinglet	Great Crested Flycatcher	** Veery	American Robin	** Winter Wren
** Veery	Brown Creeper	** Tennessee Warbler	** Nashville Warbler	** Veery
** Hermit Thrush	** Winter Wren	** Black-throated Green Warbler	** Black-and-white Warbler	** Hermit Thrush
Nashville Warbler	Veery	** Ovenbird	** Ovenbird	** Nashville Warbler
** Black-and-white Warbler	** Hermit Thrush	** Northern Waterthrush	** Mourning Warbler	** Ovenbird
** Ovenbird	** Nashville Warbler	Mourning Warbler	** Common Yellowthroat	** Mourning Warbler
** Common Yellowthroat	** Yellow Warbler	Common Yellowthroat	Swamp Sparrow	** Common Yellowthroat
Song Sparrow	Blackburnian Warbler	Scarlet Tanager	White-throated Sparrow	** Scarlet Tanager
White-throated Sparrow	** Ovenbird	Chipping Sparrow	** Brown-headed Cowbird	Song Sparrow
** Red-winged Blackbird	** Connecticut Warbler	** White-throated Sparrow		** White-throated Sparrow
** Evening Grosbeak	Common Yellowthroat	** Rose-breasted Grosbeak		** Rose-breasted Grosbeak
	Scarlet Tanager			
	Song Sparrow			
	** White-throated Sparrow			
	Brown-headed Cowbird			

Table 3. Summary of species with increasing or decreasing trends ($P \leq 0.05$). Individual species graphs can be found in Appendix A.

Increased in one study area	**Increased in two study areas**	**Increased in three or more study areas**
Alder Flycatcher	Least Flycatcher	Black-capped Chickadee (3)
Eastern Kingbird	White-breasted Nuthatch	Cedar Waxwing (3)
Blue-headed Vireo	Chestnut-sided Warbler	Blackburnian Warbler (3)
Red-breasted Nuthatch		Red-eyed Vireo (4)
Brown Creeper		American Redstart (4)
Gray Catbird		
Northern Parula		
Yellow Warbler		
Magnolia Warbler		
Black-throated Blue Warbler		
Pine Warbler		
Palm Warbler		
Black-and-white Warbler		
Northern Waterthrush		
Canada Warbler		
Scarlet Tanager		
Indigo Bunting		
Decreased in one study area	**Decreased in two study areas**	**Decreased in three or more study areas**
Yellow-bellied Sapsucker	Great Crested Flycatcher	Veery (3)
Hairy Woodpecker	Brown Creeper	Nashville Warbler (3)
Golden-crowned Kinglet	Hermit Thrush	Eastern Wood-Pewee (4)
Ruby-crowned Kinglet	Black-and-white Warbler	Winter Wren (4)
American Robin	Mourning Warbler	Ovenbird (4)
Tennessee Warbler	Scarlet Tanager	Common Yellowthroat (4)
Yellow Warbler	Song Sparrow	White-throated Sparrow (4)
Black-throated Green Warbler	Brown-headed Cowbird	
Blackburnian Warbler		
Northern Waterthrush		
Connecticut Warbler		
Chipping Sparrow		
Swamp Sparrow		
Rose-breasted Grosbeak		
Red-winged Blackbird		
Evening Grosbeak		

Table 4. Species with highly significant trends ($P \leq 0.01$) in multiple study areas.

Increasing			**Decreasing**	
Species	# of study areas		Species	# of study areas
Least Flycatcher	2		Eastern Wood-Pewee	4
Red-eyed Vireo	4		Winter Wren	4
Black-capped Chickadee	2		Veery	2
Cedar Waxwing	2		Hermit Thrush	2
Blackburnian Warbler	2		Nashville Warbler	2
American Redstart	4		Black-and-white Warbler	2
			Ovenbird	4
			Common Yellowthroat	2
			White-throated Sparrow	2

Table 5. Summary of changes in trends between 2002 and 2003 analyses.

Species with new significant trends (P ≤ 0.05) in 2003

Increasing		*Decreasing*	
Species	Study area	Species	Study area
Alder Flycatcher	Cheq. NF	Yellow-bellied Sapsucker	Reg.
Red-eyed Vireo	Chip. NF	Hairy Woodpecker	Chip. NF
Black-capped Chickadee	St.Cr., Reg.	Brown Creeper	Cheq. NF, Chip. NF
Red-breasted Nuthatch	St.Cr.	Winter Wren	St.Cr.
White-breasted Nuthatch	Chip. NF	Golden-crowned Kinglet	Cheq. NF
Cedar Waxwing	Sup. NF	Veery	Chip. NF
Yellow Warbler	Cheq. NF	American Robin	St.Cr.
Chestnut-sided Warbler	Reg.	Tennessee Warbler	Sup. NF
Black-throated Blue Warbler	Sup. NF	Nashville Warbler	Chip. NF, St.Cr., Reg.
Blackburnian Warbler	Sup. NF, St.Cr.	Blackburnian Warbler	Chip. NF
Palm Warbler	Chip. NF	Ovenbird	Sup. NF, St.Cr.
American Redstart	Sup. NF	Northern Waterthrush	Sup. NF
		Mourning Warbler	Sup. NF, Reg.
		Scarlet Tanager	Sup. NF
		Swamp Sparrow	St.Cr.
		White-throated Sparrow	Cheq. NF, St.Cr.
		Rose-breasted Grosbeak	Reg.

Species with new non-significant trends (P > 0.05) in 2003

Was increasing in 2002		*Was decreasing in 2002*	
Species	Study area	Species	Study area
Yellow-bellied Flycatcher	Cheq NF, Sup. NF	Mourning Warbler	Chip. NF
Alder Flycatcher	Reg.		
Red-breasted Nuthatch	Chip. NF		
Swainson's Thrush	Sup. NF		
Wood Thrush	Cheq. NF, St.Cr.		
Chestnut-sided Warbler	Cheq. NF		
Eastern Towhee	Cheq. NF		
Vesper Sparrow	Cheq. NF		
Swamp Sparrow	Sup. NF		

Table 6. Test statistics and sample sizes for guild analyses. Change = percent annual change. N = number of stands analyzed. See Appendix A for trend graphs.

		Chequamegon NF				Chippewa NF				Superior NF				St. Croix, MN				Regional			
		change	*P*	R^2	N	change	*P*	R^2	N	change	*P*	R^2	N	change	*P*	R^2	N	change	*P*	R^2	N
Mig-ration	Short-distance	**-0.025**	**0.000**	**0.883**	**129**	**-0.028**	**0.000**	**0.869**	**126**	**-0.031**	**0.000**	**0.905**	**147**	**-0.027**	**0.004**	**0.947**	**159**	**-0.028**	**0.000**	**0.942**	**402**
Mig-ration	Long-distance	**-0.008**	**0.004**	**0.734**	**129**	-0.003	0.064	0.053	126	**-0.009**	**0.000**	**0.518**	**147**	**0.004**	**0.028**	**0.136**	**161**	**-0.009**	**0.000**	**0.394**	**402**
Mig-ration	Permanent Resident	-0.011	0.180	0.517	126	**0.017**	**0.016**	**0.368**	**125**	**0.025**	**0.004**	**0.890**	**147**	**0.028**	**0.000**	**0.578**	**156**	**0.013**	**0.004**	**0.554**	**398**
Nest	Ground	**-0.036**	**0.000**	**0.986**	**129**	**-0.043**	**0.000**	**0.944**	**126**	**-0.029**	**0.000**	**0.869**	**147**	**-0.024**	**0.000**	**0.865**	**161**	**-0.037**	**0.000**	**0.919**	**402**
Nest	Shrub/Sub-canopy	**0.016**	**0.004**	**0.740**	**129**	**0.032**	**0.000**	**0.780**	**126**	**0.007**	**0.024**	**0.335**	**147**	**0.027**	**0.000**	**0.885**	**161**	**0.017**	**0.000**	**0.649**	**402**
Nest	Canopy	-0.008	0.076	0.562	129	-0.007	0.052	0.207	126	-0.004	0.196	0.341	147	**0.016**	**0.012**	**0.611**	**158**	**-0.006**	**0.016**	**0.758**	**402**
Nest	Cavity	-0.007	0.164	0.578	128	-0.003	0.352	0.033	126	**0.029**	**0.000**	**0.825**	**147**	0.012	0.092	0.309	157	0.007	0.056	0.416	401
Veg. Prefer.	Coniferous forest	-0.003	0.348	0.015	121	**0.013**	**0.016**	**0.542**	**122**	**0.017**	**0.000**	**0.720**	**147**	**0.040**	**0.000**	**0.860**	**116**	**0.009**	**0.004**	**0.480**	**390**
Veg. Prefer.	Lowland coniferous	**-0.030**	**0.000**	**0.974**	**120**	**-0.034**	**0.000**	**0.853**	**118**	**-0.010**	**0.008**	**0.758**	**147**	**-0.038**	**0.000**	**0.731**	**121**	**-0.024**	**0.000**	**0.939**	**385**
Veg. Prefer.	Deciduous forest	**-0.010**	**0.004**	**0.707**	**129**	**-0.012**	**0.000**	**0.238**	**126**	**-0.008**	**0.012**	**0.309**	**147**	**0.013**	**0.000**	**0.594**	**160**	**-0.010**	**0.000**	**0.425**	**402**
Veg. Prefer.	Mixed forest	**-0.038**	**0.000**	**0.991**	**126**	**-0.018**	**0.000**	**0.684**	**126**	**-0.027**	**0.000**	**0.915**	**147**	**-0.019**	**0.020**	**0.703**	**159**	**-0.025**	**0.000**	**0.910**	**399**
Veg Prefer.	Early-succession	0.008	0.336	0.414	123	**0.019**	**0.020**	**0.530**	**123**	**-0.025**	**0.000**	**0.497**	**147**	0.009	0.148	0.229	157	**-0.012**	**0.020**	**0.124**	**393**

Table 7. Comparison of species trends and % of the range of natural variability (RNV) for current populations on the Chippewa and Superior National Forests (from Hanowski and Danz 2003). 100% of RNV indicates that a species was considered to be within its historic range of natural variability.

Species	Chippewa NF trend	% of RNV	Superior NF trend	% of RNV
Yellow-bellied Sapsucker	D**	100%	ns	100%
Downy Woodpecker	ns	122%		
Hairy Woodpecker	D*	71%		
Olive-sided Flycatcher	ns	53%		
Eastern Wood-Pewee	D**	100%	D**	100%
Yellow-bellied Flycatcher	ns	60%	ns	100%
Least Flycatcher	I**	100%	ns	100%
Great Crested Flycatcher	D*	100%		
Yellow-throated Vireo	ns	110%		
Blue-headed Vireo	I*	39%	ns	66%
Red-eyed Vireo	I**	100%	I**	97%
Gray Jay	ns	69%	ns	69%
Blue Jay	ns	72%	ns	69%
Black-capped Chickadee	I**	95%	I**	70%
Red-breasted Nuthatch	ns	56%	ns	70%
White-breasted Nuthatch	I**	100%		
Brown Creeper	D*	91%	ns	77%
Winter Wren	D**	60%	D**	87%
Golden-crowned Kinglet	ns	80%	ns	82%
Ruby-crowned Kinglet			D*	100%
Veery	D*	100%	D**	100%
Swainson's Thrush			ns	100%
Hermit Thrush	D**	70%	ns	68%
American Robin	ns	62%	ns	99%
Gray Catbird	I**	244%		
Cedar Waxwing	I**	88%	I**	87%
Golden-winged Warbler	ns	112%	ns	
Tennessee Warbler			D**	100%
Nashville Warbler	D**	52%	ns	83%
Northern Parula	ns	44%	I**	65%
Chestnut-sided Warbler	I**	100%	ns	100%
Magnolia Warbler	ns	38%	I**	100%
Black-throated Blue Warbler			I*	100%
Yellow-rumped Warbler	ns	46%	ns	63%
Black-throated Green Warbler	ns	76%	D**	80%
Blackburnian Warbler	D*	70%	I*	88%

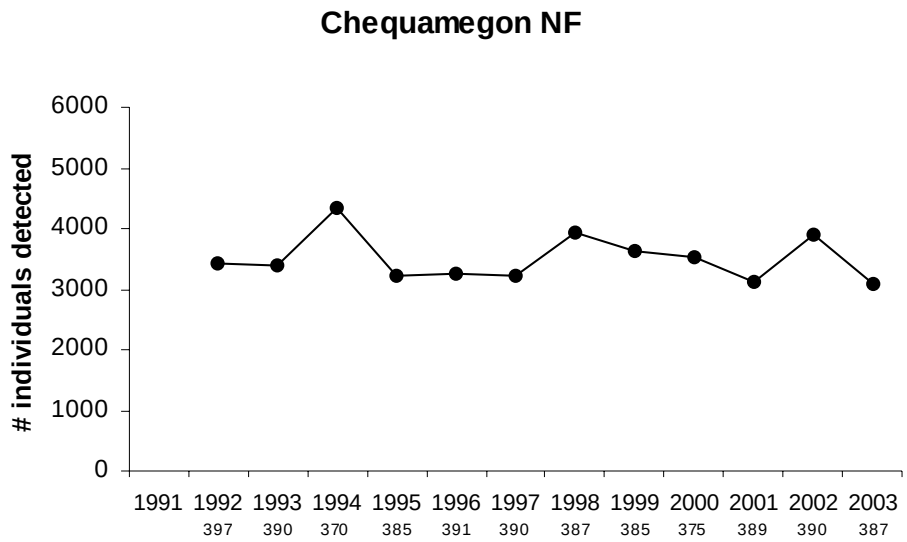
Table 7 (continued)

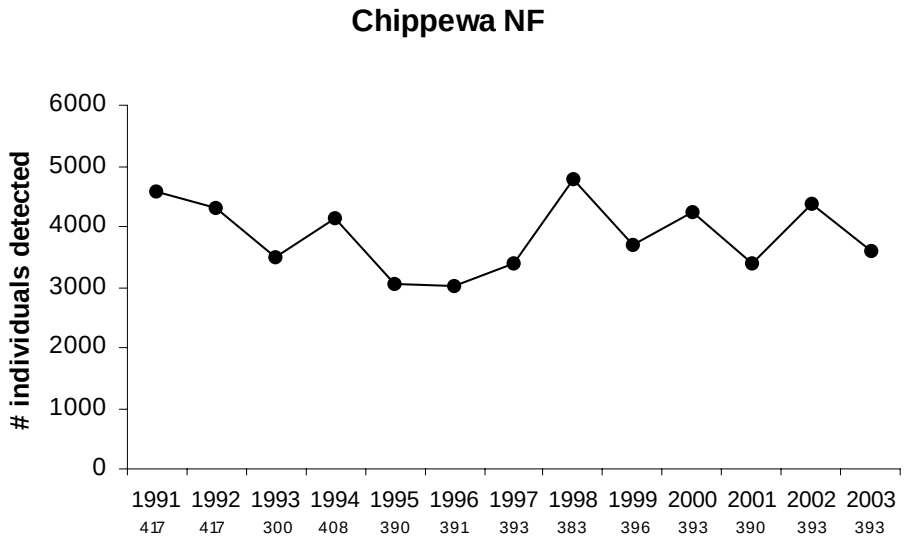
Species	Chippewa NF trend	% of RNV	Superior NF trend	% of RNV
Pine Warbler	ns	56%	I*	72%
Palm Warbler	I*	28%		
Black-and-white Warbler	I**	59%	ns	100%
American Redstart	I**	100%	I**	78%
Ovenbird	D**	88%	D**	99%
Northern Waterthrush			D**	51%
Connecticut Warbler	D**	97%		
Mourning Warbler	ns	100%	D*	100%
Canada Warbler	ns	47%	ns	100%
Scarlet Tanager	D*	105%	D*	58%
Chipping Sparrow	ns	88%	D*	82%
Song Sparrow	D*	110%	ns	86%
White-throated Sparrow	D**	42%	D**	89%
Rose-breasted Grosbeak	ns	100%	D**	97%
Indigo Bunting	I*	160%		
Brown-headed Cowbird	D*	120%		
Purple Finch	ns	62%		

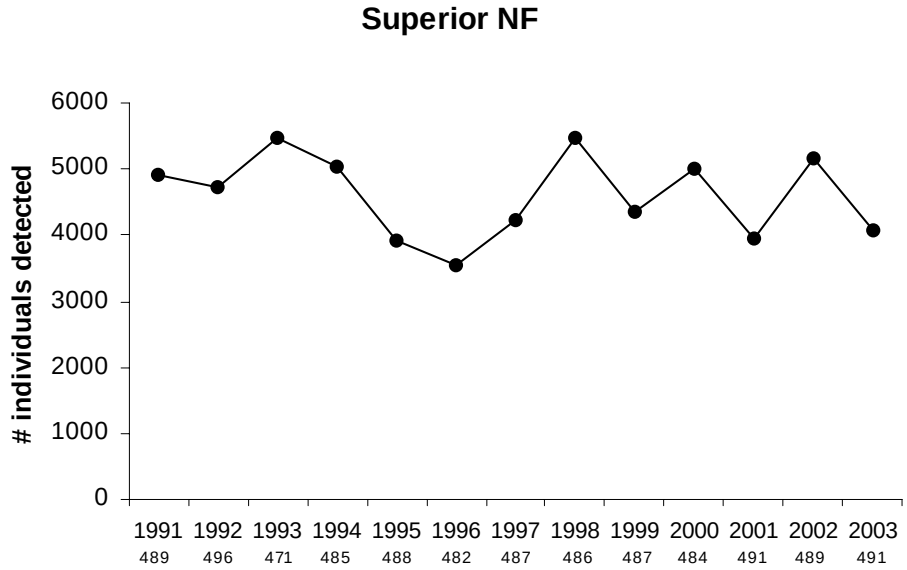
Table 8. Number of harvested points in each study area since the beginning of monitoring.

Study Area	Total # of sites	# clearcut	# partially or selectively cut*	% harvested
Chequamegon NF	390	13	31	11.2%
Chippewa NF	393	21	42	16.2%
Superior NF	491	42	28	14.3%
St. Croix, MN	171	4	12	9.4%

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







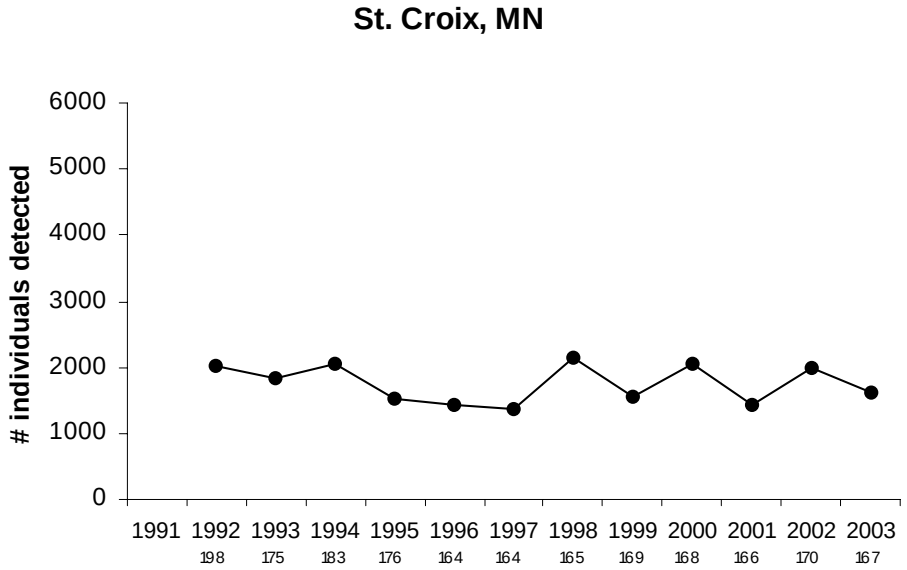
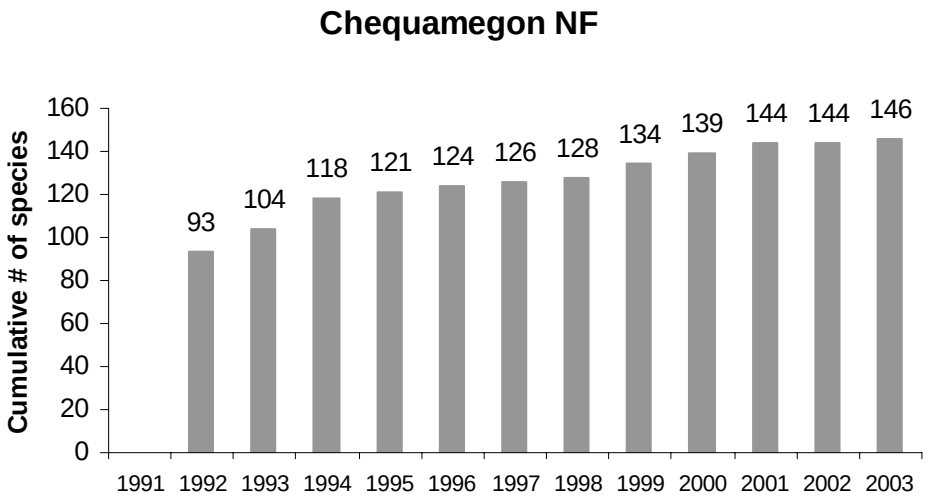
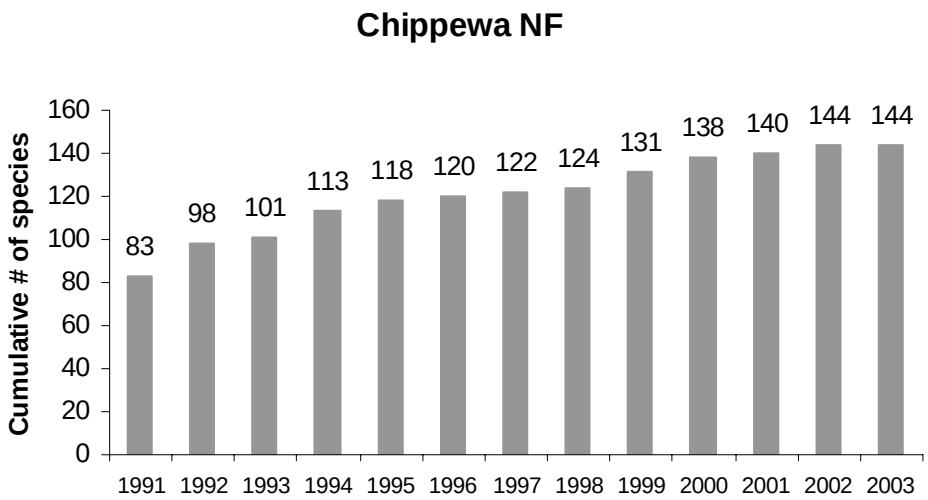
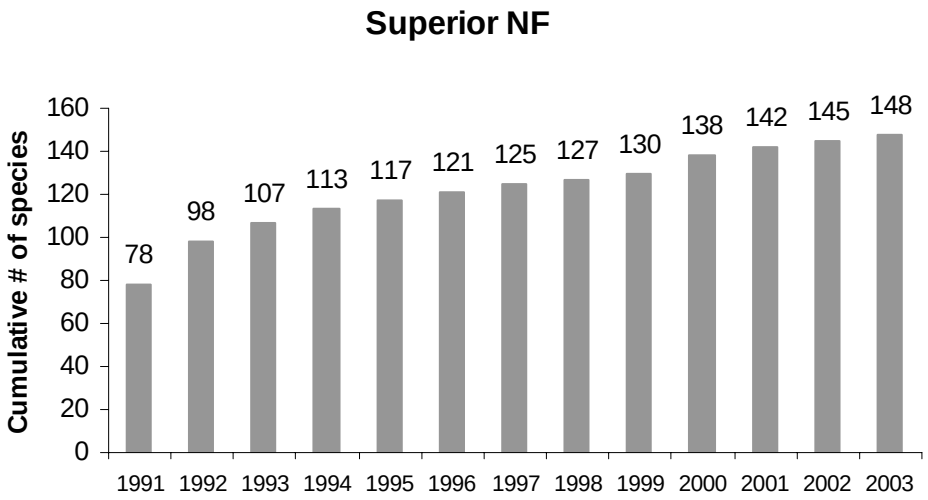


Figure 2. Total number of individuals detected annually in each study area, based on raw data before applying analysis criteria (e.g. includes flyovers, etc.). The number of sites sampled is presented below each year.







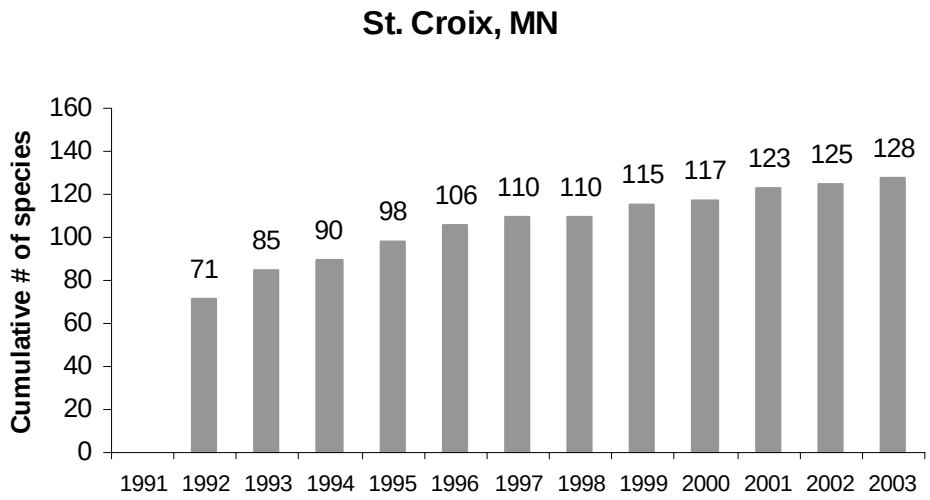


Figure 3. Accumulation of total species detected in each study area, based on raw data before applying analysis criteria (e.g. includes flyovers, etc.).

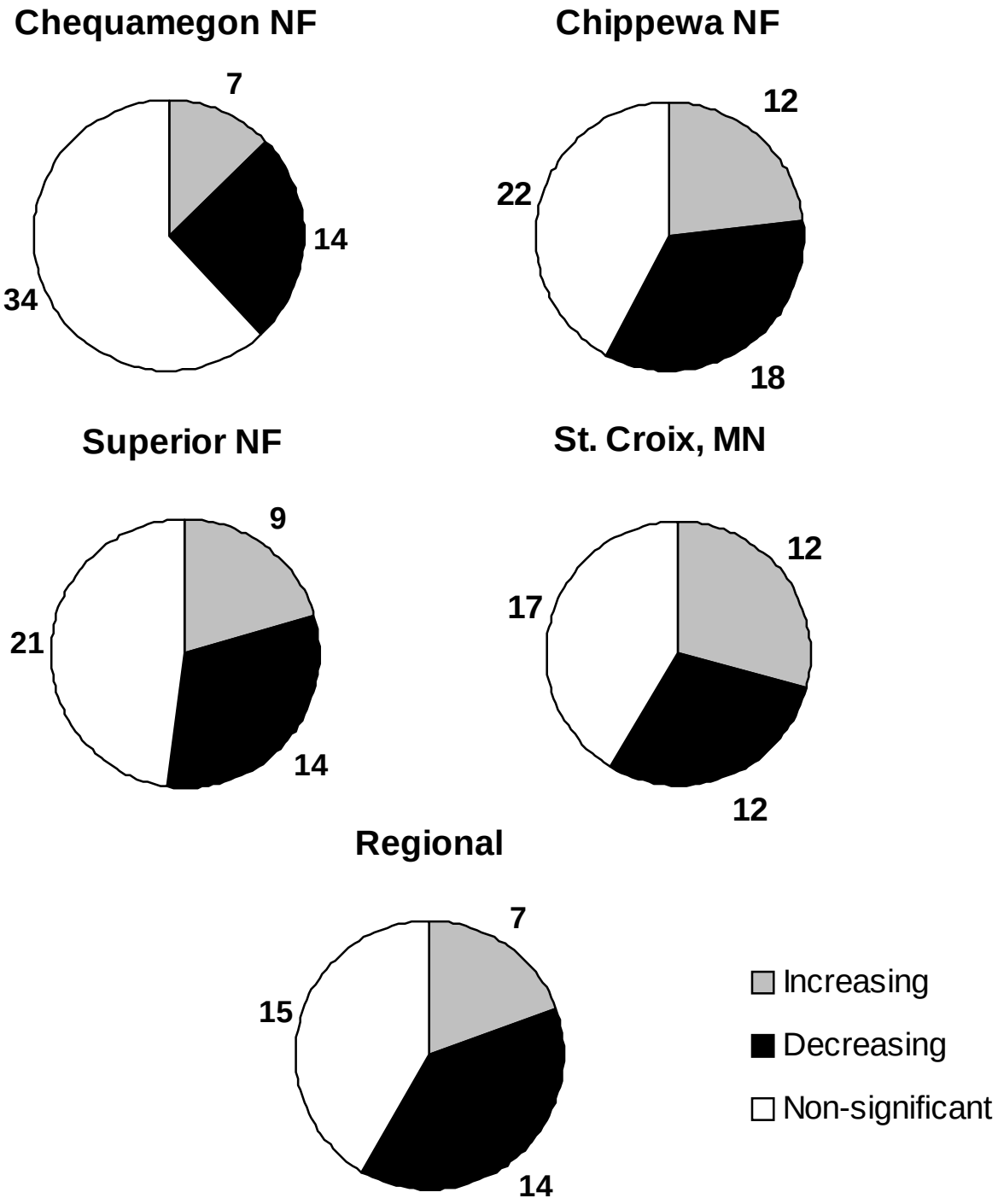


Figure 4. Summary of significant trends ($P \leq 0.05$) by study area. Regional trends include three national forests combined. See Table 1 for list of species trends by study area.

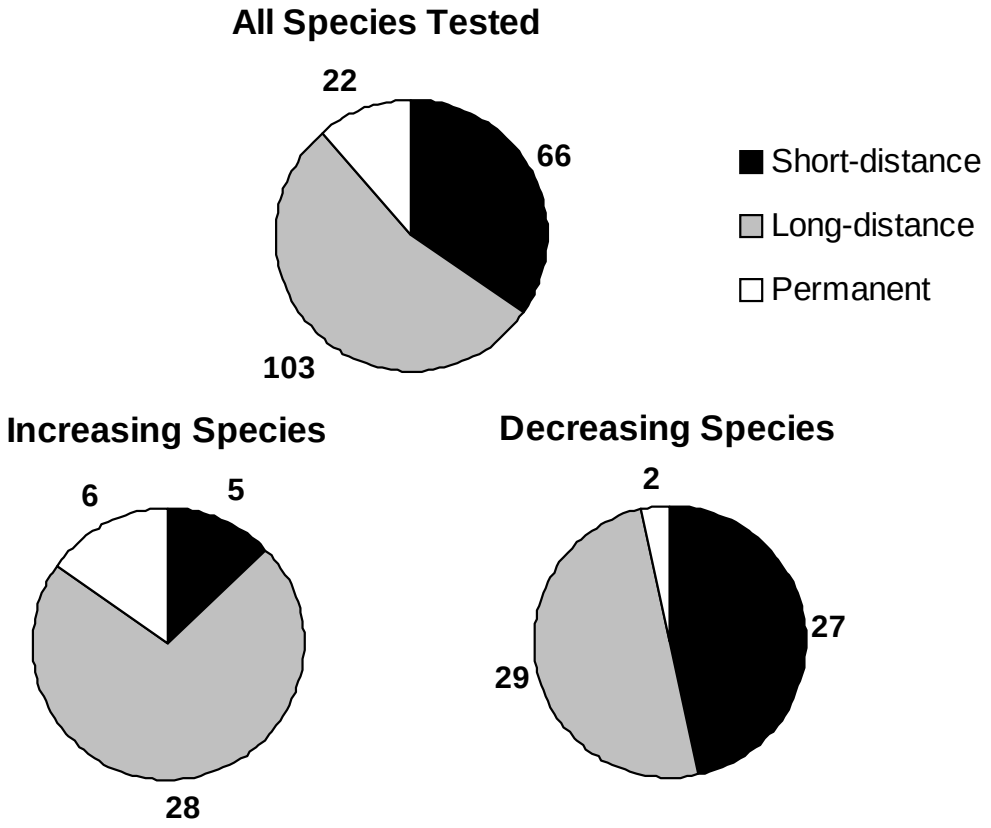


Figure 5. Distribution of species among migration guilds for all 192 species/study area trends (a), and increasing (b) or decreasing trends (c).

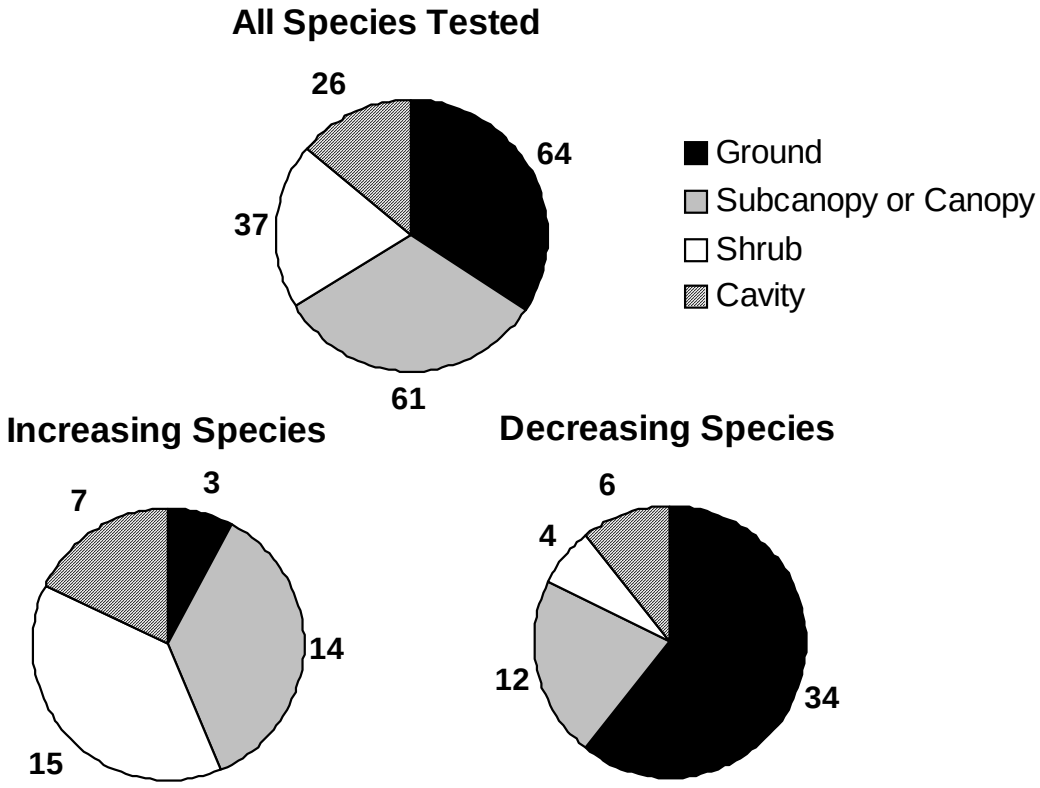


Figure 6. Distribution of species among nesting guilds for 189 species/study area trends (a), and increasing (b) or decreasing trends (c). Brown-headed Cowbird trends not included.

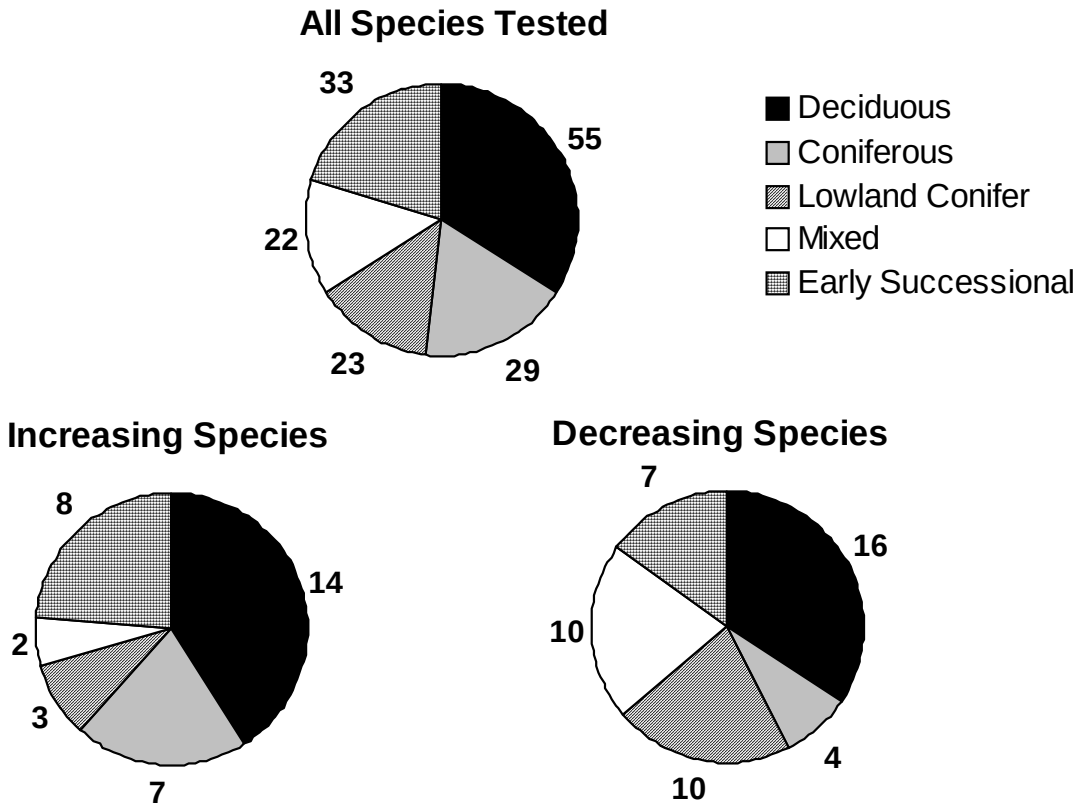


Figure 7. Distribution of species among vegetation-type guilds for 162 species/study area trends (a), and increasing (b) or decreasing trends (c).

Appendix A

Trends in relative abundance by study area for all species and guilds tested

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