A 15 and 20-Year Summary of Breeding Bird Trends in National Forests of Northern Minnesota and Wisconsin

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Introduction

The breeding bird communities of the western Great Lakes region have among the richest diversity of breeding bird species in North America (Robbins et al. 1987; Green 1995, Rich et al. 2004). The importance of this diversity and concerns with potential declines of some species has led to a strong interest in monitoring forest bird populations in the region. The relatively heavily forested landscapes of northern Minnesota and Wisconsin are considered to be population 'sources' for many forest bird species and may be supplementing population 'sinks' in the agricultural landscapes of the lower Midwest (Robinson et al. 1995, Temple and Flaspohler 1998). Analysis of population trends is used as an 'early-warning system' of potential problems in a species population and serves as a measure of the ecological condition of the environment (Niemi and McDonald 2004).

Large-scale population monitoring programs such as the U.S. Geological Survey's Breeding Bird Survey (BBS) provide important information on trends at a continental scale. However, limited coverage in some areas can make it difficult to use BBS data to characterize population trends at smaller geographic scales (Peterjohn et al. 1995). Continental trends also have the potential to mask regional population trends (Holmes and Sherry 1988), thus there is a need for regional monitoring programs that can provide more localized information (Howe et al. 1997). In response to the need for regional population data, a long-term forest breeding bird monitoring program was established in 1991 in the Chippewa and Superior NFs, and in 1992 in the Chequamegon NF. The Forest Service is mandated to monitor certain management indicator species (Manley 1993), and our monitoring program expands beyond indicator species to include all forest songbird species that we can adequately sample. Currently, approximately 420 stands (1,271 points) within the three national forests are surveyed during the breeding season (June 1 to July 10).

The primary objective of this report is to update U.S. Forest Service personnel on results of the forest bird monitoring program. Here we focus on relative abundance trends of individual species. Because we slightly changed our point count methodology in 1995 by including unlimited point counts, here we focus on a comparison of the results from three different distance radii x time categories: 1) 100 m radius distance for 1991-2009, 2) 100 m radius distance for 1995-2009, and 3) unlimited distance for 1995-2009. Our intent here is to summarize the most important results and to provide detailed information in appendix form for those who need more specific results.

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

Stands were large enough to accommodate three sampling points a minimum of 220 meters apart. Changes to forest cover through natural and anthropogenic disturbance have occurred on sampling locations since the beginning of the study and may have caused concomitant changes in bird populations.

Because sampling locations are permanently marked, we are able to incorporate such changes into our descriptions of bird population patterns through time.

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, Hanowski et al. 2005, Etterson et al. 2009). Point counts are appropriate for determining the relative abundance of most singing passerine species, but are likely 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 1995-2009, 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. However, recently we have also begun to gather data at one minute intervals, after the first two minutes of sampling in an attempt to gain a better understanding of bird detectability (Etterson et al. 2009).

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

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

Analysis

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

Relative abundance

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

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

Population trajectory

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

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

Population trend

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

would be equivalent to 99% of bootstrapped slopes being greater than zero, which would give us a high degree of confidence that the true population slope was different from zero.

Guild analyses

In this report we have limited the presentation of the guild analyses and have focused exclusively on the migration guild: permanent residents, short-distance migrants, and long-distance migrants. The results for this guild are interesting, plus the relationships for the other guilds are complicated by the various distance categories used in this report. A more thorough analysis of the remaining guilds will be completed following the 2010 data gathering. Guild categories were taken from Ehrlich et al. (1988) and Freemark and Collins (1992), with modifications based on personal experience and data from the region.

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

RESULTS AND DISCUSSION

Over the course of 18 field seasons we have detected over 320,000 individual birds of 173 species on more than 22,500 ten-minute point counts (over 3,700 hours of sampling) in the three national forests (Figure 1). In 2009, we sampled 131 stands in the Chequamegon NF, 126 stands in the Chippewa NF, and 168 in the Superior NF. A total 6,465 individuals were detected in the Chequamegon NF, 7,384 individuals in the Chippewa NF, and 8,866 individuals in the Superior NF.

This year we report results from the three different distance radii by time interval. A total of 61 species in the Chequamegon NF, 60 species in the Chippewa NF, 50 species in the Superior NF, and 42 species among all 3 "Regional" NFs were tested for trends in 100 m radius distance for the period of 1991 to 2009. A total of 58 species in the Chequamegon NF, 57 in the Chippewa NF, 46 in the Superior NF, and 40 species in the Regional NFs were tested for trends in the 100 m radius distance from 1995 to 2009. In contrast, 75 species in the Chequamegon NF, 63 in the Chippewa NF, 58 in the Superior NF, and 47 in the Regional NFs analysis using the unlimited distance and 1995-2009 period. The number of tested species has increased steadily from 36 in 2000, when our inclusion criteria were first applied, to a high of 75 this year. Appendix A includes trend graphs of individual species trajectories and Appendix B includes a complete summary of the trends summarized below. Appendix B includes the number of stands included, the annual slope of the trend, the significance of the trend, and the explained variation of the trend. The combination of the p-value and the explained variation indicate the strength of the trend for each species within each NF and for the Regional analysis.

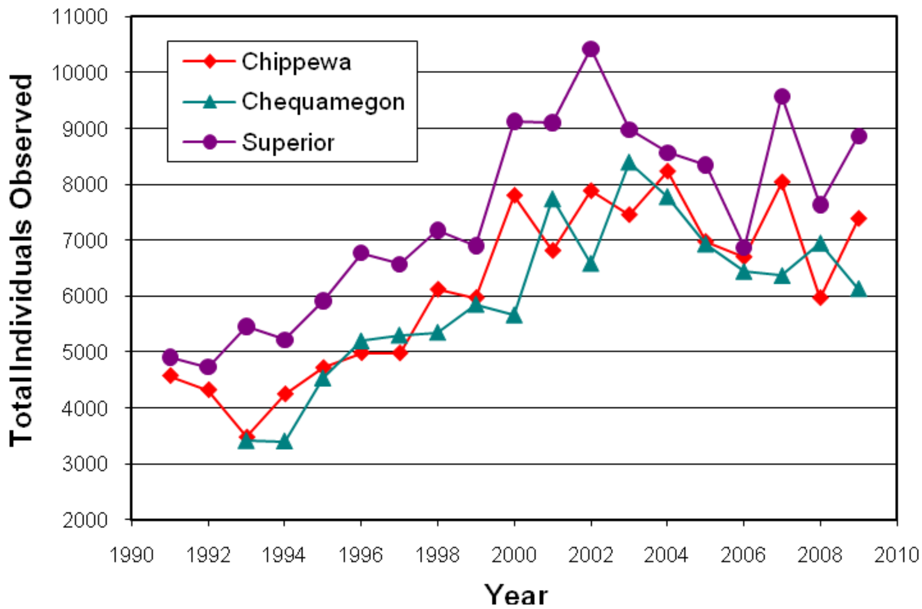

Figure 1. Total number of individuals detected annually (1991-2009) based on raw data before applying analysis criteria (e.g., includes flyovers). In 1995, the monitoring protocol changed from recording only individuals within 100 m to recording all individuals regardless of distance from observer.

Overview of Population Trends

In general, the analysis of population trends for the "traditional" analyses that we have been reporting in the past are similar to the current results through 2009 (Table 1). The number of species increasing and decreasing in the Chequamegon NF is 13 and 13 respectively. Similarly, the ratios for the Chippewa and Superior NFs are 20:11 and 13:8 species increasing to decreasing, respectively (Table 1). The ratio of increasing:decreasing species changes substantially when different time intervals / detection radii are used. For example, when data from the 1991 to 1994 period are excluded, the ratio of species increasing to decreasing in the Chequamegon NF at the 100 m radius distance was 16:10, while it was 17:3 and 18:3 in the Chippewa and Superior NF respectively (Table 1). The ratios change more dramatically when data are used from unlimited distance during the 1995 to 2009 time interval. In the Chequamegon, Chippewa, and Superior NFs the ratios of species increasing to decreasing with these data were 30:5, 28:2, and 29:3 respectively (Table 1). These same patterns are also evident when all three NFs are combined for the regional analysis.

The primary reason for these changes (changes in the ratios of increasing:decreasing or changes to population trends) is evident for those species that changed from a decreasing pattern during the 1991 to 2009 interval using 100 m radius data to a stable or increasing pattern during the 1995 to 2009 time interval. The change in the pattern is strongest using the unlimited radius data in comparison with the 100 m radius distance category because the sample size of observations is substantially larger with the unlimited radius data. For example, the Black-throated Green Warbler in the Chippewa NF, the Hermit Thrush in the Chippewa NF, and Winter Wren in the Superior NF have a pattern of either relatively high relative abundance or a declining trend from 1991 to 1994 followed by either an increasing trend or relatively stable population from 1995 to 2009 . The inclusion of the unlimited count data adds approximately 40% more observations to the analysis that was previously being excluded. This is also a major contributor to the increased number of species that can be analyzed for trends and increases the statistical power to detect change in trends.

An illustration of a typical pattern is shown in Fig. 2 where the Ovenbird is relatively common in the first three years and the lowest counts were in the late 1990s followed by a slight increase from 2002 to 2009. Thus, removing the first three years from the analysis resulted in an increasing trend from 1995 to 2009.

Figure 2. The population trend for Ovenbird from 1991 to 2009 using the pooled National Forests and 100-m radius data.

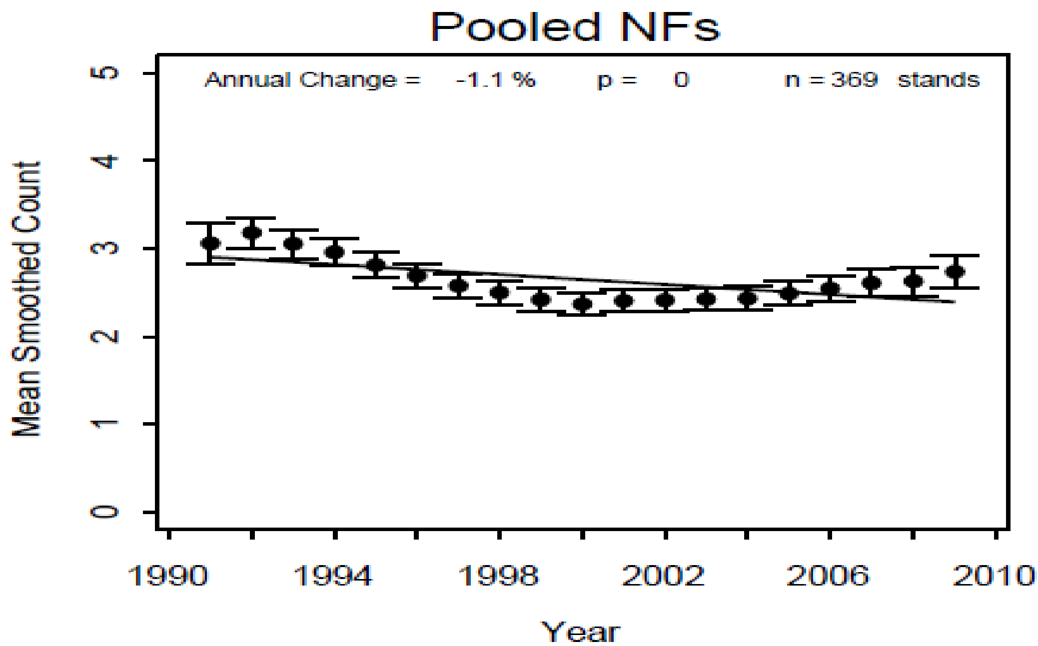

Table 1. Summary of number of species with significant trends in the three national forests and combined regionally.

National Forest	Distance of point radius and time interval	Number of species increasing	Number of species decreasing
Chequamegon	100 m-1992 to 2009	13	13
	100 m-1995 to 2009	16	10
	Unlimited-1995 to 2009	30	5
Chippewa	100 m-1991 to 2009	20	11
	100 m-1995 to 2009	17	3
	Unlimited-1995 to 2009	28	2
Superior	100 m-1991 to 2009	13	8
	100 m-1995 to 2009	18	3
	Unlimited-1995 to 2009	29	3
Regional- all 3	100 m-1991 to 2009	17	8
	100 m-1995 to 2009	17	3
	Unlimited-1995 to 2009	25	2

Species-specific Population Trends

The long-term trend data using 100 m radius distance 1991-2009 indicated a relatively large number of species decreasing over this period. Eight species have shown significant decreases when all three NFs were combined. They included the Eastern Wood Pewee, Winter Wren, Veery, Hermit Thrush, Myrtle Warbler, Ovenbird, Scarlet Tanager, and Song Sparrow. Interestingly, when we shorten the interval to 1995-2009 using 100-m data, only three species show a decrease in relative abundance on the combined three NFs: Yellow-bellied Flycatcher, Myrtle Warbler, and Scarlet Tanager. When we include the unlimited distance data during the 1995-2009 period for the three NFs combined, only two species show a declining trend, the Yellow-bellied Flycatcher and Myrtle Warbler.

Because of the large increase in sample size using the unlimited data (an approximate 40% increase in the number of observations), we suggest that this data set likely represents the most defendable data for our current analysis of trend; albeit this conclusion is subject to further analysis. This does eliminate the use of the 1991-1994 data for the Chippewa and Superior NFs and 1992-1994 data in Chequamegon NF for trend analysis, but does not exclude the use of these data for habitat and landscape analyses (e.g., see Niemi et al . 2004, Lapin 2010). The unlimited distance data from 1995-2009 (15 years) indicated that a large number of species, approximately 50% of the species that we are confident of testing for significant trends, are increasing within each NF. Similarly, 53% of those species tested for the three NFs combined were significantly increasing. In contrast, less than 7% of those species tested in the each of the NFs were identified as significantly decreasing and only 2 of 47 species (4%) were significantly decreasing.

The greatest concern is generally with species that are decreasing and, therefore, we focus on those species within each NF. The exception would be if a species is increasing, and is detrimental (e.g., competitive or interacting) with another species causing it to decline. With the unlimited distance data and for the period from 1995-2009, five species are significantly declining in the Chequamegon NF: Great Crested Flycatcher, Myrtle Warbler, Scarlet Tanager, Brewer’s Blackbird, and Evening Grosbeak. Sample sizes are relatively small for both the Brewer’s Blackbird and Evening Grosbeak so those decreases are suspect. In addition, the Brewer’s Blackbird is primarily found around human habitations and near roads. It is not a forest-dependent species. In the Chippewa NF, two species are significantly declining: Myrtle Warbler and Connecticut Warbler. Three species have shown significant declines in the Superior NF, Ruffed Grouse, Yellow-bellied Flycatcher, and Connecticut Warbler. The point count methodology is not among the best techniques to detect trends in Ruffed Grouse, primarily because the counts are completed in June. The decline in the Yellow-bellied Flycatcher is of interest and should be followed carefully. Its breeding habitat use closely coincides with the Connecticut Warbler. There is strong evidence of a widespread decline of the Connecticut Warbler in the US and in Canada where it is more abundant. Lapin (2010) has recently analyzed both habitat and landscape relationships of this species and found that the species was largely associated with a matrix of large forest patches comprised of lowland and upland coniferous forests. It may be a species that is sensitive to fragmentation of large blocks of these forest types.

There are several possible hypotheses on why so many species seem to be increasing in relative abundance, especially in reference to its comparison with the longer time series (1991-2009) using a 100 m radius distance. Two hypotheses include the following. (1) The relative abundance of many breeding bird species was high during the early years of sampling (1991-1994) (Figure 2) or their populations were in decline from 1991 to 1994. Therefore, removing the 1991-1994 time period for those species would have resulted in a statistically more positive population trend over the past 15 years. (2) Bird counters in 1991-1994 were including too many individuals in the 100 m radius circle that were actually beyond 100 m. The tendency to include birds at the 100-m border so they are not 'lost' from the observation pool is often called "heaping" (Etterson et al. 2009) – it is due to the interest of the counter to want to include a species observation within the count circle or simply the difficulty in estimating distance from the point. This phenomenon would artificially inflate the number of observations for the earlier periods of sampling when individuals observed beyond 100 m would have been excluded. It is likely a combination of both that contribute to the different interpretations we find over the different time intervals.

Some evidence does suggest that "heaping" may have been a contributing factor. For instance, several species that have loud songs or calls that clearly can be heard beyond 100 m have had the greatest changes in their population trends when unlimited counts were included. These species include the Great Crested Flycatcher and Yellow-throated Vireo in the Chippewa NF; Blue Jay, American Crow, Winter Wren, Veery (call note), Hermit Thrush, Brown Thrasher, Ovenbird, Scarlet Tanager (in regional analysis only); and White-throated Sparrow. In addition, species such as the Common Loon, Sandhill Crane, Pileated Woodpecker and Common Raven can now be included in trend analysis with the unlimited data. All of these species can be heard at a great distance and are included when the radius is not restricted to 100 m.

Migration Guild Analysis

The use of the unlimited distance data and the 1995-2009 time frame resulted in all guilds showing an increasing trend. The few species that have declined during this period are not abundant enough to influence a guild that has many species with increasing trends. However, we focus on the migration guild because of the interesting patterns that emerged within that group. Permanent residents have shown the greatest overall percentage increase over the past 15 years with an overall increase of 4.1% per year when all three NFs are combined (Table 2). Short-distance migrants have shown the next greatest percentage increase of 2.6%, except in the Chippewa NF where the increase of long-distance migrants was greater. When all three NFs are combined, then the overall increase in long-distance migrants is 2.1%. Note that a 4.1% per year increase over a 15 year period represents an approximate 60% increase in the number of permanent resident individuals within the three NFs.

There are several possible hypotheses why permanent residents may be increasing at a greater rate than the short and long distance migrants; none of which are mutually exclusive. (1) Over-winter survival has increased for permanent residents because the climate is warming and winters are less severe in terms of temperature. (2) Winter feeding of birds has been increasing over the past 15 years and supplemental food aids in over-winter survival. (3) Climatic warming results in earlier emergence of food (insects, berries, buds, etc.) and, hence, the earlier nesting species such as permanent residents would gain the greatest benefit from this shift in phenology. Because short-distance migrants have also shown increases greater than the long-distance migrants, they may also benefit from these purported hypotheses but perhaps not as much as the permanent residents.

Table 2. Summary of percentage increase per year and explained variation (all significant at p < 0.01) for species within three migration guilds in three National Forests and the three combined into a Regional analysis for the period 1995-2009 using unlimited radius counts (see also Appendix B for details).

National Forest	Migration Guild	Increase per Year -%	Explained Variation% (p-value)
Chequamegon	Permanent Residents	3.1	66
	Short-distance Migrants	2.0	78
	Long-distance Migrants	1.5	45
Chippewa	Permanent Residents	4.7	85
	Short-distance Migrants	2.7	83
	Long-distance Migrants	2.9	76
Superior	Permanent Residents	4.5	90
	Short-distance Migrants	3.0	88
	Long-distance Migrants	2.0	57
Regional- all 3	Permanent Residents	4.1	82
	Short-distance Migrants	2.6	84
	Long-distance Migrants	2.1	61

CONCLUSIONS

During the past year we have engaged in extensive analyses of these trend data, including a substantial amount of work on the issues of detectability (e.g., Etterson et al. 2009). We will continue to work on these analyses, but feel it is best to include the 2010 data since we have recently completed the gathering of these data. Our plan is to complete a detectability paper for these data and including the Nicolet NF. It is imperative to consider detectability because we do not believe that the use of these traditional analyses will survive a peer-review without the inclusion of detectability. However, we do have confidence in these trend values and suspect that the interpretations of the trends will not change substantially, unless of course the populations themselves change. We emphasize that Etterson et al. (2009) observed that the statistical characterization of trend (i.e. the value you get) doesn’t seem to be affected in our data by the choice of analytical method. That is, you get the same answer whether you incorporate detectability or not.

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