APPENDIX G

STUDY DESIGN AND METHODS

Sample Design

At the onset of the monitoring program, sampling locations were distributed across the forest mosaic in a proportionally stratified random manner. For each NF, stands ≥ 16 ha were grouped from their respective compartment inventories into strata defined by dominant tree species (i.e., forest cover type) and stocking density. Because the Superior NF is large, we randomly selected three of the six districts to sample (Tofte, Kawishiwi, and LaCroix). We also excluded the Boundary Waters Canoe Area Wilderness because there is no timber management and it is logistically difficult to access. For each NF, stands were randomly selected from each stratum so the final proportion of stands was equal to the proportion of forested land area of each cover type and stocking density for each of the NFs (Hanowski and Niemi 1995a). A total of 135 and 169 stands were originally selected in the Chippewa and Superior NFs, respectively (Figure 1). A total of 13 habitat types were sampled in the Chippewa NF and 12 in the Superior NF (Niemi et al. 2016, p. 11). Due to potential interest in logging lowland-conifer forests, 25 stands primarily composed of productive black spruce forest were added to the Superior NF in 2008. Twenty-seven non-forested (open, early-successional, shrubby wetland) stands (81 points) were added to the monitoring program in Chippewa NF in 2016 to more adequately monitor populations of Golden-winged Warblers. The overall design of the monitoring project has been peer-reviewed as part of two national breeding bird monitoring meetings (Hanowski and Niemi 1995a; Hanowski et al. 2002, 2005) and in several peer-reviewed publications (e.g., Niemi et al. 2004; Etterson et al. 2009; Lapin et al. 2013; Grinde and Niemi 2016; Grinde et al. 2017).

Breeding Bird Counts

Three permanent point count sites were established within each stand in 1991; point count sites were initially located a minimum of 220 m apart and at least 100 m from the edge of the forest stand (Hanowski et al. 1990, 1995a; Blake et al. 1992). Ten-minute point counts are conducted at each site between early to mid-June in the Superior NF, and late June to early July in the Chippewa NF (Etterson et al. 2009; Niemi et al. 2016). Point counts are conducted by trained observers (see observer training below) from approximately 0.5 h before to 4 h after sunrise on days with little wind (< 15 km hr^{-1}) and little or no precipitation. All birds heard or seen from the site were recorded, and distance was estimated as 0–25 m, 25–50 m, 50–100 m, or > 100 m (Howe et al. 1997; Niemi et al. 2016). Weather data (cloud cover, temperature, and wind speed) and time of day were recorded before each count.

Observer Training

Testing and training of counters is an important component of the monitoring program. Prior to the field season, recordings of 120+ bird species were provided to all potential counters. Counters are tested on their ability to identify 86 of these species by song. Songs on the recording were grouped by habitat (e.g., upland deciduous, lowland coniferous) to simulate field cues that would aid in song identification. A standard for number of correct responses was established by giving the test to observers who had four to five years of field experience. Based on their results, the standard for passing was set at 85% correct responses. All point counters employed to collect data for this project have reached this benchmark. In late May of each monitoring year, observer field training was conducted over a four-day period to ensure accuracy and consistency in data collection. In addition to field training and testing, all observers were required to have a hearing test to ensure their hearing was within the normal range, as established by audiologists, for frequencies 125 to 8,000 hertz.

Analysis

Population/abundance estimates

Bird population estimates are defined here as the annual mean number of observations of a species in a 10-min point count for each NF and for the NFs combined (i.e., regional trends). Stand-level abundance estimates for species trend analyses in the Chippewa and Superior NFs were calculated by summing the numbers of individuals across the two furthest points per stand. The middle point in each stand was excluded because an unlimited radius count from the center of the middle point sometimes overlapped areas counted on the other points. In addition, Hanowski and Niemi's (1995a) analysis of these data determined that two points per stand were nearly equivalent in power to detect change as the use of three points per stand. The mid-point of the stand has been recorded regardless because 1) it may be used as a test point for habitat prediction modeling, 2) little time is saved by skipping the point, 3) occupancy models require a minimum of three replications in a stand (MacKenzie et al. 2006; Grinde and Niemi 2016), and 4) data collected annually from the point still can be used to estimate population change. The following criteria were used to ensure trend analyses provide reliable population information: 1) Stands have been sampled for at least six years, 2) Data were included for trend analyses if a species was observed at a minimum of five stands per NF and during at least three years at each stand, 3) Species that were observed at five or fewer stands in each of the NFs, the data were pooled into a "regional" analysis.

Population trajectories

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

Population trend

A population trend defines the direction and magnitude of population change over a given time period (Link and Sauer 1997). Non-linear trends notwithstanding, we view a significant trend as a unidirectional change, therefore linear methods can be used to detect a trend without asserting that the population trajectory is linear (Urquhart and Kincaid 1999). Population trends were assessed using simple linear regression applied to an annual index of population size for a study area (described above) and time. We used the slope coefficient to characterize direction and magnitude of the trend. To facilitate comparison, slopes were converted to units of percent annual change by dividing annual population indexes by the predicted value of the index at the midpoint of the entire survey period (1995 to 2019) prior to regressing the index with time (Bart et al. 2003). We assessed the significance of the regressions using a bootstrap procedure (Manly 1991) in which trends were computed for 500 bootstrap resamples of the stands used to calculate the annual population index. For each bootstrap resample, trend was calculated using the same steps as for the original trend. For each original trend, an exact p-value was calculated as the percentile at which zero occurred in the distribution of 500 bootstrapped slopes. For example, $P = 0.01$ would be equivalent to 99% of bootstrapped slopes being greater than zero, which would give us a high degree of confidence that the true population slope was different from zero. We are currently exploring the feasibility of using a hierarchical modeling approach for these data that is similar to methods used for trend detection in the BBS (Sauer and Link 2011; Link et al. 2017).

Guild analyses

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

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