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Submitted by:

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SUMMARY

- A total of 351 forest stands were surveyed for breeding birds including 160 and 191 stands (1028 survey points) in the Chippewa and Superior National Forests (NFs), respectively, in 2022.
- Trends in relative abundance were calculated for 78 bird species (77 in 2021), including 71 species in the Chippewa NF and 67 in the Superior NF for 28 years from 1995 to 2022. There were 33 additional species that were detected in Chippewa NF and 32 species in Superior NF that did not meet our inclusion criteria for trend analysis.
- In Chippewa NF, 52 species that met our inclusion criteria had stable or increasing trends over the past 28 years. Overall, 19 species trends were significantly increasing (18 in 2021), 33 species trends (34 in 2021) were relatively stable, and 19 species trends had significantly decreasing trends (17 in 2021) from 1995 to 2022.
- In Superior NF, 42 species that met our inclusion criteria had stable or increasing trends over the past 28 years. Of these, 15 species trends were significantly increasing (13 in 2021), 27 species (29 in 2021) had relatively stable trends, and 25 species had significantly decreasing trends (25 in 2021) from 1995 to 2022.
- Eight species increased in both the Chippewa and Superior NFs: Black-and-white Warbler, Black-throated Green Warbler, Blue Jay, Nashville Warbler, Northern Waterthrush, Pine Warbler, Red-breasted Nuthatch, and Ruby-crowned Kinglet. With the exception of Nashville Warbler, these species tend to be associated with more mature forests.
- Ten species decreased in both NFs: Black-capped Chickadee, Chipping Sparrow, Common Loon, Common Yellowthroat, Connecticut Warbler, Hermit Thrush, Red-eyed Vireo, Song Sparrow, Winter Wren, and Yellow-rumped Warbler. However, 24 species had significantly declining regional trends when the two National Forests were combined: American Crow, American Robin, Black-capped Chickadee, Brown Creeper, Canada Jay, Chestnut-sided Warbler, Chipping Sparrow, Common Loon, Common Raven, Common Yellowthroat, Connecticut Warbler, Downy Woodpecker, Hermit Thrush, Magnolia Warbler, Mourning Warbler, Olive-sided Flycatcher, Red-eyed Vireo, Red-winged Blackbird, Scarlet Tanager, Song Sparrow, Swamp Sparrow, White-throated Sparrow, Winter Wren, and Yellow-rumped Warbler.
- Regional trends for guilds were mixed over the period from 1995-2022. Species associated with upland conifer, lowland conifer, canopy nesting, and permanent resident species all significantly increased. Shrub nesting, early-successional, and short-distance migrant species significantly decreased, while deciduous forest, mixed forest, ground and cavity nesting, and long-distance migrant species had no significant change.
- Connecticut Warbler has shown one of the most consistent declines of any species in the monitoring program. In 2022, only one individual was detected in Superior NF.
- 815,000 acres, or roughly 60% of Minnesota's tamarack, have been impacted by eastern larch beetle (*Dendroctonus simplex*) since 2001. The changes to forest habitats are likely impacting breeding bird communities and potentially influencing trends for some bird species.
- The overall trend results indicate the majority of breeding bird species that are abundant enough to analyze have either increasing or stable trends. However, the declining trends for lowland conifer obligate breeders, aerial insectivores, species that require old growth, and short-distance migrants continue to be a concern.

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Appendix B. Population trend estimates (% annual change) and associated test statistics for the Chippewa NF, Superior NF, and a combined regional analysis (1995–2022). Included for each species are its trend (% annual change) within each NF, a regional trend (if possible), the significance of the trend (*P*), the explained variation of the trend (r^2), and the number of stands (n) in which the species was detected sufficiently to include in the trend calculation.

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Appendix H. Estimated annual indices from 1995 to 2022 for breeding birds in Chippewa NF. A stretched color scheme was applied to each species with red for low indices, yellow average, and green high, to visualize relative changes in indices over time.

Appendix I. Estimated annual indices from 1995 to 2022 for breeding birds in Superior NF. A stretched color scheme was applied to each species with red for low indices, yellow average, and green high, to visualize relative changes in indices over time.

OVERVIEW

The Avian Ecology Lab at the Natural Resources Research Institute completed the 28th year of Minnesota's National Forest Breeding Bird Monitoring Program in 2022. These data have provided insight into the impacts of forest management on breeding bird populations and informed the development of management policies and conservation initiatives. This report summarizes forest bird monitoring data gathered from 1995 through 2022. Here we summarize the current status of species trends and overall trends for migration, habitat, and nesting guilds. We focus our discussion on species of conservation importance in the state to provide an ecological context and discuss management implications of the observed patterns in the region for these species.

INTRODUCTION

The breeding bird communities of the western Great Lakes region have among the richest species diversity in North America (Green 1995; Howe et al. 1997; Rich et al. 2004; Niemi et al. 2016). Maintaining avian diversity in forest ecosystems affords many benefits for forest health and productivity; diverse bird communities play a vital role in maintaining both the structure and function of ecosystems by providing numerous ecological services such as seed dispersal and pest control (Krieger 2001, Whelan et al. 2008, Philpott et al. 2009, Sekercioğlu et al. 2012, 2017). Further, because birds integrate environmental variables over space and time, changes in forest bird communities provide meaningful signals of local forest health or degradation (Niemi and McDonald 2004; Gnass Giese et al. 2015).

The USDA Forest Service manages 191 million acres in 44 states, comprising the largest amount of single-ownership breeding bird habitat in the United States. The ecological setting of Superior and Chippewa National Forests (NFs) is particularly important because they are located in the transition zone between boreal forest and eastern deciduous forest. These forests are characterized by a diverse mosaic of forest communities varying from upland pine and aspen-birch to lowland conifer and open shrub bog and provide important habitat for over 150 breeding bird species (Niemi et al. 2016). However, changes in climate, disturbance regimes, and land-use practices have led to significant changes in forest composition in the region; these ongoing changes are likely to have substantial consequences on avian populations and communities (Meynard and Quinn 2008, Eglington and Pearce-Higgins 2012, Riordan and Rundel 2014, Grinde and Niemi 2016, Niemi et al. 2016).

Adaptive forest management has the potential to mitigate impacts of climate and land use changes on bird communities by conserving and cultivating critical habitats. Moreover, actively integrating forest bird communities into forest management planning and implementation will ensure the health and diversity of ecosystems while also meeting society's needs. The development of successful adaptive management plans is contingent on understanding the long-term impacts of forest management on forest-dependent breeding bird species. The Minnesota National Forest Breeding Bird Monitoring Project was established in 1991 in the Chippewa and Superior NFs in response to the need for habitat-specific regional population data. Currently, more than 350 stands (> 1,000 points) within the two NFs are surveyed annually during the breeding season (June 1 to July 10) using standardized, 10-min point counts (Figure 1; see Appendix E for detailed designs and methods).

This monitoring program was designed to 1) establish a baseline inventory of local forest breeding bird assemblages, 2) monitor population changes of forest bird species over time, and 3) identify bird-habitat associations, particularly those relevant to forest management activities.

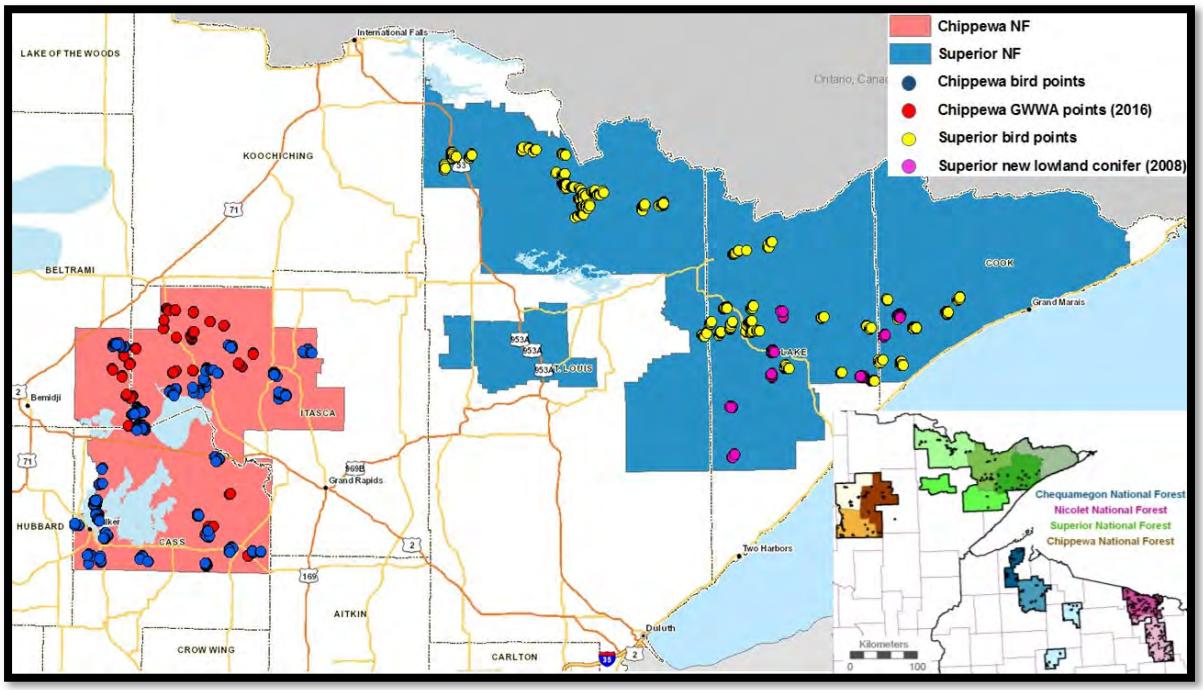

Figure 1. Locations of forest breeding bird point counts in northern Minnesota's Chippewa and Superior NFs. Approximately 1,000 individual points are annually sampled between the Chippewa and Superior NFs. Inset shows the regional scope of NFs included in Niemi et al. (2016).

RESULTS

Observers have detected over 425,000 individual birds of 166 species on approximately 26,000 ten-minute point counts in the Chippewa and Superior NFs during the 28 field seasons of the Minnesota National Forest Breeding Bird Monitoring Project (Figure 2). In 2022, we sampled 160 stands in the Chippewa NF and 190 in the Superior NF. Seventy-eight species were assessed for trends in at least one national forest, including 71 in the Chippewa NF and 67 in the Superior NF (Table 1). As monitoring continues through the years, new species meet our criteria for inclusion in trend analyses on each national forest. The number of species assessed has increased steadily from 36 in 2000, when the criteria were first applied, to 78 in 2022. Regional trends that incorporate both NFs were calculated for 60 species.

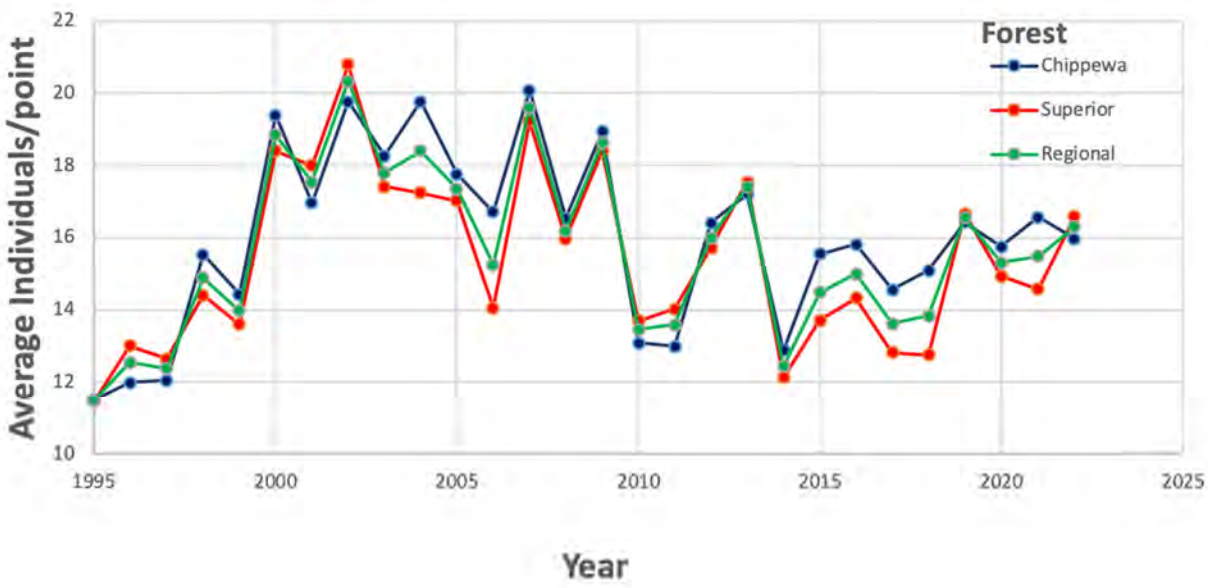

Figure 2. Average number of individual birds detected per point each year in the Chippewa and Superior NFs. The 25 stands added to the Superior NF in 2008 and the 24 stands added to the Chippewa NF in 2016 were included in the summary.

Overview of Data Summaries

We summarized current species and guild (migration, habitat, and nesting) trends. In order to provide an ecological context to our results, we focus our discussion on species of statewide conservation importance and the management implications of the observed regional patterns on these species.

Appendix A includes trend graphs of calculated annual index for individual species within each NF and regionally over the last 28 years. Appendix B is a complete statistical summary of the trend analysis including species, trend within each NF, regional trend (if applicable), trend significance (*P*), variation explained by trend (r^2), and the number of stands (n) in which the species trend calculation inclusion criteria. The combination of significance and explained variation indicate the strength of the trend for each species within each NF and the region. While this monitoring program was designed to survey territorial forest songbirds, we also detect and monitor several species despite not lacking this behavior. For example, trends for non-forest dwelling species (e.g., Common Loon) and species with large territories (e.g., American Crow) should be interpreted with caution. However, because we conduct surveys using consistent methodology, data from such species may provide useful insights.

Trend significance is a valuable way to assess large-scale patterns within and between NFs, but the annual index influences the significance (how different the trend is from zero) of the trend line from year to year. To help visualize patterns in trend index over time we applied a heat map approach to annual indices for species and guilds in each NF (see Figure 3; Figure 4; Table 10; Appendix H; Appendix I). A stretched color scheme was applied to each species spanning from red (low) to green (high); colors were applied to individual species in order to visualize the relative changes that have occurred over time instead of the raw index value.

The U.S. Geological Survey's Breeding Bird Survey (BBS) provides important information on trends at large geographic scales. The Minnesota National Forest Breeding Bird Monitoring Project was specifically designed to complement the BBS by strategically and systematically sampling forest habitat types away from edges associated with roads (on which BBS routes are located) using standardized point-count methods. Comparing trends at multiple spatial scales provides ecological context for species trends observed in the NFs. For this reason, we compare NF species trends to BBS trends calculated for Bird Conservation Region in which the NFs lie (BCR 12) and BBS survey-wide (North America; Table 10).

Appendix C tabulates the common name, scientific name, four-letter code used in field records, and a summary of the three major guilds included here: migration strategy, nest site, and vegetation type primarily used by the species. Appendices D and E identify the number of individuals observed for species excluded from trend analysis from 1995 to 2022 in Chippewa and Superior NFs, respectively. Appendix F is discussed in more detail below and includes results of trend analysis for lowland-conifer forests in the Superior NF, 2008–2022. Appendix G is a comprehensive overview of the study design and methods. Appendix H and Appendix I provide the estimated annual indices with a stretched color scheme for each species analyzed in Chippewa and Superior NFs, respectively, to visualize relative changes in trend indices over time.

Chippewa National Forest																												
Common Name	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Black-billed Cuckoo	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.3
Canada Warbler	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6
Common Loon	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Connecticut Warbler	0.9	1.0	0.8	0.8	0.7	0.6	0.6	0.6	0.5	0.5	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0
Golden-winged Warbler	0.4	0.4	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.6	0.6	0.6	0.7
Olive-sided Flycatcher	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
Purple Finch	0.1	0.1	0.1	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Veery	1.3	1.4	1.4	1.4	1.6	1.6	1.7	1.7	1.7	1.8	1.9	1.9	1.9	1.9	1.9	1.6	1.9	1.9	1.9	1.8	1.9	1.9	1.9	1.8	1.8	1.8	1.8	1.8
Winter Wren	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4
Wood Thrush	0.1	0.2	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Superior National Forest																												
Common Name	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Black-billed Cuckoo	0.1	0.1	0.2	0.3	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Black-throated Blue Warbler	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4
Canada Warbler	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Cape May Warbler	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4
Common Loon	0.3	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
Connecticut Warbler	0.8	0.8	0.7	0.7	0.7	0.6	0.6	0.6	0.5	0.5	0.5	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.1	0.0
Golden-winged Warbler	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2
Olive-sided Flycatcher	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.2
Purple Finch	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Veery	1.4	1.3	1.4	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.2	1.2	1.2	1.2	1.2	1.3	1.3	1.3	1.3	1.4	1.4	1.4	1.5	1.5
Winter Wren	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5
Wood Thrush	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.3	0.3	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4

Figure 3. Estimated annual indices from 1995–2022 for breeding bird species of state, national, or international conservation interest. A stretched color scheme was applied to each species with red for low indices, yellow average, and green high to visualize changes in indices over time.

Chippewa National Forest																												
Habitat Guilds	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Coniferous forest species	2.2	2.4	2.6	2.9	2.7	2.7	2.8	2.8	2.9	3.0	3.0	3.1	3.1	3.3	3.1	3.5	3.0	2.9	2.8	2.8	2.7	2.7	2.6	2.6	2.5	2.5	2.4	2.3
Deciduous forest species	12.0	13.3	13.2	13.3	14.4	14.9	15.3	15.6	15.8	16.2	16.4	16.5	16.4	16.5	15.9	14.9	15.6	15.9	15.1	15.0	15.0	14.9	14.9	14.7	14.6	14.6	14.6	14.5
Early-successional species	3.9	4.2	4.3	4.5	4.5	4.6	4.6	4.7	4.8	4.9	4.9	4.9	4.8	4.8	4.6	4.5	4.5	4.4	4.4	4.3	4.4	4.4	4.3	4.4	4.4	4.4	4.4	4.5
Lowland-conifer species	2.6	2.7	2.9	3.1	2.9	2.8	2.9	2.9	3.0	3.0	3.1	3.0	3.1	2.9	3.3	3.4	3.0	2.8	3.1	3.1	3.1	3.1	3.0	3.1	3.0	3.0	3.0	3.0
Mixed forest species	2.3	2.4	2.5	2.7	2.6	2.7	2.8	2.9	3.0	3.0	3.1	3.1	3.2	3.1	3.2	3.4	3.1	3.1	3.0	3.1	3.0	3.0	2.9	3.0	2.9	2.9	2.9	2.9
Migration Guilds	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Long-distance migrants	17.9	18.8	18.9	19.4	20.3	20.7	21.1	21.5	21.9	22.3	22.6	22.6	22.5	22.5	22.0	21.4	21.5	21.6	21.1	21.0	21.1	21.1	21.0	21.0	21.0	21.0	21.0	21.1
Permanent residents	1.8	2.0	2.1	2.3	2.3	2.4	2.5	2.6	2.7	2.8	2.8	2.8	2.8	2.8	2.9	2.9	2.8	2.8	2.7	2.7	2.7	2.6	2.6	2.6	2.5	2.5	2.5	2.5
Short-distance migrants	7.1	7.2	7.8	8.3	8.0	8.0	8.2	8.4	8.6	8.7	8.8	8.6	8.6	8.4	8.4	8.5	7.8	7.5	7.5	7.3	7.1	6.9	6.6	6.4	6.2	6.0	5.8	5.6
Nesting Guilds	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Canopy nesting species	5.0	5.3	5.6	5.9	5.7	5.8	6.0	6.0	6.1	6.2	6.3	6.3	6.3	6.4	6.2	6.5	5.9	5.9	5.7	5.8	5.7	5.7	5.6	5.6	5.5	5.5	5.5	5.4
Cavity nesting species	1.5	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.6	2.6	2.6	2.6	2.5	2.5	2.6	2.4	2.4	2.4	2.3	2.2	2.2	2.1	2.1	2.1	2.0
Ground nesting species	11.0	11.3	11.9	12.5	12.5	12.6	12.9	13.3	13.6	13.9	14.1	14.0	14.2	13.7	14.2	13.8	13.7	13.5	13.7	13.6	13.6	13.5	13.4	13.4	13.3	13.3	13.2	13.1
Shrub nesting species	9.1	9.6	9.5	9.6	10.3	10.5	10.6	10.7	10.9	11.0	11.2	11.1	10.9	10.9	10.2	9.9	9.9	9.8	9.4	9.2	9.1	9.0	8.9	8.8	8.7	8.6	8.6	8.5
Nest parasites	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1
Superior National Forest																												
Habitat Guilds	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Coniferous forest species	2.7	2.8	2.8	3.0	3.0	3.0	3.1	3.2	3.3	3.5	3.4	3.5	3.5	3.6	3.6	3.6	3.5	3.6	3.5	3.5	3.5	3.4	3.5	3.4	3.4	3.4	3.2	3.3
Deciduous forest species	11.0	11.2	11.6	11.7	12.1	12.3	12.4	12.6	12.8	12.9	13.1	13.0	12.7	12.4	12.3	12.0	11.8	11.5	11.5	11.5	11.5	11.4	11.3	11.5	11.4	11.4	11.6	11.6
Early-successional species	5.1	5.3	5.3	5.4	5.6	5.8	5.9	6.0	6.1	6.3	6.3	6.2	6.1	6.1	5.9	5.7	5.5	5.2	5.1	5.0	4.9	4.8	4.7	4.5	4.5	4.3	4.2	4.3
Lowland-conifer species	4.1	4.2	4.3	4.5	4.5	4.6	4.7	4.8	5.0	5.1	5.1	5.0	5.1	5.2	5.1	5.1	5.0	5.0	5.0	4.9	4.9	4.8	5.0	4.7	4.7	4.7	4.6	4.7
Mixed forest species	2.4	2.4	2.5	2.6	2.6	2.7	2.7	2.8	2.8	2.9	2.9	3.0	2.9	2.9	2.9	2.8	2.8	2.8	2.7	2.7	2.6	2.6	2.6	2.5	2.5	2.4	2.4	2.3
Migration Guilds	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Long-distance migrants	18.4	18.8	19.2	19.5	19.9	20.3	20.5	20.8	21.1	21.5	21.6	21.4	21.1	20.9	20.6	20.2	19.9	19.5	19.5	19.4	19.4	19.4	19.4	19.3	19.4	19.4	19.5	19.5
Permanent residents	1.9	2.0	2.1	2.2	2.4	2.4	2.5	2.6	2.7	2.9	2.9	3.0	2.9	3.0	2.9	2.9	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.7	2.7	2.7	2.7	2.7
Short-distance migrants	7.0	7.3	7.4	7.7	7.8	8.1	8.3	8.5	8.7	9.0	9.0	9.0	9.0	9.0	8.8	8.7	8.3	8.1	7.9	7.7	7.4	7.2	7.1	6.5	6.4	6.1	5.7	5.5
Nesting Guilds	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Canopy nesting species	3.8	4.0	4.1	4.3	4.3	4.5	4.6	4.7	4.8	5.0	5.0	5.1	5.1	5.2	5.2	5.3	5.1	5.2	5.1	5.1	5.0	5.0	5.1	4.9	4.9	4.9	4.8	4.8
Cavity nesting species	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.2	2.2	2.2	2.2	2.2	2.1	2.0	2.0	1.9	1.9	1.8	1.8	1.7	1.7	1.6	1.6	1.5	1.5
Ground nesting species	14.4	14.8	15.0	15.4	15.7	16.0	16.2	16.5	16.8	17.1	17.1	17.0	16.9	16.8	16.5	16.3	16.0	15.5	15.5	15.3	15.2	15.0	14.9	14.6	14.6	14.4	14.3	14.1
Shrub nesting species	7.7	7.8	8.0	8.1	8.3	8.5	8.6	8.7	8.8	9.1	9.1	9.0	8.8	8.6	8.4	8.1	7.9	7.7	7.6	7.6	7.6	7.5	7.5	7.4	7.3	7.3	7.2	7.2

Figure 4. Estimated annual indices from 1995–2022 for breeding bird habitat, migration, and nesting guilds. A stretched color scheme was applied to each species with red for low indices, yellow average, and green high to visualize changes in indices over time.

Chippewa NF Trends

Seventy-one species in the Chippewa NF were included in our analysis in 2022; of these, 19 species had significantly increasing trends (Table 2; Table 3), 19 species had significantly declining trends (Table 4), and 33 species had non-significant trend indices (see Table 5; Appendix A).

***Increasing Species*.** Only Wood Thrush showed new significantly increasing trends this year in Chippewa NF (Table 6). Eleven species have shown increasing trends over the last six years: Black-and-white Warbler, Black-throated Green Warbler, Blue Jay, Canada Warbler, Nashville Warbler, Ovenbird, Pileated Woodpecker, Pine Warbler, Red-breasted Nuthatch, Veery, and Yellow-bellied Sapsucker. Ruby-throated Hummingbird, Mourning Dove, Ruby-crowned Kinglet and Lincoln's Sparrow have been increasing the last four years. Most notable in this list are two species of conservation concern, Canada Warbler and Veery.

Canada Warbler inhabit a wide range of deciduous and coniferous forests but are most common in moist mixed coniferous-deciduous forests that have well-developed understory shrub layers (Reitsma et al. 2010; Grinde and Niemi 2016). Observations of the species have varied annually, but we suspect the steady increase is associated with a combination of thinning, wind, and insect disturbances that have occurred in some stands. The significantly increasing trend for Canada Warbler in Chippewa NF is important; by comparison, BBS population trend estimates for Canada Warblers indicate a -1.3% continental population decline and -1.6% in BCR 12 since 1966 (Sauer et al. 2020; Figure 3; Table 10). Because of the long-term population declines throughout their range, Canada Warbler was designated as "threatened" in Canada in 2010 and is included on the list of species of conservation concern at the national level in the United States (Butcher et al. 2007; U.S. Fish and Wildlife Service 2008; Environment Canada 2015).

Veery are designated as a Species in Greatest Conservation Need (SGCN) by the Minnesota Department of Natural Resources (MNDNR; MNDNR 2015) because this species has shown long-term population declines (Sauer et al. 2020; Figure 3; Table 10) and six percent of the total population breeds in Minnesota, the highest of any U.S. state (Pfannmuller 2012). Veery breed in a variety of cover types, including regenerating stands, but forest stands with a well-developed understory of shrubs and small trees are common features and research also suggests sensitivity to fragmentation (Robbins et al. 1989; Blake 1991). Similar to Canada warbler, Veery may be increasing in Chippewa NF due to a combination of thinning, wind, and insect disturbances that have occurred in some stands.

***Decreasing Species*.** The only species to show new significantly decreasing trends in Chippewa NF this year was Common Loon, but trends for this species may not be reliable (see text below; Appendix A; Table 6). Two species have shown significantly decreasing trends for at least the last eleven years: Connecticut Warbler and Song Sparrow. Chipping Sparrow, Least Flycatcher, and Winter Wren have had declining trends for nine years, and American Robin has shown a declining trend for the past eight years. Brown-headed Cowbird, Common Yellowthroat, Olive-sided Flycatcher, Red-eyed Vireo, and Scarlet Tanager have been declining for the past six years. Alder Flycatcher and Blue-headed Vireo have been declining for the past five years, and Black-capped Chickadee and Indigo Bunting have declined over the past four years. Three of these species are designated as a SGCN by MNDNR: Connecticut Warbler, Olive-sided Flycatcher, and Winter Wren (Figure 3; MNDNR 2015). Conservation considerations for these species are summarized below in the "Regional Trends" section.

Non-forest (Golden-winged Warbler) Stands. In 2016, 25 stands were added to the NFB surveys to focus on non-forested habitat types that are important for many early-successional bird species. In 2022, a total of 974 individuals of 57 species were detected in these stands. The most abundant species (mean observations/stand) were Veery (5.5), Common Yellowthroat (5.0), Red-eyed Vireo (4.5), Nashville Warbler (4.4), and Ovenbird (4.2; Table 7). A total of 47 Golden-winged Warblers were recorded; an average of 1.9 per stand were detected at 20 of the 25 stands surveyed (Table 7). The average number of Golden-winged Warblers detected at these stands is 31 but the number has fluctuated annually, with a minimum of 15 observed in 2018 to a maximum of 52 individuals observed in 2019.

Superior NF Trends

Sixty-seven species in the Superior NF were included in our analysis; of these, 15 species had significantly increasing trends (Table 2; Table 3), 25 species had significantly decreasing trends (Table 4), and 27 species had non-significant trends (see Table 5; Appendix A).

***Increasing Species*.** Golden-crowned Kinglet and Black-and-white Warbler both showed new significantly increasing species trends this year in Superior NF (Table 6). Seven species have shown increasing trends over the last six years or longer: Cape May Warbler, Black-throated Green Warbler, Blue Jay, Nashville Warbler, Pine Warbler, Red-breasted Nuthatch, Ruby-crowned Kinglet, and Tennessee Warbler. Other increases include Purple Finch over the last five years, Ruffed Grouse, Cedar Waxwing and Northern Waterthrush four years, and American Redstart three years. Two of these species are designated as SGCN (MNDNR 2015): Cape May Warbler and Purple Finch.

Cape May Warbler was listed as an SGCN due to steep, range-wide population declines (MNDNR 2015). This species also faces several threats including high mortality during migration, habitat loss, and narrow thermal preferences (MNDNR 2015, Pfannmuller et al. 2017). BBS population trends showed a significant increase in Minnesota (2.36%) and a non-significant trend in the BCR 12 (0.99%) and continental scale (0.94%; Sauer et al. 2020; Figure 3; Table 10). Cape May Warblers are most abundant

in a variety of medium- to old-aged coniferous habitats with spruce and balsam fir. They are considered spruce budworm specialists, and populations fluctuate widely with spruce budworm outbreaks; recent increases in this species are likely due to local spruce budworm outbreaks that have been occurring in and around Superior NF since 2010 (Sturtevant et al. 2013). Maintaining healthy coniferous forests across the landscape and increasing conifer components in existing forest stands, especially in the northern portions of the state, will be beneficial to the long-term conservation of this species.

BBS population trends indicate Purple Finch has experienced a statistically valid decline of 0.73% at the continental scale and -1.07% in BCR 12 since 1966 (Sauer et al. 2020; Table 10). This species uses a variety of habitat types including bogs, upland coniferous forests, pine forests, pine-oak barrens, lowland coniferous forests, and northern mixed forest types (Niemi et al. 2016). The reasons for the population declines in Minnesota are unknown, but changes in climate and high collision risks have been proposed. In Ontario, Cadman et al. (2007) suggested that the recent Purple Finch declines were linked to low spruce budworm populations. If this is the case, it may be a reason why the species is increasing in Superior NF.

***Decreasing Species*.** Both Swamp Sparrow and Yellow-rumped Warbler showed a new significantly decreasing trend this year in Superior NF (Appendix A; Table 6). Common Loon, Connecticut Warbler, Swainson's Thrush, and Yellow-bellied Flycatcher have shown declining trends for the last ten years. American Crow, Chipping Sparrow, Mourning Warbler, and Red-eyed Vireo have been declining for eight years, Hermit Thrush has declined for the last seven years, and Song Sparrow, Chestnut-sided Warbler, and Broad-winged Hawk have been declining for five years. Winter Wren was significantly declining in 2016, started a non-significant trend in 2017, but has returned to a significant decline since 2018. Magnolia Warbler and Common Yellowthroat have shown declines since 2018 and Black-billed Cuckoo, Black-capped Chickadee, Evening Grosbeak, Common Raven, Brown Creeper, Canada Jay, and Lincoln's Sparrow showed declining trends from 2019 that have continued through 2022.

Five of these declining species are designated as SGCN: Black-billed Cuckoo, Common Loon, Connecticut Warbler, Evening Grosbeak, and Winter Wren (MNDNR 2015). Common Loons are not well surveyed by point counts so trend indices for Superior NF should be interpreted with caution. Conservation considerations for Connecticut Warbler and Winter Wren are summarized in the "Regional Trends" section.

Black-billed Cuckoo has experienced a statistically valid trend of -2.07% at the continental scale and -1.34% in BCR 12 since 1966 (Sauer et al. 2020; Table 10). Causes of the population declines are unclear but food supply, pesticide use, and habitat changes have been implicated. Over 10% of the breeding population is found in Minnesota, thus the state has an important role in the overall conservation of the species (Pfannmuller 2012).

Evening Grosbeak populations have declined 2.52% at the continental scale and -5.02% in BCR 12 since 1966 (Sauer et al. 2020; Table 10). Reasons for this population decline are not well known, but multiple causes such as large-scale forestry that has reduced the age structure of forests, diseases, and a reduced number of insect infestations (e.g., spruce budworm; Pfannmuller 2012) have been suggested.

***Lowland-conifer Forest Stands*.** We completed a separate trend analysis for lowland conifer stands in the Superior NF from 2008 to 2022 (Table 8; Appendix F). Forty-two stands primarily composed of black spruce, tamarack, or mixed swamp conifer are sampled annually in the Superior NF and were included in this analysis. Mixed swamp conifer is dominated by northern white cedar, balsam fir, and black spruce, though occasionally mixed with tamarack, paper birch, and black ash. Twenty-five of the 42 stands were added to the sampling design in 2008 and are primarily productive black spruce forests. Twenty species

that are associated with conifer or lowland-conifer for breeding habitat were included in the analysis. Unsurprisingly, the results of the lowland conifer analyses differed from the forest-scale trends due to the shortened time-series and restricted forest types. However, we feel that focusing on conifer-associated species in these stands can provide valuable insights for management over time (Table 8; Appendix B). Results indicate that Cape May Warbler, Northern Waterthrush, Red-breasted Nuthatch, Tennessee Warbler, and Yellow-bellied Flycatcher were significantly increasing while Common Raven, Connecticut Warbler, and Winter Wren had trends that were significantly decreasing in lowland-conifer forests from 2008 to 2022 (Table 8; Appendix B).

Regional Trends - Pooled National Forests

We calculated regional trends that combine data from both Chippewa and Superior NFs for 60 species in 2022. Overall, 15 species were increasing significantly (Table 2), 24 species were decreasing significantly, and 21 had non-significant trends (Table 4).

***Increasing Species*.** Three species showed new significant regional increases in 2022: Blackburnian Warbler, Veery, and Wood Thrush (Table 6). Eight species have shown regionally increasing trends over the last six years: Blue Jay, Black-and-white Warbler, Black-throated Green Warbler, Cedar Waxwing, Nashville Warbler, Ovenbird, Pine Warbler, and Red-breasted Nuthatch. Northern Waterthrush and American Redstart have increased in each of the last five years and Purple Finch, Ruby-crowned Kinglet and Ruby-throated Hummingbird the last four years. Recently released eBird regional trends largely agree with trends derived from our analysis, although there are some exceptions (Figure 5). This may be a result of the differing analysis time scales (15 years vs. 28 years) or differences in methodologies (off-road and vigorous point count protocols vs. the variety of data collected by eBird citizen scientists).

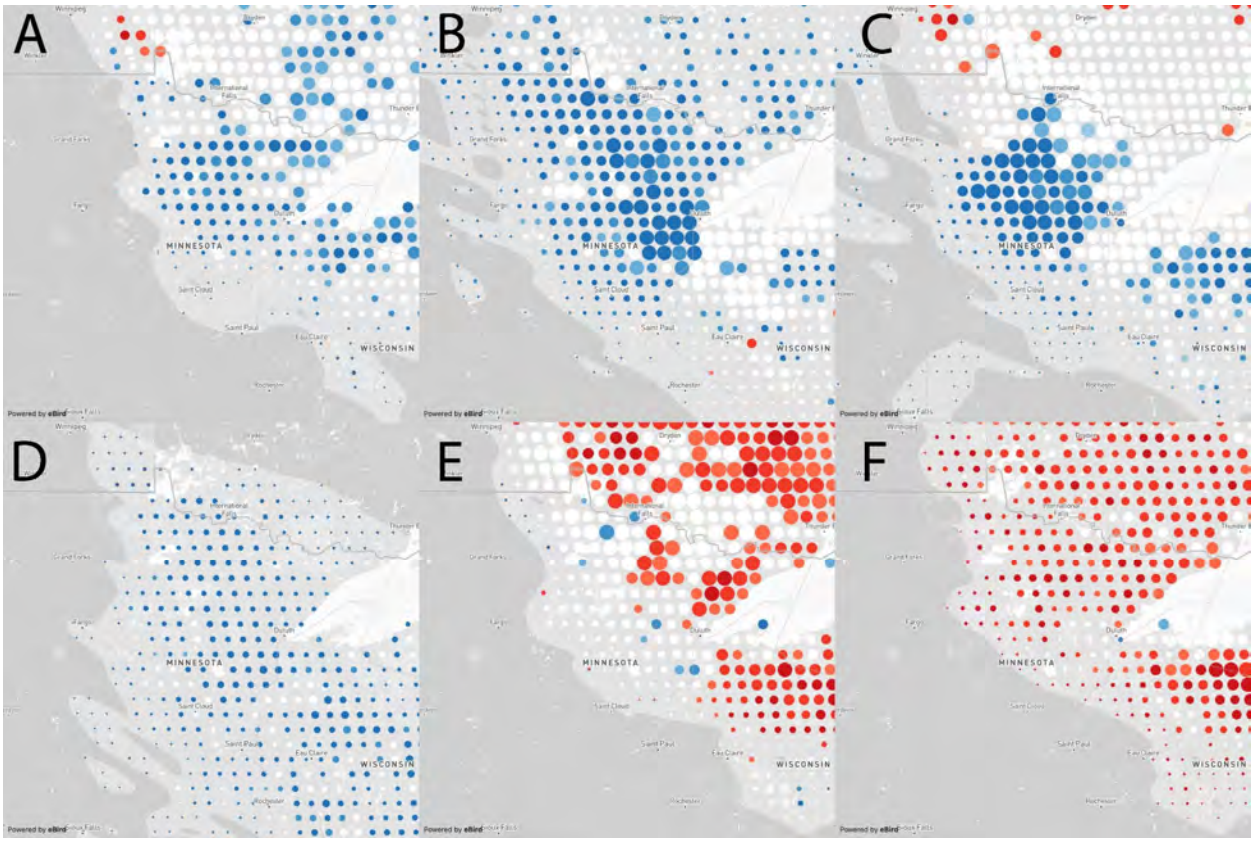

Figure 5. Breeding season trends modeled from eBird data collected between 2007–2021 for Blackburnian Warbler (A), Veery (B), Black-and-white Warbler (C), Wood Thrush (D), Nashville Warbler (E), and Black-throated Green Warbler (F), all of which are significantly increasing in our analysis. Red dots represent decreases in relative abundance during this time frame while blue dots represent increases; the size of the circle represents relative abundance. Note that eBird results for Nashville and Black-throated Green Warblers do not mirror our trends. Maps from Fink et al. (2022).

***Decreasing Species*.** Red-winged Blackbird, Swamp Sparrow, and White-throated Sparrow all showed new region-wide decline this year (Table 6). Fifteen species have shown declining trends over the last six years: American Crow, American Robin, Chestnut-sided Warbler, Chipping Sparrow, Common Loon, Common Yellowthroat, Connecticut Warbler, Downy Woodpecker, Hermit Thrush, Mourning Warbler, Olive-sided Flycatcher, Red-eyed Vireo, Scarlet Tanager, Song Sparrow, and Winter Wren. Of these, four species are identified as SGCN by the MNDNR: Common Loon, Connecticut Warbler, Olive-sided Flycatcher, and Winter Wren (MNDNR 2015). Black-capped Chickadee, Common Raven, Canada Jay, Brown Creeper, and Magnolia Warbler have shown declining trends over the last four years. Recently released eBird regional trends largely agree with trends derived from our analysis, although there are some exceptions (Figure 6). This may be a result of the differing analysis time scales (15 years vs. 28 years) or differences in methodologies (off-road and vigorous point count protocols vs. the variety of data collected by eBird citizen scientists).

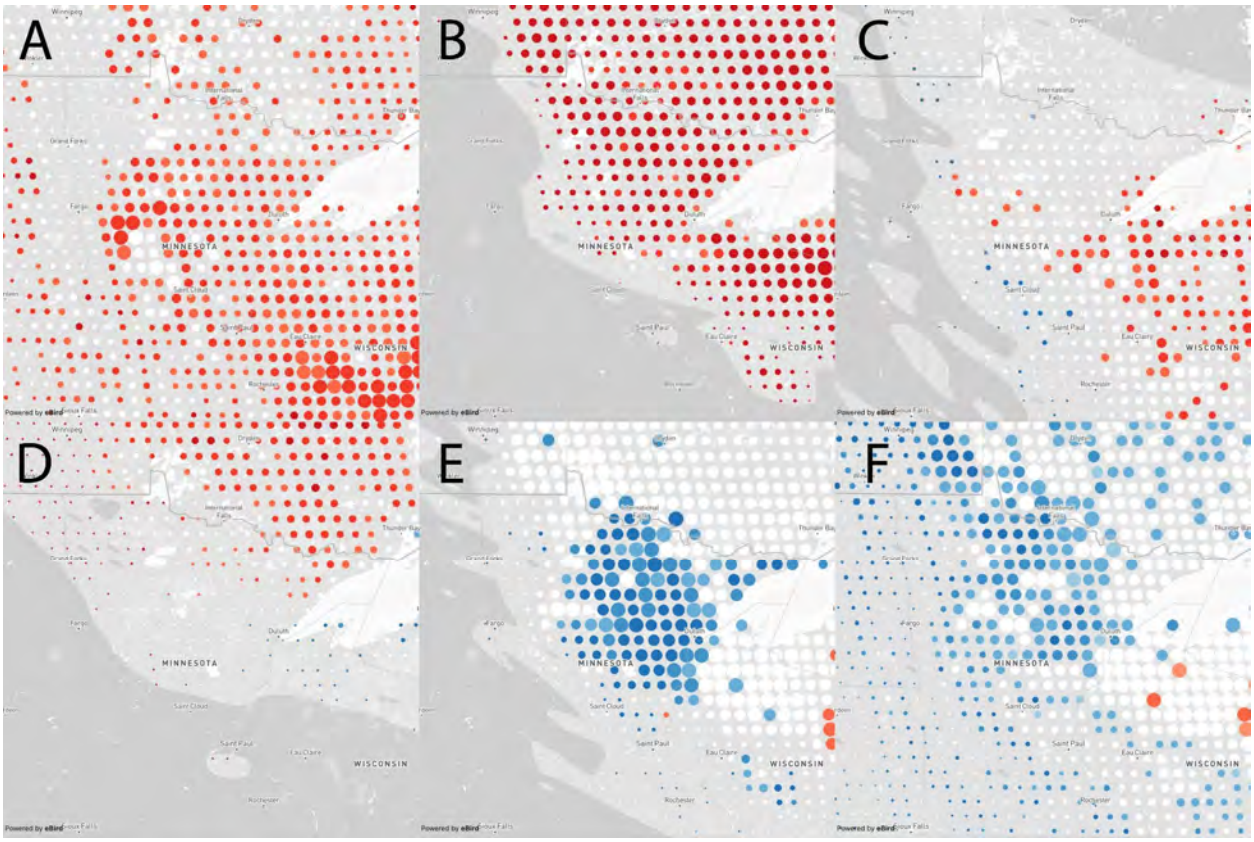

Figure 6. Breeding season trends modeled from eBird data collected between 2007–2021 for Chipping Sparrow (A), Hermit Thrush (B), Scarlet Tanager (C), Swainson's Thrush (D), Chestnut-sided Warbler (E), and Red-eyed Vireo (F), all of which are significantly decreasing in our analysis. Red dots represent decreases in relative abundance during this time frame while blue dots represent increases; the size of the circle represents relative abundance. Note that eBird results for Chestnut-sided Warbler and Red-eyed Vireo do not mirror our trends. Maps from Fink et al. (2022).

Connecticut Warbler has shown the most consistent decline of any species in this monitoring program. The 2018 field season was the first time there were no Connecticut Warbler detections in either NF; there were two detections in 2020, one detection in 2021, and one detection in 2022 (Figure 3). Connecticut Warbler is one of the rarest and most narrowly distributed wood-warblers in the northern coniferous forest. In Minnesota, the species is most common in mature, lowland coniferous forests comprised of widely scattered black spruce and tamarack trees. An understory of sphagnum moss and low shrubs such as Labrador tea, leatherleaf, and swamp laurel is also a common habitat characteristic (Pfannmuller et al. 2017). Because of the restricted breeding range, specific habitat requirements, and a small and declining population, Connecticut Warbler has received multiple conservation designations. It is listed as a Yellow Watch List species, a designation reserved for species that "require constant care and long-term assessment" by Partners in Flight (PIF; Rosenberg et al. 2016). MNDNR identified population declines, habitat loss, and habitat fragmentation as species stressors that prompted their designation as a SGCN (MNDNR 2015). Connecticut Warbler is also designated a Sensitive Species in both the Chippewa and Superior NFs (U.S. Forest Service 2012).

Connecticut Warblers have experienced statistically valid declines at all spatial scales: -8.76% in Chippewa NF, -8.18% in Superior NF, and -8.65% regionally. BBS trends indicate a significant decline (-1.79%) in BCR 12, but a non-significant trend (-0.77%) at the continental scale (Sauer et al. 2020; Figure 3; Table 10). The reasons for these steep declines are unknown, and detailed studies to assess demographic information as well as full life-cycle analyses are needed. Niemi et al. (2016) also highlighted the need to protect and conserve large tracts of black spruce-tamarack forests and emphasized the importance of selecting stands found adjacent to upland coniferous stands, which also provide suitable habitat for this species.

Olive-sided Flycatcher has shown a relatively consistent decline in both forests since 2008 (Figure 3). Habitat loss and degradation on both breeding and non-breeding grounds, coupled with long-term population declines, have led to its classification as a Yellow Watch species by PIF (Rosenberg et al. 2016). In Minnesota, the species was designated a SGCN due to the long-term declines in population (MNDNR 2015) and is also on the regional forester's Sensitive Species List for both the Chippewa and Superior NFs (U.S. Forest Service 2012). Olive-sided Flycatchers have shown a significant decline of -4.94% in Chippewa NF, -0.54% in Superior NF, and -3.66% regionally. BBS trends indicate a 3.05% decline in BCR 12 and a -2.08% decline at the continental scale (Sauer et al. 2020; Figure 3; Table 10). This species is most common in northern bogs and coniferous forests with natural or anthropogenic forest openings and edges (Pfannmuller et al. 2017). Although habitat loss and degradation have been cited as potential stressors, few studies have identified best management practices critical for maintaining populations due to its low density and remote breeding habitat. Recommendations generally focus on protecting existing sites that provide suitable habitat, retaining snags and tall trees in harvested stands, and ensuring the availability of forest openings in appropriate habitats at the landscape scale (Kreitinger and Paulios 2013).

Winter Wren has shown a consistent decline since 2006 in Chippewa NF and since 2011 in Superior NF (Figure 3). Habitat loss is generally identified as the cause of the decline and led to its designation as a SGCN (MNDR 2015). Significant decreasing population trends were detected in Chippewa NF (-2.76%), Superior NF (-1.12%), and regionally (-1.65%) in 2022. However, BBS population trends are relatively stable in BCR 12 (0.69%) and continentally (0.23%; Sauer et al. 2020; Figure 3; Table 10). Winter Wren uses a variety of forest cover types including mixed swamp conifer, lowland hardwood, black spruce-tamarack, and upland aspen-spruce-fir stands. Common features of occupied habitats include the presence of water and a dense understory littered with coarse woody debris including dead logs, slash piles, and upturned roots at the base of fallen trees (Pfannmuller et al. 2017). These structures provide foraging opportunities, nesting sites, and singing perches for Winter Wrens. Forest management plans that aim to conserve mature forest stands across the landscape and promote management practices that ensure the retention of snags and downed and decaying wood help provide additional suitable habitat for Winter Wren.

As stated above, we caution the reliability of the trends for Common Loon and note that BBS trends indicate Common Loon populations are increasing (0.52%) in BCR 12 (Sauer et al. 2020; Figure 3; Table 10). We refer readers to the Minnesota Loon Monitoring Program, a long-term, volunteer-based monitoring program designed to monitor loon populations in the state for more detailed information specific to this species. The Minnesota Loon Monitoring Program reports that while overall loon populations in the northern and central portion of the state have remained relatively stable, those in the Cook/Lake index area (i.e., Superior NF) have shown a marginally significant decline since 1994 (Larson 2019).

Guild Analyses

At both the NF and regional scale, the majority of migratory, nesting, and habitat association guilds showed significant increases from 1995 to 2022 (Table 9).

Migration Guilds. A continued noteworthy pattern is the trends among the migratory guilds; short-distance migrants showed significant declines in Chippewa NF (-1.06%), Superior NF (-0.85%), and regionally (-0.94%). Short-distance migrants are arriving on the breeding grounds earlier as spring phenology advances (Zuckerberg et al. 2015). If birds are initiating territorial behavior earlier each year, our rigid survey window could be failing to detect individuals in a manner that would appear as a declining trend. Increasingly volatile weather during the spring season may be causing true declines in short-distance migrants, especially as species arrive to the breeding grounds earlier.

Long-distance migrants showed stable trends in Superior NF and region-wide but also displayed a significant positive trend in Chippewa NF (0.26%; Figure 4, Table 9). Permanent residents continue to show the greatest overall percentage increase over the past 28 years with an increase of 0.71% per year regionally (Table 9).

Early-successional Habitat Guild. Trend estimates for early-successional species were highest from 2000 to 2010 in Chippewa NF and Superior NF but have been steadily decreasing since that time (Figure 4). Several species associated with open areas and early-successional habitats showed statistically significant declines regionally in 2022 including Chipping Sparrow, Mourning Warbler, Chestnut-sided Warbler, and Song Sparrow. All the aforementioned species are declining in BCR 12 with the exception of the Chestnut-sided Warbler, and overall trends for these species are consistent with continental BBS trends (Sauer et al. 2020; Table 10). These results are likely due to the reduction in logging that has occurred in the two NFs over the past 20 years as documented in Niemi et al. (2016, p. 48–52). However, with the increased focus on the creation of early-successional habitat on state and county land throughout the state, we are not overly concerned with this decline on the NFs. We do not recommend additional cutting aimed at early-successional habitat creation for birds.

Golden-winged Warbler is a species of high conservation concern in Minnesota and has received considerable attention from federal, regional, and local agencies. This species is designated a Red Watch List species by PIF and a SGCN by the MNDNR (MNDNR 2015, Rosenberg et al. 2016). Golden-winged Warbler uses shrub wetlands and young successional habitats with dense ground cover and scattered trees. In Minnesota, most birds of this species have been observed in alder-willow wetlands and young aspen forests (Niemi et al. 2016). While Golden-winged Warbler population trends continue to decrease at the continental scale, population trends in Minnesota have remained stable, likely due to multi-agency efforts to create habitat across the state (Golden-winged Warbler Working Group, 2019, Figure 7).

Currently, over 50% of all Golden-winged Warblers breed in Minnesota, and habitat management of Minnesota forests is critical for the long-term survival of the species. Golden-winged Warbler populations in Minnesota's NFs have remained fairly stable over time, and trend estimates showed a non-significant trend in both Chippewa (1.56) and Superior (-0.54) NFs (Appendix B; Table 10). Importantly, trend estimates have been increasing in Chippewa NF since 2014, likely the result of active habitat management that has occurred in the forest during this time period (Figure 3). Currently, we are conducting a study to determine management actions that maximize productivity of Golden-winged Warblers focusing on the post-fledging period.

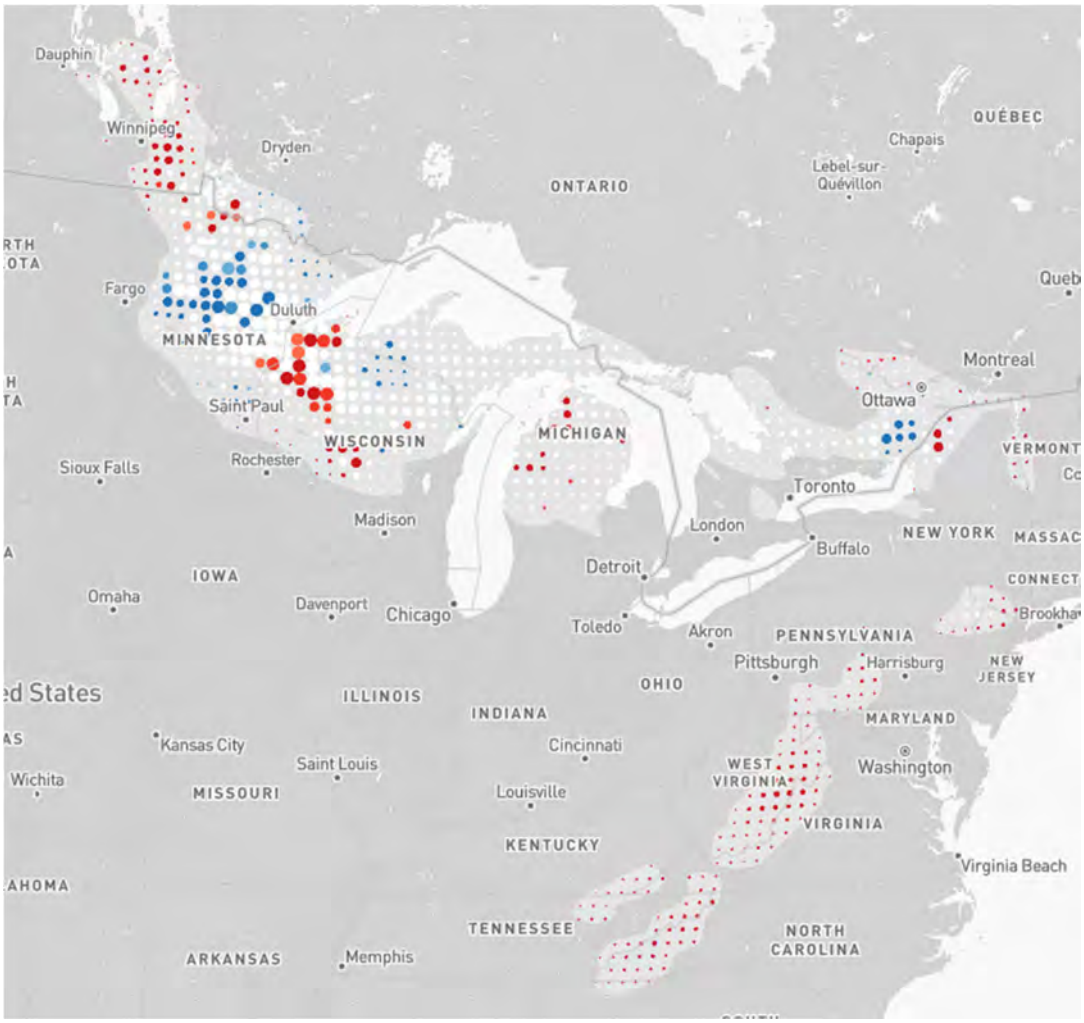

Figure 7. Breeding season trends modeled from eBird data collected between 2007–2021 for Golden-winged Warbler. Red dots represent decreases in relative abundance during this time frame while blue dots represent increases; the size of the circle represents relative abundance. Note that Golden-winged Warbler abundances are highest in the Upper Great Lakes region and that declines are present virtually range-wide outside of north-central Minnesota. Map from Fink et al. (2022).

Lowland Conifer Habitat Guild. Trend estimates for lowland conifer guilds are significantly increasing. This guild includes Canada Jay, Connecticut Warbler, Dark-eyed Junco, Lincoln Sparrow, Nashville Warbler, Northern Parula, Northern Waterthrush, Palm Warbler, Swainson's Thrush, Tennessee Warbler, Winter Wren, and Yellow-bellied Flycatcher. Importantly, of the 12 species that are classified in this guild, only two of the species – Nashville Warbler and Northern Waterthrush – have increasing trends at the regional level. The increasing trend for the lowland conifer guild is likely driven by trends for these two species.

Sub-canopy and Shrub Nesting Guild. Results of the guild analysis showed that there was a significant regional decrease (-0.61, $P < 0.01$) in the subcanopy and shrub-nesting species. Of these, three had increasing regional trends (American Redstart, Black-throated Green Warbler, Wood Thrush), seven species had stable regional trends (Alder Flycatcher, American Goldfinch, Black-Billed Cuckoo, Blue-headed Vireo, Cedar Waxwing, Least Flycatcher, Rose-breasted Grosbeak), and six species had

decreasing trends (American Robin, Canada Jay, Chestnut-sided Warbler, Magnolia Warbler, Red-eyed Vireo, and Red-winged Blackbird); six species (Black-throated Blue Warbler, Eastern Kingbird, Gray Catbird, Indigo Bunting, Swainson's Thrush, Yellow Warbler) did not have sufficient data to calculate trends at a regional level. Management options such as increasing uneven-aged management could be considered to increase nesting structures for these species.

Aerial Insectivores. There are six flycatcher species observed in the national forests that we are able to run trend analysis for: Alder Flycatcher, Eastern Wood-Pewee, Great Crested Flycatcher, Least Flycatcher, Olive-sided Flycatcher, and Yellow-bellied Flycatcher. Four of these species (Alder Flycatcher, Olive-sided Flycatcher, Yellow-bellied Flycatcher, and Least Flycatcher) showed either regional or single NF declines. Eastern Wood-Pewee has had a non-significant trend in both forests for the past two years. Great Crested Flycatcher has a non-significant trend ($P = 0.70$) in the Chippewa NF, the only NF of the two where it is found in suitable abundance for trend analysis. Olive-sided Flycatcher, Least Flycatcher, and Eastern Wood-Pewee are experiencing widespread, significant declines in eastern North America (Pfannmuller et al. 2017; Sauer et al. 2020; Table 10). Yellow-bellied Flycatcher is declining in the northeastern U.S., in Superior NF, and regionally when both NFs are combined. In contrast, Great Crested Flycatcher has maintained a relatively stable population over the past 40 plus years, although there are many areas where their populations are declining. Great Crested Flycatcher is a species that readily uses fragmented forests as long as suitable nest cavities remain (Pfannmuller et al. 2017). The decline in flycatchers may be related to similar issues and declines in aerial insectivores such as swallows and swifts reported by Nebel et al. (2010). Recent research in Europe suggests that the flying insect populations have declined by more than 75% over the duration of a 27-year study. If loss of insect diversity and abundance is also occurring in North America, cascading effects on food webs are likely (Hallman et al. 2017). However, these issues are complex because each bird species has a unique life history and we are unsure how resources or the timing in the availability of resources are changing due to climate and other forest disturbances, but these issues deserve further study (Spiller and Dettmers 2019). In response to our growing concern over the status of aerial insectivore populations, we submitted a research proposal to assess the connections between land-use, food availability and quality, and productivity of aerial insectivores and hope to provide management recommendations to address some of these issues. Identifying connections between forest structure and insect availability is an important next step in the development of conservation and management plans for aerial insectivores.

CONCLUSIONS

The majority (63–73%) of bird species surveyed on the NFs show either stable or increasing trends. However, due to the loss of forest that has occurred over the past century, most forest-associated breeding species likely have much lower populations today than in the past. Minnesota has lost almost half of its forested area: from an estimated 31 million acres in the mid-1800s, the state's forests cover less than 17 million acres today. The fact that there are fewer forested acres on the landscape heightens the importance of the NFs as breeding bird habitat: the Chippewa and Superior National Forests play an essential role in the creation and maintenance of sustainable forest bird populations in Minnesota and the region.

While the majority of species are showing stable trends, the consistent declines in species and species guilds are cause for growing concern. Lowland conifer specialists such as Canada Jay, Olive-sided Flycatcher, Yellow-bellied Flycatcher, and Connecticut Warbler are significantly declining across the NFs. These species are habitat specialists, and Minnesota is the southern edge of the breeding population. We strongly recommend limiting black spruce harvest whenever and wherever possible, especially in non-productive sites where economic margins are slim. Maintaining as much black spruce on the

landscape as possible will be the only way to mitigate the declines in these species while on the breeding grounds.

Aerial insectivores such as Olive-sided, Least, and Yellow-bellied Flycatchers continue to show a pattern of decreasing trends across the NFs. It is likely that aerial insectivores are suffering from a decrease in insect populations, and these effects likely compound from breeding, migration, and non-breeding seasons. While some of these effects are beyond the scope of the NFs, we recommend any actions on the forests that enhance the complexity and heterogeneity of forest stands, an action that will likely benefit insect and corresponding bird populations. All aerial insectivores face compounding threats; for example, Olive-sided Flycatcher and Yellow-bellied Flycatcher are also lowland conifer specialists as discussed above. Declines in species that fit into two or more declining guilds should receive additional consideration with regard to forest management planning and impacts.

While Minnesota's forests are currently, on average, getting older, few stands are ecologically old. As a result, species that require old growth forests continue to decline. Species such as Brown Creeper and Winter Wren rely on stands in which trees grow to maturity, die, and fall over (e.g., decadent aspen stands) for breeding and foraging. Many woodpecker species require large-diameter trees for cavity nests which are subsequently used by species such as Wood Duck, Northern Saw-whet Owl, and Great Crested Flycatcher. Scarlet Tanager, Yellow-throated Vireo, and Wood Thrush populations rely on old deciduous forests and their populations continue to decline as well. We recommend any management that allows forest stands to remain on the landscape well beyond typical rotation age and, ideally, through senescence and natural regeneration.

Recent and future changes to the forested regions of Minnesota will have significant impacts on forest bird populations. The dramatic increase in tamarack killed by eastern larch beetle (665,000 acres; ~50% in the last 19 years; MNDNR 2019) is undoubtedly affecting breeding birds, but the extent and nature of these effects is largely unknown. It is unclear what bird species use tamarack during and after stand infestation, and the long-term consequences of the outbreak are also unknown. Unfortunately, few tamarack stands are sampled in the current monitoring program.

The Chippewa and Superior National Forests continue to play a critical role in the health of bird populations in Minnesota and the Upper Midwest. Because national forests are managed for sustainable multiple uses, as opposed to economic return, the trends reported here likely represent a "best case scenario" for mature and lowland conifer bird species across public ownership. There are ample opportunities to use forest management to conserve and improve breeding bird habitats to ensure the long-term conservation of Minnesota's biodiversity. We believe that many bird populations are reaching critical tipping points that, if passed, will necessitate considerable conservation action. Researchers at the Natural Resources Research Institute are committed to conserving healthy populations of Minnesota's birds and are eager to work together to find creative solutions to provide management recommendations and guidance to any interested parties.

LITERATURE CITED

Bart, J., B. Collins, and R.I.G. Morrison. 2003. Estimating population trends with a linear model. The Condor 105:367-372.

Blake, J.G. 1991. Nested subsets and the distribution of birds on isolated woodlots. Conservation Biology 5(1): 58-66.

Blake, J.G., G.J. Niemi, and J.M. Hanowski. 1992. Drought and annual variation in bird populations: effects of migratory strategy and breeding habitat. Pages 419-429 *in* J.M. Hagan III and D.W. Johnston, editors. Ecology and conservation of Neotropical migrant landbirds. Smithsonian Institution Press, Washington, DC.

Butcher, G.S., D.K. Niven, A.O. Panjabi, D.N. Pashley, and K.V. Rosenberg. 2007. The 2007 WatchList for United States Birds. American Birds 61:18-25.

Cadman, M.D., D.A. Sutherland, G.G. Beck, D. Lepage, and A.R. Couturier. 2007. The Atlas of the Breeding Birds of Ontario, 2001–2005. Toronto: Bird Studies Canada, Environment Canada, Ontario Field Ornithologists, Ontario Ministry of Natural Resources, and Ontario Nature.

Eglington, S.M., and J.W. Pearce-Higgins. 2012. Disentangling the relative importance of changes in climate and land-use intensity in driving recent bird population trends. PLoS One 7(3).

Environment Canada. 2015. Recovery Strategy for Canada Warbler (*Cardellina canadensis*) in Canada [Proposed]. Species at Risk Act Recovery Strategy Series. Environment Canada, Ottawa.

Etterson, M.A., G.J. Niemi, and D.P. Danz. 2009. Estimating the effects of detection heterogeneity and overdispersion on trends estimated from avian point counts. Ecological Applications 19:2049-2066.

Ehrlich, P.R., D.S. Dobkin, and D. Wheye. 1988. The Birder's Handbook: A Field Guide to the Natural History of North American Birds. Simon and Schuster, New York.

Fink, D., T. Auer, A. Johnston, M. Strimas-Mackey, S. Ligocki, O. Robinson, W. Hochachka, L. Jaromczyk, A. Rodewald, C. Wood, I. Davies, A. Spencer. 2022. eBird Status and Trends, Data Version: 2021; Released: 2022. Cornell Lab of Ornithology, Ithaca, New York.

Freemark, K., and B. Collins. 1992. Landscape ecology of birds breeding in temperate forest fragments. Pages 443-454 *in* J.M. Hagan and D.W. Johnston, editors. Ecology and conservation of Neotropical migrant landbirds. Smithsonian Institution Press, Washington, DC.

Gnass Giese, E.E., R.W. Howe, A.T. Wolf, N.A. Miller, and N.G Walton. 2015. Sensitivity of breeding birds to the "human footprint" in western Great Lakes forest landscapes. Ecosphere 6(6).

Golden-winged Warbler Working Group. 2019. Best Management Practices for Golden-winged Warbler Habitats in the Great Lakes Region. 2nd Edition.

Green, J.C. 1995. Birds and forests: A management and conservation guide. Minnesota Department of Natural Resources. St. Paul, MN. 182 pp.

Grinde, A., and G.J. Niemi. 2016. Influence of landscape, habitat, and interspecific interactions on occupancy dynamics of Canada Warblers. The Condor 118:513-531.

Grinde, A.R., G.J. Niemi, B.R. Sturtevant, H. Panci, W. Thogmartin, and P. Wolter. 2017. Long-term avian responses to land cover and climate. Forest Ecology and Management 405:295-308.

Hallmann, C.A., M. Sorg, E. Jongejans, H. Siepel, N. Hofland, H. Schwan, W. Stenmans, A. Müller, H. Sumser, T. Hörren, and D. Goulson. 2017. More than 75 percent decline over 27 years in total flying insect biomass in protected areas. PloS one, 12(10), p.e0185809.

Hanowski, J.M., and G.J. Niemi. 1995a. Experimental design considerations for establishing an off-road, habitat specific bird monitoring program using point counts. Pages 145-150 *in* C.J. Ralph, J.R. Sauer, and S. Droege. Monitoring bird populations by point counts. General Technical Report PSW-GTR-149. Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture, Albany, CA.

Hanowski, J.M., G.J. Niemi, and J.G. Blake. 1990. Statistical perspectives and experimental design in bird censusing with line transects. The Condor 92:326-335.

Hanowski, J.M., J. Lind, N.P. Danz, G.J. Niemi, and M.T. Jones. 2002. Regional breeding bird monitoring in western Great Lakes national forests. Pages 974-981 *in* C.J. Ralph and T.D. Rich, editors. Bird conservation implementation and integration in the Americas. Proceedings of the third international Partners in Flight conference.

Hanowski, J., J. Lind, N. Danz, G. Niemi, and T. Jones. 2005. Regional breeding bird monitoring in western Great Lakes national forests. Pages 974-981 *in* C.J. Ralph and T.D. Rich, editors. Bird conservation implementation and integration in the Americas: proceedings of the Third International Partners in Flight Conference. 2002 March 20-24; Asilomar, California; Volume 2. Gen. Tech. Rep. PSW-GTR-191. Albany CA: Pacific Southwest Research Station, Forest Service, 643 pp.

Howe, R.W., G.J. Niemi, G.J. Lewis, and D.A. Welsh. 1997. A standard method for monitoring songbird populations in the Great Lakes region. Passenger Pigeon 59:182-194.

James, F.C., C.E. McCulloch, and D.A. Wiedenfeld. 1996. New approaches to the analysis of population trends in land birds. Ecology 77:13-27.

Kreitinger, K., and A. Paulios. 2013. The Wisconsin All-Bird Conservation Plan. Madison: Wisconsin Department of Natural Resources, Wisconsin Bird Conservation Initiative.

Krieger, D. 2001. Economic value of forest ecosystem services: A review. The Wilderness Society.

Larson, K. 2019. Minnesota Loon Monitoring Program: 2019 Annual Report. Nongame Wildlife Program.

Lapin, C.N., M.A. Etterson, and G.J. Niemi. 2013. Occurrence of Connecticut Warbler increases with coniferous forest patch size. The Condor 115:168-177.

Link, W.A., and J.R. Sauer. 1997. New approaches to the analysis of population trends in land birds: comment. Ecology 78:2632-2634.

Link, W.A., J.R. Sauer, and D.K. Niven. 2017. Model selection for the North American Breeding Bird Survey: A comparison of methods. The Condor 119:546-556.

MacKenzie, D.I., J.D. Nichols, J.A. Royle, K.H. Pollock, L.L. Bailey, and J.E. Hines. 2006. Occupancy estimation and modeling: inferring patterns and dynamics of species occurrence. Academic Press, New York.

Manly, B.F.J. 1991. Randomization and Monte Carlo methods in biology. Chapman & Hall, London, UK.

Meynard, C. N., and J.F. Quinn. 2008. Bird metacommunities in temperate South American forest: vegetation structure, area, and climate effects. Ecology 89: 981–990.

Minnesota Department of Natural Resources. 2015. Minnesota's Wildlife Action Plan 2015-2025. Division of Ecological and Water Resources, Minnesota Department of Natural Resources.

Minnesota Department of Natural Resources. 2019. Forest Health Annual Report. Division of Forestry, Minnesota Department of Natural Resources.

Nebel, S., A. Mills, J.D. McCracken, and P.D. Taylor. 2010. Declines of aerial insectivores in North America follow a geographic gradient. Avian Conservation and Ecology 5:1. doi: 10.5751/ACE-00391-050201

Niemi, G.J., J.M. Hanowski, N.P. Danz, R.W. Howe, M. Jones, J. Lind, and D. Mladenoff. 2004. Hierarchical scales in landscape responses by forest birds. Pages 56-68 *in* L.A. Kapustka, H. Gilbraith, M. Luxon, and G.R. Biddinger, editors. Landscape ecology and wildlife habitat evaluation: critical information for ecological risk assessment, land-use management activities, and biodiversity enhancement practices. STP 1458. ASTM International, West Conshohocken, PA.

Niemi, G.J., and M. McDonald. 2004. Application of ecological indicators. Annual Review of Ecology and Systematics 35:89-111.

Niemi, G.J. R.W. Howe, B.R. Sturtevant, L.R. Parker, A.R. Grinde, N.P. Danz, M.D. Nelson, E.J. Zlonis, N.G. Walton, E.E. Gnass Giese, and S.M. Lietz. 2016. Analysis of long-term forest bird monitoring data from national forests of the western Great Lakes Region. Gen. Tech. Rep. NRS-159. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 322 p.

Pfannmuller, L. 2012. Stewardship birds of Minnesota. Audubon Minnesota. St. Paul MN. 28 pp.

Pfannmuller, L., G. Niemi, J. Green, B. Sample, N. Walton, E. Zlonis, A. Bracey, G. Host, J. Reed, K Rewinkel, and N. Will. 2017. The Minnesota Breeding Bird Atlas.

Philpott, S.M., O. Soong, J.H. Lowenstein, A.L. Pulido, D.T. Lopez, D.F. Flynn, and F. DeClerc. 2009. Functional richness and ecosystem services: bird predation on arthropods in tropical agroecosystems. Ecological Applications 19(7): 1858-1867.

Reitsma, L., M. Goodnow, M.T. Hallworth, and C.J. Conway. 2010. Canada Warbler (*Cardellina canadensis*). *In* A. Poole, editor. The Birds of North America Online. Cornell Lab of Ornithology, Ithaca, NY, USA.

Rich, T.D., C.J. Beardmore, H. Berlanga, P.J. Blancher, M.S. Bradstreet, G.S. Butcher, D.W. Demarest, E.H. Dunn, W.C. Hunter, E.E. Iñigo-Elias, J.A. Kennedy, A.M. Martell, A.O. Panjabi, D.N. Pashley, K.V. Rosenberg, C.M. Rustay, J.S. Wendt, and T.C. Will. 2004. Partners in Flight North American Landbird Conservation Plan. Cornell Lab of Ornithology, Ithaca, NY.

Riordan, E.C., and P.W. Rundel. 2014. Land use compounds habitat losses under projected climate change in a threatened California ecosystem. PLoS One 9(1).

Robbins, C. S., D. K. Dawson, and B. A. Dowell. 1989. Habitat area requirements of breeding forest birds of the Middle Atlantic states. Wildlife Monographs 103.

Rosenberg, K.V., J.A. Kennedy, R. Dettmers, R.P. Ford, D. Reynolds, J.D. Alexander, C.J. Beardmore, P.J. Blancher, R.E. Bogart, G.S. Butcher, A.F. Camfield, A. Couturier, D.W. Demarest, W.E. Easton, J.J. Giocomo, R.H. Keller, A.E. Mini, A.O. Panjabi, D.N. Pashley, T.D. Rich, J.M. Ruth, H. Stabins, J. Stanton, and T. Will. 2016. Partners in Flight Landbird Conservation Plan: 2016 Revision for Canada and Continental United States. Partners in Flight Science Committee.

Sauer, J.R., D.K. Niven, J.E. Hines, D.J. Ziolkowski, Jr, K.L. Pardieck, J.E. Fallon, and W.A. Link. 2020. BBS trends 1966-2017. Patuxent Wildlife Research Center - Bird Population Studies. USGS Patuxent Wildlife Research Center, Laurel, MD.

Sauer, J.R., and W.A. Link. 2011. Analysis of the North American breeding bird survey using hierarchical models. The Auk 128:87-98.

Sauer, J.R., G.W. Pendleton, and B.G. Peterjohn. 1996. Evaluating causes of population change in North American insectivorous songbirds. Conservation Biology 10:465-478.

Şekercioğlu, Ç.H., R.B. Primack, and J. Wormworth. 2012. The effects of climate change on tropical birds. Biological Conservation 148(1): 1-18.

Sekercioğlu, Ç.H., D.G. Wenny, and C.J. Whelan. 2017. Why birds matter: avian ecological function and ecosystem services. The University of Chicago Press, Chicago.

Spiller, K.J. and R. Dettmers. 2019. Evidence for multiple drivers of aerial insectivore declines in North America. Condor 121:1-13.

Sturtevant, B.R., G.L. Achtemeier, J.J. Charney, D.P. Anderson, B.J. Cooke, and P.A. Townsend. 2013. Long-distance dispersal of spruce budworm (*Choristoneura fumiferana* Clemens) in Minnesota (USA) and Ontario (Canada) via the atmospheric pathway. Agricultural and Forest Meteorology 168:186-200.

United States Department of Agriculture, Forest Service. 2012. National Forest System Land Management Planning, RIN 0569-AD02.

U.S. Fish and Wildlife Service. 2008. Birds of Conservation Concern 2008. U.S. Department of Interior, Fish and Wildlife Service, Division of Migratory Bird Management, Arlington, VA, USA.

Urquhart N.S., and T.M. Kincaid. 1999. Designs for detecting trend from repeated surveys of ecological resources. Journal of Agricultural, Biological, and Environmental Statistics 4:404-414.

Whelan, C.J., D.G. Wenny, and R.J. Marquis. 2008. Ecosystem services provided by birds. Annals of the New York academy of sciences 1134(1): 25-60.

Zuckerberg, B., E.J. Ross, K. Princé, and D.N. Bonter. 2015. Climate on wintering grounds drives spring arrival of short-distance migrants to the Upper Midwest. Pp. 83–94 in E.M. Wood and J.L. Kellermann (editors), Phenological synchrony and bird migration: changing climate and seasonal resources in North America. Studies in Avian Biology (no. 47), CRC Press, Boca Raton, FL.

TABLES

Table 1. Trends for two NFs and pooled NFs based on linear regression of loess-smoothed annual index of abundance (See Methods) (1995–2021). I = significantly increasing, D = significantly decreasing. * $P < 0.05$, ** $P < 0.01$. See Appendix A for species graphs and Appendix B for test statistics and sample sizes.

Species	Chippewa NF	Superior NF	Regional
Alder Flycatcher	D*	ns	ns
American Bittern	-	ns	-
American Crow	ns	D**	D**
American Goldfinch	ns	ns	ns
American Redstart	ns	I*	I**
American Robin	D**	ns	D**
Black-and-white Warbler	I**	I**	I**
Black-billed Cuckoo	I**	D**	ns
Black-capped Chickadee	D**	D**	D**
Black-throated Blue Warbler	-	ns	-
Black-throated Green Warbler	I*	I**	I**
Blackburnian Warbler	ns	ns	I*
Blue-headed Vireo	D*	ns	ns
Blue Jay	I**	I**	I**
Broad-winged Hawk	ns	D*	ns
Brown-headed Cowbird	D**	-	-
Brown Creeper	ns	D**	D**
Canada Jay	ns	D**	D**
Canada Warbler	I**	ns	ns
Cape May Warbler	-	I**	-
Cedar Waxwing	ns	I*	ns
Chestnut-sided Warbler	ns	D**	D**
Chipping Sparrow	D**	D**	D**
Common Loon	D*	D**	D**
Common Raven	ns	D**	D**
Common Yellowthroat	D*	D**	D**
Connecticut Warbler	D**	D**	D**
Dark-eyed Junco (Slate-colored)	ns	ns	ns
Downy Woodpecker	ns	ns	D*
Eastern Kingbird	D**	-	-
Eastern Towhee	ns	-	-

Species	Chippewa NF	Superior NF	Regional
Eastern Wood-Pewee	ns	ns	ns
Evening Grosbeak	-	D*	-
Golden-crowned Kinglet	ns	I*	ns
Golden-winged Warbler	ns	ns	ns
Gray Catbird	ns	-	-
Great Crested Flycatcher	ns	-	-
Hairy Woodpecker	ns	ns	ns
Hermit Thrush	D**	D**	D**
Indigo Bunting	D**	-	-
Least Flycatcher	D**	ns	ns
Lincoln's Sparrow	I**	D**	ns
Magnolia Warbler	ns	D**	D*
Mourning Dove	I*	-	-
Mourning Warbler	ns	D**	D**
Nashville Warbler	I**	I**	I**
Northern Flicker (Yellow-shafted)	ns	ns	ns
Northern Parula	ns	ns	ns
Northern Waterthrush	I**	I**	I**
Olive-sided Flycatcher	D**	ns	D**
Ovenbird	I**	ns	I**
Palm Warbler (Western)	ns	-	-
Pileated Woodpecker	I*	ns	ns
Pine Warbler	I**	I**	I**
Purple Finch	ns	I*	I*
Red-breasted Nuthatch	I**	I**	I**
Red-eyed Vireo	D**	D**	D**
Red-winged Blackbird	ns	ns	D*
Rose-breasted Grosbeak	ns	ns	ns
Ruby-crowned Kinglet	I**	I**	I**
Ruby-throated Hummingbird	I**	ns	I**
Ruffed Grouse	-	I**	-
Scarlet Tanager	D**	ns	D**
Song Sparrow	D**	D**	D**
Swainson's Thrush	-	D**	-
Swamp Sparrow	ns	D**	D*

Species	Chippewa NF	Superior NF	Regional
Tennessee Warbler	-	I**	-
Veery	I**	ns	I**
White-breasted Nuthatch	ns	-	-
White-throated Sparrow	ns	D**	D**
Wilson's Snipe	ns	ns	ns
Winter Wren	D**	D**	D**
Wood Thrush	I*	ns	I*
Yellow-bellied Flycatcher	I**	D**	ns
Yellow-bellied Sapsucker	I*	ns	ns
Yellow-rumped Warbler (Myrtle)	D**	D*	D**
Yellow-throated Vireo	ns	-	-
Yellow Warbler	ns	-	-

Table 2. Species with significantly increasing trends ($P \leq 0.05$) for two NFs and region-wide (1995–2022), based on regression of loess-smoothed annual index of abundance. ** $P \leq 0.01$. Species graphs can be found in Appendix A.

Chippewa NF	Superior NF	Regional
Black-and-white Warbler**	American Redstart*	American Redstart**
Black-billed Cuckoo**	Black-and-white Warbler**	Black-and-white Warbler**
Black-throated Green Warbler*	Black-throated Green Warbler**	Black-throated Green Warbler**
Blue Jay**	Blue Jay**	Blackburnian Warbler*
Canada Warbler**	Cape May Warbler**	Blue Jay**
Lincoln's Sparrow**	Cedar Waxwing*	Nashville Warbler**
Mourning Dove*	Golden-crowned Kinglet*	Northern Waterthrush**
Nashville Warbler**	Nashville Warbler**	Ovenbird**
Northern Waterthrush**	Northern Waterthrush**	Pine Warbler**
Ovenbird**	Pine Warbler**	Purple Finch*
Pileated Woodpecker*	Purple Finch*	Red-breasted Nuthatch**
Pine Warbler**	Red-breasted Nuthatch**	Ruby-crowned Kinglet**
Red-breasted Nuthatch**	Ruby-crowned Kinglet**	Ruby-throated Hummingbird**
Ruby-crowned Kinglet**	Ruffed Grouse**	Veery**
Ruby-throated Hummingbird**	Tennessee Warbler**	Wood Thrush*
Veery**		
Wood Thrush*		
Yellow-bellied Flycatcher**		

Table 3. Summary of species with increasing trends ($P \leq 0.05$) on two NFs (1995–2022). Individual species graphs can be found in Appendix A.

Increased in one NF	Increased in both NFs
American Redstart	Black-and-white Warbler
Black-billed Cuckoo	Black-throated Green Warbler
Canada Warbler	Blue Jay
Cape May Warbler	Nashville Warbler
Cedar Waxwing	Northern Waterthrush
Golden-crowned Kinglet	Pine Warbler
Lincoln's Sparrow	Red-breasted Nuthatch
Mourning Dove	Ruby-crowned Kinglet
Ovenbird	
Pileated Woodpecker	
Purple Finch	
Ruby-throated Hummingbird	
Ruffed Grouse	
Tennessee Warbler	
Veery	
Wood Thrush	
Yellow-bellied Flycatcher	
Yellow-bellied Sapsucker	

Table 4. Species with significantly decreasing trends (p < 0.05) for two NFs (1995–2022), based on regression of loess-smoothed annual index of abundance. ** *P* < 0.01. Species graphs can be found in Appendix A.

Chippewa NF	Superior NF	Regional
Alder Flycatcher*	American Crow**	American Crow**
American Robin**	Black-billed Cuckoo**	American Robin**
Black-capped Chickadee**	Black-capped Chickadee**	Black-capped Chickadee**
Blue-headed Vireo*	Broad-winged Hawk*	Brown Creeper**
Brown-headed Cowbird**	Brown Creeper**	Canada Jay**
Chipping Sparrow**	Canada Jay**	Chestnut-sided Warbler**
Common Loon*	Chestnut-sided Warbler**	Chipping Sparrow**
Common Yellowthroat*	Chipping Sparrow**	Common Loon**
Connecticut Warbler**	Common Loon**	Common Raven**
Eastern Kingbird**	Common Raven**	Common Yellowthroat**
Hermit Thrush**	Common Yellowthroat**	Connecticut Warbler**
Indigo Bunting**	Connecticut Warbler**	Downy Woodpecker*
Least Flycatcher**	Evening Grosbeak*	Hermit Thrush**
Olive-sided Flycatcher**	Hermit Thrush**	Magnolia Warbler*
Red-eyed Vireo**	Lincoln's Sparrow**	Mourning Warbler**
Scarlet Tanager**	Magnolia Warbler**	Olive-sided Flycatcher**
Song Sparrow**	Mourning Warbler**	Red-eyed Vireo**
Winter Wren**	Red-eyed Vireo**	Red-winged Blackbird*
Yellow-rumped Warbler (Myrtle)**	Song Sparrow**	Scarlet Tanager**
	Swainson's Thrush**	Song Sparrow**
	Swamp Sparrow**	Swamp Sparrow*
	White-throated Sparrow**	White-throated Sparrow**
	Winter Wren**	Winter Wren**
	Yellow-bellied Flycatcher**	Yellow-rumped Warbler (Myrtle)**
	Yellow-rumped Warbler (Myrtle)*	

Table 5. Species with marginally significant trends ($0.05 < P \leq 0.10$) for two NFs and region-wide (1995–2022), based on regression of loess-smoothed annual index of abundance. Direction of trend indicated by either positive (+) or negative-sign (-). Species graphs can be found in Appendix A.

Chippewa NF	Superior NF	Regional
Blackburnian Warbler (+)	Black-throated Blue Warbler (+)	Blue-headed Vireo (-)
Swamp Sparrow (-)		Canada Warbler (+)
		Cedar Waxwing (+)

Table 6. Species with changes in trend significance from 2021 to 2022. Changes were either in a positive direction, from decreasing (2021) to non-significant (2022) or non-significant to increasing, or in a negative direction, from increasing to non-significant or non-significant to decreasing. The specific National Forest where the change occurred is indicated. Species graphs can be found in Appendix A.

Decreasing to non-significant	Non-significant to increasing	Increasing to non-significant	Non-significant to decreasing
Downy Woodpecker, Superior	Black-and-white Warbler, Superior	Cedar Waxwing, Regional	Common Loon, Chippewa
Rose-breasted Grosbeak, Superior	Blackburnian Warbler, Regional	Purple Finch, Chippewa	Red-winged Blackbird, Regional
Yellow-bellied Flycatcher, Regional	Golden-crowned Kinglet, Superior		Swamp Sparrow, Regional
	Veery, Regional		Swamp Sparrow, Superior
	Wood Thrush, Chippewa		White-throated Sparrow, Regional
	Wood Thrush, Regional		Yellow-rumped Warbler (Myrtle), Superior

Table 7. Summary of the 20 most common species in 2021 from 25 stands (75 points) first added to the Chippewa NF in 2016. Included in the summary are total individuals observed, mean abundance (observations/point, stand), and percent occupied (points, stands). Points sampled are intended to target Golden-winged Warblers or non-forested habitats. Sites chosen represent a broad range of environmental conditions from open, wet shrubby habitats to dryer, forested upland habitats.

Species	Total Individuals	Point		Stand	
		Mean Abundance	% Occupied	Mean Abundance	% Occupied
Alder Flycatcher	38	0.5	40	1.5	76
American Crow	30	0.4	28	1.2	56
American Redstart	12	0.2	13	0.5	32
Black-and-white Warbler	83	1.1	76	3.3	92
Blue Jay	50	0.7	51	2.0	84
Chestnut-sided Warbler	73	1.0	60	2.9	88
Common Yellowthroat	126	1.7	85	5.0	100
Golden-winged Warbler	47	0.6	51	1.9	80
Least Flycatcher	13	0.2	8	0.5	12
Nashville Warbler	111	1.5	73	4.4	96
Northern Parula	13	0.2	13	0.5	32
Ovenbird	105	1.4	73	4.2	84
Red-breasted Nuthatch	19	0.3	21	0.8	48
Red-eyed Vireo	112	1.5	85	4.5	100
Rose-breasted Grosbeak	29	0.4	33	1.2	60
Swamp Sparrow	73	1.0	45	2.9	68
Veery	138	1.8	80	5.5	100
White-throated Sparrow	65	0.9	51	2.6	76
Yellow-bellied Sapsucker	19	0.3	23	0.8	44
Yellow Warbler	16	0.2	17	0.6	40

Table 8. Population trend estimates (% annual change) and associated test statistics for lowland-conifer forests in the Superior NF (2008–2022). Only species in "conifer" and "lowland-conifer" habitat guilds were analyzed. Included for each species are its trend within the Superior NF, the significance of the trend (*P*), the explained variation of the trend (r^2), and the number of stands (n) in which the species was detected sufficiently to include in the trend calculation.

Species	Trend (%)	*P*	r^2	n
Blackburnian Warbler	1.57	0.44	0.31	30
Blue-headed Vireo	2.20	0.36	0.27	22
Canada Jay	-1.12	0.80	0.04	9
Cape May Warbler	15.77	<0.01	1.00	14
Chipping Sparrow	-3.56	0.14	0.62	9
Common Raven	-8.31	<0.01	0.92	10
Connecticut Warbler	-15.55	<0.01	0.97	5
Dark-eyed Junco (Slate-colored)	7.02	0.16	0.45	8
Golden-crowned Kinglet	-0.42	0.64	0.25	34
Magnolia Warbler	0.58	0.70	0.03	38
Nashville Warbler	-0.16	0.80	0.09	42
Northern Parula	-4.09	0.08	0.84	20
Northern Waterthrush	7.03	<0.01	0.78	13
Red-breasted Nuthatch	2.18	0.05	0.32	41
Ruby-crowned Kinglet	0.82	0.66	0.19	30
Swainson's Thrush	1.78	0.20	0.65	34
Tennessee Warbler	17.76	<0.01	0.98	19
Winter Wren	-2.17	0.02	0.58	41
Yellow-bellied Flycatcher	3.70	<0.01	0.92	38
Yellow-rumped Warbler (Myrtle)	-1.84	0.20	0.20	36

Table 9. Test statistics and sample sizes for guild trend analyses on two NFs and a combined regional analysis (1995–2022). All species combined within each guild category and analyzed as a group, regardless of whether a species meets criteria for individual species analyses. Trend = percent annual change in population trend. n = number of stands with detections. See Appendix A for trend graphs.

Guild Category	Chippewa NF				Superior NF				Regional			
	Trend (%)	*P*	r^2	n	Trend (%)	*P*	r^2	n	Trend (%)	*P*	r^2	n
Coniferous forest species	-0.18	0.36	0.02	125	0.65	<0.01	0.43	147	0.30	<0.01	0.09	272
Deciduous forest species	0.19	0.02	0.05	126	-0.20	0.07	0.10	147	0.01	0.91	0.00	273
Early-successional species	-0.04	0.94	0.01	126	-1.02	<0.01	0.47	147	-0.62	<0.01	0.34	273
Lowland-conifer species	0.29	0.17	0.21	120	0.27	0.02	0.15	147	0.26	0.01	0.17	267
Mixed forest species	0.56	<0.01	0.28	126	-0.19	0.21	0.05	147	0.17	0.18	0.04	273
Long-distance migrants	0.26	<0.01	0.15	126	-0.10	0.12	0.04	147	0.07	0.13	0.02	273
Permanent residents	0.60	<0.01	0.22	126	0.79	<0.01	0.36	147	0.71	<0.01	0.29	273
Short-distance migrants	-1.06	<0.01	0.47	126	-0.85	<0.01	0.27	147	-0.94	<0.01	0.36	273
Canopy nesting species	-0.10	0.43	0.02	126	0.62	<0.01	0.40	147	0.26	<0.01	0.11	273
Cavity nesting species	0.52	0.01	0.10	126	0.03	0.98	0.00	147	0.29	0.06	0.03	273
Ground nesting species	0.39	<0.01	0.28	126	-0.30	<0.01	0.17	147	-0.02	0.76	0.00	273
Shrub nesting species	-0.64	<0.01	0.35	126	-0.58	<0.01	0.39	147	-0.61	<0.01	0.36	273
Nest parasites	-4.39	<0.01	0.82	21	-	-	-	-	-	-	-	-

Table 10. Trend direction for 77 bird species in Chippewa and Superior NFs and corresponding Breeding Bird Survey (BBS) trends in Bird Conservation Region 12 (BCR12) and survey-wide (North America). Color-coding indicates direction if the trend 95% CI did not include zero: red is a negative trend, green is a positive trend. Yellow indicates that the 95% CI included zero. NF trends are 1995 through 2022, while BBS trends are 1966 through 2019 (Sauer et al. 2020). Note BBS trends for American Redstart and Downy Woodpecker were not available.

Common Name	Chippewa	Superior	Regional	BCR12	North America
Alder Flycatcher	-2.36	0.28	-0.49	0.07	-0.54
American Bittern	-	-0.59	-	-0.25	-0.74
American Crow	-0.60	-3.78	-1.36	-0.03	-0.23
American Goldfinch	-0.34	1.14	0.10	-0.97	-0.60
American Redstart	0.83	1.13	0.96	-	-
American Robin	-2.05	-0.35	-0.99	-0.28	0.13
Black-and-white Warbler	4.00	0.86	2.17	-0.11	-0.28
Black-billed Cuckoo	5.21	-4.55	-0.79	-1.34	-2.07
Black-capped Chickadee	-1.37	-1.34	-1.35	1.48	0.49
Black-throated Blue Warbler	-	2.57	-	1.26	1.24
Black-throated Green Warbler	1.15	1.44	1.30	0.04	0.00
Blackburnian Warbler	0.91	0.45	0.58	0.26	0.17
Blue-headed Vireo	-1.49	-0.28	-0.89	2.97	2.02
Blue Jay	1.45	1.10	1.24	0.42	-0.59
Broad-winged Hawk	3.34	-5.08	-1.40	0.49	0.60
Brown-headed Cowbird	-4.39	-	-	-4.19	-0.51
Brown Creeper	-1.06	-2.15	-1.56	2.18	0.37
Canada Jay	-2.17	-2.51	-2.40	-0.16	-0.27
Canada Warbler	3.52	0.16	0.66	-1.58	-1.33
Cape May Warbler	-	5.09	-	0.99	0.94
Cedar Waxwing	-0.06	2.10	1.11	-1.27	-0.14
Chestnut-sided Warbler	-0.22	-1.36	-0.85	0.04	-0.80
Chipping Sparrow	-3.84	-4.20	-3.95	-0.73	-0.63
Common Loon	-1.31	-4.24	-2.14	0.52	0.29
Common Raven	-0.57	-1.71	-1.15	2.42	1.99
Common Yellowthroat	-1.27	-2.32	-1.54	-0.28	-0.56
Connecticut Warbler	-8.76	-8.18	-8.65	-1.79	-0.77
Dark-eyed Junco (Slate-colored)	4.96	2.17	3.91	-1.52	-0.70
Downy Woodpecker	-2.16	-5.26	-2.94	-	-
Eastern Kingbird	-2.96	-	-	-2.26	-0.99
Eastern Towhee	-1.08	-	-	-1.81	-1.40
Eastern Wood-Pewee	-0.55	0.47	-0.37	-0.69	-1.07
Evening Grosbeak	-	-5.50	-	-5.02	-2.52
Golden-crowned Kinglet	-1.39	1.20	0.58	1.59	-0.71
Golden-winged Warbler	1.56	-0.54	1.10	-0.71	-1.85
Gray Catbird	-1.48	-	-	-1.05	0.02

Common Name	Chippewa	Superior	Regional	BCR12	North America
Great Crested Flycatcher	0.29	-	-	-1.39	-0.10
Hairy Woodpecker	1.23	0.76	1.05	1.32	0.66
Hermit Thrush	-1.13	-2.66	-1.84	0.45	-0.01
Indigo Bunting	-5.53	-	-	-0.14	-0.62
Least Flycatcher	-1.56	1.06	-0.64	-1.66	-1.04
Lincoln's Sparrow	5.20	-4.69	2.74	-1.13	0.22
Magnolia Warbler	0.40	-1.18	-1.06	1.00	0.80
Mourning Dove	2.08	-	-	2.19	-0.42
Mourning Warbler	-0.42	-2.29	-1.70	-0.56	-1.60
Nashville Warbler	0.97	0.97	0.95	0.12	-0.20
Northern Flicker (Yellow-shafted)	-0.18	-0.77	-0.60	-0.78	-1.21
Northern Parula	0.49	0.51	0.51	3.88	1.16
Northern Waterthrush	3.09	4.58	3.83	-0.39	1.05
Olive-sided Flycatcher	-4.94	-0.54	-3.66	-3.05	-2.08
Ovenbird	1.21	-0.16	0.45	0.01	0.28
Palm Warbler (Western)	1.68	-	-	1.10	0.65
Pileated Woodpecker	2.19	-0.21	0.52	3.88	1.28
Pine Warbler	1.58	4.33	2.12	3.43	1.29
Purple Finch	1.71	2.48	2.05	-1.07	-0.73
Red-breasted Nuthatch	2.60	2.80	2.71	2.55	0.81
Red-eyed Vireo	-0.58	-0.74	-0.63	0.82	0.59
Red-winged Blackbird	-1.55	-1.87	-1.61	-0.36	-0.62
Rose-breasted Grosbeak	-0.29	-0.72	-0.55	-0.54	-0.24
Ruby-crowned Kinglet	7.27	6.14	6.25	-0.84	0.70
Ruby-throated Hummingbird	4.55	0.85	3.91	0.97	0.95
Ruffed Grouse	-	3.17	-	0.12	0.61
Scarlet Tanager	-1.29	-0.47	-1.12	-0.95	-0.13
Song Sparrow	-5.51	-4.63	-5.13	-0.88	-0.59
Swainson's Thrush	-	-3.54	-	-0.71	-0.46
Swamp Sparrow	-1.76	-1.97	-1.80	1.14	0.86
Tennessee Warbler	-	8.12	-	-0.98	-0.60
Veery	0.92	0.22	0.59	-0.91	-0.61
White-breasted Nuthatch	-0.81	-	-	1.63	1.15
White-throated Sparrow	-0.32	-0.85	-0.70	-0.75	-0.74
Wilson's Snipe	0.82	-2.06	-0.77	-0.17	0.71
Winter Wren	-2.76	-1.12	-1.65	0.69	0.25
Wood Thrush	3.09	0.51	2.53	-1.69	-1.30
Yellow-bellied Flycatcher	1.91	-1.39	-0.51	1.22	2.02
Yellow-bellied Sapsucker	1.11	-0.46	0.35	1.67	0.88
Yellow-rumped Warbler (Myrtle)	-1.48	-0.73	-1.05	0.24	0.21
Yellow-throated Vireo	-0.19	-	-	1.58	0.90
Yellow Warbler	-0.50	-	-	-0.38	-0.40

APPENDICES

The following appendices are individually attached to this document:

Appendix A. Population trend graphs of calculated annual index for individual species within the Chippewa and Superior NFs, and regionally over the 25-year time period (1995–2022) of the study.

Appendix B. Population trend estimates (% annual change) and associated test statistics for the Chippewa NF, Superior NF, and a combined regional analysis (1995–2022). Included for each species are its trend (% annual change) within each NF, a regional trend (if possible), the significance of the trend (*P*), the explained variation of the trend (r^2), and the number of stands (n) in which the species was detected sufficiently to include in the trend calculation.

Appendix C. Common and scientific name, four-letter abbreviation, migration strategy, nest site, and typical habitat of each species with adequate information for trend analysis in 2022.

Appendix D. Number of observations on the Chippewa NF for species not tested for population trends in 2022. Includes flyovers and all birds regardless of distance.

Appendix E. Number of observations on the Superior NF for species not tested for population trends in 2022. Includes flyovers and all birds regardless of distance.

Appendix F. Results of trend analysis for 20 species that are associated with conifer or lowland-conifer for breeding habitat. Forty-two lowland conifer stands, including 25 stands that were added to the sampling design in 2008, that are primarily composed of black spruce, tamarack, or mixed swamp conifer were included in this analysis.

Appendix G. Study and design methods.

Appendix H. Estimated annual indices from 1995 to 2022 for breeding birds in Chippewa NF. A stretched color scheme was applied to each species with red for low indices, yellow average, and green high, to visualize relative changes in indices over time.

Appendix I. Estimated annual indices from 1995 to 2022 for breeding birds in Superior NF. A stretched color scheme was applied to each species with red for low indices, yellow average, and green high, to visualize relative changes in indices over time.