Peer-reviewed

Recent Declines in Gray Jays on Christmas Bird Counts in Northern Wisconsin

Ryan C. Menebroeker

Northland College
1411 Ellis Avenue
Ashland, WI 54806
menebr199@myemail.northland.edu

Paula Spaeth Anich

Northland College
1411 Ellis Avenue
Ashland, WI 54806
panich@northland.edu

Derek H. Ogle

Northland College
1411 Ellis Avenue
Ashland, WI 54806
dogle@northland.edu

Nicholas M. Anich

Wisconsin Department of Natural Resources
2501 Golf Course Road
Ashland, WI 54806
nicholas.anich@wisconsin.gov

Abstract

*Gray Jays (*Perisoreus canadensis*) are resident, boreal birds of northern Wisconsin, typically associated with Black Spruce (*Picea mariana*) bogs. Gray Jays cache perishable food items for over-winter consumption, and are therefore dependent on cold weather and the antibacterial and antifungal properties of the Black Spruce trees in which they store their food for cache-preservation. Warming climate trends and loss of Black Spruce habitat may adversely affect Gray Jay populations. In recent years, there have been anecdotal reports of declines on Gray Jays in northern Wisconsin. Here we investigate trends in Gray Jay abundance in Northern Wisconsin using Christmas Bird Count data from 1956 to 2013. After compiling data from five suitable locations across northern Wisconsin, we examined temporal trends in the relative abundance of Gray Jays by fitting joinpoint regressions (segmented line regressions) to the data. Our resulting models show recent declines in Gray Jay abundance at all five locations (including locations where Gray Jay abundance had previously been increasing). All locations appear to have started their downward trends during the early 1990s. With a decline in Gray Jay abundance having been confirmed, further research may be able to determine if the decline can be directly linked to climate-driven habitat loss, loss of cached food due to spoiling from a warmer climate, direct human influences such as logging or habitat fragmentation, or a combination of these factors.*

Keywords: abundance, Black Spruce, boreal, Christmas Bird Count, climate change, Gray Jay, joinpoint, segmented line regression, Wisconsin

Introduction

Gray Jays (*Perisoreus canadensis*) are resident birds of North American boreal forests that form life-long mated pairs, produce only one clutch per year, and occupy permanent territories of 25 to 100 hectares (about 60 to 250 acres) (Waite and Strickland 2006; Strickland and Ouellet 2011; Strickland 2014). They survive in the highly seasonal cold-climate forests of the boreal and sub-alpine zones by scatter-hoarding food caches, a behavior that maintains annual adult mortality rates as low as 20% (Strickland 2014). Gray Jays are omnivorous and opportunistic feeders that deposit saliva-coated food caches under the scales of tree bark (Waite and Strickland 2006; Strickland and Ouellet 2011). Unlike food stored by many other species (e.g., acorns and conifer seeds stored by Acorn Woodpeckers [*Melanerpes formicivorus*] and Clark's Nutcrackers [*Nucifraga columbiana*]), Gray Jay caches are perishable (e.g., animal tissue and berries) and are best preserved in cool weather or under spruce (*Picea* spp.) or pine (*Pinus* spp.) bark scales (Strickland et al. 2011). Strickland et al. (2011) concluded that food caches housed under spruce (*Picea*) or pine (*Pinus*) bark scales were better preserved than caches deposited under the bark of deciduous trees in Ontario, Canada. These caches provide a critical overwinter food source for adult Gray Jays, which begin nesting in February, and their young, which fledge weeks before leaf-out and the regeneration of many Gray Jay food sources (Waite and Strickland 2006; Strickland and Ouellet 2011; Strickland 2014). The dominant hatchling will remain in its parents' territory and expel all other siblings. Up to 80% of juvenile Gray Jays expelled from their parental territory may die in their hatch year, but surviving expelled juveniles may move into nearby territories held by failed breeding pairs (Strickland and Ouellet 2011).

Climate change projections for northern Wisconsin suggest that temperatures may be higher during autumn and winter months (Kucharik et al. 2010; Wisconsin's Changing Climate: Impacts and Adaptation 2011; Janowiak et al. 2014). These higher temperatures may lead to the spoiling of cached food, adversely affecting Gray Jay populations by reducing reproductive success, while seemingly having a minimal effect on the mortality rate of adults (Waite and Strickland 2006; Strickland 2014). A reduction in reproductive success leads to a juvenile shortage, and thus an emerging phenomenon of vacant territories going unfilled. This has been observed in Algonquin Park, Quebec, where currently less than half of territories occupied in 1970 remained occupied in 2014 (Strickland 2014).

Climate-related reductions in the extent of spruce-dominated forests (Prasad et al. 2007–ongoing; Janowiak et al. 2014) are expected to negatively affect Gray Jays, particularly at the southern edge of their range. For example, Gray Jay populations on the southern edge of the species' range in Ontario and Quebec, Canada, have declined in recent years (Waite and Strickland 2006; Strickland and Ouellet 2011; Strickland 2014). The Gray Jay population of Wisconsin is similarly on the southern edge of the species' range, and is restricted to the northern portion of the state (Fig. 1). In Wisconsin, Gray Jays are associated with Black Spruce (*Picea mariana*) bogs in the

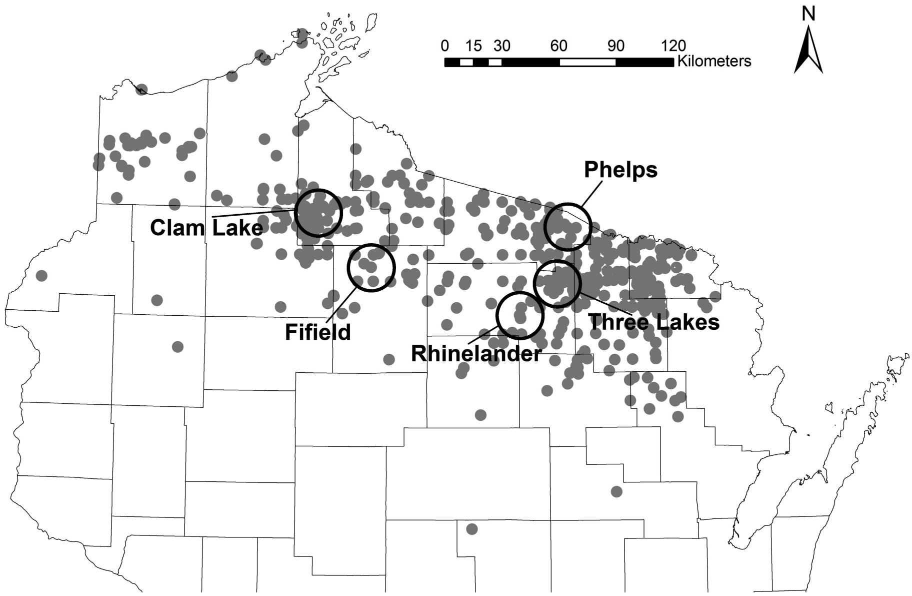

Figure 1. Black circles indicate the five 7.5-mile-radius Christmas Bird Count circles at which we analyzed Gray Jay data. Gray dots are data from eBird (2015), used here to illustrate typical Gray Jay range in northern Wisconsin.

northern two tiers of counties (Robbins 1991; Gregg 2006) and there is anecdotal evidence of a decline of Gray Jays in Wisconsin (T. Nicholls, personal communication). Gregg (2006) compared the Gray Jay's statewide range described in Robbins (1991) with the locations of breeding populations from the *Wisconsin Breeding Bird Atlas* and noted a possible range contraction along the species' southernmost border, though he could not rule out that this pattern may have been due to uneven sampling effort.

In the winter months, in suitable habitat, Gray Jays are often curious and can be easily observed during Christmas Bird Counts (Robbins 1991). Christmas Bird Counts (CBCs) are standardized, citizen-scientist surveys conducted once annually in late December or early January that can provide valuable information on the abundance of Gray Jays on their breeding grounds, which are occupied year-round as permanent territories. CBC records are a rich source of data that span decades in many locations across North America. Analyses of long-term CBC data have revealed patterns such as shifts in the distribution of wintering Western Grebes (*Aechmophorus occidentalis*; Wilson et al. 2013), declines in abundance of corvids due to West Nile Virus (Crosbie et al. 2008), and fluctuations in the abundance of boreal bird species with seed-crop size (Koenig and Knops 2001).

In this paper, we examine the hypothesis that the abundance of Gray Jays has declined in northern Wisconsin. We test this hypothesis by reporting changes in Gray Jay abundance from the late 20th and early 21st century using CBC data for northern Wisconsin.

Methods

We compiled a list of effort (party-hours) and Gray Jay abundance for CBC circles in Wisconsin from the CBC database (National Audubon Society 2014), CBC reports in *The Passenger Pigeon* from 1958–2013 (Appendix), and personal communication with CBC compilers. We attempted to resolve any data discrepancies between sources by contacting the compilers who oversaw field data collection. Circles with discrepancies that could not be resolved were excluded from further analysis. To rigorously examine temporal trends in Gray Jay abundance, we further limited our sample to five CBC circles (Clam Lake, Fifield, Phelps, Rhinelander, and Three Lakes; Fig. 1) within the Gray Jay range defined by Robbins (1991) where (1) recent (2000–present) observations existed, and (2) there were ≥ 20 years of observations with ≥ 8 party-hours of effort per year. To correct for varying effort, we calculated relative abundance of Gray Jays by dividing the number of Gray Jays observed during a count by the total number of party-hours of that count.

We examined temporal trends in the relative abundance of Gray Jays for each circle by fitting joinpoint or segmented line regressions (Brenden and Bence 2008) with the Joinpoint Regression Program, Version 4.1.1.1 (Statistical Research and Application Branch, National Cancer Institute 2014). For each circle, regressions with between 0 and 5 joinpoints (i.e., where two segments met) were fit to the relative abundance of Gray Jays across years (i.e., calendar year of start of CBC) and the model with the lowest Bayesian Information Criterion (BIC; Schwarz 1978) was chosen as the best-fit model. Years that defined joinpoints and the slopes of each segment were compared within and among locations to describe regional trends in Gray Jay abundance at the five sample sites in northern Wisconsin over the sampling period.

Results

The number of segments in the best-fit joinpoint models differed by circle (Fig. 2, Table 1). A linear model (i.e., no joinpoints) best described Gray Jay relative abundance at Clam Lake and Fifield. However, a model with three segments was chosen for Fifield when the abnormally large count of Gray Jays in 1972 was excluded from the analysis. Gray Jay relative abundance at Phelps, Three Lakes, and Rhinelander were each modeled with two, three, and four segments, respectively.

Gray Jay relative abundance has been in a state of decline since the mid to late 1990s for all circles (Fig. 2, Table 2). In every case, the slopes of the segment for the most recent observations (from the late 1990s to 2012) were negative, ranging from −0.013 to −0.074 (Table 2). Prior to the declines in the 1990s, Gray Jay relative abundance increased from the beginning of our time series for Fifield (if the larger 1972 observation was excluded), Phelps, and Three Lakes. Gray Jay relative abundance also increased at Rhinelander before the decline in the 1990s, except for a brief interruption in the 1980s. There was no evidence for an increase in relative abundance before the decline in the 1990s for Fifield when the large 1972 observation was included in the analy-

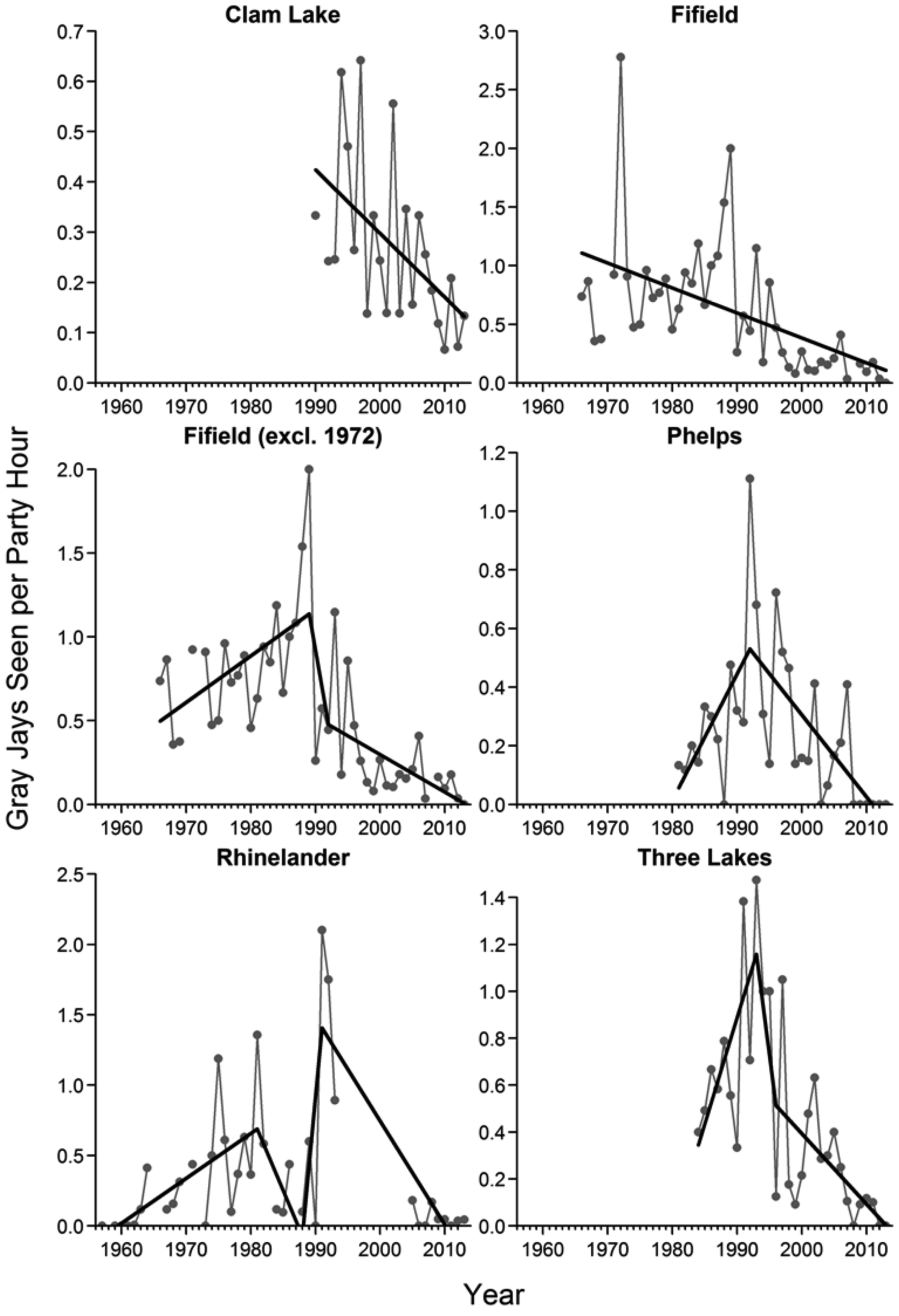

Figure 2. Best-fit joinpoint models (solid black line) for the relative abundance of Gray Jays by year at the Clam Lake, Fifield, Fifield (excluding 1972), Phelps, Rhinelander, and Three Lakes, Wisconsin Christmas Bird Count circles. Observed data are depicted with gray points connected with gray lines.

Table 1. Bayesian information criterion values (BIC) for joinpoint models with between 0 and 5 joinpoints fit to the number of observed Gray Jays per party hour over time at five Wisconsin Christmas Bird Count circles. Degrees of freedom are in parentheses. The best-fitting model (i.e., lowest BIC) for each location is identified with an asterisk.

	Number of Joinpoints					
Location	0	1	2	3	4	5
Clam Lake	−3.7007 (21)*	−3.5495 (19)	−3.2973 (17)	−3.0642 (15)	−2.8029 (13)	−2.5449 (11)
Fifield	−1.4161 (44)*	−1.3879 (42)	−1.3146 (40)	−1.2953 (38)	−1.3028 (36)	−1.3048 (34)
Fifielda	−1.8420 (43)	−2.0404 (41)	−2.0791 (39)*	−2.0787 (37)	−1.9512 (35)	−1.3048 (33)
Phelps	−2.6838 (31)	−2.9646 (29)*	−2.8415 (27)	−2.7611 (25)	−2.6089 (23)	−2.4048 (21)
Rhinelander	−1.2368 (37)	−1.4911 (35)	−1.5223 (33)	−1.5960 (31)*	−1.4901 (29)	−1.3299 (27)
Three Lakes	−2.0556 (28)	−2.1637 (26)	−2.1763 (24)*	−2.0905 (22)	−1.9292 (20)	−1.7390 (18)

[a] The count in 1972 was excluded from the analysis due to an outlying high number of Gray Jays.

Table 2. Number of segments (Segs), coefficient of determination (r^2), years (and 95% confidence interval) of significant joinpoints, and slopes (95% confidence interval in parentheses) for each segment of the joinpoint model that best fit the number of Gray Jays observed per party hour over time at five Wisconsin Christmas Bird Count circles.

				Year of Joinpoint			Segment Slope			
Location	n	Segs	r2	First	Second	Third	First	Second	Third	Fourth
Clam Lake	23	1	0.278	–	–	–	−0.013 (−0.003, −0.022)	–	–	–
Fifield	46	1	0.289	–	–	–	−0.021 (−0.011, −0.031)	–	–	–
Fifielda	45	3	0.601	1989 (1985, 1994)	1992 (1990, 2009)	–	0.028 (0.044, 0.012)	−0.22 (0.469, −0.909)	−0.022 (−0.005, −0.040)	–
Phelps	33	2	0.449	1992 (1989, 1997)	–	–	0.043 (0.074, 0.013)	−0.028 (−0.016, −0.040)	–	–
Rhinelander	39	4	0.603	1981 (1961, 1990)	1988 (1982, 1993)	1991 (1990, 2011)	0.032 (0.048, 0.016)	−0.109 (0.067, −0.284)	0.493 (1.226, −0.241)	−0.074 (−0.051, −0.097)
Three Lakes	30	3	0.636	1993 (1986, 1996)	1996 (1990, 2011)	–	0.09 (0.155, 0.026)	−0.215 (0.490, −0.920)	−0.03 (−0.005, −0.055)	–

[a] The count in 1972 was excluded from the analysis.

sis. The Clam Lake CBC record does not extend back far enough to assess pre-1990s trends in the relative abundance of Gray Jays.

Discussion

We used CBC data to statistically demonstrate an ongoing decline in

Gray Jay relative abundance in northern Wisconsin. All areas appear to have entered a decline around the early 1990s, while the abundance of Gray Jays in Fifield may have been decreasing since our earliest records of 1965 (when the count from 1972 is included in the analysis). Why are we seeing this declining trend in observed Gray Jays in Northern Wisconsin?

Errors or variability in the methodology of citizen scientists are potential concerns; but we do not think there is a systematic bias in the data that could result in the observed pattern, nor do we feel that Gray Jays are likely to be improperly identified or go undetected, given their distinct appearance and inquisitive, trusting disposition. While low numbers of birds recorded in the beginning years of counts could be due to observers being unfamiliar with the count circle, this explanation would not account for declines observed after 1990. Our circle with the longest record, Fifield, has been compiled by the same individual since 1965 and we believe this represents exceptionally reliable data. Fifield's trends in abundance closely resemble the recent trends we observed at all other locations. This becomes more apparent if the 1972 count for Fifield is excluded from the analysis, as this count was far enough removed from the other observed values that the best fit model failed to detect the pre-1990 population increase. The value of long-term data sets created by citizen scientists cannot be overstated. In our review of the CBC database, we encountered several count circles that were active (and recorded Gray Jays) in the middle of the 20th century but were discontinued prior to the 1990s (e.g., the Oxbo CBC) and thus were not included in our analysis.

The well-documented increase in winter temperatures across our study area and concurrent with our study period (Wisconsin's Changing Climate: Impacts and Adaptation 2011) may have triggered the downward trend in Gray Jay abundance we observed. Our study sites are located in a part of Wisconsin that has also experienced a delay in the first fall freeze (0.0° C) of between three and twelve days and a lengthening of the growing season by up to two weeks (Kucharik et al. 2010). This warming trend may be having a direct, adverse impact on the preservation of cached food that is critical to raising young (Waite and Strickland 2006; Strickland and Ouellet 2011; Strickland 2014). In addition, the observed Gray Jay declines could be indicative of the initial effects of predicted poleward shifts in Wisconsin's boreal conifer tree species, including Black Spruce, related to climate change (Prasad et al. 2007–ongoing; Wisconsin's Changing Climate: Impacts and Adaptation 2011).

Black Spruce is typically harvested in the United States for the manufacture of paper and, to a lesser extent, for lumber and for Christmas trees (Viereck and Johnston 1990). However, in Wisconsin, White Spruce [*Picea glauca*] represents approximately 90% of all spruce harvested, despite only representing 55% of in-state spruce, indicating Black Spruce is not of great economic value. The USFS Forest Inventory and Analysis (2014) estimated that the number of Black Spruce trees in Wisconsin increased from about 181,000,000 in 1968 to about 347,000,000 in 2014. Despite this increase in numbers, the mortality rate of spruce has also increased, having quadrupled between 1983 and 2013, with the ratio of mortality to gross growth currently at 45.5% (Wisconsin Department of Natural Resources 2014, 2015). This increase in mortality may indicate a decline in the health, condition, and age structure of Wisconsin's spruce stock, and the initiation of Black Spruce's poleward range contraction anticipated by Prasad et al. (2007–ongoing) and Janowiak et al. (2014).

The decline we have observed in the relative abundance of Gray Jays is concordant with projections of significant reductions in abundance of nearly two-thirds of boreal bird species (Virkkala et al. 2008). Regardless of whether the decline in Gray Jays over the last several decades arose from a reduction in conifer quality or by a more direct warming period in recent years affecting cache preservation, climate effects on conifers pose a major threat to Gray Jays in Wisconsin in the years to come. Northern Wisconsin's lowland conifer forests hold rich and diverse bird populations (Hoffman and Mossman 1993). As the regional climate changes, these areas may be the last refuge in Wisconsin for boreal species like the Gray Jay. Increased conservation attention to protecting remaining intact boreal conifer forests is necessary for the persistence of these species in the state.

Acknowledgements

We thank the following individuals for correspondence about CBC data: Dennis Allaman, John Bates, Katie Connolly, Bob Domagalski, Joan Elias, Tim Ewing, Joel Flory, Vanessa Haese-Lehman, Robin Maercklein, Keith Merkel, Thomas Nicholls, Bill Reardon, Nancy Richmond, Joe Scott, and Nancy Stevenson. We thank Thomas Nicholls and Matthew Hayes for their thoughtful comments which improved this manuscript, and Andrew Stoltman for assistance with the acquisition of forestry data. We also credit Thomas Nicholls with inspiring this analysis and thank the many CBC participants who gathered these data.

Literature Cited

Brenden, T. O., and J. R. Bence. 2008. Comment: Use of piecewise regression models to estimate changing relationships in fisheries. *North American Journal of Fisheries Management* 28: 844–846.

Crosbie, S. P., W. D. Koenig, W. K. Reisen, V. L. Kramer, L. Marcus, R. Carney, E. Pandolfino, G. M. Bolen, L. R. Crosbie, D. A. Bell, and H. B. Ernest. 2008. Early impact of West Nile Virus risk on the Yellow-billed Magpie (*Pica nuttalli*). *Auk* 125: 542–550.

eBird Basic Dataset. 2015. Version: EBD_relNov-2015. Cornell Lab of Ornithology, Ithaca, New York. [accessed from http://ebird.org/content/ebird/ on January 1, 2016].

Gregg, L. 2006. Gray Jay. Pgs 296–297 *in* (N. J. Cutright, B. R. Harriman, R. W. Howe, Eds.) *Atlas of the Breeding Birds of Wisconsin*. Wisconsin Society for Ornithology, Waukesha.

Hoffman, R. M., and M. J. Mossman. 1993. Birds of Wisconsin's northern swamps and bogs. *Passenger Pigeon* 55: 113–137.

Janowiak, M. K., L. R. Iverson, D. J. Mladenhoff, E. Peters, K. R. Wythers, W. Xi, L. A. Brandt, P. R. Butler, S. D. Handler, P. D. Shannon, C. Swanston, L. R. Parker, A. J. Amman, B. Bogaczyk, C. Handler, E. Lesch, P. B. Reich, S. Matthews, M. Peters, A. Prasad, S. Khanal, F. Liu, T. Bal, D. Bronson, A. Burton, J. Ferris, J. Fosgitt, S. Hagan, E. Johnston, E. Kane, C. Matula, R. O'Connor, D. Higgins, M. St. Pierre, J. Daley, M. Davenport, M. R. Emery, D. Fehringer, C. L. Hoving, G. Johnson, D. Neitzel, M. Notaro, A. Rissman, C. Rittenhouse, and R. Ziel. 2014. *Forest ecosystem vulnerability assessment and synthesis for northern Wisconsin and western upper Michigan: A report from the Northwoods Climate Change Response Framework Project*. USDA Forest Service. General Technical Report NRS-136: 1-259. [accessed from http://www.fs.fed.us/nrs/pubs/gtr/gtr_nrs136.pdf on January 10, 2016].

Koenig, W. D., and J. M. H. Knops. 2001. Seed-crop size and eruptions of North American boreal seed-eating birds. *Journal of Animal Ecology* 70: 609–620.

Kucharik, C. J., S. P. Serbin, S. Vavrus, E. J. Hopkins, and M. M. Motew. 2010. Patterns of climate change across Wisconsin from 1950–2006. *Physical Geography* 31: 1–28.

National Audubon Society. 2014. *Christmas Bird Count Historical Results.* [accessed from http://www.audubon.org/bird/cbc/hr/index.html on September 1, 2013].

Prasad, A. M., L. R. Iverson., S. Matthews, and M. Peters. 2007–ongoing. *A climate change atlas for 134 forest tree species of the eastern United States.* Northern Research Station, U.S. Forest Service, Delaware, Ohio, USA. [accessed from http://www.nrs.fs.fed.us/atlas/tree on December 18, 2014].

Robbins, S. D., Jr. 1991. *Wisconsin Birdlife: Population and Distribution Past and Present.* University of Wisconsin Press, Madison.

Schwarz, G. 1978. Estimating the dimension of a model. *Annals of Statistics* 6: 461–464.

Statistical Research and Applications Branch. 2014. Joinpoint Regression Program, Version 4.1.1.1. National Cancer Institute.

Strickland, D. 2014. A half-century of Canadian Gray Jay Studies. *BirdWatch Canada* 67: 8–11.

Strickland, D., B. Kielstra, and D. R. Norris. 2011. Experimental evidence for a novel mechanism driving variation in habitat quality in a food-caching bird. *Oecologia* 167: 934–950.

Strickland, D., and H. Ouellet. 2011. Gray Jay (*Perisoreus canadensis*). *The Birds of North America Online* (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology. [accessed from http://bna.birds.cornell.edu/bna/species/040 on January 1, 2015].

USFS Forest Inventory and Analysis. 2014. [accessed from http://www.fia.fs.fed.us/ on November 6, 2015].

Viereck, L. A., and W. F. Johnston. 1990. "*Picea mariana* (Mill.) B. S. P. Black Spruce." *Silvics of North America* 1: 227–237. [accessed from http://www.na.fs.fed.us/pubs/silvics_manual/Volume_1/picea/mariana.htm on October 29, 2015].

Virkkala, R., R. K. Heikkinen, N. Leikola, and M. Luoto. 2008. Projected large-scale range reductions of northern-boreal land bird species due to climate change. *Biological Conservation* 141: 1343–1353.

Waite, T. A., and D. Strickland. 2006. Climate change and the demographic demise of a hoarding bird living on the edge. *Proceedings of the Royal Society B* 273: 2809–2813.

Wilson, S., E. M. Anderson, A. S. G. Wilson, and P. Arcese. 2013. Citizen science reveals an extensive shift in the winter distribution of migratory Western Grebes. *PLoS ONE* 8(6): e65408.

Wisconsin's Changing Climate: Impacts and Adaptation. 2011. *Wisconsin Initiative on Climate Change Impacts.* Nelson Institute for Environmental Studies, University of Wisconsin-Madison and the Wisconsin Department of Natural Resources, Madison.

Wisconsin Department of Natural Resources. 2014. *Spruce.* Division of Forestry. [accessed from http://dnr.wi.gov/topic/ForestBusinesses/documents/SpruceReport.pdf on November 6, 2015].

Wisconsin Department of Natural Resources. 2015. Information about growth, mortality and removals. *Forest Businesses. Growth, mortality, and removals.* [accessed from http://dnr.wi.gov/topic/ForestBusinesses/documents/tables/GrowthMortalityRemovals.pdf on October 29, 2015].

APPENDIX

Appendix. Records of Gray Jays observed on Christmas Bird Counts in Wisconsin from 1956 to 2012 were taken from the following articles in *The Passenger Pigeon.*

Publication Year	Author (s)	Title	Volume (pages)
1957	M. Lound & R. Lound	The 1956 Christmas Bird Count	19: 16–24
1958	M. Lound & R. Lound	The 1957 Christmas Bird Count	20: 9–20
1959	H. A. Winkler	The 1958 Christmas Bird Count	21: 3–14
1960	H. A. Winkler	The 1959 Christmas Bird Count	22: 3–17
1960	H. A. Winkler	The 1960 Christmas Bird Count	22: 163–180
1961	H. A. Bauers	The 1961 Christmas Bird Count	23: 123–137
1963	H. A. Bauers	The 1962 Christmas Bird Count	25: 3–17
1964	H. A. Bauers	The 1963 Christmas Bird Count	26: 118–137

Publication Year	Author (s)	Title	Volume (pages)
1965	H. A. Bauers	The 1964 Christmas Bird Count	27: 91–110
1966	W. L. Hilsenhoff	The 1965 Christmas Bird Count	28: 87–102
1967	W. L. Hilsenhoff	The 1966 Wisconsin Christmas Bird Counts	29: 120–133
1968	W. L. Hilsenhoff	The 1967 Wisconsin Christmas Bird Counts	30: 151–163
1969	W. L. Hilsenhoff	The 1968 Wisconsin Christmas Bird Counts	31: 161–172
1970	W. L. Hilsenhoff	The 1979 Wisconsin Christmas Bird Counts	32: 3–16
1971	W. L. Hilsenhoff	The 1970 Wisconsin Christmas Bird Counts	33: 4–17
1972	W. L. Hilsenhoff	The 1971 Wisconsin Christmas Bird Counts	34: 3–17
1973	W. L. Hilsenhoff	The 1972 Wisconsin Christmas Bird Counts	35: 3–13
1974	W. L. Hilsenhoff	The 1973 Wisconsin Christmas Bird Counts	36: 3–15
1975	W. L. Hilsenhoff	The 1974 Wisconsin Christmas Bird Counts	37: 3–19
1976	W. L. Hilsenhoff	The 1975 Wisconsin Christmas Bird Counts	38: 4–18
1977	W. L. Hilsenhoff	The 1976 Wisconsin Christmas Bird Counts	39: 173–187
1978	W. L. Hilsenhoff	The 1977 Wisconsin Christmas Bird Count	40: 358–370
1979	W. L. Hilsenhoff	The 1978 Wisconsin Christmas Bird Counts	41: 1–15
1980	W. L. Hilsenhoff	The 1979 Wisconsin Christmas Bird Counts	42: 9–22
1981	W. L. Hilsenhoff	The 1980 Wisconsin Christmas Bird Count	43: 5–17
1982	W. L. Hilsenhoff	The 1981 Wisconsin Christmas Bird Count	44: 1–15
1983	W. L. Hilsenhoff	The 1982 Wisconsin Christmas Bird Count	45: 1–16
1984	W. L. Hilsenhoff	The 1983 Wisconsin Christmas Bird Count	46: 1–16
1985	W. L. Hilsenhoff	The 1984 Wisconsin Christmas Bird Count	47: 1–16
1986	W. L. Hilsenhoff	The 1985 Wisconsin Christmas Bird Count	48: 2–16
1987	W. L. Hilsenhoff	The 1986 Wisconsin Christmas Bird Count	49: 2–17
1988	W. L. Hilsenhoff	The 1987 Wisconsin Christmas Bird Count	50: 21–36
1989	W. L. Hilsenhoff	The 1988 Wisconsin Christmas Bird Count	51: 67–82
1990	W. L. Hilsenhoff	The 1989 Wisconsin Christmas Bird Counts	52: 3–18
1991	W. L. Hilsenhoff	The 1990 Wisconsin Christmas Bird Counts	53: 3–20
1992	W. L. Hilsenhoff	The 1991 Wisconsin Christmas Bird Counts	54: 34–18
1993	W. L. Hilsenhoff	The 1992 Wisconsin Christmas Bird Counts	55: 3–20
1994	W. L. Hilsenhoff	The 1993 Wisconsin Christmas Bird Counts	56: 3–20
1995	W. L. Hilsenhoff	The 1994 Wisconsin Christmas Bird Counts	57: 3–22
1996	W. L. Hilsenhoff	The 1995 Wisconsin Christmas Bird Counts	58: 3–22
1997	W. L. Hilsenhoff	The 1996 Wisconsin Christmas Bird Counts	59: 3–20
1998	W. L. Hilsenhoff	The 1997 Wisconsin Christmas Bird Counts	60: 45–76
1999	W. L. Hilsenhoff	The 1998 Wisconsin Christmas Bird Counts	61: 71–100
2000	W. L. Hilsenhoff	The 1999 Wisconsin Christmas Bird Counts	62: 21–50
2000	R. C. Domagalski	The 2000 Wisconsin Christmas Bird Counts	62: 251–282
2001	R. C. Domagalski	The 2001 Wisconsin Christmas Bird Counts	63: 265–298
2003	R. C. Domagalski	The 2002 Wisconsin Christmas Bird Counts	65: 5–38
2004	R. C. Domagalski	The 2003 Wisconsin Christmas Bird Counts	66: 3–35
2005	R. C. Domagalski	The 2004 Wisconsin Christmas Bird Counts	67: 195–230
2006	R. C. Domagalski	The 2005 Wisconsin Christmas Bird Counts	68: 87–122
2007	R. C. Domagalski	The 2006 Wisconsin Christmas Bird Counts	69: 291–326
2008	R. C. Domagalski	The 2007 Wisconsin Christmas Bird Counts	70: 237–274
2009	R. C. Domagalski	The 2008 Wisconsin Christmas Bird Counts	71: 203–237
2010	R. C. Domagalski	The 2009 Wisconsin Christmas Bird Counts	72: 231–266
2011	R. C. Domagalski	The 2010 Wisconsin Christmas Bird Counts	73: 195–228
2012	R. C. Domagalski	The 2011 Wisconsin Christmas Bird Counts	74: 207–243
2013	R. C. Domagalski	The 2012 Wisconsin Christmas Bird Counts	75: 235–275