Does the American Goshawk (Accipiter atricapillus) Display a 10-year Cycle in Eastern and Central North America?

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Introduction

The American Goshawk is a regular breeder and migrant across northern U.S. and Canada (Squire and Reynolds 2023). Large prey items such as the snowshoe hare and several grouse species comprise a substantial part of the goshawk's diet across its range (Squires and Kennedy 2006). Prey items such as the hare and grouse often show 10-year population fluctuation, which is often connected to a classic predator-prey oscillation cycle with the Canadian lynx and the Great Horned Owl (Krebs et al. 2001).

These cycles, where they exist, can affect other predators, including inducing rapid population increases of predators such as the goshawk (Doyle et al. 1994). These population cycles impact the numbers of goshawks detected at migration count locations south of the core range, with migratory goshawks displaying 10-year irruption cycles reported in literature for more than one hundred years (e.g., Mueller et al. 2008, Squires and Reynolds 1997). On non-irruptive years, migration counts may primarily reflect dispersing young birds although age data is difficult to obtain at many sites. In contrast, in irruption years, most of the migrants appear to be adults (F. Nicoletti - pers. obs.), with banding data indicating longer distance movements occur. At Hawk Ridge Bird Observatory in Minnesota, irruption year counts can be comprised of 90% adult goshawks (F. Nicoletti, unpub. data) which is very different than other years.

Although some research has been conducted on breeding populations of American Goshawks in the western states and of the Eurasian Goshawk in Europe, less research has been published on goshawk populations in eastern or central North America.

In recent years, goshawk populations in eastern North America have been in a steep decline, with 69% of eastern migration count sites reflecting a downward trend (Farmer et al. 2007, Oleyar et al. 2021). As well as fewer migratory goshawks showing up at hawk watch sites, goshawks in the southern extent of their breeding range are disappearing in many areas. Once a regular breeder in much of the Appalachian region, including Pennsylvania, Maryland and West Virginia, there have been few nesting records south of New York state in recent years (D. Brinker, pers comm). Wintering goshawks in Ontario have also declined in recent years (Oleyar et al. 2021). In addition to a widespread decline, the question has been raised as to whether irruptions are still being observed in this species.

Therefore, in this study we seek to investigate how recent population declines, and other factors, have impacted the historical cyclical pattern in this species. We predict that cycles will be evident in the migration counts at all five sites we examine, however we also predict that the populations decline in recent decades will reduce the evidence of cycles in the recent two decades. To explore this question, we analyzed annual hawk count data from five hawk watch sites with long-term coverage in northeastern and central United States and southeast Canada.

Methods

American Goshawk count data was obtained from five hawk watches in the HMANA database, hawkcount.org, Hawk Mountain Sanctuary, Pennsylvania (N 40.64158, W -75.99153), Hawk Ridge Observatory, Minnesota, (N 46.84722, W -92.03194), Holiday Beach, Ontario (N 42.03317, W -83.0455), Derby Hill Observatory, New York (N 43.5275, W -76.23944), and Whitefish Point Observatory, Michigan (N 46.77111, W -84.95528) (Figure 1).

Figure 1. Location of watch sites used in this study.

Of the five sites, three were fall sites (Hawk Mountain, Hawk Ridge and Holiday Beach) and two were spring sites (Whitefish Point and Derby Hill). An autocorrelation analysis was conducted for three different periods for each site: 1) all years surveyed, 2) all data collected up to and including the year 1999, and all data collected from 2000 to 2022.

To account for recent declines in goshawk populations, transformed counts were detrended by selecting the best fit ordinary least-squares regression model. The models were either linear, second-order, third-order, or fourth-order polynomials. The best fit was determined by choosing the lowest AICc value, regardless of significance. The model with the lowest AIC value explained the most variation in the data with the fewest parameters. To remove any downward trend, we used the residuals of this best fitting model in our temporal autocorrelation analysis. The residuals reflected any cyclical patterns within these data without the original negative slope. We calculated temporal autocorrelation using statistical package R's acf function (lag max (k) = 12). All statistical analyses were

conducted in R version 4.2.2. These statistics were modeled after the analysis on cycles in harriers published in Schimpf et al. (2020).

Results

American Goshawks per site for all years of the study varied from a mean of 468.61 per year at Hawk Ridge, Minnesota, to a mean of 25.52 per year at Holiday Beach, Ontario. Counts varied across years of study from 3957 total birds across all sites in 1982, to only 91 birds across the same sites in 2022 (Figure 2, 3, and 4).

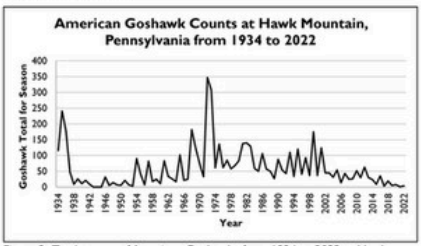

Figure 2: Total counts of American Goshawks from 1934 to 2022 at Hawk Mountain, Pennsylvania. Hawk Mountain's data was graphed separately due to the longer period surveyed compared to the other sites.

When examining all years surveyed, only three migration count sites showed a significant autocorrelation reflecting cyclical patterns in the count data. Hawk Mountain Sanctuary had a weak significant autocorrelation coefficient at the two- and four-year lags or cycle periods (Figure 2, $p<0.05$, autocorrelation coefficients: 0.248, 0.269, respectively). Hawk Ridge had significant autocorrelation coefficients at the nine-, and 10-year lags (Figure 3, $p<0.05$, autocorrelation coefficients: 0.395, 0.391, respectively). Derby Hill also showed a significant autocorrelation coefficient at a nine-year lag (Figure 4, $p<0.05$, autocorrelation coefficient: 0.305).

When examining the historical count data from before the year 2000, two sites had a significant autocorrelation reflecting a cycle: Hawk Ridge showed a significant autocorrelation at nine- and 10-year lags (Figure 3, $p<0.05$, autocorrelation coefficients:0.427, 0.445 respectively), and Whitefish Point had a significant autocorrelation at a two-year lag (Figure 4, $p< 0.05$, autocorrelation coefficient: 0.542). When examining the count data after 1999, none of the five watch sites showed any significant autocorrelation.

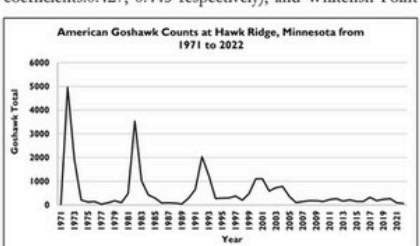

Figure 3: American Goshawks from 1971 to 2022 at Hawk Ridge, Minnesota. Hawk Ridge's data was graphed separately due to the much higher volume of birds compared to the other sites.

Discussion

In this study, we found a lack of a consistent irruptive pattern among the five migration watch sites when analyzing all years in each dataset and in all years prior to 2000 (Figures 2, 3, and 4). Hawk Ridge, in western Great Lakes, had the strongest cyclical pattern across all years between 1971 and 2022 and for years prior to 2000 (Figure 3). The count data supports our prediction that the cyclical pattern would decline over time, as we found no significant autocorrelation after the year 2000 for any of the five sites.

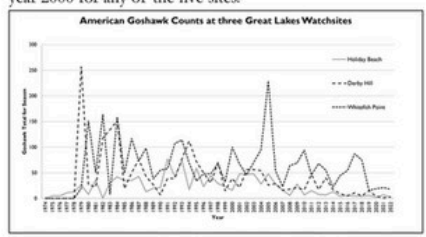

Figure 4: Total counts of American Goshawks from 1971 to 2022 at Holiday Beach (fall), Derby Hill (spring) and Whitefish Point (spring).

When examining all years, only Hawk Ridge and Derby Hill had a significant autocorrelation at a 10- or nine-year cycle period as suggested by historical references (Mueller et al. 2008; Figures 3 and 4). Hawk Ridge had the highest autocorrelation coefficient, suggesting a stronger cycle pattern compared to Derby Hill. Prior research examining some of these sites did not find a significant goshawk cycle when analyzing hawk watch data from 1983- 2017 (Schimpf et al. 2020). However, in this paper the authors summed Hawk Ridge, Hawk Mountain, and Holiday Beach counts before analysis, which may have diluted the cyclical pattern as these sites derive from different breeding populations. Moreover, Hawk Mountain data did not show a strong decadal pattern but rather a two- or four-year cycle. The reason for different cycles is unclear and warrants further investigation of weather, prey and population fluctuations.

Goshawk migration tendencies may vary latitudinally, with a more irruptive pattern occurring primarily in northern forest populations although more research is needed (Goodrich and Smith 2008). If irruptions are more common in northern populations, it may explain why we did not detect a strong cycle at Hawk Mountain, the most southern site. The low numbers of goshawks seen annually at some sites may also inhibit the detection of cycles even if they occur.

When examining years surveyed prior to 2000, only Hawk Ridge showed a significant 10-year cycle. Any significant 10-year cyclical pattern may not have been detected due to the

short time span analyzed at some sites. Four of the five sites surveyed began consistent effort in the 1970s (Hawk Ridge: 1971, Holiday Beach: 1974, Derby Hill:1979, and Whitefish Point:1979). Three of these sites began after the notable 1972-73 irruption (Squires and Kennedy 2006).

Hawk Ridge was the only site with a significant ten-year irruptive pattern when we analyzed all years counted and years prior to 2000 (Figure 3). Hawk Ridge also consistently had the highest number of migrants during irruptions (Figure 2, 3, and 4). Goshawk irruptions appear relatively higher in the western Great Lakes compared to more easterly sites. It is possible that migrant goshawks at Hawk Ridge, Minnesota, mostly derive from western Canada rather than Ontario (D. Green, F. Nicoletti, pers. Obs.). If this is the case, birds at Hawk Ridge may show a different pattern than more easterly populations passing by the other four sites. Analysis of band recovery data may be helpful in understanding source populations and cycle patterns.

Analyzing more historical data suggests there are other regional variations in irruptions. For example, H. Mueller and colleagues noted a goshawk irruption near Cedar Grove, Wisconsin, in 1963 that was also shown in Hawk Ridge data but is not obvious in Hawk Mountain's migration data (Mueller et al. 1977). Further research to understand regional differences in patterns would be insightful and might help elucidate why the cycles occur and the significance of declining evidence of cycles recently. Perhaps habitats and communities in eastern forests provide a more dampening impact on cycles even when goshawk numbers are at a higher level. We do not yet fully understand how landscape changes, fragmentation of forest in eastern North America and other factors may be impacting this species and its prey. One key result was a lack of irruptions evident in migration data collected from 2000-2022 at any site. This may have occurred due to changes in prey populations or reductions in goshawk populations unraveling the cycle mechanisms.

Additionally, migration or irruptive patterns maybe changing over wide areas possibly due to climate shifts. Research in Yukon, Canada, found that shallow snow heights impacted snowshoe hare survival rates, decreasing their peak during their natural fluctuations and possibly impacting cyclical patterns (Peers et al. 2020). Additionally, Ruffed Grouse, another important goshawk prey species, has been declining since 2000, likely due to West Nile virus, a disease introduced in 1999 (e.g., Nemeth et al. 2021). Environmental disruptions such as disease and climate change may be changing the natural fluctuations in predator and prey species across the eastern range of the goshawk but further research is needed.

Migration count data is often used to investigate raptor population trends and response to weather factors, but it also can be used to understand how populations respond to large scale environmental change. Some species, e.g., Red-tailed Hawk are wintering farther north and migrating shorter distances in response to climate change (Paprocki et al. 2017). As goshawks continue to show declines, it is imperative to tease out where changes shown in migration and winter counts reflect changes in behavior or changes in populations.

Future Research

The observed change in goshawk cycles at some sites raises many questions about the goshawk and the species' status and distribution. Research is needed to investigate goshawk populations in the eastern and central breeding range. Data is particularly needed on how goshawks and their dominant prey species are responding to climate change and associated environmental impacts. In addition, as forest landscapes change in extent and structure, we need further research on how populations respond to habitat shifts during the nesting, migration, and winter periods.

Migration behavior is not well understood in this species. Future research could investigate sex and age differences in goshawk movement patterns, migration distance and behavior, and compare patterns observed in irruptions or non-irruption years. In the future HMANA could add to this knowledge by encouraging more migration sites to collect age data on birds observed and to add more watch sites in northern states and Canada to better understand goshawk movements across their range. Analysts could also examine Christmas Bird Count data to compare changes in the wintering distribution in irruption years.

Acknowledgements

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Dinosaur Ridge Remembers Charlie

By Carol Cwiklinski

The Hawk Watch family is heartbroken over the recent passing of our friend and fellow hawk watcher, Charlie Wall. Charlie suffered medical issues while volunteering on the ridge and passed away at the hospital a short time later, with his wife Shelley at his side.

Charlie loved the hawk watch, and he was enjoying his passion for raptors on the day he left us. After seeing his first American Goshawk from the ridge earlier this season, Charlie told fellow volunteers that their efforts reminded him of fishing: "A lot of waiting and then you spot something that makes it all worth it."

We express our heartfelt condolences to Charlie's wife and family, the hawk watch and birding communities, and the many friends whose lives he touched. He will be missed.