Twenty-five year population trends in Northern Saw-whet Owl (Aegolius acadicus) in eastern North America

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Twenty-five year population trends in Northern Saw-whet Owl (*Aegolius acadicus*) in eastern North America

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ABSTRACT—Due to the low detectability of Northern Saw-whet Owls (*Aegolius acadicus*; hereafter, NSWO) throughout their annual cycle, standardized monitoring during migration allows for population assessments over time. We assessed age-class population trends in NSWO throughout eastern North America using banding data from 7 sites over a 25 year period. Using a mixed linear model, we did not detect any significant trends over time for the total owl count, adult owl count, and juvenile owl count from 1992 to 2017. During the period when all 7 sites were active from 2001 to 2017, trend estimates remained nonsignificant despite showing negative slopes. We confirmed this nonsignificant, negative trend through a similar mixed linear model of NSWO data from Christmas Bird Counts. Our results suggest that NSWO populations across eastern North America have been relatively stable since 1992 throughout their migration and winter ranges and demonstrate the value of standardized banding data for monitoring the regional population status of NSWO. *Received 29 October 2019. Accepted 29 October 2020.*

Key words: banding, demographics, migration.

Tendances populationnelles chez la Petite Nyctale (*Aegolius acadicus*) dans l'est de l'Amérique du Nord sur une période de vingt-cinq ans

RÉSUMÉ (French)—Étant donné les difficultés à détecter la présence de Petites Nyctales (*Aegolius acadicus;* ci-après, NSWO) tout au long de leur cycle annuel, le suivi standardisé de leur migration permet l'évaluation du statut des populations dans le temps. Nous avons évalué les tendances populationnelles par classe d'âge chez la NSWO à travers l'est de l'Amérique du Nord à l'aide de données de baguage provenant de 7 sites sur une période de 25 ans. En utilisant un modèle linéaire mixte, nous n'avons détecté aucune tendance temporelle significative au niveau du nombre total de nyctales, du nombre de nyctales adultes et du nombre de juvéniles, entre 1992 et 2017. Au cours de la période durant laquelle les 7 sites étaient actifs, entre 2001 et 2017, les valeurs de tendance estimées se sont également avérées non-significatives, malgré la présence de pentes négatives. Nous avons confirmé cette tendance négative non-significative à l'aide d'un modèle linéaire mixte similaire utilisant les données de NSWO du Recensement des oiseaux de Noël. Nos résultats suggèrent que les populations de NWSO à travers l'est de l'Amérique du Nord sont demeurées relativement stables depuis 1992 à travers leurs aires de migration et d'hivernage; ils démontrent également l'utilité des bases de données

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standardisées dans le suivi régional du statut populationnel de la NSWO.

Mots-clés: baguage, données démographiques, migration.

In order to identify and conserve species at risk, we need accurate estimates of population trends. This can be challenging for nocturnal, secretive species such as Northern Saw-whet Owls (*Aegolius acadicus*; hereafter, NSWO). NSWO are common breeders of forested habitats across southern Canada and the northern United States and in winter have been observed as far south as central Florida along the Atlantic coast (Rasmussen et al. 2008). Like most owls, NSWO occur at low densities and often inhabit large, relatively inaccessible areas, making detectability challenging (Rasmussen et al. 2008, Kissling et al. 2010). As a result of this perceived rarity, NSWO populations were believed to be at risk. For example, the species was listed as special concern in Pennsylvania until widespread mist netting and targeted surveys in the late 1990s revealed higher abundances, both as a breeding species and migrant (Weidensaul 2015). Beginning in the mid-1980s, the incorporation of an audiolure broadcasting male advertisement calls significantly increased capture rates over passive mist netting, also altering previous assumptions of NSWO population sizes (Erdman and Brinker 1997, Erdman et al. 1997).

Since the early 1990s, NSWO have been consistently trapped and banded at various stations along their migration routes and winter range in eastern North America (Erdman and Brinker 1997, Erdman et al. 1997). Given the inconspicuous nature of the species throughout its annual cycle, long-term, standardized monitoring during migration is one of the primary tools available for assessing population trends among age classes in eastern North America.

NSWO feed primarily on small mammals, such as deer mice and voles (Swengel and Swengel 1992, Rasmussen et al. 2008), whose densities tend to fluctuate on a 3–5 year cycle (Cheveau et al. 2004, Côté et al. 2007). This leads to periodic pulses in NSWO reproduction, with large numbers of juveniles migrating south in autumn (Davis 1966, Newton 2006, Rasmussen et al. 2008, Confer et al. 2014). Although population trends of NSWO have been little studied, research suggests increased forest loss and fragmentation can lead to reduced foraging efficiency, increased stress, and reduced reproductive success (Hinam and Clair 2008), likely as a result of both reduced perch availability and reduced prey availability (Bayne and Hobson 1998). In addition, juvenile NSWO are disproportionately impacted by road mortalities (Davis 1966, Loos and Kerlinger 1993, Hager 2009).

With various ongoing threats facing this boreal forest species, we assessed population trends of NSWO throughout eastern North America using banding data to analyze age-related differences of migrants over a 25 year period. Given the potential for low reproductive success and increased juvenile mortality, we hypothesized migratory populations would decline over time with greatest negative patterns exhibited by juveniles.

Methods

We trapped NSWO nightly each autumn at 7 sites from 1992 to 2017 (Table 1, Fig. 1). In northern Dauphin County, Pennsylvania, the Berry Mountain site was moved to Small Valley in 2002, where it has operated since. We treated both sites as one location operating from 1998 to 2017 in our analysis. Individuals were captured during their fall migration, with stations operating between August or September and late November or early December, depending on latitude, utilizing a site-specific standardized protocol involving both mist net and audio lure techniques (Brinker et al. 1997, Côté et al. 2007). Mist nets 9–12 m in length consisting of 60 mm mesh were opened 2–4 m apart and positioned in a single line, multiple lines, or an "L" shaped array. At Assateague, we used 2 nets stacked one above the other. Our audiolure consisted of either a tape player, CD player, or MP3 player (depending on the site and year) connected to an amplifier, positioned at the center of the net array, broadcasting the male NSWO solicitation call at 80–85 dB. Sites were open from dusk to between 2300 h and dawn (depending on the site and year) throughout the migratory season, unless closed due to inclement weather, such as wind over 30 km/h, constant rain or snow, and/or heavy fog.

Table 1. Location and years of operation for the 7 Northern Saw-whet Owl banding sites in eastern North America selected for this study.

Site	Location	Latitude	Longitude	Years of operation	Total number of owls banded
Assateague	Maryland, USA	38.0917	−75.2056	1992–2017	1,727
Casselman	Pennsylvania, USA	39.8863	−79.2110	1993–2017	3,304
Hidden Valley	Pennsylvania, USA	40.6206	−76.2686	2000–2017	2,731
King's Gap	Pennsylvania, USA	40.0922	−77.2683	2001–2017	1,598
Berry Mtn. / Small Valley	Pennsylvania, USA	40.5494 / 40.4939	−76.7408 / −76.7836	1998–2001 / 2002–2017	2,739
Prince Edward Point	Ontario, Canada	43.9397	−76.8614	1997–2017	11,757
Tadoussac	Québec, Canada	48.1572	−69.6656	1997–2017	3,246

To assess if the observed trapping trends correlated with another long-term index, we used NSWO data from Christmas Bird Counts (CBC; National Audubon Society 2020) from northeastern states and provinces in the United States and Canada (i.e., Connecticut, Delaware, Maine, Maryland, Massachusetts, New Brunswick, New Hampshire, New Jersey, New York, Nova Scotia, Ontario, Pennsylvania, Québec, and Rhode Island) from 1992 to 2017. The CBC gathers annual birding records from thousands of volunteers during a single day annually between 14 December and 5 January across North America. The surveys include the number of hours spent in the field per party (i.e., a group of persons counting birds together) and observer effort is calculated in party-hours.

Statistical analyses

We standardized capture data per site by factoring in total operational hours, nets open, and net area to account for differences in effort, number of nets open, and single vs. double high nets. We processed data in R 3.3.2 (R Core Team 2018) using the packages *devtools* (Wickham et al. 2018) and *lme4* (Bates et al. 2015). Because we were comparing variation in numbers between sites to examine population trends over time, we used a linear mixed model (Bates et al. 2015). Models included total owls/100 h, adult owls/100 h, and juvenile owls/100 h as dependent variables with site as a random factor and the fixed variable (time) run for 2 periods (1991–2017 covers all available data and 2001–2017 includes data when all 7 sites were active). We assessed for a latitudinal effect in temporal trends using a linear mixed model with year and an interaction with the latitude of the sites. We also used a linear mixed model to assess temporal trend in CBC data with states and provinces as a random factor. We adjusted for increased sampling frequency over time by analyzing the number of owls recorded divided by the number of counts recording data.

Results

Over the study period, we trapped and banded a total of 27,102 owls (mean per site = 3,872 owls, range = 1,727–11,757; Table 1). We observed high interannual variability in the number of trapped individuals (annual mean, all sites combined = 174 owls, range = 30–448; Fig. 2). Our mixed linear regression model did not reject the null hypothesis and resulted in a positive, nonsignificant population trend for total owl count (slope = 0.21, $P =$ 0.11, $F = 2.6$, $r^2 = 0.01$), adult owl count (slope = 0.11, $P = 0.08$, $F = 3.1$, $r^2 = 0.01$), and juvenile owl count (slope = 0.096, $P = 0.22$, $F = 1.5$, $r^2 =$ 0.003) for the overall 1992–2017 period. When all 7 sites were active (2001–2017), our results revealed negative, nonsignificant population trends for total owl count (slope = –0.20, $P = 0.29$, $F =$ 1.1, $r^2 = 0.001$), adult owl count (slope = –0.11, P = 0.23, $F = 1.4$, $r^2 = 0.004$), and juvenile owl count (slope = –0.089, $P = 0.46$, $F = 0.55$, $r^2 =$ –0.004) and again did not reject the null hypothesis. We did not detect any latitudinal pattern in temporal trend overall (all $P > 0.05$). For the CBC data, our mixed linear regression model did not reject the null hypothesis and

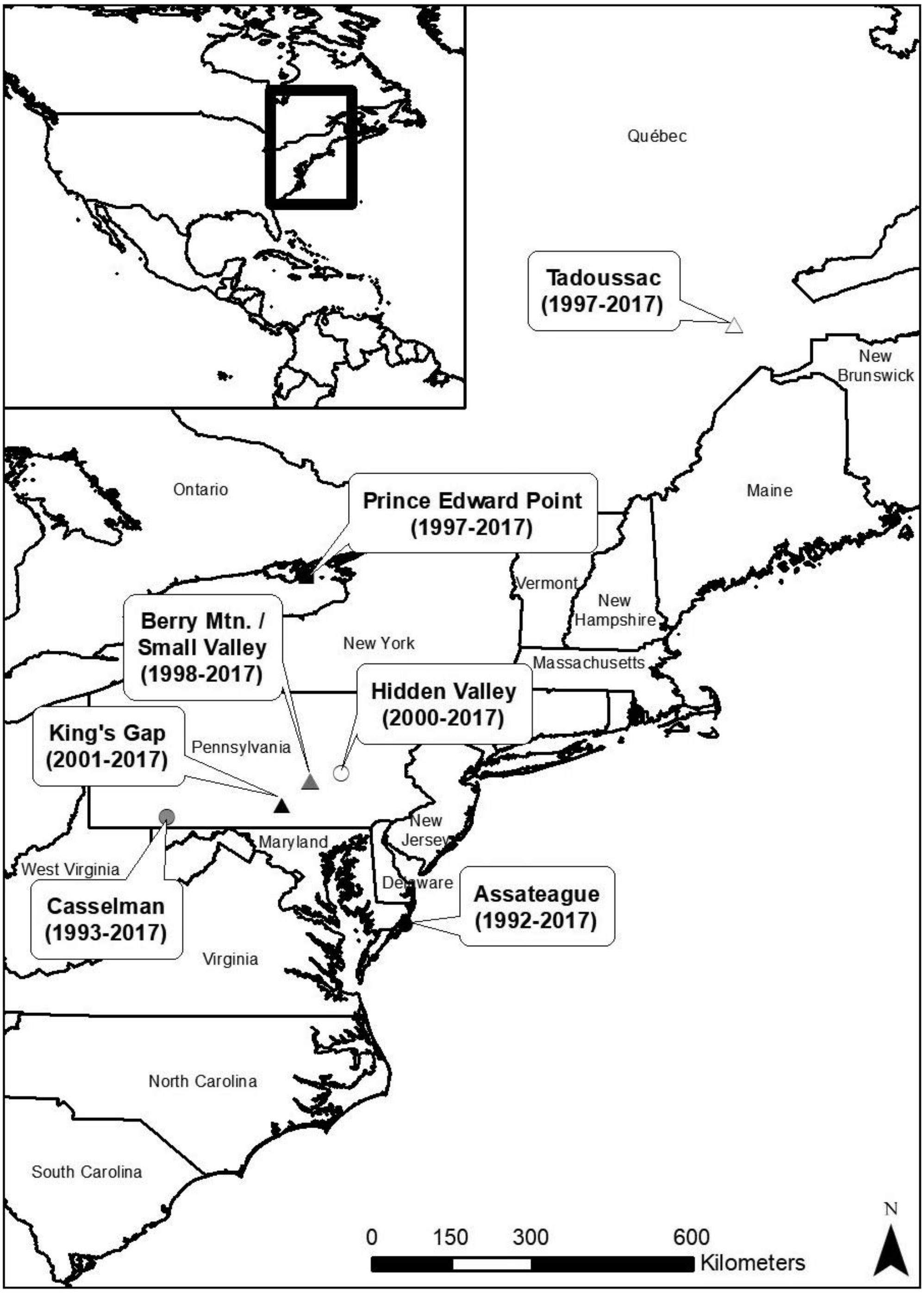

Figure 1. Location and years of operation for the 7 Northern Saw-whet Owl banding sites selected for this study.

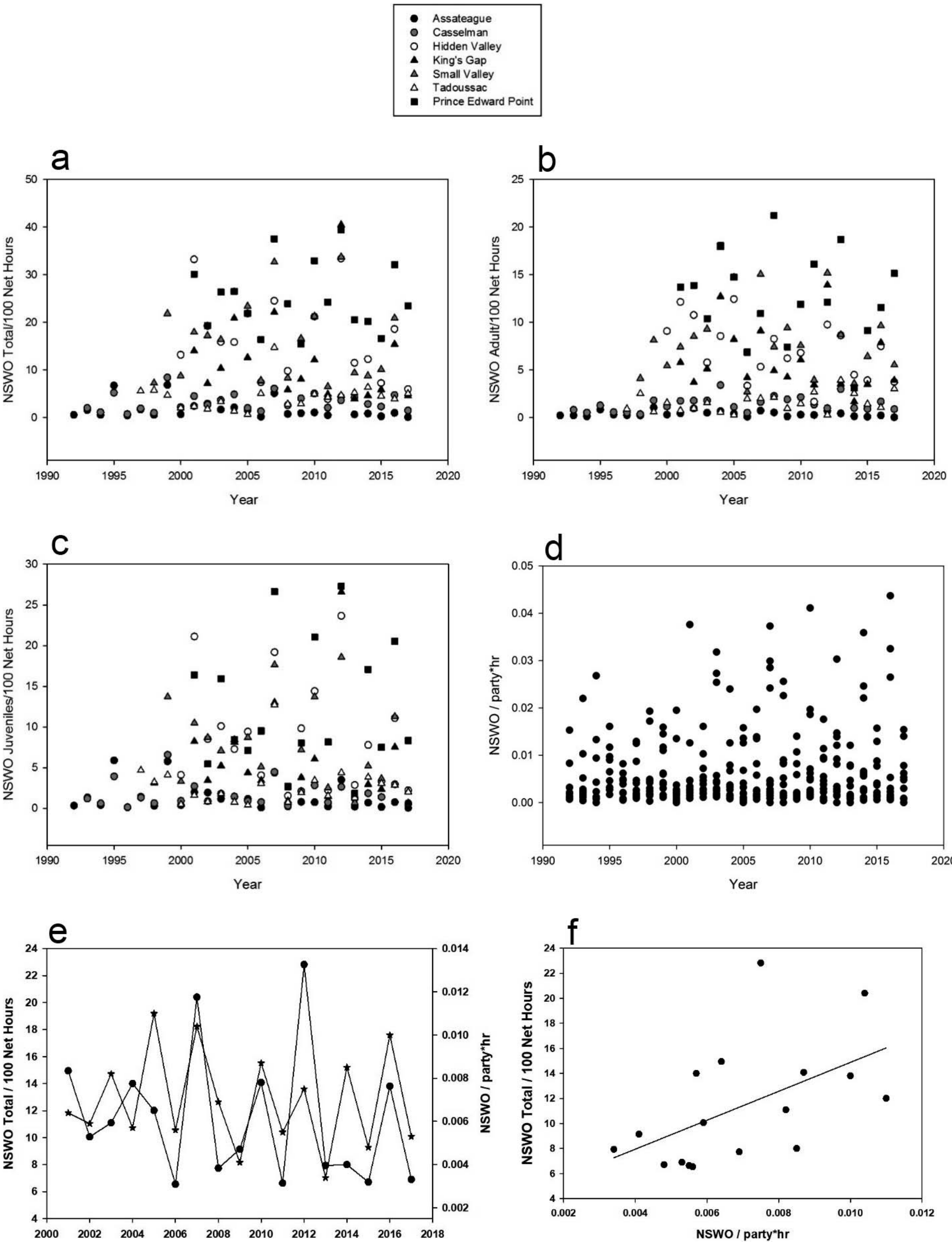

Figure 2. Population trends for (a) total, (b) adult, (c) juvenile Northern Saw-whet Owls from 7 banding sites during autumn migration in northeastern North America from 1992 to 2017 and (d) from Christmas Bird Counts (CBC) in 15 northeastern states and provinces (one point per year per state or province) from 1992 to 2017. Numbers of trapped NSWO (all sites combined, filled circles) and counted via CBC (all 15 states and provinces combined, stars) annually (e) and the correlation between the 2 indexes (f) are presented for the 2001–2017 period.

resulted in a slightly negative, nonsignificant population trend for total owls per count (slope = –0.002, $P = 0.83$, $F = 0.04$, $r^2 = -0.003$) from 1992 to 2017, but a significant correlation between the 2 indexes (Pearson correlation, $r = 0.53$, df = 15, $P = 0.03$; Fig. 2).

Discussion

Our findings suggest NSWO populations across eastern North America have been relatively stable since 1992. Interestingly, the population trends from 1992 to 2017 and from 2001 to 2017 displayed opposing, nonsignificant trends, with positive slopes from 1992 to 2017 and negative slopes from 2001 to 2017. This could foreshadow a possible significant decreasing population trend in future studies. It is also possible the positive, nonsignificant trends observed when using the whole dataset might be a result of increased trapping efficiency over time (due to acquired experience in the first few years), despite using standardized protocols regarding audio lures and trapping values (individual owls trapped per net*hours) across all sites throughout the dataset, making the actual trend closer to a significant decline. We also compared our results with CBC data from sites within the same geographical range and found negative, nonsignificant population trends from 1992 to 2017, supporting the trends we observed with the banding data. Breeding Bird Survey data was also considered for our analysis in order to compare results between migration, wintering, and breeding surveys. However, NSWO were not detected in high enough numbers to analyze properly.

The scope of our project was limited to NSWO population trends across eastern North America during migration. However, it does not encompass trends for other populations, or possible population fluctuations in other areas of the NSWO range. Other studies have consistently reported distinct populations with limited exchange between eastern and western North America (Holroyd and Woods 1975, Priestly et al. 2010, Beckett and Proudfoot 2011). Recapture data between birds throughout eastern North America (Confer et al. 2014) also supports our model's assumption that one population is likely moving through all 7 sites.

Due to the low detectability of NSWO, standardized banding data during autumn migration is one of the best methods for monitoring regional population trends. The large interannual fluctuations in numbers observed regionally in NSWO migration patterns are consistent with those of both nomadic (Marks and Doremus 2000, Bowman et al. 2010) and irruptive (Davis 1966, Rasmussen et al. 2008, Confer et al. 2014) migrants. Given that breeding NSWO feed predominantly on small mammals, the populations of which fluctuate tremendously on an annual basis in the boreal forest (Rasmussen et al. 2008), it is very likely that the pattern seen here (large fluctuations of migrating juvenile NSWO) reflects the overall reproductive output resulting from good or bad years on the breeding grounds. Although there is limited research on NSWO population trends during migration and even less during other periods of the year, other diet specialist raptors with similar behavioral patterns, such as Snowy Owls (*Bubo scandiacus*), often exhibit migration patterns based on both reproduction and resource availability (Therrien et al. 2014, Robillard et al. 2016). Research suggests this may also be the case with NSWO (Côté et al. 2007). To further explore this possibility, we should increase our research and monitoring efforts during the NSWO breeding season to assess how food availability during breeding affects reproductive output and, in turn, migration volume (or dispersion), the following fall season. In addition, a global initiative to monitor small mammal populations within NSWO breeding, wintering, and migration ranges would be warranted to ensure continued population stability.

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