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Insights from Project FeederWatch: Changes in the abundance and occurrence of birds in New Hampshire over the past 24 years

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Abstract

Changes in the climate and land use over time can lead to changes in the composition of wildlife communities. Using data from Project FeederWatch, we examine trends in the abundance and occurrence of birds documented in the winters from 1988 to 2012 in New Hampshire. Changes in abundance and occurrence are summarized for individual bird species as well as across species based on life history traits. In addition, we examined trends for the state as a whole as well as in subregions, using counties as area designators. We discuss these changes with regards to the variations of climate and land use that are occurring throughout New Hampshire.

Introduction

Citizen Science is a growing concept that refers to the participation of the public in scientific projects. There are two main benefits from the use of citizen science: the acquisition of information, and the involvement and consequential education of the public (Riesch and Potter, 2013). Involving the public in a project increases the amount of data that can be collected because of an increase in participants; a large group of citizens will collect more information than a small group of researchers. Thus, citizen science projects can consider a broader range of information, which may lead to patterns on a larger scale (Nov *et al.*, 2014). Additionally, an important part of citizen science is education of the public. While not all citizen science projects require training or certification for involvement, the projects provide an opportunity to involve the public in an issue of environmental concern and educate them on the subject, which may lead to increased environmental stewardship by the public (Piesch and Potter, 2013).

Citizen science projects have been successful both terrestrially and in aquatic ecosystems (Delaney *et al.*, 2008; Abolafya *et al.*, 2013). A study of invasive crabs, *Carcinus maenas* and

Hemigrapsus sanguineus, on the northeast coast of the United States was completed with help from citizen scientists of varying ages (Delaney *et al.*, 2008). Delaney *et al*. (2008) found that there was high accuracy in the data collected that increased with age and experience. Additionally, the use of citizen scientists allowed for the development of a large-scale standardized database that includes information on the distribution and abundance of native and invasive crabs (Delaney *et al*., 2008).

Birds are a common group of terrestrial fauna for study using citizen science (Abolafya *et al.*, 2013; Lepage and Francis, 2002; Wells *et al.*, 1998). In Turkey, citizen science data was used to detect changes in common songbirds. Specifically, Abolafya *et al.* (2013) studied biodiversity data based on bird counts and related these to how the distributions of common songbirds will change as climate change progresses. The data gathered by public participants enabled the full extent of the study, as funding for biodiversity is limited and interest in birds, specifically, is growing (Abolafya *et al.*, 2013).

Project FeederWatch, through the Cornell Lab of Ornithology and Bird Studies Canada, provides a similar database of information. Starting in 1988, participating individuals record the number of each species of bird observed at one time at their feeders over two consecutive days, once a week from November through early April (Project FeederWatch, 2014). These data are then collected by Cornell and organized by species, feeder location, date, and other characteristics. The program also assesses the validity of the observations and flags potential invalid data points (Project FeederWatch, 2014). Due to the fact that data collection occurs throughout the winter, Project FeederWatch allows for an analysis of changes of populations throughout the winter (Lepage and Francis, 2002). Additionally, Project FeederWatch has a standardized protocol for data submission, which contributes to a consistent effort over time, and together with the length of time provides a valuable tool for monitoring birds (Lapage and Francis, 2002).

Our project used data from Project FeederWatch from 1988-2012 in New Hampshire. We examined both general trends over time based on life history characteristics, such as habitat and nesting, as well as specific trends in individual species. Overall, we asked three questions: [1] Do the FeederWatch data capture regional trends in reforestation? [2] Has increased development led to an increase in shrubland? If so, is this reflected in the abundance of winter feeder birds, which have an affinity for shrubland habitat? And [3] do the trends in New Hampshire align with trends documented by Project FeederWatch throughout the northeast region? Or are there changes that should be considered on a state or county scale? By answering these questions, we hope to aid in the analysis of important information regarding the winter status, potential annual variation, and decadal-scale trends in the distribution and abundance of species.

Project FeederWatch has been used as a dataset for many studies across North America (Lapage and Francis, 2002; Wells *et al.*, 1998; Bonter and Harvey, 2008; Hochachka *et al.*, 1999). We were interested in using Project FeederWatch data at a finer scale to assess the wintering populations of feeder birds across the state of New Hampshire. To do so, we examined trends for individual species as well as community composition defined by life history traits. Trends in bird data may also give an insight into the status of forests and open woodlands in New Hampshire over the past 24 years.

Methods

Categorization

We refined the FeederWatch data collected from 1988-2012 by eliminating invalid data points as determined by Project FeederWatch. We also accounted for synonymy within the data. Our analyses were limited to the top 45 species, as they made up greater than 99 percent of the observations in each county of New Hampshire. In order to evaluate the data over time, we created two different twelve-year time bins: before 2000 (1988-1999) and after 2000 (2000-2012). In addition, we categorized each species by multiple life history traits: foraging behavior, food, migration, habitat and nesting. However, we limited our analyses to those of habitat, (forest, open woodland, town, grassland, mountains, and marsh), and nesting (cavity, ground, shrub, tree, cliff, and building) as they are most indicative of potential reforestation across New Hampshire. Of the habitat categories, mountains, marsh, and grassland were not considered due to the low amount of species that were dependent on these habitat types. Of the nesting categories, cliff and building nesting locations were also excluded due to a low sample size.

Trait-based comparisons

Using ArcGIS (v10.2) and the latitude and longitude points for each observation from Project FeederWatch, we determined the county within which each bird sighting was recorded. We then aggregated all localities within a given county, and based on the habitat and nesting determination, examined trends at the county level by analyzing the changes in proportion of each life history trait category from before and after 2000. Additionally, we performed a Spearman's rank abundance test in Microsoft excel within each trait category for each county and for the state as a whole. By completing this test, we were able to determine if community structure changed over time. We also performed a Wilcoxon signed-rank test in JMP for each life history trait to ascertain whether species' rank in the trait groups were mostly increasing, decreasing, or remaining the same within each county.

Species trends

We selected species that changed greatly over time as well as representative species from each category to analyze specifically. We investigated two species of forest specialists: the evening grosbeak (*Coccothraustes vespertinus*), a tree nesting species, and the red-bellied woodpecker (*Melanerpes carolinus*), a cavity nesting species. The other two species we analyzed were open woodland specialists: the common redpoll (*Acanthis flammea*) and the American tree sparrow (*Spizella arborea*), which are shrub and ground nesting species, respectively. We evaluated changes in proportional abundance over time both county and statewide. Based on these data we investigated four species that increased in some counties and decreased in others. These too, were divided between open woodland and forest specialist species, the forest including the black-capped chickadee (*Poecile atricapillus*) and the dark-eyed junco (*Junco hyemalis*), and the open woodland including the American goldfinch (*Spinus tristis*) and mourning dove (*Zenaida macroura*). These trends in species were compared to those documented by Project FeederWatch for the Northeast region of the United States.

Results

Life history trends: Habitat

The proportion of forest specific birds decreased in nine of the ten counties (all except Merrimack county) in New Hampshire from before 2000 to after 2000, while the proportion of open woodland specific birds increased in nine of the ten counties (all except Strafford county). There was not a general trend for town specific species, however the Wilcoxon signed-rank test identified a significant ($p<0.10$) trend across species in the direction of change for town species in Belknap and for forest species in Hillsborough (Figure 1).

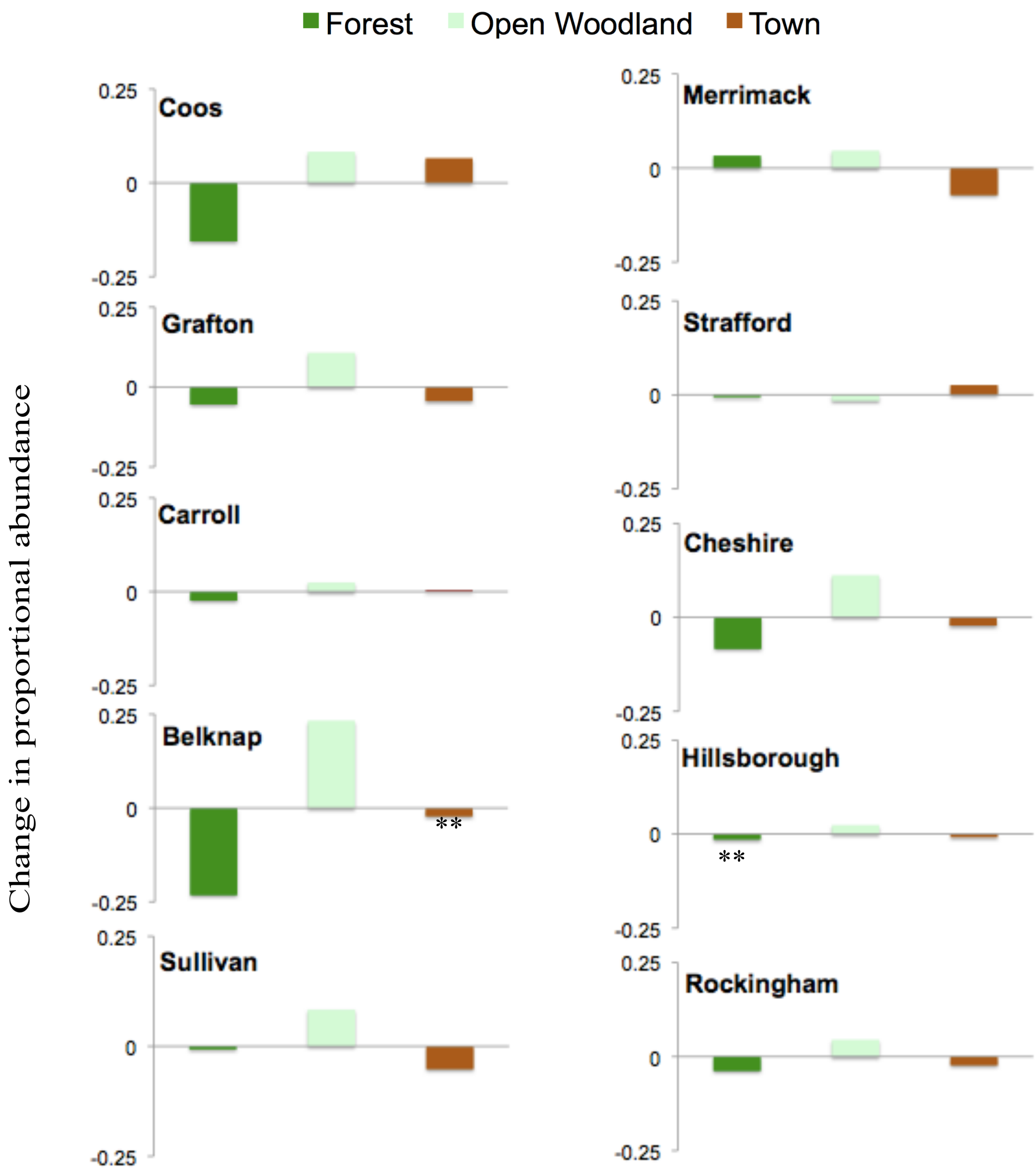

Figure 1. Proportional abundance of habitat specialists prior to and after 2000 in each of the ten counties in New Hampshire. Counties are arranged from north to south and west to east. Wilcoxon signed-rank test: identified consistent trends across species in the direction of change for each life history category. Significance denoted as *<0.05 and **<0.10.

Town specific species also changed the greatest in rank abundance based on the Spearman's rank abundance test, specifically in Belknap, Carroll, Merrimack, Strafford, and Sullivan, with correlation values of 0.40, -0.50, 0.60, 0.30, and 0.12, respectively. Neither open woodland species nor forest species changed greatly in rank within the counties as the rank abundance structure of the assemblages were strongly correlated over time ($r>=0.71$).

Life history trends: Nesting

Generally, cavity and tree nesting species declined in proportional abundance (six of ten counties and eight of ten counties, respectively) while ground and shrub nesting species increased in proportional abundance (ten of ten counties and nine of ten counties, respectively) over time (Figure 2). The Wilcoxon signed-rank test indicated a significant trend in the direction of change in ground specific species for both Cheshire and Hillsborough counties ($p<0.10$). There was also a significant trend in direction of change in cavity nesting birds in Hillsborough ($p<0.10$) and in tree nesting birds in Cheshire ($p<0.05$).

Ground nesting birds changed greatly in rank abundance in Belknap, Carroll, Coos, Hillsborough, and Merrimack with rank correlation values of 0.24, 0.66, 0.54, 0.43, and 0.66, respectively. Cavity, shrub, and tree nesting species did not change in rank abundance as they all had high correlation values of greater than 0.71, except tree specific nesting species in Rockingham ($r=0.69$).

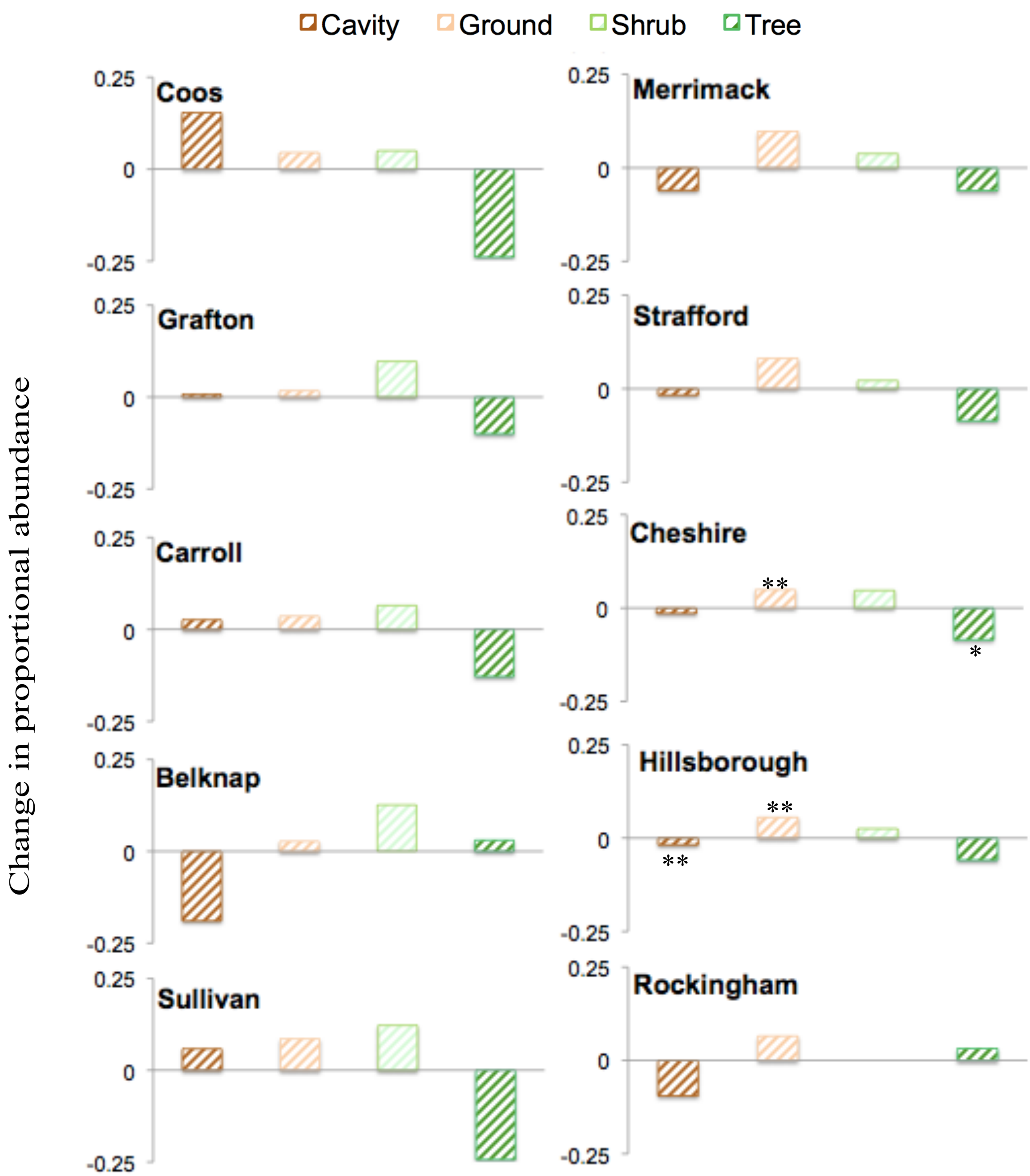

Figure 2. Proportional abundance of nesting specialists prior to and after 2000 in each of the ten counties in New Hampshire. Counties are arranged from north to south and west to east. Wilcoxon signed-rank test: identified consistent trends across species in the direction of change for each life history category. Significance denoted as *<0.05 and **<0.10.

Species-specific trends

The percentage of evening grosbeak is in decline across all ten counties in New Hampshire. Evening grosbeaks were highest in percent of total sightings in Coos, Carroll, Cheshire, and Sullivan counties, but have decreased from a high of 0.1% of total sightings before 2000 to a high of approximately .02% after 2000 (Figure 3). The red-bellied woodpecker has increased over the past 24 years from a high of approximately 0.01% of total sightings before 2000 to a high of approximately 0.06% after 2000. The greatest increases were in Rockingham, Strafford, Sullivan, and Hillsborough (Figure 3). The common redpoll data represents an irruptive population that peaks approximately every other year. Peaks are highest in Coos county in the mid- to late 1990s (up to approximately 2.5% of total sightings), in Carroll county in 2003 (approximately 3.5% of total sightings), and in Sullivan county in 2010 (approximately 3% of total sightings; Figure 4). The American tree sparrow increased gradually over time, with a high of approximately 0.04% of total sightings in Cheshire county before 2000, and a high of approximately 0.10% of total sightings in Coos county after 2000 (Figure 4).

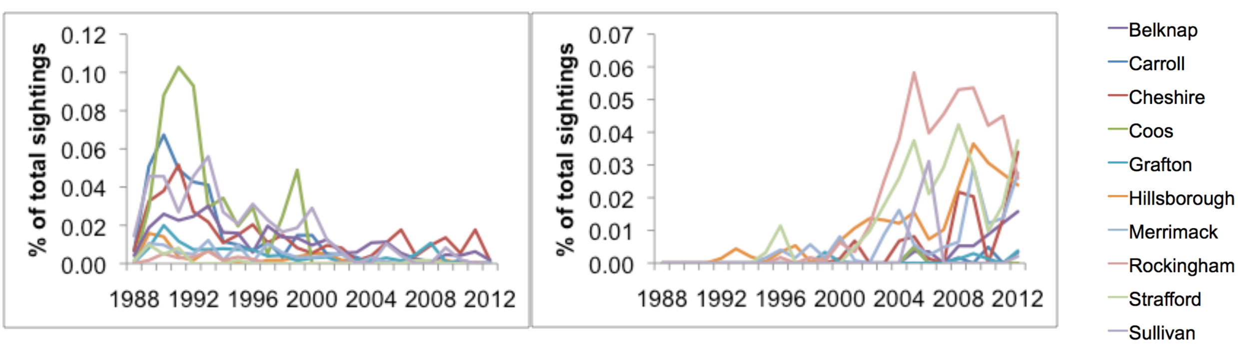

Figure 3. Trends of percent of total sightings for forest specialist species across counties in New Hampshire from 1988-2012. Decreasing population in evening grosbeak (left) and increasing population in red-bellied woodpecker (right).

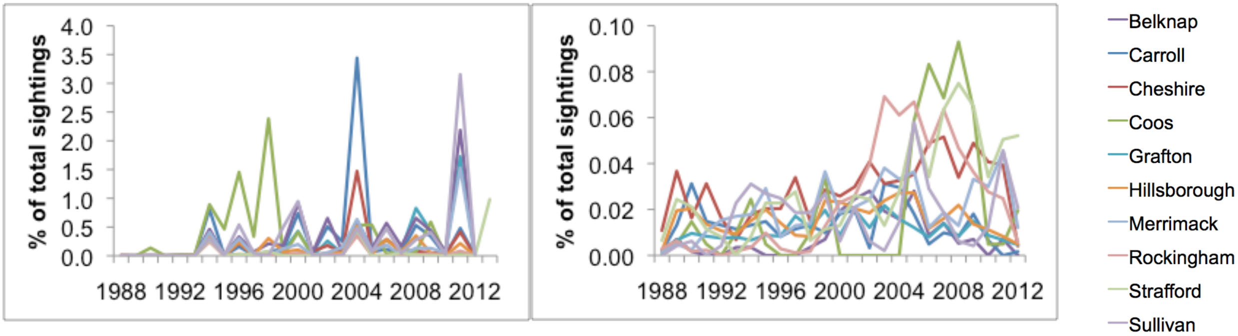

Figure 4. Trends of percent of total sightings for open woodland specialist species across counties in New Hampshire from 1988-2012. Irruptive population in common redpoll (left) and increasing population in American tree sparrow (right).

Discussion

Life history group trends

The decrease in proportion of species dependent on forest as a habitat and the increase in open woodland dependent species (Figure 1) suggests that there has been a decrease from 1988 to 2012 in forests across New Hampshire, which is allowing for an increase in open woodlands (but see *Possible sources of change* below). This is supported by the decrease proportion of cavity and tree nesting species, both of which are associated with forests, and an increase in proportion of ground and shrub-nesting birds, which are associated with open woodlands (Figure 2). There was not a visible trend in the proportional change of the three habitat dependent species groups traveling north to south between the counties, suggesting the change is not climate based. Cavity nesting birds may be impacted by latitudinal change as they increased in proportional abundance in the northernmost counties and decreased in the mid to lower counties. Furthermore, the high amount of significant Wilcoxon signed rank results for ground-nesting species across the counties indicates that there have been changes in the most abundant and the rare species over time. More research on the species and county level is necessary to explain these phenomena and determine the significance of the patterns.

Species-specific trends

For many birds, trends for New Hampshire align well with the broader regional analysis conducted by Project FeederWatch. We focused on common species that were representative of 1 of 4 general trends, and observed consistency in pattern at county and state level. There is more variation on the county-scale, which leads to questions with regards to specific species. Additionally, trends at the trait level may mask strong species-specific patterns. For example, if cavity-nesting species are generally increasing in the northernmost counties, why are red-bellied woodpeckers, which are cavity nesters, independently increasing the greatest in mid to southern counties (Figure 3)? Continued research is necessary to answer this and other species-specific questions, such as why some species are increasing in some counties and decreasing in others.

The evening grosbeak is in decline at the county, state, and broader Northeastern regional scale (Project FeederWatch, 2014; figure 3). Based on another analysis of FeederWatch data, it was found that sites reporting evening grosbeaks decreased by a total of 50 percent in eighteen years (Bonter and Harvey, 2008). It is suggested that the decline could be due to habitat loss, disease, parasitic infection or a decline in abundance of a food item. However, the cause of this decrease is unknown, and while it may be a combination of these factors, further investigation is recommended (Bonter and Harvey, 2008). Based on our results, the decrease in percent of evening grosbeak sightings parallels the decrease in proportional abundance of forest dependent species. While this supports the idea that habitat loss could be impacting the grosbeak, it also suggests that the decline in the evening grosbeak may be, in part, driving the pattern of decline in proportion of forest specialist species. This hypothesis is maintained by the fact that the Wilcoxon signed-rank test was not significant for forest specialists.

It is valuable to compare trends across the county, state and region, as these comparisons continue to validate the importance of citizen scientist projects, and Project FeederWatch specifically. The common redpoll is an example of a species that varies greatly in population due to migration over the years (Hochachka *et al.*, 1999; Figure 4). The fact that this is evident not only within the state but also within the counties further supports that FeederWatch is a valuable tool for examining species trends and trends across a geographic region. The American tree sparrow represents a species that while increasing in general across the state, is not changing in all counties (Figure 4). Therefore, Project FeederWatch allows researchers to examine subtle changes that vary geographically. This can help to tease apart the mechanisms for change for individual species.

Possible sources of change

Forests have increased dramatically in New Hampshire over the past century due to widespread farm abandonment and natural successional processes (Vadeboncoeur *et al*., 2012). Based on this information, the results we found are surprising. However, there have been declines in the percent forest cover in New Hampshire beginning in 1983 that may contribute to the increases in open woodland dependent species and decreases in forest dependent species (Thorne and Sundquist, 2001). From 1980 to 2020, there is a hypothesized seven percent decrease in forest cover, and fragmentation will continue to occur throughout the state. The quality of the forests is also decreasing (Thorne and Sundquist, 2001). Songbirds are especially sensitive to the edge effects associated with fragmented habitat. Thus, even if the percent forest cover does not change dramatically, if the forest that remains is fragmented, birds may be negatively impacted (Holmes and Sherry, 2001). Also, the area of forest adjacent to a clearcut may not be suitable habitat for birds, and for that reason birds will still live in the internal part of the forest but avoid the edge and the clearcut land (King *et al*., 1997).

The impact of forest clearcuts and fragmention on birds suggests an additional alternative hypothesis to explain the changes observed. There may be a sampling bias in the Project FeederWatch data stemming from the location of the participants. The signal we detected may represent local changes in development rather than regional changes in forest cover. Along with the concept of fragmentation is the idea of subdivision of land resulting from development, which may cause feeder placement relative to forest to decline over time. Therefore, forest species may not be in decline, but feeder locations today may instead promote detection of open woodland and town species. In order to test this hypothesis, we suggest including an option for land cover data on the FeederWatch data collection sheet. If the species recorded are specified in an area that is rural, the analysis of these data will be different than if the species are recorded in an urban or suburban area. This will help reduce the potential sampling bias.

Overall, grouping birds by life history traits is useful for evaluating their status on a local and regional scale. Comparing county to state and region wide trends can help provide a strong framework for teasing apart the different mechanisms that are causing change in individual species and also in life history trait categories. Project FeederWatch is a valuable tool that allows researchers to distinguish these trends and provides an avenue for future research.

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