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# Abstract

We recreated a historical bird survey that started in 1898 to investigate how bird diversity and community composition changed in Lincoln Park – the largest park in Chicago, IL. While species richness did not change through time, community composition did. Of 121 species analyzed, 32 increased in frequency. Some species that increased include the red-winged blackbird, European starling, and American crow. A total of 22 species decreased in frequency, which included the red-headed woodpecker, eastern bluebird, and blue jay. Overall, the changes observed throughout Lincoln Park reflected statewide bird population trends over the last 100 years.

# Introduction

Long-term ecological research is important albeit rarer and less funded than short-term but spatially expansive research (Likens, 1989, Hughes et al. 2017). This contrast between temporal and spatial ecology research may arise from a key difference between space and time: space can be manipulated over many scales while time cannot be fundamentally changed (Wolkovich et al. 2014). Certainly, the relative timing of events can be modified (Verhulst & Nilsson 2007, Vanette & Fukami 2014), but it is impossible to alter time absolutely. Thus, increasing temporal extent requires the time to do so or, if available, historic data for comparison.

Fortunately, historic bird surveys are somewhat common and can be recreated to explore temporal changes in bird diversity and community composition over long times spans (Igl and Johnson 2005, Fidino and Magle 2017). Tingley et al. (2013), for example, resurveyed locations that Joseph Grinnell surveyed between 1911 and 1929 along an elevation gradient in the Sierra Nevada mountains of California, USA. Species richness decreased over this century. Further, urbanization at low elevations caused substantial community turnover as birds better suited for human-modified habitats replaced those that were not (Tingley et al. 2013). Similarly, by recreating a century old survey throughout Illinois, USA, Ward et al. (2018) showed that many bird species became more common statewide by adapting to urban habitats. These studies, and many others, demonstrate how essential historical surveys are to evaluate changes in bird populations through time (Igl and Johnson 2005 and references therein).

We recreated a historical survey to investigate a century of change in bird community composition and diversity in Lincoln Park, Chicago, IL, USA. The original surveyors, Herbert and Alice Walter, walked the park from March to May between 1898 and 1903 and wrote a field guide for the city birder (Walter, 1904). Along with general species descriptions, the Walter’s book summarized their field notes for future comparison. The Walter’s survey was continued by William Dreuth between 1927 and 1932 (Clark and Nice, 1950). Eighty years later, we continued the survey between 2012 and 2015. Our goals were to determine 1) which species increased or decreased over this century and 2) if the temporal trends observed in Lincoln Park mimic those observed throughout Illinois.

# Methods

## Study Area

Lincoln Park is mostly linear and located along the western shore of lake Michigan, roughly 4.5 km north of Downtown Chicago (Figure 1). The largest park in Chicago, Lincoln Park has increased in size since the original bird survey from about 125 ha to 481 ha (Figure 1). The land added has been north of its original boundary. The southern end has remained at North Avenue since the park was created (Clark and Nice 1950; Figure 1). Primarily made for recreation, Lincoln Park has multiple ponds, sports fields, nature areas, and expanses of turf grass peppered with mature trees and shrubs. These qualities have changed little since 1898. The Lincoln Park Zoo, which lies in the middle of the original park boundaries, was also present across all three survey periods.

Throughout Chicago, temperatures increase from near freezing at the start of the migratory season to roughly 15 °C by May (Table 1). In March, sunrise begins near 7:30 AM and, by May, advances to about 5:00 AM. Regarding weather, snow is common in March. Sometimes it snows in April.

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| Table 1. Average Temperature (°C) on the three months birds were surveyed in Lincoln Park, Chicago, IL, USA. Values in parentheses are average monthly minimum and maximum temperature during a survey period. | | | |
| Survey period | March | April | May |
| 1898 – 1903 | 1.88 (-1.67 – 4.72) | 8.11 (6.88 – 10.00) | 14.22 (12.28 – 15.44) |
| 1927 – 1933 | 2.90 (-1.05 – 6.28) | 8.92 (7.05 – 10.61) | 14.45 (13.11 – 16.22) |
| 2012 – 2015 | 3.50 (-0.17 – 11.94) | 9.39 (8.28 – 10.39) | 16.58 (15.78 – 18.67) |

## Recreating the historical bird surveys

There is little information about the paths historic surveyors walked to count birds. Thus, we assumed the first surveyors did not follow a standard methodology, walked the park, and counted species by sight and sound (Walter 1904). Dreuth, the surveyor between 1927 – 1933, included the count’s date, time, and end points of the path traveled in his field notes. Both historical surveys did not describe the specific path traveled in the park, the distance at which birds were identified from the travelled path, or the speed at which a surveyor walked.

At a minimum, both historical surveys included the number of days per year counts were conducted during the migratory season. Between 1898 – 1903, an average of 75.66 (min = 66, max = 87) counts happened per year. This number is roughly equal to counting birds each weekday in March and April and then every day in May. Because the Walter’s included a figure of observed species richness per day between May 7 and 20 in their birding guide – a time they deemed the height of migration – we assumed they arranged their counts this way (Walter 1904). Between 1927 – 1933, an average of 57.66 (min = 17, max = 85) counts were conducted per year.

Some species were not included in the historical surveys. House sparrows (*Passer domesticus*) were and still are abundant in Lincoln park but the Walters and Dreuth did not count them. The Walter’s also excluded ‘water and shore birds’ from their counts, which they classified as gannets and grebes, cranes and rails, waterfowl such as ducks and geese, loons, and shorebirds such as terns and gulls, and pelicans. During the second survey, Drueth documented all species but the house sparrow.

We recreated these surveys with the available information, but followed a standard methodology to increase repeatability. To mimic a walk through Lincoln park, we delineated a 2.45 km line-transect from the northern-most point to the southern-most point of the original park boundaries. In the last century, many walking paths have not moved. We walked them whenever possible (Figure 1). To count birds, one trained observer (MF or KL) walked the transect at a steady rate, 2 km hour-1, and started about one hour past local sunrise during clear weather. All bird species were identified by sight and sound within 50 m of the transect. A count’s start point was switched each day and started in the north or the south of the park. Counts were conducted each weekday of March and April and then every day in May. This protocol is closer to the Walter’s 1898 – 1903 survey, which occurred within the original park boundaries at similar frequency. Their book was the original basis for this study. We only became aware of Dreuth’s second survey from birders in the park while we conducted our counts.

## Statistical analysis

Because abundances were not available from the first survey we used the proportional days species were observed per year as an abundance index. This metric is comparable within but not between species (Royle and Nichols 2003). We calculated alpha diversity across surveys as the number of unique species observed each survey period. We compared proportional similarity in bird communities as 1 – Jaccard dissimilarity using the proportional days a species was observed each survey period.

We used binomial generalized linear models (GLM) to determine if a species frequency changed between survey periods. Our response variable was the proportional days a species was observed per year weighted by the number of counts conducted per year. We used survey period (1898 – 1903, 1922 – 1927, and 2012 – 2015) as categorical variables in each species model. After fitting the GLM to a species’ data we used analysis of deviance to determine differences between survey periods (α ≤ 0.05). If a difference was observed we calculated pairwise contrasts between survey periods with the Tukey multiple comparison test, which adjusts P-values to correct for multiple testing (CITATION). Based on pairwise differences between three survey periods a species could follow one of 13 possible trends over time. For example, a species could have similar frequency in the first two survey periods followed by a higher frequency in the last survey period. Following Shultz (2012) we placed these 13 patterns into five groups. Thus, a species occurrence frequency through time could either 1) not change, 2) monotonically increase, 3) monotonically decrease, 4) be highest on the second survey period (mid-best) or 5) be lowest on the second survey period (mid-worst). Species were censored from the GLM analysis if they were only observed in one survey period.

Water and shorebirds were excluded from all analyses due to their omission from the first survey period. House sparrows were excluded for the same reason. Analyses were done in R version 3.5.3 (R core team 2019) with the vegan package (Oksanen et al., 2019) to calculate proportional similarity and the emmeans package for Tukey multiple comparison tests (CITATION).

# Results

## Bird richness and similarity

A total of 145 species in 34 families were observed across all survey periods. *Parulid* warblers represented the greatest portion at 33 species, followed by New World sparrows in *Passerelidae* (n = 19), and blackbirds in *Icteridae* (n = 10). Fewer species were observed between 1898 – 1903, while an equal number of species were observed in the last two survey periods (Figure 2). Community composition was most similar between the first two survey periods, which were closer together in time, and most dissimilar between the first and third survey periods (Figure 2). Only two species, the American robin (*Turdus migratorius*) and common grackle (*Quiscalus quiscula*), remained in the 10 most common species across survey periods (Table 2).

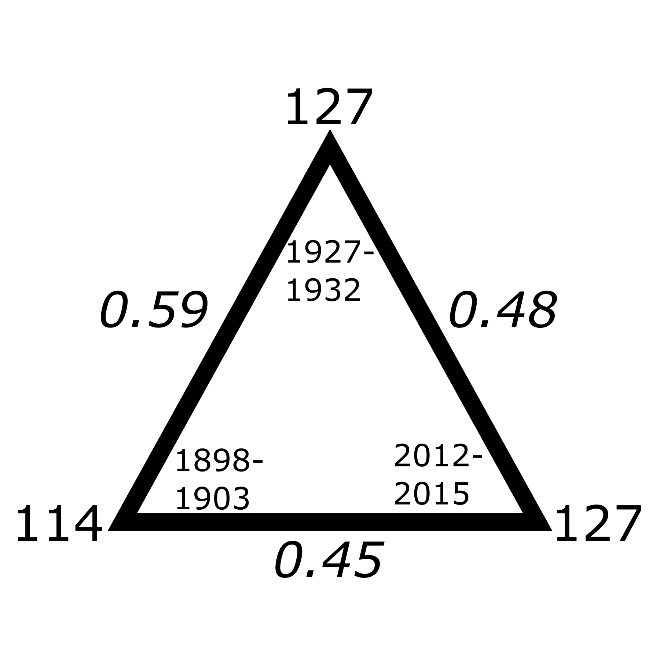


Figure 2. Alpha and beta diversity between survey periods in Lincoln Park, Chicago, IL, USA. Alpha diversity for a survey period is located on the edges of the triangle while proportional similarity (1 – Jaccard’s dissimilarity) between survey periods is along the edges.

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| **Table 2.** The proportional days the 10 most common species were observed during each survey period in Lincoln Park, Chicago, IL, USA between March to May. Species are listed from most to least frequent. The proportional days a species was observed per survey period follows their name. | | |
| 1898 – 1903 | 1922 – 1927 | 2012 – 2015 |
| American Robin – 0.84 | Common Grackle – 0.90 | red-winged blackbird – 0.91 |
| Common Grackle – 0.80 | American Robin – 0.71 | European starling – 0.91 |
| Blue Jay – 0.72 | Northern Flicker – 0.72 | American crow – 0.89 |
| Brown-headed Cowbird – 0.56 | Red-winged Blackbird – 0.62 | American robin – 0.80 |
| Dark-eyed Junco – 0.50 | Purple Martin – 0.55 | common grackle – 0.79 |
| Eastern Towhee – 0.47 | Dark-eyed Junco – 0.51 | northern cardinal – 0.76 |
| Song Sparrow – 0.42 | White-throated Sparrow – 0.50 | song sparrow – 0.72 |
| Northern Flicker – 0.40 | Brown Thrasher – 0.49 | black-capped chickadee – 0.72 |
| Ruby-crowned Kinglet – 0.38 | Eastern Towhee – 0.45 | rock pigeon – 0.68 |
| White-throated Sparrow – 0.37 | Yellow-rumped Warbler – 0.43 | downy woodpecker – 0.64 |

## Species trends over time

Of the 145 species, 121 could be analyzed with a binomial GLM. We failed to detect a frequency change for 35 species (Figure 3). Of these, 19 species were common across all survey periods – being detected on more than 5% of days per survey period – while 16 were rare (Figure 3). Of the common species, American robin were observed on 84% (80.72–87.74%) of days across survey periods. Of the rare species, golden-winged warbler (*Vermivora chrysoptera*) were observed on less than 1% of days. Nine species were least frequent between 1927 – 1933 (i.e., mid-worst). Notable species in this category are the American crow (*Corvus brachyrhynchos*) and black-capped chickadee (*Poecile atricapillus*), who greatly increased in frequency between 2012 – 2015 relative to the other survey periods (Figure 3). From the oldest to most recent survey American crow were observed on 14.76% (11.78–18.33%), 8.38% (5.89–11.80%), and 89.36% (84.73-92.71%) of days. Chickadees followed a similar pattern and were observed on 3.96% (2.51–6.20%), 0.57% (0.14 – 2.28%), and 71.91% (65.83–77.29%) of days across surveys.

Twenty-three species were most common during the second survey (i.e., mid-best; Figure 3). Common grackle, for example, were observed on 90.46% (86.88–93.14%) of days between 1927–1933 and 79.52% (75.55–82.98%) of days during the first and third survey period. Ove the last century a total of 22 species became less common (Figure 3). Blue jay precipitously declined over time and were observed on 71.37% (67.03–75.33%), 40.46 (35.41–45.72%), and 15.74% (11.63–20.98%) of days per year across survey periods. Eastern bluebird (*Sialia sialis*) followed a similar pattern and were observed on 33.04% (28.86–37.50%), 11.56% (8.59–15.38%), and 2.55% (1.15–5.57%) of days across the three surveys. Conversely, yellow-bellied sapsucker (*Sphyrapicus varius*) started their decline after the second survey and waere observed on 31.06% (26.97–35.47%) of days during the first two surveys but only on 17.45% (13.11–22.84%) of days between 2012–2015.

Thirty-two species became more frequent over time (Figure 3). This includes species the northern cardinal (*Cardinalis cardinalis*), red-winged blackbird (add scientific name), and European starling (*Sturnus vulgaris*). Many swallows and new world sparrows were placed in this category (Figure 3). American goldfinch (*Spinus tristis*) also became more common during the migratory season and were historically observed on 20.93% (17.43–24.91%) of days during the first two surveys but 47.66% (41.34–54.49%) of days between 2012–2015.

# Discussion

In one century Lincoln Park’s migratory community has changed. The rock pigeon (science name) and American crow were rare 100 years ago but are now common (Table 2). Blue jay were historically common and present year-round but are now rare and only seen during the migratory season (Walter 1904). These changes, however, are probably not related to the park itself – over 100 years many paths, ponds, and plantings remain relatively unchanged. Lincoln Park is also one of many stopover sites for migrant birds, and therefore community turnover could arise from habitat alteration at larger spatial scales. If this is the case, then our results should reflect statewide bird population trends. They do (Walk et al. 2010, Ward et al. 2018), though there are some key differences.

The Northern Illinois landscape, where Chicago resides, has become more forested and urban between 1898 and 2015, which has benefited some birds (Walk et al. 2010). Northern cardinal and red-bellied woodpecker, for example, were rare in Northern Illinois but have expanded their range northward due to increased forest cover (Walk et al. 2010). Both species are now common in Lincoln Park (Figure 3). The black-capped chickadee – a common cavity nester of Illinois’ deciduous or mixed forests – was historically rare in Lincoln Park but became the 7th most common species (Table 2). Likewise, urban tolerant species like the chimney swift (*Chaetura pelagica*), European starling, American robin, and common grackle have become more common statewide (Ward et al. 2018). In Lincoln Park these species either increased in frequency or remained common through time (Figure 3). Thus, many of the differences in the Lincoln Park migratory community reflect statewide population trends over the last century, especially for Illinois breeding birds.

The red-winged blackbird was one species whose frequency change in Lincoln Park did not reflect statewide population trends. In Lincoln Park, the blackbird had one of the greatest frequency increases over time. In Illinois, however, red-winged blackbird populations have not increased through time, they have been high for at least a century (Walk et al. 2010). But it is not blackbird abundance that has changed over time more so than where they are seen. Historically, red-winged blackbirds were marsh specialists and rarely observed in urban green spaces such as Lincoln Park (Ridgway 1889, Walter 1904). Now – owing to the loss of 90% of Illinois marsh and wetland habitat in the last century – the species nests along roadsides and in agricultural fields, upland habitats, and urban green space (Walk et al. 2010). Red-winged blackbirds began nesting in Lincoln Park, for example, during the second survey period (1927 – 1933) and continue to do so today (Clark and Nice 1950). Thus, the blackbirds adaptive capacity let it go from rare during the first survey period to the most common species between 2012–2015 (Table 2). Many other marsh specialists, unfortunately, do not share the red-winged blackbird’s adaptive capacity and have become less abundant with the loss of Illinois’ wetlands and marshes (Ward et al. 2010).

About 20% of the species analyzed decreased in frequency over time. The blue jay decreased in frequency despite stable or increasing populations in Illinois. As a common suburban bird, 100 years of urbanization around Lincoln Park possibly pushed the blue jay to Chicago’s less urban periphery (Walk et al. 2010). Red-headed woodpeckers (*Melanerpes erythrocephalus*) also decreased since the first two surveys, which reflects statewide population trends (Walk et al. 2010). Other decreases may be from methodological differences between surveys. Common nighthawks (*Chordeiles minor*) were seen on the first two survey periods, but not on our own. At dusk, nighthawks are common in Lincoln Park, but we never observed the species on morning counts. Thus, it could be that historic surveyors counted birds at different times of day. We did not. Despite possible methodological differences across surveys these results share many similarities to statewide trends, which likely indicates these data could be used for future comparisons.

Recreating historical surveys provides a glimpse into community change over long time spans. The data that we generated, if combined with other sources, can likely be used to answer a variety questions about bird population trends. We hope that our efforts in standardizing and compiling these data across surveys will be useful for others in the future, and potentially may encourage a future naturalist to recreate the survey again. If this survey is picked up again in 50 or 100 years, we suggest wearing a hat. Not only does it shield your eyes from the sun, it also protects your head from the bountiful male blackbirds that now defend their nesting territory throughout Lincoln Park.

ONE EXTRA PARAGRAPH

Attitude changes towards some species over time may be why their frequency has increased in Lincoln Park. Historically, hawks were persecuted and seen as vermin. Now, most Illinois residents indicate they would like hawk populations to increase or stay the same, which indicates a shift in attitudes towards such species (Walk et al. 2010). For example, while Cooper’s hawks (*Accipiter cooperii*) were not observed by previous park surveyors, the species has colonized much of Chicago in the last few decades (McCabe et al. 2018). On our own surveys, we detected the species numerous times per year and observed multiple nesting pairs. Though statewide habitat changes through time likely accounts for much of the observed differences, a decrease in persecution could also aid species that were historically disliked.

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