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Both Citizen Science Data and Field Surveys Detect Negative Impacts of Urbanization on Bird Communities

Caryn Ross[1] and Sujan Henkanaththegedara[1,*]

Abstract - Birds have become a model species for observing the effects of urbanization on wildlife in urban ecology research. Although challenging to perform, broad scale analysis of urban impacts on bird populations may be necessary for conservation management strategies and urban planning. We assessed the feasibility of using citizen science data to determine the effects of urbanization on bird communities focusing on species richness, abundance, biomass, and feeding guild composition. We conducted field surveys to document narrow-scale differences of bird communities in non-urban (i.e., state parks) and urban (i.e., cities) sites in Virginia, USA. Subsequently, we collected comparable data using an online citizen science database (eBird) for the same sites to assess the correlation between field and eBird data. Additionally, we performed a broad-scale analysis using eBird data, covering 300 sites in five states in the southeastern United Sates. Our narrow-scale analysis showed that the average species richness in non-urban sites (36.80 ± 2.20) was significantly higher than that of urban sites (16.40 ± 1.50; $W = 25$, $p = 0.0058$). Additionally, Shannon-Wiener diversity of birds in non-urban sites were significantly higher than that of urban sites ($W = 25$, $p = 0.0040$). The feeding guild composition in urban areas was dominated by omnivores (48%) while insectivores (44%) dominated non-urban areas. Data gathered from eBird generated comparable outcomes for bird species richness and feeding guild composition for both non-urban and urban sites compared to our field survey results. The overall analysis showed a strong positive linear correlation between field survey data and eBird data for species richness ($R^2 = 0.8579$, $F_{1,8} = 55.33$, $p < 0.001$). This indicates the importance of using untapped potential of eBird data to assess species richness, especially when traditional monitoring is not an option.

Introduction

Environmental conditions are constantly changing due to human activities with urbanization being one of the most significant human-induced issues in the contemporary world (Partecke et al. 2006, Sushinsky et al. 2013, Silva et al. 2016). It is well known that the global human population is projected to grow rapidly, increasing urbanization, while consequently affecting many wildlife species and their habitats (Gagne and Fahrig 2011, Ikin et al. 2013, Miller and Hobbs 2002). Changes associated with urbanization such as habitat loss and fragmentation, changes in vegetation structure and food supply, and introduction of exotic, predatory or competitor species cause an array of negative impacts on native species and their habitats (McDonnell and Pickett 1993, Chase and Walsh 2006, Zhou and Chu 2012). Recent work in the United States has shown urbanization to be a leading cause of decline in more than 50% of threatened or endangered species declared under the Endangered Species Act (Czech et al. 2000, McKinney 2002, Miller and Hobbs 2002, Smith and Chow-Fraser 2010). On the other hand, urban areas also support populations of urban adapted bird species contributing to the regional biodiversity (Blair 1996; Fuller et al. 2009), and in some cases, even healthy refuge populations of conservation concern species (see Fuller et al. 2009).

Birds have become a frequently used model species for studying the effects of urbanization on wildlife populations (Blair 1996, Gagne and Fahrig 2011, Mills et al. 1989, Ormond et al. 2014, Zuckerberg et al. 2011). A plethora of studies have shown strong negative correlations

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between degree of urbanization and bird species richness with relatively low richness of native bird species in urbanized areas (Chase and Walsh 2006, MacGregor-Fors et al. 2012, Mills et al. 1989, Zhou and Chu 2012). However, the abundance and biomass of bird species are higher in urban settings than nearby natural areas due to large populations of exotic or generalist species (Blair 1996, Chase and Walsh 2006, McKinney 2002, Mills et al. 1989, Warren and Lepczyk 2012). Furthermore, Blair (1996) showed that the peak diversity is at the moderately disturbed areas compared to both undisturbed and highly developed areas in an urban gradient supporting intermediate disturbance hypothesis (Connell 1978). Bird community composition also changed from mostly native species in the undisturbed areas to mostly invasive and exotic species in highly developed areas (Blair 1996, Crooks et al. 2003, Gagne and Fahrig 2011, MacGregor-Fors et al. 2012, McKinney and Lockwood 2001).

The majority of previous studies have a narrow focus and confined to localized areas (Blair 1996, Cam et al. 2000, Crooks et al. 2003, Mills et al. 1989). However, broad scale patterns of urban impacts on bird populations may be necessary to achieve sound conservation management strategies (Miller and Hobbs 2002), and urban planning (Ikin et al. 2013). Obtaining large-scale data sets covering wider geographic areas and long spans of time is very challenging due to limited labor, time, and funding (Cohn 2008). However, development of citizen science and publicly available citizen science data may bridge this gap allowing large-scale exploration of ecological and conservation oriented research questions (Bonney et al. 2009, Cohn 2008, Dickinson et al. 2012). These citizen science databases provide large quantities of previously unavailable free data on species occurrences and distribution at global scale, allowing conservation practitioners to assess the status, distribution and ecological interactions of targeted species (Bonney et al. 2009, Devictor et al. 2010, Dickinson et al. 2012).

The purpose of this study is to assess the feasibility of using citizen science data (eBird, Sullivan et al. 2009) to determine the effects of urbanization on bird communities focusing on species richness, abundance, biomass, and feeding guild composition. The use of citizen science data gives access to a rich data set, allowing us to analyze and compare vast geographic areas in state and/or national levels. Understanding broad scale ecological patterns in bird communities across an urban gradient may help us implement better management strategies within urban and non-urban areas (Dickinson and Bonney 2012, Ikin et al. 2013, Lepczyk and Warren 2012, Zhou and Chu 2012). First, we conducted field surveys to document narrow-scale differences of bird diversity in selected non-urban (i.e., state parks) and urban (i.e., cities) sites in Virginia. Second, we collected comparable data using an online citizen science database (eBird.org) for the same sites to assess the feasibility of using citizen-collected data for large-scale analyses. Third, we performed a broad-scale analysis of the impacts of urbanization on bird diversity using citizen-collected data, covering five states in the southeastern United Sates.

Methods

Narrow-scale Analysis

Study area. We conducted narrow-scale field surveys to document the bird species richness and abundance within the Piedmont region of Virginia in five state parks (non-urbanized) and in five cities (urbanized). All state parks selected (see Table 1) are frequently visited for recreational activities, such as, multi-use hiking trails, biking, kayaking, and swimming. Each park contains at least one source of water, all of those being man-made reservoirs with the exception of the James River State Park, which has three miles of shoreline along the James River. Holliday Lake State Park and Bear Creek Lake State Park are both located within State Forests, and James River State Park is located at the foothills of the Blue Ridge Mountains, making these three parks furthest from urbanized areas. The two remaining state parks are in closer proximity to an urban area. Twin Lakes State Park is located outside of Farmville, VA and Pocahontas State Park is located outside of Richmond, VA (Table 1). The five cities selected (see Table 1) as field sites have a wide range of populations; however, all exceeded the minimum requirement of 2,500 people to be deemed urban by the US Census Bureau (uscensus.gov). Midlothian contains a large reservoir and multiple creeks that ultimately feed into the James River below the fall line located within Richmond. The James River also runs through the cities of Charlottesville and Lynchburg. Farmville is the only urban field-site to be traversed by the Appomattox River, the major southern tributary of the James River. Each urban field survey was conducted in the center of the cities, where the landscape is primarily man-made structures, roads, and heavily trafficked by humans (Table 1).

Field surveys. Field surveys were conducted in order to generate baseline data on bird diversity and to ground-truth citizen-collected data. In May–June 2014, we visited five selected state parks and five selected cities in Virginia and conducted bird surveys. Each site was surveyed once during the study period using a series of random point counts along a pre-determined transect documenting all bird species and number of individuals recognized by sight or calls. Each point count lasted 10–15 minutes and each location was surveyed approximately 2 hours between the hours of 7.00 and 11.00 am. We included only species identified with certainty for the analysis.

Citizen science data mining. We utilized eBird citizen science database (www.ebird.org; Sullivan et al. 2009) to gather citizen-collected data on bird occurrences. Information on bird species richness for the same state parks and cities covered by field surveys were gathered using Explore Hotspots tool. We restricted our search to include only the past 10 years for all months and collected data only on bird species richness (i.e., the total number of species

Table 1. Description of the field survey sites. Number of visitors for each state park was obtained from Virginia Department of Conservation and Recreation (dcr.virginia.gov/state-parks/) and residential population for each city was obtained from US Census Bureau (uscensus.gov).

Field site	Area (km^2)	Human population size
State Park (Non-urban)		Visitor Population (2015)
Holliday Lake State Park	2.27	46,076
Bear Creek Lake State Park	1.33	90,398
Twin Lakes State Park	2.22	112,480
James River State Park	6.32	116,335
Pocahontas State Park	32.84	1,142,601
City (Urban)		Residential Population (2015)
Farmville	19.00	8,169
Midlothian	83.92	48,386
Richmond	161.90	220,289
Lynchburg	128.49	79,812
Charlottesville	26.70	46,597

recorded for each site). We utilized this citizen-collected data to compare with our field-survey data and to assess the feasibility of using citizen-collected data for broad-scale analysis.

Data Analysis. The mean differences of bird species richness between urban (cities) and non-urban (state parks) areas for field-collected data were compared using non-parametric Wilcoxon rank sum test due to small sample size (N = 5). The number of bird species was treated as the response variable and location (urban vs. non-urban) was treated as the predictor variable. We also compared Shannon-Wiener species diversity index (H'), overall abundance, overall biomass and Simpson's dominance index (D) of birds between non-urban and urban field sites in a similar fashion using non-parametric Wilcoxon rank sum test. Shannon-Wiener diversity index (H') and Simpson's dominance index (D) were computed using the formulae (Krebs 1999):

$$H' = -\sum (Pi * \ln Pi)$$

$$D = \sum (Pi)^2$$

Where: Pi = fraction of the entire population made up of species i.

Relative abundance and percentage occurrence of bird species were estimated using following formulae (Krebs 1999):

$$\text{Relative abundance} = \frac{\text{Abundance of a given species}}{\text{The total abundance of all species combined}}$$

$$\text{Percentage occurrence} = \frac{\text{Number of occurrences of a given species in sampling units}}{\text{Total number of sampling units}}$$

In order to analyze functional diversity of bird communities, we utilized feeding guild composition (Mills et al. 1989, Blair 1996). Each bird species was assigned to one of seven feeding guilds (insectivore, omnivore, carnivore, herbivore, granivore, nectarivore and frugivore) based on their major food source. The information of the diet of birds was extracted from *The Birds of North America Online* (Poole 2005). Differences of feeding guild composition between non-urban and urban sites were analyzed using a two-way ANOVA test considering number of species as the response variable and both location (Non-urban vs. urban) and feeding guild as predictor variables.

The mean differences of bird species richness between urban (cities) and non-urban (state parks) areas for eBird data (N = 30) were compared using parametric two sample t-test using number of bird species as the response variable and the degree of urbanization as the predictor variable. Differences of feeding guild composition between non-urban and urban sites were also analyzed for eBird data using a two-way ANOVA test considering number of species as the response variable, and both sites (non-urban vs. urban) and feeding guild as predictor variables. Finally, any correlations of species richness of birds between field survey data and eBird data were assessed using a simple linear regression model on pooled data (N = 10) to determine the feasibility of using eBird data to assess broad-scale analysis.

Broader-scale analysis

Study area. We selected 30 state parks and 30 cities for this analysis from Virginia, North Carolina, South Carolina, Georgia, and Florida covering the southeastern United States. When selecting state parks, we attempted to cover all physiogeographic zones of the state to get a wider coverage of habitat types. When selecting cities from each state, we used 2012 census data from US Census Bureau (uscensus.gov) and chose the top 30 most populated cities/ towns in each state to represent our urban areas.

Citizen science data mining. Each state park and city were then searched for bird species richness using the eBird Explore Hotspots tool with a time range set to the past 10 years for all months. In some rare occurrences, a new randomly selected state park was added to the list when there was no eBird data for the selected state park. Similarly, if a city/town did not have eBird data, the next highest populated location in that state was added to the list. Overall, we sampled 150 cities and 150 state parks in the southeastern United States for bird species richness.

Data analysis. Average differences of species richness of birds between non-urban and urban sites for each state and for pooled data for all five states were individually analyzed using two sample t-test. Subsequently, a two-way ANOVA test was conducted on pooled data to partition the variation across states considering number of species as the response variable and both site (non-urban vs. urban) and state as predictor variables including interaction terms between site and state. All statistical analyses were conducted using the R statistical software program (version 3.2.2; R Development Core Team 2016).

Results

Narrow-scale analysis

Our field surveys yielded an overall of 77 bird species belonging to 64 genera and 33 families (see Supplemental File 1, available online at https://eaglehill.us/URNAonline2/suppl-files/urna-152-Ross-s1.pdf). A total of 72 bird species was reported from non-urban sites (i.e., state parks) and 28 species from urban sites (i.e., cities). The average species richness in non-urban sites (36.80 ± 2.20) was significantly higher than that of urban sites (16.40 ± 1.50; W = 25.0, p = 0.0058). Additionally, Shannon-Wiener diversity of birds in non-urban sites were significantly higher than that of urban sites (W = 25.0, p = 0.0040). Furthermore, Simpson's dominance index was significantly higher in urban sites compared to non-urban sites (W = 0.0, p = 0.0079) due to large populations of a few dominant species, indicating higher species diversity of birds in non-urban areas. However, overall bird abundance (W = 5.0, p = 0.9524) and overall biomass (W = 10.0, p = 0.7262) did not vary significantly between non-urban and urban sites (Table 2).

The relative abundance of individual species in non-urban sites was much lower than that of urban sites. The most abundant bird species in non-urban sites were *Branta Canadensis* (Canada Goose, relative abundance [RA] = 0.072) and *Polioptila caerulea* (Blue-gray Gnatcatcher, RA = 0.071) followed by *Baeolophus bicolor* (Tufted Titmouse, RA = 0.046), *Bombycilla cedrorum* (Cedar Waxwing, RA = 0.043), and *Spinus tristis* (American Goldfinch, RA = 0.043). In urban sites, the most abundant bird species were non-native *Sturnus vulgaris* (European Starling, RA = 0.300), *Chaetura pelagic* (Chimney Swift, RA = 0.162), and non-native *Passer domesticus* (House Sparrow, RA = 0.133). The highest biomass in non-urban sites was represented by relatively large bodied birds such as, Canada Goose (70.51%), *Cathartes aura* (Turkey Vulture, 5.73%), *Meleagris gallopavo* (Wild Turkey, 5.45%), and *Corvus brachyrhynchus* (American Crow, 3.95%). Similarly in urban sites, relatively large-bodied birds such as Turkey Vulture (39.22%) and American Crow (21.40%) represented the highest biomass. Although relatively small, it is surprising that non-native European Starlings represented 18.23% of the total biomass in urban sites, due to large population size. Only 18% of bird species were reported in each of five survey sites for both urban (5 species) and non-urban (13 species) sites (see Supplemental File 1).

Field survey data also revealed significant differences of feeding guild composition of birds between non-urban and urban sites ($F_{1,56} = 80.97$, $p < 0.001$), between feeding guilds ($F_{6,56} = 113.92$, $p < 0.001$) and significant interactions between sites and feeding guilds ($F_{6,56} = 36.77$, $p < 0.001$; Fig. 1). Feeding guild composition from non-urban sites was dominated by insectivores (44%) followed by omnivores (39%). By contrast, the feeding guild composition in urban sites was dominated by omnivores (48%) followed

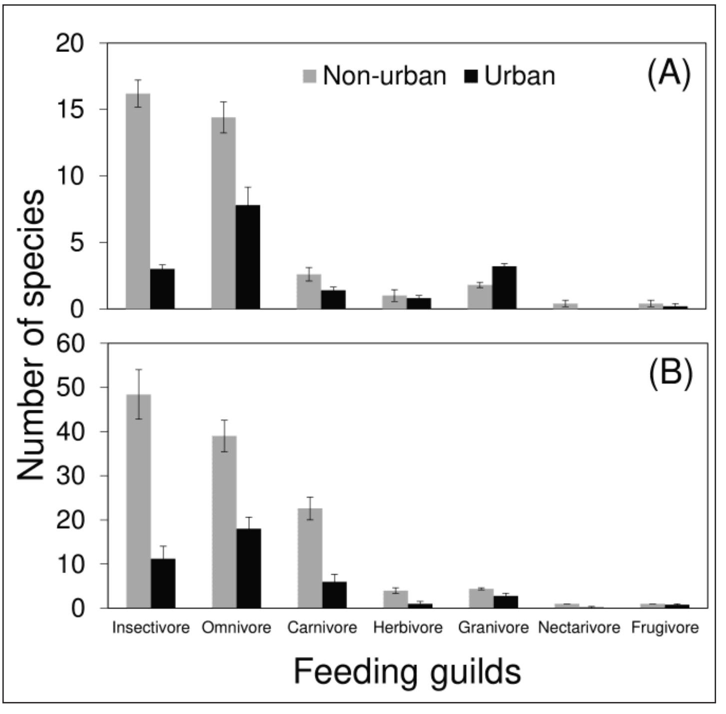

Figure 1. Bird species richness in each feeding guild based on field surveys (A) and eBird data (B) for five non-urban (i.e. state parks) and urban (i.e. cities) sites in Central Virginia. Both field surveys and eBird data showed insectivore-dominant non-urban sites and omnivore-dominant urban sites.

Table 2. A comparison of ecological parameters of bird species diversity between non-urban (i.e., state parks) and urban (i.e., cities) field sites (N = 5). Values in parentheses show standard error of the mean.

Ecological parameter	Non-urban site (State parks)	Urban site (City)	W value	p value
Species richness	36.8 (± SE 2.20)	16.4 (± SE 1.50)	25.0	0.0058
Shannon-Weiner Diversity Index (H)	3.252 (± SE 0.024)	2.236 (± SE 0.155)	25.0	0.004
Overall abundance	138 (± SE 18.46)	193 (± SE 38.19)	5.0	0.9524
Overall biomass (kg)	63.82 (± SE 45.39)	29.86 (± SE 7.89)	10.0	0.7262
Simpson's Dominance Index (D)	0.053 (± SE 0.009)	0.266 (± SE 0.046)	0.0	0.0079

by granivores (19%) and insectivores (18%, see Supplemental File 2, available online at https://eaglehill.us/URNAonline2/suppl-files/urna-152-Ross-s2.pdf).

Citizen-collected data mined from eBird database for the same non-urban sites (i.e., state parks) and urban sites (i.e., cities) also showed high diversity of birds in non-urban sites compared to urban sites. The average species richness of birds in non-urban sites (120.4 ± SE 10.84) was significantly higher (t = 7.223, $p < 0.001$) than that of urban sites (40.0 ± SE 5.56), indicating higher bird diversity in non-urban areas compared to urban sites. Furthermore, this also indicates that eBird data yields much higher species richness values probably due to data saturation. Similarly, eBird data revealed significant differences of feeding guild composition of birds between non-urban and urban sites ($F_{1,56} = 47.64$, $p < 0.001$), between feeding guilds ($F_{6,56} = 20.95$, $p < 0.001$) and significant interactions between sites and feeding guilds ($F_{6,56} = 19.35$, $p < 0.001$; Fig. 1). Feeding guild composition generated with eBird data showed a very similar pattern compared to our field survey data. Feeding guild composition in non-urban sites was dominated by insectivores (40%) followed by omnivores (32%). Additionally, eBird data picked up a considerable fraction of carnivores (19%) for non-urban sites. By contrast, the feeding guilds in urban sites were dominated by omnivores (45%) followed by insectivores (28%). Surprisingly, the contribution from granivores was very limited (7%) and a considerable fraction of carnivores (15%) was represented compared to the field survey data (see Supplemental File 2).

Although eBird data resulted in significantly higher values for species richness than the field survey data ($F_{1,16} = 59.65$, $p < 0.001$, Fig. 2), a simple linear regression model showed a strong positive linear correlation between field survey data and eBird data (N = 10, Adjusted $R^2 = 0.8579$, $F_{1,8} = 55.33$, $p < 0.001$, Fig. 3). This indicates that it is reasonably appropriate to use eBird data to assess broader-scale patterns of bird species richness.

Broad-scale Analysis

The average species richness of birds across five states for non-urban sites (i.e., state parks) ranged from 105.1 (Georgia) to 159.4 (Florida). The average bird species richness for urban sites (i.e., cities) varied within a narrow range from 27.4 (North Carolina) to 37.53 (Georgia). The bird species richness was significantly higher for non-urban sites

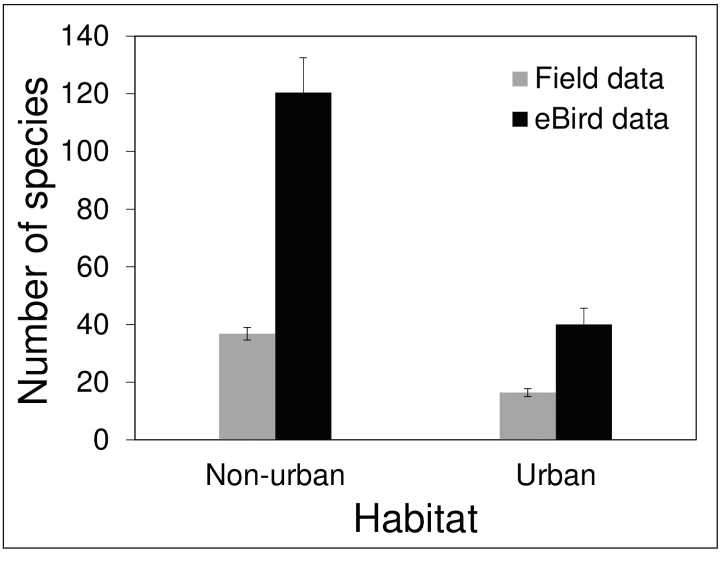

Figure 2. Relative species richness of birds generated by field surveys and eBird data. eBird data resulted in significantly higher values for species richness than the field survey data (F1,16 = 59.65, p < 0.001).

(125.82 ± 3.83) compared to urban sites (33.35 ± 1.16) for pooled data across all states ($F_{1, 290}$ = 612.984, $p < 0.0001$), and for individual states (see Table 3). Additionally, there were significant differences of species richness between states ($F_{4,290}$ = 7.091, $p < 0.0001$) including significant interactions between sites and states ($F_{4,290}$ = 5.873, $p < 0.001$).

Discussion

Our narrow-scale analysis showed that bird species diversity in urban areas was consistently lower than that of non-urban areas, providing evidence for negative impacts of urbanization on bird species diversity. A few species dominated the bird community structure in urban areas reducing the overall diversity compared to non-urban sites. Specifically, three bird species including two non-native species (i.e., European Starling and House Sparrow) represented nearly 60% of the overall abundance of the birds in urban areas. By contrast, in non-urban areas, the most abundant three species represented less than 20% of the overall abundance of birds. Feeding guild composition also showed significant differences between urban and non-urban areas. Urban areas were dominated by omnivores (48%), while non-urban areas were dominated by insectivores (44%).

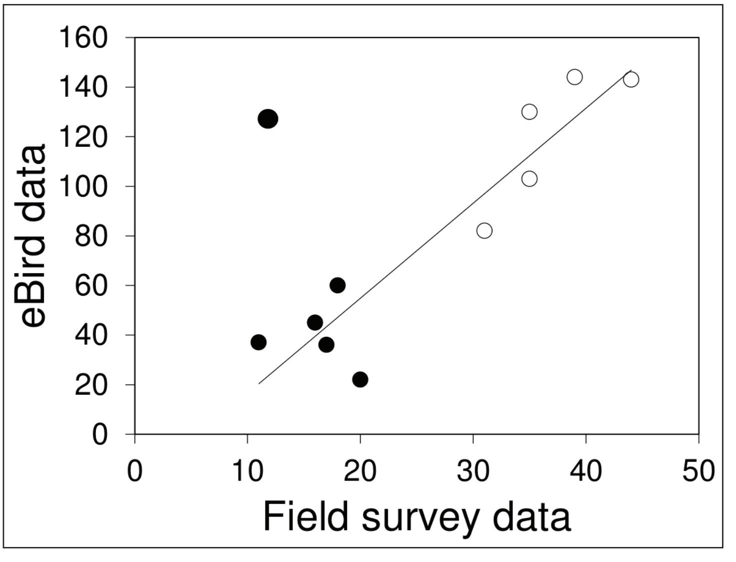

Figure 3. A simple linear regression model showed a strong positive linear correlation between field survey data and eBird data (N = 10, Adjusted R2 = 0.8579, F1,8 = 55.33, $p < 0.001$) for non-urban (i.e. state parks) and urban (i.e. cities) sites (N = 10).

Table 3. A comparison of average bird species richness in non-urban (i.e. state parks) and urban (i.e. cities) sites across five southeastern states. Values in parentheses show standard error of the mean.

State	Non-urban	Urban	N	t value	p value
Virginia	130.37 (± 8.94)	30.40 (± 2.16)	30	10.87	< 0.001
North Carolina	116.43 (± 5.70)	27.4 (± 1.89)	30	14.81	< 0.001
South Carolina	117.80 (± 10.83)	34.07 (± 3.02)	30	7.44	< 0.001
Georgia	105.1 (± 5.73)	37.53 (± 3.02)	30	10.44	< 0.001
Florida	159.4 (± 7.35)	37.37 (± 2.36)	30	15.8	< 0.001
All states	125.82 (± 3.83)	33.35 (± 1.16)	150	23.16	< 0.001

Consistent with previous research, our results clearly show significantly higher species diversity of birds in natural areas compared to urban areas (Blair 1996, Chase and Walsh 2006, MacGregor-Fors et al. 2012, McKinney 2002). This is most likely due to the sensitivity of birds to different effects of urbanization such as habitat loss and fragmentation, changes in vegetation structure, altered resource availability and nesting sites, new competitors and predators (Lowe et al. 2011, McDonnell and Pickett 1993). It has been shown that the disturbance caused by urbanization may negatively affect some species (urban avoiders), benefit some others (urban exploiters), and benefit the rest up to a moderate level before negatively affecting them (suburban adaptable) (Blair 1996, Pauw and Louw 2012). Urbanization may cause generalist species (including non-native species) to exploit urban resources more effectively and replace native specialist species that can no longer survive in the altered habitats (Gagne and Fahrig 2011, McKinney and Lockwood 1999). While overall species diversity of birds decrease in urban areas, overall abundance and biomass tend to increase due to generalist species that are able to thrive in an urban setting (Chase and Walsh 2006, Crooks 2003, Smith and Chow-Fraser 2010). More urbanized habitats provide a wide array of roosting and nesting structures from man-made building cavities to bird houses, thus favoring cavity-nesting bird species such as non-native European Starlings and House Sparrows (Chase and Walsh 2006). These species-specific interactions with the environment lead to an overall biodiversity loss and biotic homogenization (McKinney and Lockwood 1999), creating a much more simplified bird community within urbanized areas.

Our results also showed significant differences in feeding guild composition between urban and non-urban areas. Both field data and eBird data showed similar patterns for feeding guild composition with insectivore-dominated community composition in non-urban areas, while omnivore-dominated community structure in urban areas. These results were most likely due to species-specific traits associated with urbanization sensitivity (McKinney and Lockwood, 1999). Previous research has shown that urbanized areas tend to select for generalist, omnivores and granivores because of their ability to exploit the resources in urban areas much effectively (Crooks 2003, McKinney and Lockwood 1999, Silva 2016). By contrast, urban settings discourage insectivores, which is the leading feeding guild in non-urban areas, possibly due to poor insect availability and altered habitat structure (MacGregor-Fors et al. 2012, McKinney and Lockwood 1999).

Although urbanization generally poses a negative impact on native bird species diversity, not all bird species show consistent declines in urban settings; hence, urban habitats are not always present ecological sinks (Warren and Lepczyk 2012). Our field surveys showed that native Chimney Swifts thrive in urban settings due to the availability of man-made nesting and roosting sites making them the third most abundant (16.2%) bird species in urban sites. Moreover, we reported a single *Falco peregrine* (Peregrine Falcon) in Richmond city center during our field surveys endorsing the positive impacts of man-made nest boxes in tall buildings for this once imperiled, cliff nester (Barclay and Cade 1983). We also noted that native scavengers such as Turkey Vultures thrive in urban habitats representing the largest biomass (39.2%) possibly due to the availability of novel food items such as road kills (Henkanaththegedara, unpubl. data). Other studies have shown that backyard bird feeding in urban areas may also have positive effects on some adaptable native bird species resulting in stable or increasing populations and increased reproductive success (Robb et al. 2008). Fuller et al. (2009) reported that urban areas support high densities of nationally threatened bird species, such as Song Thrush in the United Kingdom, making urban habitats important as refuge populations for such species.

Data gathered from eBird generated very similar outcomes for bird species richness and feeding guild composition for both non-urban and urban sites compared to our field survey results. The correlation between eBird data and field survey data for the narrow-scale analysis yielded a strong positive linear relationship validating the utility of eBird data to assess bird species richness and allowing us to expand our analysis to a broader geographic area. However, eBird consistently generated higher values for species richness compared to our field survey data. This may be due to data saturation (Krebs 1999) in eBird data base, since we have set the parameters to extract data covering past 10 years for all 12 months for every site (vs. our field surveys conducted in May-June during a single season). Broad-scale analysis covering 300 sites across five southeastern states consistently resulted in low bird species richness for urban sites, compared to non-urban sites, which suggests widespread negative impacts of urbanization on bird species richness. Our results also suggest that state park systems (i.e., non-urban sites) have a positive impact on conservation of native bird assemblages. Overall, our findings using citizen-collected data from eBird database generated results consistent with previous work (Mills et al. 1989, Blair 1996, McKinney 2002, MacGregor-Fors et al. 2012) suggesting the feasibility of wider application of citizen science data such as eBird to assess broad-scale impacts of urbanization.

Citizen science data has a significant utility in environmental and conservation research such as environmental pollution, climate change, species occurrence, distribution and composition (Cohn 2008, Bonney et al. 2009, Devictor et al. 2010, Dickinson and Bonney 2012). Furthermore, recent extensive engagement of citizen scientists with scientific research coupled with the ready availability of data due to advances in information technology makes citizen science data a powerful tool for environmental and conservation research. Although some citizen science databases such as USGS Breeding Bird Survey (Sauer et al. 2003) and Audubon Society's Christmas Bird Count (Bock and Root 1981) has generated hundreds of ecological and conservation publications, eBird is still underutilized, despite its untapped potential as an extensive data base with quality data and ready access. A limited number of researchers have utilized eBird data for avian research including modeling large scale bird distributions (Fink et al. 2013, Humphries and Huettmann 2014), assessing regional bird diversity (Akresh and King 2015, More et al. 2015) and bird migration patterns (La Sorte et al. 2014). However, we realize much broader application of eBird data for a wide array of avian research such as monitoring of species with conservation concerns, tracking spatial and temporal dynamics of bird populations/communities, and assessing responses of bird populations to anthropogenic stressors (e.g., this study) as well as natural stressors. More importantly, eBird provides extensive bird occurrence data covering a vast geographic area allowing researchers to conduct national and/or global scale analyses.

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