University of North Carolina Asheville
Journal of Undergraduate Research
Asheville, North Carolina
May 2019

Bird Abundance and Diversity Along an Urban Greenway Gradient in Asheville, North Carolina

Kelley Coleman
Environmental Studies: Ecology and Environmental Biology
The University of North Carolina Asheville
One University Heights
Asheville, North Carolina 28804 USA

Faculty Advisor: Dr. Andrew Laughlin

Abstract

Urban areas are increasing in size throughout the world, removing habitat for wildlife. The construction of urban greenways creates places of recreation for humans and potentially wildlife habitat, but the effects on wildlife vary from place to place. The city of Asheville, NC has plans to extend its greenway system, connecting the north and south greenways together. This study is designed to determine how the greenway system affects wildlife in Asheville, using the indicator species of birds as the focus. Bird species abundance, richness, and evenness along with vegetation surveys were measured across three different sites in Asheville, NC: an already established greenway site, a proposed greenway site, and a control street site. Along each site, there were five points 200 m apart where 10-minute fixed-radius point count surveys were taken during May, June, and July 2018. These surveys were repeated five times, recording all bird species seen or heard and categorizing them into different distance classes and time intervals to better estimate abundance. The vegetation surveys estimated the percent of invasive vines in 5 height strata at each point. The established greenway had the largest number of open canopy trees, meaning there were no vines engulfing the tree, while the unestablished greenway had significantly more invasive shrub and vine cover. The established greenway had a higher bird species abundance, richness, and evenness than the unestablished greenway site, and both had more diversity and abundance than the city street site. This study is in line with other studies that show the importance of greenways and green spaces in urban areas to help promote biodiversity.

1. Introduction

Asheville, NC is located in a unique spot, with a populated city surrounded with forests and rivers that contribute to the tremendous biodiversity of the Southern Appalachian region. However, Asheville is a growing city; the number of residents is increasing by an estimated 9% since 2010[1] and there is a large influx of tourists throughout the year. To help support the traffic of more people, the city has established greenway trails and has plans to establish even more throughout the city in the next couple of years. Urban greenways hold the potential to secure wildlife habitat, expand outdoor recreation, increase property value, increase business trade, improve water quality, and improve overall quality of life.[2] Most of the greenway paths in Asheville follow a water pathway, such as the French Broad river or small tributaries, which both helps to purify the water and increase the riparian buffer vegetation biomass.[3] Trees along urban greenways act as a shield from snow and heavy wind, help mitigate carbon dioxide 15 times more efficient than rural trees, and counteracts the urban-heat problem by 10 to 15 percent. Urban greenways can directly benefit humans as well by providing a natural landscape to reduce stress levels, blood pressure, and aid "healing" processes.[4]

To determine if urban greenways are just as beneficial for wildlife, I have chosen to study the population of birds at three sites: along an established greenway path, a proposed greenway path, and a city street site as a control. Birds have the largest range of functional roles than any other classes of organisms and contribute to an ecosystem's success.[5] Birds can be ecosystem engineers, a method of biological control, and act as indicators of biodiversity.

A healthy ecosystem will have a balance of avian functional diversity. Their feeding behaviors can directly impact the abundance of pests. Many birds are insectivores which reduces the risk of insect-borne illness, like tick-borne lyme disease.[6] Meat-eating birds like raptors indirectly control the population of rodent pests by forcing competition between the prey and altering their behaviors and foraging durations.[7] Balance between birds of different diets and foraging behaviors is key to keeping the ecosystem in homeostasis.

Birds are also indicator species because they are sensitive to pollution and other types of environmental degradation.[8] Some sensitive species are gray herons, peregrine falcons, and brown headed nuthatches. These, and other sensitive species, will vary in abundance, diversity, and richness across the sites because of the level of urbanization and different vegetation compositions. This is especially true for migrant species who struggle to complete their journeys with increasing habitat loss and environmental degradation.[9] However, greenways could provide the resources needed for refueling these birds during their travels.

The study sites' characteristics before and during the course of the study is as follows. The established Reed Creek Greenway has small pastures of grass which are mowed with tractors monthly during the spring, summer and fall seasons. The greenway path is used by walkers, runners, bikers, and dog-walkers alike. The unestablished Town Branch Greenway is currently overgrown with vegetation and has no foot traffic. The Youthbuild program of Green Opportunities spent two weeks in March 2018 hand-picking invasive Japanese knotweed and kudzu from one portion of the proposed greenway path. However, this did not significantly alter the vegetation composition at the site. The same group established a temporary trail of stone and sand along the Town Branch Greenway site but not on the section that this study took place. The city street control site is also trafficked by walkers, runners, bikers, and dog-walkers, but has closer proximity to cars than the other sites. Houses are also more abundant at this city street site, yet houses are not completely absent at the other sites. The management of vegetation and landscaping is dictated through the residents rather than the city of Asheville. Each site runs parallel to a car-trafficked street on one side and a small river or stream on the other side.

I hypothesize that the established greenway site will have the highest bird abundance, richness, and evenness. I compared the woodpecker and migratory bird abundance and richness across the three gradients of urban greenways to further assess functional diversity along this greenway gradient. Additionally, I conducted vegetation surveys as an attempt to further explore differences in bird communities by comparing percent of invasive vine and shrub cover to correlate with bird population.

2. Methods

To address the hypothesis, species abundance, species richness, and species evenness was measured at each site and compared. I performed 5 point-count surveys at each site, 5 times during the breeding season in mid-May, early June, mid-June, late June, and early July. Every bird seen or heard was identified and recorded as well as the birds distance to the point. These distances were placed into one of three categories: Distance class 1 includes birds 30 meters or closer, distance class 2 includes birds 30 meters or further, and distance class 3 includes birds that are flying overhead. At each greenway site, I established five points, 200 m apart along an approximately 1 km transect. I waited one minute upon the arrival of a point before beginning the survey. This minute is a settling period to reduce double counting birds who may have been startled. After the one minute settling period, 10 minutes were spent listening, looking, and recording birds. Birds were also placed into two time categories (first 5 minutes or last 5 minutes) to estimate detection probabilities.

I estimated the abundances for each species after calculating their detection probabilities.[10] I used Simpson's Index of Diversity to calculate the species evenness. I compared abundance, species richness (simply the number of each unique species present at a site), and evenness across sites. Further, the birds of each site were categorized into foraging behaviors and feeding behaviors to address functional diversity. Trophic groups were also compared across sites, such as woodpeckers and raptors, since they hold a strong ecological importance in an ecosystem. Migrant species were also counted and compared across sites to indicate potential habitat suitability. I also compared invasive bird species richness and abundance across sites.

To further an attempt to explain bird communities, I conducted a general habitat survey at each site. The number of tall canopy trees that were 30 meters or closer to the point-count point on either side of greenway or path was recorded. Predominant vegetation was noted as either native or invasive at five different height strata; canopy, sub-canopy, mid-story, lower level, and ground level (Figure 7). This data was compiled and compared across sites.

3. Results

I recorded 34 species of birds throughout the study. The Reed Creek Greenway hosted the most individual birds, followed closely by the Town Branch Greenway site and then the City Street site (Table 1 & Figure 1). The Reed Creek Greenway site also had greatest species richness, followed by the Town Branch site and the City Street site (Figure 2). The Simpsons Index of Diversity was used to calculate the species evenness, which follows the trend of the Reed Creek Greenway being the most even, followed by the Town Branch Greenway site and the City Street site. However, the differences in the values of species evenness are statistically insignificant. (Figure 3 & 4).

The Reed Creek Greenway site has the greatest number of woodpeckers, birds of prey, migrant birds, and invasive birds, which was followed by the Town Branch Greenway site and the City Street site respectively. Reed Creek had the most individual woodpeckers, compared to the Town Branch Greenway site with 33% less woodpeckers than the Reed Creek Greenway and the City Street site had 88% less woodpeckers than the Reed Creek Greenway. Additionally, Reed Creek had three species of woodpecker (Northern Flicker [*Colaptes auratus*], Red-bellied woodpecker [*Melanerpes carolinus*] and Downy woodpecker [*Picoides pubescens*]), whereas the other two sites only had the latter two species (Figure 5). The Reed Creek Greenway had one raptor, red-tailed hawk (*Buteo jamaicensis*) present (Table 1). Of the 436 birds recorded at Reed Creek Greenway site 18.1% are migrant birds, including Chimney Swifts (*Chaetura pelagica*), Gray Catbird (*Dumetella carolinensis*), House Wren (*Troglodytes aedon*), Indigo Bunting (*Passerina cyanea*), Ruby Throated Hummingbird (*Archilochus colubris*), and Yellow Throated Warbler (*Setophaga dominica*). Town Branch had 17.7% migrant birds, which included the species at Reed Creek as well as a Canada Warbler (*Cardellina canadensis*). The City Street had 18.3% migrant birds, which consisted of Chimney Swifts, Gray Catbirds, House Wrens, Ruby Throated Hummingbird, and Common Yellowthroat (*Geothlypis trichas*) (Figure 6). The percentage of invasive vines is greater at the unestablished Town Branch Greenway site than the established Reed Creek, especially in the sub-canopy, lower level, and ground level zones of the area (Table 2). Reed Creek had double the amount of canopy trees open and free of vines than the Town Branch Greenway site.

Table 1: Total list and quantity of each bird species present across the three sites.

# of individuals Species	Reed Creek	Town Branch	City Street
American Crow	15	38	27
American Goldfinch	20	7	4
American Robin	35	39	34
Blue Jay	11	15	7
Brown Thrasher	5	0	0
Canada Warbler	0	1	0
Carolina Chickadee	7	7	3
Carolina Wren	28	25	7
Cedar Waxwings	11	12	0
Chimney Swift	44	50	36
Common Grackle	54	9	26
Common Yellowthroat	0	1	1
Downy Woodpecker	2	3	1
Eastern Bluebird	0	0	1
Eastern Phoebe	1	7	0
Eastern Towhee	31	26	19
European Starling	3	1	0
Fish Crow	1	2	0
Gray Catbird	34	12	12
House Finch	2	3	1
House Wren	4	1	4
Indigo Buntings	3	7	0
Belted Kingfisher	1	0	0
Mourning Dove	12	6	25
Northern Cardinal	28	43	23
Northern Mockingbird	4	19	8
Northern Flicker	3	0	0
Red-shouldered Hawk	1	0	0
Red-bellied Woodpecker	13	9	1
Ruby-throated Hummingbird	1	1	2
Song Sparrow	43	42	38
Tufted Titmouse	17	26	15
White-breasted Nuthatch	1	0	0
Yellow-throated Warbler	1	0	0
Total	436	412	295

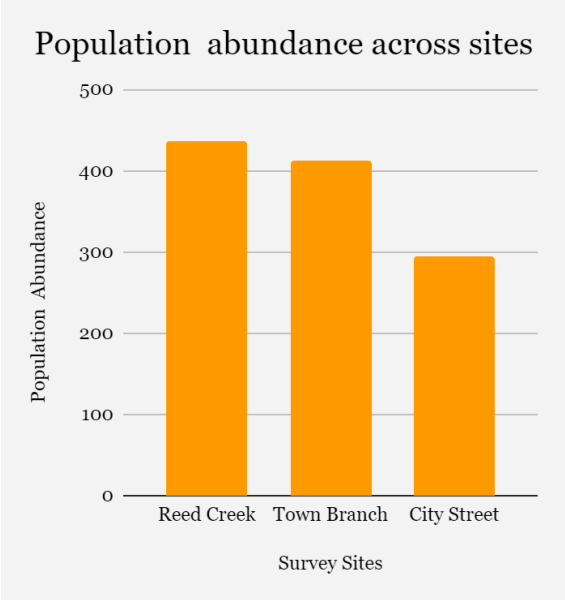

Figure 1: Population Abundance is compared across sites.

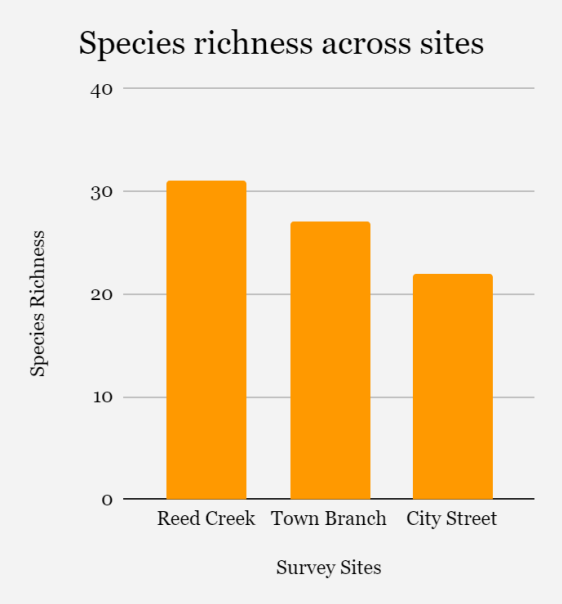

Figure 2: Species richness is compared across sites.

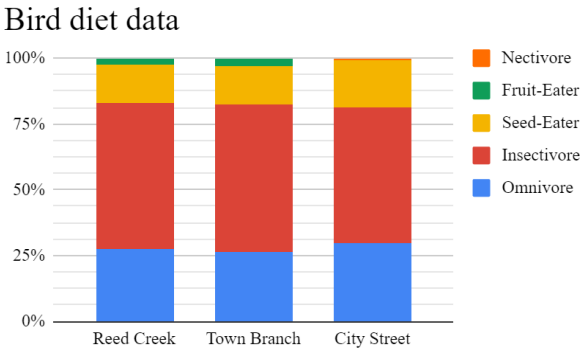

Figure 3: Compares relative proportions of feeding guilds across the three sites.

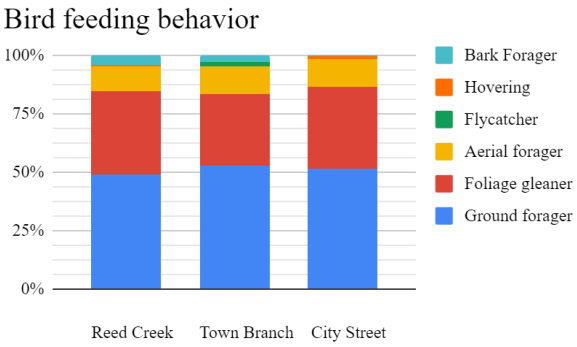

Figure 4: Compares relative proportions of feeding behaviors across the three sites.

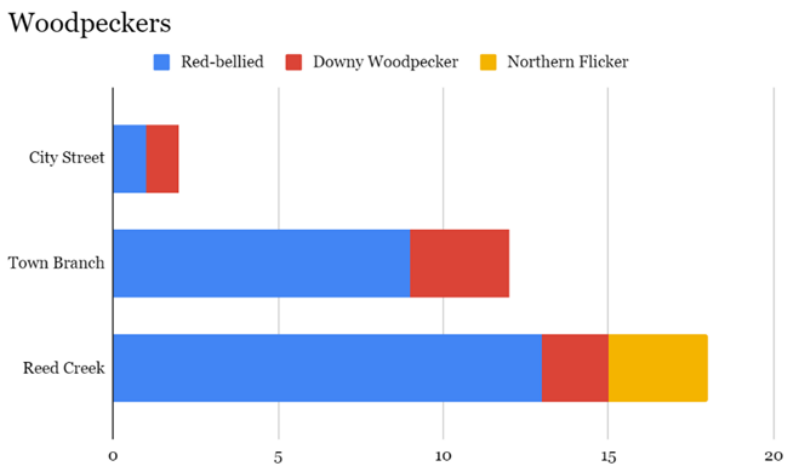

Figure 5: The number of individual woodpeckers and species is compared across sites.

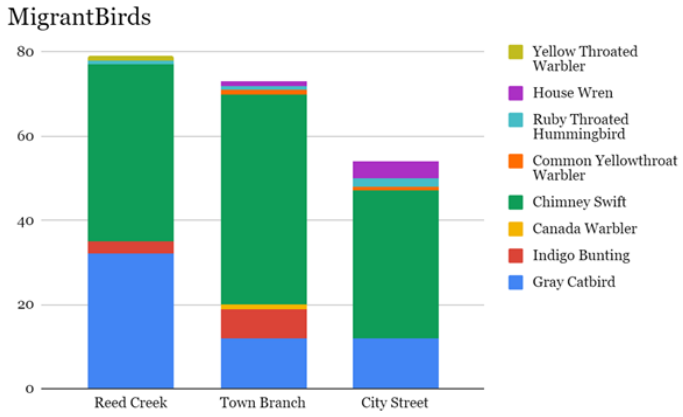

Figure 6: The number of migrant birds categorized by their species across the different sites.

Figure 7: The five height strata distinctions used during the vegetation surveys.

Table 2: The average percent of Kudzu and Japanese Knotweed at each site at each strata layer, with the number of open canopy trees available at the points along the study sites.

	Reed Creek	Town Branch	City Street
Canopy (%)	14	19	4
Sub-Canopy (%)	43	81	15.50
Mid-Story (%)	62	85	4
Lower Level (%)	49	100	18
Ground (%)	10	82	18
Open Canopy Trees	46	24	39

4. Discussion

The established Reed Creek Greenway has a higher diversity and abundance of birds compared to the unestablished Town Branch greenway site and the residential street control site. The findings of this study agree with other studies of bird diversity throughout an urban gradient. Greenways in California were found to have the greatest avian abundance, diversity, and richness when disturbance was intermediate.[11] Another North Carolina study from Raleigh found that greenways to be best suitable with minimal management.[12]

The City street site had the lowest diversity and abundance of birds. This could be due to the adjacent land cover of more residential housing and increased vehicle traffic. Mason et al. (2007) concluded that neotropical migrant diversity and abundance decrease in areas of high development intensity adjacent to remnant woods.[12]

The bird feeding behavior and the bird diet data demonstrate functional diversity. The feeding guild is dominated by insectivores, with strong representation of omnivores and seed-eaters at every site. The sites also have the same dominate feeding behavior methods, mostly ground foragers and foliage gleaners. Since each site has similar proportions of each feeding guild and of feeding behavior types, this could suggest the functional diversity may be similar across the sites.

Woodpecker abundance and diversity was looked at because woodpeckers are the ecosystem engineers that create cavities for secondary nesting birds, mammals and other organisms. Secondary cavity nesting birds, like tufted titmice, small mammals, and a variety of insects move into abandoned woodpecker tree cavities. Also, woodpeckers can effectively remove any threatening insects from trees and can release sap for other organisms to consume.[13] Reed Creek Greenway had greater abundance and diversity than the other two sites, suggesting there is better habitat for secondary cavity nesters and more control over pests.

Migratory birds were also examined in greater detail since these birds are most affected by urbanization.[14] I predicted that the established greenway would host the most migrant birds and greatest diversity of birds because the site is a managed greenspace. The Reed Creek Greenway had more individual migratory birds present, however the Town Branch Greenway had more species of migratory birds present. There is no conclusion about how the greenways are preferred over other green spaces or residential habitats.

I attempted to further explore differences in bird communities through vegetation surveys. The unestablished Town Branch Greenway had much more invasive Kudzu and Japanese knotweed than the established Reed Creek Greenway at every height stratum, especially at the ground, lower, and mid-story level. The amount of open canopy trees is the number of large trees without vines climbing up the trunk or vines engulfing branches. There were more open canopy trees at the Reed Creek Greenway, perhaps leading to more abundance of more species. Overall, the vegetation analysis does not help explain bird communities.

This study supports most of the hypothesis; the established greenway site at Reed Creek Greenway did have greater avian abundance and diversity, however the species evenness cannot be considered different across the sites. The greenway systems can be an efficient way for the growing city of Asheville to accommodate their residents and population of tourists, as well as being friendly to their wildlife.

This study encourages the city of Asheville to establish the Town Branch Greenway. Surveys should be conducted at these three sites the following five years to see if bird abundance and richness pattern holds true. If the Town Branch Greenway does become established, then bird surveys should be conducted along the trail to monitor any shifts in the bird communities at that site. I do encourage more surveys of bird communities to be taken along other greenway systems in Asheville to determine if the trend of avian abundance, diversity, and richness follows the pattern found in this study. I believe that connecting established greenway trails with other greenway trails will provide birds with suitable habitat in an urban area and may have the potential to increase biodiversity.

5. Acknowledgements

The author wishes to thank UNCA's McCullough Fellowship program for providing funding to conduct the research over the summer of 2018 and the opportunity present later that fall. She also wishes to acknowledge Green Opportunities, especially Susan Andrews, Davis Jones, and the students of the Youthbuild program for their enthusiasm and collaboration on the project at the Town Branch Greenway Site throughout the summer of 2018. Lastly, the author wishes to thank UNCA Undergraduate Research fund for funding the trip to the Association of Southeastern Biologists for another presentation in the spring 2019.

6. References

1. World Population Review. http://worldpopulationreview.com/us-cities/asheville-population/ Accessed 26 March 2019.
2. Reichenbach, K. 1989. Greenways: cornucopia of opportunities. Parkways, Greenways, Riverways: The Way More Beautiful, pp 270-275.
3. Kaplan, R. 1977. Down by the riverside: influence factors in waterscape preference. Proceedings of the River Recreation Management and Research Symposium, Minneapolis, MN. North Central Forest Experiment Station, St. Paul, MN, pp. 265–289.
4. Rogers, G. F. and R. A. Rowntree. 1988. Intensive surveys of structure and change in urban natural areas. Landscape and Urban Planning 15:59-78.
5. Sekercioglu, C. H. 2006. Increasing awareness of avian ecological function. Trends in Ecology and Evolution 21(8):464-471.
6. Ostfeld, R. S., A. Price, B. L. Hornbostel, M. A. Benjamin, and F. Keesing. 2006. Controlling ticks and tick-borne zoonoses with biological and chemical agents. BioScience 56 (5):383-394.
7. Korpimaki, E., V. Koivunen, and H. Hakkarainen. 1996. Microhabitat use and behavior of voles under weasel and raptor predation risk: predator facilitation? Behavioral Ecology, 7 (1): 30–34.
8. Furness, R. W. 1993. Birds as monitors of environmental change. London, Chapman and Hall, pp 86-143.
9. Robbins, S. C., J. R. Sauer, R. S. Greenberg, and S. Droege. 1989. Population declines in North American birds that migrate to the neotropics. Proceedings of the National Academy of Sciences of the United States of America 86(19):7658-7662.
10. Pierce, B.L., R. R. Lopez, and N. J. Silvi. 2012. Estimating animal a bundance. In The Wildlife Techniques Manual. Ed. NJ Silvi. Johns Hopkins University Press.
11. Blair, R. B. 1996. Land use and avian species diversity along an urban gradient. Ecological Applications, 6(2):506-519.
12. Mason, J., C. Moorman, G. Hess, and K. Sinclair. 2007. Designing suburban greenways to provide habitat for forest-breeding birds. Landscape and Urban Planning, 80:153-164.
13. Fayt, P., M. M. Machmer, and C. Steeger. 2005. Regulation of spruce bark beetles by woodpeckers—a literature review. Forest Ecology and Management 206:1-14.
14. Martensen, A C, M. C. Ribeiro, C. Banks-Leite, P. I. Prado, and J. P. Metzger. 2012. Associations of forest cover, fragment area, and connectivity with neotropical understory bird species richness and abundance. Conservation Biology, 26(6):1100-1111.