
THE IMPACT OF URBANIZATION ON THE TYPE AND DISTRIBUTION OF DIFFERENT NORTHERN BIRD SPECIES

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ABSTRACT

A bird's choice in its habitat influences all aspects of the bird being able to acquire energy for growth and reproduction. With the increasing urbanization, due to humanity's impact on the environment, it puts added stressors on several native northern bird species. Birds are increasingly being able to be classified as urban exploiter, adapters, or avoiders in response to their behavior to urban cities and developments. A total of 191 birds were observed, 150 at a rural feeding site in Houtzdale, Pennsylvania, and 41 at an urban feeding site in Northampton, Pennsylvania. A bird's preference for feeding on the feeder or the ground below the feeder was also observed, with 94 birds feeding on the feeder in the rural site and 56 feedings on the feeder in the urban site. A total of 56 birds feedings on the ground at the rural site and 13 birds at the urban site, in both field sites the birds had access to the same energetically rich black oil sunflower seeds. A Simpson's Diversity Index was performed and found the diversity value to be 0.93 in the rural site and 0.83 at the urban site indicating that northern bird species diversity is greater in rural environments than urban ones regardless if there is additional feeding in these areas.

Keywords: Urbanization, anthropogenic pollution, wintering, supplemental food, ecological stressors

INTRODUCTION

Urbanization is increasing across the globe and becoming a major factor affecting a species' geographic distribution. Although urbanization is a major threat to biodiversity, there is increasing evidence that urban habitats may play a role in conservation. However, the general belief is that a more natural the environment, the more suitable the habitat is for a species and thus for their conservation. Human settlements in rural and urban areas differ in structural and biotic components including human attitudes concerning the role of wildlife. The habitat that composes urban environments results in species being limited by the number of available habitats, human disturbances, and ecological stressors which cause changes in a species behavior to maximize its energy-budgets.

The effects of urbanization on species begins with an understanding of how humans have exploited and changed the land over time. Urbanization began

with the earliest human settlements and their massive, yet local, destruction and deforestation of land surrounding those settlements. Ancient Rome is a prime example of this early urbanization with the transformation of the Mediterranean into the treeless landscape people are familiar with today, undoubtedly affecting species distributions (Isaksson, 2018). However, it was not until the Anthropocene—the current geological age—during which human activities have become the dominant influence on the environment, that urban human societies started to grow significantly. Western industrialization started in the 1700s, and with urbanization came urban sprawl as a significant part of the landscape (Isaksson, 2018; Tryjanowski et al., 2015). Today urbanization is a global phenomenon with major implications for birds and other animals. Yet, there are still several countries undergoing industrialization with the impact on the environment expected to compound as human population increases (McKinney, 2008). Together with climate change, another byproduct of the Anthropocene age, urbanization is one of the largest

threats to wildlife specifically the persistence of many bird species (Aronson et al., 2014; Tryjanowski et al., 2015). The foremost threat is habitat fragmentation forcing species once in proximity into increasing isolation, ultimately leads to local extinctions and, if lucky, evolution (Seress & Liker, 2015). New urban conditions are appearing because of growing unchecked urban sprawl leading to a shift in existing “green” spaces in urban areas. The impact of this urban sprawl is then compounded further with the introduction of non-native plant species, management of closely trimmed lawns, and the removal of the mid-story canopy that several species of bird require to create their nests (Isaksson, 2018; McKinney, 2002). Although the total number of bird species decline once an area is urbanized, (Tryjanowski et al., 2015) many species do flourish after the initial shock (Aronson et al., 2014). Birds are by far the most visible and vocal animals in urban areas are successful in changing to change their phenotypic behaviors to allow them to survive and reproduce in these areas (McKinney, 2002). Urban bird species often exploit anthropogenic resources created, such as a high abundance of novel food sources and artificial nesting spots (e.g. under roof tiles and nest boxes) (Tryjanowski et al., 2015). In urban centers birds benefit from the urban heat island effect, caused by the heat absorbing properties of impervious surfaces. This is compounded by the effects of air pollution which further traps heat radiation within the atmosphere surrounding the city (Jokimäki, Suhonen, Jokimäki-Kaisanlahti, & Carbó-Ramírez, 2016). This heat island effect is especially favorable for birds in the wintering months when climatic conditions are harsh, and food is scarce.

Depending on a bird’s reliance upon human resources, species can be divided into three groups: urban avoiders, urban (suburban) adapters, and urban exploiters (Isaksson, 2018; Seress & Liker, 2015). Each bird species often has their own unique responses once an area is urbanized; some species will vanish, and others will flourish. Urban avoiders are birds that immediately vanish when an area is urbanized and are generally characterized by low natal dispersal, migratory behavior, fear towards humans, insectivory, and low yearly fecundity (Vaugoyeau et al., 2016). This leads to a homogenizing effect and, in general, lower species richness in urban areas (Cam, Nichols, Sauer, Hines, & Flather, 2000). Identifying urban avoider birds is easy because of a lack of their presence, but for many bird species there is a slower response to urbanization with population decline over time as a result. Urban environments, to varying degrees, function as an ecological trap by luring and attracting birds as a result of a higher abundance of food resources and milder winter temperatures

(Isaksson, 2018; Lima, 1986). But once birds arrive they often suffer the negative impact of an urban environment’s high rate of nest predation by corvids, abundant but poor nutritional food sources, predation at feeding sites (e.g., by feral cats and dogs), exposure to high levels of pollution, and the high incidence of collision with windows and cars. These factors all negatively influence the overall fitness of bird populations in an urban area (Lima, 1986). If the ecological trap is strong, the urban habitat will attract rural birds into urban areas where they suffer negative consequences forcing many bird species to go locally extinct.

Although many species vanish from urbanized areas, some species thrive or persist. These species are urban exploiters because they flourish by exploiting human resources (Isaksson, 2018) to such an extent that they now depend on them to maintain their current populations. Several urban exploiter species are often invasive species (e.g. the House Sparrow and Feral pigeon) (Tryjanowski et al., 2015). In fact, urban areas have greater abundance of birds per sampling unit than in nonurban habitats (Isaksson, 2018; Lima, 1986). This phenomenon is something that several raptor species have taken advantage of, becoming increasingly common in urban areas. These urban exploiter species are characterized by large breeding distributions, high dispersal rates, high rates of feeding innovation (novel way to collect food resources), and a life history of high annual fecundity and adult survival (Seress & Liker, 2015). These urban bird species also have a larger bursa of Fabricius, a specialized organ in bird’s immune system allowing them to mount a stronger immune response compared to urban avoiders (Aronson et al., 2014). Additionally, urban exploiters have higher levels of dietary antioxidants (vitamin E and carotenoids) than the urban avoiders, helping them to counteract oxidative pollution (McKinney, 2002; Tryjanowski et al., 2015). It is because of urbanization that these birds have genotypically evolved in response to their environment to allow them to maintain their population. These characteristics are commonly seen in urban birds but do not indicate if a bird species is an urban exploiter or an urban adapter. The urban adapter birds are not dependent on human resources but for a time willing to use them to ensure their survival (Jokimäki et al., 2016). Urban adapter birds are typically small perching birds like the Great Tit (*Parus major*) or the House Finch (*Haemorphous mexicanus*). These urban bird species often vary during different seasons, being more common in urban areas in winter and less common during summer and spring (Vaugoyeau et al., 2016).

There are at least four primary ecological stress factors directly related to urbanization: chemical pollution, noise, artificial light at night (ALAN), and human presence (Cam et al., 2000; Isaksson, 2018). These factors suggest that a homogenizing pressure is occurring in urban areas that force the birds to vanish, persist, or adapt. Chemical pollution is generated from the combustion of fossil fuels and leads to elevated level of nitrogen oxides (NO_x) and soot. Finding a silent place in urban areas is difficult due to the constant presence of cars, horns, sirens, hammering from construction, and airplanes taking off (McKinney, 2008). This noise pollution will affect bird species differently based on the loudness, frequency, and consistency of the sound (Aronson et al., 2014). Similarly, darkness is rare in urban environments with night lights making it difficult for bird species to regulate their circadian rhythms (Lima, 1986). Additionally, birds often view a human's presence as a threat which causes an increase in the stress to the birds when they are feeding. (Lima, 1986; Vaugoyeau et al., 2016). These factors are all reduced in rural settings which leads to the conclusion that more rural areas may be better habitat. Additionally, food abundance, pathogens, and predation can influence the types of birds found in urban areas but varies across geographic regions (Devictor, Julliard, Couvet, Lee, & Jiguet, 2007). All these factors influence the type and distribution of bird species and are ever more important during the wintering months when birds are looking to maximize their energy intake while limiting their energy expenditure.

During the winter temperature in urban areas are around 1-2 °C higher than the surrounding rural landscape, (Tryjanowski et al., 2015) making them more preferable than colder rural regions for birds. Urban areas often have less natural food sources (Isaksson, 2018) but increased human feeding. But the use of supplementary feeding, in the form of bird feeders and other devices, could make birds wintering in urban areas more energetically favorable (McKinney, 2002). Since the presence of food is a major limiting factor for bird populations, the effects of supplementary feeding—or lack of—should be most pronounced in areas where food is the most scarce. This though leads to two conflicting thoughts: whether the scarcity of food is most prevalent in rural or urban areas and is this offset using supplementary feeding. It is our hypothesis that if there is supplementary feeding in urban environments then that area will have a greater variety of different bird species. This rationale is based on the idea that despite the negative pressure birds face in urban areas in winter—when natural food sources are scarce and temperatures are colder—birds will be attracted to warmer cities with a more reliable

sources of food. The birds that will be present in these urban environments will be urban exploiters and some urban adapters while the urban avoider species will remain in more rural regions.

FIELD SITE

This study took place in two different field sites. The urban field site of the feeder was located in an open yard and hung in maple tree in Northampton, Pennsylvania. This site is near an alley prone to vehicle, dog, and human activity. Conversely, the rural field site feeder was placed in a maple tree on the edge of a forested area in Houtzdale, Pennsylvania. This site has infrequent human activity but does have a large population of Eastern Gray Squirrels (*Sciurus carolinensis*) and the occasional dog present. The presence of humans, dogs, and vehicle in both sites may be problematic because of the influence of these compounding variables.

METHODS AND MATERIALS

In order to determine the differences in bird species present in two different habitats, we observed bird feeding habits in the urban area of Northampton, PA and rural area of Houtzdale, PA. In both habitats a hanging bird feeder was placed in a tree with black oily sunflower seeds that are rich energetically due to their high oil content and are easy to crack, making them attractive to birds. Observations were made in both sites over the course of two weeks to attempt assessing if there was a difference in bird species present feeding at the feeders. We would count the species of birds, the number present, if they were feeding on the ground or on the feeder, and any other observations about the study sites. At both feeding sites the bird feeders were watched from a distance in effort to not scare away any birds. Binoculars were used for a closer look at the birds and the *Merlin Bird ID* mobile app was used to help identify the specific species.

DOI



Figure 1. Urban bird feeder placed in Northampton, PA.



Figure 2. Rural bird feeder placed in Houtzdale, PA.

RESULTS

During the two weeks a total of 191 birds were observed feeding at the feeder and on the ground at the rural and urban feeding sites. Of the total 191 events, 49% (94) of birds were observed feeding on the feeder and 29% (56) of birds feeding on the ground below the feeder at the rural site in Houtzdale, PA. There was 15% (28) of birds feeding on the feeder and 7% (13) of birds feeding on the ground at the urban site in Northampton, PA.

Table SEQ Table * ARABIC 1. A table showing the number and type of species present feeding on the feeder itself or on the ground, at the rural feeding site in Houtzdale, PA and the urban feeding site in Northampton, PA.

Type of Species	On Feeder		On Ground	
	Rural Site	Urban Site	Rural Site	Urban Site
American Crow	0	0	0	2
American Goldfinch	10	11	5	0
American Robin	0	0	7	1
Black-Capped Chickadee	17	0	3	1
Blue Jay	1	0	0	0
Chipping Sparrow	5	2	0	0
Common Grackle	0	2	0	0
Dark-Eyed Junco	6	0	7	0
Downy Woodpecker	4	0	0	0
Eastern Towhee	10	0	0	0
Field Sparrow	7	0	0	0
Golden Winged Warbler	3	0	0	0
House Finch	0	11	0	1
House Sparrow	6	0	0	1
Morning Dove	0	0	16	6
Northern Cardinal	0	2	6	1
Rose-Breasted Grosbeck	5	0	10	0
Song Sparrow	11	0	0	0
Titmouse	7	0	2	0
White-Throated Sparrow	2	0	0	0
Totals	94	28	56	13

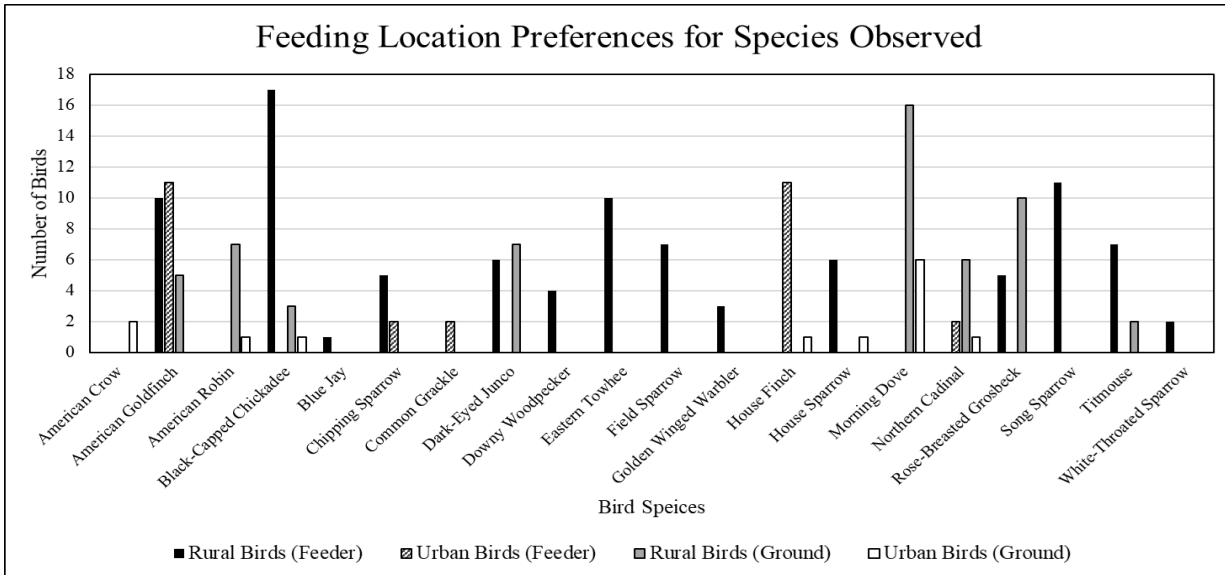


Figure SEQ Figure * ARABIC 2. A graph showing each type of bird species and the site at which they were observed. The black bars represent the number of birds seen feeding at the rural site in Houtzdale, PA on the feeder. The gray striped bars are the number of birds feeding on the feeder at the urban site in Northampton, PA. The gray bars represent the number of birds feeding on the ground below the feeder at the rural site and white bars representing the number of birds feeding on the

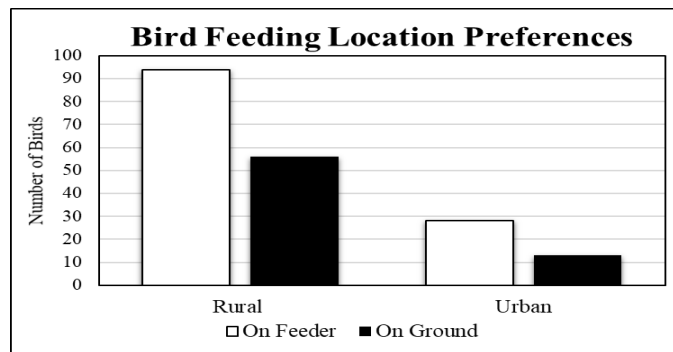


Figure SEQ Figure * ARABIC 1. A graph showing the total number of birds feeding on the feeder (in white) or on the ground (in black) at the rural and urban sites in Houtzdale and Northampton, PA.

Table SEQ Table * ARABIC 2. Charts showing the calculations for the Simpson Diversity Index for the rural and urban field sites in Houtzdale, PA and Northampton, PA.

Rural Site			
Species	Population	(n-1)	n(n-1)
American Goldfinch	15	14	210
American Robin	7	6	42
Black-Capped Chickadee	20	19	380
Blue Jay	1	0	0
Chipping Sparrow	5	4	20
Dark-Eyed Junco	13	12	156
Downy Woodpecker	4	3	12
Eastern Towhee	10	9	90
Field Sparrow	7	6	42
Golden-Winged Warbler	3	2	6
House Sparrow	6	5	30
Mourning Dove	16	15	240
Northern Cardinal	6	5	30
Red-Breasted Grosbeak	15	14	210
Song Sparrow	11	10	110
Tufted Titmouse	9	8	72
White-Throated Sparrow	2	1	2
Total	150	133	1652
Simpson's Diversity Index	0.93		

Urban Site			
Species	Population	(n-1)	n(n-1)
American Crow	2	1	2
American Goldfinch	11	10	110
American Robin	1	0	0
Black-Capped Chickadee	1	0	0
Common Crackle	2	1	2
House Finch	12	11	132
House Sparrow	1	0	0
Mourning Dove	6	5	30
Northern Cardinal	3	2	6
Chipping Sparrow	2	1	2
Total	41	31	284
Simpson's Diversity Index	0.83		

A Simpson's Diversity Index was performed on the data to examine the diversity of bird species found at both the urban and rural site. The observed data was that 17 bird species were present at the rural site with a population of 150 birds. At the urban site there was 10 species of birds with a total population of 41 birds. The Simpson's Diversity Index for the rural site was 0.93 and the Index at the urban site was 0.83, the closer the value is to 0.1 the more diverse the habitat is. The data for the test is provided in the Table 2 and tells us that we should reject our hypothesis of, "if there is supplementary feeding in urban environments then that area will have a greater variety of different bird species" since our Simpson's Diversity Index is greater in the rural site than the urban site.

DISCUSSION

Knowing how birds respond to urbanization, the resulting data from our observations rejects the hypothesis of urban environments having a greater diversity of bird species if there is supplementary feeding. Since our diversity value is greater in rural sites at 0.93 than in urban sites with a value of 0.83. Meaning that supplementary feeding may not have as large of an impact on the species present in urban areas as initially believed. We believed that this would be true due to the scarcity of food in rural areas and the lower temperatures would make the birds want to live near the more urban areas since there will be more food there and will be warmer due to the urban heat island effect. We thought that even though the birds would experience more negative pressure from the urban areas, they would still prefer to have more food and warmth. These assumptions turned out to be wrong. The negative pressure from urban areas seems to be too much for some species and they end up only living in more rural areas.

There were only three species, the American Crow (*Corvus brachyrhynchos*), the Common Crackle (*Quiscalus quiscula*), and the House Finch (*Haemorhous mexicanus*) were present at the urban field site. Whereas, in the rural field site a total of 11 unique species were found: Blue Jay (*Cyanocitta cristata*) feeding only the ground, Chipping Sparrow (*Spizella passerina*), Dark-Eyed Junco (*Junco hyemalis*), Downy Woodpecker (*Picoides pubescens*), Eastern Towhee (*Pipilo erythrophthalmus*) feeding only on the feeder, Field Sparrow (*Spizella pusilla*), Golden-Winged Warbler (*Vermivora chrysoptera*), Red-Breasted Grosbeak (*Pheucticus ludovicianus*) feeding mostly on the ground, Song Sparrow (*Melospiza melodia*), only eating at the feeder, Tufted

Titmouse (*Baeolophus bicolor*) and White-Throated Sparrow (*Zonotrichia albicollis*). Only six species were shared among both the rural and urban sites: American Goldfinch (*Spinus tristis*) feeding exclusively on the feeder in both sites, American Robin (*Turdus migratorius*), Black-Capped Chickadee (*Poecile atricapillus*) mostly feeding on the feeder, House Sparrow (*Passer domesticus*), Mourning Dove (*Zenaid macroura*) feeding only on the ground, and the Northern Cardinal (*Cardinalis cardinalis*). Looking at the overall totals 150 birds feed at the rural field site with 94 birds feeding on the feeder and 56 feeding on the ground beneath the feeder. Meanwhile, 41 birds total feed at the urban site with 28 feeding on the feeder and 13 feeding on the ground beneath the feeder. The results of the Simpsons Diversity Index shows that birds are not only preferring to feed at rural habitat but they are also preferring to feed on the feeder, except for a few species. Initially, it was believed that birds would feed at the urban site because of the added feeding. Throughout the experiment, at the urban site, there were additional challenges unaccounted for that would put additional stress on the birds. Often if there was a dog outside, it would scare most, if not all, of the birds away from the feeder and they would not come back until they the dog was gone. The same would happen with people and vehicles. If people would be outside and near the feeder, the birds would not go to the feeder until they knew that there was no danger to them. If a loud car would drive by the feeder, it would startle all of the birds and force them to fly away from the feeder and not come back for a long time. These additional factors can explain why the diversity of birds in urban sites is lower because it is difficult for birds to adapt to these types of disturbances.

A flaw in this study was that it was conducted during a shift in the seasons from winter to summer which could explain why their was a greater diversity of birds found in the rural habitat. Because some birds that are urban adapters may be returning to the rural environments for the summer months and then move to the urban areas during the winter months to take advantage of the slightly higher temperatures are additional feeding. Another factor for why the birds that were seen could be different is due to the bird seed type that we chose. We decided to use black oily sunflower seeds. This could be a problem for smaller bird species since they have a shell on them, and some birds might not be able to break them open. Once the bird sees that kind of seed in the feeder, they might not come back to it since they know they are unable to get the seed open, especially at the urban feeder since there might be another feeder with seeds that are easier to get. If we would have used a mixed bird seed, we

might have had more diverse species visiting the feeder, at least at the urban feeder. Furthermore, birds are migratory and easily adapt to different environments at different times of the year making it difficult to predict where whether a bird favors urban or rural environments. This study could be expanded on by tracking the exact temperatures in urban and rural environments to see if the temperature of a bird's habitat directly affects their range. Additionally, tracking a population of birds migration habitats between these two habitats are relating it to different food sources found in each could provide further evidence for explaining why some birds are common in urban settings and others more common in rural environments.

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