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Effects of Urbanization on Buff-bellied Hummingbirds in Subtropical South Texas

Urbanization and its associated processes affect wildlife in a variety of ways. Understanding how this increasing land use type affects biological communities is important for conservation efforts. Hummingbirds (family Trochilidae) are one taxon that has showed positive responses to varying intensities of urban development. We surveyed for Buff-bellied Hummingbird (*Amazilia yucatanensis*), a species on its northern range-limits, in urban woodlands, residential, natural, and revegetated habitats. We examined how urbanization is affecting Buff-bellied Hummingbird populations in South Texas with point-count surveys and GIS analysis. We found that Buff-bellied Hummingbirds had greater relative abundances in urban settings when compared with peri-urban habitats, and were more likely to be found with increasing impervious cover. Our results support the growing literature showing how, in some species, urbanization can have positive impacts.

Keywords
urban wildlife, citizen science

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INTRODUCTION

Urbanization, the increased population density and expansion of the area occupied by humans and their built environments, affects wildlife in a variety of ways (Forman 2014). Primary biophysical processes associated with urbanization, such as removal of existing vegetation and replacement by impermeable surfaces, result in direct habitat loss along with fragmentation and isolation (Parris 2016). While there is a general trend of decreased biodiversity in urban areas, there is much variation among and within taxonomic group; urbanization may be beneficial to some and detrimental to others (Faeth et al. 2011).

Hummingbirds are one avian group that has shown positive responses to urbanization. A subspecies of Allen's Hummingbird (*Selasphorus sasin sedentarius*) expanded its population in urban Southern California (Clark 2017). Similarly, Anna's Hummingbird (*Calypte anna*) and Black-chinned Hummingbird (*Archilochus alexandri*) have expanded their ranges in the United States, presumably due to urbanization and associated increases in nectar plant availability (Zimmerman 1973; Emlen 1974; Baltosser and Russel 2000). Greig et al. (2017) found that the northward range expansion of wintering Anna's Hummingbird was significantly related to human-modified habitats and supplemental feeding, adding support to the hypothesis that increased resource availability in urban areas can affect avian survival (Evans et al. 2015).

Bird communities change across gradients of urbanization, with some species and guilds increasing with urban intensity and others declining; synanthropic species, such as House Sparrow (*Passer domesticus*) increase, while species more reliant on native habitats decrease (Marzluff 2008). Similarly, hummingbirds appear to respond to different intensities of urbanization. Leveau and Leveau (2005), for instance, found that White-throated Hummingbirds (*Leucochloris albicollis*) were significantly more abundant in peri-urban areas (as opposed to suburban and rural areas), whereas Emlen (1974) observed more Black-chinned Hummingbirds in suburban areas in Tucson, Arizona than in natural habitats.

The Buff-bellied Hummingbird (*Amazilia yucatanensis*) occurs along the Gulf of Mexico coastal plain, from the Yucatan Peninsula west and north to South Texas (Chavez-Ramirez and Moreno-Valdez 2015). In that range, they are found in a variety of habitats, including riparian forest, scrubby woodlands, and urban parks and gardens (Chavez-Ramirez and Moreno-Valdez 2015). Oberholser (1974) describes them as favoring dense thickets with flowering bushes in riparian habitats. They are known to utilize a variety of plant species as nectar sources, including both native and non-native species (Oberholser 1974; Villarreal 2016). Native ornithophilous flowers in the region have long blooming periods, depending on soil moisture and winter temperatures, often extending from spring through the fall (Richardson and King 2011).

While there is little information on the nature and timing of Buff-bellied Hummingbird migration, they appear to have seasonal movements in their U.S. range. Individuals disperse along the Gulf Coast between October and March (Chavez-Ramirez and Moreno-Valdez 2015). In the Lower Rio Grande Valley of Texas (an area which includes the four southernmost counties in the state; hereafter, LRGV), Buff-bellied Hummingbirds reach their lowest population density between December and March (Villarreal 2016). Brush (2005) has found evidence of breeding activity from as early as February to as late as October, indicating the species has a long potential breeding season. Peak breeding activity appears to be between April and June, however (Chavez-Ramirez and Moreno-Valdez 2015).

While the LRGV appears to host a substantial population of Buff-bellied Hummingbirds, little quantitative data are available on abundance, trends, and habitat use (Brush 2005; Sullivan et al. 2009). Oberholser (1974) speculated that agricultural expansion and intensification negatively affected the species, yet noted they still occupied patches of thorn-forest along the Rio Grande. Partners in Flight scored the Buff-bellied Hummingbird population trend at 3, "Uncertain population change, possible small decrease, or significant small decrease" (Partners in Flight Science Committee 2013). Given the previous loss of much native habitat throughout the 20th century and a recent upturn in urban development in the LRGV (Huang and Fipps 2011), it has become increasingly relevant to evaluate bird species response to land use change in the region. Here, we quantitatively explored the impact of urbanization on Buff-bellied Hummingbird populations by comparing presence-absence and relative abundance data along an urban-rural gradient in the LRGV, using impervious land cover as a proxy for urbanization.

METHODS

Study area

We conducted this study in Hidalgo County, Texas. Hidalgo is the most populous and rapidly growing county in the LRGV, having grown from a population of 569,463 in 2000 to an estimated 860,661 in 2017 (US Census Bureau 2000, 2017). Between 90-98% of the natural habitats in the LRGV have been lost or degraded due to human activities, largely due to conversion to agriculture or urban land covers (Leslie 2016). Prior to large-scale agriculture and urbanization the region was characterized by annual flooding, which created complex vegetation patterns in the delta (Brush 2005). Away from the Rio Grande, outside of the flood plain, there were large areas of sparsely wooded grasslands and savannah grasslands (Brush 2005).

We established 141 survey plots in a variety of land use types (Figure 1). Natural plots were placed in remnant tracts of riparian forest, thorn-forest, and thorn-scrub along the Rio Grande corridor. These plots generally had high canopy cover and a diverse assemblage of woody plant species (n = 43). Revegetated (reveg) plots were in agricultural or other heavily disturbed lands that underwent restoration efforts by the USFWS within the past 20-35 years. Because of different restoration methods, along with environmental variables such as soil type and existing seed bank, revegetated plots had highly variable woody plant structure and species composition (n = 35). Some revegetated plots were relatively successful with high woody plant diversity while others were less so, being dominated by a few woody species and extensive exotic grass cover (Brush and Feria 2014). Urban woodland plots were located in or just on the edge of cities, and were generally 1-5 ha of either remnant thorn-forest or lush, restored woodland (n = 9). Plots at one urban woodland site, Estero Llano Grande State Park (Weslaco, TX), were placed in a former recreational-vehicle park that had lush vegetation and natural thorn-forest. Suburban plots were placed in residential neighborhoods in the cities of Edinburg, McAllen, and Weslaco (n = 54; Brush 2016). Neighborhood age and tree cover varied, but were predominantly single-family residences.

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Figure 1. Location of Hidalgo County, Texas, and our 141 study plots. Triangles represent urban plots (black = urban woodland, gray = residential). Circles represent peri-urban plots (black = natural, gray = revegetated) Light gray represents the 2009 US Census Urban Area.

Collection and Analysis of Data

We surveyed birds from 2013-2016 in the months of May and June using limited radius point-count methodology (10 minutes, 50-m radius, following Ralph et al. 1993), recording all birds seen or heard during a 4-hour period starting at sunrise. Each site was surveyed a total of 2 times per season – once in May and once in June – for a total of 4 visits over the study period. The natural and revegetated habitats were surveyed in 2013 and 2014, while the urban woodland and residential habitats were surveyed in 2015 and 2016. We counted all birds during the surveys, but for this paper we only analyzed Buff-bellied Hummingbird data. We selected point-count locations in a stratified, random fashion. Only birds using the habitat (i.e. foraging or perching) within the 50-m radius were counted, excluding fly-through and fly-over sightings. All point-count locations were at least 200 meters away from their nearest neighbor, as recommended for point-counts in woody vegetation by Bibby et al. (1992). Point-count methodology, particularly with limited-radius design and temporal restrictions (time of day, time of year), can yield reliable data to be used to elucidate bird-habitat relationships (Hutto 2016). See Tinoco et al. (2017) as an example of point-counts in hummingbird surveys.

We used land cover imperviousness as a proxy for the level of urban development in our survey plots. We downloaded data from the 2011 National Land Cover Database (Homer 2015); specifically the Percent Developed Imperviousness dataset. This dataset gives each 30x30 m^2 pixel a percent impervious value ranging from 0-100%. Using QGIS, we calculated average percent imperviousness of our point-count plots, taking the average value of imperviousness in a 100-m radius buffer around each point-count location. Typically each buffer had 27-32 pixels, including all pixels that had a portion of their coverage within the buffer area. As in Germaine et al. (1998), we used a land cover plot 2x greater than our bird sampling plot. We used average percent imperviousness in the aforementioned logistic regression.

We explored the relationship between percent imperviousness and Buff-bellied Hummingbirds with logistic regression. We converted the average relative abundance of hummingbirds at each survey plot (from all four survey periods) to presence-absence data and analyzed it with Minitab 19™, using percent imperviousness of survey plots as the explanatory variable. We also compared unconverted Buff-bellied Hummingbird average relative abundance in peri-urban (natural and revegetated habitats) and urban (residential and urban woodland habitats) areas. Average relative abundance was calculated from all surveys at a plot. Because our data was not normally distributed, we used a Kruskal-Wallis analysis of variance to evaluable differences in hummingbird relative abundance in our four habitat types. We followed it with a Conover-Iman test (Conover-Iman 1979) in SYSTAT 13™ for all pairwise comparisons, as we rejected the null hypothesis of the Kruskal-Wallis test.

RESULTS

We detected Buff-bellied Hummingbirds at least once at 68 of 141 of survey plots, with urban woodland and residential plots (8/9 and 43/54 plots, respectively) having greater detection rates than natural and revegetated plots (6/43 and 11/35, respectively). On average, we documented 0.25 hummingbirds per point-count.

Logistic regression showed a significant relationship between Buff-bellied Hummingbird presence and percent impervious cover (Figure 2; $p < 0.001$, area under ROC curve = 0.795). The odds ratio (1.0695) indicates that as imperviousness increases, so too does the probability of Buff-bellied Hummingbird occurrence.

Buff-bellied Hummingbird average relative abundance was greatest in urban woodlands, followed by residential, revegetated, and natural habitats (Figure 3). Based on the results of the Kruskal-Wallis test, we rejected the null hypothesis that all medians in the four habitat types were equal ($p < 0.005$). Furthermore, results of the subsequent Conover-Iman test indicated that there were significant differences between peri-urban and urban habitats, but not among the habitats within those groups (Table 1A).

We replicated the Kruskal-Wallis (Figure 4) and Conover-Iman (Table 1B) tests to compare percent imperviousness values in the four habitat types. Residential plots averaged the greatest percent imperviousness, followed by urban woodland, natural, and revegetated plots. All but the natural-reveg comparison were significant.

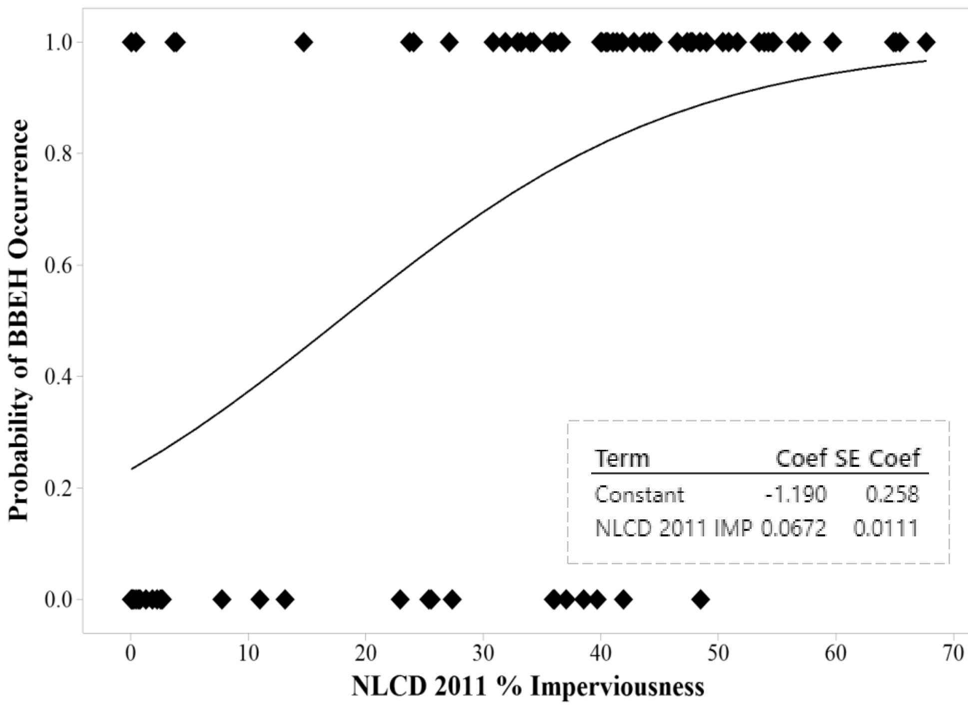

Figure 2. Logistic-regression of Buff-bellied Hummingbird presence as related to percent imperviousness of our study plots. Inset shows coefficient values.

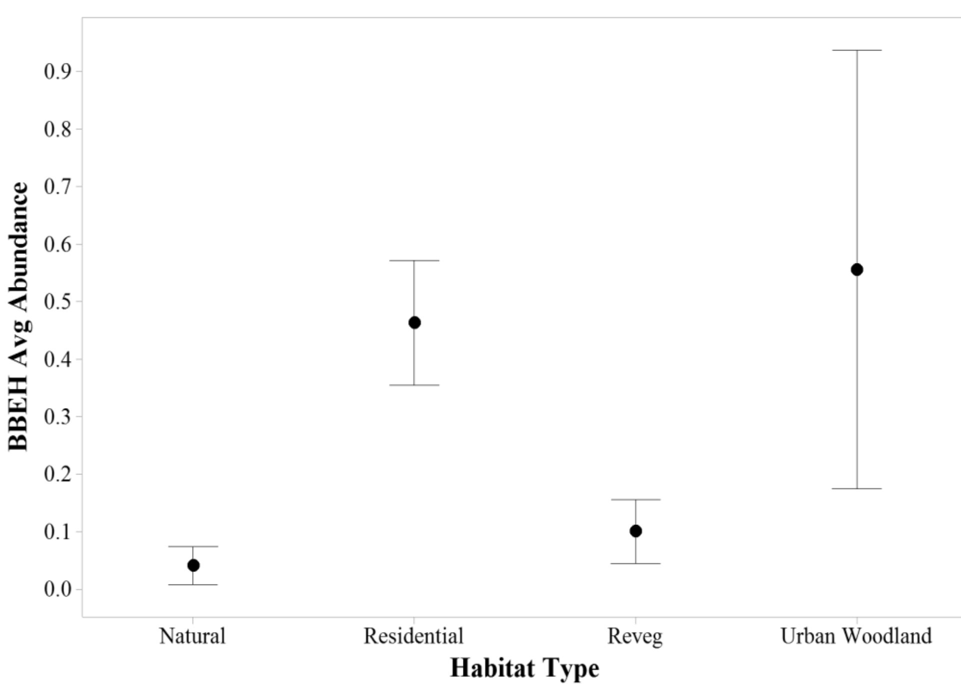

Figure 3. Average relative abundance of Buff-bellied Hummingbirds in peri-urban (natural & reveg) and urban (residential & urban woodland).

Table 1. Results of the Conover-Iman test for all pairwise comparisons with Buff-bellied Hummingbird average relative abundance (A), and with NLCD 2011 % imperviousness (B).

A: Buff-bellied Hummingbird comparisons				**B: NLCD 2011 % Imperviousness comparisons**			
Group 1	Group 2	Statistic	p-Value	Group 1	Group 2	Statistic	p-Value
Natural	*Residential*	*8.665*	*< 0.005*	*Natural*	*Residential*	*1.492*	*< 0.005*
Natural	*Reveg*	*1.614*	*0.109*	*Natural*	*Reveg*	*0.071*	*0.944*
Natural	*Urban Wood*	*5.416*	*< 0.005*	*Natural*	*Urban Wood*	*4.701*	*< 0.005*
Residential	*Reveg*	*6.468*	*< 0.005*	*Residential*	*Reveg*	*1.398*	*< 0.005*
Residential	*Urban Wood*	*0.595*	*0.533*	*Residential*	*Urban Wood*	*3.687*	*< 0.005*
Reveg	*Urban Wood*	*4.329*	*< 0.005*	*Reveg*	*Urban Wood*	*4.567*	*< 0.005*

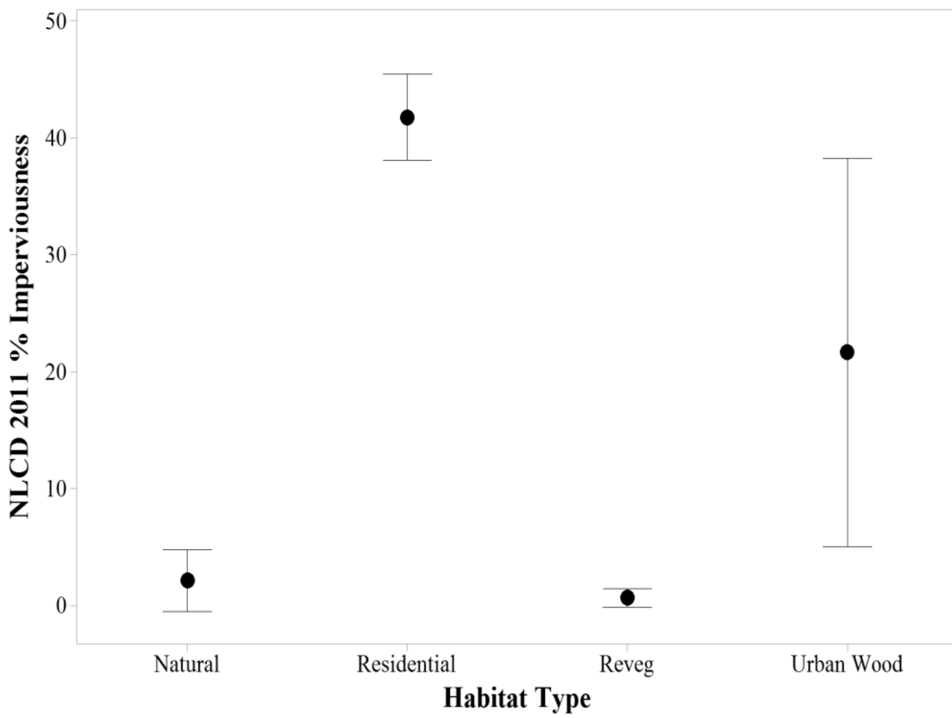

Figure 4. Average percent imperviousness of plots in peri-urban (natural & reveg) and urban (residential & urban woodland) habitats.

DISCUSSION

The LRGV bird community has experienced significant changes during the 20th century, with former breeding species being extirpated, new species colonizing, and others experiencing varying levels of population decline or increase – predominantly due to anthropogenic land use changes (Brush 2005, 2008). Although the effects of earlier habitat losses are poorly known, our results indicate that the Buff-bellied Hummingbird appears to be a species that has acclimated to urban habitats in the region.

Our data show that Buff-bellied Hummingbirds tended to be found at sites with greater impervious cover. Imperviousness is a key measure of urbanization, and here we interpret it as a proxy for factors associated with urbanization that favor hummingbirds, such as increased resource availability (more regularly available natural and artificial nectar sources) and warmer urban temperatures (Greig et al. 2017). In our study area, urban sites – those in urban woodlands and residential neighborhoods – hosted the greatest relative abundance of Buff-bellied Hummingbirds. Many of the urban woodland sites were nature centers, including several in the World Birding Center system that are specifically designed to attract bird watchers (http://www.theworldbirdingcenter.com/). Accordingly, these centers are often landscaped with lush gardens and feature many ornithophilous flowers such as *Malvaviscus drummondii* and *Justicia brandegeeana* (Villarreal 2016). In contrast, vegetation surveys conducted at the natural and revegetated plots, though primarily used to summarize overall habitat structure and composition as part of an adjunct revegetation assessment, detected very few ornithophilous flowers (Brush and Feria 2014). In residential habitats, many residents allow or encourage growth of ornithophilous flowering species. Supplemental feeders, along with ornithophilous flowers, likely provide hummingbirds with a stable and abundant food resource – a 2016 US Department of the Interior survey found that 59.1 million US residents participate in supplemental wildlife feeding (US Department of the Interior 2016). Given the mild subtropical climate of the LRGV, we hypothesize that increased abundance of ornithophilous flowers and supplemental hummingbird feeding play a larger role than warmer urban temperatures caused by the urban heat island effect.

While we did not directly link Buff-bellied Hummingbird population growth to urbanization, it does come during a period of increased urban development. The region has rapidly urbanized since the 1970s, growing in total population from 400,000 to over 1.3 million (Leslie 2016). Correspondingly, its urban development has grown in extent. Huang and Fipps (2011) reported that, on average, the Lower Rio Grande Valley saw a 46% increase in urbanized area between 1993 and 2003, and Hidalgo County (where our study was based) saw a 59.7% increase. Given the far-reaching impacts urbanization has on the region – habitat destruction, fragmentation, xerification (due to lack of flooding and increased water consumption) – the fact that Buff-bellied Hummingbirds remain common in urban areas supports the idea that they are an urban-affiliated species.

Our study identifies the pattern of Buff-bellied Hummingbird response to urbanization, but not the mechanism. Increased availability of food resources is one possibility, but others may exist. In southeastern Arizona, for example, Black-chinned Hummingbirds had increased reproductive success when nesting in association with Accipiter species, with hawk presence altering the foraging behavior of a common nest predator (Greeney et al. 2015). We do not know how nest depredation varies along the urban-rural gradient in the Lower Rio Grande Valley, and there have been no before/after studies of the effects of planting ornithophilous flowers and hummingbird feeders on hummingbird numbers. However, given the trends we saw in our data, there is evidence that urban areas can be important for Buff-bellied Hummingbirds in their United States distribution.

Hummingbirds may play a role as wildlife ambassadors. In an increasingly urbanized region, common native bird species may play a role in generating public support for conservation

(Dunn et al. 2006; Correia et al. 2016). Hummingbirds also may serve as a reminder of the cultural ecosystem services birds provide – Woosnam et al. (2012) reported that ecotourism in the LRGV contributed $463.0 million US dollars to the local economy. The Buff-bellied Hummingbird is part of a cadre of "Rio Grande Valley Specialty" birds that drive birdwatcher visitation to the region (Rio Grande Valley Birding Festival 2018), and as such is linked to that economic benefit. Given the loss and degradation of riparian areas due to habitat destruction and persistent lack of flooding, urban areas may be increasingly important for Buff-bellied Hummingbirds, a species that historically occupied those impacted habitats. Overall, our work supports previous studies demonstrating how urbanization can have positive effects on urban-affiliated bird taxa, including hummingbirds.

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