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Research paper

Examining the occurrence of mammal species in natural areas within a rapidly urbanizing region of Texas, USA

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HIGHLIGHTS

- Motion-activated cameras were used to document the existence of wildlife species in natural areas surrounded by urbanization.
- Two generalist species (raccoons and opossums) became more common as surrounding urbanization increased.
- Even relatively sensitive species (notably grey foxes and ringtails) existed in the natural areas despite urbanization.
- Ten urbanization factors were tested but none were more influential than others.
- Preservation of wildlife habitat should be recognized as a benefit of protecting natural areas.in urban landscapes.

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ABSTRACT

In much of the United States and elsewhere, urbanization continues to transform landscapes. In central Texas, anthropogenic conversion of land is due in part to a rapidly growing population in the Austin and San Antonio metro areas and the subsequent infrastructure and resources needed to support that growth. Protected natural areas adjacent to urbanized landscapes are often intended to mitigate the impact of land development by serving as wildlife habitat. To maximize the potential of this habitat, we must assess how urbanization influences the occurrence of species in these natural areas (e.g., parks, greenspaces, preserves). We used motion-activated cameras to survey 72 sites (points) across six different regions throughout the urban corridor from San Antonio to Austin. Using occupancy modeling, we examined the influence of ten different urbanization factors (model covariates) on the occurrence of a variety of medium-sized mammal species. Generalist species, such as raccoons and opossums, had an increased probability of occurrence at sites with greater urban influence and were most likely to occur in smaller more urbanized study areas. Ringtails and grey foxes appeared to be unaffected by urbanization and were equally likely to occur across all sites. None of the other examined species were found to have a conclusively positive or negative response to urbanization. Knowledge of the effect of urbanization on wildlife will be important in evaluating current preserves as well as planning future preserves. Our study suggests that natural areas within urbanizing landscapes can be effective in providing habitat for some wildlife species.

1. Introduction

Habitat loss and fragmentation resulting from the anthropogenic conversion of land poses one of the greatest threats to biodiversity world-wide (McKinney, 2006). The negative effects of urbanization are primarily manifested as the ongoing loss of natural habitat and fragmentation of remaining habitat that is critical for various organisms such as mammals (Crooks, 2002; Crooks, Burdett, Theobald, Rondinini, & Boitani, 2011; Soga & Koike, 2013; Spinozzi, Battisti, & Bologna, 2012; Tigas, Van Vuren, & Sauvajo, 2002), birds (Croci, Butet, & Clergeau, 2008), reptiles/amphibians (Rizkalla & Swihart, 2006), and even insects (Soga et al., 2015). In addition to species-specific effects, landscape-level alterations can lead to shifts in the composition and structure of entire biological communities (Beasley & Rhodes, 2010; Prange & Gehrt, 2004). Environmental alterations may be the temporary result of disturbances such as grazing (Fuhlendorf, Briske, & Smeins, 2001), fire, and flood (Barbour, Burk, Pitts, Gilliam, & Schwartz, 1999; Karsai & Kampis, 2011) but some anthropogenic disturbances often result in the permanent transformation of wildlife habitat that is further

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compromised by a rapidly growing and urbanizing human population (Markovchick-Nicholls et al., 2008; McKinney, 2006).

Alteration and loss of natural habitat may be due to the construction of housing, roads, utility infrastructure, agriculture, commercial and industrial development, and natural resource extraction (Bateman & Fleming, 2012; Randa & Yunger, 2006; Riley et al., 2003; Whittington, St. Clair, & Mercer, 2005). Characteristics of urbanizing areas include changes in microclimate, water availability, light intensity, ambient noise, habitat connectivity, and increased invasive species prevalence (Gehrt, Riley, & Cypher, 2010). Because these effects can be far-reaching, beyond the boundaries of urban centers, the term 'urbanization' typically describes a wide array of human influences regardless of their point intensity (Bateman & Fleming, 2012). Also, urbanization can lead to habitat fragmentation that results in smaller patches that often experience increased isolation, increased edge effects, and higher levels of direct human disturbance (Prange & Gehrt, 2004; Spinozzi et al., 2012). When dispersal of organisms is restricted due to habitat isolation, some animal populations may face extirpation or extinction (Crooks et al., 2011; Markovchick-Nicholls et al., 2008; Mills, 2013). Urbanization has led to range contraction in some species (Bateman & Fleming, 2012; Tigas et al., 2002) while others, especially non-native species, have expanded their ranges, in part because they are able to actively use human-modified environments (McKinney, 2006; Veech, Small, & Baccus, 2011).

Clearly, wildlife species respond to urbanization in various ways. Species that react favorably to urbanization, urbanophiles, are typically adept in exploiting anthropogenic structures for habitation (Harrison, 1997), utilizing human refuse and agriculture as a food source (Newsome et al., 2015; Prange & Gehrt, 2004), and avoiding predators that may be less inclined to venture near human habitation (Muhly, Semeniuk, Massolo, Hickman, & Musiani, 2011). Urbanophobic species, those that are deterred by urbanization, may be displaced through loss of essential resources and are generally intolerant of human activity and disturbance (Markovchick-Nicholls et al., 2008; Møller, 2009; Prange & Gehrt, 2004). Urban-neutral species are those that are neither attracted nor deterred by urbanization. The urbanophilic/urbanophobic distinction and categorization have become well-established for some groups of organisms, such as birds (Blair, 1996; Croci et al., 2008; Shwartz, Muratet, Simon, & Julliard, 2013). For example, among ornithologists "backyard bird" is a frequently used label applied to urbanophilic species. Mammal species, however, are likely not as easily placed into the urbanophilic/urbanophobic categories. Nonetheless, some species might tend to being urbanophilic more so than urbanophobic and vice-versa.

The basic life history attributes of a species likely determine how the species is affected by urbanization, as has been demonstrated in various studies of birds (Clucas & Marzluff, 2015; Croci et al., 2008; Møller, 2009; Sol, González-Lagos, Moreira, Maspons, & Lapiedra, 2014). As for mammals, species that have large home-ranges, occur in low densities, have low reproductive rates, are highly specialized with regard to diet and habitat, have low dispersal rates, and are susceptible to human persecution are the most likely to be negatively affected by urbanization and fragmentation (Crooks, 2002; Crooks et al., 2011; Randa & Yunger, 2006; Riley, 2006; Spinozzi et al., 2012). Large- and medium-sized mammals, especially carnivores, typically possess these characteristics (Musiani, Anwar, McDermid, Hebblewhite, & Marceau, 2010). Conversely, mammal species that are more likely to flourish in urban environments are generally smaller in body size, have flexible diets, and exhibit high behavioral plasticity (Crooks, 2002), although a recent review suggested that even large-bodied predators can increase in abundance in urbanizing landscapes if such species also utilize anthropogenic food sources (Newsome et al., 2015). Similarly, bird species that most easily adapt to urban environments are those that are wide-ranging, have a high capacity for dispersal and fast reproduction, and are opportunistic in diet and behavior related to acquiring food resources (Møller, 2009).

The goal of our study was to identify anthropogenic landscape factors that affect the occurrence of large- and medium-sized mammals, specifically mesocarnivores, within natural areas surrounded by various levels of urbanization. Previous studies have revealed an ability of generalist mesocarnivore species to adapt, and even thrive, near urbanized areas (Markovchick-Nicholls et al., 2008; Ordeñana et al., 2010; Prange & Gehrt, 2004; Randa & Yunger, 2006). Based on these studies, we expected occurrence of opossums (*Didelphis virginiana*), raccoons (*Procyon lotor*), ringtails (*Bassariscus astutus*), and skunks (*Spilogale putorius* and *Mephitis mephitis*) to increase with proximity to urban areas and with high levels of anthropogenic influence. In light of conflicting research regarding effects of urbanization on coyotes (*Canis latrans*) (Bateman & Fleming, 2012; Gehrt, Anchor, & White, 2009; George & Crooks, 2006; Mitchell, Strohbach, Pratt, Finn, & Strauss, 2015; Ordeñana et al., 2010) and gray foxes (*Urocyon cinereoargenteus*) (Crooks, 2002; Harrison, 1997; Markovchick-Nicholls et al., 2008; Ordeñana et al., 2010; Riley, 2006) we predicted that occurrence of these species would remain relatively constant across all sites due to their ability to travel great distances within and between urban and rural landscapes. Beyond these predictions, we did not attempt to exactly predict where each species might fall on an urbanophilic to urbanophobic continuum, although such an attempt could be done in studies with a greater number of surveyed sites.

An important first step in understanding urban wildlife populations is to quantify the rate of occurrence of species in protected natural areas close to urbanization. More practically, maintaining viable populations of various species in urbanizing landscapes is a key component in some wildlife management plans (Thompson, 2004). Urban parks and greenspaces that are covered by habitat conservation plans mitigate incidental take of protected and sensitive species and may allow remaining patches of habitat to serve as necessary refuges for wildlife in urbanizing landscapes (Miller & Hobbs, 2000; Wilhere, 2002). Alternatively, in an urbanizing landscape some mesocarnivore species may be detrimental to other species such as endangered songbirds suffering increased rates of nest predation (Conkling et al., 2012; Miller & Hobbs, 2000). Mesocarnivores residing in or near urbanized areas face many potential detriments such as increased competition for resources, exposure to disease, pollution, and casualties on roads (Gehrt et al., 2010; Magle, Hunt, Vernon, & Crooks, 2012; Mills, 2013). Knowledge of mesocarnivore response to urbanization is needed in order to more effectively manage natural areas and their constituent species.

2. Methods

2.1. Study region and natural areas

The Interstate-35 corridor stretching approximately 125 km from Austin to San Antonio, Texas (Fig. 1) is one of the fastest growing regions in the USA (U.S. Census Bureau, 2014) with regard to human population. Between 2011 and 2013, San Marcos was the fastest growing city in the USA with an average annual growth of 8%, Cedar Park (about 30 km NW of Austin) was fourth with 5.6%, and Georgetown (about 45 km N of Austin) was seventh with 4.5%. San Antonio was ranked fourth in numerical population growth between 2001 and 2010 (U.S. Census Bureau, 2014).

Nine study areas, all of which were some type of publicly-owned and protected natural area, were selected within six regions throughout the San Antonio-Austin urban corridor (Fig. 1). All study areas are located within the Edwards Plateau ecoregion with the exception of McKinney Falls State Park. The Edwards Plateau