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Effects of Landscape and Yard Features on Mammals in Residential Yards in Northwest Arkansas

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Effects of Landscape and Yard Features on Mammals in Residential Yards in Northwest Arkansas

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ABSTRACT

The human footprint is rapidly expanding, and wildlife habitat is continuously being converted to human residential properties. Most wildlife residing in developing areas are displaced to nearby undeveloped areas. However, some animals can coexist with humans and acquire the necessary resources (food, water, shelter) within the human environment. This may be particularly true when development is low intensity, as in suburban yards. Due to the wide variety in how homeowners utilize their yards, they can be considered individually managed "greenspaces." These yards can provide a range of food (e.g., bird feeders, compost, gardens), water (bird baths and garden ponds), and shelter (e.g., brush-piles, outbuildings) resources to wildlife.

Due to their larger space requirements and vulnerability to human persecution, larger mammalian predators often respond differently to the presence of humans and human development than smaller mammals. Some medium-bodied mammalian predators such as coyote (*Canis latrans*), red fox (*Vulpes vulpes*), and gray fox (*Urocyon cinereoargenteus*), have adapted to coexist in human-dominated areas. There is a currently a need to understand how human-created land use such as residential yards can support wildlife as well as how certain yard features may facilitate human-wildlife conflict.

In Chapter I, I evaluated which landscape and yard features influence the richness and diversity of the herbivores and mesopredators within residential yards in a rapidly developing region. I deployed game cameras in 46 residential yards in summer 2021 and 96 yards in 2022 from approximately April 15-August 15th. I found that mesopredator diversity was negatively impacted by fences and positively influenced by the number of bird feeders present in a yard. Mesopredator richness increased with the amount of forest within 400m of the camera.

Herbivore diversity and richness were positively influenced by the area of forest within 400m of the yard and by the area of garden space within the yard, respectively. Our results suggest that while landscape does play a role in the presence of wildlife in a residential area, homeowners also have some agency over the richness and diversity of mammals using their yards based on the features they create or maintain on their properties.

For chapter II, I used the data collected over the summers of 2021 and 2022 from deployed game cameras in 46 and 96 residential yards in Northwest Arkansas USA to understand which landscape and yard features influenced the occupancy of the predators; coyotes (*Canis latrans*) and both gray and red foxes (*Urocyon cinereoargenteus* and *Vulpes vulpes*). I found that predator occupancy was marginally influenced by yard level features as opposed to landscape composition. Fences had significant negative effects on the occupancy of coyotes in our study. The total area of potential den sites in a yard also slightly increased the probability of coyote occupancy in a yard. When present in a yard, I found that gray foxes have increased detection rates in yards with poultry, highlighting a likely source of conflict with homeowners. I found that the interspecific interactions between our focal predator species were all modest but positive, indicating that these species likely use yards for similar resources and have ways of minimizing antagonistic interactions with one another in the suburban environment. As the number of residential yards continues to grow across the country, our results suggest that there are ways in which our yards can provide valuable resources to suburban predators and that homeowners also have the agency to mitigate interactions with predators through management of their yard features.

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TABLE OF CONTENTS

LIST OF PUBLISHED PAPERS

Chapter 1

Johansson, E. P., & DeGregorio, B. A. (2023). The Effects of Landscape and Yard Features on Mammal Diversity in Residential Yards . *Journal of Urban Ecosystems*. *Submitted for review*.

INTRODUCTION

Human development is converting wildlands to anthropogenic uses at unprecedent rates and as a result changing the way wildlife uses the space (Wilby and Perry 2016). Since 1980, residential area growth has surpassed population growth by 25% (Theobald 2005). Suburban yards now account for approximately 17.4% of the United States and comprising more than 1.74 million km^2 (Mathieu et al., 2007, Giner et al., 2013, Hedblom et al., 2017). Given that residential yards are ubiquitous across the landscape, they can provide both habitat and connectivity for wildlife (Bolger et al., 2001). Despite the average size of a residential lawn only being 0.1 ha, they can provide crucial resources to wildlife (Daniels and Kirkpatrick, 2006, Goddard et al., 2010, Hansen et al., 2020, Fardell et al., 2022, Grade et al., 2022). Our study site of Northwest Arkansas is one of the fastest growing residential areas in the United States with the population of Fayetteville and surrounding towns expected to double by 2045 (Reynolds et al., 2017). Because homeowners utilize their yard for different purposes, they can vary widely in the resources that they offer, and from a management perspective can be considered individually managed greenspaces (Bolger et al., 2001, Gallo et al., 2017).

Residential yards often provide a number of human subsidized resources such as food, shelter and water (Goddard et al., 2010, Kays and Parsons, 2014, Lepczyk et al., 2004, Lerman and Warren, 2011, Murray and St. Clair, 2017). Humans supply both intentional and unintentional food sources for wildlife, by providing supplemental food (food left out for wildlife or bird feeders) and by leaving out waste, compost, or pet food (Reed and Bonter, 2018). The widespread planting of gardens (both ornamental and vegetable) provides an additional food resource, as well as shelter for many animals (Goddard et al., 2010). Some yards also provide water to wildlife in the form of birdbaths, fountains, or frog ponds. Finally, residential yards often unintentionally provide shelter and denning resources for wildlife that are able to burrow under decking and storage sheds or that seek shelter in stacked firewood and brush piles (Gross et al., 2011).

Some wildlife species can adapt to human environments and are referred to as urban exploiters (McKinney 2006, McKinney, 2008, Bateman and Flemming 2012). Raccoons (*Procyon lotor*) and opossum (*Didelphis virginianus*) are some of the most notorious urban exploiters and utilize a variety of food sources, from bird feeders to trash (Bozek et al., 2007). Striped skunks (*Mephitis mephitis*) and red fox (*Vulpes vulpes*) are often found in suburban areas and use anthropogenic structures for denning sites (Lesmeister et al., 2015, Moll et al. 2018). The herbivorous urban exploiters: white-tailed deer (*Odocoileus virginianus*), cottontails (*Sylvilagus floridanus*), and groundhogs (*Marmota monax*), also utilize anthropogenic food. These species are widely considered to be pests that can cause large scale damage to both the crop industry and that of backyard gardeners (Manning 2021). Smaller mammals such as groundhogs and cottontails may also benefit by living in residential yards because the proximity to humans which allows them to confer safety from their natural predators could be wary of being near humans (Berger 2007; Moll et al., 2018; Gallo et al., 2017).

Understanding how yard features and landscape composition influences wildlife presence in a yard can be important to future management endeavors as land continues to be converted for human uses (Gallo et al., 2017). I used game cameras to assess how mesopredator and herbivore diversity and richness would vary based on both landscape composition and backyard features. I surveyed all yards features I thought would influence mammals to be in yards, and calculated landscape composition within 500 m around the residential site. Chapter I was formatted with the intent of publication in the *Journal of Urban Ecosystems* with Brett A. DeGregorio.

Although most yards are far smaller than the home range of larger mammalian predators, they frequently are used by these species for foraging, traveling, or denning if the proper resources are present (Gittleman et al., 2001, 2005, Hansen et al., 2020). Predators found in developed areas are often concentrated in green spaces such as parks and cemeteries (Parsons et al. 2019) but foray into residential areas to take advantage of subsidized resources (Prevedello et al., 2013). Yards may be particularly attractive to predators when they have dense populations of prey species due to the presence of compost or refuse, bird feeders, pet food, or outdoor pets (Contesse et al., 2004, Timm et al., 2004, Newsome et al., 2014, Soulsburry and White 2015, Hansen et al., 2020). Though food sources are most likely the top attractant for suburban predators, many yards also offer water sources, which can be important for smaller species that can dehydrate quickly (Harrison 1997). Infrastructure in a yard can also provide safe and attractive denning opportunities for both predators and their prey species (Gosselink et al., 2003, Duduś et al., 2014, Vuorisalo et al., 2014). Though the suburban environment can provide many useful resources it can also be heavily fragmented by fences separating yards which can restrict wildlife access to particular yards (Hansen et al., 2020). In some areas of the United States, 86% percent of suburban lawns are fenced which creates major fragmentation and limits accessibility to much of the area within a predator's home range (Ossola et al., 2019, Van Helden et al., 2020).

To understand predator occupancy in residential yards I used multispecies occupancy models (MacKenzie et al., 2004). This allowed us to address imperfect detection which is crucial for monitoring for more rare or cryptic species (Kellner and Swihart 2014) and to account for interspecific interactions between our focal species (coyotes, gray fox, and red fox). These species have large home ranges in suburban areas (often > 5 km^2) (Gittleman et al., 2001, Šálek et al., 2015), given that they certainly visit numerous yards per night. I included detection rate as I predicted that this would be a more nuanced look at the use of yards than occupancy analysis (which relied on a 7-day survey period). High detection rates in particular yards could be indicative of species seeking out particular resources. Chapter II was formatted with the intent of publication in the *Journal of Wildlife Management* with Brett A. DeGregorio.

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CHAPTER I

EFFECTS OF LANDSCAPE AND YARD FEATURES ON MAMMALS IN RESIDENTIAL YARDS IN NORTHWEST ARKANSAS

Emily P. Johansson and Brett A. DeGregorio

ABSTRACT

The human footprint is rapidly expanding, and wildlife habitat is continuously being converted to human residential properties. Most wildlife residing in developing areas are displaced to nearby undeveloped areas. However, some animals can co-exist with humans and acquire the necessary resources (food, water, shelter) within the human environment. This may be particularly true when development is low intensity, as in residential suburban yards. Yards arey managed “greenspaces” that can provide a range of food (e.g., bird feeders, compost, gardens), water (bird baths and garden ponds), and shelter (e.g., brush-piles, outbuildings) resources and are surrounded by varying landscape cover. To evaluate which landscape and yard features influence the richness and diversity of the herbivores and mesopredators within residential yards in a rapidly developing region; we deployed wildlife game cameras in 46 residential yards in summer 2021 and 96 yards in summer 2022. We found that mesopredator diversity was negatively impacted by fences and positively influenced by the number of bird feeders present in a yard. Mesopredator richness increased with the amount of forest within 400m of the camera. Herbivore diversity and richness were positively influenced by the area of forest within 400m of the yard and by the area of garden space within the yard, respectively. Our results suggest that while landscape does play a role in the presence of wildlife in a residential area, homeowners also have agency over the richness and diversity of mammals using their yards based on the features they create or maintain on their properties.

INTRODUCTION

Human development is converting wildlands to anthropogenic uses at an unprecedent rate and wildlife communities are being displaced and altered as a result (Wilby and Perry 2016). Since 1980, residential area growth has surpassed population growth by 25% (Theobald 2005). According to the center for Sustainable Systems at the University of Michigan residential areas now encompass more than 27.5 million ha in the United States. In these suburban areas, residential lawns account for approximately one third of the space (Matthew and Aryal 2007, Giner et al., 2013). Given that residential yards are ubiquitous across the landscape, they can provide both habitat and connectivity for wildlife (Bolger et al., 2001). Despite the average size of a residential lawn only being 0.1 ha, they are independently managed “greenspaces” that can potentially offer a variety of resources to wildlife depending on the features present (Daniels and Kirkpatrick, 2006, Goddard et al., 2010, Hansen et al., 2020, Fardell et al., 2022, Grade et al., 2022).

Residential yards often provide a number of human subsidized resources such as food, shelter and water (Goddard et al., 2010, Kays and Parsons, 2014, Lepczyk et al., 2004, Lerman and Warren, 2011, Murray and St. Clair, 2017). The overall richness and diversity of mammals in human-dominated areas can be directly influenced by these yard features (Hansen et al. 2020). Humans supply both intentional and unintentional food sources for wildlife, by providing supplemental food (food left out for wildlife or bird feeders) and by leaving out waste, compost, or pet food (Reed and Bonter, 2018). The widespread planting of gardens (both ornamental and vegetable) provides an additional food resource, as well as shelter for many animals (Goddard et al., 2010). Some yards also provide water to wildlife in the form of birdbaths, fountains, or frog ponds. Finally, residential yards often unintentionally provide shelter and denning resources for wildlife that are able to burrow under decking and storage sheds or that seek shelter in stacked firewood and brush piles (Gross et al., 2011).

Some wildlife species can adapt to human environments and are referred to as urban exploiters (McKinney 2006, McKinney, 2008, Bateman and Flemming 2012). Some common mammalian urban exploiters include raccoons (*Prison lotor*), Virginia opossums (*Didelphis virginiana;* hereafter opossum), red fox (*Vulpes vulpes*), striped skunk (*Mephitis mephitis*), groundhogs (*Marmota monax),* white-tailed deer (*Odocoileus virginianus*), and cottontails (*Sylvilagus floridanus*). These species often seek out residential yards and use anthropogenic food, water, and shelter. They can attain population densities higher than those in rural areas and some have been concentrated in human dominated areas for over 100 years (Haididian et al., 2010). Raccoons and opossum notoriously use a variety of food sources, from bird feeders to trash (Bozek et al., 2007), while striped skunks and red fox use anthropogenic structures as denning sites (Lesmeister et al., 2015, Moll et al. 2018). The herbivorous urban exploiters also utilize anthropogenic food. White-tailed deer (*Odocoileus virginianus*), cottontails, and groundhogs (*Marmota monax*) are widely considered to be pests that can cause large scale damage to both the crop industry and that of backyard gardeners (Manning 2021). Smaller mammals such as groundhogs and cottontails also may benefit by living in residential yards because the proximity to humans may confer safety from their natural predators that may be wary of being near humans (Berger 2007; Moll et al., 2018; Gallo et al., 2017).

While some species of wildlife can adapt readily to residential environments, other species are intolerant of human activity and development and may be rare or absent in developed areas (Ordeñana et al., 2010; Dorresteijn 2015). Though entrepreneurial wildlife can take advantage of human-subsidized resources there are numerous dangers to wildlife co-existing in the residential environment. Suburban areas are louder, brighter, and have a higher density of roads than natural areas (Swaddle et al., 2015). Road mortality accounts for more than 30% of wildlife deaths in developed areas (Bateman and Fleming 2012). Larger species of wildlife may be perceived as threats to human safety or human property and may be more at risk of persecution or removal (Montgomery et al., 2020). Human pets including dogs and free-roaming cats kill innumerable wildlife in developed areas (Young et al., 2011; Loss et al., 2013). Additionally suburban environments also have an increased number of fences that disrupt movement and create fragmentation and prevent access to resources (Jakes et al., 2018).

Because some species of mammals can survive and sometimes thrive in suburban areas, the potential for human-wildlife interaction and conflict increases. From the anthropogenic perspective some of these interactions can be positive and allow for time spent viewing wildlife and studies have found that these interactions can be beneficial to people (Soulsbury and White 2015). While other interactions can be negative such as destruction of resources, pet-wildlife conflict, and transmission of diseases such as distemper and rabies between wildlife and pets (Kapil 2011; Frank et al., 2019). Understanding how wildlife associate with yard features can provide homeowners agency to increase or reduce interactions with particular wildlife (Hansen et al., 2020).

Northwest Arkansas is one of the fastest growing residential areas in the United States with the population of Fayetteville and surrounding towns expected to double by 2045. As a result, wildlands are being converted to suburban cover at a startling rate, and some wildlife are frequenting residential lawns and interacting with homeowners and homeowner property. Our objectives were to use motion-triggered wildlife cameras to evaluate the wildlife associated with residential yards and to identify how surrounding land use and yard features influence mesopredator and herbivore diversity and richness. We predicted that mesopredator and herbivore diversity and richness would vary based on both landscape composition and backyard features. Specifically, we predicted that as forest cover increased and housing unit density decreased, more animal species would be present in yards. Furthermore, we predicted that yard features associated with supplemental food (bird feeders, gardens, and compost) would be most associated with increased species diversity and richness.

METHODS

Study Sites

Our study took place from 4 April to 4 August 2021 and 2022 within an 80.5 km radius of downtown Fayetteville, Arkansas USA. Northwest Arkansas is a rapidly developing area with a current population of approximately 349,000 people. Fayetteville is located in the Ozark Highlands ecoregion and the landscape is primarily forested by mixed hardwood trees with open areas used for cattle pastures and some scattered cultivated areas. Our study took place in residential yards ranging from downtown Fayetteville to yards situated in more rural areas. We solicited volunteers from the Arkansas Master Naturalist Program and the University of Arkansas Department of Biological Sciences who allowed us to place cameras in their yards. We attempted to choose yards that represented the continuum of urban to rural settings and provided a range of yard features that wildlife was likely to respond to.

Camera Setup

To document the presence of wildlife in residential yards, we deployed motion-triggered wildlife cameras (Browning StrikeForce or Spypoint ForceDark) in numerous residential yards (46 yards in 2021 and 96 yards in 2022). We placed cameras approximately 0.95 m above the ground on either a tripod or a tree and at least 5 m from houses and at most 100 m from houses. When possible, we positioned cameras near features such as compost piles, water sources (natural or man-made), and fence lines to maximize detections of wildlife. We coordinated with homeowners to choose locations that would not interfere with yard maintenance or compromise homeowner privacy. When necessary, we removed vegetation that obscured the field of view of cameras. We set cameras to trigger with motion and take bursts of 3 photographs per trigger with a 5 s reset time. We did not use any bait or lures. We checked and downloaded cameras every 2 weeks to check batteries and download data. We moved cameras upwards of 3 times within the season to ensure we captured the full range of wildlife present in each yard.

At each yard, we recorded eight variables associated with food, water, or cover features (Table 1). First, we recorded the area of maintained gardens occurring in each yard. Next, we recorded the volume of potential den sites available in each yard. Potential denning sites included the total available area under sheds and outbuildings as well as decking that was less than 0.3 m off the ground and provided opportunities for wildlife to burrow beneath and be sheltered. Similarly, we also measured the volume of all brush and firewood piles present in each yard that could be used by smaller wildlife species for shelter or foraging. We counted the number of bird feeders in each yard that were regularly kept filled during the study period. We also counted the number of water sources available including bird baths and frog (garden) ponds (any human subsidized water source on the ground usually within a lined basin or container). We distinguished between these types of water sources in analyses because bird baths were likely not available to all wildlife because of their height. We also categorized the presence and type of natural water source present in each yard including vernal streams, permanent streams or ponds, rivers, or lakes. We also recorded the presence of agricultural animals (such as chickens or ducks) present in each yard.

We documented whether the part of the yard where each camera was deployed was surrounded by a fence. If there was a fence, we categorized the fence type based upon its permeability to wildlife. We categorized fences into one of four categories ranging from those that posed little barrier to wildlife movement to those that were impassable to most species. For example, fences in our first category presented relatively little resistance to wildlife movement (i.e., barbed wire). A second category of fence consisted of fences made of semi-spaced wood slats or beams that offered enough room for most animals to squeeze through but that may have prevented passage of the largest bodied of the species. Fences that were about at least 1 m in height, but were closed off on the bottom (i.e., privacy or chain-link), meaning that few wildlife would be able to pass through without climbing or jumping over were placed in a third category. Finally, the fourth category of fences were those that were 1.8 m or greater in height and were made from a solid material that would prevent all wildlife except capable climbers from entering.

Landscape Variables

We used GIS (ArcGIS Pro 10.2; ESRI, Inc. Redlands Inc) to plot the location of all cameras and to quantify the composition of the surrounding landscape. We first created 400 m buffers around each camera, to encompass the average home range area of most wildlife species likely to occur in suburban yards (e.g., Trent and Rongtad, 1974; Hoffman and Gotschang, 1977; Atkins and Stott, 1998). Within each buffer, we calculated the amount of forest cover, developed open land (e.g., cemeteries, parks, and grass lawns), agriculture, and development using the 2019 National Land Cover Database (Dewitz 2021). Developed land constituted of areas with 20% or greater impervious surface. We also quantified the maximum housing unit density (HUD) around each camera using the SILVIS Housing Data Layer (Hammer et al., 2004). Finally, we calculated the straight-line distance from each camera to the nearest downtown city center (Fayetteville, Rogers, Bentonville, or Eureka Springs). Distance to downtown is an additional index of urbanization and human activity that has been correlated with animal behavior in this area (DeGregorio et al. 2021).

Photo Processing

We used timelapse 2.0 (Greenberg et al. 2019) to sort and classify all wildlife photographs. We grouped photographs within 5 minutes to be counted as one sequence to reduce double counting individuals (Forrester et al., 2016). We extracted metadata (e.g., date, time) from photographs, assigned species ID, and the number of individuals present in each sequence of photographs.

For our analyses, we focused on two guilds of mammals that are frequently encountered in yards and are reliably detected by cameras: mesopredators (medium-sized mammalian predators including raccoons, Virginia opossums, striped skunks, coyote (*Canis latrans*), bobcat (*Lynx rufus*), gray fox, red fox, and American black bears (*Ursus americanus*)) and herbivores (white-tailed deer, Eastern cottontails, and groundhogs). This approach allowed us to assess how landscape and backyard features affected a group of species that used resources in similar ways. Mesopredators are omnivorous and could use a variety of food resources as well as resources that attracted smaller prey and would also be associated with denning and shelter resources. Herbivores likely used yards primarily for access to gardens and ornamental shrubs to browse and forage on. At each camera, we calculated the Simpson's diversity (Simpson 1949) and richness of mesopredators and herbivores.

Statistical Analyses

Before we began analyses, we conducted a collinearity test to evaluate relationships between variables. We considered two variables that had correlation coefficients ≥ |0.6| collinear. From those, we would then decide which of the two variables were predicted to be more meaningful and only include that variable in subsequent analyses. We found that developed land and forest were highly correlated, r^2= -0.706. Because we had a second measure of human impact, housing unit density (HUD), already included we chose to keep forest cover going forward. We also found a high correlation, r^2= 0.72 between the area of gardens and the volume of brush/firewood piles and subsequently removed brush/firewood piles from analyses. All other variables were retained for analyses. We scaled and centered all landscape variables on their mean to facilitate comparison between variables measured on different scales (Schielzeth 2010).

Because this study spanned two summers, we sampled forty-three individual yards in both years. To account for this repeated sampling, we randomly selected one year of monitoring for inclusion in analyses and excluded the other year.

To evaluate which landcover and yard variables most influenced the Simpson's diversity and richness of mesopredator, and herbivore guilds recorded in yards we used a Generalized Linear Model (GLM) analysis. We conducted four GLM analyses to explore the effects of landscape and yard features on the response variables of mesopredator diversity, mesopredator richness, herbivore diversity, and herbivore richness. For each analysis we used an iterative approach to assemble ninety-two candidate models. The candidate model set for each analysis consisted of simple one-way variable models and all additive two-way combinations of the eight yard and four landscape predictor variables as well as a global model (including all additive variables) and a null model (Supplemental appendices 1-4).

For each analysis we ranked candidate models using an information theoretic approach with Akaike's Information Criterion (AIC). When appropriate, we derived parameter estimates for candidate models by model averaging all models within 3 ΔAICc (Burnham and Anderson 2002) in R (R Core Team 2022) with the AICcmodavg package (Mazerolle MJ 2023).

To improve clarity in presenting model selection tables, we only display models that were competitive within 3 ΔAIC for each analysis (Table 2-4). Initial exploratory analyses indicated that relationships between predictor variables and response variables were linear and thus models were not corrected. Model goodness-of-fit was assessed using residual plots.

RESULTS

From April 4^{th} to August 4^{th}, 2021, we deployed 46 cameras in yards for a total of 4,107 camera nights. We deployed 96 cameras from April 4^{th} to August 4^{th} in 2022 for a total of 12,688 camera nights. After randomly excluding one year of sampling from yards that were studied in both years, we retained 103 individual residential yards with 10,246 camera nights for analyses. Of the yards retained for analyses, 99% (n=102) had at least one species of wildlife detected.

We documented 8 species of mesopredators including raccoons (4,874 individuals in 97 yards), Virginia opossum (2,268 individuals in 94 yards), red foxes (732 individuals in 49 yards), coyotes (417 individuals in 61 yards), gray foxes (150 individuals in 17 yards), striped skunks (71 individuals in 14 yards), bobcats (25 individuals in 10 yards), and black bears (2 individuals in 2 yards). Mesopredator Simpson's diversity values ranged from 0-0.94 with an average of 0.45 (± 0.25 SD). Mesopredator richness ranged from 0-6 species per yard with an average of 3 (± 1 SD).

We detected 3 herbivore species: white-tailed deer (7,372 individuals in 90 yards), cottontails (917 individuals in 50 yards), and groundhogs (347 individual in 33 yards). Herbivore diversity ranged from 0-1 with an average of 0.22 (± 0.35 SD). Herbivore richness ranged from 0-3 species with an average of 2 (± 1 SD).

Mesopredator diversity was most influenced by fence type at a yard. Fence type and number of bird feeders in a yard both appeared in the top model, collectively accounting for 14.8% of the weight of evidence. As fence permeability decreased (i.e., fewer species were able to freely move in and out of yards), the diversity of mesopredators documented in a yard decreased ($\beta = -0.08$ 95% CI=-0.16- -0.01) (Fig.1). The number of bird feeders in a yard were positively associated with mesopredator diversity ($\beta = 0.02$ 95% CI=0-0.03) (Fig. 2).

Mesopredators richness was best predicted by area of forested land within 400m of a yard. Forested area appeared in all 7 of the top models (Table 2). Cumulatively, all models accounted for 66.6% of the weight of evidence. As forested area in the buffer around the yard increased so did richness of mesopredators (model averaged $\beta = 2.84$, 95% CI=1.08-4.6) (Fig.3).

Herbivore diversity was best predicted by the amount of forest within 400 m of a yard. Forest appeared in 13 (92.8%) of the 14 top models (Table 3). Cumulatively, these 13 models accounted for 62% of the weight of evidence. Forest was positively related to herbivore diversity, suggesting that more herbivores are present in yards surrounded by higher forest cover (model averaged $\beta = 0.59$ 95% CI=0.06-1.12) (Fig.4).

Herbivore richness was best predicted by the area of gardens in a yard. Garden area appeared in 13 of the 19 top models (Table 4). Cumulatively, all 13 models containing the garden variable accounted for 40.1% of the weight of evidence. Area of gardens was positively related to herbivore richness, suggesting that more garden cover in a yard equates to more herbivore species present in a yard however the effect size was modest, and the 95% confidence intervals overlapped 0 (model averaged $\beta = 0.002$ 95% CI=-0.001-0.004).

DISCUSSION

We found that both backyard and landscape features had both positive and negative relationships with diversity and richness of mesopredators and herbivores in residential yards. Residential yards account for approximately one third of the landscape in urbanizing areas in the Eastern US (Mathieu et al., 2007, Giner et al., 2013, Hedblom et al., 2017). Despite these extreme landscape changes, some wildlife are able to co-exist with humans in residential habitats (Soulsburry and White 2015).

Unsurprisingly, we found that mesopredator diversity was lowest in yards surrounded by solid, impermeable fencing. This result aligns well with results from another study of wildlife diversity in residential yards (Hansen et al. 2020). We found that larger species such as coyote, bobcats, and black bear were essentially excluded from yards with solid fences. However, via some combination of climbing, burrowing under, or squeezing through, we often documented striped skunks, gray fox, red fox, opossum, and raccoon in yards with either solid or chain link fences. From the perspective of larger-bodied wildlife, fencing creates fragmentation and barriers to movement across the suburban landscape, this can limit access to resources and areas (Jakes et al., 2018). This may be particularly detrimental in areas where up to 86% of suburban lawns have fencing (Van Helden et al., 2020). From the homeowner's perspective, certain types of fencing may be effective at reducing interactions with some wildlife species.

We found that the number of bird feeders in a yard had a positive influence on mesopredator diversity in a yard. Studies have shown that raccoons tend to be documented at sites with feeders more often than those without (Reed and Bonter 2018). Although bird feeders are placed in order to increase positive connection between the public and wildlife it also can increase negative interactions (Barden et al., 1995). Other mesopredator species such as coyote and red fox also may be attracted to yards with bird feeders due to an increase in rodents and other small mammals that forage on fallen seed (Saad et al., 2020). During our study we photographed raccoons and opossum eating from or eating seed under bird feeders indicating that some mesopredators are attracted to feeders because they represent a food source. Surprisingly, other food sources that we measured didn't influence mesopredator diversity, such as compost piles or poultry presence in a yard. Other studies have found that compost piles are an attractant for many species, but of particular interest to coyotes in residential yards (Murray and St. Claire, 2017; Hansen et al., 2020). Similar to our findings, other studies have found that poultry presence in a yard did not attract most mesopredators, however raccoons have been positively associated with yards containing chicken coops (Kays and Parsons 2014).

Not surprisingly mesopredator richness and herbivore diversity both increased with the amount of forested area around yards. Although many species can use and even thrive in residential areas, forested areas are important to create spillover into suburban areas for mesopredators that require forest cover (Villaseñor et al., 2014). Species such as raccoons likely den in forested areas and move into residential yards to forage at night (Bozek et al., 2007; Bateman and Flemming 2012). Many of the mesopredators comprising our mesopredators guild have been found to be associated with forest cover (Tucker et al., 2008, Rodriguez et al., 2021). Of the three species included in the calculations of herbivore diversity, all have been reported to have associations with forest cover. White-tailed deer, the most frequently detected herbivore species in our study, are commonly associated with forest cover and while they forage in residential areas, they are reliant on forested areas for bedding and resting (DeNicola et al., 2000). White-tailed deer have been found to be more abundant in residential areas with higher forest cover (Urbanek and Nielsen 2013). Although relatively little is known about groundhog ecology and their habitat preferences, it has been documented that they preferentially burrow along wooded areas and forest edges (Grizzell 1995, Armitage 2000, Erb et al., 2012). Eastern cottontails are often associated with open habitats, but in human dominated landscape they can often be pushed to more forested areas (Tash and Litvaitis 2007, Erb et al., 2012, Herrera et al. 2022). This result suggests that while owners have some agency over the features present in their yard and wildlife they attract, landscape context plays a significant role in the wildlife present and homeowners are unable to influence this.

Although herbivore diversity was associated with forest cover on a landscape scale, we found some evidence for a relationship between garden area and the richness of herbivores, although the relationship was modest. While some homeowners enjoy seeing deer, groundhogs, and cottontails in their yards, they are viewed by others negatively (DeNicola et al., 2000). All three species included in our herbivore category have been identified as nuisances that can cause damage to gardens (Manning 2021). Thus, the association between garden area and herbivore richness is not surprising, it can lead to conflicts. Furthermore, not only are gardens used as a food source by these herbivores, but they can also provide dense cover for cottontail bedding and maybe predator-free areas due to frequent visitation by humans tending the gardens (Baker and Harris 2007, Van Helden et al., 2020). The association of herbivore richness with garden area is likely to lead to negative interactions with homeowners due to the damage these animals can inflict upon flower and vegetable gardens (Flyger et al., 1983).

Perhaps the most surprising result, or lack thereof, from this study is that housing unit density did not significantly affect diversity or richness of either mammalian guild. Previous studies have found that wildlife often respond to intensity of development with some species showing a preference to higher development (McKinney 2006, McKinney 2008, Bateman and Flemming 2012, Hansen et al., 2020) and others shying away from high intensity development (McKinney 2006, Bateman and Fleming 2012, Rodriguez et al., 2021). However, a similar study (Hansen et al., 2020), found that only one species, coyote, responded to housing unit density, while diversity and richness of the mammal community were not affected.

Our results suggest that mammalian wildlife is present in most residential yards and diversity and richness vary based on some homeowner practices. We found that amount of forested land area is an important driver for most species to be in an area, increasing both herbivore diversity and mesopredators richness. Homeowners do have some control however, as backyard features such gardens, bird feeders, and fences all influenced the mammal community in yards. Given the vast area covered by residential yards, the resources they supply, and the level of connectivity they provide to greenspaces they are important to the conservation and management of suburban wildlife (Bolger et al., 2001, Hansen et al., 2020). So as the suburban landscape expands an understanding of how homeowners maintain their yards and how this influences wildlife will be crucial in maintaining space for wildlife.

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TABLES

Table 1 Description of all variables predicted to affect diversity and richness of mammals in residential yards within 80km of downtown Fayetteville, Arkansas USA during the summers of 2021 and 2022.

Landscape Variables	
Forest Cover	Area of forest cover within 400m buffer
Open Land	Area of open land, (parks, cemeteries, and lawns) within 400m buffer
Agricultural Land	Area of land used for agricultural purposes within 400m buffer
Developed Land	Area of developed land within 400m buffer
Housing Unit Density (HUD)	Maximum Housing Unit Density within 400m buffer of camera (houses/km^2)
Yard Variables	
Volume of Denning Sites	Volume under sheds/outbuildings and under decks less than 1m off the ground.
Volume of Brush/Firewood Piles	Total volume of denning sites including brush and firewood piles
Water Source	Number of human-maintained water sources
- Bird Bath	Water source that is raised off the ground, so much so that animals that cannot climb or jump cannot access it
- Frog Pond	Water source on or embedded within the ground
Bird Feeder	Number of bird feeders present in yard
Garden	Area of total maintained gardens
Compost Pile	Area of compost pile
Fence	If a camera was within a fence, it was given a score between 1-4, 1 being the most permeable fence and 4 being the most impassable. 0: not in a fence 1: Barbed wire 2: Open slat fence 3: 1.2 m Chain-link or Privacy 4: 1.8 m chain-link or Privacy
Poultry	Presence or absence of poultry being kept in yard
Water	Score of presence or absence of natural water source. 0: No natural water source 1: Vernal stream 2: Stream or pond 3: River 4: Lake

Table 2 Model selection statistics for the influence of landscape and yard features on mesopredator richness. Only top candidate models within 3 ΔAICc, are presented. Predictor variables of relative abundance included surrounding landscape and backyard variables. Models

were ranked using Akaike's Information Criterion (AIC) and included with each model is the number of parameters (K), AICc difference between model of interest and model with lowest AIC (ΔAICc), model weight (AICwt) and log-likelihood estimate (LL).

Models	K	AICc	ΔAICc	ModelLik	AICcWt	LL	Cum.Wt
Forest + Water	4	328.499	0.000	1.000	0.200	-160.045	0.200
Poultry Presence + Forest	4	329.418	0.919	0.632	0.126	-160.505	0.326
Forest	3	329.543	1.044	0.593	0.119	-161.650	0.445

Table 2 (Cont.)

Hay + Forest	4	330.628	2.129	0.345	0.069	-161.110	0.514
Bird Bath + Forest	4	331.121	2.622	0.270	0.054	-161.356	0.567
Frog Pond + Forest	4	331.151	2.652	0.266	0.053	-161.371	0.621
Garden + Forest	4	331.482	2.983	0.225	0.045	-161.537	0.666

Table 3 Model selection statistics for the influence of landscape and yard features on herbivore diversity. Only top candidate models within 3 ΔAICc, are presented. Predictor variables of relative abundance included surrounding landscape and backyard variables. Models were ranked using Akaike's Information Criterion (AIC) and included with each model is the number of parameters (K), AICc difference between model of interest and model with lowest AIC (ΔAICc), model weight (AICwt) and log-likelihood estimate (LL).

Model	K	AICc	ΔAICc	ModelLik	AICcWt	LL	Cum.Wt
Forest	3	80.393	0.000	1.000	0.103	-37.074	0.103
Frog Pond + Forest	4	81.691	1.297	0.523	0.054	-36.639	0.157
Forest +Dens	4	81.764	1.371	0.504	0.052	-36.676	0.209
Fence Type + Forest	4	81.903	1.509	0.470	0.049	-36.745	0.258
HUD + Forest	4	82.176	1.782	0.410	0.042	-36.882	0.300
Poultry Presence + Forest	4	82.200	1.806	0.405	0.042	-36.894	0.342
Forest + Water	4	82.333	1.939	0.379	0.039	-36.960	0.381
Compost + Forest	4	82.436	2.043	0.360	0.037	-37.012	0.418
Garden + Forest	4	82.499	2.106	0.349	0.036	-37.044	0.454
Bird Bath + Forest	4	82.512	2.118	0.347	0.036	-37.050	0.490
Forest +Open	4	82.543	2.150	0.341	0.035	-37.066	0.525
Forest + Bird Feeder	4	82.549	2.155	0.340	0.035	-37.068	0.560
Hay + Forest	4	82.551	2.158	0.340	0.035	-37.070	0.596
HUD	3	83.169	2.775	0.250	0.026	-38.462	0.621

Table 4 Model selection statistics for the effects of landscape and yard variables on herbivore richness. Only top candidate models within 3 ΔAICc, are presented. Predictor variables of relative abundance included surrounding landscape and backyard variables. Models were ranked using Akaike's Information Criterion (AIC) and included with each model is the number of parameters (K), AICc difference between model of interest and model with lowest AIC (ΔAICc), model weight (AICwt) and log-likelihood estimate (LL).

Model	*K*	*AICc*	*ΔAICc*	*ModelLik*	*AICcWt*	*LL*	*Cum.Wt*
Garden + Forest	4	279.691	0.000	1.000	0.039	-135.640	0.039
Garden	3	279.843	0.152	0.927	0.036	-136.799	0.075
Forest	3	280.315	0.623	0.732	0.029	-137.035	0.104
Forest +Dens	4	280.393	0.702	0.704	0.027	-135.990	0.131
Dens	3	280.434	0.742	0.690	0.027	-137.094	0.158
Garden +Dens	4	280.603	0.912	0.634	0.025	-136.095	0.183
HUD	**3**	281.040	1.349	0.509	0.020	-137.398	0.203
Compost	3	281.055	1.364	0.506	0.020	-137.405	0.223
HUD + Garden	4	281.141	1.449	0.484	0.019	-136.364	0.241
Garden + Compost	4	281.188	1.496	0.473	0.018	-136.388	0.260
Bird Bath	3	281.231	1.539	0.463	0.018	-137.493	0.278
Garden +Hay	4	281.372	1.680	0.432	0.017	-136.480	0.295
HUD +Dens	4	281.398	1.707	0.426	0.017	-136.493	0.311
Hay	3	281.555	1.863	0.394	0.015	-137.655	0.327
Poultry Presence	3	281.599	1.907	0.385	0.015	-137.677	0.342
Garden + Poultry Presence	4	281.614	1.923	0.382	0.015	-136.601	0.357
Open	3	281.624	1.933	0.381	0.015	-137.690	0.372
Garden + Frog Pond	4	281.635	1.944	0.378	0.015	-136.611	0.386
Bird Bath + Forest	4	281.669	1.977	0.372	0.015	-136.628	0.401
Compost+ Dens	4	281.721	2.029	0.363	0.014	-136.654	0.415
Garden +Open	4	281.774	2.083	0.353	0.014	-136.681	0.429
Forest +Open	4	281.838	2.146	0.342	0.013	-136.713	0.442
Fence Type + Garden	4	281.856	2.165	0.339	0.013	-136.722	0.455
Frog Pond	3	281.916	2.225	0.329	0.013	-137.836	0.468
Fence Type	3	281.935	2.243	0.326	0.013	-137.845	0.481
Bird Feeder	3	281.944	2.253	0.324	0.013	-137.850	0.494
Garden + Bird Bath	4	281.950	2.258	0.323	0.013	-136.769	0.506
Compost + Forest	4	281.961	2.269	0.322	0.013	-136.774	0.519
Water	3	281.965	2.273	0.321	0.013	-137.860	0.531
Garden + Water	4	281.987	2.296	0.317	0.012	-136.787	0.544
Garden + Bird Feeder	4	282.004	2.313	0.315	0.012	-136.796	0.556
Poultry Presence + Forest	4	282.022	2.331	0.312	0.012	-136.805	0.568
Bird Bath +Dens	4	282.025	2.334	0.311	0.012	-136.807	0.580
Poultry Presence +Dens	4	282.270	2.579	0.275	0.011	-136.929	0.591

Table 4 (Cont.)

Hay +Dens	**4**	**282.273**	**2.582**	**0.275**	**0.011**	**-136.930**	**0.602**
HUD + Forest	4	282.312	2.620	0.270	0.011	-136.950	0.612
Hay + Forest	4	282.387	2.696	0.260	0.010	-136.987	0.622
HUD +Hay	4	282.436	2.744	0.254	0.010	-137.012	0.632
Frog Pond + Forest	4	282.445	2.753	0.252	0.010	-137.016	0.642
Open +Dens	4	282.445	2.753	0.252	0.010	-137.016	0.652
HUD + Bird Bath	4	282.457	2.766	0.251	0.010	-137.023	0.662
Fence Type + Forest	4	282.460	2.769	0.250	0.010	-137.024	0.672
Forest + Water	4	282.475	2.784	0.249	0.010	-137.031	0.681
Forest + Bird Feeder	4	282.482	2.791	0.248	0.010	-137.035	0.691
Compost +Hay	4	282.508	2.817	0.245	0.010	-137.048	0.701
Dens + Bird Feeder	4	282.521	2.829	0.243	0.009	-137.054	0.710
Frog Pond +Dens	4	282.527	2.835	0.242	0.009	-137.057	0.720
Compost +Open	4	282.528	2.837	0.242	0.009	-137.058	0.729
Fence Type +Dens	4	282.560	2.868	0.238	0.009	-137.074	0.738
HUD + Compost	4	282.582	2.890	0.236	0.009	-137.085	0.747
Dens + Water	4	282.598	2.906	0.234	0.009	-137.093	0.757
Compost + Bird Bath	4	282.636	2.945	0.229	0.009	-137.112	0.766

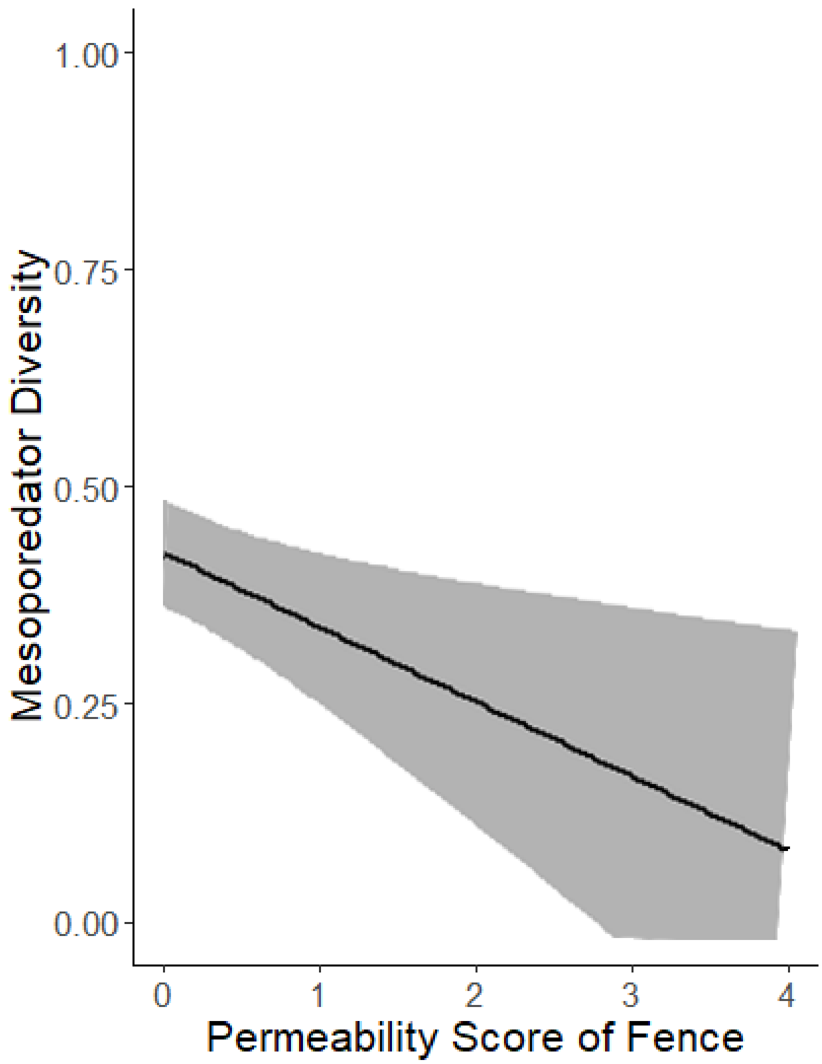

Figure 1
Influence of permeability of fences around yards on mesopredators diversity in yards of homes in Northwest Arkansas. Fences were categorized based on their permeability to wildlife with 1 being the most permeable fence offering little resistance to wildlife and 4 representing an impermeable barrier unless wildlife were capable climbers.95% confidence intervals are presented using a gray band.

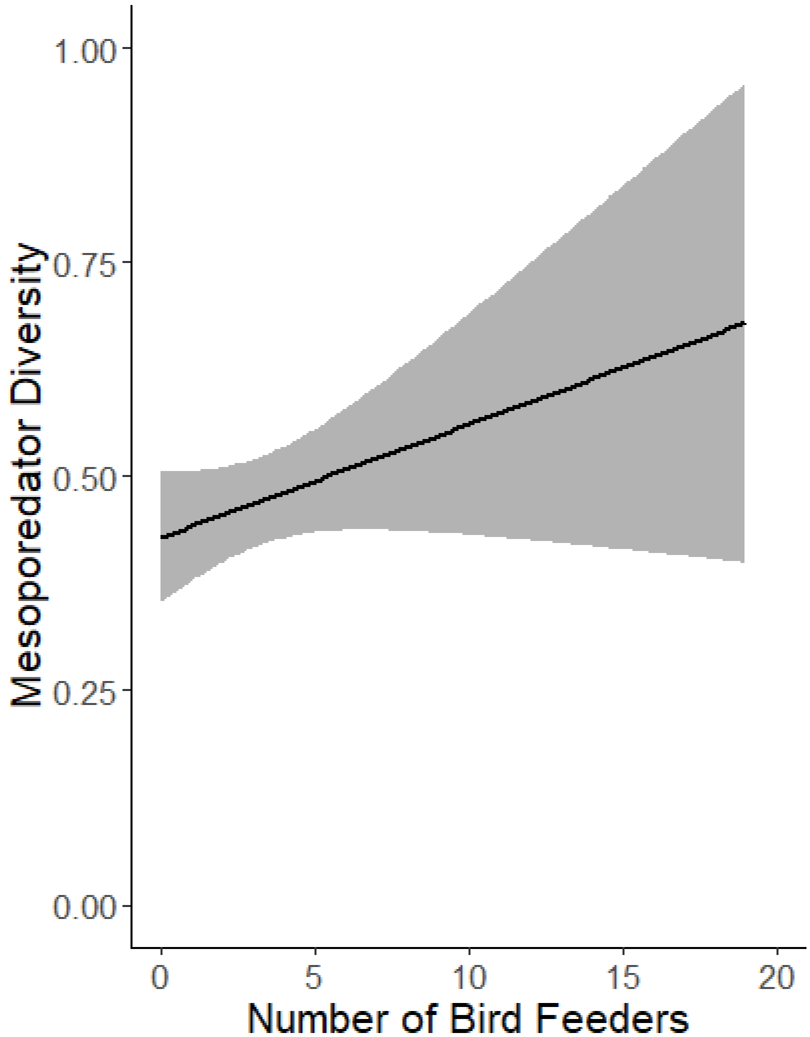

Figure 2
Influence of number of bird feeders present in a yard on mesopredators diversity in yards of homes in Northwest Arkansas. 95% confidence intervals are presented using a gray band.

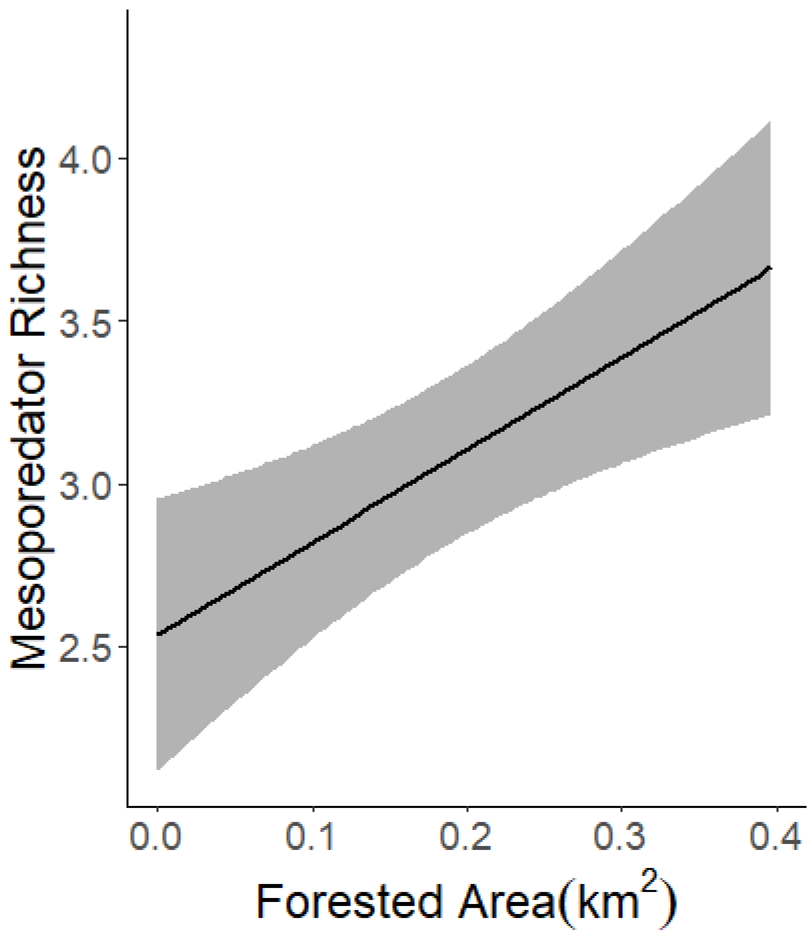

Figure 3
Influence of standardized area (km^2) of forest within a 400m buffer of a yard on mesopredators richness in yards of homes in Northwest Arkansas. 95% confidence intervals are presented using a gray band.

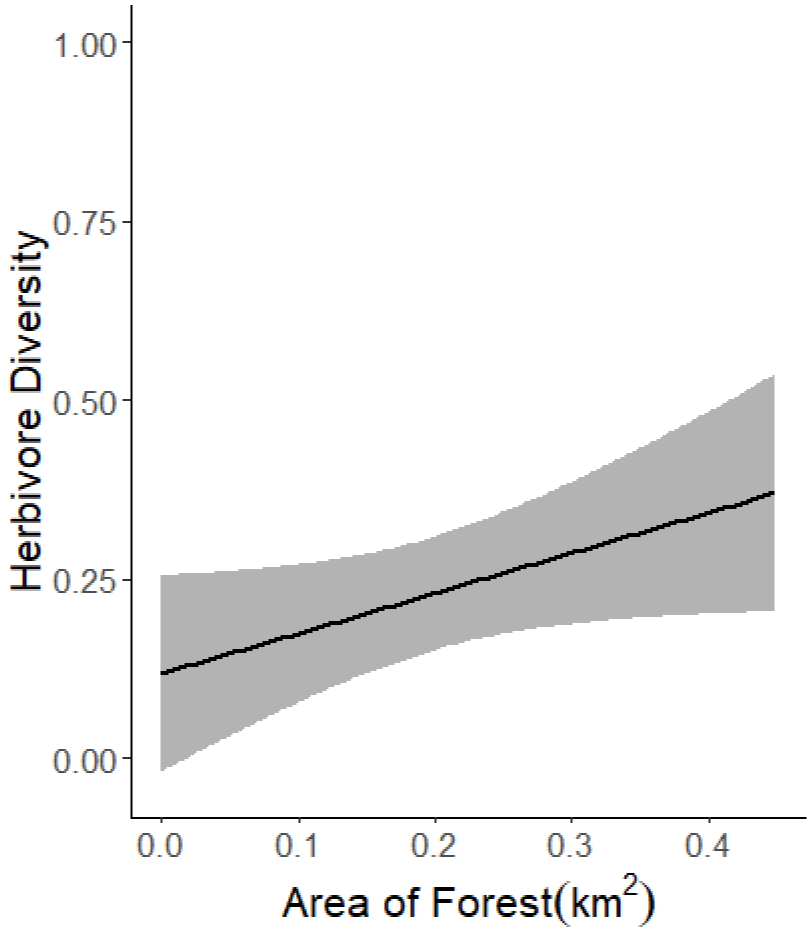

Figure 4
Influence of forest cover within a 400m buffer of a yard on herbivore diversity in yards of homes in Northwest Arkansas. 95% confidence intervals are presented using a gray band.

SUPPLEMENTAL INFORMATION

Table 5 Model selection statistics for the influence of landscape and yard features on mesopredator diversity. Predictor variables of relative abundance included surrounding landscape and yard variables. Models were ranked using Akaike's Information Criterion (AIC) and included with each model is the number of parameters (K), AICc difference between model of interest and model with lowest AIC (ΔAICc), model weight (AICwt) and log-likelihood estimate (LL).

Mesopredator Diversity							
Models	K	AICc	ΔAICc	ModelLik	AICcWt	LL	Cum.Wt
Fence Type + Bird Feeder	4.000	7.941	0.000	1.000	0.148	0.233	0.148
Fence Type	3.000	10.979	3.038	0.219	0.033	-2.368	0.181
Bird Feeder	3.000	11.269	3.328	0.189	0.028	-2.513	0.209
Fence Type +Open	4.000	11.469	3.528	0.171	0.025	-1.531	0.235
Fence Type +Dens	4.000	11.516	3.574	0.167	0.025	-1.554	0.259
Fence Type +Hay	4.000	11.843	3.901	0.142	0.021	-1.717	0.280
Fence Type + Bird Bath	4.000	11.943	4.002	0.135	0.020	-1.767	0.301
Fence Type + Poultry Presence	4.000	11.957	4.016	0.134	0.020	-1.775	0.320
Hay + Bird Feeder	4.000	12.004	4.063	0.131	0.019	-1.798	0.340
Poultry Presence + Bird Feeder	4.000	12.042	4.101	0.129	0.019	-1.817	0.359
Forest + Bird Feeder	4.000	12.154	4.213	0.122	0.018	-1.873	0.377
Dens + Bird Feeder	4.000	12.157	4.216	0.122	0.018	-1.874	0.395
Fence Type + Forest	4.000	12.323	4.382	0.112	0.017	-1.958	0.412
Forest	3.000	12.420	4.479	0.107	0.016	-3.089	0.428
Garden + Bird Feeder	4.000	12.466	4.525	0.104	0.015	-2.029	0.443
Poultry Presence	3.000	12.482	4.541	0.103	0.015	-3.120	0.458
Open + Bird Feeder	4.000	12.553	4.612	0.100	0.015	-2.073	0.473
Dens	3.000	12.562	4.621	0.099	0.015	-3.160	0.488
Fence Type + Frog Pond	4.000	12.751	4.810	0.090	0.013	-2.171	0.501
Hay	3.000	12.810	4.869	0.088	0.013	-3.284	0.514
Forest +Open	4.000	12.900	4.959	0.084	0.012	-2.246	0.527
Fence Type + Compost	4.000	12.955	5.014	0.082	0.012	-2.273	0.539
Fence Type + Garden	4.000	12.956	5.015	0.081	0.012	-2.274	0.551
Frog Pond + Bird Feeder	4.000	12.957	5.016	0.081	0.012	-2.274	0.563
Poultry Presence + Forest	4.000	13.024	5.083	0.079	0.012	-2.308	0.575
Open +Dens	4.000	13.047	5.106	0.078	0.012	-2.319	0.586
Fence Type + Water	4.000	13.056	5.114	0.078	0.012	-2.324	0.598
Open	3.000	13.060	5.118	0.077	0.011	-3.409	0.609
HUD + Bird Feeder	4.000	13.096	5.155	0.076	0.011	-2.344	0.621
Poultry Presence +Dens	4.000	13.100	5.159	0.076	0.011	-2.346	0.632
Hay +Dens	4.000	13.124	5.182	0.075	0.011	-2.358	0.643
Fence Type + HUD	4.000	13.134	5.193	0.075	0.011	-2.363	0.654

Table 5 (Cont.)

Water + Bird Feeder	4.000	13.263	5.322	0.070	0.010	-2.427	0.664
Bird Bath + Bird Feeder	4.000	13.267	5.326	0.070	0.010	-2.430	0.675
Compost + Bird Feeder	4.000	13.275	5.334	0.069	0.010	-2.433	0.685
Forest +Dens	4.000	13.349	5.408	0.067	0.010	-2.471	0.695
Poultry Presence + Frog Pond	4.000	13.429	5.488	0.064	0.010	-2.510	0.704
Bird Bath	3.000	13.514	5.572	0.062	0.009	-3.636	0.714
Frog Pond	3.000	13.558	5.617	0.060	0.009	-3.658	0.723
Poultry Presence +Hay	4.000	13.712	5.771	0.056	0.008	-2.652	0.731
Garden	3.000	13.740	5.799	0.055	0.008	-3.749	0.739
Bird Bath +Dens	4.000	13.835	5.894	0.052	0.008	-2.714	0.747
Bird Bath + Forest	4.000	13.848	5.907	0.052	0.008	-2.720	0.755
Frog Pond + Forest	4.000	13.867	5.926	0.052	0.008	-2.730	0.762
Hay + Forest	4.000	13.872	5.930	0.052	0.008	-2.732	0.770
Poultry Presence +Open	4.000	13.914	5.973	0.050	0.007	-2.753	0.777
HUD	3.000	13.926	5.985	0.050	0.007	-3.842	0.785
Compost	3.000	13.972	6.031	0.049	0.007	-3.865	0.792
Frog Pond +Dens	4.000	14.026	6.085	0.048	0.007	-2.809	0.799
Bird Bath +Hay	4.000	14.155	6.214	0.045	0.007	-2.874	0.806
Water	3.000	14.160	6.219	0.045	0.007	-3.959	0.812
Garden + Poultry Presence	4.000	14.181	6.239	0.044	0.007	-2.886	0.819
Bird Bath + Poultry Presence	4.000	14.221	6.279	0.043	0.006	-2.906	0.825
HUD + Poultry Presence	4.000	14.308	6.367	0.041	0.006	-2.950	0.832
Garden +Dens	4.000	14.349	6.407	0.041	0.006	-2.970	0.838
Garden + Forest	4.000	14.350	6.409	0.041	0.006	-2.971	0.844
HUD +Hay	4.000	14.355	6.414	0.040	0.006	-2.974	0.850
Garden + Bird Bath	4.000	14.358	6.417	0.040	0.006	-2.975	0.856
Compost + Poultry Presence	4.000	14.367	6.426	0.040	0.006	-2.979	0.862
Hay + Frog Pond	4.000	14.465	6.523	0.038	0.006	-3.028	0.867
Compost +Hay	4.000	14.480	6.538	0.038	0.006	-3.036	0.873
Compost + Dens	4.000	14.486	6.545	0.038	0.006	-3.039	0.879
Compost + Forest	4.000	14.540	6.599	0.037	0.005	-3.066	0.884
Forest + Water	4.000	14.557	6.616	0.037	0.005	-3.074	0.890
HUD + Forest	4.000	14.571	6.630	0.036	0.005	-3.081	0.895
HUD +Dens	4.000	14.574	6.633	0.036	0.005	-3.083	0.900
Hay +Open	4.000	14.583	6.642	0.036	0.005	-3.087	0.906
Poultry Presence + Water	4.000	14.606	6.665	0.036	0.005	-3.099	0.911
Bird Bath +Open	4.000	14.630	6.689	0.035	0.005	-3.111	0.916
Garden +Open	4.000	14.655	6.713	0.035	0.005	-3.123	0.921
Garden +Hay	4.000	14.665	6.724	0.035	0.005	-3.128	0.927
Compost +Open	4.000	14.698	6.757	0.034	0.005	-3.145	0.932
Dens + Water	4.000	14.708	6.766	0.034	0.005	-3.150	0.937

Table 5 (Cont.)

Hay + Water	4.000	14.834	6.893	0.032	0.005	-3.213	0.941
Frog Pond +Open	4.000	14.849	6.908	0.032	0.005	-3.220	0.946
HUD +Open	4.000	14.886	6.945	0.031	0.005	-3.239	0.951
Garden + Frog Pond	4.000	14.925	6.984	0.030	0.005	-3.258	0.955
Bird Bath + Frog Pond	4.000	15.099	7.157	0.028	0.004	-3.345	0.959
Open + Water	4.000	15.219	7.278	0.026	0.004	-3.405	0.963
HUD + Bird Bath	4.000	15.416	7.475	0.024	0.004	-3.504	0.967
Compost + Frog Pond	4.000	15.426	7.485	0.024	0.004	-3.509	0.970
HUD + Frog Pond	4.000	15.529	7.587	0.023	0.003	-3.560	0.974
Compost + Bird Bath	4.000	15.535	7.594	0.022	0.003	-3.563	0.977
HUD + Garden	4.000	15.625	7.683	0.021	0.003	-3.608	0.980
Garden + Compost	4.000	15.663	7.721	0.021	0.003	-3.627	0.983
Bird Bath + Water	4.000	15.664	7.723	0.021	0.003	-3.628	0.986
Frog Pond + Water	4.000	15.720	7.779	0.020	0.003	-3.656	0.989
Garden + Water	4.000	15.866	7.924	0.019	0.003	-3.729	0.992
HUD + Compost	4.000	15.953	8.011	0.018	0.003	-3.772	0.995
HUD + Water	4.000	16.067	8.125	0.017	0.003	-3.829	0.998
Compost + Water	4.000	16.123	8.182	0.017	0.002	-3.857	1.000
Bird Feeder+ Fence Type + Dens + Garden + Poultry Presence + Frog Pond+ Bird Bath + Compost+ HUD+ Hay + Forest +Open+ Water	15.000	27.948	20.007	0.000	0.000	3.784	1.000

Table 6 Model selection statistics for the influence of landscape and yard features on mesopredator richness. Predictor variables of relative abundance included surrounding landscape and backyard variables. Models were ranked using Akaike's Information Criterion (AIC) and included with each model is the number of parameters (K), AICc difference between model of interest and model with lowest AIC (ΔAICc), model weight (AICwt) and log-likelihood estimate (LL).

Mesopredator Richness							
Models	K	AICc	ΔAICc	ModelLik	AICcWt	LL	Cum.Wt
Forest + Water	4.000	328.499	0.000	1.000	0.200	-160.045	0.200
Poultry Presence + Forest	4.000	329.418	0.919	0.632	0.126	-160.505	0.326
Forest	3.000	329.543	1.044	0.593	0.119	-161.650	0.445
Hay + Forest	4.000	330.628	2.129	0.345	0.069	-161.110	0.514
Bird Bath + Forest	4.000	331.121	2.622	0.270	0.054	-161.356	0.567
Frog Pond + Forest	4.000	331.151	2.652	0.266	0.053	-161.371	0.621
Garden + Forest	4.000	331.482	2.983	0.225	0.045	-161.537	0.666
Forest +Open	4.000	331.583	3.084	0.214	0.043	-161.587	0.708
Fence Type + Forest	4.000	331.591	3.092	0.213	0.043	-161.591	0.751
Forest + Bird Feeder	4.000	331.670	3.171	0.205	0.041	-161.631	0.792

Table 6 (Cont.)

Forest +Dens	4.000	331.675	3.175	0.204	0.041	-161.633	0.833
Compost + Forest	4.000	331.690	3.191	0.203	0.041	-161.641	0.873
HUD + Forest	4.000	331.704	3.205	0.201	0.040	-161.648	0.913
HUD + Water	4.000	336.220	7.721	0.021	0.004	-163.906	0.918
Water	3.000	336.272	7.773	0.021	0.004	-165.015	0.922
Fence Type + Water	4.000	336.862	8.363	0.015	0.003	-164.227	0.925
Poultry Presence + Water	4.000	336.877	8.378	0.015	0.003	-164.234	0.928
HUD	3.000	336.953	8.454	0.015	0.003	-165.355	0.931
Garden + Water	4.000	337.440	8.941	0.011	0.002	-164.516	0.933
Poultry Presence	3.000	337.484	8.985	0.011	0.002	-165.621	0.935
Open + Water	4.000	337.515	9.016	0.011	0.002	-164.553	0.937
HUD + Poultry Presence	4.000	337.621	9.122	0.010	0.002	-164.607	0.940
Water + Bird Feeder	4.000	337.731	9.232	0.010	0.002	-164.661	0.942
Fence Type	3.000	337.907	9.408	0.009	0.002	-165.832	0.943
Fence Type + Poultry Presence	4.000	337.941	9.442	0.009	0.002	-164.767	0.945
Bird Bath + Water	4.000	338.091	9.592	0.008	0.002	-164.841	0.947
HUD + Garden	4.000	338.233	9.734	0.008	0.002	-164.912	0.948
Frog Pond + Water	4.000	338.279	9.780	0.008	0.002	-164.935	0.950
Compost + Water	4.000	338.346	9.847	0.007	0.001	-164.969	0.951
Garden	3.000	338.350	9.851	0.007	0.001	-166.054	0.953
Dens + Water	4.000	338.392	9.893	0.007	0.001	-164.992	0.954
Hay + Water	4.000	338.404	9.905	0.007	0.001	-164.998	0.956
Open	3.000	338.480	9.981	0.007	0.001	-166.119	0.957
Fence Type + HUD	4.000	338.484	9.985	0.007	0.001	-165.038	0.958
HUD +Open	4.000	338.593	10.094	0.006	0.001	-165.092	0.960
HUD + Bird Bath	4.000	338.668	10.169	0.006	0.001	-165.130	0.961
Bird Bath	3.000	338.703	10.204	0.006	0.001	-166.230	0.962
HUD + Bird Feeder	4.000	338.706	10.207	0.006	0.001	-165.149	0.963
Frog Pond	3.000	338.773	10.274	0.006	0.001	-166.265	0.964
Bird Feeder	3.000	338.803	10.304	0.006	0.001	-166.280	0.966
Garden + Poultry Presence	4.000	338.867	10.368	0.006	0.001	-165.229	0.967
HUD + Frog Pond	4.000	338.889	10.390	0.006	0.001	-165.240	0.968
Bird Bath + Poultry Presence	4.000	338.927	10.428	0.005	0.001	-165.260	0.969
Compost	3.000	338.935	10.436	0.005	0.001	-166.346	0.970
HUD +Hay	4.000	339.074	10.575	0.005	0.001	-165.333	0.971
Dens	3.000	339.082	10.583	0.005	0.001	-166.420	0.972
HUD + Compost	4.000	339.087	10.588	0.005	0.001	-165.339	0.973
HUD +Dens	4.000	339.109	10.610	0.005	0.001	-165.350	0.974
Hay	3.000	339.125	10.626	0.005	0.001	-166.441	0.975
Garden + Bird Bath	4.000	339.136	10.637	0.005	0.001	-165.364	0.976

Table 6 (Cont.)

Poultry Presence + Bird Feeder	4.000	339.164	10.665	0.005	0.001	-165.378	0.977
Fence Type + Bird Feeder	4.000	339.272	10.773	0.005	0.001	-165.432	0.978
Poultry Presence +Open	4.000	339.284	10.785	0.005	0.001	-165.438	0.979
Fence Type + Bird Bath	4.000	339.388	10.889	0.004	0.001	-165.490	0.980
Compost + Poultry Presence	4.000	339.495	10.996	0.004	0.001	-165.544	0.980
Fence Type + Garden	4.000	339.515	11.016	0.004	0.001	-165.554	0.981
Poultry Presence + Frog Pond	4.000	339.532	11.033	0.004	0.001	-165.562	0.982
Poultry Presence +Dens	4.000	339.571	11.072	0.004	0.001	-165.582	0.983
Fence Type +Open	4.000	339.592	11.093	0.004	0.001	-165.592	0.984
Poultry Presence +Hay	4.000	339.637	11.138	0.004	0.001	-165.615	0.984
Garden + Frog Pond	4.000	339.788	11.289	0.004	0.001	-165.690	0.985
Fence Type + Frog Pond	4.000	339.823	11.324	0.003	0.001	-165.708	0.986
Fence Type + Compost	4.000	339.886	11.387	0.003	0.001	-165.739	0.986
Garden +Open	4.000	339.956	11.457	0.003	0.001	-165.774	0.987
Garden + Bird Feeder	4.000	339.963	11.464	0.003	0.001	-165.777	0.988
Fence Type +Dens	4.000	340.021	11.522	0.003	0.001	-165.806	0.988
Fence Type +Hay	4.000	340.051	11.552	0.003	0.001	-165.821	0.989
Frog Pond +Open	4.000	340.057	11.558	0.003	0.001	-165.825	0.990
Bird Bath +Open	4.000	340.150	11.651	0.003	0.001	-165.871	0.990
Open + Bird Feeder	4.000	340.224	11.725	0.003	0.001	-165.908	0.991
Garden + Compost	4.000	340.275	11.776	0.003	0.001	-165.933	0.991
Garden +Hay	4.000	340.474	11.975	0.003	0.001	-166.033	0.992
Garden +Dens	4.000	340.477	11.978	0.003	0.001	-166.034	0.992
Bird Bath + Frog Pond	4.000	340.533	12.034	0.002	0.000	-166.062	0.993
Compost +Open	4.000	340.570	12.071	0.002	0.000	-166.081	0.993
Hay +Open	4.000	340.582	12.083	0.002	0.000	-166.087	0.994
Open +Dens	4.000	340.634	12.135	0.002	0.000	-166.113	0.994
Frog Pond + Bird Feeder	4.000	340.645	12.146	0.002	0.000	-166.118	0.995
Compost + Frog Pond	4.000	340.674	12.175	0.002	0.000	-166.133	0.995
Bird Bath + Bird Feeder	4.000	340.686	12.187	0.002	0.000	-166.139	0.996
Compost + Bird Bath	4.000	340.721	12.222	0.002	0.000	-166.156	0.996
Bird Bath +Dens	4.000	340.780	12.281	0.002	0.000	-166.186	0.996
Compost + Bird Feeder	4.000	340.785	12.286	0.002	0.000	-166.188	0.997
Bird Bath +Hay	4.000	340.863	12.364	0.002	0.000	-166.227	0.997
Frog Pond +Dens	4.000	340.873	12.374	0.002	0.000	-166.232	0.998
Hay + Frog Pond	4.000	340.913	12.414	0.002	0.000	-166.252	0.998
Dens + Bird Feeder	4.000	340.935	12.436	0.002	0.000	-166.263	0.999
Hay + Bird Feeder	4.000	340.955	12.456	0.002	0.000	-166.274	0.999
Compost+Dens	4.000	341.040	12.541	0.002	0.000	-166.316	0.999
Compost +Hay	4.000	341.100	12.601	0.002	0.000	-166.346	1.000
Hay +Dens	4.000	341.238	12.739	0.002	0.000	-166.415	1.000

Table 6 (Cont.)

Bird Feeder+ Fence Type + Dens + Garden + Poultry Presence + Frog Pond+ Bird Bath + Compost+ HUD+ Hay + Forest +Open+ Water	15.000	349.588	21.089	0.000	0.000	-157.036	1.000

Table 7 Model selection statistics for the influence of landscape and yard features on herbivore diversity. Predictor variables of relative abundance included surrounding landscape and yard variables. Models were ranked using Akaike's Information Criterion (AIC) and included with each model is the number of parameters (K), AICc difference between model of interest and model with lowest AIC (ΔAICc), model weight (AICwt) and log-likelihood estimate (LL).

Herbivore Diversity							
Models	**K**	**AICc**	**ΔAICc**	**ModelLik**	**AICcWt**	**LL**	**Cum.Wt**
Forest	3.000	80.393	0.000	1.000	0.103	-37.074	0.103
Frog Pond + Forest	4.000	81.691	1.297	0.523	0.054	-36.639	0.157
Forest +Dens	4.000	81.764	1.371	0.504	0.052	-36.676	0.209
Fence Type + Forest	4.000	81.903	1.509	0.470	0.049	-36.745	0.258
HUD + Forest	4.000	82.176	1.782	0.410	0.042	-36.882	0.300
Poultry Presence + Forest	4.000	82.200	1.806	0.405	0.042	-36.894	0.342
Forest + Water	4.000	82.333	1.939	0.379	0.039	-36.960	0.381
Compost + Forest	4.000	82.436	2.043	0.360	0.037	-37.012	0.418
Garden + Forest	4.000	82.499	2.106	0.349	0.036	-37.044	0.454
Bird Bath + Forest	4.000	82.512	2.118	0.347	0.036	-37.050	0.490
Forest +Open	4.000	82.543	2.150	0.341	0.035	-37.066	0.525
Forest + Bird Feeder	4.000	82.549	2.155	0.340	0.035	-37.068	0.560
Hay + Forest	4.000	82.551	2.158	0.340	0.035	-37.070	0.596
HUD	3.000	83.169	2.775	0.250	0.026	-38.462	0.621
HUD +Hay	4.000	84.191	3.798	0.150	0.015	-37.890	0.637
HUD +Dens	4.000	84.278	3.885	0.143	0.015	-37.933	0.652
Dens	3.000	84.470	4.076	0.130	0.013	-39.112	0.665
HUD + Frog Pond	4.000	84.880	4.486	0.106	0.011	-38.234	0.676
Fence Type + HUD	4.000	84.984	4.591	0.101	0.010	-38.286	0.686
HUD + Water	4.000	85.124	4.730	0.094	0.010	-38.356	0.696
Frog Pond	3.000	85.176	4.783	0.091	0.009	-39.466	0.706
HUD + Poultry Presence	4.000	85.192	4.799	0.091	0.009	-38.390	0.715
HUD + Bird Feeder	4.000	85.281	4.887	0.087	0.009	-38.434	0.724
HUD + Compost	4.000	85.296	4.903	0.086	0.009	-38.442	0.733
HUD + Bird Bath	4.000	85.305	4.912	0.086	0.009	-38.446	0.742
HUD +Open	4.000	85.306	4.912	0.086	0.009	-38.447	0.750
HUD + Garden	4.000	85.317	4.924	0.085	0.009	-38.453	0.759

Table 7 (Cont.)

Hay	**3.000**	**85.362**	**4.968**	**0.083**	**0.009**	**-39.558**	**0.768**
Water	3.000	85.628	5.235	0.073	0.008	-39.692	0.775
Poultry Presence	3.000	85.628	5.235	0.073	0.008	-39.692	0.783
Open	3.000	85.770	5.377	0.068	0.007	-39.763	0.790
Fence Type	3.000	85.809	5.416	0.067	0.007	-39.782	0.797
Bird Feeder	3.000	85.809	5.416	0.067	0.007	-39.782	0.804
Bird Bath	3.000	85.813	5.419	0.067	0.007	-39.784	0.811
Compost	3.000	85.828	5.435	0.066	0.007	-39.792	0.817
Garden	3.000	85.833	5.439	0.066	0.007	-39.794	0.824
Frog Pond +Dens	4.000	85.900	5.507	0.064	0.007	-38.744	0.831
Hay +Dens	4.000	86.014	5.620	0.060	0.006	-38.801	0.837
Poultry Presence +Dens	4.000	86.385	5.992	0.050	0.005	-38.986	0.842
Dens + Water	4.000	86.440	6.046	0.049	0.005	-39.014	0.847
Bird Bath +Dens	4.000	86.563	6.169	0.046	0.005	-39.075	0.852
Fence Type +Dens	4.000	86.602	6.209	0.045	0.005	-39.095	0.857
Compost+Dens	4.000	86.619	6.225	0.044	0.005	-39.103	0.861
Open +Dens	4.000	86.632	6.239	0.044	0.005	-39.110	0.866
Dens + Bird Feeder	4.000	86.632	6.239	0.044	0.005	-39.110	0.870
Garden +Dens	4.000	86.636	6.242	0.044	0.005	-39.112	0.875
Hay + Frog Pond	4.000	86.928	6.535	0.038	0.004	-39.258	0.879
Poultry Presence +Hay	4.000	87.163	6.770	0.034	0.003	-39.376	0.882
Hay +Open	4.000	87.165	6.772	0.034	0.003	-39.376	0.886
Frog Pond +Open	4.000	87.168	6.775	0.034	0.003	-39.378	0.889
Hay + Water	4.000	87.179	6.786	0.034	0.003	-39.383	0.893
Frog Pond + Water	4.000	87.214	6.821	0.033	0.003	-39.401	0.896
Garden + Frog Pond	4.000	87.253	6.859	0.032	0.003	-39.420	0.899
Poultry Presence + Frog Pond	4.000	87.256	6.862	0.032	0.003	-39.422	0.903
Fence Type + Frog Pond	4.000	87.277	6.883	0.032	0.003	-39.432	0.906
Compost + Frog Pond	4.000	87.306	6.913	0.032	0.003	-39.447	0.909
Bird Bath + Frog Pond	4.000	87.326	6.933	0.031	0.003	-39.457	0.913
Frog Pond + Bird Feeder	4.000	87.328	6.934	0.031	0.003	-39.458	0.916
Compost +Hay	4.000	87.466	7.073	0.029	0.003	-39.527	0.919
Bird Bath +Hay	4.000	87.485	7.091	0.029	0.003	-39.536	0.922
Hay + Bird Feeder	4.000	87.491	7.097	0.029	0.003	-39.539	0.925
Fence Type +Hay	4.000	87.497	7.104	0.029	0.003	-39.543	0.928
Garden +Hay	4.000	87.529	7.135	0.028	0.003	-39.558	0.931
Poultry Presence + Water	4.000	87.596	7.203	0.027	0.003	-39.592	0.933

Table 7 (Cont.)

Open + Water	**4.000**	**87.702**	**7.309**	**0.026**	**0.003**	**-39.645**	**0.936**
Water + Bird Feeder	4.000	87.735	7.342	0.025	0.003	-39.662	0.939
Bird Bath + Poultry Presence	4.000	87.742	7.348	0.025	0.003	-39.665	0.941
Poultry Presence + Bird Feeder	4.000	87.748	7.354	0.025	0.003	-39.668	0.944
Poultry Presence +Open	4.000	87.760	7.367	0.025	0.003	-39.674	0.947
Fence Type + Water	4.000	87.774	7.381	0.025	0.003	-39.681	0.949
Bird Bath + Water	4.000	87.774	7.381	0.025	0.003	-39.681	0.952
Garden + Water	4.000	87.782	7.389	0.025	0.003	-39.685	0.954
Fence Type + Poultry Presence	4.000	87.782	7.389	0.025	0.003	-39.685	0.957
Compost + Poultry Presence	4.000	87.788	7.394	0.025	0.003	-39.688	0.959
Garden + Poultry Presence	4.000	87.788	7.395	0.025	0.003	-39.688	0.962
Compost + Water	4.000	87.791	7.397	0.025	0.003	-39.689	0.965
Fence Type +Open	4.000	87.892	7.498	0.024	0.002	-39.740	0.967
Open + Bird Feeder	4.000	87.898	7.505	0.023	0.002	-39.743	0.969
Bird Bath +Open	4.000	87.904	7.511	0.023	0.002	-39.746	0.972
Garden +Open	4.000	87.933	7.539	0.023	0.002	-39.760	0.974
Compost +Open	4.000	87.935	7.541	0.023	0.002	-39.761	0.977
Garden + Bird Bath	4.000	87.947	7.554	0.023	0.002	-39.767	0.979
Fence Type + Bird Bath	4.000	87.956	7.562	0.023	0.002	-39.772	0.981
Fence Type + Bird Feeder	4.000	87.958	7.565	0.023	0.002	-39.773	0.984
Bird Bath + Bird Feeder	4.000	87.961	7.567	0.023	0.002	-39.774	0.986
Garden + Bird Feeder	4.000	87.962	7.568	0.023	0.002	-39.775	0.988
Fence Type + Compost	4.000	87.963	7.569	0.023	0.002	-39.775	0.991
Fence Type + Garden	4.000	87.963	7.570	0.023	0.002	-39.775	0.993
Compost + Bird Feeder	4.000	87.966	7.572	0.023	0.002	-39.777	0.995
Compost + Bird Bath	4.000	87.971	7.578	0.023	0.002	-39.779	0.998
Garden + Compost	4.000	87.987	7.593	0.022	0.002	-39.787	1.000
Bird Feeder+ Fence Type + Dens + Garden + Poultry Presence + Frog Pond+ Bird Bath + Compost+ HUD+ Hay + Forest +Open+ Water	15.000	106.124	25.731	0.000	0.000	-35.271	1.000

Table 8 Model selection statistics for the influence of landscape and yard features on herbivore richness. Predictor variables of relative abundance included surrounding landscape and yard variables. Models were ranked using Akaike's Information Criterion (AIC) and included with each model is the number of parameters (K), AICc difference between model of interest and model with lowest AIC (ΔAICc), model weight (AICwt) and log-likelihood estimate (LL).

Herbivore Richness							
Models	K	AICc	ΔAICc	ModelLik	AICcWt	LL	Cum.Wt
Garden + Forest	4.000	279.691	0.000	1.000	0.039	-135.640	0.039
Garden	3.000	279.843	0.152	0.927	0.036	-136.799	0.075
Forest	3.000	280.315	0.623	0.732	0.029	-137.035	0.104
Forest +Dens	4.000	280.393	0.702	0.704	0.027	-135.990	0.131
Dens	3.000	280.434	0.742	0.690	0.027	-137.094	0.158
Garden +Dens	4.000	280.603	0.912	0.634	0.025	-136.095	0.183
HUD	3.000	281.040	1.349	0.509	0.020	-137.398	0.203
Compost	3.000	281.055	1.364	0.506	0.020	-137.405	0.223
HUD + Garden	4.000	281.141	1.449	0.484	0.019	-136.364	0.241
Garden + Compost	4.000	281.188	1.496	0.473	0.018	-136.388	0.260
Bird Bath	3.000	281.231	1.539	0.463	0.018	-137.493	0.278
Garden +Hay	4.000	281.372	1.680	0.432	0.017	-136.480	0.295
HUD +Dens	4.000	281.398	1.707	0.426	0.017	-136.493	0.311
Hay	3.000	281.555	1.863	0.394	0.015	-137.655	0.327
Poultry Presence	3.000	281.599	1.907	0.385	0.015	-137.677	0.342
Garden + Poultry Presence	4.000	281.614	1.923	0.382	0.015	-136.601	0.357
Open	3.000	281.624	1.933	0.381	0.015	-137.690	0.372
Garden + Frog Pond	4.000	281.635	1.944	0.378	0.015	-136.611	0.386
Bird Bath + Forest	4.000	281.669	1.977	0.372	0.015	-136.628	0.401
Compost+ Dens	4.000	281.721	2.029	0.363	0.014	-136.654	0.415
Garden +Open	4.000	281.774	2.083	0.353	0.014	-136.681	0.429
Forest +Open	4.000	281.838	2.146	0.342	0.013	-136.713	0.442
Fence Type + Garden	4.000	281.856	2.165	0.339	0.013	-136.722	0.455
Frog Pond	3.000	281.916	2.225	0.329	0.013	-137.836	0.468
Fence Type	3.000	281.935	2.243	0.326	0.013	-137.845	0.481
Bird Feeder	3.000	281.944	2.253	0.324	0.013	-137.850	0.494
Garden + Bird Bath	4.000	281.950	2.258	0.323	0.013	-136.769	0.506
Compost + Forest	4.000	281.961	2.269	0.322	0.013	-136.774	0.519
Water	3.000	281.965	2.273	0.321	0.013	-137.860	0.531
Garden + Water	4.000	281.987	2.296	0.317	0.012	-136.787	0.544
Garden + Bird Feeder	4.000	282.004	2.313	0.315	0.012	-136.796	0.556
Poultry Presence + Forest	4.000	282.022	2.331	0.312	0.012	-136.805	0.568
Bird Bath +Dens	4.000	282.025	2.334	0.311	0.012	-136.807	0.580
Poultry Presence +Dens	4.000	282.270	2.579	0.275	0.011	-136.929	0.591
Hay +Dens	4.000	282.273	2.582	0.275	0.011	-136.930	0.602

Table 8 (Cont.)

HUD + Forest	**4.000**	**282.312**	**2.620**	**0.270**	**0.011**	**-136.950**	**0.612**
Hay + Forest	4.000	282.387	2.696	0.260	0.010	-136.987	0.622
HUD +Hay	4.000	282.436	2.744	0.254	0.010	-137.012	0.632
Frog Pond + Forest	4.000	282.445	2.753	0.252	0.010	-137.016	0.642
Open +Dens	4.000	282.445	2.753	0.252	0.010	-137.016	0.652
HUD + Bird Bath	4.000	282.457	2.766	0.251	0.010	-137.023	0.662
Fence Type + Forest	4.000	282.460	2.769	0.250	0.010	-137.024	0.672
Forest + Water	4.000	282.475	2.784	0.249	0.010	-137.031	0.681
Forest + Bird Feeder	4.000	282.482	2.791	0.248	0.010	-137.035	0.691
Compost +Hay	4.000	282.508	2.817	0.245	0.010	-137.048	0.701
Dens + Bird Feeder	4.000	282.521	2.829	0.243	0.009	-137.054	0.710
Frog Pond +Dens	4.000	282.527	2.835	0.242	0.009	-137.057	0.720
Compost +Open	4.000	282.528	2.837	0.242	0.009	-137.058	0.729
Fence Type +Dens	4.000	282.560	2.868	0.238	0.009	-137.074	0.738
HUD + Compost	4.000	282.582	2.890	0.236	0.009	-137.085	0.747
Dens + Water	4.000	282.598	2.906	0.234	0.009	-137.093	0.757
Compost + Bird Bath	4.000	282.636	2.945	0.229	0.009	-137.112	0.766
HUD +Open	4.000	282.778	3.087	0.214	0.008	-137.183	0.774
Bird Bath + Poultry Presence	4.000	282.857	3.165	0.205	0.008	-137.222	0.782
HUD + Poultry Presence	4.000	282.891	3.200	0.202	0.008	-137.239	0.790
Bird Bath +Hay	4.000	282.899	3.207	0.201	0.008	-137.243	0.798
Compost + Poultry Presence	4.000	282.901	3.209	0.201	0.008	-137.244	0.805
Bird Bath +Open	4.000	283.099	3.407	0.182	0.007	-137.343	0.813
HUD + Frog Pond	4.000	283.104	3.413	0.182	0.007	-137.346	0.820
HUD + Bird Feeder	4.000	283.168	3.477	0.176	0.007	-137.378	0.827
Poultry Presence +Hay	4.000	283.183	3.492	0.175	0.007	-137.385	0.833
Fence Type + Compost	4.000	283.194	3.503	0.174	0.007	-137.391	0.840
Compost + Water	4.000	283.197	3.506	0.173	0.007	-137.392	0.847
HUD + Water	4.000	283.201	3.510	0.173	0.007	-137.394	0.854
Compost + Frog Pond	4.000	283.204	3.512	0.173	0.007	-137.396	0.860
Fence Type + HUD	4.000	283.207	3.515	0.172	0.007	-137.397	0.867
Compost + Bird Feeder	4.000	283.207	3.515	0.172	0.007	-137.397	0.874
Poultry Presence +Open	4.000	283.268	3.577	0.167	0.007	-137.428	0.880
Fence Type + Bird Bath	4.000	283.300	3.609	0.165	0.006	-137.444	0.887
Bird Bath + Frog Pond	4.000	283.325	3.634	0.163	0.006	-137.456	0.893
Bird Bath + Water	4.000	283.384	3.692	0.158	0.006	-137.486	0.899
Bird Bath + Bird Feeder	4.000	283.395	3.703	0.157	0.006	-137.491	0.905
Hay +Open	4.000	283.601	3.910	0.142	0.006	-137.594	0.911
Poultry Presence + Frog Pond	4.000	283.629	3.938	0.140	0.005	-137.608	0.916
Hay + Frog Pond	4.000	283.643	3.951	0.139	0.005	-137.615	0.922

Table 8 (Cont.)

Frog Pond +Open	**4.000**	**283.673**	**3.981**	**0.137**	**0.005**	**-137.630**	**0.927**
Fence Type + Poultry Presence	4.000	283.692	4.000	0.135	0.005	-137.640	0.932
Fence Type +Hay	4.000	283.693	4.001	0.135	0.005	-137.640	0.938
Hay + Bird Feeder	4.000	283.696	4.004	0.135	0.005	-137.642	0.943
Poultry Presence + Bird Feeder	4.000	283.720	4.028	0.133	0.005	-137.654	0.948
Hay + Water	4.000	283.721	4.029	0.133	0.005	-137.654	0.953
Fence Type +Open	4.000	283.726	4.034	0.133	0.005	-137.657	0.959
Poultry Presence + Water	4.000	283.757	4.066	0.131	0.005	-137.673	0.964
Open + Water	4.000	283.777	4.085	0.130	0.005	-137.682	0.969
Open + Bird Feeder	4.000	283.778	4.087	0.130	0.005	-137.683	0.974
Fence Type + Frog Pond	4.000	284.038	4.347	0.114	0.004	-137.813	0.978
Frog Pond + Bird Feeder	4.000	284.052	4.361	0.113	0.004	-137.820	0.983
Fence Type + Bird Feeder	4.000	284.056	4.364	0.113	0.004	-137.822	0.987
Frog Pond + Water	4.000	284.082	4.390	0.111	0.004	-137.835	0.991
Fence Type + Water	4.000	284.098	4.407	0.110	0.004	-137.843	0.996
Water + Bird Feeder	4.000	284.109	4.418	0.110	0.004	-137.848	1.000
Bird Feeder+ Fence Type + Dens + Garden + Poultry Presence + Frog Pond+ Bird Bath + Compost+ HUD+ Hay + Forest +Open+ Water	15.000	302.195	22.504	0.000	0.000	-133.307	1.000

CHAPTER II

PREDATORS IN RESIDENTIAL YARDS: INFLUENCE OF YARD FEATURES ON THE OCCUPANCY OF COYOTES (*CANIS LATRANS), GRAY FOX (UROCYON CINEREOARGENTEUS), AND RED FOX (VULPES VULPES)*

Emily Johansson and Brett A. DeGregorio

ABSTRACT

As conversion of natural areas to human development continues, there is a need to understand how developed areas can support wildlife. While large predators are often extirpated from areas of human development, some medium-bodied mammalian predators have adapted to coexist in human-dominated areas. There is a currently a need to understand how human-created land use such as residential yards can support wildlife as well as how certain yard features may facilitate human-wildlife conflict. Over the summers of 2021 and 2022, we deployed game cameras in 46 and 96 residential yards in Northwest Arkansas USA to understand which yard and landscape features influenced the occupancy and detection rates of the mammalian predators; bobcats (*Lynx rufus*), coyotes (*Canis latrans*), and both gray and red foxes (*Urocyon cineroargenteus* and *Vulpes vulpes*). We found that predator occupancy was marginally influenced by yard level features as opposed to landscape composition. Fences had significant negative effects on the occupancy of coyotes in our study. The total area of potential den sites in a yard also increased the probability of coyote occupancy in a yard. We found that gray fox detection rates were highest in yards with poultry highlighting a likely source of conflict with homeowners. We found that the interspecific interactions between our focal predator species were all modest but positive, indicating that these species likely use yards for similar resources and have ways of minimizing antagonistic interactions with one another in the suburban environment. As the number of residential yards continues to grow across the country, our results suggest that there are ways in which our yards can provide valuable resources to suburban predators and that homeowners also have the agency to mitigate interactions with predators through management of their yard features.

INTRODUCTION

Predators and humans have a long and tumultuous history of struggling to coexist (Fardell et al., 2020). Larger mammalian predators frequently conflict with humans as they are often viewed as competitors for game species or threats to the safety of humans, pets, or livestock (Caro and Fitzgibbon 1992, Woodroffe 2000, Treves and Karanth 2003). Because of these views, mammalian predators often have been extirpated from areas of human development (Rust and Taylor 2016). As large and medium-sized mammalian predators are eliminated from developed areas, their ecological roles in the community are lost or shifted to smaller mesopredators (Atickem et al., 2014; Moll et al. 2018, Gámez & Harris 2021**)**.

The loss of larger mammalian predators can lead to high densities of mesopredators in suburban areas (Prugh et al., 2009, Cove et al., 2012). This shift in the wildlife community can lead to further trophic cascades, altered disease dynamics, and increased human-wildlife conflict (Estes 1996, Beschta and Ripple 2009, Hollings et al., 2013). While there are still situations in which large alpha predators coexist in and around human residential areas (e.g., mountain lions (*Puma concolor*) in Los Angeles, USA), examples are becoming rarer and rarer (Baruch-Mordo, 2014, Lewis et al., 2015, Benson et al., 2016**)**.

However, in contrast to alpha predators, medium-sized mammalian predators such as coyote (*Canis latrans*), bobcat (*Lynx rufus*), and foxes (*Vulpes vulpes* and *Urocyon cinereoargenteus*) are often able to successfully co-existence around human dominated landscapes (Gehrt et al., 2011, Lombardi et al., 2015, Parsons et al. 2019). As human development expands, these species are beginning to occupy spaces further into human dominated areas (Breck et al., 2019**)**. In these human dominated areas, coyotes, bobcat, and fox are often at the top of the food chain and exert predatory pressure on smaller mesopredators, deer, birds, and small mammals (Gompper 2002, Jones et al., 2016, Dyck et al., 2021). The presence of these species in and around human dominated areas often draws extreme public interest in both positive and negative ways (Røskaft et al., 2007, Wilkinson 2023) and feelings can be the most extreme when these predators are seen living in and around where humans reside.

One of the most prevalent human-created landcover types in North America is the suburban yard with yards accounting for approximately 17.4% of the United States and comprising more than 1.74 million km^2 (Mathieu et al., 2007, Giner et al., 2013, Hedblom et al., 2017). Because homeowners use their yards for a variety of purposes, residential yards can be viewed as independently managed greenspaces that can vary widely in the resources that are of potential use to wildlife (Bolger et al., 2001, Gallo et al., 2017, Johansson and DeGregorio In Press). Although most yards are far smaller than the home range of mammalian predators, they are frequently used by these species for foraging, traveling, or denning if the proper resources are present (Girrleman et al., 2001, Noss et al., 2019, Hansen et al., 2020).

Predators found in developed areas are often concentrated in green spaces such as parks and cemeteries (Parsons et al. 2019) but foray into residential areas to take advantage of subsidized resources (Prevedello et al., 2013). Additionally, some predators such as red fox will den and raise young in residential yards (Gosselink et al., 2003, Vuorisalo et al., 2014). Yards may be particularly attractive to predators when they have dense populations of small mammal prey species due to the presence of compost or refuse, bird feeders, pet food, or outdoor pets (Contesse et al., 2004, Timm et al., 2004, Newsome et al., 2014, Soulsburry and White 2015, Hansen et al., 2020). Stomach content studies have shown that the diets of some suburban predators can consist almost entirely of anthropogenic food sources (Contesse et al., 2004, Murray et al., 2015, Newsome et al. 2015, Reshamwala et al., 2018) including domestic pets and poultry (Larson et al., 2015). Multiple studies have found that yards containing compost piles are an attractant to coyotes, red fox, and gray fox species (Murray and St. Claire 2017, Hansen et al., 2020). However, coyotes in urban environments may rely on natural prey items such as eastern cottontails (*Sylvilagus floridanus*) (Morey et al., 2007) but these species may be associated with yard features such as gardens. Though food sources are most likely the top attractant for suburban predators, many yards also offer water sources, which can be important for smaller species that can dehydrate quickly (Harrison 1997). Though one study found that yards with more water sources had a negative association with coyotes (Hansen et al., 2020). Additionally, infrastructure can provide safe and attractive denning opportunities under garages, decks, or outbuildings for both predators and their prey species (Gosselink et al., 2003, Duduś et al., 2014). However, the suburban environment can also be heavily fragmented by fences separating yards which can restrict wildlife access to particular yards. Coyotes and both fox species were shown to be less likely to be present in a yard if there was a fence (Hansen et al., 2020).

However, because yards are typically small, the features present in a yard may not be the only factors that influence where mammalian predators occur, and the composition of the surrounding landscape is almost certainly an important driving factor in where these predators occur. Residential yards situated in largely forested areas or surrounded by more open greenspace may be more likely to have predators present whereas those in high density housing areas or those surrounded primarily by impervious surface (roads, parking lots, buildings) may not, even if the yards provide similar resources (Riley 2006, Roberts 2007, Riley et al., 2010, Kays et al. 2008, Morin et al., 2022).

In the altered mammalian communities occurring around human development in the United States, bobcats, coyotes, red and gray fox are often present and represent the largest carnivores (aside from black bears (*Ursus americanus*) that regularly coexist near people (Gehrt et al., 2009, Bateman and Fleming 2012, Lombardi et al., 2017). Red and gray foxes commonly occur in suburban environments and may even prefer these areas as opposed to more rural areas (Parsons et al., 2019, Hansen et al., 2020). Red foxes benefit by occurring in suburban areas because they can be protected from larger dominant carnivores such as coyotes and bobcats (Moll et al. 2018) a phenomenon referred to as the "human shield" effect (Berger 2007). Though coyotes are more cautious of residing in human dominated areas than red fox, they can also be regularly present throughout suburban and urban areas (Gehrt et al., 2011, Gil-Fernández et al., 2020). In fact, coyotes are becoming bolder and more exploratory of highly developed areas which may have ramifications for species such as the red fox (Farias et al., 2012, Breck et al. 2019). Gray foxes are not nearly as common across developed areas; however, they often select denning sites near suburban development (Farias et al., 2012; Herr et al. 2008, Shannon et al. 2014, Moll et al., 2018, Sarkar and Bhadra 2022). Bobcats can occur in developed areas although they often require large tracts of nearby greenspace to persist (Riley 2006, Roberts 2007, Riley et al., 2010). When a portion of their home range overlaps with development, they rely on corridors to navigate through the fragmented land (Riley 1999) to forage and will return to more rural environments for resting (Tigas et al., 2002, Lowry et al., 2012). It is unclear if and how bobcats use specific yard features, (Hansen et al., 2020).

Despite these species being able to co-occur with humans they still have resource requirements that they must satisfy. The distribution of these resources throughout suburban environments likely influences where they will occur and spend their time. Understanding these relationships can help us better understand how to conserve these species in human-dominated environments as well as assist managers in predicting practices likely to result in conflict between these species and humans and or our pets.

Our objectives were to use motion-triggered wildlife cameras to identify how yard features and surrounding landscape composition influenced predator occupancy and detection rate in residential yards in a rapidly developing suburban area. We predicted that predator occupancy would vary based on both yard and landscape features. Specifically, we predicted that yard features associated with supplemental food and water such as compost piles, bird feeders, and poultry and garden ponds would be most associated with predator occupancy and detection rates. Furthermore, we predicted that fences would decrease occupancy and detection rates of all four species. We also predicted that both fox species would be less likely to occur in yards with coyote or bobcat presence (Egan et al., 2020). We did not expect that the presence of one fox species would influence the occupancy of the other (Morin et al., 2022). Finally, we also predicted that as forest cover increased and housing unit density decreased, both bobcat and coyote occupancy probability and detection rate would increase (Riley 2006, Roberts 2007, Riley et al., 2010, Kays et al. 2008) while the opposite would be true for gray and red fox which would be most associated with developed open space (lawns, cemeteries, parks, golf courses etc.) (Moll et al., 2018).

Study Area

We set our study in the northwest region of Arkansas, USA, which is a rapidly developing area with a population of approximately 350,000 people. We set our sites within an 80.5 km radius of downtown Fayetteville, Arkansas USA from April 4th to August 4th in 2021 and 2022. This. Our study sites were all within the Ozark Highlands Ecoregion which is primarily forested intermixed with open areas and some pasture lands used for cattle and agriculture. Our study sites encompassed residential yards in and near the centers of Fayetteville, Springdale, Rogers, Eureka Springs, and Bella Vista to more undeveloped areas up to 32 km from city centers. Residential yards were volunteered by owners from the Arkansas Master Naturalist Program and University of Arkansas Department of Biological sciences. Yards represent a continuum of urban to rural and contain a range of yard features that we thought would influence predator occupancy.

METHODS

Camera deployment

We deployed motion-triggered wildlife cameras (Browning StrikeForce or Spypoint ForceDark) in residential yards in 2021 and 2022. We deployed cameras approximately 0.95 m above the ground on either a tripod or strapped to a tree. We placed cameras at least 5 m away from and no more than 100 m from a house. We positioned cameras to maximize wildlife detections, when possible, near features such as compost piles, water sources (natural or maintained), and fence lines or game paths. We coordinated with homeowners to choose locations that would allow them to maintain their privacy and that also would not interfere with yard maintenance. If vegetation grew to impede the view of the camera, we would remove it. We to take bursts of 3 photos per trigger with a 5 s reset time when triggered. We did not use any bait or lures at camera sites. We checked and downloaded cameras every 2 weeks for failure, battery life, and to download data. We moved cameras within yards up to 3 times within the season to ensure we captured the full range of wildlife present in each yard.

We surveyed each yard for features that we predicted would influence predator occupancy (Table 1). We first recorded variables representing possible food sources, including the presence and number of bird feeders (both seed/suet and nectar), the volume of brush and firewood piles, area of compost piles, and the presence or absence of poultry. We reasoned that bird feeders could provide direct food to some of our focal species and could also serve as an attractant to prey species such as mice, rats, and birds (Saad et al., 2020). We considered the volume of firewood and brush piles as a food source because they could similarly be associated with high numbers of prey species (Goguen et al., 2015).

We also recorded the area of potential denning sites in a yard. Denning sites included the total available area under sheds and outbuildings as well as decking that was less than 0.3 m off the ground (Linduska 1947, Moll et al. 2018). We counted the number of supplemental water sources present in a yard which included bird baths to garden ponds and fountains that were actively maintained by the homeowner.

If a camera was deployed in an area in which it was surrounded by a fence, we scored the type of fence based on its permeability to wildlife (both our focal species and other species that may be an attractant to coyote, bobcat, or fox). We scored each yard with a binary score of 0 or1. Yards without fences or with fences that presented minimal resistance to the movement of our focal species or other wildlife (barbed wire or those made of semi spaced slats 1 m tall that allowed for smaller bodied species to pass through and most larger species to jump over) were given a 0. Fences that were at least 1 m in height and didn't allow for passage through or under (i.e., privacy or chain-link) or fences that were 1.8 m or taller and were made of a solid material that likely prevented the passage of most wildlife, with the exception of capable climbers, were given a 1.

Landscape and environmental covariates

To acquire landscape level covariates to explain predator occupancy and detection rate, we calculated the area of several landcover types surrounding each focal yard. First, we imported all camera location points to GIS (ArcGIS Pro 10.2; ESRI, Inc. Redlands Inc) and created 1.5 km buffers around each camera (Šálek et al., 2015). Within each buffer we then calculated the area of forest cover, developed open land (e.g., cemeteries, parks, and grass lawns), and agricultural land using the 2019 National Land Cover Database (Dewitz 2021). We used two different development categories for analyses because we predicted that wildlife might respond differently to development of varying intensities. We used low intensity development which was represented by areas containing 20-49% of impervious surface. We then grouped the NLCD categories of medium and high intensity development (which we refer to as high intensity development) that contains areas with over 49% impervious surface. We also quantified the maximum housing unit density (HUD) around each camera using the SILVIS Housing Data Layer (Hammer et al., 2004).

We also compiled a number of environmental covariates that we predicted would influence the activity of our four focal species. Both rainfall and temperature can influence how active our species were and therefore would affect our detection probability (Madsen et al., 2020). To gather environmental variables, we used publicly available data from a NOAA weather station located at the Fayetteville Experimental Station. This weather station was 75 km from the furthest yard studied. We used this data to calculate the average weekly air temperature and average weekly precipitation for each camera site.

Photo processing

We used timelapse 2.0 (Greenberg et al. 2019) to review photographs, extract metadata (date and time of each wildlife detection) and to assign identities to all species detected. Detections were grouped into 5-minute intervals to reduce double counting of individuals (Forrester et al., 2016). Within that 5-minute period, we identified all species, and the number of individuals present in that series of photographs.

Predator occupancy

To explore the effects of covariates on the detection and occupancy of our four focal predator species (bobcats, coyotes, red and gray foxes), we used a single-season multi-species occupancy model (MacKenzie et al. 2002). These models were used to estimate the probability of predator occurrence in yards and to explore the influence of covariates on occupancy probability while accounting for imperfect detection and to explore how different covariates influenced detection probability (MacKenzie et al., 2004). We chose multispecies models to account for interspecific interactions between our focal species. Multispecies occupancy allows us to simultaneously model environmental covariates, while letting the occupancy of one species vary based on the presence of another. We used one-week sampling periods across the seasons. We assigned a 1 or a 0 if the focal species was detected at least once (1) or not detected (0) during each survey period for each sampling site. We used a one-week sampling period as this represented an appropriate amount of time as to not over or under compress statistical power and is consistent with numerous occupancy analyses conducted on game-camera data (Trolle and Kery 2003, Lie et al., 2018, MacDougall and Sander 2022). During the summer of 2022 we resampled 41 of our study sites from 2021. For these sites, we created year-site combinations and treated them as independent sites (Devenish-Nelson and Nelson 2021, Murray et al., 2021). We used year as an occupancy covariate (Linden and Roloff 2013) to explore if patterns differed between the two years of the study. Not all cameras in yards were actively functioning for the duration of the entire season due to camera malfunctions or staggered deployment and pickup dates, to correct for this we censored weeks in which the camera was not operating continuously for all 7 days. We censored these camera weeks by assigning a ‘NA’ value as opposed to a 0 or a 1.

Before model fitting, we assessed collinearity of covariates and considered any two covariates to be collinear if they had correlation coefficients ≥ |0.6|. For detection covariates, we found that temperature was correlated with both precipitation (r = -0.61) and week of survey (r = 0.72) and was therefore subsequently removed. When assessing occupancy covariates, high intensity development was correlated with area of low intensity development (r = 0.75) as well as forested area (r= -0.74). Area of low development was also found to be correlated with forested areas (r = 0.73). Both development levels were subsequently removed from analyses. We scaled and centered all landscape covariates on their means to facilitate comparison between variables measured on different scales (Schielzeth 2010).

To avoid model over-fitting, we used a multi-stage fitting approach (Fuller et al., 2016) to select for the best detection covariate. We modeled all two way and single models of week of season and precipitation as covariates for detection against null occupancy parameters and selected the top covariate model using Akaike’s Information Criterion (AIC). The covariate(s) in the top model were then used as the detection covariates in all subsequent analyses of occupancy probability.

For occupancy covariates, we included area of compost pile, supplemental water sources, poultry presence, number of bird feeders, fence type, as well as area of denning sites, firewood piles, and brush piles (Table 1). We also included 4 landscape level occupancy covariates including area of open development, agriculture, forest, and HUD.

Our candidate model set included all possible two-way additive combinations of occupancy covariates with our top identified detection covariate(s). All model fitting was performed in R (R Core Team 2022) with the unmarked package (Fiske and Chandler 2011). To improve clarity in presenting model selection tables, we only display models that were competitive within 2 ΔAICc. Since there was model uncertainty, we averaged all the models estimates to generate an average of unconditional occupancy estimates (Cade 2015).

Predator detection rate

In addition to predator occupancy, we also examined how yard and landcover covariates influenced the detection rate of each focal predator species. We defined detection rate as the number of focal species detections at each site divided by the total number of trap nights at that site. While this metric often correlates with true abundance (Campbell et al., 2015), it is more often used as an index of intensity of use within an area and thus could be a good complement to occupancy (Martin et al., 2010). To evaluate which landcover and yard variables most influenced the detection rate of our predator species in each yard we used a Generalized Linear Model (GLM) analysis. We used separate GLM analyses for each species to explore how landscape and yard features affected how frequently a predator was detected in a yard. For each analysis we used an iterative approach to evaluate the same models used for assessing occupancy covariates. The candidate model set for each analysis consisted of simple one-way variable models and all additive two-way combinations as well as a global and a null model.

For each analysis, we ranked candidate models using an information theoretic approach with Akaike's Information Criterion (AIC). When appropriate, we derived parameter estimates for candidate models by model averaging all models within 2 ΔAICc (Burhnham and Anderson 2002) in R (R Core Team 2022) with the AICcmodavg package (Mazerolle MJ (2020).

To improve clarity in presenting model selection tables, we only display models that were competitive within 2 ΔAIC for each analysis. Initial exploratory analyses indicated that relationships between predictor variables and response variables were linear and thus models were not corrected. Model goodness-of-fit was assessed using residual plots.

RESULTS

Over the course of two seasons, we surveyed 138 sites in yards across Northwest Arkansas. During the 2021 season we deployed cameras in 46 sites between 1 May and 10 Aug and surveyed these sites for up to 15 weeks (avg= 14 $\pm$1.5 sd). In 2022, we deployed cameras at 92 sites between 1 May and 10 Aug and surveyed these sites for up to 15 weeks (avg= 14 $\pm$2.5 sd). Cumulatively, we conducted 1456 surveys for a total of 10,192 trap nights and accumulated 1,526 focal predator detections (32 bobcat, 507 coyote, 157 gray fox, and 830 red fox). We detected at least one predator (coyote, gray fox, or red fox) in 74% of our surveyed residential yards. Two species were at 25 of our sites, while only 6 had three species present.

Overall, bobcats were only recorded at 0.05 sites and only during 12 surveys, due to this low naïve occupancy rate which caused model convergence issues, we removed this species from subsequent analyses. Coyotes were detected at 51% of sites in 191 of our survey periods, gray fox at 14% of sites in 52 surveys, and red fox at 40% of sites during 160 surveys. The occupancy probability ($\psi)$ for at least one predator in a yard was 0.74 (95% CI: 0.66-0.80). The ψ of coyotes was 0.54 (95% CI: 0.43-0.63), ψ of gray fox 0.14 (95% CI: 0.09-0.26), and ψ of red fox was 0.41 (95% CI: 0.31-0.53). The detection probability ($p_{i)}$ was similar between the three species with p_i of coyotes averaging 0.18, p_i of gray fox averaging 0.19, and p_i of red fox averaging 0.20.

Detection covariates

Preliminary modeling for detection covariates suggested that the best predictors for predator detection at a site was the interactive effect between week and average precipitation and this model accounted for 63% of the weight of evidence (Table 2). Coyotes and red fox were less likely to be detected later in the summer and coyotes and gray fox were more likely during rainy weeks. Therefore, we used week and average precipitation as the p_i covariates for all analyses of ψ.

Occupancy covariates

The 3 models that fell within 2 △AICc units of one another all assumed pairwise dependence between species. These top models accounted for 36% of the weight of evidence (Table 3). Two of the top models included fence type, one of which was interactive with compost piles. The other model that received some weight of evidence was the area of den sites (Table 3). These models suggest that the ψ of coyotes was negatively associated with fence type (β = -0.92, 95% CI =-0.93, -0.07) as well as marginally associated with increased denning area (β = 0.01, 95% CI =0.00, 0.01) (Figure 1). These models also suggest that our other species had no significant effects from our occupancy covariates (Table 4).

We found that Ψ of all our study species increased in a yard if another species was present (Table 5). This relationship was strongest for coyote given that a red fox was present, with gray fox having the weakest influence from coyote presence.

Detection rate

We found little evidence for the effects of covariates influencing the detection rate of coyote or red fox in a yard and the null model was the top ranked model for both species. We found 2 top models for gray fox detection rate within 2 $\triangle$AICc that accounted for 42% of the weight of evidence (Table 6). Both top models included poultry presence (Table 6). These models suggest that gray foxes had a higher detection rate in yards with a chicken coop (β = 0.06, 95% CI: 0.03 – 0.1) (Figure 2).

DISCUSSION

Despite the challenges that are set forth by an ever-urbanizing environment, predators can still persist in human dominated landscapes and are able to persist in these with surprising regularity. Our study found that at least one predator (coyote, gray fox, or red fox) was detected in 74% of our surveyed residential yards, and that there was a 74% chance of occupancy of a predator in each yard during any given 7-day survey. We found that yard features had both positive and negative roles in the occurrence of predators in yards in Northwest Arkansas, although these effects were modest.

The detection rate of all three species was relatively high throughout our study and both precipitation and week of season influenced detection probability of most species. Though we found no significant effect of rain fall on red fox other studies have shown that precipitation influences red fox behavior, and that they are more likely to be active right before rainfall and would seek shelter during (Ables et al., 1967). We did find that coyotes and gray fox increased activity with rainfall (Richmond 1952, Windberg et al., 1997), this is likely due to small mammals and amphibians increasing activity during this time as well (Stokes et al., 2001). Detection probability of coyotes decreased throughout the summer, similar to trends reported in other studies (Madsen et al., 2020). Red fox detection probability may be highest in the early summer because adults are still taking care of kits and may have elevated activity rates (Storm et al., 1976). Gray fox breed later and juveniles leave the den later than red fox and thus it was surprising that there was no significant effect of week on detection probability (Duele et al., 2017).

We found that coyotes, the largest predator in this study, were detected in the most yards (51%). This is unsurprising as many studies show coyotes becoming more exploratory of suburban habitats and able to persist in numerous urban and suburban settings (Gehrt et al., 2011, Miranda et al., 2013, Breck et al., 2019**)**. Though larger species often face public persecution, coyotes continue to persist in suburban areas despite fear of them or negative public perception (Bonnell and Breck 2016). Unexpectedly, we found that coyote occupancy increased in yards as area of potential denning sites increased. We found this result surprising because we are unaware of studies showing them denning in residential yards in the suburban environment. We also found that coyotes were less likely to occur in those with fences. It is not surprising that yards with large and impermeable fences had the lowest chances of being occupied by coyotes. This result is comparable to that of other studies that show fences to be a deterrent to larger species of wildlife that cannot climb well (Hansen et al., 2020). This is a positive outcome for homeowners unwilling share their space with large predators that they may perceive as threats to domestic pets or agricultural animals (Baker and Timm 1998). However, in some areas of the United States, 86% percent of suburban lawns are fenced which creates major fragmentation and limits accessibility to much of the area that could have been usable habitat (Ossola et al., 2019, Van Helden et al., 2020). This could become detrimental to predators such as coyote that exist in suburban areas and cannot climb or burrow under fences (Jakes et al., 2010).

Given their long history of residing in and around humans, it was unsurprising that red foxes were also frequently detected in residential yards. We detected red fox at 40% of residential yards. Red foxes are commonly associated with urban and suburban areas, and it has been suggested that by residing in developed areas red fox benefit by reducing spatial or temporal overlap with more dominant predators such as coyotes and bobcats (Moll et al., 2018). Our results did not find evidence of a spatial partitioning of yards by red fox and coyotes, thus red fox may be reducing contact with coyotes in this environment by changing their activity patterns instead (Moll et al., 2018). It is unsurprising that red foxes were not affected by the presence of a fence around the yard. Studies have shown that red foxes are very capable of climbing over or digging under fences (West et al., 2007, Robley et al., 2007). We expected that red fox occupancy would be associated with den sites because this species has frequently been documented denning in residential yards (Gosselink et al., 2003, Vuorisalo et al., 2014) including observations of fox denning under garden sheds during this study. Not only do red fox frequently den in residential yards but they prey on smaller species that are likely attracted to denning sites such as groundhog (*Marmota monax*), eastern cottontails (*Sylvilagus floridanus*) etc. (Linduska 1947, Goguen et al., 2015, Moll et al. 2018).

Gray foxes were our least detected species found in only 14% of sites, which is unsurprising given that they do not typically utilize human dominated areas but rather occur on the outskirts of development (Farias et al., 2012). It is surprising that gray foxes were not significantly influenced by any yard or landscape features at or surrounding a camera site. Though it is possible that our sample size was too small to highlight effects.

Coyotes are the largest predator in our system and have been documented killing both red and gray fox (Fedriani et al., 2000) and thus we predicted that red fox and gray fox should avoid yards with coyote (Egan et al., 2020). However, we found no avoidance of coyote by either species, in fact both saw positive associations. Perhaps abundance of prey limits hostile interactions between these species (Gese et al., 1996). This could also suggest that there could be temporal niche partitioning occurring and although these species overlap in space, they do not overlap in time (Gosselink et al., 2003). These positive associations between species may be because the three predator species overlap in diet and resource needs and thus are attracted to similar yards (Larson et al., 2015). Given that our survey period was 7-days in length this limits our ability to fully identify if the species are co-occurring in a yard relatively simultaneously or days a part. Other studies would suggest that though these species may overlap in territory (i.e., a yard) and activity periods, they tend not to use the same area at the same time (Mueller et al., 2018).

Contrary to our predictions, food resources provided by homeowners were not included in top models influencing occupancy of any of the three predator species. Many predators found in suburban areas can supplement the majority of their diet with anthropogenic food sources (Bateman and Flemming 2012, Murray et al., 2015, Hansen et al., 2020). Studies have found that wildlife, particularly coyotes are attracted to compost and refuse (Murray et al., 2016, Hansen et al., 2020). Coyote and red fox have also been found to be attracted to yards with bird feeders due to an increase in rodents and small mammals that forage on fallen seed (Saad et al., 2020). It is also surprising that water sources were not present in top models, as all species have been found to utilize anthropogenic water sources especially gray fox (Harrison 1997, Ochoa et al., 2021).

We had expected that landscape composition and housing unit density would have a large influence on predator occupancy in suburban areas and instead found no evidence for this contrary to other studies that have shown correlations between predator occupancy and landscape composition (Garden et al., 2010, Villaseñor et al., 2014). Other studies have found that coyotes and red foxes do seem to have some variability in how much they rely on landscape and can choose suburban resources over landscape composition (Gehrt et al. 2011). Since our study area is largely forested overall, there was modest landscape composition variation between sites and future studies should explore the occupancy of suburban predators in a more heterogeneous landscape (Ossola et al., 2019).

The species studied here have large home ranges in suburban areas (often > 5 km^2) (Gittleman et al., 2001, Šálek et al., 2015, Noss et al., 2019), and because of this they certainly visit numerous yards per night. We included detection rate as we predicted that this would be a more nuanced look at the use of yards than occupancy analysis (which relied on a 7-day survey period). High detection rates in particular yards could be indicative of species seeking out particular resources. However, we found that neither coyote nor red fox detection rate varied based on any of our measured variables. This suggests that these species are generally spread across urban landscapes and come and go through yards regardless of any features or landscape type, which correlates well with other findings (Gehrt et al., 2011, Moll et al. 2018, Parsons et al., 2019, Hansen et al., 2020, Gil-Fernández et al., 2020). Our finding that detection rates of gray fox were highest in yards with chicken coops contrasts with other studies that did not find an association (Kays and Persons 2014, Hansen et al., 2020). All three of our focal predators are likely predators of domestic poultry.

As the number of residential yards continues to grow across the country, there is a need to understand how yards can support our wildlife but also to mitigate negative human-wildlife interactions (Bolger et al., 2001, Hansen et al., 2020). The understanding of how and why homeowners maintain their yards in the way that they do could become important in creating suitable environments for predators in suburban areas.

Management implications

Our results suggest that predators can be detected in most residential yards in the greater Fayetteville area this result likely applies to other similar suburban areas. We found that predator occupancy of residential yards was influenced by yard level features as opposed to surrounding landscape composition. This means that homeowners do have some agency to attract or deter predators from their yards primarily through the use of fences to deter coyote and maybe other predators. This may be especially important to homeowners that have domestic poultry that can attract species such as what we found for gray fox. Conversely, we found some modest evidence that homeowners that want to attract wildlife to their yard are able to best do it through the creation or maintenance of denning sites. These sites may be directly used by predators themselves such as red fox or merely attract prey species of interest to suburban predators. As residential lawns become a more prominent cover type across the United States, managers could benefit from understanding how these lawns provide resources that benefit predators and other wildlife surviving in suburban settings and also how yard features can create hot spots of conflict with these species of wildlife.

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TABLES

Table 1. Covariates predicted to influence the detection, occupancy, or detection rate of Coyotes (*Canis latrans*), Gray Fox (*Urocyon cinereoargenteus*), and Red Fox (*Vulpes vulpes*) in residential yards within 80km of downtown Fayetteville, Arkansas USA during the summers of 2021 and 2022.

Landscape Covariates	
Forest Cover	Area of forest cover within 1.5 km buffer
Open Developed Land	Area of open developed land, (parks, cemeteries, and lawns) within 1.5 km buffer
Agricultural Land	Area of land used for agricultural purposes within 1.5 km buffer
Housing Unit Density (HUD)	Maximum Housing Unit Density within 1.5 km buffer of camera (houses/km^2)
Developed Land (High + Medium Intensity)	Area of land that with greater than 49% impervious surface within 1.5 km buffer
Developed Land (Low Intensity)	Area of land that contains between 20-49% impervious surface within 1.5 km buffer
Environmental Covariates	
Average Temperature	Average temperature over a 7-day period
Average Precipitation	Average precipitation over a 7-day survey period
Yard Feature Covariates	
Volume of Denning Sites	Volume under sheds/outbuildings and under decks less than 1m off the ground.
Volume of Brush Piles	Volume of brush piles
Volume of Firewood	Volume of firewood piles
Supplemental Water Source	Number of human-maintained water sources
Compost Pile	Area of compost pile
Fence Type	If a camera was within a fence, it was given a score of either 0-1, 0 being a fence that is permeable to most wildlife and 1 being the most impassable.
Poultry Presence	Presence or absence of poultry being kept in yard
Bird Feeders	Number of bird feeders at a camera site, including seed feeders, suet, hummingbird feeders, and dried fruit.
Year	Year that the yard was surveyed

Table 2. Model selection statistics for detection covariates of coyotes (*Canis latrans*), gray fox (*Urocyon cinereoargenteus*), and red fox (*Vulpes vulpes*) based on a 2 year study done in 2021 and 2022 in northwest Arkansas, USA. Covariates of detection included week of survey and average weekly precipitation. Models were ranked using Akaike's Information Criterion (AIC) and included with each model is the number of parameters (K), AIC difference between model of interest and model with lowest AIC (ΔAIC), model weight (AICwt) and log-likelihood estimate (LL).

Model	**K**	**AICc**	**ΔAICc**	**AICcWt**	**LL**
Ψ(**.**), p(**Week * Rain**)	15	2492.04	0.00	0.63	-1229.07
Ψ(**.**), p(**Week**)	12	2493.30	1.26	0.34	-1233.41

Table 3. Model selection statistics for detection (p_i) and occupancy probability (ψ) of coyotes (*Canis latrans*), gray fox (*Urocyon cinereoargenteus*), and red fox (*Vulpes vulpes*) based on a 2 year study done in 2021 and 2022 in northwest Arkansas, USA.Only top candidate models, models within 2 ΔAIC, are presented. Covariates of occupancy included surrounding landscape and yard features and the interaction of average precipitation and week of survey were set at the covariates of detection. Models were ranked using Akaike's Information Criterion (AIC) and included with each model is the number of parameters (K), AIC difference between model of interest and model with lowest AIC (ΔAIC), model weight (AICwt) and log-likelihood estimate (LL).

Model	**K**	**AICc**	**ΔAICc**	**AICcWt**	**LL**
Ψ(Fence), p(Precipitation * Week)	18	0.00	0.00	0.17	-1225.85
Ψ(Fence * Compost), p(Precipitation * Week)	18	1.12	1.12	0.10	-1226.41
Ψ(Den Site), p(Precipitation * Week)	18	1.35	1.35	0.09	-1226.53

Table 4. Top three models with beta values showing influence of different site covariates affecting occupancy (ψ) and detectability (p) of coyotes (*Canis latrans*), gray fox (*Urocyon cinereoargenteus*), and red fox (*Vulpes vulpes*) based on a 2 year study done in 2021 and 2022 in northwest Arkansas, USA.

Species	Model	ψ(Fence)	ψ(Compost)	ψ(Den Site)	*p*(Rain)	*p*(Week)
Coyote	Ψ(Fence), *p*(Rain * Week)	-0.92 (95% CI = -0.93,-0.07)	-	-	0.43 (95% CI= 0.05, 0.82)	-0.05 (95% CI=-0.09, -0.01)
	Ψ(Fence * Compost), *p*(Rain * Week)	-0.50 (95% CI= -0.93, -0.07)	-0.08 (95% CI= -0.37, 0.21)	-	0.43 (95% CI= 0.05, 0.82)	-0.05 (95% CI= -0.09, -0.01)
	Ψ(Den Site), p(Rain * Week)	-	-	0.01 (0.00,0.01)	0.44 (95% CI= 0.05, 0.81)	-0.05 (95% CI=-0.09, -0.01)
Gray Fox	Ψ(Fence), *p*(Rain * Week)	-0.20 (95% CI= -0.82, 0.42)	-	-	0.83 (95% CI= 0.03, 1.61)	-0.05 (95% CI= -0.12, 0.02)
	Ψ(Fence * Compost), *p*(Rain * Week)	-0.18 (95% CI= -0.80, 0.43)	0.15 (95% CI= -0.15, 0.47)	-	0.82 (95% CI= 0.03, 1.61)	-0.05 (95% CI= -0.12,0.02)
	Ψ(Den Site), *p*(Rain * Week)	-	-	-0.01 (-0.03, 0.01)	0.82 (95% CI= 0.03, 1.61)	-0.05 (95% CI= -0.12, 0.02)
Red Fox	Ψ(Fence), *p*(Rain * Week)	-0.07 (95% CI= -0.31, 0.45)	-	-	0.06 (95% CI= -0.39,0.51)	-0.05 (95% CI= -0.09, -0.01)
	Ψ(Fence * Compost), *p*(Rain * Week)	-0.06 (95% CI= -0.32, 0.45)	-0.35 (95% CI= -0.79, 0.08)	-	0.06 (95% CI= -0.39,0.50)	-0.05 (95% CI= -0.09, -0.01)
	Ψ(Den Site), *p*(Rain * Week)	-	-	0.00 (-0.00,0.00)	0.06 (95% CI= -0.39,0.50)	-0.05 (95% CI= -0.09, -0.01)

Table 5. Conditional ψ values showing influence of interspecific interactions of coyotes (*Canis latrans*), gray fox (*Urocyon cinereoargenteus*), and red fox (*Vulpes vulpes*) based on a 2 year occupancy study done in 2021 and 2022 in northwest Arkansas, USA. ψ of species A given that species B occupies a site (A: B).

Species Interaction	**Conditional Occupancy**
Coyote: Gray Fox	0.55
Coyote: Red Fox	0.58
Gray Fox: Coyote	0.15
Gray Fox: Red Fox	0.17
Red Fox: Coyote	0.45
Red Fox: Gray Fox	0.50

Table 6. Model selection statistics for detection of gray fox (*Urocyon cinereoargenteus*) based on a 2 year study done in 2021 and 2022 in northwest Arkansas, USA. Only top candidate models, models within 2 ΔAIC, are presented. Covariates of occupancy included surrounding landscape and yard features and the interaction of average precipitation and week of survey were set at the covariates of detection. Models were ranked using Akaike's Information Criterion (AIC) and included with each model is the number of parameters (K), AIC difference between model of interest and model with lowest AIC (ΔAICc), model weight (AICwt) and log-likelihood estimate (LL).

Models	**K**	**AICc**	**ΔAICc**	**AICcWt**	**LL**
Poultry Presence + Forest	4.00	-445.66	0.00	0.27	226.98
Poultry Presence	3.00	-444.44	1.22	0.15	225.31

FIGURES

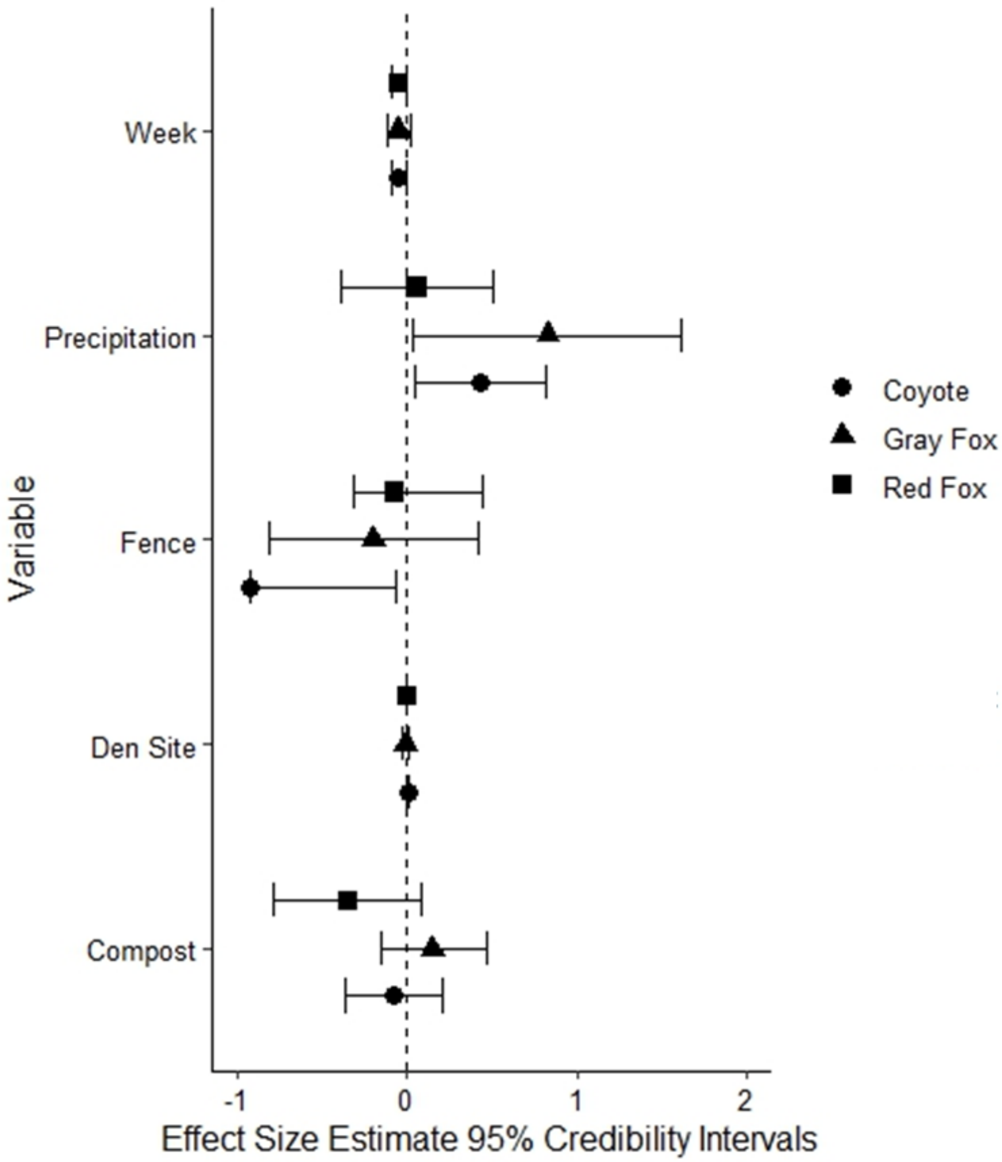

Figure 1. 95% credibility intervals for covariates from our top a priori models evaluating detection and occupancy probability of coyotes (*Canis latrans*), gray fox (*Urocyon cinereoargenteus*), and red fox (*Vulpes vulpes*) based on a 2 year occupancy study done in 2021 and 2022 in northwest Arkansas, USA.

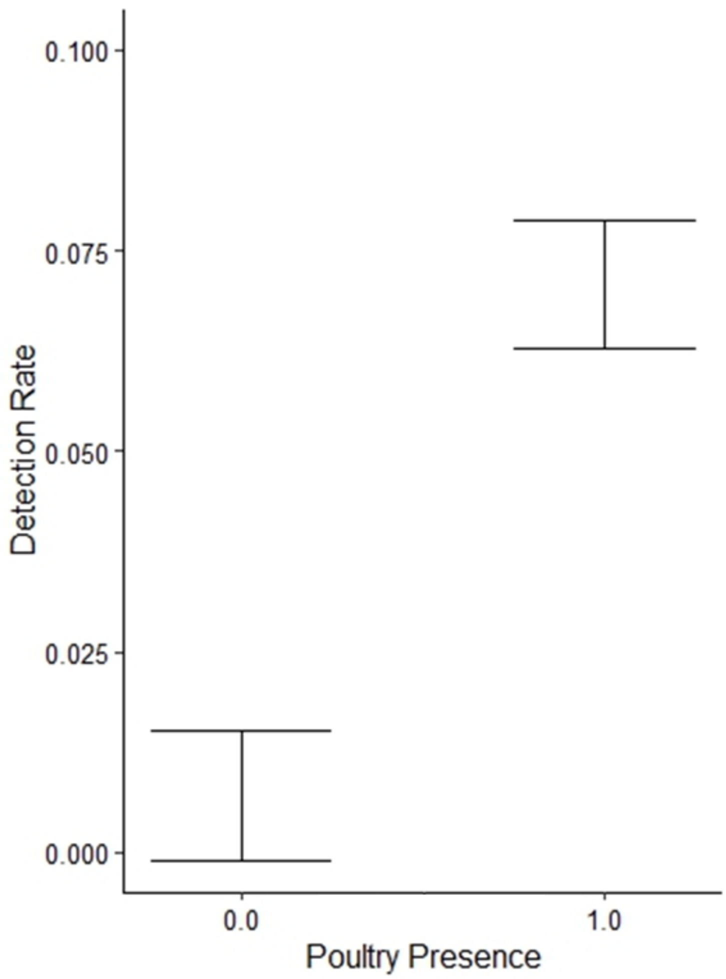

Figure 2. Influence of poultry presence on detection rates of gray fox (*Urocyon cinereoargenteus*) based on a 2 year occupancy study done in 2021 and 2022 in northwest Arkansas, USA.

SUPPLEMENTAL INFORMATION

Table 6. Model selection statistics for detection and ψ of Coyotes (*Canis latrans*), Gray Fox (*Urocyon cinereoargenteus*), and Red Fox (*Vulpes vulpes*) based on a 2 year study done in 2021 and 2022 in northwest Arkansas, USA. Covariates of occupancy included surrounding landscape and backyard variables and the interaction of average precipitation and week of survey were set at the covariates of detection. Models were ranked using Akaike's Information Criterion (AIC) and included with each model is the number of parameters (K), AIC difference between model of interest and model with lowest AIC (ΔAIC), model weight (AICwt) and log-likelihood estimate (LL).

Models	**K**	**AICc**	**ΔAICc**	**ModelLik**	**AICcWt**	**LL**	**Cum.Wt**
Fence	18.00	2492.70	0.00	1.00	0.18	-1225.50	0.18
Fence + Compost	21.00	2494.45	1.74	0.42	0.08	-1222.28	0.26
Den Site	18.00	2494.52	1.82	0.40	0.07	-1226.41	0.33
Fence + Open	21.00	2494.71	2.00	0.37	0.07	-1222.41	0.39
HUD + Open	18.00	2494.75	2.05	0.36	0.06	-1226.53	0.46
Den Site + Compost	18.00	2495.20	2.50	0.29	0.05	-1226.75	0.51
Firewood	18.00	2495.21	2.51	0.29	0.05	-1226.76	0.56
Fence + Den Site	21.00	2495.69	2.99	0.22	0.04	-1222.90	0.60
~1	9.00	2495.93	3.22	0.20	0.04	-1238.27	0.68
Fence + Firewood	21.00	2496.20	3.49	0.17	0.03	-1223.15	0.71
Bird Feeder	18.00	2497.25	4.55	0.10	0.02	-1227.78	0.73
Brush Pile	18.00	2497.36	4.66	0.10	0.02	-1227.83	0.74
Forest	18.00	2497.82	5.12	0.08	0.01	-1228.06	0.76
Agricultural + Water Source	18.00	2497.96	5.25	0.07	0.01	-1228.13	0.77
Brush Pile + Open	21.00	2498.06	5.35	0.07	0.01	-1224.08	0.78
Forest + Open	21.00	2498.09	5.39	0.07	0.01	-1224.10	0.79
Forest + Compost	21.00	2498.12	5.42	0.07	0.01	-1224.11	0.81
Den Site + Open	21.00	2498.76	6.06	0.05	0.01	-1224.43	0.83
Fence + Bird Feeder	21.00	2498.78	6.07	0.05	0.01	-1224.44	0.84
Fence + Water Source	21.00	2498.87	6.17	0.05	0.01	-1224.49	0.85
Fence + Brush Pile	21.00	2498.91	6.21	0.04	0.01	-1224.51	0.86
Open + Agricultural	18.00	2499.18	6.47	0.04	0.01	-1228.74	0.87
Firewood + Den Site	21.00	2499.27	6.57	0.04	0.01	-1224.69	0.88

Table 6 (Cont.)

Compost + HUD	**18.00**	**2499.33**	**6.63**	**0.04**	**0.01**	**-1228.82**	**0.89**
Brush Pile + Compost	21.00	2499.37	6.66	0.04	0.01	-1224.73	0.89
Fence + Forest	21.00	2499.57	6.86	0.03	0.01	-1224.83	0.90
Poultry Presence	18.00	2499.83	7.13	0.03	0.01	-1229.07	0.91
Open + Bird Feeder	21.00	2500.02	7.32	0.03	0.00	-1225.06	0.91
Fence + Agricultural	21.00	2500.22	7.51	0.02	0.00	-1225.16	0.92
Den Site + Bird Feeder	21.00	2500.35	7.65	0.02	0.00	-1225.23	0.92
Brush Pile + Den Site	21.00	2500.36	7.66	0.02	0.00	-1225.23	0.93
Fence + HUD	21.00	2500.40	7.69	0.02	0.00	-1225.25	0.93
HUD + HUD	21.00	2500.47	7.77	0.02	0.00	-1225.29	0.93
Compost + Bird Feeder	21.00	2500.66	7.95	0.02	0.00	-1225.38	0.94
Firewood + Bird Feeder	21.00	2500.82	8.12	0.02	0.00	-1225.46	0.94
Firewood + Open	21.00	2500.82	8.12	0.02	0.00	-1225.46	0.94
Forest + Den Site	21.00	2500.89	8.19	0.02	0.00	-1225.50	0.95
Den Site + Den Site	21.00	2501.15	8.44	0.01	0.00	-1225.62	0.95
Brush Pile + Firewood	21.00	2501.20	8.50	0.01	0.00	-1225.65	0.95
Forest + Water Source	21.00	2501.21	8.50	0.01	0.00	-1225.65	0.96
HUD + Water Source	21.00	2501.24	8.53	0.01	0.00	-1225.67	0.96
Firewood + Compost	21.00	2501.36	8.66	0.01	0.00	-1225.73	0.96
Den Site + Water Source	21.00	2501.51	8.81	0.01	0.00	-1225.81	0.97
Firewood + Forest	21.00	2501.65	8.95	0.01	0.00	-1225.88	0.97
HUD + Agricultural	21.00	2501.82	9.11	0.01	0.00	-1225.96	0.97
Brush Pile + Water Source	21.00	2501.85	9.14	0.01	0.00	-1225.98	0.97
Forest + HUD	21.00	2502.21	9.51	0.01	0.00	-1226.16	0.98
Forest + Agricultural	21.00	2502.29	9.58	0.01	0.00	-1226.19	0.98
Compost + Open	21.00	2502.50	9.80	0.01	0.00	-1226.30	0.98
Poultry Presence + Den Site	21.00	2502.72	10.01	0.01	0.00	-1226.41	0.98

Table 6 (Cont.)

Brush Pile + Agricultural	**21.00**	**2502.78**	**10.08**	**0.01**	**0.00**	**-1226.44**	**0.98**
Forest + Bird Feeder	21.00	2502.83	10.13	0.01	0.00	-1226.47	0.99
Den Site + Agricultural	21.00	2502.85	10.14	0.01	0.00	-1226.48	0.99
Brush Pile + HUD	21.00	2502.87	10.17	0.01	0.00	-1226.49	0.99
Poultry Presence + Open	21.00	2502.95	10.24	0.01	0.00	-1226.53	0.99
Den Site + HUD	21.00	2503.07	10.36	0.01	0.00	-1226.59	0.99
Agricultural + Agricultural	21.00	2503.10	10.40	0.01	0.00	-1226.60	0.99
Brush Pile + Bird Feeder	21.00	2503.36	10.65	0.00	0.00	-1226.73	0.99
Poultry Presence + Compost	21.00	2503.40	10.70	0.00	0.00	-1226.75	0.99
Poultry Presence + Firewood	21.00	2503.41	10.71	0.00	0.00	-1226.76	0.99
Water Source + Bird Feeder	21.00	2503.48	10.77	0.00	0.00	-1226.79	0.99
Brush Pile + Forest	21.00	2503.83	11.13	0.00	0.00	-1226.97	1.00
Firewood + Water Source	21.00	2504.21	11.51	0.00	0.00	-1227.16	1.00
HUD + Bird Feeder	21.00	2504.83	12.12	0.00	0.00	-1227.47	1.00
Agricultural + Bird Feeder	21.00	2504.93	12.22	0.00	0.00	-1227.52	1.00
Compost + Compost	21.00	2505.04	12.33	0.00	0.00	-1227.57	1.00
Firewood + Agricultural	21.00	2505.30	12.59	0.00	0.00	-1227.70	1.00
Firewood + HUD	21.00	2505.40	12.70	0.00	0.00	-1227.75	1.00
Poultry Presence + Bird Feeder	21.00	2505.45	12.74	0.00	0.00	-1227.78	1.00
Open + Water Source	21.00	2505.47	12.77	0.00	0.00	-1227.79	1.00
Compost + Water Source	21.00	2505.50	12.80	0.00	0.00	-1227.80	1.00
Poultry Presence + Brush Pile	21.00	2505.56	12.85	0.00	0.00	-1227.83	1.00
Poultry Presence + Forest	21.00	2506.02	13.31	0.00	0.00	-1228.06	1.00
Poultry Presence + Water Source	21.00	2506.15	13.45	0.00	0.00	-1228.13	1.00

Table 6 (Cont.)

Compost + Agricultural	**21.00**	**2506.80**	**14.10**	**0.00**	**0.00**	**-1228.45**	**1.00**
Poultry Presence + Agricultural	21.00	2507.38	14.67	0.00	0.00	-1228.74	1.00
Poultry Presence + HUD	21.00	2507.53	14.83	0.00	0.00	-1228.82	1.00
Open + Open	21.00	2507.60	14.90	0.00	0.00	-1228.85	1.00
Year + Den Site	21.00	2512.89	20.19	0.00	0.00	-1231.50	1.00
Forest + HUD + Open + Agricultural	27.00	2516.63	23.92	0.00	0.00	-1224.50	1.00
Year + Firewood	21.00	2522.32	29.61	0.00	0.00	-1236.21	1.00
Year + Compost	21.00	2545.28	52.58	0.00	0.00	-1247.69	1.00
Year	18.00	2553.72	61.01	0.00	0.00	-1256.01	1.00
Year + Brush Pile	21.00	2562.79	70.08	0.00	0.00	-1256.45	1.00
Global	45.00	2566.05	73.35	0.00	0.00	-1215.77	1.00
Year + Forest	21.00	2576.84	84.13	0.00	0.00	-1263.47	1.00
Year + Open	21.00	2582.44	89.73	0.00	0.00	-1266.27	1.00
Year + Water Source	21.00	2590.45	97.75	0.00	0.00	-1270.28	1.00
Year + Agricultural	21.00	2593.30	100.59	0.00	0.00	-1271.70	1.00
Year + HUD	21.00	2596.15	103.44	0.00	0.00	-1273.12	1.00
Year + Bird Feeder	21.00	2600.02	107.31	0.00	0.00	-1275.06	1.00

CONCLUSION

Within my thesis, I explored how wildlife responded to urbanization and used residential yards. I found that wildlife was detected in 99% of yards in our study indicating that wildlife is present in essentially all yards across the suburban environment. My analyses found that wildlife use yards based on varying features and landscape composition. In chapter I, I found that mammalian guild diversity and richness can vary based on how homeowners maintain their yards. Homeowners can increase herbivore richness in backyards by adding features such as gardens and increase mesopredator diversity with more bird feeders. However, increasing richness and diversity of certain guilds does not come without risk of conflict. An increase in herbivores in yards with more gardens may be a burden to the owners, as these species can be especially destructive to gardens (Manning 2021). Increasing mesopredators in a yard with bird feeders, may create positive viewing opportunities but can have negative outcomes such as destruction of the resource, pet-wildlife conflict, and transmission of diseases such as distemper and rabies between wildlife and pets (Kapil 2011; Frank et al., 2019). Homeowners also have the ability to decrease the diversity of mesopredators in yards by implementing more solid fences. I found that the amount of forested land area is an important driver for most species to be in an area, increasing both herbivore diversity and mesopredator richness. Given the vast area covered by residential yards, the resources they supply, and the level of connectivity they provide to greenspaces they are important to the conservation and management of suburban wildlife (Bolger et al., 2001, Hansen et al., 2020).

In chapter II, our results suggested that predators (coyote, gray fox, or red fox) were in most residential yards in the greater Fayetteville area. This result is likely applicable to other similar suburban areas (Gehrt et al., 2011, Lombardi et al., 2015, Parsons et al. 2019). I found that predator occupancy of these yards was influenced by yard level features as opposed to surrounding landscape composition. This finding shows that homeowners have some modest control over what predators are found in the yard. This can be done primarily through the use of fences to deter coyotes and maybe other predators. This may be especially important to homeowners that have domestic poultry that can attract species such gray fox. Conversely, I found some modest evidence that homeowners that want to attract wildlife to their yard are able to best do it through the creation or maintenance of shelter sites. These sites may be directly used by predators themselves such as red fox or merely attract prey species of interest to suburban predators (Gosselink et al., 2003, Vuorisalo et al., 2014).

As residential lawns become a more prominent cover type across the United States, managers could benefit from understanding how these lawn spaces provide resources that benefit predators and other wildlife surviving in suburban settings and how yard features can create hot spots of conflict with these species of wildlife. An understanding of how homeowners maintain their yards and how this influences wildlife will be crucial in maintaining habitats and corridors for wildlife in the future.

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