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Investigating the Effects of Urban Coyotes on Free-Range Cats in Culver City, California Using Occupancy Analyses of Camera Trap Data

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Investigating the effects of urban coyotes on free-range cats in Culver City, California using occupancy analyses of camera trap data

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Abstract

As a habitat generalist, coyotes are known to thrive in urban environments given the abundance and diversity of suitable food sources throughout the cityscape. Within Southern California, cats have been found to comprise a higher proportion of coyote diet than in other urban areas throughout the country. However, it is unclear what factors are contributing to these higher rates of cat depredation by coyotes in the Los Angeles region. While previous research suggests that coyote presence may have a negative effect on free-range cat distributions, few studies have determined whether urban green spaces affect coyote or free-range cat occurrence within a dominantly urban landscape. For this study, we set up 20 camera traps across a range of green spaces and residential sites in Culver City, California. Using data collected for six months, we conducted a preliminary analysis of the influence of green space on coyote and cat occupancy. Coyotes exhibited a preference for sites with higher green space values, while cats appeared largely unaffected by the proportion of green space. Unlike other cities where there is strong partitioning of the landscape by coyotes and cats, our cat distributions indicated substantial overlap with coyotes. We suggest that this pattern of overlap, as well as evidence of green space use by free-range cats, may be responsible for the increased rates of cat depredation by coyotes in Culver City.

Introduction

More than four billion people currently live in urban areas, exceeding half of the world's human population (Ritchie & Roser, 2018). As cities continue to expand in size and development, wildlife is forced to respond to dramatic changes in their natural landscapes. Urbanization is often responsible for interfering with biodiversity through habitat fragmentation, altered home ranges, changes in available resources and diet, varied temporal and/or spatial activity, and behavioral plasticity (Ellington & Gehrt, 2019; Fuirst et al., 2018; Graser et al., 2012; Hurtado & Mabry, 2019; Lopucki & Kitowski, 2017). Large-scale anthropogenic influence often produces novel community dynamics and trophic interactions between urban mammals (Turrini et al., 2016). Urbanization can be responsible for driving out apex predators, thus dramatically altering trophic webs within developed regions. For example, the absence of the grey wolf (*Canis lupus*) and the mountain lion (*Puma concolor*) has led to the rise of coyote (*Canis latrans*) populations in several urban landscapes across the United States (Newsome & Ripple, 2015). In the absence of apex predators, mesopredators such as Virginia opossums (*Didelphis virginiana*), common raccoons (*Procyon lotor*), striped skunks (*Mephitis mephitis*) and cats (*Felis catus*) are common in urban systems and have been shown to exploit anthropogenic resources at varying scales (Fascione et al., 2004; Prange & Gehrt, 2004).

As a habitat generalist, coyotes can thrive in urban environments given the abundance and diversity of suitable food sources (e.g. ornamental fruits, human garbage, pet food) throughout the cityscape (Fedriani et al., 2001; Larson et al., 2020; Poessel et al., 2016) Moreover, coyotes are an excellent model organism through which to research the effects of urbanization on mammals due to their presence throughout the urban-rural gradient (Adducci II et al., 2020; Cove et al., 2012; Ordeñana et al., 2010). Coyotes localized within urban environments may have the capacity to interact with urban organisms in novel ways. Given coyotes' behavioral adaptations to cities all around the United States, numerous studies have examined the effects of coyote presence on the distribution and abundance of urban mesocarnivores (Fascione et al., 2004; Greenspan et al., 2018). Several researchers have reported minimal influence of coyote abundance on populations of raccoons and skunks (Cove et al., 2012; Crooks & Soule, 1999; Gehrt & Clark, 2003; Gehrt & Prange, 2007). However, there is strong evidence to suggest that coyotes play a role in reducing free-range cat populations (Brashares, 2010; Cove et al., 2012; Crooks & Soule, 1999; Grubbs & Krausman, 2009).

Due to their popularity as domestic pets, cats are one of the most prevalent introduced species in the world (Dickman, 1996; Medina et al., 2011). For the purposes of this paper, free-range cats will be defined as domestic cats that are owned and given outdoor access, or stray/feral cats. In urban systems, free-range cats have been responsible for significant levels of predation on native organisms, especially songbirds (Baker et al., 2008; Dickman, 2009; Gillies & Clout, 2003; Santiago-Alarcon et al., 2017). Reasonably, conservationists have directed much of their attention to investigating the community dynamics between urban wildlife and this invasive carnivore, as well as the implications of such wildlife conflict for urban/residential cat owners (Hall et al., 2016; Kikillus et al., 2016; Seymour et al., 2020). However, the distribution of apex predators and mesocarnivores may introduce various limitations for urban cats. Given that free-range cats are widely dispersed in urban matrices, they are a frequent source of prey for urban coyotes. (Crooks & Soule, 1999; Grubbs & Krausman, 2009; Larson et al., 2020).

Several studies have quantified the effect of anthropogenic resource availability on coyote diet composition, both in rural and urban areas (Fedriani et al., 2001; Murray et al., 2015; Poessel et al., 2017). Coyote-cat interactions are a significant source of wildlife conflict, especially in urban and residential areas, as cat owners often let their pets roam around freely. However, much research suggests that cats account for only a moderate percentage of coyote diet in various urban systems. In several studies, domestic animals comprised merely 1-2 percent of coyote diet (Gehrt & McGraw, 2007; Hernandez et al., 2002; Murray et al., 2015; Poessel et al., 2017; Prugh, 2005). For example, a study in Chicago found that domestic cats occurred in 1.3 percent of coyote scats (Morey et al., 2007). Interestingly, a study in southern New York did not locate any identifiable cat remains in coyote scats (Peterson et al., 2020). In Alabama and Washington, cats accounted for 8 and 13 percent of coyote diet, respectively (Santana & Armstrong, 2017; Quinn, 1997). However, within Southern California, cats have been found to comprise a significantly higher proportion of coyote diet than elsewhere in the country (Larson et al., 2015). Larson et al. (2020) identified cat remains in 20 percent of coyote scat within the greater Los Angeles area. It is unclear what factors are contributing to higher rates of cat depredation by coyotes in the Los Angeles region.

One factor that may be contributing to coyote-cat conflict is the relative site use and site overlap between each respective species. Previous research suggests that coyote presence and/or abundance may have a significantly negative effect on free-range cat distributions (Cove et al., 2012; Crooks & Soule, 1999; Kays et al., 2015; Sims et al., 2008). Additionally, Gehrt et al. (2013) found that coyotes exhibited a preference for natural habitats whereas cats selected for urbanized and residential spaces. While these studies generally found distinctive habitat ranges for each species, most of them analyzed coyote-cat interactions across an urban-rural gradient. In other words, these broad analyses assessed if coyotes and cats occupy separate spheres between urban, suburban, and rural areas. On the other hand, few studies have determined whether urban green spaces affect coyote versus free-range cat occurrence within a dominantly urban landscape. Given the range of parks, neighborhoods, and developed areas within a narrow urban grid, it is possible that there are additional nuances to species site use and overlap at a local scale. We predict that an overlap in coyote and cat occupancy across both green spaces and residential areas may account for higher rates of cat mortality in Los Angeles.

Camera traps are a common remote research method used to survey urban mammals (Anton et al., 2018; Hegglin et al., 2004; Smith et al., 2020). As a noninvasive survey tool, they are especially useful for mammalian carnivores, such as coyotes and cats (Cove et al., 2012; Lombardi et al., 2020; Ordeñana et al., 2010). Occupancy models are often used to analyze camera trap studies, as these models account for imperfect detection and can reveal correlations between species and their habitat selection (Davis et al., 2018; Neilson et al., 2018; Sollmann, 2018; Tobler et al., 2015). Using data collected for six months, we conducted a preliminary analysis of coyote-cat interactions in Culver City, California. Our main objectives were to: a) determine the influence of green space versus residential land use on urban coyote and cat occurrence, and b) assess the relationship between coyote site use and free-range cat distributions. We hypothesize that in our study system, coyotes will prefer green space while cats will primarily occupy residential space, but that coyote and cat distributions may overlap on spatial and temporal scales. This information will assist in directing future research and management protocol for coyotes in this region.

Methods

Study Site

Culver City, California, is a city in Los Angeles County with a human population of approximately 39,185 and a total area of 13.31 km^2. This small region is comprised of a number of residential areas, a range of local and commercial businesses, and several fragments of green space. There are eight major public parks distributed across Culver City. Culver City Park and Veterans Memorial Park are the largest, covering 41.55 acres and 12.9 acres, respectively (Fig. 1). Lindberg Park, Carlson Park, Syd Kronenthal Park, Tellefson Park, Blanco Park, and Hillside Memorial Park range from 1.5 to 4.39 acres. The Holy Cross Catholic Cemetery comprises 200 acres, serving as a significant green space in this region of Los Angeles County.

Culver City is bordered by Baldwin Hills, a potential point of origin and entry for urban coyotes given its relative green space and proximity to the Kenneth Hahn State Recreation Area (Fig. 1). This city also shares a border with the Inglewood Oil Fields, which covers approximately 1,000 acres and is the second-most productive oil field in the Los Angeles Basin (Inglewood Oil Field, 2017). One of the most distinctive geographic features in the region is Ballona Creek, an 8.8-mile watershed which runs from northeast to southwest Culver City, ultimately emptying into the Santa Monica Bay. Access to Ballona Creek is mostly limited to a bike path that begins at Syd Kronenthal Park in east Culver City and runs past Culver City Park and Lindberg Park. This geographic feature may potentially serve as a necessary water source and means of transportation for urban wildlife.

Camera Trap Analyses

From December 2019 through June 2020, we conducted camera trap surveys in Culver City, California. During the study, 20 camera traps were active for a total of 3,736 sampling nights across all cameras. Compared to other camera trap studies, 20 sites constitute a relatively small sample size. However, Kays et al. (2020) found that less than 20 camera sites are necessary when assessing the occupancy of common species. We have reason to believe that coyotes and

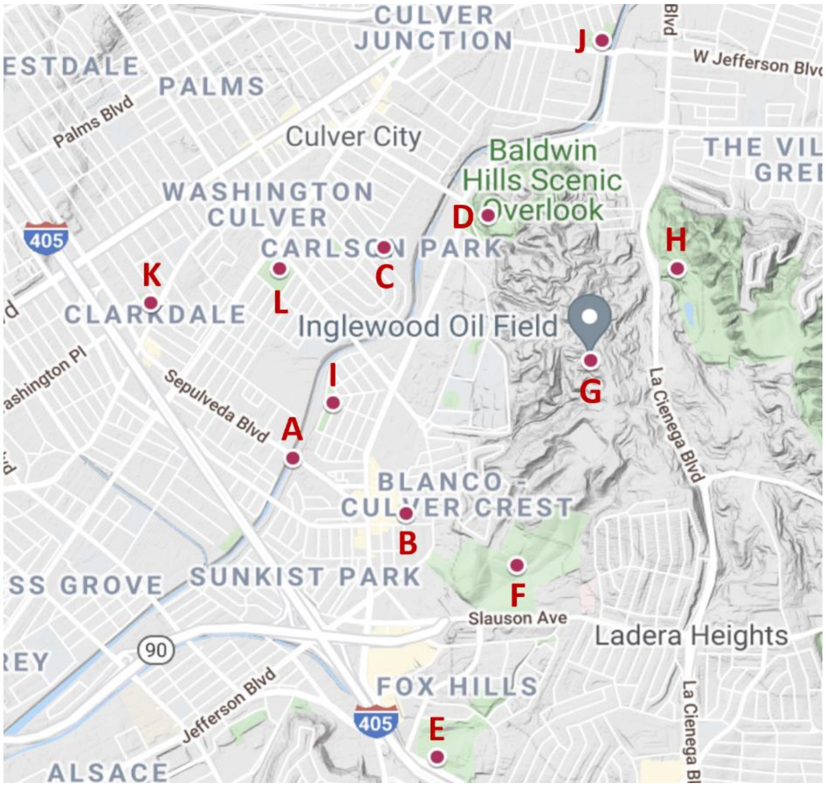

Figure 1.—Relevant geographic features and landmarks in Culver City, California. A – Ballona Creek, B – Blanco Park, C – Carlson Park, D – Culver City Park, E – Hillside Memorial Park, F – Holy Cross Catholic Cemetery, G – Inglewood Oil Fields, H – Kenneth Hahn State Recreation Area, I – Lindberg Park, J – Syd Kronenthal Park, K – Tellefson Park, L – Veterans Memorial Park.

cats are not rare species in Culver City given the high rates of coyote sightings and cat mortality within Culver City neighborhoods, as well as the high proportion of cat remains in coyote diet within southern California (Larson et al., 2020). Ideally, our study would have included additional camera sites; however, this project was restricted to reasonable locations for cameras given the high amount of development in Culver City, as well as a narrow land area of 13.31 km^2. The logistics associated with cameras in urban settings are more complicated than in traditional rural studies, as each camera placed on private property required the owner's permission, while cameras in public spaces were often subject to repeated vandalism.

Seventeen cameras included in the analysis were active for all six months of the study, while three of the cameras were set up during February-March. Site 14 was added to our study after a resident contacted us with reports of coyote scat in the backyard. This site is in an area where there have been a couple of cat deaths attributed to coyotes. Sites 17 and 18 lie along Ballona Creek and were added in March to further investigate this geographical feature as a potential water source for coyotes. Additionally, a coyote had been spotted in the streets adjacent to these sites. Two of the sites were removed from the analysis due to the cameras being stolen from public property. Differences in start dates were accounted for in the analysis (see *Statistical Analyses*).

We used Browning Strike Force Extreme wildlife cameras, equipped with infrared LED illumination for evening photographs (Fig. 2). When possible, cameras were positioned at roughly knee-height, about 51 centimeters high. However, several cameras were placed at

Figure 2.—Browning Strike Force Extreme wildlife cameras positioned on a lamppost at Blanco Park (left) and on a tree in Culver City Park (right).

heights above and below this average height due to limitations in the urban landscape. For sites with an upward slope, cameras were positioned higher in order to effectively capture the surrounding area. Cameras were placed at lower heights when they could not be attached to an available object at knee-height. Site 8 was repositioned higher up after a tree fell in front of the camera, obscuring its view. To test for the potential influence of camera height on the probability of coyote and cat detection, camera height was included as a covariate in our analysis (see *Statistical Analyses*).

Given the fine scale of this study, sites were positioned at least 50-m apart. If more than one camera was present within the same buffer zone, we randomly selected one camera to be used for the analysis (Table 1). While it is standard for camera trap studies to position cameras at

Table 1.—Covariates associated with each of the 20 camera trap locations. Camera height, distance from Baldwin Hills, proportion of green space, and frequency of cat detections were standardized.

Study area	Sampling nights	Camera height STND	Baldwin Hills STND	Green space STND	Number of cats STND
1 – Jackson Ave	200	-1.2337	0.07318	-0.194	0.273965
2 – Carlson Park	200	-1.01663	0.868617	-0.56	-0.51959
3 – Madison Ave	200	-0.43777	0.502716	-0.575	0.009447
4 – Blair Hills Park	200	1.443541	0.089089	0.584	-0.44401
5 – La Salle Ave	200	0.43053	0.423172	-0.707	-0.55738
6 – Stocker St	200	0.647604	-1.64496	0.334	-0.4818
7 – Jasmine Ave Bike Path	200	1.371183	0.629986	-1.616	-0.55738
8 – Marycrest Manor	200	0.43053	-1.94723	1.552	-0.51959
9 – Veteran’s Park	200	-1.16135	1.170882	-0.384	0.047235
10 – Raintree Condos	200	-1.01663	-0.49953	1.229	0.122812
11 – Culver City Park1	200	-0.43777	0.089089	1.317	3.221451
12 – Culver City Park2	200	-0.51012	0.391355	0.98	-0.51959
13 – Baldwin Ave	200	-0.7272	0.359537	-0.238	-0.10392
14 – Marietta Ave	132	0.719962	-1.42224	-1.161	0.009447
15 – Flaxton St	200	-1.16135	1.886775	-1.983	-0.40622
16 – Ballona Creek	200	0.719962	0.407263	0.569	-0.33065
17 – Revere Pl	95	0.358172	0.264085	0.07	2.352321
18 – Jasmine and Le Bourget	109	-1.16135	-0.14954	-0.399	-0.55738
19 – Bridal Path	200	1.877689	-1.75632	1.449	-0.51959
20 – Lindberg Park	200	0.864678	0.264085	-0.267	-0.51959

least one home range diameter apart to avoid detection of the same individuals, our study was under the assumption that Culver City lies within the home range of a single pack of coyotes (Sollmann, 2018). Coyote trapping, ear tagging, and radio collaring throughout the study confirmed that individuals detected across multiple sites belong to the same pack. Future genetic analyses of coyote scat will provide further evidence for this claim. Thus, our study aimed to assess local habitat selection of a single coyote pack rather than the selection of multiple populations of coyotes. Contrary to other studies, a 50-m buffer zone was necessary to assess variation in wildlife occupancy at the finer scale of neighboring green spaces and residential areas (Cove et al., 2021; Ordeñana et al., 2010).

Camera traps were distributed across a range of green spaces and residential sites (Fig. 3). Given that the initial aim of this study was to assist the Culver City local government in mitigating instances of human-wildlife conflict, cameras were intentionally placed along pathways where coyotes had been spotted, such as in residential neighborhoods and backyards. Similarly, cameras were situated in sites presumed to serve as wildlife corridors for coyotes, such as along Ballona Creek and surrounding Baldwin Hills. Site selection was informed by monthly coyote sightings collected by citizen scientists and reported to the Culver City Police Department (Fig. 4). Cameras were intentionally placed in “hotspot” areas, illustrated by yellow and red regions on the map. The northern hotspot lies adjacent to Culver City Park and includes Lindberg Park, Carlson Park, Veteran’s Park, Jasmine Avenue, and sections of Ballona Creek. The southern hotspot borders the Inglewood Oil Fields and includes Marycrest Manor, a Culver City assisted living facility that includes a large area of natural land bordering the oil fields and Holy Cross Cemetery. All of the urban park study sites were in close proximity to locations where cat

Figure 3.—Map of 20 site locations across Culver City, California, each surrounded by a 50-m buffer zone.

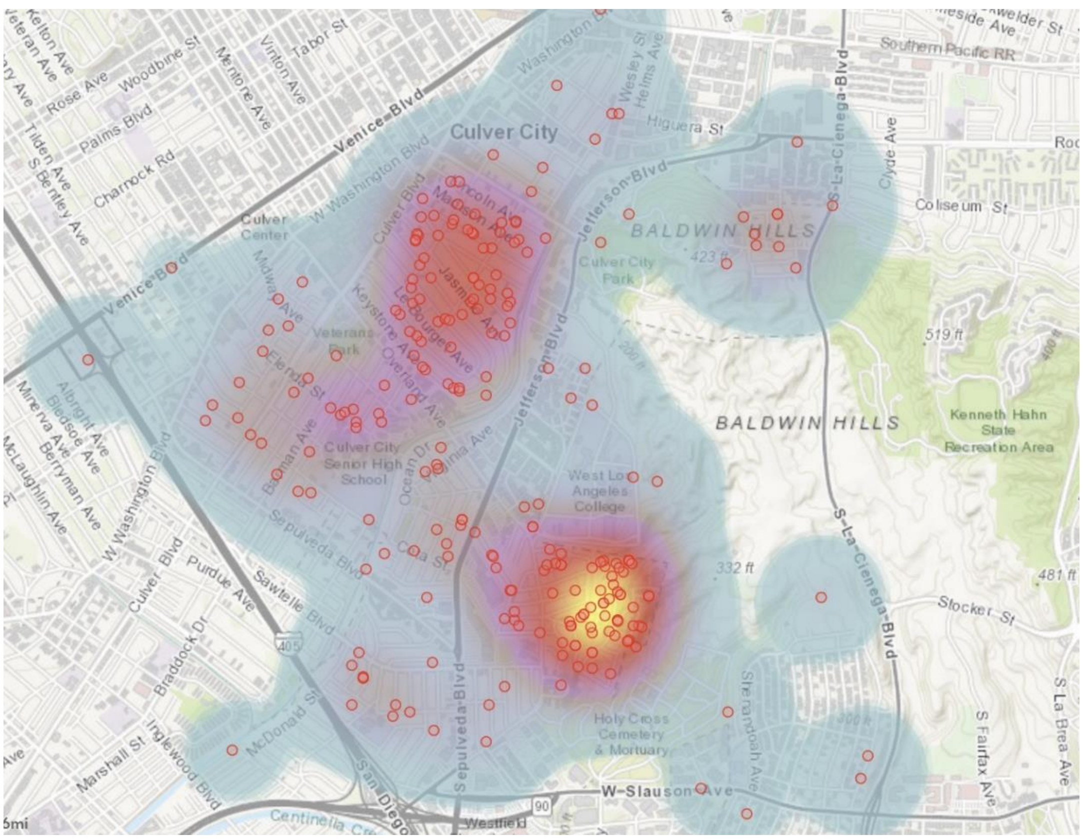

Figure 4.—Heat map of coyote sightings in Culver City between July 2013 and December 2020.

deaths had been reported. Public parks were also included so as to assess the correlation between green space percentage and coyote distribution presented in the literature (Gehrt et al., 2013).

We recognize that the biased placement of cameras in sites that were expected to detect coyotes may have skewed our data toward higher values of coyote occupancy than are representative of the entire region. However, given that our study was funded by Culver City with the goal of identifying and eradicating "problem" coyotes, in addition to the limited budget and space provided for our camera analysis, there was no alternative arrangement.

Cameras were checked weekly for damage, maintenance, and data collection and then uploaded to a file folder structure for photograph sorting. We used the Sanderson's CameraSweet method to sort the data and establish a folder hierarchy for data analysis (CameraSweet, 2020). Two independent observers sorted through each data set to avoid user error and ensure that animal detections and classifications were accurate. An expert researcher then performed quality checks for each data set to further validate the collections prior to analysis. We considered photographs of free-range cats and coyotes taken at individual sites to be independent if the images were captured more than 30 minutes apart.

Distance from Baldwin Hills

There were numerous sightings of coyotes near Marycrest Manor and the Inglewood Oil Fields, both of which lie adjacent to the city of Baldwin Hills (BH). This suggested that BH and its surrounding natural areas, such as the Kenneth Hahn State Recreation Area, may be an entry point for coyotes into the city. Thus, we predicted that sites in closer proximity to BH would positively influence the probability of coyote detection, while sites further away from BH would negatively influence coyote detection. We used the ruler function on Google Maps to calculate the distance from each camera trap to a fixed coordinate on the western edge of the Inglewood Oil Fields, in close proximity to Marycrest Manor (34°00'06.7"N 118°22'52.0"W) (Table 1). Distance from BH was later included in our occupancy models as a potential covariate influencing probability of detection of coyotes.

Geographic Information System Analyses

To calculate green space versus residential space land coverage, we used ArcGIS to construct a 150-m radius around each site. We recognize that broadening our original 50-m radius to 150-m buffer zones for this landscape assessment resulted in substantial overlap between some of the neighboring sites. However, we felt that 50-m buffers would be insufficient in reflecting the distinguishing landscape features surrounding each site's immediate vicinity. Although sites with overlapping buffers may have correlated green space values, we decided that it was important to capture a broader radius of landscape features that may have contributed to the detection of coyotes and cats in our study area. Additionally, Ordeñana et al. (2020) justified this particular radius by noting that a 150-m buffer would be able to distinguish habitat types at a smaller-scale, thereby classifying the vegetation directly surrounding each camera trap.

Using the tessellation function on ArcGIS, we constructed a continuous non-overlapping hexagon (100-m^2) layer for each of the 20 sites per McDonald et al. (2008). Using satellite view, we then counted the number of hexagons reflective of green space versus residential space. Green space was classified as vegetation, public parks, natural areas, baseball fields, cemeteries, oil fields, dirt patches, and water sources (including Ballona Creek). Residential space included neighborhoods, buildings, roadways, and other man-made features. Values of green space were standardized across the 20 sites (Table 1).

Statistical Analyses

To assess the influence of relative green space and distance from BH on the probability of site use by coyotes and free-range cats, we developed a series of occupancy models. We tested our habitat covariates of green space and distance from BH on coyote and cat occupancy (Ψ), and evaluated the influence of camera height on coyote and cat detection probability (p). For each species, we ran a Pearson's correlation matrix to ensure that our variables were not too highly correlated. In all cases, no variables had a correlation equal to or above +/- 0.6. We then modeled all eight possible combinations of Ψ and p for free-range cats, which included a null intercept model with no covariates. We also performed a set of occupancy analyses on coyotes where the number of cats detected at each site per period (30 minutes) was included as an additional covariate (Table 1), resulting in 16 total occupancy models for coyotes. This covariate was tested on Ψ to determine if the number of cats detected at a site (since cat occupancy was otherwise high throughout our study area) was associated with coyote detection. Candidate models were then ranked using values of the Akaike Information Criterion corrected for small sample size (AICc). Occupancy modeling was performed using R version 4.0.3.

Results

Occupancy and detectability of coyotes

The highest ranked models with weights of 0.328 and 0.286, respectively, both included green space as a predictor of coyote occupancy (Table 2). To account for the minimal yet potentially influential effects of the lower-ranked models, β coefficients and estimates of occupancy (Ψ) and detectability (p) were averaged across all 16 occupancy models according to

Table 2.—Sixteen coyote occupancy models (including null/dot models) with all possible combinations of covariates. Green space, DistBH, and NumCat were tested on occupancy (*Ψ*), while camera height was tested on coyote detectability (*p*). DistBH, distance from Baldwin Hills; NumCat, frequency of cat detections.

Model	Npar	AICc	DeltaAICc	Weight	Deviance
Ψ.Greenspace_p.CamHeight	4	116.7893	0	0.327504082	106.12259
Ψ.Greenspace_p.Dot	3	117.0624	0.2731733	0.28569187	109.56243
Ψ.Greenspace.NumCat_p.Dot	4	119.5272	2.73795	0.083306412	108.86054
Ψ.DistBH.Greenspace_p.Dot	4	119.6959	2.90666	0.076567333	109.02925
Ψ.Greenspace.NumCat_p.CamHeight	5	119.7169	2.9276876	0.075766535	105.43123
Ψ.DistBH.Greenspace_p.CamHeight	5	119.8819	3.0926776	0.069767041	105.59622
Ψ.DistBH.Greenspace.NumCat_p.Dot	5	122.7567	5.9674376	0.016573113	108.47098
Ψ.DistBH_p.CamHeight	4	123.0325	6.24328	0.014437955	112.36587
Ψ.DistBH_p.Dot	3	123.2736	6.4843133	0.012798703	115.77357
Ψ.DistBH.Greenspace.NumCat_p.CamHeight	6	123.5071	6.7178818	0.011387994	105.0456
Ψ.Dot_p.CamHeight	3	123.7017	6.9123933	0.010332599	116.20165
Ψ.Dot_p.Dot	2	124.5224	7.7331257	0.006854721	42.30984
Ψ.DistBH.NumCat_p.Dot	4	126.37	9.58078	0.002721302	115.70337
Ψ.DistBH.NumCat_p.CamHeight	5	126.5932	9.8039276	0.002434002	112.30747
Ψ.NumCat_p.CamHeight	4	126.8517	10.06241	0.002138908	116.185
Ψ.NumCat_p.Dot	3	127.2906	10.5013433	0.00171743	119.7906

the relative weight of each model per Lewis et al. (2015). Consequently, model-averaged *Ψ* for coyotes was 0.524, while model-averaged *p* was 0.465 (Table 3).

The model-averaged β estimate for green space revealed a positive relationship with coyote occupancy with 95% confidence (Table 4). Similarly, green space had a variable importance value (VIV) of 0.947, indicating that of the covariates assessed, green space was the most important of the four covariates included in the models (Table 5). Of the covariates assessed, camera height was ranked second, with a VIV of 0.515. The model-averaged β estimate of camera height suggested a positive relationship with coyote probability of detection. However, confidence intervals overlapped zero, indicating that this covariate did not have a significant impact on detectability. Moreover, covariates of distance from Baldwin Hills (DistBH) and frequency of cat detections per site (NumCat) had relatively low VIVs of 0.207 and 0.196, respectively. Their model-averaged β estimates also had confidence intervals that overlapped zero. Consequently, their negative relationships with coyote occupancy were considered nominal and insignificant.

Table 3.—Estimated occupancy (*Ψ*) and detection (*p*) of coyotes with a 95% confidence interval. CI, confidence interval.

	Estimate	Standard Error	Lower CI	Upper CI
Model-averaged *Ψ*	0.524	0.155	0.246	0.788
Model-averaged *p*	0.465	0.064	0.343	0.590

Table 4.—Estimated β coefficients for each covariate of coyote occupancy models, averaged according to the relative weight of each model. DistBH, distance from Baldwin Hills; NumCat, frequency of cat detections.

Covariate	Model-averaged β estimate	Model-averaged SE	Model-averaged Lower CI	Model-averaged Upper CI
Greenspace	2.090	0.993	0.103	4.077
Camera height	0.247	0.191	-0.136	0.630
DistBH	-0.146	0.401	-0.949	0.657
NumCat	-0.104	0.300	-0.703	0.496

Table 5.— Variable importance value (VIV) calculations for each covariate, ranked in order of their relative weights for the coyote occupancy models.

Covariate	VIV	Rank
Greenspace	0.947	1
Camera height	0.515	2
DistBH	0.207	3
NumCat	0.196	4

Occupancy and detectability of cats

Compared to the coyote occupancy models, the highest-ranked cat models had relatively low weights of 0.297 and 0.212, respectively (Table 6). The top-ranked models included camera height as a predictor of cat detectability. Overall, camera height was modeled as the most influential covariate, with a VIV of 0.615 (Table 7). Green space was also among the top covariates, included in two of the three highest-ranked models with a VIV of 0.449. On the other hand, DistBH had a low VIV of 0.184 and was the poorest predictor of cat occupancy of the eight models.

Despite the ranking of models that included camera height on *p* and green space on *Ψ*, all three covariates had confidence intervals that overlapped zero (Table 8). Camera height appeared

Table 6.—Eight free-range cat occupancy models (including null/dot models) with all possible combinations of covariates. Green space and DistBH were tested on occupancy (Ψ), while camera height was tested on cat detectability (p). DistBH, distance from Baldwin Hills.

Model	Npar	AICc	DeltaAICc	Weight	Deviance
Ψ.Dot_p.CamHeight	3	178.8029	0	0.29748475	171.30291
Ψ.Greenspace_p.CamHeight	4	179.4795	0.6765767	0.21210355	168.81282
Ψ.Greenspace_p.Dot	3	179.9926	1.18968	0.1641077	172.49259
Ψ.Dot_p.Dot	2	180.281	1.4780724	0.14207098	64.06358
Ψ.DistBH_p.CamHeight	4	181.7531	2.9501467	0.06805319	171.08639
Ψ.DistBH_p.Dot	3	182.6671	3.86424	0.04308793	175.16715
Ψ.DistBH.Greenspace_p.CamHeight	5	182.9518	4.1489143	0.0373714	168.66611
Ψ.DistBH.Greenspace_p.Dot	4	183.0422	4.2392767	0.03572049	172.37552

Table 7.— Variable importance value (VIV) calculations for each covariate, ranked in order of their relative weights for the free-range cat occupancy models.

Covariate	VIV	Rank
Camera height	0.615	1
Greenspace	0.449	2
DistBH	0.184	3

Table 8.—Estimated β coefficients for each covariate of cat occupancy models, averaged according to the relative weight of each model. DistBH, distance from Baldwin Hills.

Covariate	Model-averaged β estimate	Model-averaged SE	Model-averaged Lower CI	Model-averaged Upper CI
Greenspace	0.633	0.650	-0.667	1.934
Camera height	-0.255	0.167	-0.588	0.079
DistBH	-0.026	0.358	-0.741	0.689

to have a negative relationship with cat detectability, but this relationship is less informative within a 95% confidence interval. Model-averaged Ψ for free-range cats was 0.906, while model-averaged p was 0.440 (Table 9). However, these values cannot be significantly explained by the covariates of green space, distance from Baldwin Hills, or camera height.

Table 9.—Estimated occupancy (Ψ) and detection (p) of cats with a 95% confidence interval. CI, confidence interval.

	Estimate	Standard Error	Lower CI	Upper CI
Model-averaged Ψ	0.906	0.083	0.587	0.985
Model-averaged p	0.440	0.050	0.346	0.538

Discussion

To determine the factors influencing coyote-cat conflict within Culver City, this study examined the effect of green space fragments within an urban landscape on the occupancy of urban coyotes and free-range cats. Our models tested covariates of green space and distance from Baldwin Hills on species occupancy, and camera height on species detection. Additionally, to investigate a potential relationship between coyote and cat distributions, we included the frequency of cat detections per site as a covariate for the coyote occupancy models.

Coyote occupancy was best predicted by the proportion of green space within Culver City. This positive correlation is very promising considering the relatively small sample size of 20 sites used for this analysis (Kays et al., 2020). Occupancy models may reveal more accurate and significant correlations with the covariates when the analysis pertains to a large study area with additional data points. Thus, a more expansive and long-term study of coyote occupancy in this region would be likely to yield even stronger results.

Moreover, our findings aligned with those of other studies, which found coyotes to show a preference for natural areas (Gehrt et al., 2013; Lombardi et al., 2017). Given that coyotes prefer green spaces and urbanization is encroaching on their landscape, it is possible that coyotes are selecting for habitat fragments with more green space as a means of navigating through residential neighborhoods and more urbanized regions. Green space is also an essential factor for coyote dens and access to water (Schmidly & Bradley, 2016; Way et al., 2002). This would explain coyotes in our study selecting for habitat fragments with access to Ballona Creek, or in regions surrounding Baldwin Hills for pup rearing. Even so, coyotes may have to occasionally travel through neighborhoods to obtain resources (Gehrt et al., 2011; Grinder & Krausman, 2001). This may be the case in Culver City, where there is a lack of full continuity between forested habitats. However, other studies have found that coyotes will primarily forage within green spaces if such natural areas are widely available (Gehrt & Riley, 2010). Therefore, if Culver City coyotes are primarily occupying habitat fragments, higher rates of cat depredation may be a result of cats simultaneously occupying these natural areas, rather than the coyotes repeatedly seeking access to food near residences.

Although green space was the only significant covariate associated with the coyote occupancy models, there was a relationship observed between camera height and coyote detection. Cameras that are positioned higher may be more likely to detect coyotes due to the relatively large body size of coyotes compared to cats and other mesopredators. Similarly, although insignificant, the cat occupancy models suggested a slight negative relationship between detection and camera height. Nevertheless, a linear regression of green space and camera height revealed a very weak and insignificant relationship between these covariates. Therefore, we are confident that camera height was not a confounding factor in assessing the effect of green space or cat abundance on coyote occupancy.

Interestingly, coyote occupancy was not predicted by the frequency of cat detections among the 20 sites. Cats were detected in 17 out of 20 sites, leaving minimal variation to be explained by landscape patterns and coyote occupancy. Since cat presence appeared fairly uniform across our study system, we wanted to evaluate whether or not the relative abundances of free-range cats affected coyote occupancy. Even with this additional covariate, there was no relationship observed in the occupancy models. It is possible that cat abundances did not vary enough between sites to have a significant effect on coyote site selection. If cats really are as widely distributed and spatially abundant as our camera trap analyses suggest, coyotes may not need to specifically select for sites with higher cat frequencies in order to utilize cats as a food source. Assuming that cats are regularly present within green space patches across Culver City, coyotes may still be able to select for natural areas while also encountering large quantities of free-range cats.

These results may partially explain why in Culver City, cats make up a disproportionate percentage of coyote diet compared to other urban landscapes across the country. In Chicago, cats and coyotes appeared to partition the landscape, with minimal overlap in home range (Gehrt et al., 2013). On the other hand, cats in our study were detected in all but one of the sites in which coyotes were detected. Clearly, patterns of site use overlap in Culver City dramatically differ from other cityscapes, where coyotes seem to directly restrict cats to developed areas through intraguild competition (Cove et al., 2012; Crooks & Soule, 1999; Kays et al., 2015; Sims et al., 2008). Theoretically, if a large percentage of these cats are feral or stray, numerous individuals may have less of an incentive to remain near residences like owned cats. Cats in other studies were presumed to avoid coyotes by remaining on the periphery of natural habitat fragments (Gehrt et al., 2013). However, there may be such a high abundance of free-range cats in Los Angeles that residential spaces are no longer sufficient to support their populations. Further research should investigate the demographics and population densities of free-range cats in Los Angeles compared to other cities with coyote-cat conflict. Additionally, the expansion of our camera trap analyses across a wider urban-rural gradient could potentially reveal greater variability in cat detection and frequency than is currently reflected in our analyses.

Cat occupancy within residential spaces *and* green spaces could also be a result of factors at a landscape scale. The geographical features of Culver City, such as the distribution and/or prevalence of public parks and other green spaces, may partially account for the lack of landscape partitioning between coyotes and cats. Perhaps in other cities, there is more of a defined boundary between neighborhoods and developed areas versus natural habitat fragments. If not a factor of cat demography, higher rates of cat depredation in Culver City may be due to a different spatial arrangement of these normally partitioned habitats.

Additional research is needed to confirm that the elevated coyote-cat conflict is a consequence of cat prevalence or site use, rather than a result of coyote occupancy and behavior. Further radio collaring, tracking, and DNA sampling of this coyote pack will assist in comparing our study to other coyote populations. Although these preliminary analyses suggest a relationship between coyote occupancy and green space, we do not know how their population size and density compares to other urban matrices.

Assuming that the higher rates of cat mortality are not a factor of coyote population size, it is possible that cats are more available to coyotes on both spatial and temporal scales within Culver City. Further research will involve conducting activity analyses to assess if coyote and cat activity patterns may partially account for the increased proportion of domestic cats in coyote diets within Culver City. Comparative analyses with other cities in Southern California may reveal behavioral adaptations and differences in diet selection that distinguish Culver City coyotes in their activity patterns. However, if the higher rates of cat depredation are simply a factor of cats being widely available food sources, then the reduction of coyote-cat conflict may depend on the control of free-range cat populations.

Conclusion

As urbanization continues to encroach on the natural habitats of coyotes in southern California, the influx of this habitat generalist to developed areas will undoubtedly cause substantial human-wildlife conflict. In this case, coyotes have been linked to abnormally high rates of cat depredation in Culver City. Using a small-scale camera trap analysis within a dominantly urban landscape, we determined that the inflated conflict is likely due to interspecific overlap in home range. Our occupancy models revealed a positive correlation between coyote occupancy and green space, while cats were instead widely detected across both developed areas and natural habitat fragments. This lack of landscape partitioning may, in combination with additional demographic factors and geographical features, be responsible for the high percentage of cat remains in coyote scat within Los Angeles (Larson et al., 2020), in comparison with other urban areas throughout the country in which this is not the case (Gehrt & McGraw, 2007; Poessel et al., 2017). Our study will serve to focus further research toward important differences in the site use of free-range cats in Culver City compared to other cities. Assuming that this issue is not a factor of population-specific adaptations in coyote behavior, future work may redirect some attention toward the social implications of permitting non-native cats to roam free-range in Los Angeles.

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