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RESEARCH ARTICLE

Scale of effect of landscape patterns on resource selection by bobcats (*Lynx rufus*) in a multi-use rangeland system

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Abstract

Context There is a growing appreciation that wildlife behavioral responses to environmental conditions are scale-dependent and that identifying the scale where the effect of an environmental variable on a behavior is the strongest (i.e., scale of effect) can reveal how animals perceive and respond to their environment. In South Texas, brush management often optimizes agricultural and wildlife management objectives through the precise interspersion of vegetation types creating novel environments which likely affect animal behavior at multiple scales. There is a lack of understanding of how and at what scales this management regime and associated landscape patterns influence wildlife.

Objectives Our objective was to examine the scale at which landscape patterns had the strongest effect on wildlife behavior. Bobcats (*Lynx rufus*) our model species, are one of the largest obligated carnivores in the system, and have strong associations with vegetation structure and prey density, two aspects likely to influenced by landscape patterns. We conducted a multiscale resource selection analysis to identify the characteristic scale where landscape patterns had the strongest effect on resource selection.

Methods We examined resource selection within the home range for 9 bobcats monitored from 2021 to 2022 by fitting resource selection functions which included variables representing landcover, water, energy infrastructure, and landscape metrics (edge density, patch density, and contagion). We fit models using landscape metrics calculated at 10 different scales and compared model performance to identify the scale of effect of landscape metrics on resource selection.

Results The scale of effect of landscape metrics occurred at finer scales. The characteristic scale for edge density and patch density was 30 m (the finest scale examined), and the characteristic scale for contagion occurred at 100 m. Bobcats avoided locations with high woody patch density and selected for greater woody edge density and contagion. Bobcats selected areas closer to woody vegetation and water bodies while avoiding herbaceous cover and energy development infrastructure.

Conclusions A key step in understanding the effect of human development and associated landscape patterns on animal behavior is the identifying the scale of effect. We found support for our hypothesis that resource selection would be most strongly affected by landscape configuration at finer scales. Our study demonstrates the importance of cross-scale

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comparisons when examining the effects of landscape attributes on animal behavior.

Keywords Scale of effect · Bobcat · Cultural landscape · Landscape configuration · Brush

Introduction

Humans have altered terrestrial ecosystems globally and many of these impacts result in habitat fragmentation and loss (Fahrig 2017; Cross et al. 2021). Land conversion for agricultural or energy production can be detrimental due to direct causes of habitat loss (Thomas et al. 2018; Johnson et al. 2020; Lark et al. 2020) and the resulting landscape patterns likely have strong effects on wildlife communities. Cultural landscapes are a geographic area in which the relationships between human activity and the environment have created ecological, socioeconomic, and cultural patterns and feedback mechanisms that govern the presence, distribution, and abundance of species assemblages (Farina 2000; Jones 2003). While there is a robust literature on the effects of cultural landscapes on wildlife (Young 1997; Foster 2002; Fuller et al. 2017), the scale at which habitat alteration has on wildlife behavior remains an open and important question.

The issue of scale remains a primary question in ecology (Morris 1987; Levin 1992; Denny et al. 2004; Jackson and Fahrig 2015; Elderd et al. 2022). Patterns and processes occur at multiple spatio-temporal scales (Wiens et al. 1989; Liang et al. 2022) and the scale of effect is often defined as the scale, or range of scales, that explains the most variation in a given ecological response (Moraga et al. 2019; Blackburn et al. 2021; Arroyo-Rodriguez et al. 2023). Using multiple grains and extents to identify the scale of effect is a common methodology employed to understand how a given species perceives and responds to their environment (Jackson and Fahrig 2012; Moraga et al. 2019; Blackburn et al. 2021). The scale of effect of a given ecological response can be influenced by many factors ranging from a species' biology (Miguet et al. 2016; Martin 2018), an individual's physiology (Jackson and Fahrig 2015; Miguet et al. 2016), and external pressures like anthropogenic disturbance (Hamer and Hill 2000; Mangiacotti et al. 2013). There is a growing body of literature on how wildlife perceive and respond to landscape patterns and the scales at which this occurs (Delaney et al. 2010; Mérő et al. 2015; Šálek et al. 2015). There are numerous examples of mammals responding to urbanization metrics at various scales (Lombardi et al. 2017; Moll et al. 2020; Fidino et al. 2021; Robb et al. 2022). Species range from synanthropic to highly sensitive to human disturbance, and their success in human-modified landscapes depends upon their traits and tolerance of human disturbance (Ferreira et al. 2018).

The rangelands of South Texas are quintessential examples of cultural landscapes where the integration of multiple management objectives has resulted in novel landscape conditions. Despite relatively low human population densities, landscape patterns in these rangelands are heavily altered for agriculture and extraction of natural resources (Dodd et al. 2013; Tunstall 2015). The Eagle Ford Shale oil and natural gas reserve of southwestern Texas, one of the largest reserves in the world, has experienced unprecedented energy development in recent decades (Gilmer et al. 2012; Tunstall 2015). Energy development has resulted in increased fragmentation through the creation of roads and clearing of native landcover for energy infrastructure. The configuration of patches of brush and herbaceous vegetation is also a product of centuries of grazing and brush management practices (Fulbright and Ortega-Santos 2013). In more recent decades, the optimization of livestock production and wildlife management has resulted in the creation of systemic brush mosaics. Systematic brush mosaics are areas where brush is cleared at precise spacing to create alternating strips of brush and herbaceous ground cover increasing the interspersion of forage and thermal refuge resources for livestock and wildlife (Fulbright and Ortega-Santos 2013; Fulbright et al. 2018). Systematic brush mosaics are a representation of the integration of multiple objectives including livestock production and wildlife conservation and have proven effective management for target species such as white-tailed deer (*Odocoileus virginianus*) and northern bobwhite (*Colinus virginianus;* Webb et al. 2006; Hernández et al. 2013; Fulbright et al. 2018). However, the effects of these novel environments on carnivore species such as bobcats (*Lynx rufus*) that have been demonstrated to be negatively affected by fragmentation (Riley et al. 2003) have not been examined (Bradley and Fagre 1988). A key component to understanding the effects that landscape patterns have on ecological responses of bobcats is identifying the scale at which the effects are strongest.

Carnivores are often used as means of monitoring ecosystems due to their trophic position (Marneweck et al. 2022). The bobcat is an ambush predator that relies on concealment cover to hunt and therefore is likely to be impacted by brush management through the alteration of the distribution of concealment cover, increases in patch edge density, and interspersion of cover types, which provide different prey communities in close proximity and concealment cover adjacent to herbaceous plant communities. Bobcats often respond negatively to fragmentation associated with habitat loss (Crooks 2002; Riley et al. 2003; Lewis et al. 2015; Smith et al. 2020) and some evidence suggest areas with greater fragmentation are less productive for bobcats. The Habitat Productivity Hypothesis suggests there is an inverse relationship between space use requirements and habitat productivity. Animals on less productive sites require more space to meet their dietary and life history requirements (Harestad and Bunnell 1979). Numerous studies have used home range size as a measure of habitat productivity for wildlife species (Harestad and Bunnell 1979; Riley et al. 2003; Seigle-Ferrand et al. 2021; Quinlan et al. 2022). For bobcats in agricultural areas, increased fragmentation has been associated with larger home range sizes indicating fragmentation reduces habitat productivity for bobcats in that system (Tucker et al. 2008). Bobcats also respond strongly to prey abundance and increases in prey can result in smaller home range sizes (Litvaitis et al. 1986). As jaguars (*Panthera onca*), pumas (*Puma concolor),* and red wolves (*Canis rufus*) have been extirpated or reduced to low population densities in Texas (Daggett and Henning 1974; Nowak 2002; Harveson et al. 2012), bobcats, have become the largest remaining obligate carnivore and de facto apex predator in many ecosystems (Bradley and Fagre 1988; Lombardi et al. 2020). Bobcats are currently classified as nongame in Texas and there are no harvest limits or season restrictions, however, they are believed to occur at high densities (Heilbrun et al. 2006; Symmank et al. 2008).

We assessed bobcat resource selection within the home range (i.e., Johnson's 3rd order of selection, Johnson 1980) in a landscape where patch composition and configuration were driven by agricultural practices, wildlife management, and energy development. We hypothesized bobcat resource selection would occur at multiple scales but that there would be a characteristic scale where the effects of landscape patterns on resource selection were strongest. We predicted the scale of effect of landscape patterns on resource selection would occur at finer scales since our ecological response variable is selection of a specific location within the home range. Processes within the home range such as foraging success often are influenced by landscape variables at finer scales than in processes such as dispersal (Miguet et al. 2016). Bobcats often select specific vegetation attributes such as concealment cover across systems (Kolowski and Woolf 2002; McNitt et al. 2020b; Zamuda et al. 2022). We predicted bobcats would select woody cover and woody vegetation patches that were more contiguous. We also predicted bobcats would avoid energy infrastructure due to human disturbance at these sites.

Methods

Study area

We conducted the study in a 5,665-ha ranch in the South Texas Plains ecoregion in La Salle County, Texas, during 2021–2022. The 40-year average (1981–2021) annual rainfall for the area was 57.20 cm (National Ocean and Atmospheric Administration 2021). The 2021 average summer (June–August) and winter (December–February) daily temperatures were approximately 29 °C and 13.4 °C, respectively (National Oceanic and Atmospheric Administration 2021).

The ranch included areas that have experienced brush management and contain systemic brush mosaics characterized by large tracts of brush strips alternating with herbaceous vegetation (Fig. 1). The ranch was managed for cattle (*Bos tauros*) production and wildlife with a focus on white-tailed deer (*Odocoileus virginianus*), northern bobwhite (*Colinus virginianus*), and chestnut-bellied scaled quail (*Callipepla squamata*). The site included substantial energy development with a coverage of 0.35 energy pads/km^2 and was associated with regular maintenance resulting in frequent human disturbance. From 2009 to 2019, the southern portion of the ranch was the focus

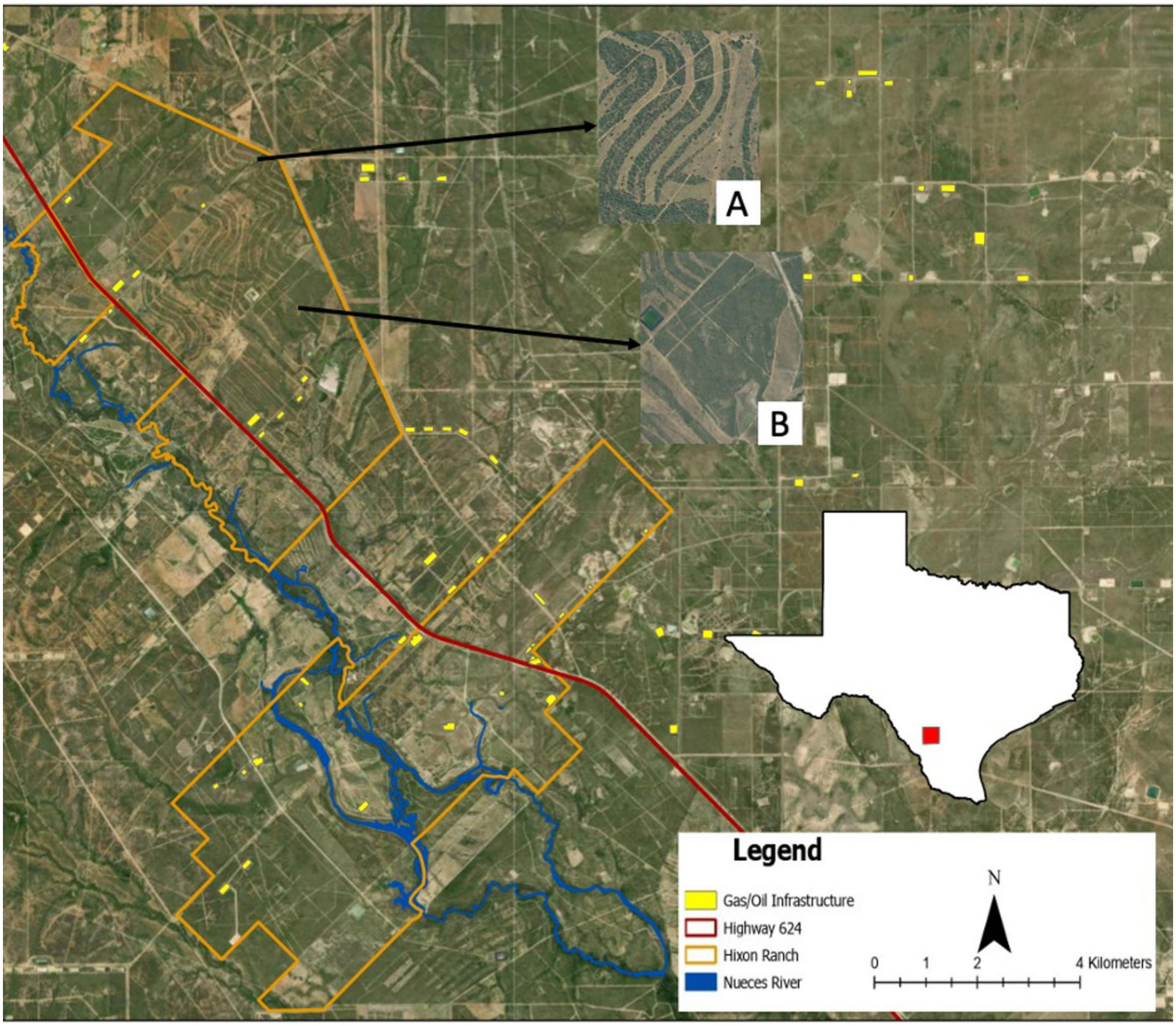

Fig. 1 The study extent of the Hixon Ranch located in La Salle County, Texas, USA with its two partitions of Hixon North and South. The area included systematic brush mosaics where brush was removed at precise spacings intervals to establish alternating strips of brush and herbaceous vegetation to promote interspersion of forage and thermal cover resources for livestock and wildlife panel **A** The ranch also maintains several larger continuous patches of woody vegetation panel **B**

of an effort to restore 300 ha of native grasslands primarily for quail conservation. Restoration efforts targeted the removal of two dominant invasive grasses, including old world bluestem (*Bothriochloa* spp.) and buffelgrass (*Dicanthium* spp.) using prescribed fire, herbicide, and native plant seeding (Olsen et al. 2018; Fulbright et al. 2018).

Woody plants included honey mesquite (*Neltuma glandulosa*), Texas live oak (*Quercus virginiana*), blackbrush acacia (*Acacia rigidula*), cenizo (*Leucophyllum frutescens*), huisache (*Acacia farnesiana*), whitebrush (*Aloysia gratissima*), spiny hackberry (*Celtis ehrenbergiana*), and guayacan (*Guaiacum angustifolium*). Common cacti observed included Texas prickly pear (*Opuntia engelmanii* var. *lindheimerii*) and tasajillo (*Cylindropuntia leptocaulis*). Herbaceous species found in the area include creeping bundleflower (*Desmanthus virgatus*), bristlegrasses (*Setaria* spp.), wild petunia (*Ruellia* spp.), gramas (*Bouteloua* spp.), and purple threeawn (*Aristida purpurea*) (Olsen et al. 2018, Palmer et al. 2021).

GPS collaring

We captured and collared adult bobcats with a single-door 108×55×40 cm wire box traps (Tomahawk Trap Co., Tomahawk, WI) baited with live pigeons (*Columba livia*) that were maintained safely in a separate enclosure. We immobilized bobcats with a mixture of medetomidine (0.6–0.8 mg per kg of bodyweight) and ketamine (2.5–4 mg per kg of body weight; Rockhill et al. 2011; Tellaeche et al. 2020). We fit bobcats with Lotek Litetrack Iridium 150 g and 250 g GPS-satellite collars (Lotek New Market, ON, Canada), and recorded locations every 2 h. We programmed GPS collars to drop-off 52-weeks following deployment. We monitored nine bobcats (five females and four males) for 12 months which resulted in a dataset with 17,881 GPS locations (Fig. 2).

Our capturing and handling of bobcats followed recommendations by Sikes and Animal Care and Use Committee of the American Society of Mammalogists (2016) and protocols were approved by Texas A&M University- Kingsville Institutional Care and Use Committee Guidelines (Protocols: IACUC 2012–12-20B-A2, 2019–2-28A-2-28B), and Texas

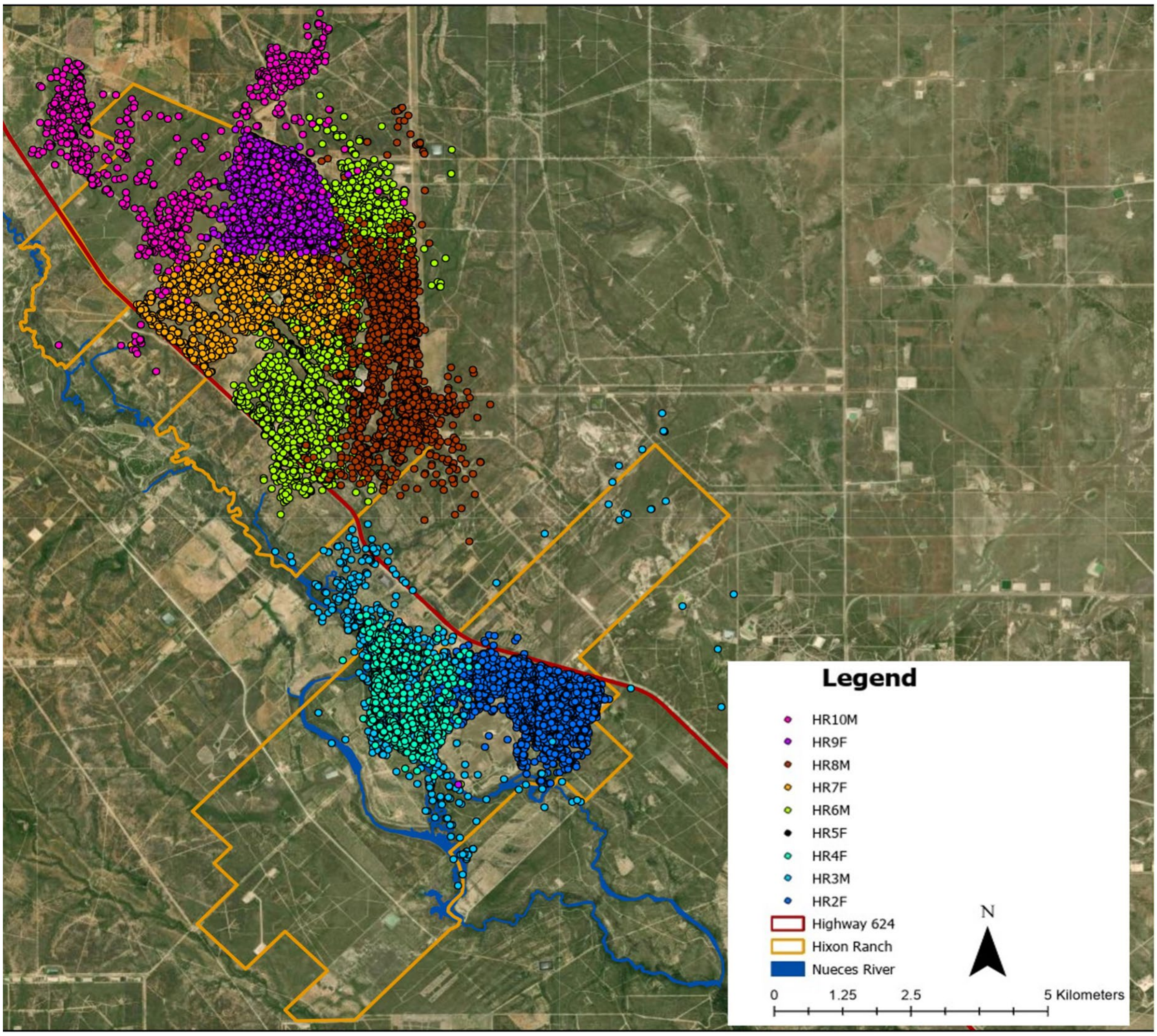

Fig. 2 GPS location of 9 adult bobcats (4 males and 5 females) located on the Hixon Ranch, La Salle, TX. Bobcats were monitored from May 2021 to May 2022 and collected 17,881 locations

Parks and Wildlife Department Scientific Research permit (no. SP0190-600).

Land cover classification

We quantified landscape configuration of vegetation cover in our study area using supervised classification with random forest models (Hayes et al. 2014). We performed supervised classification in ArcPro 2.8 (ESRI, Redlands, CA) using 2020 National Agriculture Imagery Program (NAIP; U.S. Department of Agriculture 2020) 0.6 × 0.6 m imagery and categorized our study area into woody and herbaceous vegetation. After this initial classification, we digitized the highway, paved roads, energy infrastructure, and water bodies (i.e., Nueces River, ponds, cattle tanks). Water bodies were digitized based on National Wetlands Inventory Dataset (U.S. Fish and Wildlife Service 2021). We then performed an accuracy assessment using 300 random points in a confusion matrix with 2021 Google Earth imagery to assess our classification accuracy and attained a rate of 92% accuracy (Jensen 2016; Rwanga and Ndambuki 2017).

Landscape and environmental covariates

We calculated GPS collar location error using 90 test locations with collars placed in dense brush and determined an average of 5 m ± 1.5 standard deviation (SD). Therefore, we resampled the imagery to 10 m to approximately match the resolution of the collar error (Agouridis et al. 2004; Ganskopp et al. 2007; Smith et al 2021). To quantify landscape configuration, we calculated values for three landscape metrics: woody vegetation edge density (m/ha), woody vegetation patch density (number of patches/100 ha), and contagion across cover classes (0–100%) in Fragstats 4.2 (McGarigal 1995). The contagion metric is a landscape-level metric across all class-types (i.e., woody vegetation, herbaceous vegetation highway, paved roads, energy infrastructure, and water bodies) and values increase as the landscape is more aggregated (Riitters et al. 1996). We only included metrics in our analyses if they were not correlated ($|r| < 0.7$; Dormann et al. 2012) and the metrics gave us insights into potential landscape fragmentation. To identify the scale of effect for resource selection, we performed moving window analyses with a window size set to 10 unique values representing scales of interest. Our scale range was selected based on the home ranges of regional bobcat prey ranging from *Permoyscus* genera (Morris 1992) to a white-tailed deer (Williams et al. 2012). We selected 30 m, 60 m, 100 m, 200 m, 300 m, 400 m, 500 m, 600 m, 700 m, and 800 m as our representative scales for the moving window analysis.

Distance-based approaches are a useful method for assessing the effect land cover on resource selection (Conner et al. 2003). To assess the effects of cover type on resource selection, we created distance raster layers where each pixel was characterized by the distance to the nearest patch of a specific cover type. We created distance raster layers for woody vegetation and herbaceous vegetation the two primary cover types in our system. We also created a distance raster layer for water as the distribution of water in semi-arid systems can be an important determinate of wildlife space use (Ochoa et al 2021). To assess the effects of human disturbance associated with energy extraction, we created a distance raster for energy infrastructure.

Resource selection functions

We developed resource selection function (RSF) models using Design 3 described by Manly et al. (2007) at the 3rd order (i.e., selection within home range; Johnson 1980). To quantify availability, we generated 100% minimum convex polygons (MCPs) for each bobcat and generated 10 random locations per observed animal location (Dunagan et al. 2019; Mayer et al. 2021). We selected MCPs as our home range estimator to characterize availability to be as inclusive as possible in defining what was available to each bobcat (Bosco et al. 2021; Hughey et al. 2021). We then extracted all landscape and distance class metrics to each used and random location. We used the package: *lme4* (R Core Team 2022) to fit RSFs using general linear mixed effect models with animal ID treated as a random intercept.

We employed a two-stage modeling approach: first we generated 10 univariate models for each landscape metric where each model represented one of the 10 scales. We then used Akaike Information Criterion adjusted for small sample size (AIC_c) to identify the scale of our landscape metrics that was best supported ($\Delta AIC_c < 2$) within our analytical framework, which we also compared with the null model. After identifying the characteristic scale for each landscape metric, we generated a global model that included each landscape metric and distance metrics (woody vegetation, herbaceous vegetation, water, and gas infrastructure). We then projected our final model output with the *raster* package (R Core team 2022) by reclassifying the map into 10% equal area bins to balance the skewed distributions on our predictions (Boyce et al. 2002).

Results

Female home range size was 4.16 km$^2 \pm 2.1$ (average $\pm$ SD) and for male home range size was 19.4 km$^2 \pm 5.4$. In our assessment of the scale of effect, our univariate models revealed the scale of effect for both patch density and edge density of woody vegetation for bobcat resource selection was 30 m, the finest scale examined (Tables 1, 2). For contagion, the scale that explained the most amount of variation for bobcat resource selection was 100 m (Table 3). The null model was not competitive with the top models.

Table 1 Akaike Information Criterion (AIC$_c$)table for resource selection models identifying the scale of effect of brush management for the landscape metric woody vegetation edge density across 10 different scales for bobcats (*Lynx rufus*). Data collected from 10 May 2021 to 23 May 2022 on the Hixon Ranch in La Salle County, Texas, USA

Model	AICc	Delta_AICc	Log likelihood	R2
Edge density_30	112,568.9	0.0	− 56,277.5	0.26
Edge density_60	114,394.8	1825.9	− 57,190.4	0.26
Edge density_800	114,951.9	2383.0	− 57,468.9	0.25
Edge density_100	115,195.1	2626.2	− 57,590.5	0.25
Edge density_700	115,245.5	2676.6	− 57,615.7	0.25
Edge density_600	115,431.9	2862.9	− 57,708.9	0.25
Edge density_500	115,498.8	2929.8	− 57,742.4	0.25
Edge density_200	115,505.4	2936.5	− 57,745.7	0.26
Edge density_300	115,509.8	2940.9	− 57,747.9	0.26
Edge density_400	115,519.4	2950.5	− 57,752.7	0.26
Null	230,707.7	115,628	− 115,351.9	0

Table 2 Akaike Information Criterion (AIC$_c$) table for resource selection models identifying the scale of effect of brush management for the landscape metric woody vegetation patch density across 10 different scales for bobcats (*Lynx rufus*). Data collected from 10 May 2021 to 23 May 2022 on the Hixon Ranch in La Salle County, Texas, USA

Model	AICc	Delta_AICc	Log Likelihood	R2
Patch density_30	111,387.5	0.0	− 55,686.7	0.26
Patch density_60	111,568.4	181.0	− 55,777.2	0.27
Patch density_100	111,889.4	501.9	− 55,937.7	0.27
Patch density_200	112,405.2	1017.8	− 56,195.6	0.27
Patch density_300	112,545.1	1157.6	− 56,265.5	0.27
Patch density_400	112,774.1	1386.7	− 56,380.1	0.26
Patch density_500	113,222.9	1835.44	− 56,605.4	0.26
Patch density_600	113,543.9	2156.5	− 56,764.9	0.26
Patch density_700	113,859.6	2472.12	− 56,922.8	0.26
Patch density_800	113,859.6	2472.12	− 56,922.8	0.26
Null	230,707.7	115,628	− 115,351.9	0

Bobcat probability of use decreased by 9% for every 50 m increase in distance from woody vegetation ($\beta = -1.21 \pm 0.02$ $p < 0.01$; Fig. 3) and decreased by 2% for every 500 m increase in distance from water bodies ($\beta = -0.25 \pm 0.01$ $p < 0.01$; Fig. 3). Conversely, we determined probability of use increased by 30% for every 50 m increase in distance from herbaceous vegetation ($\beta = 0.28 \pm 0.01$ $p < 0.01$; Fig. 3) and increased 0.5% for every 500 m increase in distance from gas infrastructure ($\beta = 0.01 \pm 0.01$ $p < 0.01$: Fig. 3).

Bobcat probability of use decreased by 2.5% for every increase of 500 patches per 100 ha in patch density of woody vegetation ($\beta = -0.30 \pm 0.01$ $p < 0.01$; Fig. 5) and increased 2% for every 500 m/ha increase in values of edge density ($\beta = 0.05 \pm 0.01$ $p < 0.01$; Fig. 5). However, as contagion increased by 25%,

Table 3 Akaike Information Criterion (AIC_c) table for resource selection models identifying the scale of effect of brush management for the landscape metric contagion index across 10 different scales for bobcats (*Lynx rufus*). Data collected from 10 May 2021 to 23 May 2022 on the Hixon Ranch in La Salle County, Texas, USA

Models	AICc	Delta_AICc	Log Likelihood	R2
Contagion_100	115,079.0	0.0	− 57,532.5	0.27
Contagion_200	115,084.3	5.3	− 57,535.1	0.26
Contagion_60	115,134.3	55.4	− 57,560.2	0.26
Contagion_800	115,221.9	142.9	− 57,603.9	0.27
Contagion_300	115,364.9	285.9	− 57,675.5	0.26
Contagion_700	115,392.6	313.6	− 57,689.3	0.26
Contagion_30	115,432.6	353.6	− 57,709.3	0.26
Contagion_400	115,464.1	385.1	− 57,725.0	0.26
Contagion_600	115,548.1	469.2	− 57,767.1	0.26
Contagion_500	115,607.1	528.1	− 57,796.5	0.26
Null	230,707.7	115,628	− 115,351.9	0

probability of use increased by 2.5% ($\beta = 0.06 \pm 0.01$ $p < 0.01$; Fig. 4). We then evaluated models that used multiple landscape metrics and identified that the global model performed the best (Table 4). We projected the global model across the landscape to visualize areas of high and low probability of use (Fig. 5, Table 5). This heat map allowed us to visualize patterns of bobcat resource selection with various configuration of brush alteration on the landscape.

Discussion

Resource selection occurs at a variety of spatial and temporal scales (McGarigal et al. 2016). In our investigation of the scale of effect for bobcat resource selection, we identified characteristic scales for each of our landscape configuration metrics. Our observations surrounding the scale of effect aligned with the predictions proposed by Miguet et al. (2016) and Martin (2018) regarding to finer scales in context to breeding and foraging success within the home range. We observed bobcats responded to metrics of woody vegetation configuration at finer scales within their home range, which may be associated with the potential perception of hunting efficiency and prey availability within woody patches (Dunagan et al. 2019; McNitt et al. 2020a). Bobcats avoided herbaceous cover and selected larger patches of woody vegetation, and generally avoided interspersed areas.

Creation of systematic brush mosaics and other land management practices created a landscape configuration that influenced resource selection of bobcats. Even though bobcats selected for higher amounts of woody vegetation edges, woody patch density had a negative effect on the probability of use by bobcats. Bobcats are known ambush hunters that often hunt along edges but increased patchiness of vegetation may not be advantageous (Fuller et al. 1985; Marrotte et al. 2020a; McNitt et al. 2020a). Fragmentation of woody patches can have mixed effects on carnivores as it can create structural heterogeneity which can increase prey abundance, but also creates a mosaic of smaller patches which are generally avoided by ambush predators.

Bobcats selected for aggregation of patches across our study area. Areas with greater aggregation of patches are less fragmented and are more homogenous. Contagion has been shown to have varying effects on carnivores, with some species benefiting from fragmented areas and others selecting more aggregated patches (Dijak and Thompson 2000; Kramer-Schadt et al. 2011). Aggregation of patches of similar vegetation structure can improve habitat connectivity for a variety of species, and bobcats are known to select aggregated patches of cover (Tucker et al. 2008; Ruell et al. 2012; Poessel et al. 2014; Janecka et al. 2016).

At broader scales bobcats may select for more aggregation of patches, but as we observed bobcat resource selection within the home range was influenced by woody vegetation. Bobcats selected locations closer to woody vegetation and attributes associated with the configuration of woody cover. We observed patterns of bobcats avoiding high patch densities of woody cover; however, they did select woody vegetation patches with higher edge density. This suggests a pattern of selecting for the edges of single large patches of woody vegetation. These results support the findings of previous studies with bobcats in fragmented landscapes ranging from Mexico,

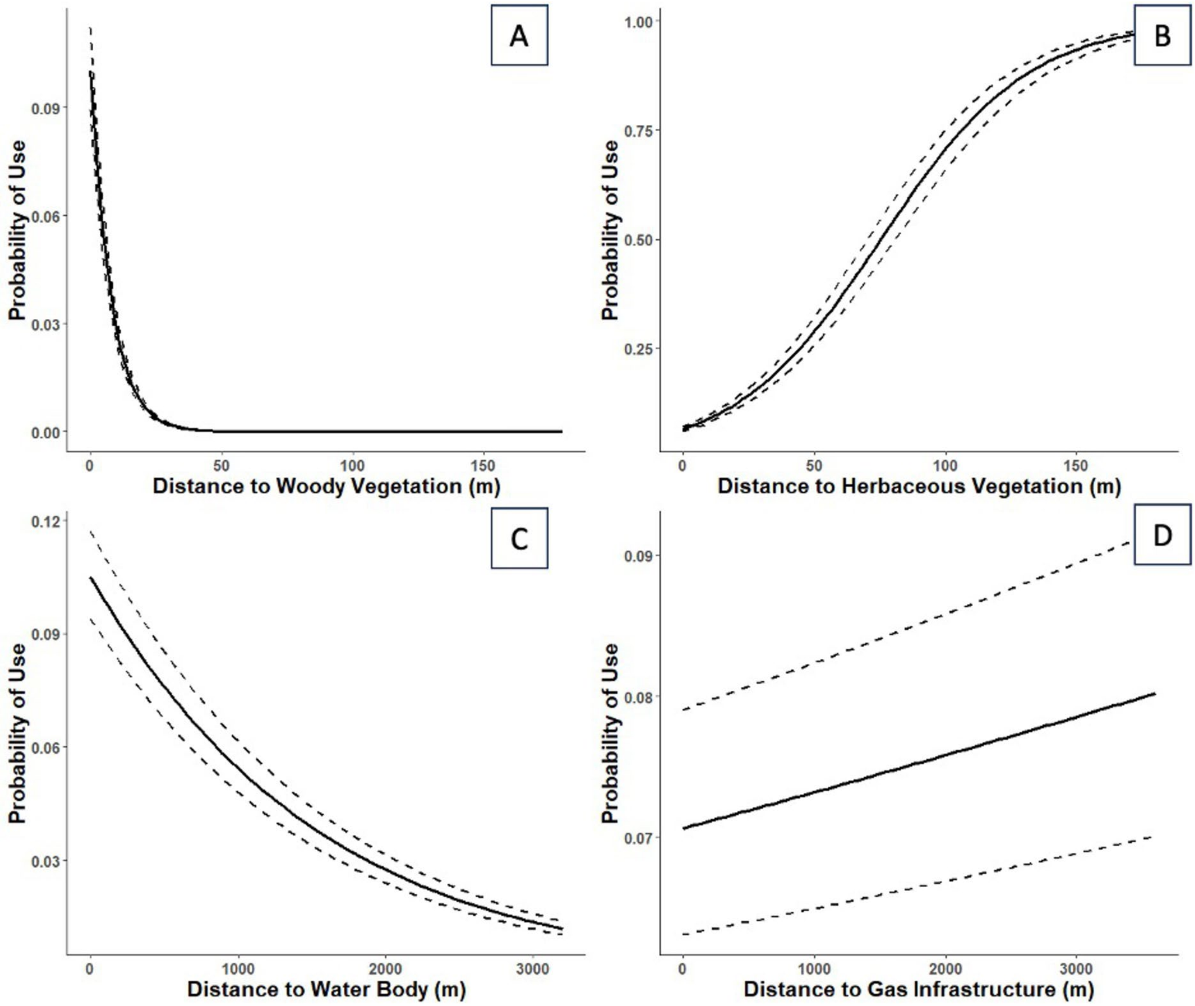

Fig. 3 Predicted responses to distance to woody vegetation **A** distance to herbaceous vegetation **B** distance to water body **C**, and distance to gas infrastructure **D** by bobcats (*Lynx rufus)* from resource selection functions fitted with data collected from 10 May 2021 to 23 May 2022 on the Hixon Ranch in La Salle County, Texas, USA

Canada, and both coasts of the United States (Poessel et al. 2014; Espinosa-Flores and López-González 2017; Farrell et al. 2018; Jones et al. 2020; Marrotte et al. 2020b).

We observed selection of open water bodies by bobcats. Water availability drives carnivore distributions in many other systems (Steiner et al. 2018; Rabaiotti and Woodroffe 2019; Perera-Romero et al. 2021), especially in arid and semi-arid landscapes. It is likely bobcats select areas near water, not only to meet their own water requirements, but also as water likely congregates prey species (Webb et al. 2006; Ochoa et al. 2021). In many semi-arid environments, open water is often ephemeral and so anthropogenically sourced water is an attribute of a cultural landscape that can strongly influence the spatial patterns of many wildlife species (Smit et al. 2007; Atwood et al. 2011; Rich et al. 2019). With more unpredictable climate regimes projected for the future of these environments, it is likely these anthropogenic sources of water will be crucial resources on for many wildlife species in these systems (Ogutu et al. 2012; Ochoa et al. 2021).

Although a relatively small effect, bobcats avoided energy infrastructure. Gas and oil extraction operations are important forms of disturbance for many

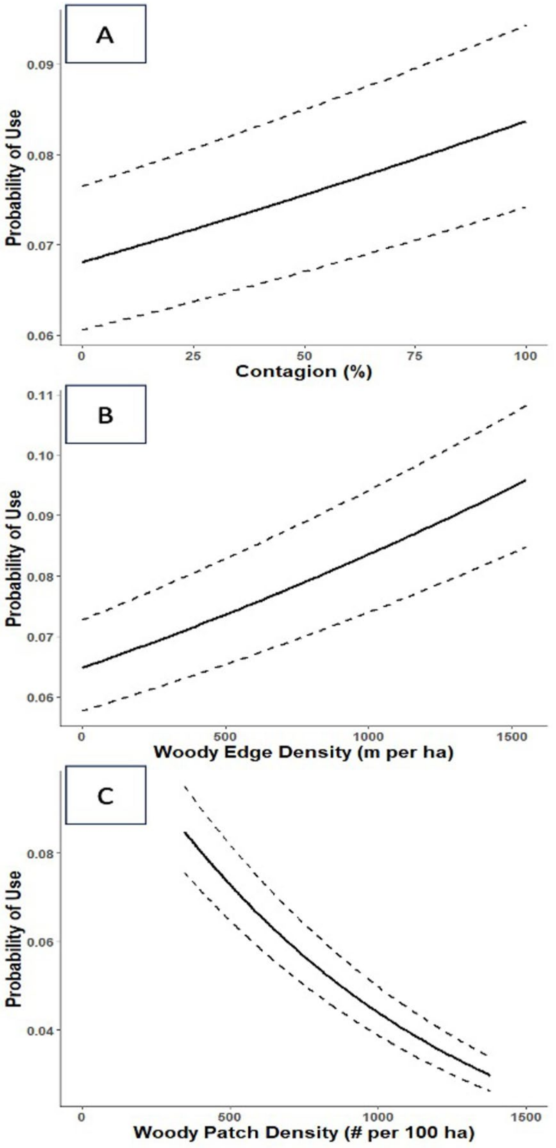

Fig. 4 Predicted responses to the landscape metrics: contagion 100 m %; **A** edge density 30 m (meters [m] per ha; **B** and patch density 30 m (number of patches [#] per 100 ha; **C** by bobcats (*Lynx rufus)* from resource selection functions fitted with data collected from 10 May 2021 to 23 May 2022 on the Hixon Ranch in La Salle County, Texas, USA

species from toxicological exposure to alteration in space use (Bowen et al. 2014; Laberee et al. 2014; Garman 2018; Walker 2022). Our study area contained a pad density of 0.35 pads/km^2 which was relatively lower in other studies (Kalyn Bogard and Davis 2014; Johnson et al. 2015; Hethcoat and Chalfoun 2015). Energy development contributes to the fragmentation of woody and herbaceous vegetation in this system, but the high amounts of human traffic associated servicing these sites likely serve as an important mechanism of anthropogenic disturbance as well (Bowen et al. 2014; Allred et al. 2015; Pattison et al. 2016). Future investigations into the role of energy infrastructure on wildlife should evaluate the relative importance of habitat fragmentation and the direct human disturbance associated with energy development.

Bobcats, similar to other generalist carnivores, have adapted to cultural landscapes across their distribution, despite the myriad of threats to survival that human-dominated areas can pose (Roberts and Crimmins 2010; Young et al. 2019). However, despite such success, there are likely responses that occur at different spatial and temporal grains and extent that influence survival (Miguet et al. 2016; Martin 2018). Multi-scale analyses of habitat selection should remain an integral component of how scientists understand the complex patterns of selection. From our analysis, we demonstrated the effects of a cultural landscape on the behavior of a generalist carnivore. While we did not conduct a multi-order analysis (Johnson 1980), we did assess multiple scales within a single order. The scale of effect may likely vary at different orders of selection (Martin 2018), which is fertile grounds for future research. The scale of effect remains an important aspect to study when trying to elucidate the effects of landscape structure on wildlife.

Conclusion

We found bobcat resource selection of landscape patterns was more strongly influenced by patterns at finer scales. In our system, systematic brush mosaics increases interspersion of patch types and are designed to cultivate high densities of prey which would theoretically benefit carnivores. However, bobcats avoided locations that were more interspersed which suggests bobcats may forgo prey rich patches if the patch configuration is not conducive to their hunting mode. As rural landscapes continue to be altered by agriculture and energy production, there is a growing need to understand the effects of this development on wildlife. Understanding the scale at which the resulting landscape patterns influence wildlife

Table 4 Akaike Information Criterion (AIC_c) for resource selection function models for identifying the best multiple landscape metric model for bobcats (*Lynx rufus*). Data collected from 10 May 2021 to 23 May 2022 on the Hixon Ranch in La Salle County, Texas, USA

Models	AICc	Delta_AICc	Log likelihood	R2
Global model	214,987.0	0.0	− 107,484.6	0.26
Edge density_30 + patch density_30	215,031.3	44.3	− 107,507.7	0.26
Contagion_100 + patch density_30	215,094.5	107.5	− 107,539.0	0.26
Edge Denisty_30 + contagion_100	216,640.4	1,653.4	− 108,312.2	0.26

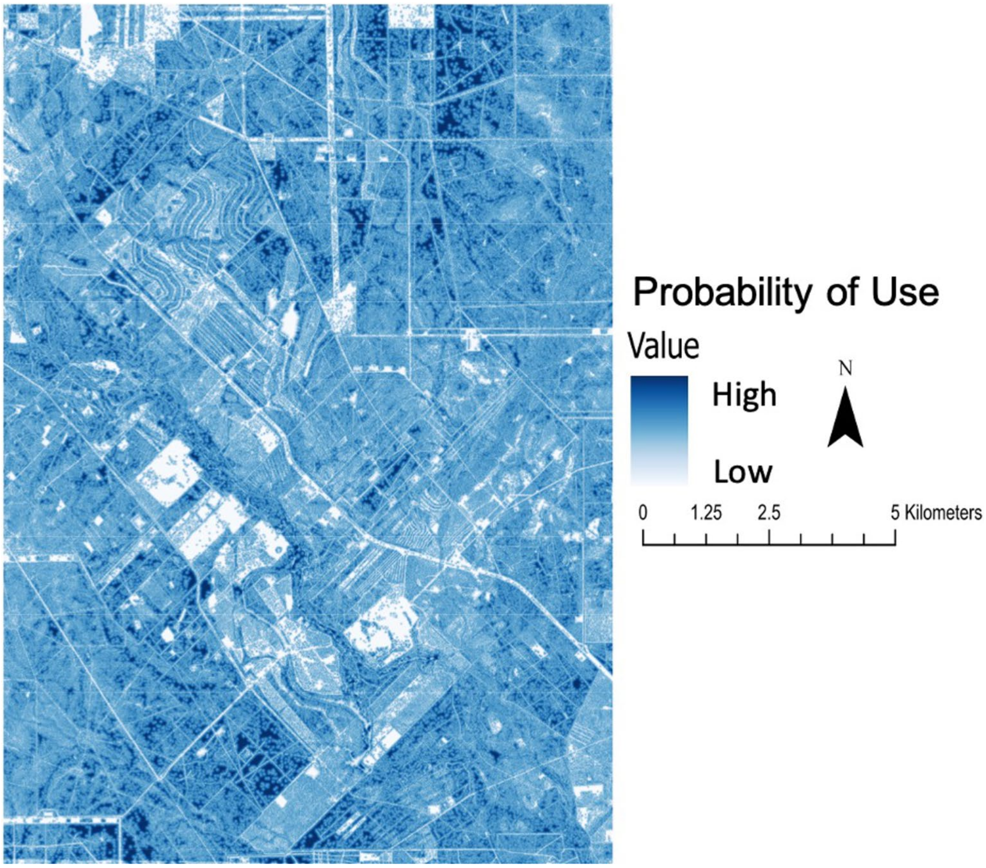

Fig. 5 Spatially explicit visualization of bobcat (*Lynx rufus*) resource selection as a function of our global model across the Hixon Ranch in La Salle County, Texas, USA. Data were collected from 10 May 2021 to 23 May 2022. Higher probability of use values (darker blue) represent areas bobcats were more likely to use on the landscape. Probability of use ranged from 0 to 100%

Table 5 Summary table from bobcat (*Lynx rufus*) global resource selection model including beta estimates, odd ratios, and 95% confidence intervals. Data collected from 10 May 2021 to 23 May 2022 on the Hixon Ranch in La Salle County, Texas, USA

Parameter	Beta Coefficient	Odds Ratio	LCI (95%)	UCI(95%)
Edge density_30 (m/ha)	0.08	1.08	0.062	0.09
Patch density_30 (#/100 ha)	− 0.30	0.74	− 0.313	− 0.282
Contagion_100 (%)	0.05	1.05	0.035	0.063
Distance to woody (m)	− 1.20	0.30	− 1.26	− 1.16
Distance to herbaceous (m)	0.28	1.32	0.27	0.30
Distance to water (m)	− 0.24	0.78	− 0.26	− 0.23
Distance to gas (m)	0.01	1.02	0.003	0.03

behavior should be a key component to future studies of investigating the effects of global change on wildlife.

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Author contributions ABB, MET, and MJC designed the field part of the study. ABB and ZMW carried out the fieldwork needed for the study. ABB conceptualized the idea for the analysis with input from MJC and EPT. ABB carried out the analysis with input from AMV. ABB led the original manuscript writing and editing with support of all co-authors. MET acquired funds and equipment for this study.

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Declarations

Competing interests The authors have not disclosed any competing interests.

Ethical approval Capturing and handling of bobcats followed Texas A&M University- Kingsville Institutional Care and Use Committee Guidelines (Protocols: IACUC—Tewes2019-28-2A; Lombardi2020-31-8A).

References

Agouridis CT, Stombaugh TS, Workman SR et al (2004) Suitability of a GPS collar for grazing studies. Transact ASAE. 47:1321–1329

Allred BW, Smith WK, Twidwell D et al (2015) Ecosystem services lost to oil and gas in North America. Sci 348:401–402

Arroyo-Rodríguez V, Martínez-Ruiz M, Bezerra JS et al (2023) Does a species' mobility determine the scale at which it is influenced by the surrounding landscape pattern? Curr Landsc Ecol Rep 8:23

Atwood TC, Fry TL, Leland BR (2011) Partitioning of anthropogenic watering sites by desert carnivores. J Wildl Mana 75:1609–1615

Blackburn A, Anderson CJ, Veals AM et al (2021) Landscape patterns of ocelot–vehicle collision sites. Landsc Ecol 36:497–511

Bosco L, Cushman SA, Wan HY et al (2021) Fragmentation effects on woodlark habitat selection depend on habitat amount and spatial scale. Anim Conserv 24:84–94

Bowen ZH, Brittingham MC, Farag AM et al (2014) Ecological risks of shale oil and gas development to wildlife, aquatic resources and their habitats. Envir Sci Tech 48:11034–11047

Boyce MS, Vernier PR, Nielsen SE, Schmiegelow FKA (2002) Evaluating resource selection functions. Ecol Modell 157:281–300. https://doi.org/10.1016/S0304-3800(02)00200-4

Bradley LC, Fagre DB (1988) Coyote and bobcat responses to integrated ranch management practices in South Texas. J Range Manag 41:322

Conner LM, Smith MD, Burger LW (2003) A comparison of distance-based and classification-based analyses of habitat use. Ecol 84:526–531

Crooks KR (2002) Relative sensitivities of mammalian carnivores to habitat fragmentation. Conserv Bio 16:488–502

Cross SL, Cross AT, Tomlinson S et al (2021) Mitigation and management plans should consider all anthropogenic disturbances to fauna. Glob Ecol Conserv 26:e01500

Daggett PM, Henning DR (1974) The jaguar in North America. Am Antiq 39:465–469

Delaney KS, Riley SPD, Fisher RN (2010) A rapid, strong, and convergent genetic response to urban habitat fragmentation in four divergent and widespread vertebrates. PLoS ONE 5:e12767

Denny MW, Helmuth B, Leonard GH et al (2004) Quantifying scale in ecology: lessons from awave-swept shore. Ecol Monogr 74:513–532

Dijak WD, Thompson FR (2000) Landscape and edge effects on the distribution of mammalian predators in missouri. J Wildl Manag 64:209–216

Dodd EP, Bryant FC, Brennan LA et al (2013) An economic impact analysis of south texas landowner hunting operation expenses. J Fish Wildl Manag 4:342–350

Dormann CF, Elith J, Bacher S, Buchmann C et al (2012) Collinearity: a review of methods to deal with It and a simulation study evaluating their performance. Ecography 36:27–46

Dunagan SP, Karels TJ, Moriarty JG et al (2019) Bobcat and rabbit habitat use in an urban landscape. J Mamm 100:401–409

Elderd BD, Mideo N, Duffy MA (2022) Looking across scales in disease ecology and evolution. Am Nat 199:51–58

Espinosa-Flores ME, López-González CA (2017) Landscape attributes determine bobcat (*Lynx rufus escuinapae)* presence in central Mexico. Mammalia 81:101–105

Fahrig L (2017) Forty years of bias in habitat fragmentation research. In: Marvier M, Silliman B (eds) Kareiva P. Data Not Dogma. Oxford University Press, effective conservation science, pp 32–38

Farina A (2000) The cultural landscape as a model for the integration of ecology and economics. BioSci 50:313

Farrell LE, Levy DM, Donovan T et al (2018) Landscape connectivity for bobcat (*Lynx rufus)* and lynx (*Lynx canadensis*) in the northeastern United States. PLoS ONE 13:e0194243

Ferreira AS, Peres CA, Bogoni JA, Cassano CR (2018) Use of agroecosystem matrix habitats by mammalian carnivores (Carnivora): a global-scale analysis. Mamm Rev 48:312–327

Fidino M, Gallo T, Lehrer EW et al (2021) Landscape-scale differences among cities alter common species' responses to urbanization. Ecol Appl 31:e02253

Foster DR, Motzkin G, Bernardos D, Cardoza J (2002) Wildlife dynamics in the changing New England landscape. J Biogeogr 29:1337–1357

Fulbright TE, Ortega-Santos JA (2013) White-tailed deer habitat: ecology and management on rangelands. Texas A&M University Press

Fulbright TE, Davies KW, Archer SR (2018) Wildlife responses to brush management: a contemporary evaluation. Rangeland Ecol Manag 71:35–44

Fuller TK, Berg WE, Kuehn DW (1985) Bobcat home range size and daytime cover-type use in northcentral Minnesota. J Mamm 66:568–571

Fuller RJ, Williamson T, Barnes G, Dolman PM (2017) Human activities and biodiversity opportunities in pre-industrial cultural landscapes: relevance to conservation. J Appl Ecol 54:459–469

Ganskopp DC, Johnson DD (2007) GPS error in studies addressing animal movements and activities. Rangeland Ecol Manag 60:350–358

Garman SL (2018) A simulation framework for assessing physical and wildlife impacts of oil and gas development scenarios in southwestern Wyoming. Environ Model Assess 23:39–56

Gilmer RW, Hernandez R, Phillips KR (2012) Oil boom in eagle ford shale brings new wealth to South Texas. Southwest Economy 2:3–7

Hamer KC, Hill JK (2000) Scale-dependent effects of habitat disturbance on species richness in tropical forests. Conserv Bio 14:1435–1440

Harestad AS, Bunnel FL (1979) Home range and body weight -- a reevaluation. Ecol 60:389–402

Harveson PM, Harveson LA, Hernandez-Santin L et al (2012) Characteristics of two mountain lion (*Puma concolor*) populations in Texas, USA. Wildlife Biol 18:58–66

Hayes MM, Miller SN, Murphy MA (2014) High-resolution landcover classification using random forest. Remote Sens Lett 5:112–121

Heilbrun RD, Silvy NJ, Peterson MJ, Tewes ME (2006) Estimating bobcat abundance using automatically triggered cameras. Wildl Soc Bull 34:69–73

Hernández F, Brennan LA, DeMaso SJ (2013) On reversing the northern bobwhite population decline: 20 years later. Wildl Soc Bull 37:177–188. https://doi.org/10.1002/wsb.223

Hethcoat MG, Chalfoun AD (2015) Energy development and avian nest survival in Wyoming, USA: A test of a common disturbance index. Biol Conserv 184:327–334

Hughey LF, Shoemaker KT, Stewart KM et al (2021) Effects of human-altered landscapes on a reintroduced ungulate: patterns of habitat selection at the rangeland-wildland interface. Biol Conserv 257:109086

Jackson HB, Fahrig L (2012) What size is a biologically relevant landscape? Landsc Ecol 27:929–941

Jackson HB, Fahrig L (2015) Are ecologists conducting research at the optimal scale? Glob Eco Biogeogr 24:52–63

Janecka JE, Tewes ME, Davis IA et al (2016) Genetic differences in the response to landscape fragmentation by a habitat generalist, the bobcat, and a habitat specialist, the ocelot. Conserv Genet 17:1093–1108

Jensen JR (2016) Introductory digital image processing: remote sensing perspective, 4th edn. Prentice-Hall, Upper Saddle River, NJ, USA

Johnson DH (1980) The comparison of usage and availability measurements for evaluating resource preference. Ecol 61:65–71

Johnson E, Austin BJ, Inlander E et al (2015) Stream macroinvertebrate communities across a gradient of natural gas development in the Fayetteville Shale. Sci Total Environ 530–531:323–332

Johnson HE, Golden TS, Adams LG et al (2020) Caribou use of habitat near energy development in arctic Alaska. J Wildl Manag 84:401–412

Jones M (2003) The concept of cultural landscape: discourse and narratives. In: Palang H, Fry G (eds) Landscape interfaces. Kluwer, Dordrecht, pp 21–51

Jones LR, Zollner PA, Swihart RK et al (2020) Survival and mortality sources in a recovering population of bobcats (*Lynx rufus)* in South-central Indiana. Amid 184:222–232

Kalyn Bogard HJ, Davis SK (2014) Grassland songbirds exhibit variable responses to the proximity and density of natural gas wells. J Wildl Manag 78:471–482

Kolowski JM, Woolf A (2002) Microhabitat use by bobcats in Southern Illinois. J Wildl Manag 66:822–832

Kramer-Schadt S, Kaiser TS, Frank K, Wiegand T (2011) Analyzing the effect of stepping stones on target patch colonisation in structured landscapes for Eurasian lynx. Landsc Ecol 26:501–513

Laberee K, Nelson TA, Stewart BP et al (2014) Oil and gas infrastructure and the spatial pattern of grizzly bear habitat selection in Alberta, Canada. Can Geogr 58:79–94

Lark TJ, Spawn SA, Bougie M, Gibbs HK (2020) Cropland expansion in the United States produces marginal yields at high costs to wildlife. Nat Commun 11:4295

Levin SA (1992) The problem of pattern and scale in ecology: the Robert H. MacArthur Award Lecture Ecol 73:1943–1967

Lewis JS, Logan KA, Alldredge MW et al (2015) The effects of urbanization on population density, occupancy, and detection probability of wild felids. Ecol Appl 25:1880–1895

Liang M, Liang C, Hautier Y et al (2021) Grazing-induced biodiversity loss impairs grassland ecosystem stability at multiple scales. Ecol Lett 24:2054–2064

Litvaitis JA, Sherburne JA, Bissonette JA (1986) Bobcat habitat use and home range size in relation to prey density. J Wildl Manag 50:110–117

Lombardi JV, Comer CE, Scognamillo DG, Conway WC (2017) Coyote, fox, and bobcat response to anthropogenic and natural landscape features in a small urban area. Urban Ecosyst 20:1239–1248

Lombardi JV, MacKenzie DI, Tewes ME et al (2020) Co-occurrence of bobcats, coyotes, and ocelots in Texas. Ecol Evol 10:4903–4917

Mangiacotti M, Scali S, Sacchi R et al (2013) Assessing the spatial scale effect of anthropogenic factors on species distribution. PLoS ONE 8:e67573

Manly BF, McDonald L, Thomas DL et al (2007) Resource selection by animals: statistical design and analysis for field studies. Springer Science & Business Media

Marneweck CJ, Allen BL, Butler AR et al (2022) Middle-out ecology: small carnivores as sentinels of global change. Mamm Rev 52:471–479

Marrotte RR, Bowman J, Morin SJ (2020a) Spatial segregation and habitat partitioning of bobcat and Canada lynx. FACETS 5:503–522

Marrotte RR, Bowman J, Wilson PJ (2020b) Climate connectivity of the bobcat in the Great Lakes region. Ecol Evol 10:2131–2144

Martin AE (2018) The spatial scale of a species' response to the landscape context depends on which biological response you measure. Curr Landsc Ecol Rep 3:23–33

Mayer AE Jr, TJM, Sullivan ME et al (2021) Population genetics and spatial ecology of bobcats (*Lynx rufus*) in a landscape with a high density of humans in New England. Northeast Nat 28:408–429

McGarigal K (1995) FRAGSTATS: spatial pattern analysis program for quantifying landscape structure. Department of Agriculture, Forest Service, Pacific Northwest Research Station. Cham, U.S

McGarigal K, Wan HY, Zeller KA et al (2016) Multi-scale habitat selection modeling: a review and outlook. Landsc Ecol 31:1161–1175

Mcnitt DC, Alonso RS, Cherry MJ et al (2020a) Influence of forest disturbance on bobcat resource selection in the central Appalachians. For Ecol Manag 465:118066

Mcnitt DC, Alonso RS, CherryFies MJ et al (2020b) Sex-specific effects of reproductive season on bobcat space use, movement, and resource selection in the appalachian mountains of virginia. PLoS ONE 15(8):e0225355

Mérő TO, Bocz R, Polyák L et al (2015) Local habitat management and landscape-scale restoration influence small-mammal communities in grasslands. Anim Conserv 18:442–450

Miguet P, Jackson HB, Jackson ND et al (2016) What determines the spatial extent of landscape effects on species? Landsc Ecol 31:1177–1194

Moll RJ, Cepek JD, Lorch PD et al (2020) At what spatial scale(s) do mammals respond to urbanization? Ecography 43:171–183

Moraga AD, Martin AE, Fahrig L (2019) The scale of effect of landscape context varies with the species' response variable measured. Landsc Ecol 34:703–715

Morris DW (1987) Ecological scale and habitat use. Ecol 68:362–369

Morris DW (1992) Scales and costs of habitat selection in heterogeneous landscapes. Evol Ecol 6:412–432

Nowak RM (2002) The original status of wolves in eastern North America. Southeast Nat 1:95–130

National Oceanic and Atmospheric Administration (2021) Climate Data Online

Ochoa GV, Chou PP, Hall LK et al (2021) Spatial and temporal interactions between top carnivores at water sources in two deserts of western North America. J Arid Environ 184:104303

Ogutu JO, Owen-Smith N, Piepho H-P et al (2012) Dynamics of ungulates in relation to climatic and land use changes in an insularized African savanna ecosystem. Biodivers Conserv 21:1033–1053

Olsen BRL, Fulbright TE, Hernández F (2018) Ground surface vs. black globe temperature in northern bobwhite resource selection. Ecosphere 9:e02441. https://doi.org/10.1002/ecs2.244

Pattison CA, Quinn MS, Dale P, Catterall CP (2016) The landscape impact of linear seismic clearings for oil and gas development in boreal forest. Northwest Sci 90:340–354

Perera-Romero L, Garcia-Anleu R, McNab RB, Thornton DH (2021) When waterholes get busy, rare interactions thrive: photographic evidence of a jaguar (*Panthera onca*) killing an ocelot (*Leopardus pardalis*). Biotropica 53:367–371

Poessel SA, Burdett CL, Boydston EE et al (2014) Roads influence movement and home ranges of a fragmentation-sensitive carnivore, the bobcat, in an urban landscape. Biol Conserv 180:224–232

Quinlan BA, Rosenberger JP, Kalb DM et al (2022) Drivers of habitat quality for a reintroduced elk herd. Sci Rep 12:20960. https://doi.org/10.1038/s41598-022-25058-9

Rabaiotti D, Woodroffe R (2019) Coping with climate change: limited behavioral responses to hot weather in a tropical carnivore. Oecologia 189:587–599

Rich LN, Beissinger SR, Brashares JS, Furnas BJ (2019) Artificial water catchments influence wildlife distribution in the Mojave Desert. J Wildl Manag 83:855–865

Riitters KH, O'Neill RV, Wickham JD, Jones KB (1996) A note on contagion indices for landscape analysis. Landsc Ecol 11:197–202

Riley SPD, Sauvajot RM, Fuller TK et al (2003) Effects of urbanization and habitat fragmentation on bobcats and coyotes in southern California. Conserv Biol 17:566–576

Robb BS, Merkle JA, Sawyer H et al (2022) Nowhere to run: semi-permeable barriers affect pronghorn space use. J Wildl Manag 86:e22212

Roberts NM, Crimmins SM (2010) Bobcat population status and management in North America: evidence of large-scale population increase. J Fish Wildl Manag 1:169–174

Rockhill AP, Chinnadurai SK, Powell RA, DePerno CS (2011) A comparison of two field chemical immobilization techniques for bobcats (*Lynx rufus*). J Zoo Wildl Med 42:580–585

Ruell EW, Riley SPD, Douglas MR et al (2012) Urban habitat fragmentation and genetic population structure of bobcats in coastal southern California. Am mid Nat 168:265–280

Rwanga SS, Ndambuki JM (2017) Accuracy assessment of land use/land cover classification using remote sensing and GIS. IJGSC 8:611–622. https://doi.org/10.4236/ijg.2017.84033

Šálek M, Drahníková L, Tkadlec E (2015) Changes in home range sizes and population densities of carnivore species along the natural to urban habitat gradient. Mamm Rev 45:1–14. https://doi.org/10.1111/mam.12027

Seigle-Ferrand J, Atmeh K, Gaillard J-M et al (2021) A systematic review of within-population variation in the size of home range across ungulates: what do we know after 50 years of telemetry studies? Front Ecol Evol 8:2020 https://doi.org/10.3389/fevo.2020.555429

Sikes RS, Animal Care and Use Committee of the American Society of Mammalogists (2016) Guidelines of the american society of mammalogists for the use of wild mammals in research and education. J Mammal 97(3):663–688

Smit IPJ, Grant CC, Devereux BJ (2007) Do artificial waterholes influence the way herbivores use the landscape? herbivore distribution patterns around rivers and artificial surface water sources in a large African savanna park. Biol Conserv 136:85–99

Smith JG, Jennings MK, Boydston EE et al (2020) Carnivore population structure across an urbanization gradient: a regional genetic analysis of bobcats in southern California. Landsc Ecol 35:659–674

Smith BD, Delgiudice GD, Severud WJ (2021) Technological advances increase fix-success for white-tailed deer GPS collars. Wildl Soc Bull 45:333–339

Steiner JL, Briske DD, Brown DP, Rottler CM (2018) Vulnerability of southern plains agriculture to climate change. Clim Change 146:201–218

Symmank M, Comer C, Kroll J (2008) Estimating bobcat abundance in East Texas using infrared-triggered cameras. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 62:64–69.

Tellaeche CG, Reppucci JI, Luengos Vidal EM et al (2020) Field chemical immobilization of Andean and pampas cats in the high-altitude Andes. Wildl Soc Bull 44:214–220

Thomas KA, Jarchow CJ, Arundel TR et al (2018) Landscape-scale wildlife species richness metrics to inform wind and solar energy facility siting: an Arizona case study. Energy Policy 116:145–152

Tucker SA, Clark WR, Gosselink TE (2008) Space use and habitat selection by bobcats in the fragmented landscape of south-central Iowa. J Wildl Manag 72:1114–1124

Tunstall T (2015) Recent economic and community impact of unconventional oil and gas exploration and production on south Texas counties in the Eagle Ford Shale Area. J Regional Anal 45:82–92

U. S. Fish and Wildlife Service (2021) National wetlands inventory website. Department of the Interior, Fish and Wildlife Service, Washington, D.C, U.S

United States Department of Agriculture (2020) Texas NAIP Imagery, 2020–04–01. Web. 2022–08–24

Walker BL (2022) Resource selection by greater sage-grouse varies by season and infrastructure type in a Colorado oil and gas field. Ecosphere 13:e4018

Webb SL, Zabransky CJ, Lyons RS, Hewitt DG (2006) Water quality and summer use of sources of water in Texas. Southwest Nat 51:368–375

Wiens JA (1989) Spatial scaling in ecology. Funct Ecol 3:385–397. https://doi.org/10.2307/2389612

Williams DM, Dechen Quinn AC, Porter WF (2012) Landscape effects on scales of movement by white-tailed deer in an agricultural–forest matrix. Landsc Ecol 27:45–57

Young KR (1997) Wildlife conservation in the cultural landscapes of the central Andes. Landsc Urban Plan 38:137–147

Young JK, Golla J, Draper JP et al (2019) Space use and movement of urban bobcats. Animals (basel) 9:E275

Zamuda KM, Duguid MC, Schmitz OJ (2022) Human land-use effects on mammalian mesopredator occupancy of a northeastern Connecticut landscape. Eco Evol 12:e9015