

SEASONAL DISTRIBUTIONS OF WILDLIFE INHABITING  
THE MADREAN ARCHIPELAGO

by

Kyle Thompson

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## ABSTRACT

Species distributions reflect the suite of resources and range of environmental conditions required by a species. Distributions of many species change seasonally, however, in response to changes in resource availability and environmental conditions, many of which are projected to shift in response to climate change. We sought to identify environmental and anthropogenic factors associated with seasonal changes in the distribution of vertebrates that inhabit the Madrean Archipelago in southern Arizona, which is important for identifying mechanisms through which climate change may affect these species. From July 2012 to February 2015 (966 days), we used remote cameras to survey 200 sites across 16 mountain ranges for a total of 69,434 trap days and used dynamic occupancy models to determine how landscape features, vegetation composition, and anthropogenic factors influenced the distributions and seasonal rates of local colonization and extinction of 13 vertebrates. For these 13 species, we recorded 37,888 detections, with gray foxes, skunks, and squirrels detected most frequently. Bobcats, cottontails, gray foxes, skunks, squirrels, javelina, puma, and coatimundis were all detected across the entire range of elevations surveyed, from 935 to 2395 m. Black bears and wild turkeys were never detected below 1270 m, Sonoran opossums never detected above 1980 m, and coyotes and ringtails never detected above 2020 m. Composition and structure of vegetation in the understory, midstory, and overstory influenced initial occupancy of several species, including skunks, coatimundis, Sonoran opossums, and cottontails. Season, either directly or as an interaction with the estimated amount of solar radiation reaching a site, influenced local extinction rates of all 13 target species and local colonization rates of 9 of 13 species. Elevation influenced local colonization rates of black bears and coatimundis positively, and coyotes, Sonoran

opossums, and cottontails negatively, and local extinction rates of skunks negatively and coyotes and black bears positively. These patterns indicate that the distributions of many species in this region change seasonally, likely as a mechanism to meet dietary, behavioral, or physiological needs in response to shifts in environmental conditions and resource availability. Therefore, species that depend on seasonal resources may be at higher risk of distributional shifts or range contractions if the distribution and phenology of these resources change in response to changes in climate.

## INTRODUCTION

Species distributions reflect the geographic limits of resources and environmental conditions required for an area to be habitable for a species (Peterson 2011). Climate, especially precipitation and temperature, governs the availability of seasonal resources and the timing of when conditions are suitable for a species (Franklin 2009). Therefore, seasonal variation in environmental conditions and resource availability manifest as spatial and temporal variation in the realized distributions of animals (Roshier et al. 2008).

Climate change will alter the distribution and phenology of many plant species (Kupfer et al. 2007, Reyer et al. 2013) and is likely to result in broad-scale distributional shifts in populations of many animal species (Parmesan 2006, Chen et al. 2011). When key resources become unavailable to animals because of significant geographical or phenological shifts, species that rely on these resources may be subject to increased risk of local extinction (Sax et al. 2013). Therefore, climate change is most likely to influence distributions of animals that depend on resources whose availability and timing are seasonal and that might no longer be available at the appropriate times in the appropriate locations (Bradshaw and Holzapfel 2008). These climate-driven interactions may have greater effects on animal species whose distributions change seasonally (Peterson 2011).

Conservation and management of species often has assumed that species' distributions are static in space and time (Pressey et al. 2007). Because distributions of many animal species are shifting, expanding, or contracting over time and in response to stressors such as climate change (Chen et al. 2011), we sought to identify environmental and anthropogenic factors that affect seasonal changes in the distribution of vertebrates, which is important for identifying mechanisms through which climate change may affect

these species. To accomplish this objective, we surveyed 200 sites with remote cameras in the Madrean Archipelago of southern Arizona and New Mexico for three years and used dynamic occupancy models to determine how landscape features, vegetation composition, and anthropogenic factors influenced the distributions and seasonal rates of local colonization and extinction of 13 vertebrates.

## METHODS

### *Study Area*

Our study area covered portions of southeastern Arizona and southwestern New Mexico (Figure 1). The western boundary was defined by the border of Tohono O’odham Nation along the crest of the Baboquivari Mountains in southern Arizona, the eastern boundary by the eastern slopes of the Peloncillo Mountains near the Arizona-New Mexico border, the southern boundary by the U.S.-Mexico border, and the northern boundary by Interstate 10. Elevations in this area range from approximately 900 m to 2,300 m, which contributes to high variation in both biotic and abiotic features.

Topography in the region is basin and range, with a series of mountain ranges that support fragments of forests that were once interconnected but are now surrounded by deserts and grasslands created by retreating glaciers during the end of the Pleistocene (Lomolino et al. 1989). This network of mountain ranges, deserts, and grasslands form the Madrean Archipelago, which creates a wide range of environmental conditions and microclimates that foster high vegetation diversity (Whittaker and Niering 1965, Gehlbach 1993). Vegetation communities at low- to mid-elevations include Sonoran desert scrub, Chihuahuan desert scrub, semi-desert grassland, plains and Great Basin grasslands, and Madrean evergreen woodland, with Rocky Mountain montane and

subalpine coniferous forest at the highest elevations (Brown 1994). In summer, maximum temperatures reach 32°C and in winter drop below 0°C, with snow common at higher elevations (NOAA 2015). Precipitation across the region is bimodal with 2 rainy seasons; lighter rains are typical during winter and heavy rains during summer, a product of monsoon storms that deliver up to 50% of annual precipitation (Sheppard et al. 2002) and influence many biotic and abiotic processes (Gottfried 2001).

Most of the area we studied is managed by the U.S. Forest Service, U.S. National Park Service, U.S. Fish and Wildlife Service, and U.S. Bureau of Land Management, although some parcels are managed by the Arizona State Land Department and private landowners.

### *Sampling Design*

Across the 16 mountain ranges in the study area, we established 200 sites that we surveyed with cameras from July 2012 to February 2015; we established 130 sites by July 2012 and all 200 sites by July 2013 (Figure 1). We surveyed between 2 and 41 sites per mountain range (mean = 12.9 sites/range), which varied based on the size of the range and ease of access. We established sites in areas where landscape features were likely to function as movement corridors for animals, including canyons, washes, ridges, saddles, along animal trails, and in areas with high vegetation cover and perennial water. We installed cameras on natural features, each outfitted with a remote trigger and white flash (DLC Covert Deuce and Scoutguard; Karanth et al. 2004); at 68% of sites we installed 2 opposing cameras and at the other 32% of sites, where chances of vandalism and theft were high, we installed 1 camera. Adjacent sites were >1 km apart. We replaced batteries and memory cards every 30-90 days.

### *Habitat Sampling*

We characterized 24 environmental features of each site (Table 1), 9 at larger spatial scales that we quantified with a GIS and 15 at each site that we measured in the field. For the 9 larger-scale environmental features, we used spatial data with 30-m<sup>2</sup>-pixel resolution to characterize a set of 12 non-overlapping concentric rings that spanned a range of areas from 1 to 10,000 ha that reflected the range of home-range sizes of species we detected (Table 2, Figure 2). We chose concentric rings because they provide more information and are more spatially independent than overlapping circular plots (Swindle 1999). Within each concentric ring, we estimated mean Terrain Ruggedness (Riley et al. 1999), density of springs (Table 1), and the area covered by the dominant biotic communities classified at a relatively coarse scale (1:1,000,000) (Brown 1994). We reduced the 7 biotic communities in the area to 5 by combining Sonoran desert scrub and Chihuahuan desert scrub into desert scrub, and coniferous forest and subalpine coniferous forest into coniferous forest; we left Madrean evergreen, semi-desert grassland, and plains grassland as unique communities. We also quantified 6 large-scale anthropogenic features: density of first-order roads (unmaintained), second-order roads (maintained and/or paved), recreational trails, and mines (active or inactive), length of the U.S.-Mexico international border bisecting each ring, and the mean Human Influence Index, a composite of 8 measures of human influences on ecosystems (Sanderson et al. 2002).

At each site, we established a 20 x 20-m plot, centered on the camera view, where we characterized physical structure, vegetation structure and composition, human activities, and climate (Figure 2). If the site was in a wash or canyon, we measured its width from a point established 1.75 m above the ground; if not in a wash or canyon, we

recorded width as 100 m. To characterize vegetation composition and structure, we established 3, 20-m transects parallel to the stream course or trail, 1 located in the middle of the plot and 2 located 5 m to either side of center transect (Figure 3). Along each transect, we used line-intercept methods at 3 heights above the ground to estimate percent cover of (1) bare soil, rock, litter/debris, grass, forbs, and midsize vegetation including shrubs and trees in the understory (<1 m), (2) subshrubs, shrubs, and trees in the midstory (1-2 m), and (3) tree canopies in the overstory (>2 m) (Elzinga et al. 2009). We recorded the species of each tree and shrub and height of each overstory tree. If a portion of a transect could not be surveyed because topography made it inaccessible, we excluded it from vegetation summaries. We combined vegetation into understory, midstory, and overstory classes for analysis. In the understory, we combined vegetation into 5 variables: forbs, succulents, litter, graminoids, and midsize vegetation, which included all other shrubs and trees. In the midstory, we combined vegetation into 4 variables: shrubs, oaks, all other trees, and dead vegetation. In the overstory, we combined vegetation into 3 variables: oaks, all other living trees, and all dead trees.

We used a Points Solar Radiation tool in ArcGIS 10.2 to estimate the amount of solar radiation at each site (Environmental Systems Research Institute, Redlands, CA, USA). We used data from NOAA to estimate mean minimum monthly temperature for each site based on a multiple linear regression of elevation, month, and UTM coordinates with data from 31 weather stations across the study area (analysis not shown; NOAA 2015). To characterize human activity, we quantified 4 variables: number of individual human footprint tracks, trash piles, cow dung piles, and individual detections of humans

captured by cameras. Lastly, we recorded whether seasonal or perennial water was present within the plot.

Prior to analysis, we used principal component analysis (PCA) derived from correlation matrices to reduce dimensionality of vegetation cover (log transformed) in the understory, midstory, and overstory separately (3 PCAs), and for cover of biotic communities (log transformed) in each concentric ring separately (12 PCAs). As covariates for analysis, we used the first 2 principal components from each vegetation PCA and the first principal component for biotic communities. We used Pearson correlations to evaluate relationships between principal components and the original variables.

#### *Dynamic Occupancy Analyses*

We selected species as targets for analysis that were neither rare nor ubiquitous, specifically those we detected at least once on >30% and <90% of sites (Table 3). We classified individuals detected in photographs as unique when there was at least 1 hour between photographs of the same species at the same site.

We used dynamic occupancy models to identify covariates that explained variation in initial occupancy ( $\psi$ ), local colonization ( $\gamma$ ) and local extinction probabilities ( $\epsilon$ ) between sequential seasons, and detection probability ( $p$ ) (MacKenzie et al. 2003, 2006), an approach that allowed us to evaluate which environmental features influenced occupancy and seasonal dynamics of each species while accounting for imperfect surveys. We identified 4 seasons as primary sampling periods (MacKenzie et al. 2003), which we classified by monthly precipitation and temperature (NOAA 2015). Specifically, we classified January, February, and March as winter/spring, a relatively

cold and wet season; April, May, and June as spring/summer, a relatively hot and dry season; July, August, and September as monsoon, a relatively hot and humid season; and October, November, and December as fall/winter, a relatively cold and dry season. We surveyed sites for 11 consecutive seasons starting with monsoon of 2012 through winter/spring of 2015. We used 2-week periods as secondary sampling periods for encounter histories of detections of each species at each site. We used the R package `unmarked` for analysis (Fiske and Chandler 2011).

We established a set of covariates with potential to influence each of the 4 parameters (Table 1) that we explored sequentially for each species. For detection probability, we considered season and corridor width as covariates. For initial occupancy, we divided covariates into 3 subsets (vegetation, landscape, and human influences) that we first explored separately (Table 1) based on set of concentric rings that matched most closely the home-range size reported for each species (Table 2). If models that included covariates for all concentric rings did not converge, we ran models for concentric rings separately. For local colonization and extinction, we considered mean minimum monthly temperature, number of human detections, elevation, and the interaction of season and solar radiation to reflect that the amount of solar radiation reaching the surface of the earth depends directly on time of year. We used backwards elimination (Ramsey and Schafer 2012) to identify covariates that influenced detection probability, then initial occupancy, and finally local colonization and extinction probability, retaining those covariates from previous steps that had some explanatory power ( $P < 0.10$ ). Lastly, we combined all remaining covariates into a final model and retained only those covariates with explanatory power ( $P < 0.10$ ).

## RESULTS

We surveyed 200 sites over a period of 966 days between July 1, 2012 and February 21, 2015 for a total of 69,434 trap days and mean of 347.2 (SE = 17.11) survey days per site (Table 3). We recorded 70,716 detections of 38 species or species groups, with white-tailed deer, humans, and gray foxes detected most frequently (Appendix 1). For the 13 target species, we recorded 37,888 detections, with gray foxes, skunks, and squirrels detected most frequently (Table 3). Bobcats, cottontails, gray foxes, skunks, squirrels, javelina, puma, and coatimundis were all detected across the entire range of elevations that we surveyed (935 to 2395 m). Black bears and wild turkeys were never detected below 1270 m, Sonoran opossums never detected above 1980 m, and coyotes and ringtails never detected above 2020 m (Table 3).

The first 2 principal components derived from vegetation features at camera focal points explained 37%, 63%, and 75% of variation in understory, midstory, and overstory vegetation, respectively (Table 4). Principal components for understory vegetation were correlated with cover of forbs, shrubs, and midsize vegetation ( $|r| > 0.13$ ,  $P < 0.07$ ); principal components for midstory vegetation were correlated with cover of dead vegetation, shrubs, and oak trees ( $|r| > 0.22$ ,  $P < 0.08$ ); and principal components for overstory vegetation were correlated with cover of oak trees and other tall trees ( $|r| > 0.16$ ,  $P < 0.03$ ). The first principal component based on cover of biotic communities in each of the 12 concentric rings explained 37-42% of variation in the original data (Table 5).

### *Initial Occupancy*

Composition of understory vegetation based on the first principal component (PC1) influenced initial occupancy by skunks positively, composition of midstory vegetation (PC1) influenced occupancy by coatimundis negatively, and composition of overstory vegetation (PC1) influenced occupancy by coatimundis positively (Figure 5, Table 6). Mean height of trees in the overstory influenced occupancy by Sonoran opossums positively and cottontails negatively (Figure 5, Table 6). Composition of biotic communities influenced only coyotes (Tables 5 and 6), which may be an artifact of the coarse scale of this measure.

The degree of human influence on the landscape based on the Human Influence Index effected initial occupancy by coyotes and Sonoran opossums positively and black bears negatively (Table 6, Figure 4). Terrain ruggedness influenced occupancy by ringtails positively (Table 6) and trail density influenced occupancy by turkeys positively (Table 6).

### *Colonization and Extinction*

Season and elevation influenced the probability of local colonization for many species (Table 7). Season, either directly or as an interaction with solar radiation, influenced local colonization rates of 9 of 13 target species (Table 7). Solar radiation alone influenced local colonization rates of bobcats and turkeys positively and the interaction between season and solar radiation influenced local colonization rates of cottontails, fox, and skunks (Table 7). Local colonization rates were highest for black bears during fall/winter and lowest during monsoons, and highest for skunks during monsoons and lowest during spring/summer (Figure 7). Elevation influenced local

colonization rates of black bears and coatimundis positively and coyotes, Sonoran opossums, and cottontails negatively (Figure 6). The number of humans detected influenced local colonization rates of javelina, Sonoran opossums, pumas, and squirrels positively (Table 7).

Season, elevation, and temperature influenced the probability of local extinction for many species. Season, either directly or as an interaction with solar radiation, influenced local extinction rates of all 13 target species (Table 8). Elevation influenced local extinction rates of skunks negatively and coyotes and black bears positively (Figure 8, Table 8). The probability of local extinction was highest for black bears during monsoons and lowest during spring/summer, and highest for cottontails during monsoons and lowest during winter/spring (Figure 9). The mean minimum monthly temperature influenced local extinction rates of coatimundis, cottontails, fox, javelina, and skunks negatively (Table 8). The number of humans detected influenced local extinction rates of black bears, bobcats, and pumas negatively (Table 8). The interaction between solar radiation and season influenced local extinction rates of bobcats, coatimundis, javelina, and ringtails (Table 8).

#### *Detection Probability*

Season influenced detection probability for all 13 species and corridor width influenced detection probability of black bears, cottontails, and fox positively (Table 9). Detection probability was relatively constant across seasons for coyotes, coatimundis, skunks, Sonoran opossums, and cottontails, and was especially low for black bears during winter/spring (Figure 10).

## DISCUSSION

Multiple factors have potential to explain seasonal shifts in distributions of animals, including changes in environmental conditions and in the availability of key resources (Sax et al. 2013). Because climate and resource availability can change markedly across seasons throughout much of the temperate zone, many species shift their distributions in response to these changes. Accordingly, we found evidence of seasonal extinctions at sites for all 13 target species and seasonal colonizations of sites for 9 of 13 species (Tables 7 and 8). These patterns suggest seasonal changes in the distributions of many species in this region, likely as a mechanism to meet dietary, behavioral, or physiological needs in response to shifts in environmental conditions and resource availability.

Food resources, which often have a strong seasonal signal (Stenseth et al. 2002), may be one of the most influential factors governing seasonal movements of animals (Dingle and Drake 2007). For example, changes in food availability in response to changes in climatic conditions are thought to explain systematic short-distance seasonal movements in many species including tropical birds (Boyle 2010) and bighorn sheep (*Ovis Canadensis*, Geist 1971), as well as long-distance migrations in African ungulates and many other species (Dingle 1996). Diets of many of the 13 target species include vegetation and invertebrates that vary in abundance and availability throughout the year (Germaine and McPherson 1998, Moore et al. 2013). Seasonal changes in distributions of omnivores and mesopredators likely reflect temporal variation in a wide range of food resources, such as fruits, nuts, insects, small mammals, birds, bird eggs, and reptiles (Kanda et al. 2009). Species that are highly mobile and depend on ephemeral food resources can move easily among dispersed resource patches (Runge 2014). Home-range

sizes and core-use areas of coatimundis, for example, vary in space with resource availability and core-use areas shift with changes in resource abundance (Bixler and Gittleman 2000), breeding season (Ratnayake et al. 1994), and water availability in drier climates (Valenzuela and MacDonald 2002). Seasonal changes in distributions of Sonoran opossums and skunks (Tables 7 and 8) likely reflect spatial and temporal variation in ephemeral food resources as their distributions change seasonally in response to shifts in resource availability (Gipson and Kamler 2001). Similarly, some black bears shift the locations of their home ranges based on seasonal availability of fruit and have been observed as far as 59 km from their home ranges (Lecount 1980). Therefore, changes in the availability of key food resources likely explain many of the seasonal distribution shifts we observed for species in the Madrean Archipelago.

Distributions of species with generalist diets may be less sensitive to seasonal changes in food resources than species with more specialized diets. Specialist predators may shift their distributions in response to vegetation that predicts reliably the presence of prey (Ujvari et al. 2011). Although many of the carnivores we observed are highly mobile and have overlapping resource requirements, including bobcats, gray foxes, and coyotes (Harestad and Bundell 1979, Gittleman and Harvey 1982, Neale and Sacks 2001), some species may rely more on seasonally variable food resources than others. We found that colonization changed seasonally for bobcats and foxes, but not coyotes (Table 7), perhaps because bobcats are specialist predators that focus on smaller mammals and whose home ranges change seasonally in response to changes in prey abundance (McKinney and Smith 2007). Although diets of gray foxes are more general than bobcats, they also depend on some food resources that are only available seasonally, such as fruits

during summer (Neale and Sacks 2001). Diets of bobcats and gray fox are more specific than coyotes, which are more opportunistic and subsequently exploit a wider variety of food resources (Neale and Sacks 2001, Arjo et al. 2002).

Distributions of species with generalist diets may not be governed entirely by the distribution of food resources, but also by physiological requirements and environmental conditions (Sax et al. 2013). This may be especially influential in the Madrean Archipelago where a wide range of microclimates occurs in close proximity, a function of large elevation gradients and varying aspects. We found that distributions of species including javelina, cottontails, and black bears changed seasonally likely in response to changes in environmental conditions and their physiological constraints. For example, 3 interrelated covariates, season, solar radiation, and elevation influenced local colonization and extinction rates of javelina (Tables 7 and 8) that may shift their distributions seasonally in response to change in temperature because they have a narrow thermal-neutral zone (Schweinsburg 1971, Zervanos 1975). Local colonization of sites by cottontails was also influenced by an interaction between solar radiation and season, although their seasonal movements are relatively small and stable given a set of physiological adaptations that conserve energy, such as fluctuating metabolic rates (Hinds 1973, Hoffmeister 1986). We also found that season influenced local colonization and extinction of sites by black bears (Tables 7 and 8), which might be explained by pregnant females that usually den during winter, which expresses as sites that were once inhabited by individuals that den become extinct and later recolonized in spring (Lecount 1982, Doan-Crider and Hellgren 1996).

### *Human Influences*

Humans have altered the structure of landscapes in a multitude of ways that affect the abundance and distribution of resources important to animals, from large-scale changes in land use, such as agriculture or residential development, to smaller-scale changes, such as installing roads or trails (Carter et al. 2012). Further, even the presence of humans in relatively natural settings for short periods can affect use by animals, such as has been observed in response to for recreational activities (Steidl and Powell 2006) and movements of immigrants and law enforcement officers along the U.S.-Mexico border (Flesch et al. 2009). We found that the number of humans detected at a site was associated positively with local colonization rates of javelina, Sonoran opossums, and pumas (Table 7) and associated negatively with local extinction rates of black bears, bobcats, and pumas (Table 8). Some of these patterns are likely artifacts of locating sites in canyons and washes that are used commonly as travel corridors by recreationists, humans traveling from Mexico, and the U.S. Border Patrol (Duncan et al. 2010). Even though the presence of humans can influence the presence and behavior of wildlife (Steven et al. 2011), within the range of human activities that occur in the areas we surveyed, transient activities by humans in the Madrean Archipelago may not have long-term effects on the presence of many species (Gill et al. 2001, Stankowitch and Blumstein 2005).

The increasing human population and associated developments in southeastern Arizona (ADOA-EPS 2016) along with changing climate patterns could be facilitating the northward range expansion of several species, such as Sonoran opossums, though few data are available (Babb et al. 2004). Human Influence Index, a synthetic measure of

human population density, land use, and infrastructure, affected initial occupancy of Sonoran opossums and coyotes positively, likely reflecting their positive responses to anthropogenically-derived resources (McKinney 2002). In contrast, although black bears in some regions forage in urban areas (Beckmann and Berger 2003), we found initial occupancy of bears to be lower in areas where human influence was high.

#### *Management Implications and Recommendations*

We found that distributions of most mid- and large-sized species in the Madrean Archipelago changed seasonally, which may have implications for species that are not classified as highly vulnerable to range contractions or population reductions from climate change (Coe et al. 2012). In particular, species that depend on resources that are available seasonally may be at higher risk of distributional shifts if the distribution and phenology of resources on which they rely change.

The southwestern U.S. is predicted to become drier and hotter over the next century (Dominguez et al. 2010), with precipitation projected to decrease by 6% and temperatures to rise 2-4 °C (Christensen et al. 2007, Garfin 2009). Long-term droughts, which may become more common because of climate change (Sterle et al. 2008), have been linked to mortality and die-offs of several dominant tree species and other important plants that may cause shifts in ecotones (Allen et al. 2010). Climate change may alter current distributions of many species by affecting the vegetation resources that governs these distributions. This is important because changes in vegetation phenology in response to climate change will likely affect a wide range of vertebrates (Coe et al. 2012). Anticipated changes in phenology could affect timing of vegetation growth and production of fruits and seeds (Reyer et al. 2013), such as acorns produced by a diverse

assemblage of oaks (*Quercus* spp.), the abundance of which is governed by precipitation and temperature (Germaine and McPherson 1998), and the availability of invertebrates (Moore et al. 2013).

Changes in the distribution of vertebrates in response to climate change could result in range contractions for some species and reduced connectivity in areas where resource availability and vegetation phenology changes (Parmesan 2006, Chen et al. 2011, Koprowski et al. 2013). Species inhabiting the highest elevation areas in the region, such as black bears, coatimundis, and ringtails, are most likely to be affected by upslope shifts in vegetation because the highest biotic communities and associated resources are most likely to recede (Breshears et al 2008). Because climate change may impact the timing and distributions of seasonal resources in the Madrean Archipelago, management and conservation actions will have to be implemented over different spatial and temporal scales (Lawler 2009). Conservation and management actions should be considered that maintain habitat characteristics necessary for vulnerable species (Sax et al. 2013), but because solutions for many species will be challenging to define, the focus of conservation and management may need to shift from maintaining historic patterns to maintaining likely species assemblages in the future.

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Figure 1. Map of study area showing locations of the 200 sites surveyed (●) in southeastern Arizona and southwestern New Mexico, 2012-2015.

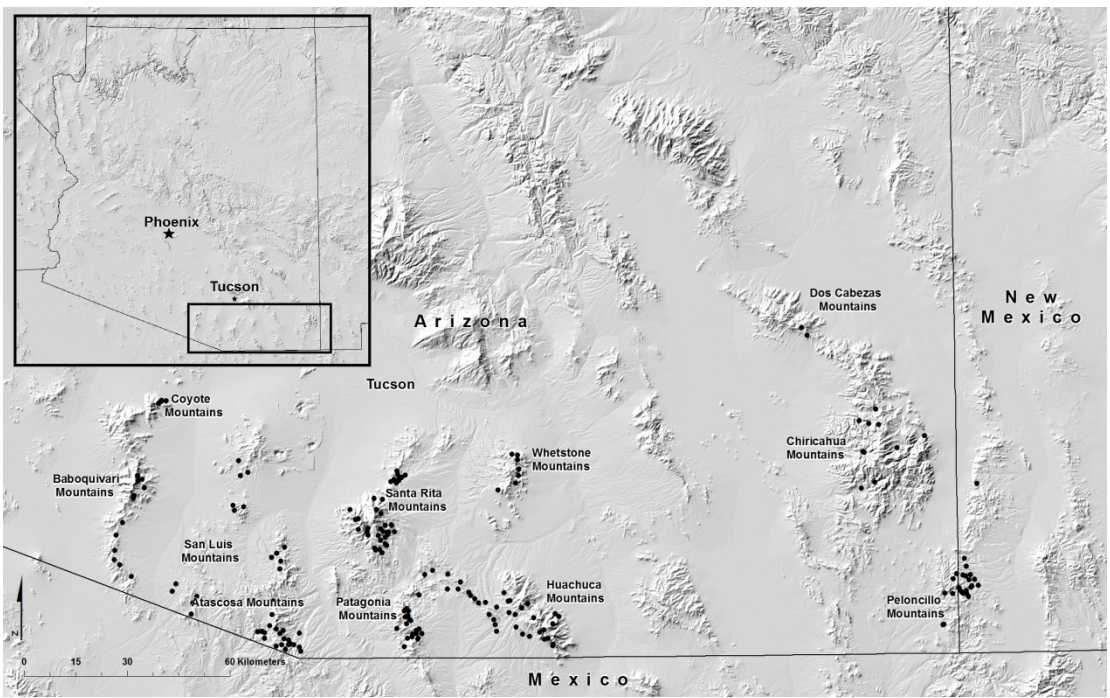


Figure 2. Sizes of concentric ring-plots based on home-range sizes of target species (Table 2).

### Concentric Ring Plots

Total Circular Area (ha)

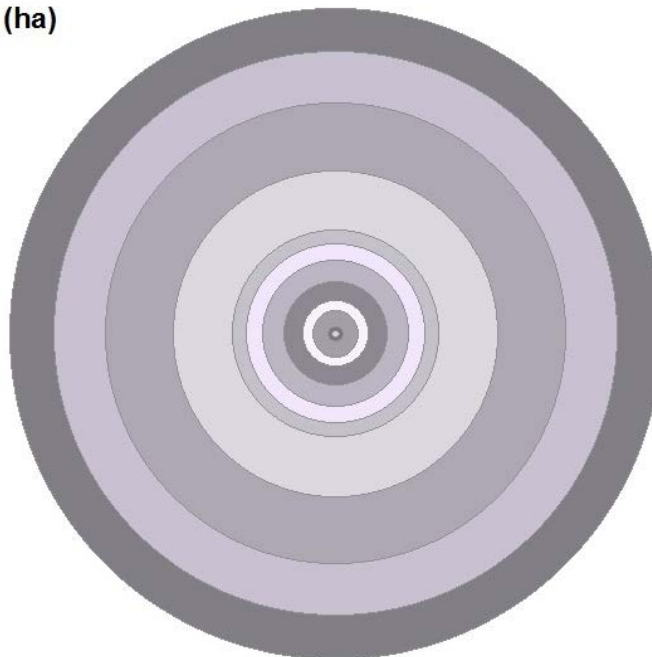
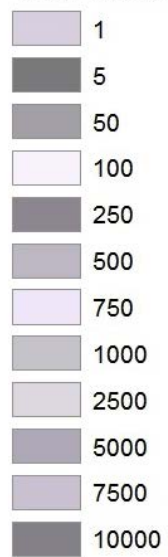


Figure 3. Layout of transects on 20-x-20-m plots established at each survey site.

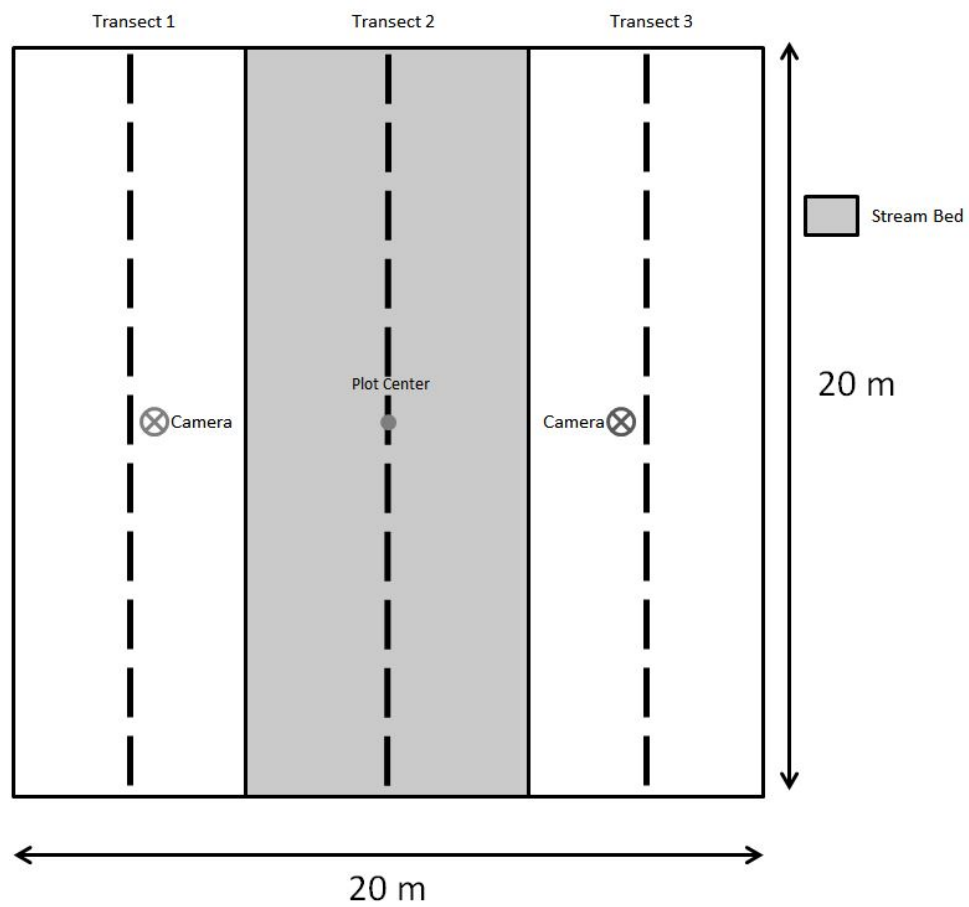


Figure 4. Influence of Human Influence Index on probability of initial occupancy by black bears, coyotes, coatimundis, skunks, Sonoran opossums, and cottontails, southeastern Arizona and southwestern New Mexico, 2012-2015.

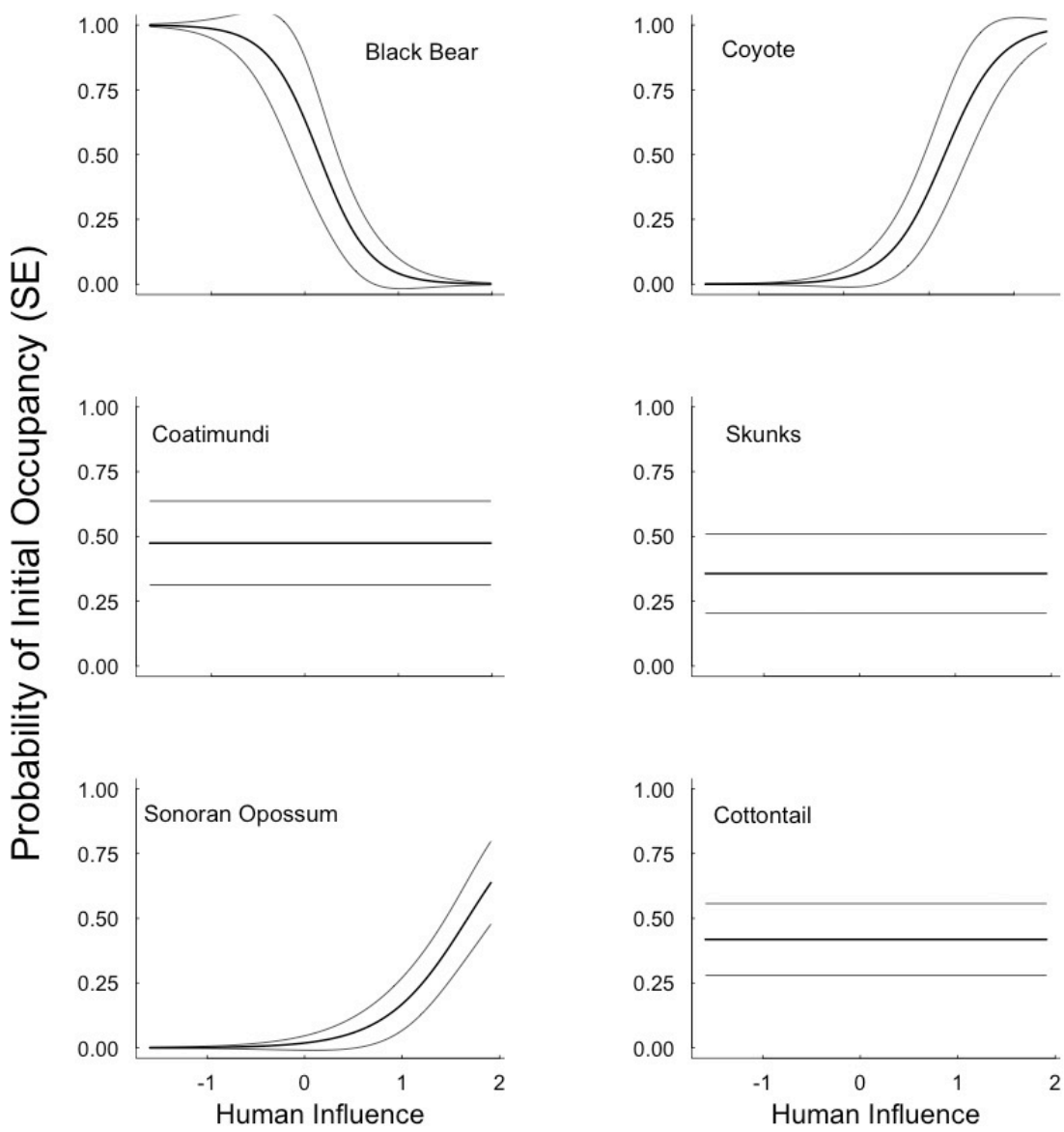


Figure 5. Influence of understory, midstory, overstory vegetation cover, and mean tree height on the probability of initial occupancy by coatimundis, skunks, Sonoran opossums, and cottontails, southeastern Arizona and southwestern New Mexico, 2012-2015.

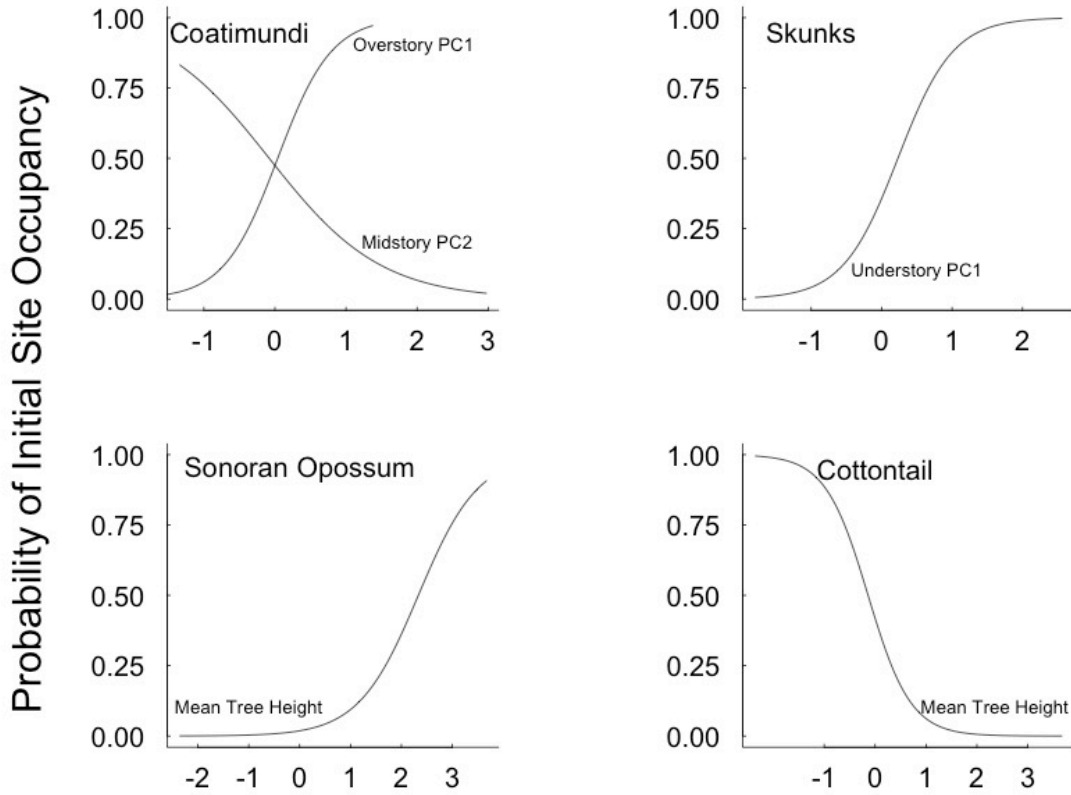


Figure 6. Influence of elevation on the probability of local colonization by black bears, coyotes, coatimundis, skunks, Sonoran opossums, and cottontails, southeastern Arizona and southwestern New Mexico, 2012-2015.

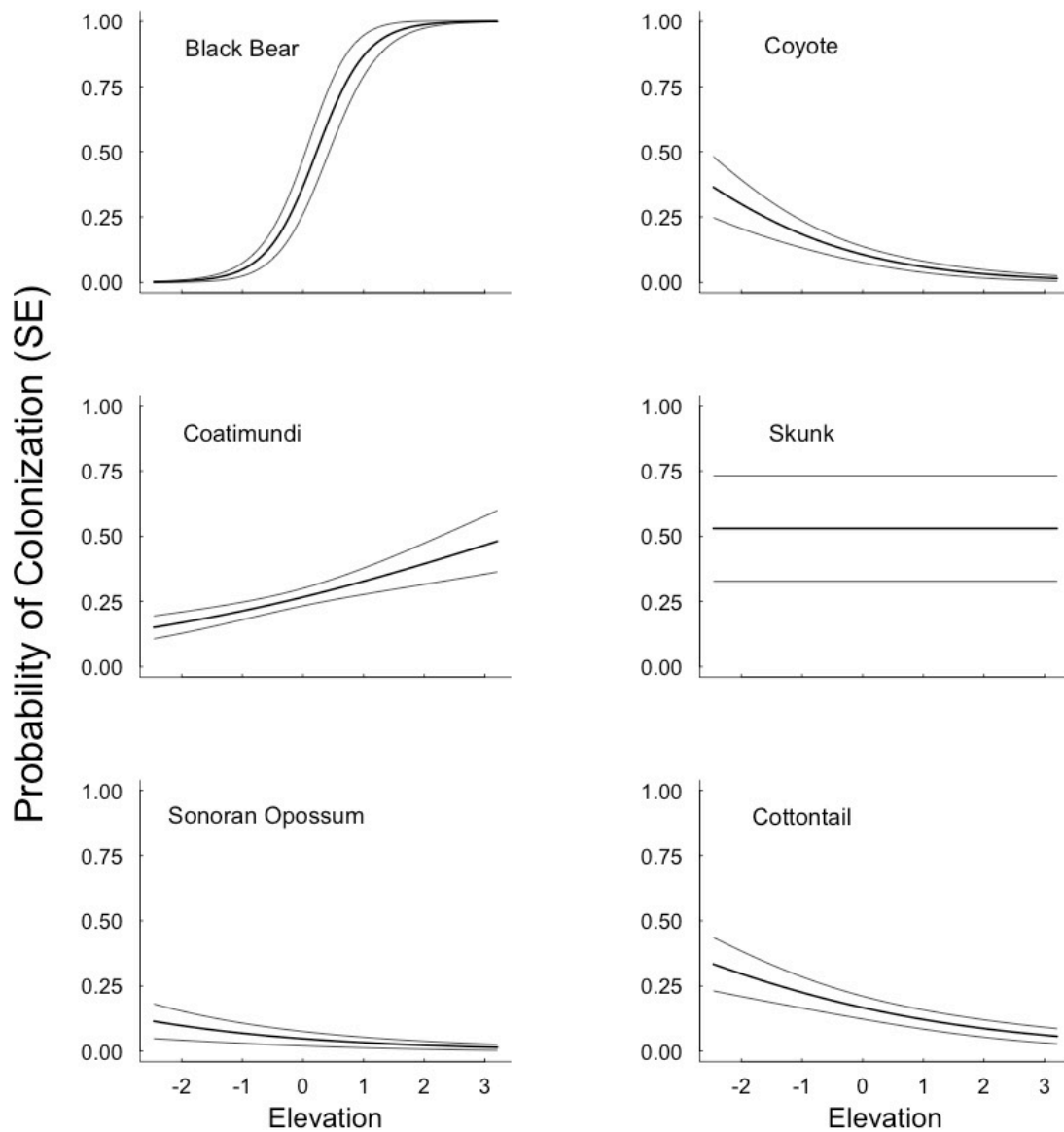


Figure 7. Influence of season on the probability of local colonization by black bears, coyotes, coatimundis, skunks, Sonoran opossums, and cottontails, southeastern Arizona and southwestern New Mexico, 2012-2015.

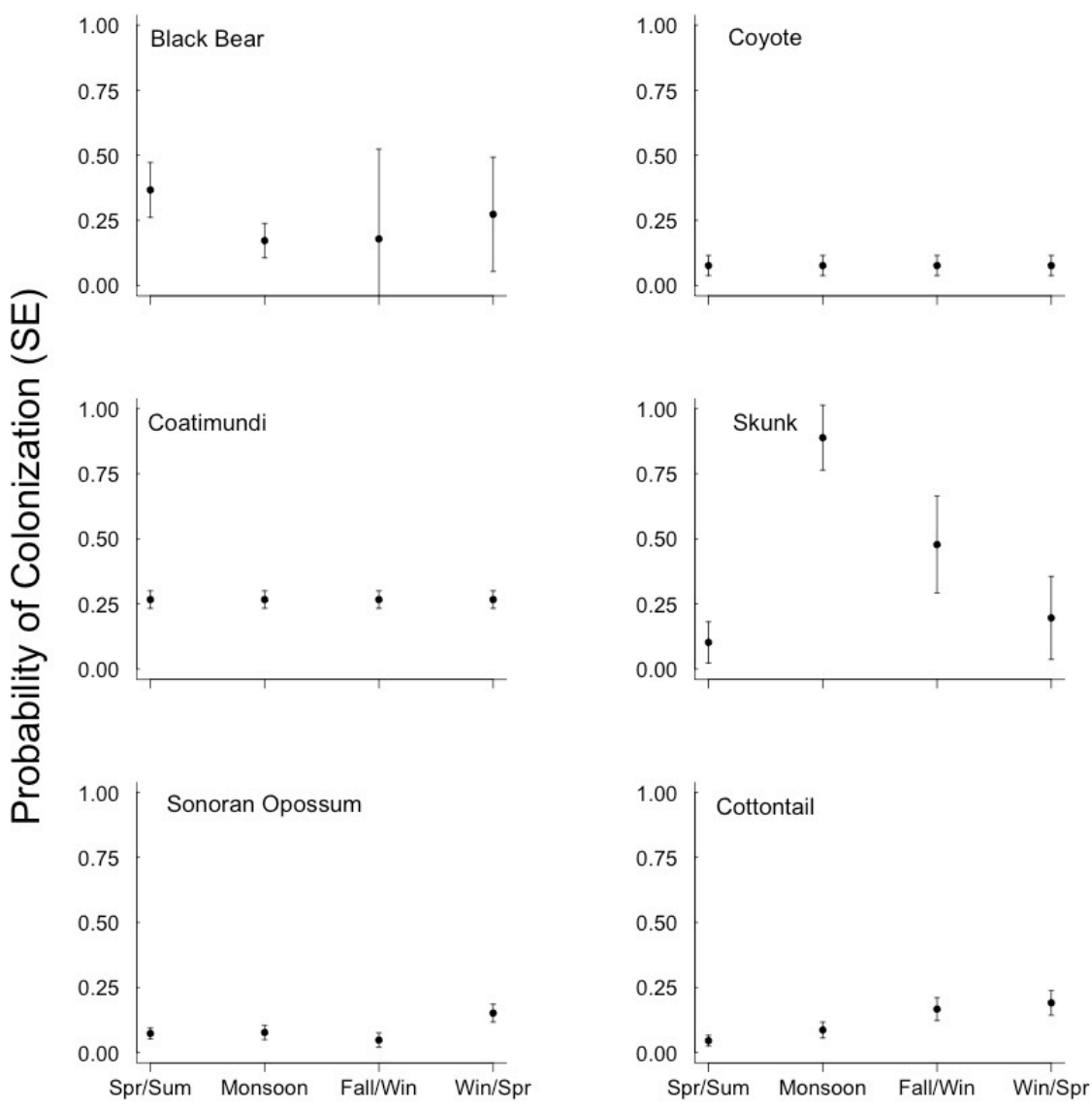


Figure 8. Influence of elevation on the probability of local extinction by black bears, coyotes, coatimundis, skunks, Sonoran opossums, and cottontails, southeastern Arizona and southwestern New Mexico, 2012-2015.

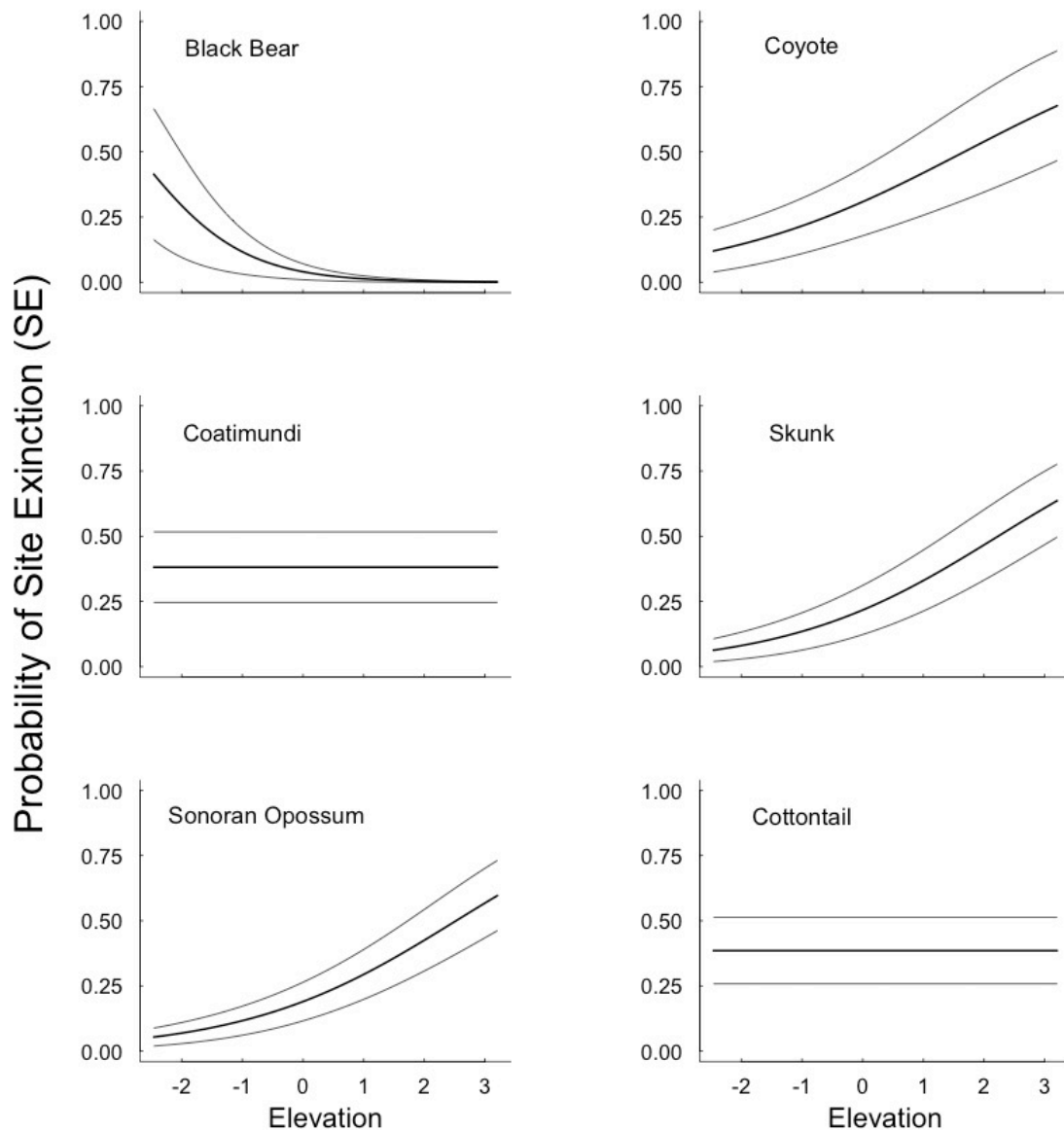


Figure 9. Influence of season on the probability of local extinction by black bears, coyotes, coatimundis, skunks, Sonoran opossums, and cottontails, southeastern Arizona and southwestern New Mexico, 2012-2015.

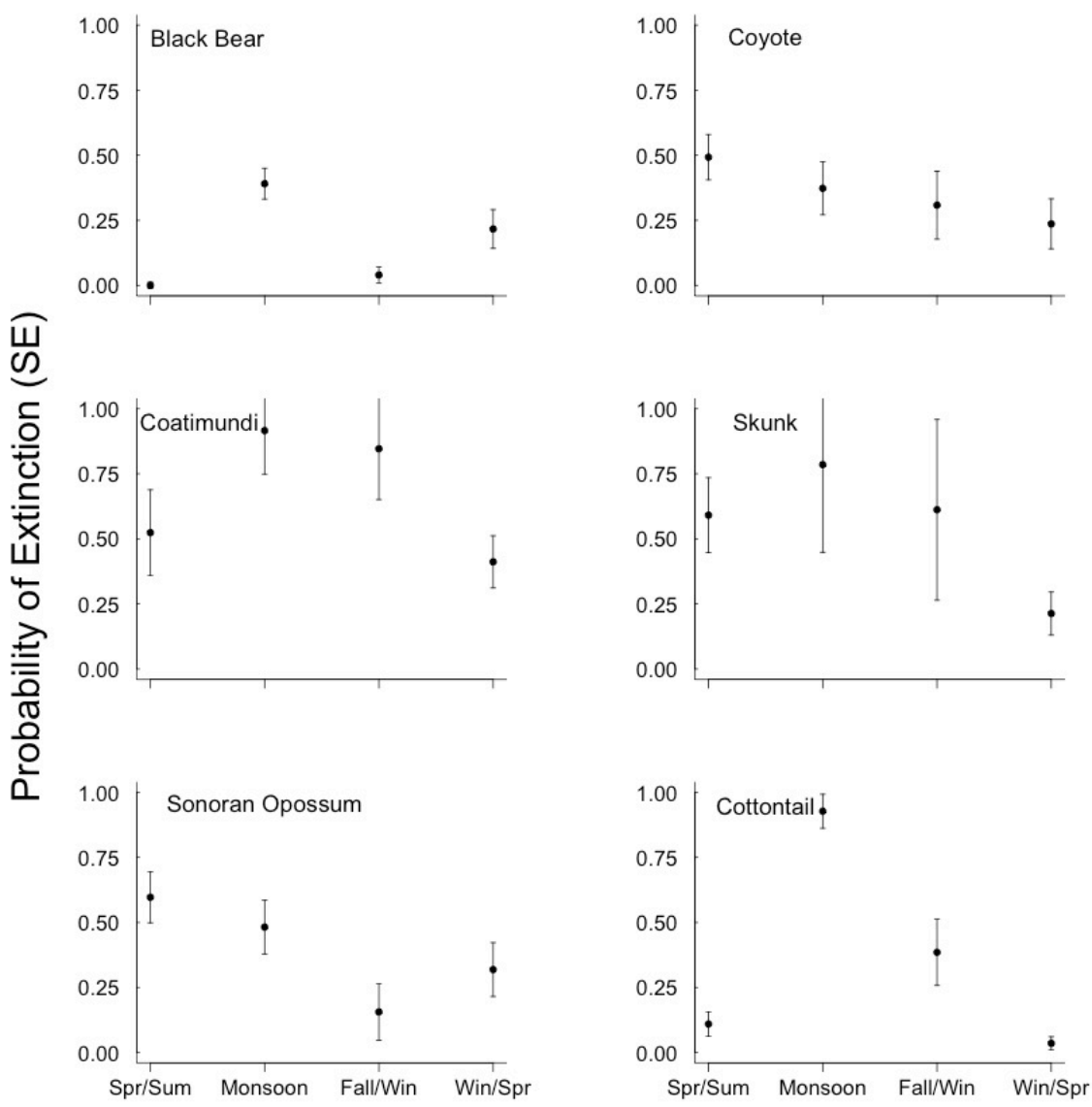


Figure 10. Influence of season on detection probability of black bears, coyotes, coatimundis, skunks, Sonoran opossums, and cottontails, southeastern Arizona and southwestern New Mexico, 2012-2015.

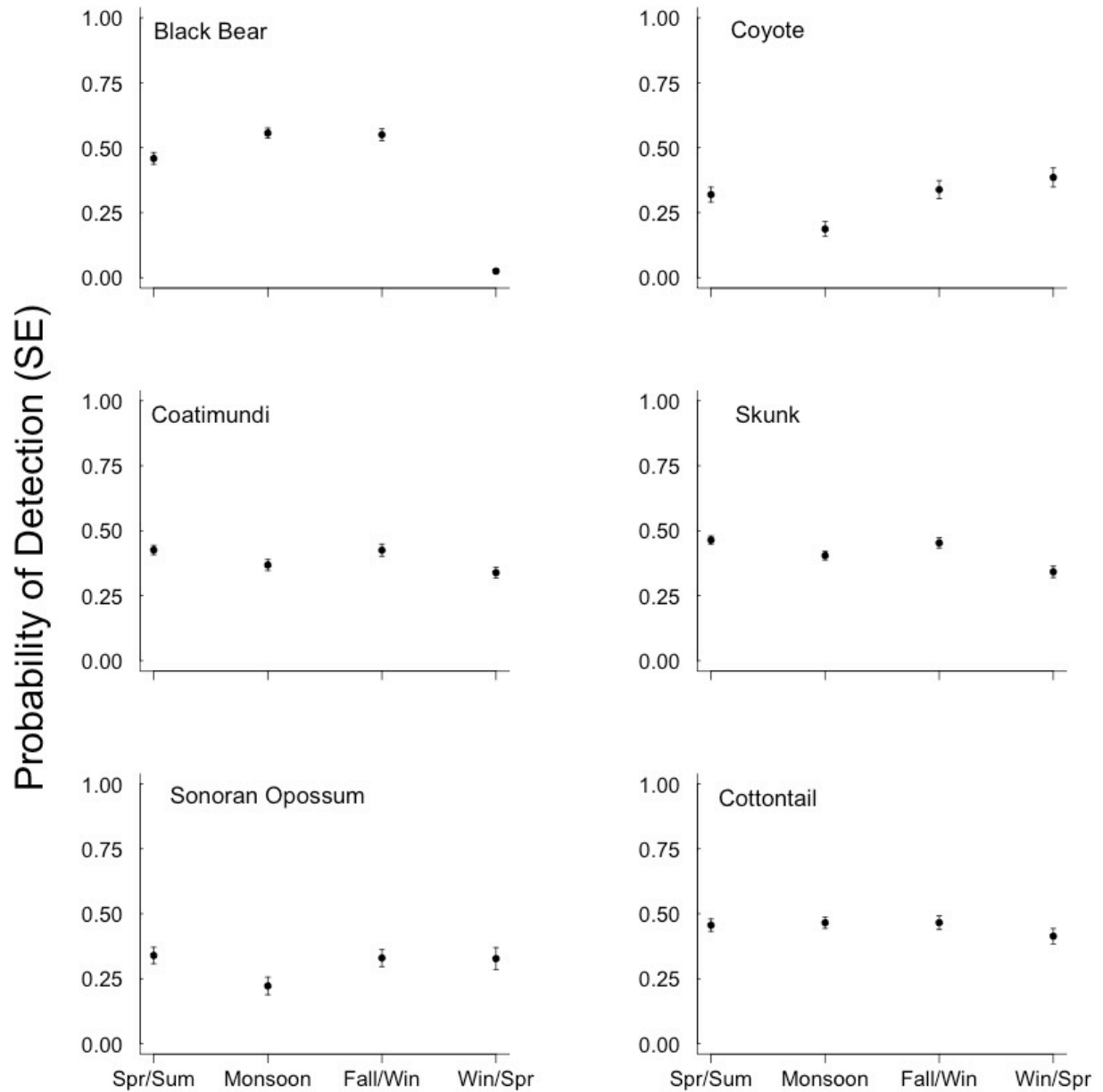


Table 1. Covariates evaluated for initial occupancy ( $\psi$ ), local colonization ( $\gamma$ ), and local extinction ( $\epsilon$ ), and detection probability ( $p$ ), and their associated scales.

Group	Covariate	Description	Scale	Parameter
Vegetation	Corridor width (m)	Width of wash or canyon 1.75 m above ground	Plot	$p$
	Vegetation species richness	Number of species recorded	Plot	$\psi$
	Mean height of trees (m)	For all trees recorded	Plot	$\psi$
	Understory vegetation cover	Cover of vegetation <1 m from ground	Plot	$\psi$
	Midstory vegetation cover	Cover of vegetation 1-2 m from ground	Plot	$\psi$
	Overstory vegetation cover	Cover of vegetation >2 m from ground	Plot	$\psi$
	Biotic community (ha)	Total area covered by biotic community	Concentric Rings	$\psi$
Human Influence	Trash piles	Number recorded	Plot	$\psi$
	Cow dung	Number recorded	Plot	$\psi$
	Human tracks	Number of unique tracks	Plot	$\psi$
	Human detections	Total number of individuals detected by camera	Plot	$\gamma, \epsilon$
	Human influence	Index of human influence 1-km pixel	Concentric Rings	$\psi$
	Mine density	Density of active and inactive mines	Concentric Rings	$\psi$
	Length of border	Total length of U.S.-Mexico border in plot	Concentric Rings	$\psi$
	Roads, first-order	Unmaintained road: 2 track and dirt roads	Concentric Rings	$\psi$
	Roads, second-order	Maintained road: dirt and paved roads	Concentric Rings	$\psi$
Trail density	Density of trails in ring	Concentric Rings	$\psi$	
Landscape	Elevation (m)	Elevation at camera location	Plot	$\gamma, \epsilon$
	Temperature (°C)	Estimated from GLM	Plot	$\gamma, \epsilon$
	Solar radiation (WH/m <sup>2</sup> )	Mean monthly solar radiation	Plot	$\gamma, \epsilon$
	Water, seasonal	Presence of ephemeral water source	Plot	$\gamma, \epsilon$
	Water, perennial	Presence of perennial water source	Plot	$\gamma, \epsilon$
	Spring density	Density of springs in ring	Concentric Rings	$\psi$
	Terrain ruggedness	Terrain ruggedness index 1-km pixel	Concentric Rings	$\psi$

Table 2. Common name, Latin binomial, estimated home-range sizes, maximum spatial scale used for analysis, and relevant references for target species in southeastern Arizona and southwestern New Mexico, 2012-2015.

Species	Common Name	Home Range (ha)	Max. scale (ha)	References	
				Home-Range Size	Seasonal Home-Range Shift
<i>Bassariscus astutus</i>	Ringtail	43	50	Toweill and Teer 1980	Harrison 2012
<i>Canis latrans</i>	Coyote	7,598	10,000	Harestad and Bundell 1979	Andelt and Gipson 1979
<i>Didelphis virginiana californicus</i>	Opossum, Sonoran	114	750	Gipson and Kamler 2001	Gipson and Kamler 2001
<i>Lynx rufus</i>	Bobcat	321	500	Harestad and Bundell 1979	Lawhead 1984
<i>Meleagris</i> spp.	Turkey, wild	4,385	5,000	York and Schemnitz 2003	York and Schemnitz 2003
<i>Mephitidae</i> spp.	Skunks	295	500	Harestad and Bundell 1979	Bixler and Gittleman 2000
<i>Nasua narica</i>	Coatimundi, white-nosed	1,357	2,500	Hass 2002	Ratnayeke et al. 1994, Hass 2002
<i>Pecari tajacu</i>	Javelina	135	250	Harestad and Bundell 1979	Schweinsburg 1971
<i>Puma concolor</i>	Puma	29,733	10,000	Harestad and Bundell 1979	Grigione et al. 2002 Ortega 1990, Cudworth and Koprowski 2010
<i>Sciuridae</i> spp.	Squirrels	1	1	Harestad and Bundell 1979	Boyce and Barry 2007
<i>Sylvilagus</i> spp.	Cottontail	3	5	Harestad and Bundell 1979	Chamberlain and Leopold 2000
<i>Urocyon cinereoargenteus</i>	Fox, gray	100	250	Gittleman and Harvey 1982	Lecount 1980
<i>Ursus americanus</i>	Bear, black	2,413	2,500	Harestad and Bundell 1979	

Table 3. Total number of detections, number of sites where a species was observed at least once, naive occupancy, number of detections per 100 traps days, and the range of elevations where each of the species was detected, southeastern Arizona and southwestern New Mexico, 2012-2015.

Species	Sites with $\geq 1$ Detection		Detections		Elevational Range (m)
	No.	Proportion	No.	No./100 Trap Days	
<i>Bassariscus astutus</i>	73	0.37	1,072	1.54	1,100-2,020
<i>Canis latrans</i>	70	0.35	968	1.39	935-2,020
<i>Didelphis virginiana californicus</i>	69	0.35	695	1.00	935-1,980
<i>Lynx rufus</i>	153	0.77	1,431	2.06	935-2,395
<i>Meleagris</i> spp.	61	0.31	743	1.07	935-2,395
<i>Mephitidae</i> spp.	172	0.86	5,035	7.25	935-2,395
<i>Nasua narica</i>	149	0.75	3,088	4.45	1100-2,320
<i>Pecari tajacu</i>	123	0.62	2,980	4.29	935-2,320
<i>Puma concolor</i>	164	0.82	2,641	3.80	935-2,320
<i>Sciuridae</i> spp.	164	0.82	4,260	6.14	935-2,395
<i>Sylvilagus</i> spp.	109	0.55	3,377	4.86	935-2,395
<i>Urocyon cinereoargenteus</i>	181	0.91	7,632	10.99	935-2,395
<i>Ursus americanus</i>	108	0.54	3,966	5.71	1,270-2,395

Table 4. Correlation and associated *P*-values between the first 2 principal components and original measures of vegetation cover, as well as amount of variation they explain, southeastern Arizona and southwestern New Mexico, 2012-2015.

Canopy Layer	Covariate	Understory				Midstory				Overstory			
		PC1		PC2		PC1		PC2		PC1		PC2	
		<i>r</i>	<i>P</i>	<i>r</i>	<i>P</i>	<i>r</i>	<i>P</i>	<i>r</i>	<i>P</i>	<i>r</i>	<i>P</i>	<i>r</i>	<i>P</i>
Understory	Bare ground	0.18	0.01	-0.41	0.00	0.09	0.19	-0.02	0.81	-0.18	0.01	0.01	0.86
	Rock	-0.39	0.00	-0.38	0.00	-0.11	0.13	0.00	0.98	0.08	0.27	-0.02	0.74
	Litter	-0.16	0.03	0.72	0.00	-0.05	0.52	0.22	0.00	0.3	0.00	0.01	0.87
	Graminoid	0.23	0.00	0.13	0.07	0.01	0.91	0.12	0.08	0.01	0.85	0.01	0.94
	Forb	0.61	0.00	-0.15	0.04	0.23	0.00	0.06	0.40	-0.16	0.03	-0.10	0.18
	Shrub	0.73	0.00	0.04	0.62	0.51	0.00	0.09	0.18	-0.38	0.00	-0.10	0.16
	Succulent	0.30	0.00	0.37	0.00	0.01	0.94	0.10	0.17	0.08	0.26	-0.19	0.01
	Mid-size vegetation	0.76	0.00	0.02	0.73	0.50	0.00	0.04	0.60	-0.35	0.00	-0.18	0.01
	Trees	-0.09	0.23	0.66	0.00	-0.30	0.00	0.22	0.00	0.38	0.00	0.07	0.33
Midstory	Shrub	0.38	0.00	-0.04	0.55	0.69	0.00	0.43	0.00	-0.25	0.00	-0.10	0.14
	Dead vegetation	0.50	0.00	0.08	0.25	0.77	0.00	0.08	0.25	-0.46	0.00	-0.08	0.29
	Oak	-0.16	0.03	0.29	0.00	-0.42	0.00	0.87	0.00	0.45	0.00	-0.31	0.00
	Trees	-0.22	0.00	0.28	0.00	-0.57	0.00	-0.02	0.82	0.47	0.00	0.36	0.00
Overstory	Dead trees	0.39	0.00	-0.02	0.74	0.57	0.00	-0.04	0.58	-0.72	0.00	0.01	0.93
	Oak	-0.11	0.11	0.39	0.00	-0.27	0.00	0.47	0.00	0.67	0.00	-0.64	0.00
	Trees	-0.34	0.00	0.39	0.00	-0.44	0.00	0.03	0.67	0.67	0.00	0.65	0.00
Variance explained (%)		20		16		39		24		47		27	

Table 5. Correlation and associated *P*-values between the first principal components based on biotic communities, as well as amount of variation they explain, southeastern Arizona and southwestern New Mexico, 2012-2015.

Scale (ha)	Desert scrub		Madrean evergreen		Conifer		Plains grassland		Semi-desert grassland		Variance explained (%)
	<i>r</i>	<i>P</i>	<i>r</i>	<i>P</i>	<i>r</i>	<i>P</i>	<i>r</i>	<i>P</i>	<i>r</i>	<i>P</i>	
1	0.08	0.2343	-0.99	0.0001	0.23	0.0008	0.19	0.0055	0.89	0.0001	37
5	0.09	0.2297	-0.99	0.0001	0.24	0.0007	0.20	0.0051	0.88	0.0001	37
50	-0.25	0.0003	0.96	0.0001	-0.07	0.3560	-0.11	0.1052	-0.91	0.0001	37
100	-0.34	0.0001	0.94	0.0001	0.08	0.2364	-0.08	0.2615	-0.90	0.0001	36
250	0.33	0.0001	-0.88	0.0001	-0.27	0.0001	0.01	0.8532	0.91	0.0001	36
500	0.36	0.0001	-0.82	0.0001	-0.36	0.0001	-0.11	0.1169	0.89	0.0001	36
750	0.38	0.0001	-0.79	0.0001	-0.41	0.0001	-0.12	0.0901	0.87	0.0001	35
1,000	0.38	0.0001	-0.79	0.0001	-0.39	0.0001	-0.24	0.0008	0.87	0.0001	35
2,500	0.47	0.0001	-0.66	0.0001	-0.49	0.0001	-0.31	0.0001	0.86	0.0001	35
5,000	0.47	0.0001	-0.62	0.0001	-0.51	0.0001	-0.44	0.0001	0.85	0.0001	36
7,500	0.56	0.0001	-0.56	0.0001	-0.54	0.0001	-0.61	0.0001	0.84	0.0001	40
10,000	0.54	0.0001	-0.52	0.0001	-0.57	0.0001	-0.69	0.0001	0.85	0.0001	42

Table 6. Covariates that explained variation in initial occupancy, their estimates, standard errors, and *P*-values for each target species, southeastern Arizona and southwestern New Mexico, 2012-2015.

Covariate	Bear			Bobcat			Coatimundi		
	Estimate	SE	<i>P</i>	Estimate	SE	<i>P</i>	Estimate	SE	<i>P</i>
Human influence (100 ha)									
Human influence (2500 ha)	-3.70	1.87	0.0481						
Human influence (7500 ha)									
Mean height of trees									
Understory PC1									
Understory PC2									
Midstory PC2							-1.27	0.66	0.0560
Overstory PC1							2.64	1.18	0.0256
Biotic community PC1 (2500 ha)									
Terrain ruggedness (5 ha)									
Terrain ruggedness (2500 ha)									
Trail density									
Mean				0.74	1.87	0.3520			

Table 6. Continued.

Covariate	Cottontail			Coyote			Fox		
	Estimate	SE	<i>P</i>	Estimate	SE	<i>P</i>	Estimate	SE	<i>P</i>
Human influence (100 ha)									
Human influence (2500 ha)									
Human influence (7500 ha)				1.77	0.70	0.0109			
Mean height of trees	-2.39	1.44	0.0973						
Understory PC1									
Understory PC2									
Midstory PC2									
Overstory PC1									
Biotic community PC1 (2500 ha)				1.62	0.65	0.0130			
Terrain ruggedness (5 ha)									
Terrain ruggedness (2500 ha)									
Trail density									
Mean							0.69	0.60	0.2510

Table 6. Continued.

Covariate	Javelina			Opossum			Puma		
	Estimate	SE	<i>P</i>	Estimate	SE	<i>P</i>	Estimate	SE	<i>P</i>
Human influence (100 ha)				2.37	0.95	0.0126			
Human influence (2500 ha)									
Human influence (7500 ha)									
Mean height of trees				1.70	0.88	0.0530			
Understory PC1									
Understory PC2									
Midstory PC2									
Overstory PC1									
Biotic community PC1 (2500 ha)									
Terrain ruggedness (5 ha)									
Terrain ruggedness (2500 ha)									
Trail density									
Mean	0.31	0.47	0.5170				0.26	0.67	0.6970

Table 6. Continued.

Covariate	Ringtail			Skunks			Squirrels		
	Estimate	SE	<i>P</i>	Estimate	SE	<i>P</i>	Estimate	SE	<i>P</i>
Human influence (100 ha)									
Human influence (2500 ha)									
Human influence (7500 ha)									
Mean height of trees							2.51	1.39	0.0713
Understory PC1				2.55	1.33	0.0554			
Understory PC2									
Midstory PC2									
Overstory PC1									
Biotic community PC1 (2500 ha)									
Terrain ruggedness (5 ha)	3.03	1.52	0.0457						
Terrain ruggedness (2500 ha)									
Trail density									
Mean									

Table 6. Continued.

Covariate	Turkey		
	Estimate	SE	<i>P</i>
Human influence (100 ha)			
Human influence (2500 ha)			
Human influence (7500 ha)			
Mean height of trees			
Understory PC1			
Understory PC2	0.90	0.54	0.0965
Midstory PC2			
Overstory PC1			
Biotic community PC1 (2500 ha)			
Terrain ruggedness (5 ha)			
Terrain ruggedness (2500 ha)	1.40	0.64	0.0290
Trail density			
Mean			

Table 7. Covariates that explained variation in local colonization, their estimates, standard errors, and *P*-values for each target species, southeastern Arizona and southwestern New Mexico, 2012-2015.

Covariate	Bear			Bobcat			Coatimundi		
	Estimate	SE	<i>P</i>	Estimate	SE	<i>P</i>	Estimate	SE	<i>P</i>
Human detections									
Elevation	2.43	0.42	0.0001				0.29	0.13	0.0246
Temperature									
Season									
Monsoon	-1.57	0.46	0.0007	1.05	0.73	0.1470			
Fall/winter	-1.53	2.35	0.5170						
Winter/spring	-0.98	1.10	0.3750	1.48	0.65	0.0203			
Springs/summer	-0.55	0.45	0.2300	1.22	0.69	0.0795			
Solar radiation				0.43	0.23	0.0606			
Season*solar radiation									
Monsoon*solar radiation									
Fall/winter*solar radiation									
Winter/spring*solar radiation									
Spring/summer*solar radiation									
Seasonal water									
Not present				-1.88	0.56	0.0008	-1.01	0.17	0.0001
Present				-2.00	0.57	0.0005	-0.98	0.24	0.0001
Perennial water									
Not present									
Present									
Unknown									

Table 7. Continued.

Covariate	Cottontail			Coyote			Fox		
	Estimate	SE	<i>P</i>	Estimate	SE	<i>P</i>	Estimate	SE	<i>P</i>
Human detections									
Elevation	-0.37	0.14	0.0068	-0.65	0.17	0.0001			
Temperature							0.29	0.15	0.0472
Season									
Monsoon	1.20	0.56	0.0158				-2.00	1.73	0.2480
Fall/winter									
Winter/spring	0.76	0.51	0.0856				2.04	0.65	0.0018
Springs/summer	0.41	0.52	0.3490				-1.09	1.09	0.3140
Solar radiation	-0.18	0.32	0.5820				0.12	0.39	0.7570
Season*solar radiation									
Monsoon*solar radiation	1.20	0.50	0.0158				0.97	0.54	0.0742
Fall/winter*solar radiation									
Winter/spring*solar radiation	0.76	0.44	0.0856				0.48	0.53	0.3660
Spring/summer*solar radiation	0.41	0.44	0.3490				-0.08	0.51	0.8740
Seasonal water									
Not present	-3.05	0.43	0.0001	-2.92	0.27	0.0001	-2.48	0.86	0.0037
Present	-2.65	0.47	0.0001	-2.52	0.40	0.0001	-2.43	0.86	0.0049
Perennial water									
Not present									
Present				1.19	0.40	0.0033			
Unknown				0.42	0.49	0.0393			

Table 7.Continued.

Covariate	Javelina			Opossum			Puma		
	Estimate	SE	<i>P</i>	Estimate	SE	<i>P</i>	Estimate	SE	<i>P</i>
Human detections	0.38	0.17	0.0211	0.50	0.16	0.0018	0.39	0.19	0.0417
Elevation	-0.50	0.18	0.0067	-0.38	0.14	0.0043			
Temperature	0.36	0.15	0.0189						
Season									
Monsoon	-4.58	1.83	0.0122	-2.48	0.39	0.0001			
Fall/winter				-2.54	0.32	0.0001			
Winter/spring	-0.09	0.62	0.8890	-1.72	0.27	0.0001			
Springs/summer	-2.37	1.11	0.0331	-2.99	0.61	0.0001			
Solar radiation									
Season*solar radiation									
Monsoon*solar radiation									
Fall/winter*solar radiation									
Winter/spring*solar radiation									
Spring/summer*solar radiation									
Seasonal water									
Not present	-2.92	0.83	0.0005						
Present	-3.16	0.83	0.0001						
Perennial water									
Not present									
Present									
Unknown									

Table 7.Continued.

Covariate	Ringtail			Skunks			Squirrels		
	Estimate	SE	<i>P</i>	Estimate	SE	<i>P</i>	Estimate	SE	<i>P</i>
Human detections							0.29	0.16	0.0647
Elevation									
Temperature				-0.27	0.16	0.0974			
Season									
Monsoon				4.43	2.66	0.0958	0.83	0.55	0.1300
Fall/winter				0.18	0.88	0.8420			
Winter/spring				0.94	0.55	0.0877	2.32	0.47	0.0001
Springs/summer				2.26	1.89	0.2310	1.48	0.54	0.0065
Solar radiation				0.20	0.43	0.6390			
Season*solar radiation									
Monsoon*solar radiation				-0.76	0.53	0.1530			
Fall/winter*solar radiation									
Winter/spring*solar radiation				-0.52	0.51	0.3070			
Spring/summer*solar radiation				1.89	1.13	0.0934			
Seasonal water									
Not present	-2.47	0.30	0.0001						
Present	-2.66	0.39	0.0001						
Perennial water									
Not present							-1.81	0.41	0.0001
Present							-1.43	0.50	0.0041
Unknown							-1.98	0.48	0.0001

Table 7. Continued.

Covariate	Turkey		
	Estimate	SE	<i>P</i>
Human detections			
Elevation	1.49	0.31	0.0001
Temperature			
Season			
Monsoon	-11.84	149.04	0.9370
Fall/winter			
Winter/spring	2.17	0.61	0.0004
Springs/summer	0.08	0.88	0.9260
Solar radiation	0.92	0.31	0.0029
Season*solar radiation			
Monsoon*solar radiation			
Fall/winter*solar radiation			
Winter/spring*solar radiation			
Spring/summer*solar radiation			
Seasonal water			
Not present	-4.24	0.60	0.0001
Present	-4.17	0.68	0.0001
Perennial water			
Not present			
Present			
Unknown			

Table 8. Covariates that explained variation in local extinction, their estimates, standard errors, and *P*-values for each target species, southeastern Arizona and southwestern New Mexico, 2012-2015.

Covariate	Bear			Bobcat			Coatimundi		
	Estimate	SE	<i>P</i>	Estimate	SE	<i>P</i>	Estimate	SE	<i>P</i>
Human detections	-0.40	0.23	0.0778	-0.36	0.18	0.0027			
Elevation	-1.15	0.29	0.0001						
Temperature							-0.27	0.13	0.0309
Season									
Monsoon	-0.44	0.25	0.0738	-0.63	0.52	0.2250	2.39	2.17	0.2720
Fall/winter	-7.94	34.40	0.8170				0.10	0.66	0.8850
Winter/spring	-1.28	0.44	0.0033	-3.08	2.54	0.2240	-0.36	0.41	0.3870
Springs/summer	-3.17	0.79	0.0001	-1.07	0.81	0.1880	1.71	1.50	0.2550
Solar radiation				0.30	0.32	0.3550	-0.43	0.24	0.0764
Season*solar radiation									
Monsoon*solar radiation				0.85	0.56	0.1250	1.03	0.56	0.0689
Fall/winter*solar radiation									
Winter/spring*solar radiation				-1.16	1.05	0.2720	0.40	0.36	0.2650
Spring/summer*solar radiation				1.88	0.90	0.0369	1.25	0.50	0.0128
Seasonal Water									
Not present				-1.36	0.39	0.0004			
Present				-0.65	0.44	0.1390			
Perennial water									
Not present									
Unknown									
Present									

Table 8. Continued.

Covariate	Cottontail			Coyote			Fox		
	Estimate	SE	<i>P</i>	Estimate	SE	<i>P</i>	Estimate	SE	<i>P</i>
Human detections									
Elevation				0.59	0.23	0.0090			
Temperature	-0.34	0.11	0.0020				-0.30	0.09	0.0013
Season									
Monsoon	5.24	1.83	0.0042	-0.52	0.46	0.2634	3.43	1.58	0.0297
Fall/winter	0.60	0.58	0.2980	0.15	0.36	0.6730	0.35	0.47	0.4640
Winter/spring	-0.61	0.53	0.2510	-0.99	0.53	0.0615	-0.77	0.37	0.0402
Springs/summer	2.23	1.32	0.0912	-0.99	0.75	0.2634	2.25	1.12	0.0452
Solar radiation				-0.91	0.28	0.0013			
Season*solar radiation									
Monsoon*solar radiation									
Fall/winter*solar radiation									
Winter/spring*solar radiation									
Spring/summer*solar radiation									
Seasonal Water									
Not present									
Present									
Perennial water									
Not present				0.08	0.34	0.8200			
Unknown				-0.36	0.49	0.4650			
Present				-1.55	0.47	0.0011			

Table 8. Continued.

Covariate	Javelina			Opossum			Puma		
	Estimate	SE	<i>P</i>	Estimate	SE	<i>P</i>	Estimate	SE	<i>P</i>
Human detections							-0.43	0.16	0.0087
Elevation	0.60	0.18	0.0006				0.56	0.15	0.0002
Temperature	-0.32	0.14	0.0228						
Season									
Monsoon	3.91	2.33	0.0930	-0.46	0.57	0.4140	-2.09	0.38	0.0001
Fall/winter	0.93	0.73	0.2010				-1.98	0.39	0.0001
Winter/spring	-0.78	0.50	0.1200	-1.15	0.62	0.0635	-1.55	0.29	0.0001
Springs/summer	1.70	1.74	0.3290	-2.08	0.90	0.0215	-0.71	0.24	0.0037
Solar radiation	-0.17	0.22	0.4430						
Season*solar radiation									
Monsoon*solar radiation	-0.21	0.36	0.5540						
Fall/winter*solar radiation									
Winter/spring*solar radiation	0.01	0.42	1.0000						
Spring/summer*solar radiation	1.63	0.81	0.0440						
Seasonal Water									
Not present									
Present									
Perennial water									
Not present				0.39	0.41	0.3370			
Unknown				-0.50	0.60	0.4090			
Present				1.57	0.75	0.0357			

Table 8. Continued.

Covariate	Ringtail			Skunks			Squirrels		
	Estimate	SE	<i>P</i>	Estimate	SE	<i>P</i>	Estimate	SE	<i>P</i>
Human detections									
Elevation				0.57	0.14	0.0001			
Temperature				-0.22	0.12	0.0768			
Season									
Monsoon	-0.31	0.77	0.6840	1.30	2.00	0.5170	-1.03	0.20	0.0001
Fall/winter				0.37	0.60	0.5370	0.00	0.19	0.9850
Winter/spring	-0.30	1.04	0.7690	-1.31	0.49	0.0082	-9.67	32.10	0.7630
Springs/summer	0.67	0.68	0.3260	0.45	1.46	0.7560	-1.56	0.26	0.0001
Solar radiation	-0.27	0.30	0.3690						
Season*solar radiation									
Monsoon*solar radiation	0.32	0.50	0.5260						
Fall/winter*solar radiation									
Winter/spring*solar radiation	1.92	1.01	0.0570						
Spring/summer*solar radiation	1.06	0.57	0.0641						
Seasonal Water									
Not present	-0.99	0.50	0.0483						
Present	-1.58	0.65	0.0146						
Perennial water									
Not present									
Unknown									
Present									

Table 8. Continued.

Covariate	Turkey		
	Estimate	SE	<i>P</i>
Human detections			
Elevation			
Temperature			
Season			
Monsoon	-1.28	0.61	0.0355
Fall/winter	-0.41	0.51	0.4240
Winter/spring	-2.41	1.02	0.0181
Springs/summer	-0.30	0.36	0.4070
Solar radiation			
Season*solar radiation			
Monsoon*solar radiation			
Fall/winter*solar radiation			
Winter/spring*solar radiation			
Spring/summer*solar radiation			
Seasonal Water			
Not present			
Present			
Perennial water			
Not present			
Unknown			
Present			

Table 9. Covariates that explained variation in detection probability, their estimates, standard errors, and *P*-values for each target species, southeastern Arizona and southwestern New Mexico, 2012-2015.

Covariate	Bear			Bobcat			Coatimundi		
	Estimate	SE	<i>P</i>	Estimate	SE	<i>P</i>	Estimate	SE	<i>P</i>
Monsoon	0.23	0.08	0.0041	-1.26	0.11	0.0001	-0.54	0.09	0.0001
Fall/winter	-0.17	0.09	0.0676	-0.67	0.08	0.0001	-0.30	0.07	0.0001
Winter/spring	-3.66	0.32	0.0001	-0.92	0.12	0.0001	-0.67	0.09	0.0001
Spring/summer	0.20	0.09	0.0313	-0.92	0.09	0.0001	-0.30	0.10	0.0016
Corridor Width	0.18	0.05	0.0002						

Table 9.  
Continued.

Covariate	Cottontail			Coyote			Fox		
	Estimate	SE	<i>P</i>	Estimate	SE	<i>P</i>	Estimate	SE	<i>P</i>
Monsoon	-0.14	0.09	0.1160	-1.41	0.18	0.0001	-0.16	0.07	0.0268
Fall/winter	-0.18	0.10	0.0668	-0.77	0.13	0.0001	0.29	0.06	0.0001
Winter/spring	-0.35	0.12	0.0044	-0.58	0.16	0.0002	0.10	0.08	0.2240
Spring/summer	-0.14	0.11	0.1910	-0.64	0.15	0.0001	0.10	0.08	0.2120
Corridor Width	0.29	0.04	0.0001				0.14	0.03	0.0001

Table 9.  
Continued.

Covariate	Javelina			Opossum			Puma		
	Estimate	SE	<i>P</i>	Estimate	SE	<i>P</i>	Estimate	SE	<i>P</i>
Monsoon	-0.27	0.08	0.0013	-1.25	0.20	0.0001	-0.69	0.09	0.0001
Fall/winter	-0.14	0.08	0.0746	-0.67	0.14	0.0001	-0.57	0.07	0.0001
Winter/spring	-0.19	0.10	0.0441	-0.72	0.19	0.0002	-0.42	0.08	0.0001
Spring/summer	-0.23	0.10	0.0243	-0.71	0.15	0.0001	-0.24	0.08	0.0001
Corridor Width									

Table 9.  
Continued.

Covariate	Ringtail			Skunks			Squirrels		
	Estimate	SE	<i>P</i>	Estimate	SE	<i>P</i>	Estimate	SE	<i>P</i>
Monsoon	-1.89	0.20	0.0001	-0.39	0.07	0.0001	-0.12	0.07	0.0853
Fall/winter	-0.96	0.14	0.0001	-0.14	0.06	0.0249	-0.37	0.08	0.0001
Winter/spring	-0.75	0.16	0.0001	-0.66	0.10	0.0001	-0.40	0.11	0.0002
Spring/summer	-1.04	0.20	0.0001	-0.19	0.08	0.0188	-0.09	0.07	0.2230
Corridor Width									

Table 9.  
Continued.

Covariate	Turkey		
	Estimate	SE	<i>P</i>
Monsoon	-1.60	0.21	0.0001
Fall/winter	-0.87	0.18	0.0001
Winter/spring	-0.87	0.25	0.0005
Spring/summer	-0.25	0.13	0.0545
Corridor Width			

Appendix 1. Total number of detections, number of sites where a species was observed at least once, proportion of sites where each species was observed, number of detections per 100 traps days, and the range of elevations each of all species detected in southeastern Arizona and southwestern New Mexico, 2012-2015.

Species	Common Name	Sites		Detections	
		No.	Proportion	No.	No./100 Trap Days
Amphibian spp.	Amphibians	6	0.03	25	0.04
<i>Antilocapra americana</i>	Pronghorn	1	0.01	1	0.01
Aves spp.	Birds	165	0.83	4,611	6.64
<i>Bassariscus astutus</i> <sup>a</sup>	Ringtail	73	0.37	1,072	1.54
<i>Bos taurus</i>	Cow	82	0.41	2,904	4.18
<i>Canis latrans</i> <sup>a</sup>	Coyote	70	0.35	968	1.39
<i>Canis lupus familiaris</i>	Dog, domestic	95	0.48	545	0.78
<i>Capra aegagrus hircus</i>	Goat	1	0.01	1	0.01
Chiroptera spp.	Bats	10	0.05	60	0.09
<i>Didelphis virginiana californicus</i> <sup>a</sup>	Opossum, Sonoran	69	0.35	695	1.00
<i>Equus caballus</i>	Horse	13	0.07	174	0.25
<i>Felis catus</i>	Cat, domestic	1	0.01	2	0.00
<i>Gopherus agassizii</i>	Tortoise, desert	6	0.03	105	0.15
<i>Heloderma suspectum</i>	Gila monster	5	0.03	11	0.02
<i>Homo sapiens</i>	Human	183	0.92	5,711	8.23
Lacertilia spp.	Lizards, other	34	0.17	115	0.17
<i>Leopardus pardalis</i>	Ocelot	8	0.04	8	0.01
Lepus spp.	Jackrabbits	9	0.05	197	0.28
<i>Lynx rufus</i> <sup>a</sup>	Bobcat	153	0.77	1,431	2.06
<i>Meleagris spp.</i> <sup>a</sup>	Turkey, wild	61	0.31	743	1.07
<i>Mephitidae spp.</i> <sup>a</sup>	Skunks	172	0.86	5,035	7.25
<i>Nasua narica</i> <sup>a</sup>	Coatimundi, white-nosed	149	0.75	3,088	4.45
<i>Odocoileus hemionus</i>	Deer, mule	8	0.04	99	0.14
<i>Odocoileus virginianus couesi</i>	Deer, white-tailed	183	0.92	16,351	23.55
<i>Ovis canadensis nelsoni</i>	Sheep, desert bighorn	1	0.01	2	0.01
<i>Panthera onca</i>	Jaguar	22	0.11	82	0.12
<i>Pecari tajacu</i> <sup>a</sup>	Javelina	123	0.62	2,980	4.29
<i>Procyon lotor</i>	Raccoon	22	0.11	35	0.05
<i>Puma concolor</i> <sup>a</sup>	Puma	164	0.82	2,641	3.80
Rodentia spp.	Rodents	43	0.22	532	0.77
Sciuridae spp. <sup>a</sup>	Squirrels	164	0.82	4,260	6.14
Serpentes spp.	Snakes	13	0.07	19	0.03
<i>Strix occidentalis</i>	Owls, spotted	1	0.01	2	0.01
<i>Sylvilagus spp.</i> <sup>a</sup>	Cottontail	109	0.55	3,377	4.86
<i>Taxidea taxus</i>	Badger	1	0.01	1	0.01

Unknown	Unknown	148	0.74	1,190	1.71
<i>Urocyon cinereoargenteus</i> <sup>a</sup>	Fox, gray	181	0.91	7,632	10.99
<i>Ursus americanus</i> <sup>a</sup>	Bear, black	108	0.54	3,966	5.71

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<sup>a</sup>Target species