

Anthropogenic niche partitioning: mesocarnivore spatial and temporal coexistence along an urban gradient

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Abstract

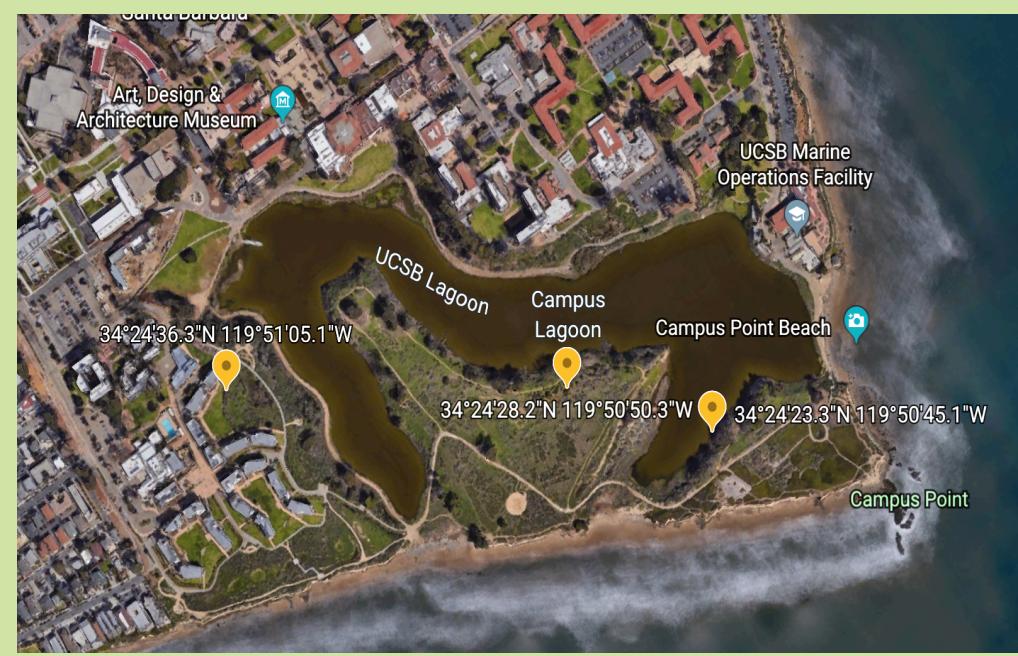
We understand little about how our urbanizing world influences temporal and spatial niche partitioning among synanthropic mammals. My research objectives include (1) to analyze how species shift temporal coexistence in response to varying degrees of urbanization, and (2) evaluate spatial niche partitioning by calculating relative mammalian diversity along an urban gradient. Urban species include the North American raccoon, striped skunk, red fox, brush rabbit, and Virginia opossum. Nine camera traps are deployed throughout three distinct habitats along an urban gradient. Urbanization positively correlates with nocturnality, and seasonality strongly predicts activity patterns that differ between species. Shifting activity patterns can disrupt delicate ecological relationships and specialized resource exploitation.

Introduction

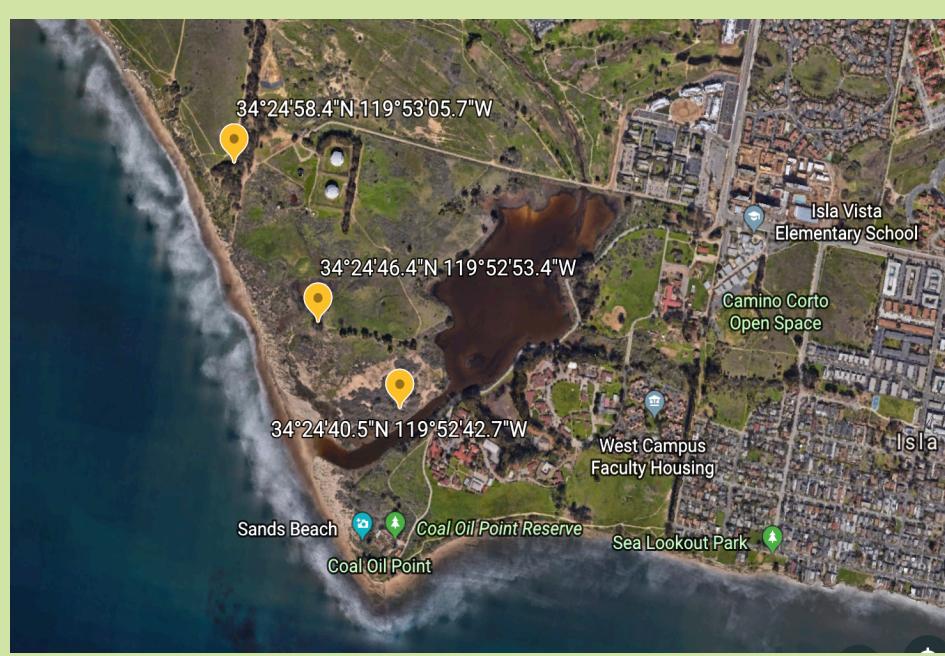
In an urbanizing world fixated on the advancement of technology and expansion of cities, mankind neglects the repercussions seen in nature. How animals coexist within these novel human-dominated habitats is an understudied area in ecology, considering that the pace at which we are researching and understanding the life around us cannot keep up with the transformation of our landscapes (Braje 2013). There is monumental potential for variation between synanthropic mammals and their rural counterparts, especially in recent decades with a clearly accelerating continuum of anthropogenic ecological influence (Braje 2013). Coastal southern California mammalian carnivores exemplify highly plastic distribution and abundance in response to urbanized habitat fragmentation, and diet homogenization is widely observed (Crooks 2002, Newsome et al. 2014). Considering how animals alter their activity in response to urban influence is vital to our own city planning and management if we hope to preserve the natural balance of local wildlife assemblages, among other practical incentives such as reducing disease transmission in cities (Brearley et al. 2012). This research strives to bridge the gap in our understanding of the urbanized coexistence between omnipresent synanthropic mammals with an emphasis on activity patterns and species diversity. The overall objectives of this project are (1) to analyze how species shift temporal coexistence in response to varying degrees of urbanization, and (2) evaluate spatial niche partitioning by calculating relative mammalian diversity along an urban gradient. I hypothesized that urbanization shifts activity periods towards nocturnality and the most rural habitat has the highest mammalian diversity.

Methods

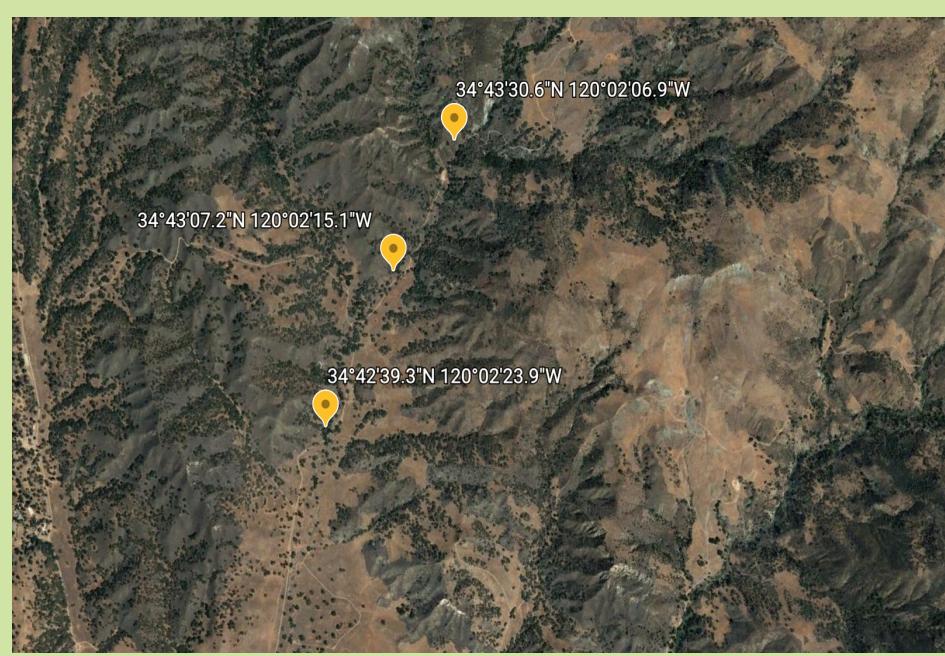
This study uses camera traps at three distinct habitats in Santa Barbara County to analyze temporal and spatial coexistence. Three camera traps were deployed at each site during summer 2018 and collected data through winter 2019. The cameras are running continuously to detect fauna activity patterns, allowing comparison between habitats, seasons, and foraging periods within a day. The locations include UCSB, Coal Oil Point Reserve, and Sedgwick Reserve, encompassing a spectrum of human development and distance to urban areas.



UCSB serves as the most extreme urban habitat, with human structures dominating the landscape, flagrant artificial light, and constant human traffic.



Coal Oil Point Reserve follows with an intermediate level of urbanization, being a natural reserve very near UC Santa Barbara and also hosting considerable human traffic, but with fewer buildings and more open space.



Sedgwick Reserve serves as a stark rural contrast as it is a virtually undisturbed natural reserve. It is 35 miles from UCSB and has insubstantial human occupancy with a much higher ratio of undisturbed habitat to human trails.

Seasonal Niche Partitioning

Rainfall, plant growth, and prey populations fluctuate with seasonality and instigate cascading effects throughout ecosystems. Similarly, a habitat's degree of urbanization acts as an important factor when shaping mammalian activity patterns.

Temporal Niche Partitioning

Mammals exhibit plasticity in their activity patterns in response to different degrees of urbanization and human activity. Depending on the hour of day, foraging and hunting occur during diurnal, crepuscular, and nocturnal time frames. Using military time, diurnal activity includes the hours of 8-16 (daytime), crepuscular activity includes 5-7 (sunrise) and 17-20 (sunset), and nocturnal activity includes 21-4 (nighttime).

Relative Diversity

The Shannon diversity index, designated as H' , is calculated for each habitat to compare mammalian species richness and evenness along an urban gradient. A large H' value represents a high uncertainty regarding the identity of any given species within that habitat. Therefore, a high H' is associated with high species diversity and evenness, meaning there are many species and no substantially dominant species.

Results

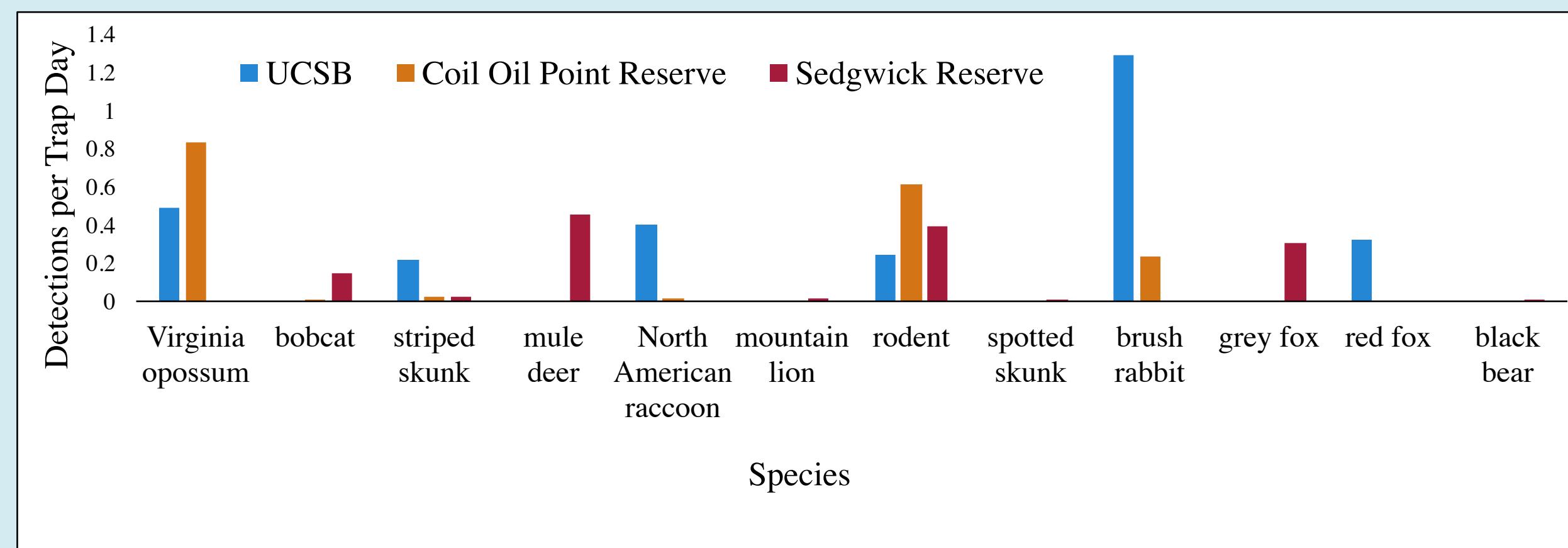


Figure 1 | Total Fauna Abundance: Fauna detection across all three sites. The Y axis represents the number of detections divided by trap days to calculate catch per unit effort. Colors reflect different habitats and therefore degrees of urbanization.

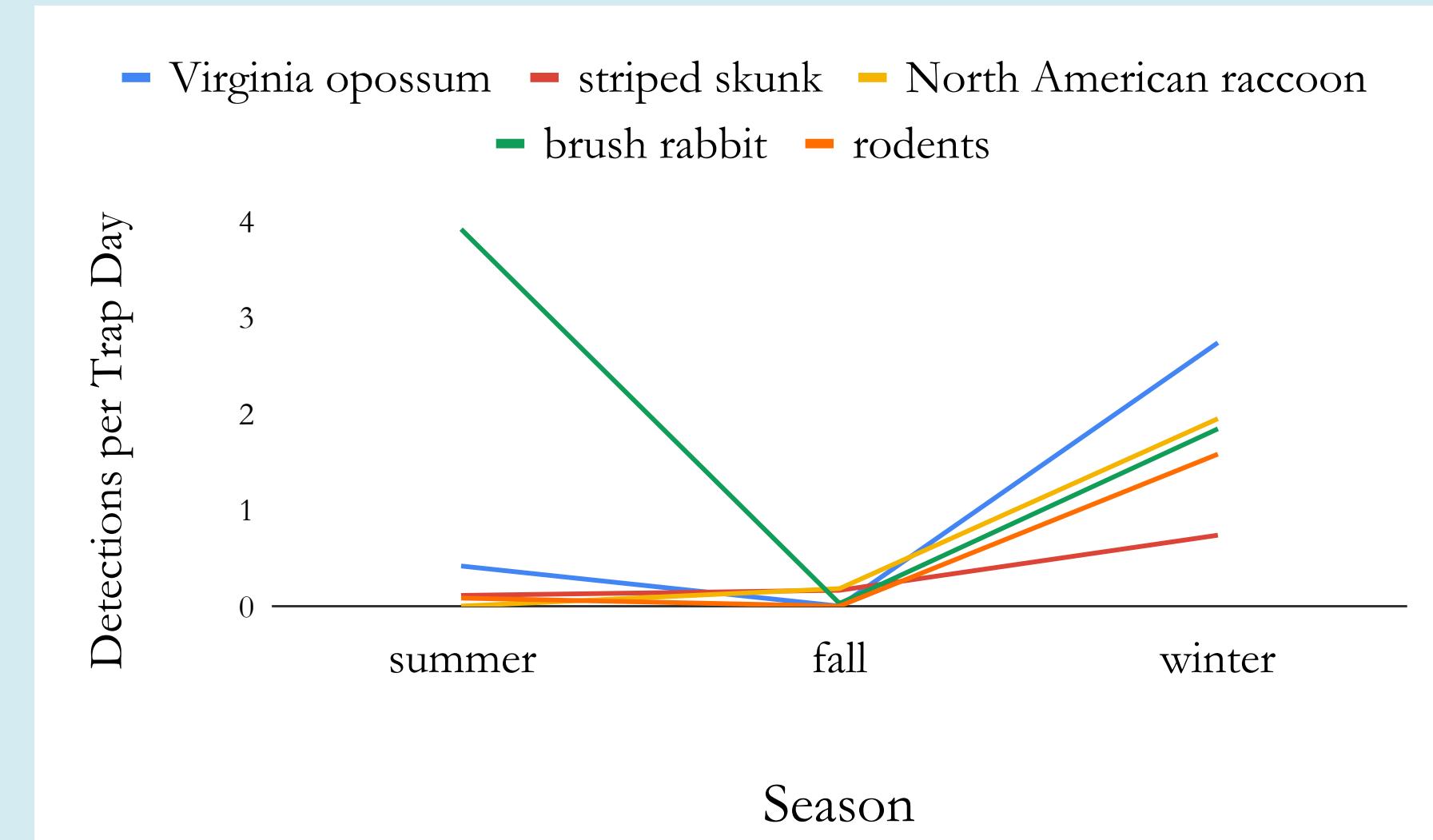


Figure 4 | UCSB Seasonal Trends: Mammals detected throughout summer, fall, and winter at UCSB. Brush rabbits are much more abundant in summer, while other mammals peak in winter.

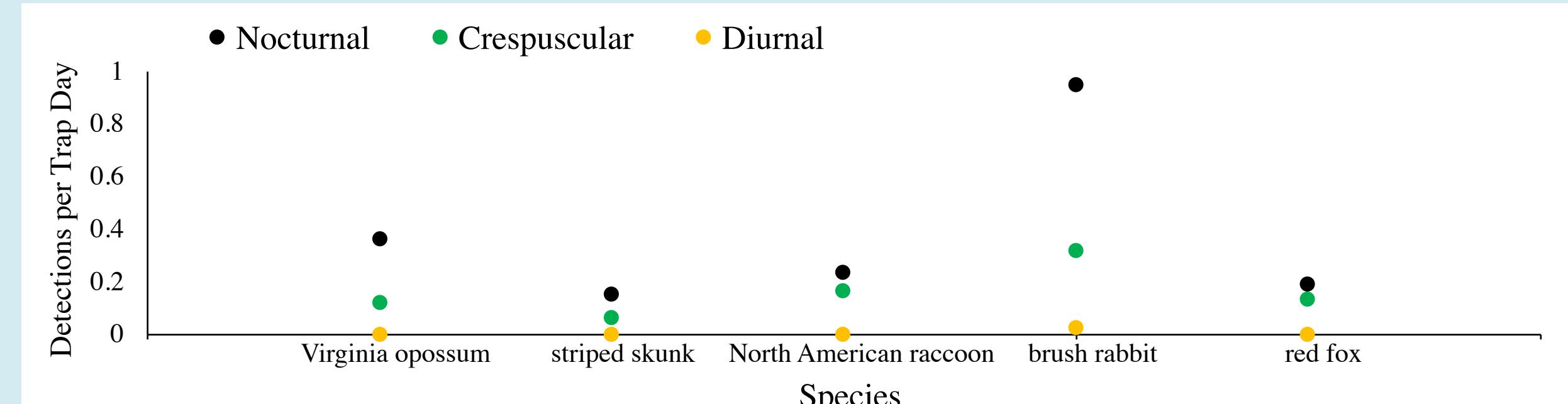


Figure 2 | UCSB Temporal Trends: Temporal activity distributions detected throughout summer, fall, and winter at UCSB. The Y axis represents the number of detections divided by trap days. This mammal community assemblage reveals heavily nocturnal activity patterns.

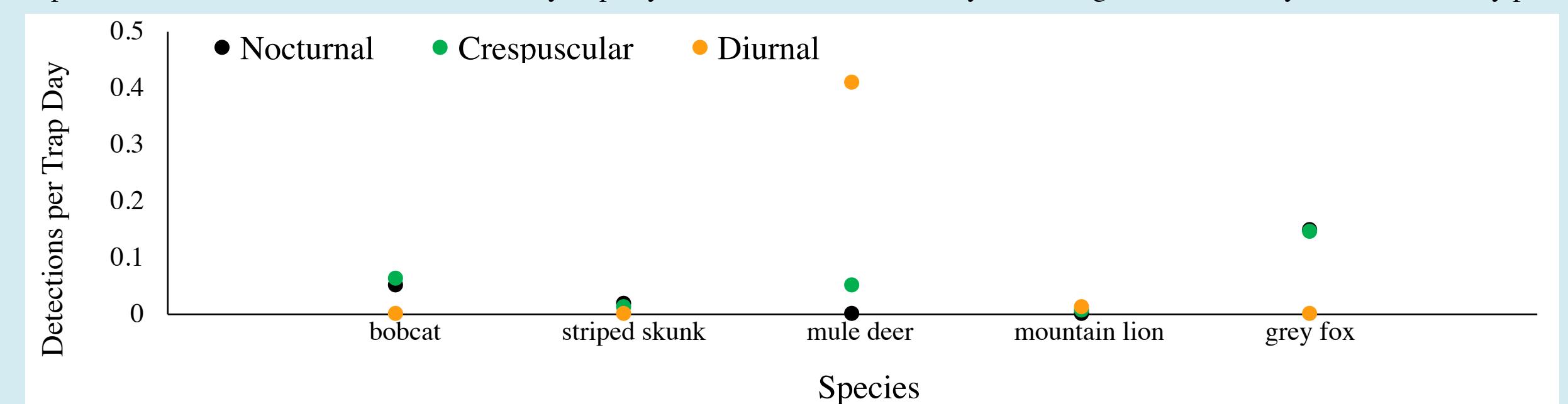


Figure 3 | Sedgwick Reserve Temporal Trends: Temporal activity distributions detected throughout summer, fall, and winter at Sedgwick Reserve. The Y axis represents the number of detections divided by trap days. This mammal community includes a balanced distribution of nocturnal, diurnal, and crepuscular activity patterns.

Location	Richness	Diversity (H')
UCSB	5	0.61
Coal Oil Point Reserve	5	0.31
Sedgwick Reserve	7	0.53

Figure 5 | Shannon Diversity Index: Species richness and H' values for each site. UCSB has the highest H' value of all three sites, Sedgwick Reserve has a similar but slightly lower H' , and Coal Oil Point Reserve has the lowest H' by a large margin.

Diversity Analysis

UCSB and Coal Oil Point Reserve have the same species richness and Coal Oil Point Reserve has a lower H' , implying that Coal Oil Point Reserve has lower evenness (Figure 5). Coal Oil Point Reserve is primarily dominated by Virginia opossums and secondarily dominated by brush rabbits. UCSB supports these populations as well as larger populations of striped skunks, North American raccoons, and red foxes that increase evenness. UCSB can support more species by providing anthropogenic food sources and dense urban architecture that prevents large felid predators from establishing territories and preying upon smaller mammalian prey. In contrast, Coal Oil Point Reserve has enough rural territory to support bobcats, explaining the relatively lower detection of brush rabbits (Figure 1). Sedgwick Reserve has a higher species richness than UCSB, but a lower H' value (Figure 5). This phenomenon implies lower species evenness at Sedgwick Reserve. Sedgwick Reserve is a remarkably rural habitat much vaster than UCSB or Coal Oil Point Reserve and does not subsidize mammalian diets with urban food, justifying the much lower abundance of raccoons and skunks (Figure 1). Sedgwick Reserve's open space allows several large mammalian predators such as black bears, bobcats, and mountain lions to coexist and collectively limit population sizes of lower trophic levels through strong top-down control. Bobcats are particularly found in high abundance in this landscape.

Discussion

While Sedgwick Reserve boasts a healthy balance of diurnal, nocturnal, and crepuscular mesocarnivores, UCSB's human presence has shifted all activity towards nocturnality (Figures 2 & 3). Human traffic pressures all synanthropic mammals to all forage and hunt at night when humans are less active, which increases competition between them. Additionally, urban structures centralize trash that replaces natural food sources. These factors increase interspecific interactions and limit healthy resource acquisition. Failure to exploit lower trophic levels can result in prey populations growing out of control.

Temporal Analysis

Activity increases in winter in urban habitats (Figure 4). The most extreme positive fluctuations can be observed in UCSB's raccoon and brush rabbit populations. Mammals are likely active during winter to stock up on resources in preparation for the cold weather and scarce primary production. At UCSB, increased activity during winter could be due to the substantial reduction in human presence on campus when students and faculty leave for winter break.

Acknowledgements

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