HABITAT-PATCH OCCUPANCY OF WESTERN SCREECH-OWLS IN SUBURBAN SOUTHERN CALIFORNIA

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ABSTRACT: Many predators can adapt to human-altered habitats, but varying responses to human activity mean that the findings of studies of a species in one region may not apply even to related species at other locations. The Eastern Screech-Owl (*Megascops asio*) has been extensively studied in suburban environments, but comparatively little research has investigated to what extent the closely related Western Screech-Owl (*M. kennicottii*) persists in developed areas. I studied Western Screech-Owl occupancy in the town of Alpine in the foothills of San Diego County, California, finding the species at the majority of sites sampled, more likely in larger wooded patches and in those adjacent to undeveloped chaparral. The distance to and size of nearby wooded patches did not statistically influence occupancy. This study confirmed that the Western Screech-Owl can persist in suburban residential areas as does its eastern relative. Ensuring that patches of woodland remain larger than the minimum modeled threshold for the Western Screech-Owl's occupancy, 4.2 ha, will be important for its persistence in the suburban sprawl of Alpine.

Urbanization has resulted in habitat fragmentation that threatens many wildlife species and communities (Öckinger et al. 2010, Barr et al. 2015, Amburgey et al. 2021), but there is ample evidence of the persistence of many other species, including predators, in developed landscapes (e.g., Haverland and Veech 2017, Parsons et al. 2018, White et al. 2018). Positive responses to urbanization have often been associated with availability of anthropogenic food (Newsome et al. 2015) or increased abundance of prey in the form of insects, small mammals, or birds (Fischer et al. 2012, McCabe et al. 2018, Rodríguez et al. 2021). Negative responses have generally been associated with habitat loss and/or disturbance (e.g., edge effects) and various forms of pollution (Schneider et al. 2015, Gaba and Vashishat 2018, Fröhlich and Ciach 2019). Responses to urbanization, however, often vary by species and life-history characteristics (Bolger et al. 1997, McKinney 2008, Amburgey et al. 2021), which means research findings may not be applicable to different species and geographic locations.

Certain owls are among the predators that have adapted to and colonized suburban and urban environments (Gehlbach 2012, Clément et al. 2021, Rodríguez et al. 2021). However, large species, such as the Tawny Owl (*Strix aluco*), may be limited by the size of urban woodland patches (Fröhlich and Ciach 2017). Although small owls are still limited by the size and availability of habitat patches (Millsap and Bear 2000, Nagy and Rockwell 2013), they may be more likely to persist in developed areas with fragmented natural habitat because they require less space than do larger species (Gehlbach 2008). An example is the Eastern Screech-Owl (*Megascops asio*), the population density and breeding success of which can be greater in suburban than in rural areas (Gehlbach 2008, 2012, Artuso 2009). Such findings have led to the suggestion that the closely related Western Screech-Owl (*M. kennicottii*) may enjoy similar success in human-altered habitats (Gehlbach 2008). Only one study of the species has addressed this topic (Rodríguez-Estrella and Careaga 2003), however, and it found the species nearly absent from an urban setting in Baja California, Mexico. Consequently, there remains a paucity of information on how Western Screech-Owls respond to development and associated habitat fragmentation.

The Western Screech-Owl is a relatively widespread resident in the woodlands of San Diego County, California (Unitt 2004), yet records are few within urbanized parts of the county (https://eBird.org). The foothills of San Diego County have experienced extensive suburban sprawl since the mid-twentieth century (Hogan 2003), and its consequences for the Western Screech-Owl have not been investigated. In this study I examined factors that influence the species' occupancy of discrete patches of woodland in the suburban town of Alpine, which is at the edge of San Diego's backcountry. I hypothesized that screech-owls should occur most consistently in larger habitat patches and in those with other large patches nearby, thus better connected. I expected isolation caused by urbanization to influence patch occupancy negatively. My study is the first to examine of the Western Screech-Owl's suburban habitat ecology and has implications for the management of natural habitat fragments in areas of urban sprawl in the foothills of southern California.

METHODS

Study Area

I studied the patterns of the Western Screech-Owl's occupancy in the town of Alpine and its vicinity in south-central San Diego County, California (Figure 1). Alpine is in the foothills of the Peninsular Ranges at an elevation of 559 m. Whereas the town is primarily suburban residential, the communities of Dehesa and Japatul on its outskirts are rural and have extensive undeveloped habitat, mostly chaparral. Drainages and woodland patches are characterized by several species of oaks (*Quercus agrifolia*, *Q. berberidifolia*, and *Q. engelmannii*) and Western Sycamore (*Platanus racemosa*), with some Fremont cottonwood (*Populus fremontii*) and willows (*Salix exigua*, *S. gooddingii*, *S. laevigata*, *S. lasiolepis*). The average maximum annual temperature is 25° C and average minimum is 10° C; the average annual precipitation is 41.6 cm (Western Regional Climate Center 2016). The human population density as of 2020 was 212 km^{-2} (U.S. Census Bureau 2020).

Surveys

I used the Western Screech-Owl's response to broadcast recordings of its "bouncing ball" song to assess the species' presence in discrete habitat patches (Johnson et al. 1981, Hardy and Morrison 2000, Rodríguez-Estrella and Careaga 2003, Artuso 2009). I broadcast calls from points adjacent to wooded habitat patches in both suburban and rural residential areas, which I identified on Google Earth via inspection of satellite imagery and verification on the ground (Figure 1). The most publicly accessible point on a road or trail adjacent to a given patch was selected for the site of broadcast. In two cases, private landowners provided access to patches that were not otherwise publicly accessible. For large narrow strips (usually along drainages), I broadcast

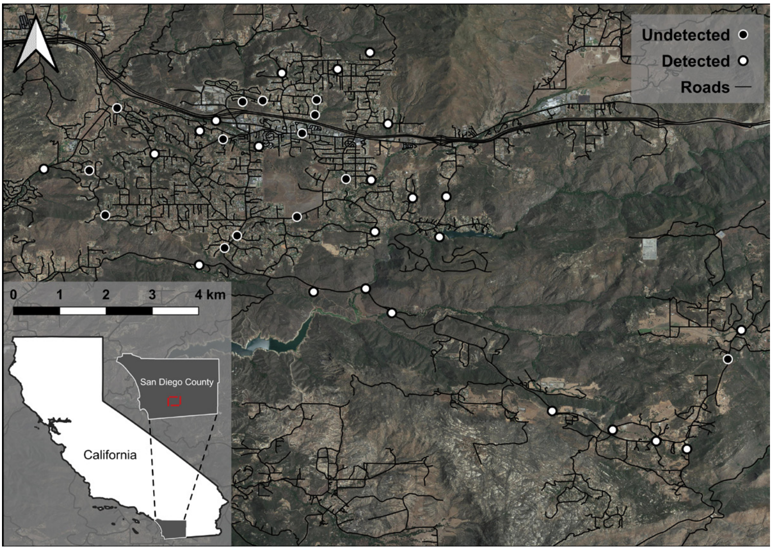

FIGURE 1. Points surveyed for the Western Screech-Owl in Alpine, California.

from multiple stations at least 0.5 km apart at publicly accessible points, so as to improve detection for a given patch. Although screech-owls may travel through shrubby habitat like chaparral, I restricted surveys to habitat patches with overlapping tree canopies, as this has best characterized the Western Screech-Owl's habitat in other parts of its range (Hayward and Garton 1984, Hardy et al. 1999, Olivas 2015). In cases where habitat occurred on either side of a road, I considered it a single patch if the tree canopy covered the road, providing unbroken screech-owl habitat. The shortest distance between two broadcast stations was 400 m, in which case the respective patches were separated by a road and houses. I surveyed from 41 points representing 36 patches, as many patches as public access and landowner permission allowed.

I completed two rounds of surveys, one in summer (7–27 July 2020) and one in winter (27 November 2020–6 January 2021). Each survey began a minimum of 30 minutes after sunset and ended a minimum of 3 hours before sunrise. Surveys were not conducted during rain or winds exceeding 25 km/hour. Stations along roads with heavy vehicle traffic were surveyed later in the night when road noise was lowest. I used a JBL Flip 4 portable Bluetooth speaker, placed on the roof of a truck approximately 1.5 m above the ground and oriented toward the habitat patch, to broadcast vocalizations at ~100 dB. Two different 40-second calls (the first from Arizona and the second from Washington) from the Cornell Lab of Ornithology's Merlin phone application were played twice alternately, followed by a 2-minute listening period after each call; each station was therefore surveyed for about 12 minutes on each visit. I broadcast the calls in the same order during each transect and recorded the time to the first detection of an owl. I did up to two surveys at each station per season. However, once I detected a screech-owl at a station, I made no subsequent surveys at it or additional stations associated with the same patch. Of the 36 patches I initially surveyed in summer, I detected screech-owls at 15 patches, and these were not visited again, even in winter. I considered screech-owls absent from a habitat patch when the cumulative survey time reached 48 minutes (i.e., two surveys per season) without a screech-owl responding.

Analysis

I manually delineated habitat patches throughout the study area and digitized them with Google Earth satellite imagery. I estimated the following metrics for each surveyed patch in QGIS 3.12 (QGIS Development Team 2020): patch size, distance to the next nearest patch, and size of the next nearest patch, considering the latter two values proxies for the connectivity of wooded patches. I also categorized each patch as isolated or connected, isolated patches being entirely surrounded by development and connected patches lying adjacent to unbroken chaparral that might facilitate movement away from the patch and into distant patches. I used logistic regression to model the effect of these four variables (including an interaction between distance to the nearest patch and the size of that patch) on screech-owl occupancy and Nagelkerke's (1991) R^2 as a coefficient of determination to assess how well the logistic regression might predict presence/absence. I did the analysis in R (R Core Team 2019) and considered differences biologically significant at $\alpha = 0.05$.

RESULTS

I detected Western Screech-Owls at 22 (61%) of the 36 habitat patches surveyed (Table 1). On average, it took two surveys to detect a screech-owl at a given station, and the average cumulative time of surveying before an owl was detected at a station was 16 minutes (range: 1–34 minutes). As predicted, there was a significant positive relationship between screech-owl occupancy and size of habitat patch (Figure 2) and a significant negative relationship between occupancy and a patch's category of isolation (Table 2). Contrary to my expectations, however, the effect of a patch's spatial relationship to nearby patches was not significant. Nagelkerke's R^2 for the model was 0.72. The model indicated the tipping point for patch size was 4.2 ha, a threshold below which screech-owls are not likely to occur.

DISCUSSION

In parallel with the Eastern Screech-Owl (Artuso 2009, Gehlbach 2012, Nagy and Rockwell 2013) but contrary to the findings of Rodríguez-Estrella and Careaga (2003) for the Western Screech-Owl in Baja California, I found Western Screech-Owls in suburban residential areas of Alpine. Although Shipley et al. (2013) peripherally mentioned Western Screech-Owls in an urban park in Oregon, and observations from https://eBird.org show sporadic occurrence in urban areas throughout the western United States, my study is the first to quantify evidence that the species can persist in a suburban environment containing a mosaic of residential housing and woodland patches. However, occurrence depends on the size of habitat patches and their

Table 1 Characteristics of Patches of Wooded Habitat Surveyed for the Western Screech-Owl in Alpine, California, by Two Categories of Isolation

Variable	Mean (SE)
Total sample (n = 36)	
Patch size (ha)	5.9 (1.3)
Distance to nearest patch (m)	236 (39)
Size of nearest patch (ha)	5.3 (1.3)
Connected patches (n = 22)	
Patch size (ha)	7.6 (1.6)
Distance to nearest patch (m)	292 (44)
Size of nearest patch (ha)	5.3 (1.3)
Isolated patches (n = 14)	
Patch size (ha)	3.2 (0.4)
Distance to nearest patch (m)	148 (26)
Size of nearest patch (ha)	5.3 (1.5)

connectivity with undeveloped habitat. The lack of a relationship between screech-owl occupancy and distance to or size of nearby habitat patches suggests the screech-owl disperses readily through the intervening habitat, at least through undeveloped chaparral, even if it does not maintain territories in such habitat. I caution that these results may not apply to other areas where patches may be distributed differently; my results may be a consequence of the relatively uniform distribution of patches in Alpine or characteristics of the intervening habitat, such as trees that allow dispersal across residential yards.

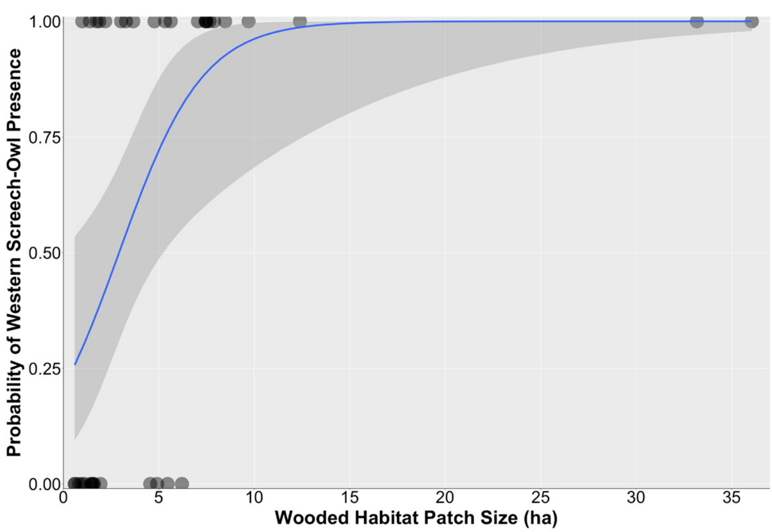

Figure 2. Prediction (±95% confidence interval in dark gray) of logistic-regression model showing the probability of detection of the Western Screech-Owl increasing with the size of patches of wooded habitat in Alpine, California. Gray dots indicate sizes of patches where owls were present (y = 1) and absent (y = 0).

Table 2 Results of the Logistic-Regression Model of Western Screech-Owl Occupancy in Alpine, California

Variable	Coefficient	LCL[a]	UCL[a]	z	p
Intercept	−3.61	−8.29	1.08	−1.51	0.13
Patch size (ha)	0.85	0.15	1.56	2.36	0.02[b]
Distance to nearest patch (m)	0.004	−0.005	0.01	0.84	0.40
Size of nearest patch (ha)	0.41	−0.64	1.45	0.76	0.45
Patch isolated? (yes/no)	−2.73	−5.37	-0.10	−2.03	0.04 [b]
Distance to nearest patch: size of nearest patch	−0.0002	−0.003	0.003	−0.13	0.90

[a]LCL, lower confidence limit; UCL, upper confidence limit.

[b]Effect significant.

Few studies have investigated owls' habitat ecology on a small scale, perhaps because delineating individual patches is difficult unless they are clearly discrete, as is generally the case in urban areas. Consequently, comparable research on owls is sparse, although Fröhlich and Ciach (2017) found that occupancy of the Tawny Owl (*Strix aluco*) was similarly positively related to the size of woodland patches in urban Poland. Although the Burrowing Owl (*Athene cunicularia*) uses habitats much different from the screech-owl's, its occurrence has been associated with smaller habitat patches in Argentina and Saskatchewan, a result that may be related to interacting complexities of prey and habitat structure (Warnock and James 1997, Villarreal et al. 2005). My findings agree with other studies that have found occupancy and abundance of other birds in habitat fragmented by urbanization—including in San Diego—to be positively associated with patch size (Soulé et al. 1988, Bolger et al. 1997, Hogg 2013, Robinson et al. 2018, Iknayan et al. 2022).

In suburban Texas Gehlbach (2008) found the average size of the Eastern Screech-Owl's home range (5.8 ha) to be similar to the average patch size in Alpine (5.9 ha). In suburban Connecticut, however, the Eastern Screech-Owl home ranges estimated by Smith and Gilbert (1984) were all larger than the average Alpine patch (Smith and Gilbert 1984). If the screech-owls in Alpine are sedentary, it is possible those in the largest patches may maintain home ranges entirely within a patch, whereas those found in small patches may have to include several patches in their movements. The close proximity of some occupied patches and the greater times to detection in some cases (i.e., up to three visits) may indicate the screech-owls I detected at nearby patches were the same individuals. This highlights the importance of maintaining the patches' connectivity with undeveloped chaparral and woodland and leaving existing wooded habitat patches intact, which will be a challenge as residential development in Alpine continues to expand.

My study of screech-owl occupancy was relatively cursory because of the limited accessibility of the habitat patches surveyed. For example, it is uncertain whether all the screech-owls I detected were residents of the sampled patches. Presumed pairs were recorded together at five stations, but other detections could plausibly represent dispersers given that I sampled after breeding at a time when immatures may leave their natal areas. Research on the species' nesting ecology and spatial use would answer such questions and improve the understanding of how urbanization affects important aspects of its population ecology. Additionally, a deeper investigation into the characteristics of suburban habitat patches, such as prey availability and vegetation type and structure (Villarreal et al. 2005, Apolloni et al. 2018), may provide more meaningful insight into the Western Screech-Owl's requirements in developed areas. It is unclear to what extent screech-owls in southern California may use patches of non-native trees such as blue gum (*Eucalyptus camaldulensis*) or Peruvian pepper (*Schinus molle*), which have largely supplanted oaks in residential yards in Alpine. Finally, my study also had a relatively small-scale approach, so a landscape scale approach may provide greater insight into the Western Screech-Owl's habitat ecology in suburban southern California (Hostetler 2001).

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