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JUVENILE BURROWING OWL NIGHTTIME SPACE-USE IN SOUTHERN NEW MEXICO

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Abstract.—In some areas, Burrowing Owls (*Athene cunicularia*) occur in human-altered, urbanized environments. However, their use of these anthropogenic land-cover types during nighttime is not well understood. We studied nocturnal and crepuscular space-use of eight juvenile Burrowing Owls in urban, greenspace, and agriculture dominated landscapes during 2012 and 2013 in Doña Ana County, New Mexico. For each owl, we obtained an average of 22 (range 14–37) nighttime telemetry fixes covering a period of 1–8.5 wk post-fledging. The juvenile Burrowing Owls avoided urban cover types and spent more time in agriculture and greenspace. In agricultural areas, owls used canals, weedy ditches, and associated farm roads, whereas in greenspace owls used city parks, golf courses, and patches of native habitat. Juvenile owls in this study were not observed to move large distances and on average most owls ($n = 5$) remained within 500 m of their roost burrow, with one owl traveling up to 743 m from its roost site. Conservation efforts for Burrowing Owls within human-altered environments should focus on the protection of nest and roost burrows near important foraging areas.

Key Words: *Burrowing Owl*; Athene cunicularia; *compositional analysis*; *human-altered environments*; *juveniles*; *New Mexico*; *radio telemetry*; *space-use*.

USO DEL ESPACIO DURANTE LA NOCHE DE INDIVIDUOS JUVENILES DE *ATHENE CUNICULARIA* EN EL SUR DE NUEVO MÉXICO

Resumen.—En algunas áreas, *Athene cunicularia* se presenta en ambientes urbanizados y alterados por el ser humano. Sin embargo, el uso nocturno de estos tipos de cobertura del suelo antropizados no está estudiado en profundidad en esta especie. Estudiamos el uso del espacio durante la noche y el crepúsculo de ocho individuos juveniles de *A. cunicularia* en paisajes dominados por ambientes urbanos, espacios verdes y agricultura durante 2012 y 2013 en el condado de Doña Ana, Nuevo México. Para cada búho, obtuvimos un promedio de 22 (rango 14-37) datos de telemetría cubriendo un periodo de 1 a 8.5 semanas posteriores al abandono del nido. Los individuos juveniles de *A. cunicularia* evitaron los tipos de cobertura del suelo urbanizado y permanecieron más tiempo en sitios con agricultura y espacios verdes. En las áreas con agricultura, los búhos utilizaron canales, acequias con vegetación herbácea y caminos asociados a granjas, mientras que en los espacios verdes, los búhos utilizaron parques, campos de golf y parches de hábitat nativo. En este estudio, los búhos juveniles no fueron observados moviéndose a grandes distancias y, en promedio, la mayoría de los búhos ($n = 5$) permanecieron dentro de los 500 m de sus madrigueras dormidero, con un búho moviéndose hasta 743 m de su dormidero. Los esfuerzos de conservación para *A. cunicularia* dentro de ambientes alterados por los humanos deberían enfocarse en la protección de los nidos y de las madrigueras dormidero cerca de las áreas importantes para la alimentación.

[Traducción del equipo editorial]

Human population growth has resulted in the conversion of large areas of natural landscapes to urban- and agricultural-dominated landscapes. Some raptor species are not tolerant of this landscape conversion. For example, among the threats to Northern Goshawks (*Accipiter gentilis*)

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and Great Gray Owls (*Strix nebulosa*) is the growing human population, as both species require large intact stands of forest (Winter 1986, Duncan 1997, Morrison et al. 2009, Hull et al. 2010), at least in North America. Alternatively, several raptor species readily occupy and breed in urban and agricultural landscapes (Berry et al. 1998, Boal and Mannan 1999, Conway et al. 2006, Palomino and Carrascal 2007, Boggie and Mannan 2014). In some instances, urban-breeding raptors occur at higher densities than in native cover types (Boal and Mannan 1998, Sergio and Bogliani 1999, DeSante et al. 2004). Raptors have the ability to cover large distances and their use of space should reflect the influence of anthropogenic landscapes. In Spain, adult Lesser Kestrels (*Falco naumanni*) preferred to forage in uncultivated grasslands and cereal crops and avoided other land-cover types (Donázar et al. 1993). In the Czech Republic, Long-eared Owls (*Asio otus*) nesting in urban environments selected foraging areas consisting of wooded areas and meadows (Lövy and Riegert 2013); urban-nesting goshawks in Europe foraged primarily in urban greenspace habitats, using built-up environments less than expected (Rutz 2006). Although many raptors do inhabit human dominated-landscapes, mortality rates can be higher due to predation, electrocution, collisions, poisonings, and disease (Mannan and Boal 2012, Griffin et al. 2017).

The post-fledging period is a vulnerable stage in the avian life cycle because inexperienced juveniles are still developing motor and foraging skills, learning their surroundings, and at times using novel spaces as they expand their home ranges with age. Space-use decisions in human-altered landscapes could further influence mortality risk. For instance, juveniles may select cover types with greater availability of prey that may be more accessible or easier to capture, or they may select sites based on cover to reduce predation risk. Among passerines, juveniles use habitats differently than adults. Juvenile Ovenbirds (*Seiurus aurocapilla*) use non-mature forest stands more than adults (Streby et al. 2011), and Black-capped Vireos (*Vireo stricapilla*) predominately nest in shrub habitat, whereas juveniles use both riparian and shrub habitats (Dittmar et al. 2014). Among birds of prey, juvenile Bonelli's Eagles (*Aquila fasciata*) dispersing from nest sites choose cover types similar to adults, selecting areas with more slope, pasture, and scrub (possibly related to prey availability); interestingly, however juveniles also select for sites farther from human habitation and roads (Balbontín 2005).

Burrowing Owls (*Athene cunicularia*) readily occupy human-altered environments (DeSante et al. 2004, Conway et al. 2006, Berardelli et al. 2010, Catlin and Rosenberg 2014, Griffin et al. 2017) and in some instances, occur at higher densities in human-dominated cover types (DeSante et al. 2004). They may benefit from the accessible prey in these environments (Moulton et al. 2006); however, we do not know how juveniles use space during typical foraging times within these areas. Burrowing Owls have a diverse diet that likely contributes to their ability to occupy a variety of land-cover types. Insects make up the majority of prey items whereas small vertebrates (small mammals, but also birds, amphibians, and reptiles) comprise the bulk of the biomass; the amount of vertebrate prey in their diets varies considerably by season, year, and location (MacCracken et al. 1985, Plumpton and Lutz 1993, York et al. 2002, Moulton et al. 2006, Marsh et al. 2014b). Burrowing Owl space-use in anthropogenic landscapes is varied, with studies showing selection for native land covers or pasturelands (Sissons et al. 2001), avoidance of tall, dense crops (Haug and Oliphant 1990, Sissons et al. 2001), or equal use of both croplands and native grasslands (Marsh et al. 2014a). In an agriculture-dominated area of California, Burrowing Owl space-use varied among years and ages of individuals; juveniles selected for grass cover in one year and cropland the second year, whereas adult males used land-cover types in proportion to availability (Gervais et al. 2003). Burrowing Owls used roads more frequently than expected in mixed-use grasslands of Saskatchewan, Canada (Marsh et al. 2014b). However, in another study, Burrowing Owls in Alberta and Saskatchewan avoided infrastructure (Scobie et al. 2016). In areas dominated by agriculture, juveniles forage along habitat edges and in fallow fields (Gervias et al. 2003), but no data are available for urban habitats or diverse landscapes that include mixtures of agriculture, urban environments, and greenspace. Thus, our objective was to characterize space-use by juvenile Burrowing Owls in a portion of southern New Mexico that included a composite of land-cover types. Using data collected from radio-tagged owls, we evaluated the prediction that owls would avoid agricultural and urban areas because of anthropogenic pressures and select greenspace.

METHODS

We studied Burrowing Owls during 2012 and 2013 in southern New Mexico (32°18.73′N 106°46.07′W) in the urban and agricultural areas of southern Doña Ana County (see Griffin et al. 2017 for a map of the study area). Doña Ana County includes Las Cruces, the second largest city in the state. The county population is 209,233, with approximately 90,000 inhabitants within the Las Cruces city limits (US Census Bureau 2010). Elevation is approximately 1191 m. Mean annual precipitation is 24.5 cm and mean temperature highs and lows are 25.3°C and 8.5°C, respectively (US Climate Data 2013). Dominant land-cover types were defined as urban (areas zoned as commercial, industrial and residential), greenspace (urban parks and patches of native habitat), and agriculture (traditional row crops, hayfields and orchards as well as fallow fields, rights-of-way and irrigation canals). Depending on the land use, vegetation was dominated by a mix of creosote bush (*Larrea tridentata*), soaptree yucca *(Yucca elata*), tarbush (*Flourensia cernua*), honey mesquite (*Prosopis glandulosa*), broom dalea *(Psorothamnus scoparius*), prickly pear (*Opuntia* spp.), desert grasses such as tobosa *(Pleuraphis mutica*) and black grama (*Bouteloua eriopoda*), irrigated row crops such as cotton (*Gossypium hirsutum*), alfalfa (*Medicago sativa*), chile (*Capsicum annuum*), and corn (*Zea mays*), pecan (*Carya illinoinensis*) orchards, manicured lawns, and ornamental trees and shrubs (Berardelli et al. 2010).

We captured juvenile owls at 30–40 d of age using $15 \times 15 \times 46$ cm walk-in-traps made from galvanized mesh wire (Conway and Garcia 2005). We placed traps at the entrance to the nest at dawn and dusk and checked traps every hour (Conway and Garcia 2005). Each owl captured was weighed to the nearest 0.1 g, and banded with a US Geological Survey band on the left leg and a yellow plastic band with a unique black alphanumeric code on the right leg. Each bird was sexed genetically using the PCR primer method of Griffiths et al. (1998) by clipping a talon and collecting a drop of blood.

Eight juvenile owls ($>$ 120 g) from eight individual nests were equipped with radio-transmitters to characterize nocturnal space-use. Each radio transmitter (Model AWE-C-1.5, American Wildlife Enterprise, Monticello, FL, USA) was attached backpack-style (D. Johnson pers. comm.) using 0.64-cm-wide teflon ribbon (Bally Ribbon Mill, Bally, PA, USA) as a harness (Davies and Restani 2006). The transmitter with harness weighed 3.5 g and bands weighed 1.1 g, for a total weight of 4.6 g. All transmitters were $<$3% of owl body weight (Davies and Restani 2006). The maximum distance transmitters could be detected was 800 m using vehicle-mounted antennas and 600 m using hand-held antennas.

At each nest location where juveniles were captured, the surrounding landscape consisted of a composite of two or all three land-use categories. Three juvenile owls were from greenspace-dominated environments, two were from agriculture-dominated environments, and three were from landscapes with nearly equal proportions of urban and greenspace.

We collected data on juvenile owl space-use during crepuscular (0530–0800 H and 1830–2100 H) and nocturnal (2300–0400 H) hours because owls forage during both time periods (Haug and Ophilant 1990, Sissons et al. 2001, Marsh et al. 2014b). We randomly selected the nocturnal or crepuscular time period for each day, with the caveat that there were an equal number of crepuscular and nocturnal tracking days each week. We rotated the order in which owls were studied each night, and focused on each radio-tagged owl twice per week, attempting to obtain four locations per owl per survey night (Gervais et al. 2003). We constrained each telemetry fix to be $\geq$ 15 min apart to ensure independence between subsequent locations (Gervais et al. 2003). When visual fixes could not be obtained, we triangulated to establish locations of owls using bearings recorded $<$5 min apart (Davies and Restani 2006). We recorded coordinates of visual locations as well as triangulation points with a Garmin GPS. When triangulating, the distance from the owl was generally 100–300 m. We collected locations during the period from 1–8.5 wk after fledging, with an average of 22 (range 14–37) telemetry fixes for each owl. Radio-tagged owls also used satellite burrows near their nest site and these were determined based on diurnal occupation by radio-tagged owls (Griffin et al. 2017). We used diurnal roost sites, which were sometimes the same as the nest site, to calculate the distance owls traveled to nighttime telemetry fixes, using the distance-measuring tool in ArcMap. For this study we defined fledging as 42 d post-hatch, which is the approximate age when juveniles are capable of extended flight (Haug and Oliphant 1990, Desmond et al. 2000, Griffin et al. 2017).

GIS Database. We used ArcMap 10.2 (ESRI, Redlands, CA, USA) for spatial analyses. Imagery was from the National Agriculture Imagery Program (NAIP 2010) and Bing Maps aerial imagery (2012) available through ArcGIS; imagery from Bing Maps provided the most recent information related to land use and was used to verify information from 2010 NAIP imagery. Using this imagery, we analyzed land uses and classified these into the three land-cover types of interest: urban (commercial, industrial, and residential), agriculture (row crops, hayfield, fallow fields, irrigation canals, farm roads, livestock), and greenspace (native habitat, parks, and golf courses). We used the coordinate geometry (COGO) feature in ArcMap to perform triangulation. We removed locations that were ≤50 m from the nest for juveniles < 8 wk of age from analyses. We digitized a maximum space-use radius for each nest based on the farthest distance of each radio-tagged juvenile. To do this, we created a 100-m buffer around the farthest distance each juvenile traveled from its nest and calculated the availability of each land-cover type and land-cover percentages within this fixed radius. From this, we calculated the proportion of area covered for each land-cover type.

Statistical Analysis. We used compositional analysis to examine the pattern of space-use relative to availability for radio-tagged owls. We conducted compositional analysis using the log ratio transformation methods described in Aebischer et al. (1993), using greenspace as the reference cover. However, we used a mixed model as an alternative to the MANOVA, because it allowed the inclusion of individuals that were lacking one cover type within their available environment (circular plot). We replaced cover-type use of 0% (i.e., nonuse of that cover type) with 0.007 (0.7%) as suggested by Bingham et al. (2007) and Janke and Gates (2013), and we also conducted a sensitivity analysis as suggested by Aitchison (1982). To ensure that values added to zero use were below the minimum possible, we added values from 0.1 to 0.9 in increments of 0.1 to counts of zero before computing proportions. Ten analyses corresponding to 10 different reclassifications of nonuse were run. We analyzed each of these nine response variables along with the initial analysis adding 0.007 to the proportion. We report findings from the initial model adding 0.007 to the proportion and findings from the sensitivity analysis only where conclusions differed from conclusions based on the initial model. In the mixed model, we fitted an unstructured covariance to account for correlation between the two differences in log ratios (d_i) from the same bird. A two-numerator df *F*-test assessed whether cover-type selection was random by testing the hypothesis that both mean log ratios (d_i) were equal to zero; denominator degrees of freedom were computed using the Kenward-Roger method (SAS Institute Inc., Cary, NC, USA). We obtained *post hoc* pairwise comparisons by testing whether individual model-based mean log ratios were equal to zero and by comparing the two mean log ratios.

To compare cover-type use to percentage of cover types available for each individual bird, we planned to report approximate *P*-values using a χ^2 goodness of fit test (Sissons et al. 2001). However, because criteria for approximate *P*-values to be valid were not met, exact *P*-values using the multinomial distribution were obtained. To obtain the exact *P*-value for each bird, we used a multinomial distribution with the multinomial proportions set equal to the percentage of each land-cover type available and the number of trials set equal to the number of recorded locations. We computed multinomial probabilities corresponding to all possible outcomes. The *P*-value was obtained by summing all multinomial probabilities that were less than or equal to the probability of the observed outcome (McDonald 2014). We conducted analyses using SAS version 9.3 software (SAS Institute Inc., Cary, NC, USA), and defined significance as $P \leq 0.05$.

RESULTS

Juvenile owls' space-use was not random (compositional analysis, $F = 7.33$, ddf = 4.31, $P = 0.041$) and the three land-cover types were not used in proportion to their availability. The owls selected for agriculture compared to either greenspace or urban cover types ($t = 3.80$, ddf =5, $P = 0.0128$ and $t = 4.11$, ddf =5.31, $P = 0.008$, respectively); however, the finding that juveniles selected agriculture over greenspace was sensitive to the chosen methodology to address unused cover types. In the sensitivity analysis, when we added 0.1 for unused agricultural cover types in the agriculture-to-greenspace comparison, the selection for agriculture over greenspace was maintained ($P = 0.0302$). However, for the other eight of the nine reanalyses (inserting 0.2–0.9 for unused agricultural land cover), *P*-values were not significant, ranging from 0.0507 (for the addition of 0.2 to zero counts) to 0.1978 (addition of 0.9 to zero counts). Juveniles selected urban environments significantly less than greenspace ($t = -2.51$, ddf =7, $P = 0.04$; Table 1).

Three of the eight juveniles used land-cover types in proportion to their availability, whereas five exhibited selection for land-cover types (Fig. 1). Of the three birds that used land-cover types in

Table 1. Space-use selection by juvenile Burrowing Owls ($n = 8$) in Doña Ana County, New Mexico, 2012–2013. Means (log-transformed ratios), standard error (SE) and t-test results for pairwise comparison of cover types available to juvenile owls are presented. Significance was determined at P value ≤ 0.05.

COMPARISON	MEAN	SE	t-VALUE	P-VALUE
Agriculture versus greenspace	1.9356	0.51	3.80	0.0128
Urban versus greenspace	−1.4494	0.58	−2.51	0.0404
Agriculture versus urban	3.3850	0.82	4.11	0.0082

proportion to their availability, one inhabited an area dominated by agricultural cover types, one used only agricultural environments in lieu of available urban environments (relationship close to significant), and one used both urban and greenspace land-cover types (Table 2). Five of eight juveniles used urban environments less than expected based on availability, four used greenspace more than expected, and three used agricultural environments more than expected (Table 2). Agriculture composed <1% of the circular buffer plots of three juveniles (2, 4, and 7), but 25%, 7.7% and 23.8% of these owls' telemetry fixes were in agriculture, respectively. Average distance to nighttime telemetry fixes from roost or nest burrows varied between 224 ± 35 m and 839 ± 45 m (Table 2).

DISCUSSION

As predicted, we observed potential avoidance of urban areas by juvenile Burrowing Owls in that owls in our study had urban land-cover types available to them, but five used these areas less than expected based on availability. Interestingly, contrary to our prediction, juvenile owls also exhibited selection for agricultural lands. Of the six owls that had agriculture available to them, three exhibited selection for this land-cover type while the other three were primarily surrounded by agriculture and used this cover type in relation to availability. Juvenile owls foraged and loafed in fields (especially fallow fields and recently harvested fields), along field borders, near farm roads, and in irrigation ditches. When we did observe owls using urban environments, they were frequently foraging under streetlights as well as in weedy vacant lots and parking lots. Interestingly, we often observed what we assumed were family groups, including radio-tagged owls and untagged owls. Even in predominantly urban environments, owls selected agricultural patches. For example, juvenile owls in this study at New Mexico State University used small turf grass test plots (2 ha) on campus. Although areas where owls spend time during foraging hours is indicative of foraging locations, we do not have data on foraging behavior, capture rates, or type of prey captured. In Saskatchewan, Canada, Marsh et al. (2014a) used dataloggers to identify high-quality cover types based on owls' successful foraging bouts. Although foraging effort in native grassland and cropland was equal, caloric return was higher in native grassland, suggesting this is a more valuable cover type for Burrowing Owls in that region.

Studies on Burrowing Owl use or avoidance of agricultural areas have reported varied results. This variability may be due in part to inconsistencies in defining agriculture, differences in crop types, and the variety of agricultural practices across North America. For example, some studies include fallow fields, rights-of-way, irrigation ditches, farm roads, etc. as agriculture (as we did), whereas other researchers have separated crop fields and associated land uses. In Saskatchewan, Canada (where planted fields tend to be tall, dense cereal crops), owls avoided agricultural fields and grazed pastures (Haug and Ophilant 1990) and selected for rights-of-way, ungrazed pastures, and fallow fields. Similarly, Marsh et al. (2014b) found owls captured more prey in areas where the vegetation was short and less dense compared to areas with tall, dense vegetation. In contrast, in heavily agricultural areas of southern California, where crops are more varied with many low to the ground (similar to our study area), owls foraged in crop fields and as in Saskatchewan, they also used rights-of-way, fallow fields, and field edges (Gervais et al. 2003). Juvenile owls in the California study were more likely to use a land-use category that was composed of runway easements, fallow fields, and grassland patches; the authors commented that juveniles often foraged along farm roads and field edges (Gervais et al. 2003). Collectively, these observations are similar to our observation of juveniles utilizing irrigation canals, farm roads, edges of fields, and fallow and recently harvested fields in southern New Mexico. This supports the

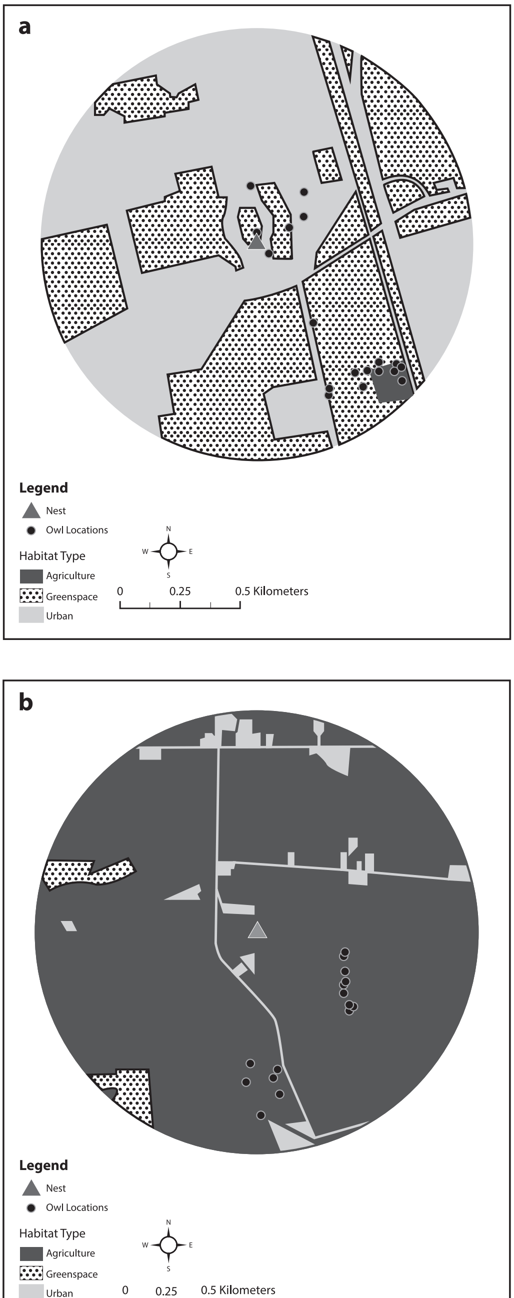

Figure 1. Examples of juvenile Burrowing Owls that (a) used land-cover types nonrandomly (owl number 2 from Table 2) and (b) used land-cover types in proportion to their availability (owl number 5 from Table 2) in Doña Ana County, New Mexico, USA. Gray triangle in each map represents the owl's natal nest.

importance of ecotones in agricultural landscapes for Burrowing Owls, possibly due to increased prey abundance and biomass in agriculture habitats (Rich 1986, Haug and Ophilant 1990, Leptich 1994, Moulton et al. 2006, Marsh et al. 2014a, Scobie et al. 2016).

Although juvenile owls seemed to avoid urban areas and select greenspace and agriculture, space-use varied among individuals. Other studies have reported similar variability among individual adult Burrowing Owls (Sissons et al. 2001, Gervais et al. 2003). There is little information on nighttime space-use of juvenile owls. In California, juvenile owls were most likely to be found in environments with grass cover types, but this varied by year and individual (Gervais et al. 2003). The most consistent result in our study was juvenile owl avoidance of urban landscapes. Owls selected agricultural landscapes over greenspace and urban, and selected greenspace over urban landscapes. Only two owls in this study used urban environments in proportion to availability; all others avoided urban areas. This result is particularly important as owl occupation of anthropogenic landscapes is increasing, but few studies have included urban environments. We also found that owls appeared to select agriculture; however, this was difficult to ascertain as not all owls had agriculture available, whereas others were in locations dominated by agriculture. In our study, most owls nesting in urban environments used nearby greenspace cover types during foraging hours. Four juvenile owls utilized greenspace more often than expected and this included parks, golf courses, and patches of native shrubs. Interestingly, in our same study area, post-fledging juvenile Burrowing Owls from nests in greenspace and urban-dominated cover types experienced higher mortality rates than those hatched in agricultural areas, suggesting that factors such as prey availability may lure owls into these environments, but there they experience higher mortality (Griffin et al. 2017).

Owls nesting in highly agricultural areas used this habitat in proportion to its availability, whereas other owls appeared to seek out this habitat type. Other studies have found extensive use of agriculture by Burrowing Owls but agriculture made up a large portion of available land-cover types (Haug and Oliphant 1990, Sissons et al. 2001, Gervais et al. 2003, Marsh et al. 2014a, Scobie et al. 2016). In these situations, owls often either used this land classification in relation to availability (Gervais et al. 2003) or

Table 2. Individual space-use of juvenile Burrowing Owls ($n = 8$) during the post-fledging period in Doña Ana County, New Mexico. No. Loc = number of locations. Age span is the age of juveniles (wk) when tracked. Land-cover types: AG = Agriculture, UB = Urban, GS= Greenspace; subscripts defined as A = % cover type available, U = % cover type used. Land-cover selection (relative to available cover types): 0 = cover type not available, – = cover type used less than available, + = cover type used more than available. Significance was defined as $P \leq 0.05$.

Owl No. and Sex	No. Loc.	Age Span (wk)	Distance Traveled (m) ($\bar{x} \pm$ SE)	Land-cover Availability and Use						Land-cover Selection			χ^2 Value	χ^2 P-value	Exact P-value
				AG_A	AG_U	UB_A	UB_U	GS_A	GS_U	AG	UB	GS			
1(f)	17	6–13	297 ± 37	n/a	n/a	42.70	11.76	57.30	88.20	0	–	+	6.65	0.01	0.01
2(m)	20	6–18	517 ± 58	0.90	25.00	54.20	30.00	44.90	45.00	+	–	+	131.23	<0.01	<0.01
3(m)	14	6–10	479 ± 39	75.0	100.0	24.20	0.00	0.80	0.00	+	–	–	4.67	0.10	0.06
4(m)	26	6–16	538 ± 61	0.70	7.70	53.90	34.60	45.40	57.70	+	–	+	20.82	<0.01	<0.01
5(f)	19	6–17	839 ± 45	93.80	100.00	3.80	0.00	2.40	0.00	+	–	–	1.26	0.53	1.00
6(m)	22	6–14	224 ± 35	n/a	n/a	34.40	0.00	65.60	100.00	0	–	+	11.54	<0.01	<0.01
7(m)	21	6–14	550 ± 49	0.83	23.80	47.60	4.80	51.50	71.40	+	–	+	143.32	<0.01	<0.01
8(m)	37	6–13	271 ± 36	0.30	0.00	40.10	64.90	59.60	35.10	–	+	–	0.51	0.77	0.66

used this land-cover type less than would be expected based on availability (Haug and Ophilant 1990, Sissons et al. 2001). Two of the juveniles in our study that used agriculture in proportion to availability occurred in predominantly agricultural landscapes. The observed heavy use of agricultural areas in southern New Mexico is likely due to (1) our grouping of all agricultural areas into one category (including rights-of-way, fallow fields, and irrigation canals) and (2) the diversity of crop types in southern New Mexico, which included grass, hay, and some low-structure row crops.

Management Implications. Our research supports the importance of irrigated agricultural areas and greenspace for nighttime space-use by juvenile Burrowing Owls and demonstrates that these birds usually avoided urban land-cover types. The irrigation canal system appears to be a particularly important component of the agriculture category, as owls foraged along canals, in weedy ditches (not lined with concrete), and along associated farm roads. Owls in agricultural areas also used fallow and recently harvested fields and field edges. Greenspace is also important for juvenile owls in urbanized areas. Owls from nests in these areas preferentially foraged in city parks, golf courses, and patches of native habitat; however, juvenile Burrowing Owls using greenspace and urban environments experience higher mortality, which makes these cover types less suitable for conservation efforts (Griffin et al. 2017). Managers should also be aware of potential risks to Burrowing Owls in human-altered environments related to pesticide exposure (Engleman et al. 2012, Justice-Allen and Loyd 2017). The irrigation canal system and associated irrigated agriculture appears to be the most important land-cover type for juvenile Burrowing Owls in the urban and agricultural areas of southern New Mexico. Conservation organizations should work to increase awareness of this species in urban and agricultural areas so property owners are aware of the importance of their landscapes to wildlife, and when possible, conservation efforts should focus on agricultural land-cover types.

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