HABITAT CHARACTERISTICS AND NESTING SUCCESS OF THE WESTERN BURROWING OWL IN A SUBURBAN DESERT LANDSCAPE

BY KERRIE ANNE T. LOYD AND RHIANNON T. WATKINS, ARIZONA STATE UNIVERSITY, LAKE HAVASU CITY, AZ, K.LOYD@ASU.EDU

ABSTRACT: Burrowing Owls (*Athene cunicularia*) are a species of conservation concern in most western states. In Lake Havasu City, Arizona, owls are common in desert washes in developed suburban and urban locations. These vegetated and steeply sloping washes host dozens of breeding pairs of owls. Suburban wash habitats may offer benefits such as a larger and more diverse prey base (due to additional and varied vegetation), perch sites, and existing burrows compared to washes in natural areas.. However, suburban owl populations are susceptible to secondary poisoning, predation, and disturbance from construction. This project examined habitat preferences and reproductive success of Burrowing Owls in Lake Havasu City. We monitored 112 active nests within the Lake Havasu City limits over a 5-year period. We surveyed microhabitat characteristics, including vegetation diversity and cover, wash slope and elevation, burrow characteristics, and presence/absence of predators. Nest success averaged 70% from 2014-2018 and the average number of juveniles produced was 4.2. To date, we have not identified any significant predictors of urban/suburban owl nest success or productivity. A primary cause of owl mortality during this study period was secondary poisoning through exposure to second-generation anticoagulant rodenticides. This research provides baseline data on our local population and will help biologists and managers understand the owls' urban/suburban habitat preferences.

The Western Burrowing Owl (*Athene cunicularia hypugaea*) is a subspecies of Burrowing Owl whose range extends from Canada across the western United States and south through Mexico to Honduras (Poulin et al. 2011). This species seasonally migrates from the northern part of its range to the far southern extent of its range during the winter; however, there are populations in the south, including southern Arizona, that remain sedentary year-round (Klute et al. 2003). Historically, Burrowing Owls were not believed to be present in the lower Colorado River valley until the early 1900s; some have hypothesized that this range expansion occurred because agriculture benefited the species (Rosenberg et al. 1991). The species is protected by the Migratory Bird Treaty Act in the United States and is a Tier 1B Species of Greatest Conservation Need in Arizona (AZGFD, 2012). Klute et al. (2003) attribute Burrowing Owl population declines to habitat loss and lethal control of burrowing rodents, which create the burrows the owls inhabit. Owls typically favor areas of short herbaceous vegetation characteristic of grasslands and desert and irrigated managed landscapes: golf courses, agricultural fields, etc. (Poulin et al. 2011). Habitats typically include arid environments with level to gentle slopes and sparse vegetation to bare ground (Haug et al. 1993). Burrowing Owls are opportunistic hunters and prefer small mammals, though arthropods are commonly captured by females during the breeding season (Poulin et al. 2011). Small mammals accounted for 78-95% of biomass in northwestern U.S. owl diets (Green 1983), although insect remains dominated diets in the agricultural Imperial Valley, California (York et al. 2002).

Greger and Hall (2009) studied Burrowing Owls in the Mojave Desert in southern Nevada and reported greater burrow occupancy in natural versus disturbed landscapes. The prevalence of owls in steeply sloping, vegetated washes in suburban Lake Havasu City, Arizona, may indicate change in habitat preference or lack of suitable habitat otherwise. Klute et al. (2003) and Lantz et al. (2007) suggest that these owls are becoming year-round residents in human-altered southwestern landscapes, possibly due to the habitat quality provided by elevated prey densities associated with developed areas. In Lake Havasu, ornamental landscaping, supplemental bird feeding, and water sources associated with suburban residential environments may attract a greater abundance and diversity of prey compared to the surrounding arid Sonoran Desert. Additionally, power lines and walls lining residential properties along washes may increase the quality of perch sites that are important for visibility and predator vigilance (Green and Anthony 1989). Potential negative effects of suburban living include reduced survival and reproductive success due to disturbance, development, and higher predator densities (Latta et al. 1999). Golf courses may provide suitable foraging habitat but may lack nesting sites (Smith et al. 2005) due to lower rodent density.

Burrowing Owl nest success in native grassland habitat has been documented as low as 50% in central Oregon (Green and Anthony 1988; Holmes et al. 2003) and as high as 81% in southern New Mexico (Berardelli et al. 2010). A strong predictor of Mojave Desert, Nevada Burrowing Owl nest success was presence of greater numbers of satellite burrows within 5 m of a nest that could be used for cover (Crowe and Longshore 2013). Nest success in urban and suburban areas is similar, ranging from 41% in southeastern Washington (Conway et al. 2006) to 79% in San Jose, California (Barclay et al. 2011). Primary causes for rural nest failure in central Oregon were desertion for unknown reason and depredation by mesopredators (Green and Anthony 1989; Holmes et al. 2003). Primary causes for urban/suburban nest failure in San Francisco, California were human disturbance and mesopredators (Trulio and Chromczak 2007).

Published nest success data for Arizona is limited to research from 2005 on owls using a prairie dog colony in northeastern Arizona (Bayless and Beier 2011). Nest success there was only 47% due to lack of prairie dog burrows and vicinity to roads. However, nest success is high in the population at Davis Monthan Air Force Base in Tucson, averaging 88% over two seasons (unpublished data, pers. comm. with D. Abbate, Arizona Game and Fish Dept.). This success may be attributed to predator control efforts on the airfields. The Burrowing Owl population in the lower Colorado River valley has never been studied and, to date, there are only 5 studies on Burrowing Owls in urban/suburban locations. Our research will provide baseline data on the ecology of Burrowing Owls in western Arizona for use in future management planning for this declining species.

RESEARCH OBJECTIVES

1. Report descriptive statistics on ecology of the Burrowing Owl population in Lake Havasu City.
2. Identify predictors of Burrowing Owl nest success and productivity in suburban Lake Havasu City, Arizona. Predictors may include: burrow and site characteristics, presence of predators, and adult mortality.

METHODS

Incorporated Lake Havasu City represents 111 km² found in the lower Colorado River valley on the border between Arizona and California. It hosts a population of 54,411 permanent human residents (U.S. Census Bureau 2017); however, the population nearly doubles seasonally. The environment is arid (lower Colorado River Sonoran Desert scrub) and dominated by creosote bush (*Larrea tridentata*) and palo verde (*Parkinsonia microphylla*), with the exception of riparian areas along the lakeshore, which are dominated by arrowweed (*Pluchea sericea*), salt cedar (*Tamarix sp.*), and mesquite (*Prosopis glandulosa*). The city meets Lake Havasu (the water body that is part of the lower Colorado River) at the western edge. Washes run east from the Mohave Mountains to the lake and temporarily hold flowing water after rain events. The washes in LHC are 92% natural surface, though many have been modified (widened, etc.) to some extent. Twelve major wash drainage systems empty into Lake Havasu within the developed area.

We examined burrow sites with suspected owl activity using passive methods (inspecting burrows for signs of nest activity, including observation of a pair of owls or ornamentation in front of the burrow [Figure 1]). We used single observer surveys on foot in the nesting season (Feb- July in Arizona) (Manning and Kaler 2010). We monitored nests using a Bushnell remote camera placed at least 1 m from the entrance of a nest, cable locked to an installed fence post and present no more than 5 days at a time. Camera footage allowed us to record the number of juveniles emerging from successful nests (Figure 2). We assumed a nest was successful if at least one juvenile reached 6 weeks of age (Conway et al. 2006). Monitoring began in February 2014 and continued through August 2018 to cover 5 complete breeding seasons. If determinable, we noted the cause for nest failure (e.g. predation, other mortality, abandonment, and human interference [Rodriguez-Estrella and Orega-Rubio 1992; Holmes et al. 2003]).

We surveyed vegetation at nest sites as we thought this variable to be important to attracting primary arthropod and vertebrate prey of the Burrowing Owls. Vegetative surveys consisted of describing vertical (range) and horizontal (percent cover) distribution of plants and species composition within a 10 m radius of a burrow site. We additionally collected descriptive information on each nest, including diameter, height, elevation, soil type, number of satellite

Figure 1. Example of urban nest ornamentation. Havasupai Wash, Lake Havasu City, AZ 9 May 2015. Photo by K. Loyd

Figure 2. Remote camera image of juveniles at a monitored nest 10 June 2017. Photo by K. Loyd

burrows within 5 m (Crowe and Longshore 2013), and perch availability (a potential perch is any structure > 0.5 m tall that could support a 150 g bird [Lantz et al. 2007]). We used a clinometer to determine the slope of the wash hosting active owl nests.

We documented presence or absence of predators near each nest site through use of Bushnell remote cameras. Cameras were randomly placed within 100 m of active burrows for 14 trap nights during the owl breeding season (when owls are most visible and vulnerable). We examined captured photographs for any mesopredators using the wash for foraging or as a travel corridor, including domestic dogs (*Canis familiaris*) and cats (*Felis catus*), bobcats (*Lynx rufus*), and coyotes (*Canis latrans*). The research on vertebrates described above was approved under Arizona State University IACUC protocol #: 14-1326R.

We used logistic regression to examine the influence of the following variables on nest success and stepwise linear regression to determine any predictors of nest productivity: burrow diameter, height from wash floor, plant cover, number of satellite burrows, predator presence/absence, and mortality. We used Mann-Whitney U tests to compare nest site variables at successful versus failed nests. We calculated averages and standard deviation for productivity and nest site characteristics.

RESULTS

We monitored 112 nests over 5 years. Nest success was 70% (range= 45% in 2014 - 75% in 2016). The mean number of fledglings produced at successful nests was 4.2 (SD=1.8 range= 1-8).

Four breeding pairs were relocated to the Phoenix area in 2017 due to wash stabilization projects. Nineteen nests were abandoned for unknown reasons and 16 experienced a mortality of one or more adults and chicks. Since we began research, 26 individual owls were found dead within 2 m of their nest due to suspected secondary poisoning. Five fresh carcasses were confirmed to be contaminated with brodifacoum (the effective compound of second generation anticoagulant rodenticides) (Justice-Allen and Loyd 2017). Twenty-one other carcasses found primarily in 2014 were too desiccated for toxicology testing.

Results of measured habitat characteristics are as follows: burrow height from wash floor (indicator of susceptibility to flooding) mean=178.4 cm (SD= 136, range 0-700 cm). Burrow diameter mean= 42.3 cm (SD=30.6, range 14-200 cm). Percent plant cover within 5 m of burrow entrance mean= 15.7% (SD=14, range 0-50%). Predators were detected at 74% of burrow sites (including coyotes, 3 free-roaming dogs, and one cat).

Results of the regression models showed that none of the included habitat characteristics (plant cover, diameter, height, satellite burrows), predator occupancy, or mortality of an adult had a significant influence on nest success or productivity. Additionally, we found no significant differences when comparing plant cover, prey availability, burrow diameter, or height from wash floor at successful versus failed nest sites (Mann-Whitney U tests).

DISCUSSION

Nest success in Lake Havasu City is comparable to other urban locations monitored, including Las Cruces, New Mexico (68%, Berardelli et al. 2010), the San Jose Airport Property (79%, Barclay et al. 2011), and *A. c. floridana* in Cape Coral, Florida (70%, Millsap et al. 2006). Nest success was significantly higher than 2 urban sites: southern Washington State 41% (Conway et al. 2006) and San Francisco Bay, California 51% (Trulio and Chromczak 1997). The mean number of fledglings was slightly higher than other urban studies that averaged 3.38 fledglings per nest (Barclay et al. 2011; Berardelli et al. 2010; Bothelho and Arrowood 1998; Conway et al. 2006; and Trulio and Chomczak 2007). Lake Havasu City is an oasis for desert wildlife with abundant natural vegetation in the washes and ornamental plantings throughout town to attract prey of predatory birds. Plentiful natural burrows of appropriate size in each wash are available for occupation by owls. These are created by populations of burrowing rodents found in high densities in Lake Havasu City, including Harris' antelope ground squirrels (*Ammospermophilus harrisii*) and white-throated woodrats (*Neotoma albigula*). This available habitat and year-round food availability likely has contributed to the high average nest success and productivity in our location.

Second-generation anticoagulant rodenticides containing brodifacoum appeared to be a primary threat to conservation of owls in Lake Havasu. Because we observed a high number of mortalities in the first year of monitoring, we began a public education campaign on alternatives to rodent poisons and other "owl-friendly" practices. Many of the pellet rodenticides previously used by property and business owners became unavailable to the public in 2015 due to EPA restrictions (EPA 2017). Since 2015 we have found just 3 suspected cases of secondary poisoning. This may be due to more controlled commercial application for pest rodent control or exposure to new rodenticide compounds. In addition to pesticides, this urban owl population is highly susceptible to disturbance from construction and other human activities. As the only species of owl to live in burrows, Burrowing Owls are especially vulnerable to being buried alive due to soil disturbance associated with new construction. Since the beginning of this project, we have observed burrows lost due to preconstruction land preparation and have found burrows with clear evidence of human disturbance.

Over 5 years of monitoring we only detected evidence of 2 predation events near nests, regardless of high occupancy by coyotes in urban washes and despite the apparent attraction of coyotes to domestic dog waste scattered in front of most active urban owl nests (Figure 3). Adaptable avian predators, including nonbreeding Cooper's Hawks (*Accipiter cooperii*) are becoming more common in urban and suburban Lake Havasu City and may be a threat to survival of young birds. Todd (2001) found that 47% of mortality of young, dispersing birds was due to avian predators. Vehicle collisions may be responsible for additive mortality in our population as well; an average of 3 birds per year with a low probability of survival are brought to our wildlife rehabilitator after being hit by cars.

Figure 3. Coyotes are frequently observed investigating nest sites in remote camera footage 25 April 2015. Photo by K. Loyd

FUTURE RESEARCH

Nest monitoring will continue at least through 2020 and we will collect additional information to include in models and to inform us about influences on nest success and productivity. In particular, future monitoring will include data on proximity to other nests (nearest neighbor, as an indicator of competition for food) and roads.

The ongoing research in Lake Havasu City will contribute to important gaps in knowledge about owl activity and population trends in human-dominated environments. During summer 2018 we began banding birds and are currently studying site fidelity of breeding adults and juvenile dispersal. Understanding more about our Lake Havasu City population can help us target conservation measures and focus future public education efforts to ensure long-term population growth.

ACKNOWLEDGMENTS

Arizona State University students that contributed substantially to this research from 2015-2018: Cimmaron Davey, Joe Osinski, Morgan Beckwith, and Jordyn Somers. Burrowing Owl conservation in Lake Havasu City is funded by Arizona State University @ Lake Havasu, Arizona Game and Fish Heritage Grant program, and Arizona Field Ornithologists Gale Monson Research Grants. We thank Greg Clark and Bob and Sam Fox for advice and Lauren Harter, Ron May, and David Vander Plyum for reviewing a draft of the article and making useful suggestions.

LITERATURE CITED

Arizona Game and Fish Department. 2012. Arizona's State Wildlife Action Plan: 2012-2022. Arizona Game and Fish Department, Phoenix, Arizona.

Barclay, J. H., N. M. Korfanta, and M. J. Kauffman. 2011. Long-term population dynamics of a managed Burrowing Owl colony. The Journal of Wildlife Management 76(6):1295-1306.

Bayless, T. A., and P. Beier. 2011. Occurrence and habitat characteristics of Burrowing Owl nests in Gunnison's prairie dog colonies of northeastern Arizona. Journal of the Arizona-Nevada Academy of Sciences 42(2): 65-74.

Berardelli, D., M. J. Desmond, and L. Murray. 2010. Reproductive success of Burrowing Oowls in urban and grassland habitats in southern New Mexico. The Wilson Journal of Ornithology 122(1): 51-59.

Botelho, E. S., and P. C. Arrowood. 1998. The effect of burrow site use on the reproductive success of a partially migratory population of western burrowing owls. The Journal of Raptor Research 3(6): 233-240.

Conway, C. J., V. Garcia, M. D. Smith, L. A. Ellis, and J. L. Whitney. 2006. Comparative demography of Burrowing Owls in agricultural and urban landscapes in southeastern Washington. The Journal of Field Ornithology 77(3): 280-290.

Crowe, D. E., and K. M. Longshore. Nest site characteristics and nesting success of the Western Burrowing Owl in the eastern Mojave Desert. The Journal of Arid Environments 94:113-120.

Environmental Protection Agency. 2017 (a), **https://www.epa.gov/safepestcontrol/mouse-and-rat-poisons-pellet-form-banned** [Accessed 14 December 2018].

Environmental Protection Agency. 2017 (b). **https://www.epa.gov/rodenticides/restrictions-rodenticide-products** [Accessed 14 December 2018].

Green, G. A. 1983. Ecology of breeding Burrowing Owls in the Columbia Basin, Oregon. M.S. Thesis. Oregon State University, Corvallis, Oregon.

Green, G. A., and R. G. Anthony. 1989. Nesting success and habitat relationships of Burrowing Owls in the Columbia Basin, Oregon. The Condor 91:347-354.

Greger, P. D., and Hall, D. B. 2009. Burrow occupancy patterns of the Western Burrowing Owl in southern Nevada. Western North American Naturalist 69:285-294.

Holmes, A. L., G. A. Green, R. L. Morgan, and K. B. Livezey. 2003. Burrowing Owl nest success and burrow longevity in north central Oregon. Western North American Naturalist 62:244-250.

Justice-Allen, A., and K. T. Loyd. 2017. Mortality of Western Burrowing Owls (*Athene cunicularia hypugaea*) associated with brodifacoum exposure. The Journal of Wildlife Diseases 53(1):165-169.

Klute, D. S., L. W. Agers, M. T. Green, W. H. Hoew, S. L. Jones, J. A. Shoffer, S. L. Sheffield, and T. S Zimmerman. 2003. Status assessment and conservation plan for the Western Burrowing Owl in the United States. US Fish and Wildlife Service Biological Technical Publication. BTP-R6001-2003. U.S. Department of the Interior.

Latta, M. J., C. J. Beardmore, and T. E. Corman.1999. Arizona Partners in Flight Bird Conservation Plan. Version 1.0. Nongame and Endangered Wildlife Program Technical Report 142. Arizona Game and Fish Department, Phoenix, Arizona.

Lantz, S. J., C. S. Conway, and S. H. Anderson. 2007. Multi-scale habitat selection by Western Burrowing Owls in black-tailed prairie dog colonies. Journal of Wildlife Management 71(8):2664-2672.

Manning, J. A., and R. S. Kaler. 2011. Effects of survey methods on Burrowing Owl behaviors. The Journal of Wildlife Management 75(3):525-530.

Mrykalo, R. J., M. M. Grigione, and R. J. Sarno. 2009. A comparison of available prey and diet of Florida Burrowing Owls in urban and rural environments: A first study. The Condor 111:556-559.

Poulin, R., L. D. Todd, E. A. Haug, B. A. Millsap, and M. S. Martell. 2011. Burrowing Owl (**Athene cunicularia**), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: **http://bna.birds.cornell.edu/bna/species/061**

Rodriguez-Estrella, R., and A. O. Ortega-Rubio. 1993. Nest site characteristics and reproductive success of burrowing owls in Durango, Mexico. The Review of Tropical Biology 41:43-48.

Rosenberg, K. V., R. D. Ohmart, W. C. Hunter and B. W. Anderson. 1991. Birds of the Lower Colorado River Valley. University of Arizona Press. Tucson, Arizona.

Rosenberg, K. V., J. A. Kennedy, R. Dettmers, R. P. Ford, D. Reynolds, J. D. Alexander, C. J. Beardmore, P. J. Blancher, R. E. Bogart, G. S. Butcher, A. F. Camfield, A. Couturier, D. W. Demarest, W. E. Easton, J. J. Giocomo, R. H. Keller, A. E. Mini, A. O. Panjabi, D. N. Pashley, T. D. Rich, J. M. Ruth, H. Stabins, J. Stanton, T. Will. 2016. Partners in Flight Landbird Conservation Plan: 2016 Revision for Canada and Continental United States. Partners in Flight Science Committee. 119 pp.

Smith, M. D., C. J. Conway, and L. A. Ellis. 2005. Burrowing Owl nesting productivity: a comparison between artificial and natural burrows on and off golf courses. The Wildlife Society Bulletin 33:454-462.

Todd, L. 2001. Dispersal patterns and post-fledging mortality of juvenile Burrowing Owls in Saskatchewan. The Journal of Raptor Research 35(4):282-287.

Trulio, L. A., and D. A. Chromczak. 2007. Burrowing Owl nesting success at urban and parkland sites in northern California. The Proceedings of the California Burrowing Owl Symposium, pp. 1-15.

York, M. M., D. K. Rosenbery, and K. K. Sturm. 2002. Diet and food-niche breadth of Burrowing Owls in the Imperial Valley, California. Western North American Naturalist 62:280-287.

Accepted 1 February 2019