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Symposium Organizer: David H. Johnson

Symposium Committee: Mike Gregg, Jeff Lincer, Troy Wellicome, Jim Belthoff, Courtney Conway, Lisa Nordstrom

ABSTRACTS

Long-term Population Dynamics of the Burrowing Owl Colony at San Jose International Airport

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We analyzed population dynamics of the burrowing owl (*Athene cunicularia*) colony at San Jose International Airport during 1990-2007. The breeding colony increased from 7 pairs in 1991 to 40 pairs in 2002 and declined to 17 pairs in 2007. Annual nesting success (pairs raising ≥1 young) averaged 79% for all nesting attempts. Nesting success by pairs in artificial burrows (87%) was not significantly different than in natural burrows (76%). Reproduction averaged 3.36 juveniles/pair. Reproduction in artificial burrows was not statistically comparable to reproduction in natural burrows because nestlings in artificial burrows were counted whereas nestlings in natural burrows were estimated. Annual change in adult owls was not significantly correlated with reproduction the previous year. Annual survival rates during 1996-2007 were estimated using program MARK at 0.545 for adults and 0.258 for juveniles. Adult survival was estimated at 0.710 during colony increase from 1996-2002 and 0.465 during decline from 2002-2007. A life table response experiment showed that changes in adult survival rate explained more than twice the variation in growth rate than other vital rates during the increasing and declining periods. We found no correlation between bird strike reports identifying owls (including Barn Owls [*Tyto alba*]) and the burrowing owl population.

Avoidance, Minimization and Mitigation Measures Used During Construction to Protect Burrowing Owls in Imperial County, California

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We offer a review of our experiences as field biologists using avoidance (worker training, project redesign, project timing), minimization (sheltering in place, road closures) and mitigation (installation of artificial burrows, passive relocation) techniques to protect Burrowing Owls (*Athene cunicularia*) and burrows during construction projects such as solar farms, road construction and resurfacing, housing and commercial development, and transmission lines. We offer examples of lessons learned during 15 years of interaction with Burrowing Owls and adaptations made to improve techniques.

Influence of Rainfall, Nest Density and Landscape Fragmentation on Burrowing Owl (*Athene cunicularia hypugaea*) Prey Deliveries to Nests

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Burrowing Owl (*Athene cunicularia hypugaea*) populations are declining, with the strongest declines in the north. This is likely, in part, due to habitat loss and fragmentation. Habitat fragmentation may result in increased nest densities and increased competition for resources. We are interested in how nest density and fragmentation influences prey delivered to nests. We hypothesized that the percentage of vertebrate prey at nests would be negatively related to owl density and measures of landscape fragmentation. To test this, in 2010 cameras (n = 54) were distributed at nests across five Forest Service National Grasslands from New Mexico and Texas to South Dakota. Video data at each nest was examined for prey deliveries (vertebrate, invertebrate, and unknown). Prey type was examined in relation to the size of the prairie dog colony, distance to colony edge, burrowing owl density, percent agriculture, precipitation and number of young fledged. A multiple regression analysis and an Information Theoretic Approach were used to test 15 *a priori* models. Our analysis identified two competing models (≤ 2 AIC_c). Our top model contained only precipitation, indicating that prey items were most strongly influenced by winter-summer rainfall. The competing model contained both precipitation and owl density, supporting our prediction that owl density has a negative influence on the amount of vertebrate prey delivered to nests. There was limited support for the percentage of agriculture negatively influencing prey quality. This research will contribute to a greater understanding of burrowing owl ecology and population declines across the Great Plains.

Conservation of At-Risk Burrowing Owls Using Active Translocation in Arizona

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Between 2002 and 2013 we trapped approximately 1,500 Western Burrowing Owls (*Athene cunicularia*) that were at risk from land development in Arizona. These Burrowing Owls (owls) were transported statewide to Wild At Heart near Phoenix awaiting translocation. A parallel habitat effort installed approximately 6,800 artificial burrows. There are two primary project goals: conservation of the owls that face immediate loss of burrows, and long-term recruitment of other owls to the artificial burrows. We created an active translocation protocol (relocation) designed to break owl site fidelity to the trapping site and build site fidelity to the release site. At a minimum, transported owls are held at the care facility in aviaries for 60 days before relocation to the release site. Relocation to a release site is not performed during the migration period (September to early February). Relocation occurs in the Spring, late February through May with low elevation sites coming first. All owls are color banded and have USFWS bands.

Owls are trapped and placed in aviaries that have soft plastic mesh to cushion owl flight impacts; each aviary holds an average of eight owls to be relocated together. Artificial burrows for relocation were installed in many types of open habitats; a typical site has 100 burrows. A steel structure covered with cattle shade cloth, enclosing eight burrows, is used for the relocation tent. The owls receive defrosted frozen mice and fresh water daily for 30 days and then the tent is removed. Volunteers construct habitat, set up the release tents and feed the owls. Relocated owls generally stay with the available artificial habitat until migration around October. After October, agricultural habitat appears

to retain more males through the winter, and more females return to the site in Spring. Artificial burrows near large farms (>200 ha), and surrounded by farm land, are continuously occupied long-term by owls that find the burrows. The current methods of owl trapping, aviary care, relocation protocol, habitat site selection, burrow creation, and release tent construction, appear to be meeting our primary goals: conserving the at-risk owls, providing more long-term habitat for owls in the local area, as well as displaced owls, dispersing juvenile owls, and migratory owls.

Latitudinal Gradients in Population Trends and Demographic Traits of Burrowing Owls: Causes and Consequences.

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Burrowing owl (*Athene cunicularia*) numbers have declined dramatically in Canada, but the status of burrowing owl populations in the U.S. has been less obvious. Local and regional declines in some areas seem to be tempered by stable or increasing populations in other areas. However, few efforts have been made to examine how numbers of changed in different regions, or to test hypotheses to explain regional variation in population trends. I analyzed data from the BBS to assess regional variation in population trends of burrowing owls throughout the U.S. Results suggest that populations in the northern half of the U.S. have declined significantly over the past 40 years, but the trends in the southern half of the U.S. are less dramatic. I also conducted a comparative analysis to evaluate correlates of population trend and a suite of burrowing owl demographic traits based on intensive field studies across the species' range. The results suggest that most demographic traits vary with latitude and with propensity to migrate. Clutch size is larger in more northern migratory populations but the number of offspring produced per successful nesting attempt does not vary with latitude or migratory behavior. Moreover, the adult return rate and natal recruitment are much lower in northern migratory populations. Given these results, it is hard to see how migratory populations can persist.

Continental Patterns in Migration and Dispersal of Burrowing Owls based on Genetics and Stable Isotopes

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Burrowing owl (*Athene cunicularia*) populations in the northern portion of the species' breeding range have declined more than those in the southern portion of their range. The underlying cause of this continental pattern is not clear. We used genetics and stable isotopes to test hypotheses to explain this pattern. Owls in the northern portion of the breeding range were more genetically similar to owls in northwestern Mexico than would be predicted based on an isolation-by-distance genetic model. Moreover, isotopic ratios of owls in the northern portion of the species' range suggest that many breeders are immigrants from further south. These data suggest that burrowing owl populations in the northern portions of their breeding range rely on a 'rescue effect', whereby annual dispersal from southern source populations bolsters northern sink populations. Hence, changes in the southern portions of the species range (including changes in land-use, irrigation and farm practices, and climate) may be responsible for population declines in the northern portion of the species' range (due to reductions in fecundity of southern populations).

Stable Isotopes Reveal High Breeding Dispersal of a Migratory Owl *(Athene cunicularia hypugaea)*

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We used stable-hydrogen isotope ratios of feathers coupled with likelihood analysis to determine previous years breeding region for adult western burrowing owls (*Athene cunicularia hypugaea*) across a latitudinal gradient within the eastern portion of their range. Estimates of breeding dispersal were calculated by comparing breeding locations between years within assignment regions. A stable hydrogen isotope basemap of burrowing owl feathers (δD_f) was created via ArcGIS using hatching year feathers (n = 196) of known locations to serve as a reference for the unknown locations of after hatching year feathers. Region assignments were determined by a likelihood analysis approach. Results revealed high breeding dispersal with 77% of the sampled population (n = 287) relocating to a new region and relatively non-existent mate fidelity. The data reveals two distinct trends; low survival for northern-origin owls and an overall trend for owls to disperse in a northerly direction. These observations, when coupled with inconsistencies in band returns and δD data, alternatively suggest burrowing owls molt rectrices either during or after migration.

Reoccupation of Habitat Under Solar Panels by Burrowing Owls at a Utility-Scale Solar Facility in Southern California. [Poster Presentation]

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The California Valley Solar Ranch (CVSR) is a photovoltaic solar power production facility located on approximately 688 hectares at the northeastern edge of the Carrizo Plain, in eastern San Luis Obispo County, California. The project was designed to minimize its impact on special-status species and their habitat, including the Burrowing Owl (*Athene cunicularia*), which nests and winters throughout the grassland habitat characteristic of the project area. During construction, a comprehensive management plan was in place to protect all nesting birds from project-related impacts. This included the use of one-way doors for passive exclusion of Burrowing Owls from construction areas during the non-breeding season, and systematic maintenance of these one-way doors throughout the breeding season to prevent owls from utilizing burrows close enough to construction activity to place them or their nests at risk. Once construction activity was completed in an area, the one-way doors were removed, opening up burrows for continued use by owls and other wildlife. During systematic maintenance of one-way doors in late summer 2013, a single adult Burrowing Owl was documented over a 3 month period using a freshly excavated mammal burrow approximately 500 ft within and directly underneath an array of solar panels. This excavation was under surveillance to confirm it was not being used by special-status mammals. In addition to this documented case of an owl occupying a burrow directly underneath solar panels, other evidence such as molted feathers and pellets suggests that foraging owls are using other areas within the solar arrays.

Juvenile Burrowing Owl Survival and Dispersal in the Urban/Agricultural Interface of Las Cruces, New Mexico

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We examined survival and dispersal patterns of juvenile Burrowing Owls in urban and agricultural environments of southern New Mexico. We hypothesized that 1) Burrowing Owl mortality would be influenced by the amount of development surrounding the nest and 2) age of dispersal would be influenced by body condition, measures of interspecific competition and/or habitat type and fragmentation. Forty-two juvenile Burrowing Owls (n= 23 and 18 in 2012 and 2013, respectively) were radio tagged at 35-42 days of age. Owls were located daily between the hours of 1000-1600 to determine diurnal roost locations and daily survival. Of the 42 owls radio-tagged, there were 6 mortalities, with the major cause of mortality being predation. We used NAIP imagery to classify habitat type and determine the number of habitat patches within a 600m radius of the nest. Habitat was classified as urban (commercial, residential), agriculture, greenspace (parks, desert scrub), and other. We defined dispersal as a permanent movement of at least 300m from the nest. Mean age at dispersal was 69.2d ± 3.72 and 50.75d ± 6.16 for 2012 and 2013, respectively. Age at dispersal is being modeled in relation to the surrounding landscape matrix using multiple regression analysis and an Akaike Information Theoretic Approach. Ten *a priori* models will be tested using combinations of the following variables: year, sex, body condition index, # fledglings per nest, distance to nearest nest, habitat classification (% urban, agricultural and greenspace) and habitat patches. Results of this modeling approach will be discussed.

A summary of extreme weather impacts on Burrowing Owls in Canada

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A long-term (2003-2010) nest monitoring dataset, along with shorter-term experimentation allowed us to quantify the effect of extreme, but relatively rare, weather events on Burrowing Owl reproductive output and nest reoccupancy patterns in Canada. Using a network of Environment Canada weather stations and monitoring of >700 nesting attempts between 2003-2010, we show that high intensity, short-duration rainfall events significantly increased the probability of complete nest failure. In 1992, 1993, and 1996 we conducted a food supplementation experiment to examine how food limitation might influence nestling survival in inclement weather. In broods that received no supplemental feeding, the youngest owlets were more likely to perish during bouts of rain compared to their older brood mates. However, almost all owlets survived bouts of inclement weather when their brood was supplementally fed. The patterns of nestling survival in unfed and fed broods suggest that food limitation during inclement weather, either due to reduced hunting effort or efficiency by adults is a likely cause of many nestling mortalities in this population. Using the long-term 2003-2010 nest monitoring dataset, we also examined how spring and breeding season conditions influence burrow reoccupancy patterns. A high water equivalent anomaly (i.e., excess water compared to average) in spring and reproductive failure the previous year were correlated with reduced nest reoccupancy rates.

Increases in both the frequency and intensity of extreme rainfall events in much of North America under various climate change scenarios could have significant negative consequences for the already small Burrowing Owl population in Canada.

Breeding and Foraging Ecology of Burrowing Owls in Southwestern Manitoba: The Manitoba Burrowing Owl Recovery Program

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In Manitoba, known nesting populations of Burrowing Owls have declined from 76 pairs in 1982 to less than 10 pairs in recent years. The Species at Risk Act's recovery strategy for the Burrowing Owl in Canada outlines specific goals and objectives to promote the recovery of Burrowing Owls to their historic range. The long-term recovery goal, specifically for Manitoba, is to re-establish a self-perpetuating, well-distributed, wild breeding population (23 pairs) to their 1993 historical range. Due to limited data available in Manitoba about the species with no specific ecological examination of food habits, home range, and/or dispersal, fulfilling specific recovery goals is difficult.

Goals of the project include: the reintroduction of first year owl pairs to promote, stimulate, and increase Burrowing Owl populations in Manitoba, identifying factors that affect the owls' survival in the province, and to collect breeding, foraging ecology and behavioural data of captive released and wild Burrowing Owl populations each breeding season (2010-2013). The project also focuses on engaging landowners in stewardship activities on their land to promote the success of nesting owls, returning owls in future seasons, and facilitates monitoring and adaptive management. A summary of data collected to date will be presented.

Why have Burrowing Owls Disappeared from Portions of their Former Breeding Range?

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Breeding distributions of many birds have shifted northward in response to recent changes in climate. In North America, grassland birds are exceptions to this pattern; distributions of grassland birds appear to be shifting southward instead of northward. For example, the breeding range of Burrowing Owls (*Athene cunicularia*) has been retracting southward since the 1970's. Why? We used logistic regression of BBS data to identify the factors influencing Burrowing Owl occupancy and used GIS to create a refined range map of Burrowing Owls based on these factors. Larger areas of prairie dog colonies increased the probability of Burrowing Owl occupancy by up to 25%. The probability of occupancy increases with percent cropland coverage until approximately 40% cropland. Occupancy was negatively correlated with soybean crops, potentially explaining range contractions in the north-eastern part of the species' range. Occupancy was also negatively correlated with precipitation, potentially explaining why the range is contracting in the Great Plains region where the amount of precipitation has increased by almost double the amount compared to the Southwest region since 1958. Climate change models predict further increases in winter/spring precipitation in the northern part of the U.S., and such changes may lead to further contraction of the burrowing owls' breeding range. Therefore identifying the factors that influence Burrowing Owl occupancy will not only help inform effective strategies for management and recovery of the species, but also help mitigate the potential adverse effects of climate change on the species breeding range.

Microclimate of Mojave Desert Tortoise Burrows as a Common Resource for Western Burrowing Owls

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In the Mojave Desert Western burrowing owls (*Athene cunicularia*) have been documented using burrows dug by the desert tortoise, kit fox and ground squirrel. Mojave desert tortoises (*Gopherus agassizii)* excavate soil burrows and also utilize caliche cave burrows associated with deeply incised washes as nest sites; both of which serve as a common resource for burrowing owls. Little is known about the microclimatic differences between these burrow types and how this might influence burrow selection and occupancy by owls. We surveyed 280 burrows (79 caliche caves, 201 soil burrows) at our tortoise translocation field site near Jean, Nevada. We selected a stratified subsample of 24 burrows and monitored temperature and humidity over a one-year period. Our preliminary results suggest that both burrow type and depth are significantly associated with differences in ability to buffer temperatures. Caliche caves are significantly deeper than soil burrows and experience narrower ranges in maximum and minimum temperatures. The provision of more buffered microclimates provided by caliche caves may influence burrow choice by both desert tortoises and owls and increase survival rates, particularly in the future as long-term climate change trends influence ambient temperature and humidity in the Mojave Desert.

Distribution Map of the Western Burrowing Owl (*Athene cunicularia hypugaea*) in the US and Canada, 2013

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Currently, the most recent rangewide distribution map for the Western Burrowing Owl (*Athene cunicularia hypugaea*) is that of Wellicome and Holroyd (2001). Data for the map was current through the 1990s. We offer an updated distribution map for the United States and Canada. This distribution map reflects data from the time period of 2004 through 2013, drawn from the following sources:

1) USGS bird banding data (2004 thru 2013),
2) Breeding Bird Atlas data,
3) Breeding Bird Survey data
4) Christmas Bird Count data
5) State-level data sets (e.g., Heritage data, Fish and Wildlife data)
6) GAP and other habitat-based potential distribution maps
7) survey project data, reports and publications
8) personal communication with Burrowing Owl and Fossorial Wildlife researchers
9) E-bird

A final draft map will be disseminated for formal peer review and then be developed for publication. The GIS layer of the final map will be made available on the Global Owl Project website: www.globalowlproject.com

Using the MP3-trap Technique to Capture Male Burrowing Owls in Cache or Temporary Burrows

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During the field seasons of 2010 thru 2013, we used MP3 players and small speakers, placed inside cache or temporary burrows, in conjunction with swing-door traps, to capture several hundred male Burrowing Owls. In prior years, we had used bownets baited with mice to capture males, resulting in the capture of about 80% of the males. This food-based solicitation did not work well on males with great hunting skills or easily available prey. So, we switched to using a territorial-based solicitation framework, starting with a wildlife caller and bownet or walk-in trap placed at nests or male cache burrows. We subsequently began using an MP3 player and folding speaker. MP3 players and folding speakers were placed inside the males' food cache/roost burrow, or if such a burrow was not present, we would add a temporary burrow (e.g., 35 cm section of 15 cm plastic drain pipe). To the entrance of these burrows we would place a swing-door walk-in trap. The MP3 player/speaker would play the "coo-cooo" contact call of the male; volume would be low, so that it could only be heard from 3-4 m away. The intention would be to replicate the calling of a pesky, intruding, sub-dominant male. The MP3-trap technique was highly efficient. In essence, the MP3-trap allowed us to capture nearly all of the males we attempted capture on, and in substantially less time and effort than bownets required. In 2013, D.H. Johnson and colleagues used this technique to capture 130 adult male owls on study areas in six states. We also captured un-paired floater female owls drawn in by the male calls on the MP3 player. In this presentation we discuss the results and the specific methods of this trapping technique.

Use of Geolocators in Assessing Migration Patterns of Western Burrowing Owls in Oregon, Washington, and Saskatchewan

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During 2010-2012, we placed backpack-mounted geolocators onto adult male and female Burrowing Owls (*Athene cunicularia*) in Oregon, Washington, and Saskatchewan. As this was a rapidly developing technology, we used two different models, both with the same basic design of an epoxy-sealed geolocator unit with sensor stalk. We used 3/16-inch diameter Teflon tubing as the harness material. We put units onto owls in 2010 and 2011, and recaptured the owls in the subsequent year. We recaptured 25 owls which returned to the sites where they were marked the previous year - 1 male from Saskatchewan, and 14 males and 10 females from Oregon/Washington. The Saskatchewan male wintered in southwestern Texas. Nine of 10 Oregon/Washington females wintered in California; one female wintered in east-central Oregon. Four of 14 Oregon/Washington males wintered in California, and 10 males wintered in east-central Washington. A number of the Oregon males actually went north to winter in Washington. Only one Washington male was confirmed to not have migrated, but rather spent the winter on his own nesting territory on the edge of Pasco, Washington.

We discuss the use of geolocators, harness materials, capture and handling of owls for this study.

The Burrowing Owl (*Athene cunicularia*) Literature—Whooo? needs it?

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Historically, the need for, and value of, bibliographies has often not been recognized and, therefore, has been underestimated and unfunded. This can result in a researcher not being adequately familiar with the relevant literature and either (1) unintentionally, and needlessly, duplicating research and/or (2) not benefiting from both the successes and learning experiences of past efforts. A researcher or educator, if they appreciate the value of knowing the literature, has to spend an inordinate amount of time and energy *properly* searching the literature (and not just conducting a quick web search) if they want to maximize the value of what they produce. In these days of limited time and funding, it behooves us to encourage and, wherever possible provide, relevant working (i.e., interactive, searchable, and updatable) bibliographies in order to maximize the contributions of all individuals working on a taxa or issue rather than forcing each to duplicate that same literature search every time a project is initiated. The Working Burrowing Owl Bibliography is part of, and a prototype for, a larger effort to update the World Owl Bibliography (WOB; Clark, Kelso, and Smith 1978)**. Although the original WOB contained 6,590 citations, with the subsequent explosion in both the research on owls (starting in the 1970s) and the electronic-based increase in the ability to publish and search the owl literature, we estimate that the current number of owl publications is likely to exceed 60,000! This is a huge effort that is yet to be funded. As part of the funding strategy, and to gain procedural insight, one or more interim income-producing products will be produced; the BUOW Bibliography (perhaps, part of "A Researcher's Guide to the Burrowing Owl") being one of them. At the time of this writing, we have amassed 2,000 citations and approximately 25% of the actual articles. The results of bibliometric analyses, which can be especially useful in any gap analysis of the existing research, will be presented. Patterns in the literature, by geography, time, subject matter/issue, etc., along with methods, constraints, opportunities, and anticipated components to this research tool, as well as progress, will be discussed. An opportunity for others to contribute to this, and the much larger, "World Owl Bibliography," will also be presented.

** Clark, R.J.; Smith, D.G.; Kelso, L.H. 1987. Working Bibliography of Owls of the World. NWF Scientific and Technical Series 1. National Wildlife Federation, Washington, D.C.

Imperial Irrigation District's Burrowing Owl Monitoring & Conservation

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The Imperial Valley, California is home to roughly 70% of California's Burrowing Owl (*Athene cunicularia*) population. In this highly agricultural area, burrows are often found along the canal and drainage system managed by the Imperial Irrigation District (IID) Water Department. This management includes conducting daily operation and maintenance (O&M) and construction activities within the IID Service Area related to the delivery, conservation and/or drainage of irrigation water. The IID has created one on the best examples of avoidance and monitoring programs to be able to provide habitat, while meeting the water needs of the area. This program is two-fold with a daily emphasis on marking potential and occupied burrows prior to activities, clearing burrows for repairs in the non-breeding season and training operators in burrow avoidance. The second part includes population studies of the species along the IID Rights-of-Way. A pilot study was conducted in 2006 and Right-of-Way census in 2007 and 2008, which utilized a full population census methodology. Based on these results, the area was divided into 3x3 km grids and stratified into high, medium and low density. A random subsampling of these grids with equal high, medium and low density representation formed the Right-of-Way Subsampling locations in 2011, 2012 and soon in 2014. The results have shown the population is variable and we are constantly looking for new information about the species and best monitoring practices.

A Review of the Burrowing Owl Program on Umatilla Chemical Depot, Oregon

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The Umatilla Ordnance Depot, located about 180 miles east of Portland, Oregon, and 3 miles south of the Columbia River, was established in 1941 as one the Army's first supply depots in preparation for World War II. The Depot stocked materiel from blankets to bombs in its warehouses and explosives magazines. Renamed as the Umatilla Chemical Depot in the 1960s, a portion of the installation was used to store approximately 12% of the nation's chemical munitions until they were destroyed in an on-site incineration facility between 2004 and 2011. With completion of chemical munitions destruction and at Congress' direction, the Army now is in the process of closing the Depot and preparing to transfer the property to several parties, including the Oregon National Guard.

The 17,170-acre Depot consists of a variety of grass- and shrub-steppe vegetation communities which, together with the relatively low intensity of development and human activities, provide valuable habitat for a variety of wildlife and plant species in the Columbia Plateau. The Western Burrowing Owl (*Athene cunicularia hypugaea*) historically has occurred on the Depot. In 2008, three or four breeding pairs of burrowing owls were found to be nesting in the few remaining natural burrows on the Depot. That same year, the Army, in collaboration with the U.S. Fish and Wildlife Service, began to install artificial burrows for the owls. Currently, 165 artificial burrows have been installed in suitable habitat, in pairs or threesomes, providing nesting sites that could potentially support 82 pairs of owls. Together with naturally occurring burrows, the artificial burrows have facilitated a significant increase in the production of owlets from the area, have provided a valuable location for burrowing owl research and international species conservation efforts, and have led to improvements in artificial burrow design, construction, and placement.

This paper reviews the history and results of the Depot's artificial burrow installation program since 2008, describes past and ongoing burrowing owl research efforts on the Depot, and looks at the potential future of the burrowing owl program on the Depot as the property transfers from Army control in the upcoming years.

Strategies for Successful Ground Squirrel Translocations in the Context of Creating Sustainable Habitat for Western Burrowing Owls in San Diego County

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California ground squirrels *(Otospermophilus beecheyi*) play a keystone role in the engineering of grasslands ecosystems, and provide critical resources for western burrowing owls *(Athene cunicularia hypugaea)*, making their re-establishment a critical component of burrowing owl and grassland recovery plans. We began California ground squirrel translocation efforts in 2011 with the goal of restoring functional grassland ecosystems and providing a more sustainable alternative to artificial burrows for western burrowing owls. Our initial trials, however, suggested that habitat suitability might be an important factor impeding successful ground squirrel establishment at some locations. In 2012-2013, we conducted habitat surveys for California ground squirrels throughout San Diego County to determine habitat suitability using a combination of vegetation sampling, soil analysis, and GIS to measure landscape features. Additionally, we characterized both the micro- and macro- habitat of western burrowing owl nests with the goal of better understanding how habitat features influence burrowing owl nesting success. Here we will provide our evaluation of the efficacy of multiple ground squirrel translocation strategies, and important habitat characteristics associated with ground squirrel and burrowing owl presence. These complimentary studies will provide greater insight into nest site and habitat requirements for western burrowing owls and California ground squirrels in San Diego County grasslands and, in turn with help inform future management decisions concerning squirrel translocations and local burrowing owl conservation efforts.

Bringing Back the Burrowing Owl (*Athene cunicularia*) to British Columbia: Community Conservation Looking Towards the next 10 Years

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The Burrowing Owl (*Athene cunicularia*) is a Species at Risk in Canada and was extirpated from British Columbia in the 1980s. In Canada, populations of Burrowing Owls migrate in the fall to the southern United States and possibly Mexico. With a loss or degradation of native habitat, both in nesting and overwintering grounds, along with the decline in fossorial mammals and the effects of climate change, Burrowing Owl populations continue to decrease in BC and Canada. In 1990, volunteers initiated a comprehensive re-introduction program, including three captive breeding facilities, artificial burrow networks and field monitoring research. The Society (formed in 2000) produces over 100 owls each year to release in the Nicola Valley and South Okanagan grasslands of BC. Artificial burrows are prepared on private ranch land, provincial land and Non-government Organization properties. Improved release techniques, including soft-release caging, has resulted in higher adult survival and greater numbers of wild-hatched offspring with the potential to return in following years. We are currently working internationally to follow and protect the owls on their migration route by employing citizen science. We have confirmed sightings of owls across their migration route in Washington, Oregon and California. The Burrowing Owl program in BC is a prime example of an applied conservation project with strong community support and also represents great opportunities for research on Burrowing Owls in the northern most region of the range. The goals and predictions for the next 10 years of the BC Burrowing Owl population will be discussed.

Assessment of Artificial Burrows for Burrowing Owls at Mineta San José International Airport

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A year-around resident burrowing owl population was actively managed at Mineta San José International Airport, California, from 1991 through 2011. Management included the installation of 113 artificial burrows on the airfield in areas where owls would not interfere with airport operations and construction projects. Artificial burrows were installed as replacement for natural burrows intentionally closed prior to ground disturbance and along the center sections of runways where strike hazard risk is greatest. Natural burrows were abundant in some infields. A total of 831 burrowing owls were banded at the airport, 803 as nestlings in artificial burrows. For my Master's thesis at San José State University, I am currently assessing artificial burrow longevity and occupancy rates, nest burrow type (artificial vs. natural) choice by burrowing owls raised in artificial burrows, as well as philopatry and nest site fidelity. The results of this study will offer tangible information on the value of artificial burrows as an effective long-term mitigation tool.

Patterns of Burrow Use by Burrowing Owls (*Athene cunicularia*) at the Mid-Columbia River National Wildlife Refuge Complex

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The Burrowing Owl is currently listed as a federal species of concern, a candidate species in Washington, and a critical sensitive species in Oregon. U.S. Fish and Wildlife Service and volunteers have been monitoring burrowing owl nest attempts from 2005 through 2013 at the Hanford Reach National Monument and at Umatilla National Wildlife Refuge. Both properties are part of the Mid-Columbia River National Wildlife Refuge Complex. We have examined burrow use and demographic data from Conway et al. (2005), as well as eight years of USFWS monitoring data to assess patterns of burrow use including re-occupancy rates and burrow longevity. In 2013, our data base contained 174 owl burrow records, of which 65 were artificial burrows and 109 were natural burrows. Average re-occupancy rate was 34%, ranging from no re-use, to 100% re-use. Burrow longevity was highly variable ranging from zero to 10 years. Monitoring effort varied each year. Goals for monitoring in 2013 included determining nest-success at each burrow and locating new nest burrow locations. In 2013, 41 burrows were monitored, 13 were occupied. I also discuss trapping and banding efforts related to the use of geolocators and a PTT transmitter.

Key Linkages between Burrowing Owls and Fossorial Wildlife

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While it is well known that burrowing owls need burrows to survive and reproduce, their interdependence on fossorial wildlife that creates these burrows is less understood. Burrows are often a limiting resource for burrowing owls, constraining population establishment and reproduction in an area. One solution has been to create artificial burrows to provide this key resource. In the short-term, this approach can be largely successful to attract burrowing owls and encourage breeding in an area.

However, this approach also requires constant human intervention, can be costly and difficult to maintain over time, and can potentially overlook the broader ecological requirements of the species, creating an ecological trap. Alternatively, recovery efforts focused on the re-establishment of functioning ecosystems and their associated fossorial wildlife could provide a long-term, self-sustaining solution. Furthermore, fossorial wildlife often play the role of ecosystem engineers, not only by creating burrows, but significantly altering the environment. Lessons learned regarding habitat and burrow characteristics, for both burrowing owls and the fossorial wildlife on which they depend, can help inform management activities to promote burrowing owl recovery. This fossorial wildlife session is intended to elucidate the relationships between burrowing owls and various fossorial species, describe key habitat/burrow characteristics, and provide future research directions for the conservation and management of these species across their range.

Protecting Owls Impacted by Development: Standards for Burrowing Owl Relocations within the Western Riverside County Multiple Species Habitat Conservation Plan Area, Riverside County, California

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California supports one of the largest populations of Burrowing Owls (*Athene cunicularia*) within its range in the U.S. However, in several southern California counties, where owls are threatened by development, populations have declined or been extirpated. The Burrowing Owl is among 146 species protected by the Western Riverside County Multiple Species Habitat Conservation Plan (MSHCP or Plan Area), a multi-jurisdictional Habitat Conservation Plan covering 1.26 million acres in southern California. Burrowing Owls are narrowly distributed at only a few sites in open lowlands in the Plan Area. Seven MSHCP conservation objectives mitigate impacts to Burrowing Owls from conflicts with development. Among these objectives is passive relocation, when appropriate, to avoid take (under ESA) of occupied nests, and active relocation of Burrowing Owls to conserved Core Areas or other conservation lands. Previously authorized relocations within the Plan Area did not use standardized protocols, making comparisons among relocations difficult or infeasible. The need for future relocations will continue with the pace of development, however, the success rates and demographic consequences of relocation methods have not been adequately evaluated. We developed a standardized program for implementing Burrowing Owl relocations within the Plan Area. We describe rigorous methods based on peer-reviewed literature. The purpose is to evaluate and improve upon the success of relocations while adaptively improving methods. By implementing consistent field, data collection, monitoring, and reporting protocols, we can analyze owl site fidelity, reproductive success, and survival to improve the future success of relocations for establishing or augmenting Burrowing Owl populations within the Plan Area.

Population dynamics and conservation status of the Western Burrowing Owl (*Athene cunicularia hypugaea*) in the United States and Canada: a 15-year update.

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The Western Burrowing Owl (BUOW) has been the focus of much research, monitoring, and conservation efforts since the first indications of population declines in the 1980s. Despite this focus, burrowing owls remain endangered in Canada, threatened in Mexico, and not yet listed but continuing to decline in the United States. I examined the population dynamics of burrowing owls using two major standardized avian counts (BBS, CBC) and reviewed the conservation status of BUOWs as I did 15 years ago to assess changes occurring over this time. In the US, burrowing owls are still listed as endangered, threatened, or a species of concern in most western states. BBS data for the US and Canada reveal that the 1966-2011 trend is slightly more than a 1% loss per year. Almost all western US states continue to show declining numbers (0.2-4.9%), with the exception of AZ, NE, NM, and WY. CBC data for the US indicate that relatively few BUOWs are seen on CBCs (0.03-0.05 owls/party hour), limiting its use. Conservation statuses of Western Burrowing Owls across the western US and Canada have not changed much in the past 15 years. Elimination of burrowing mammals through control programs and habitat loss appears to be the primary factor responsible for BUOW declines. I suggest that the most effective way to conserve BUOWs is to protect burrowing mammals and their habitats, which should include eliminating control programs and placing real limits on changing land-use for agricultural and other development. Further, conservation statuses of BUOWs in the US should be revisited and adjusted to more accurately reflect their continuing declines.

Pygmy Rabbits: Obligate Burrowers under a Sagebrush Sea

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Pygmy rabbits (*Brachylagus idahoensis*) are obligate burrowers within sagebrush-dominated landscapes in western United States. Because pygmy rabbits do not hibernate, they construct and use burrow systems with multiple entrances year round. During the breeding season from March – July, they dig special natal burrows to give birth and hide their litters for the first 2 weeks of life. Pygmy rabbits are generally solitary and have a promiscuous mating system, thus individuals use multiple burrows and each burrow may be used by multiple rabbits, with the number of burrows used varying with burrow density, sex, and season. Pygmy rabbits spend much of their time within 30-100 m from their burrows because burrows provide security and thermal cover. Pygmy rabbits select food patches closer to their burrow systems, and allow potential predators to come closer before fleeing within burrow systems. Pygmy rabbits construct their burrows in areas with deep, loamy soils with ~ 19% clay, which are often found on mima mounds and along drainages. Cottontail rabbits (*Sylvilagus spp.*) commonly use pygmy rabbit burrows for shelter, and dozens of mammal, bird, and reptile species have been documented nearby. Because pygmy rabbits are cryptic and often occur in sparse, patchy populations, the density of active burrows (identified by their size and the presence of fresh fecal pellets) is frequently used as a population index. The reliance of pygmy rabbits on burrows makes them vulnerable to fossorial predators such as weasels (*Mustela spp.*) and American badgers (*Taxidea taxus*), trampling by large ungulates, conversion of deep-soiled sagebrush rangelands to agriculture, and flooding. In turn, pygmy rabbits, like other burrowing animals, likely act as ecosystem engineers, influencing soils, plant communities, and other wildlife.

Burrowing Owls in the San Francisco Bay Area: Looking Back, Looking Forward.

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The urban Burrowing Owl population (*Athene cunicularia hypugaea*) in the south San Francisco Bay area provides an example of the fate that may face other urban owls. Once numbering in the hundreds of pairs, Burrowing Owls have declined steadily in the region for the last 30 years. One estimate indicates a nearly 30% decline in the number of pairs from 1991-1993 surveys to surveys conducted in 2006-2007 (Wilkerson and Siegel, 2010). Habitat loss to urbanization is a key factor in the decline as is impaired habitat quality, especially due to land management practices that reduce the prey base and burrow availability. Recent efforts to increase the owl population include intensive management of specific sites and the application of research findings to enhance habitat. The new Santa Clara Valley Habitat Plan also has the potential to increase the owl population. Overlaying all these efforts is global climate change, which is likely to significantly affect Burrowing Owls in the region and beyond. This paper discusses the Burrowing Owl population decline in the San Francisco Bay Area, reviews the use of research in conservation efforts, and considers the fate of this urban owl population moving forward.

Responses of Burrowing Owls to Experimental Changes in Clutch Size: Are Burrowing Owls Determinate or Indeterminate Egg-layers?

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To investigate the egg-laying behavior of free-living Burrowing Owls (*Athene cunicularia*) in southwestern Idaho, we manipulated clutch size at 18 Burrowing Owl nests by adding or removing one egg during the egg-laying period. We then compared the size of completed clutches for experimental nests and control nests. Mean clutch size was significantly larger at nests where we added an egg (10.7, SE = 0.67, $n = 9$) than at control nests (8.8, SE = 0.18, $n = 17$), while clutch sizes for control and in nests where we removed one egg (8.3, SE = 0.44, $n = 9$) did not differ. These findings suggest that female Burrowing Owls responded to the removal of an egg by laying a replacement, yet they did not curtail laying in response to the addition of an egg to their nest. Thus, female Burrowing Owls in our study area may be described as removal indeterminate and addition determinate. Our paper discusses behavior implications and potential conservation applications of these results.

Habitat Associations and Status of Burrowing Owls in Canada

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The Canadian Burrowing Owl population has declined by approximately 90% in the last three decades and they now occupy less than 40% of their historic range. It was previously thought that habitat loss was one of the main factors influencing the decline of Burrowing owls; however, current rates of population decline far outpace the rate of native grassland loss in Canada. Over the past 10 years (2003-2013), our research in Alberta and Saskatchewan, Canada has examined habitat associations of Burrowing owls at multiple scales. Our findings suggest that soil and climate indices produce the most predictive models of Burrowing Owl home-range selection and that soil and climate likely create unique environmental conditions for owls which are independent of land use. At the scale of foraging habitat, Burrowing owls selected for, or in other cases, avoided native versus non-native habitat types in the vicinity of nests. Areas of successful prey capture were characterized by increased bare ground exposure and lower overhead cover compared to random areas, contrary to previous research suggesting that tall, dense grasslands may be beneficial for foraging owls. In addition to examining owl responses to various land uses, we also examined owl space use in response to petroleum development. Owls did not avoid or select for wells, pipelines, or petroleum facilities relative to their availability on the landscape. Owls selected for roads, but selection depended on road traffic volume and speed limit. Owls in Canada apparently occur, survive, and reproduce equally well in landscapes dominated by native rangeland and those dominated by cropland and introduced grasses. Our research suggests that the cumulative impacts of habitat loss, fragmentation, human disturbance, environmental contaminants, and climate change may be the ultimate cause of population declines and range contractions of Burrowing owls in Canada.

Reproductive Success of the Western Burrowing Owl (*Athene cunicularia hypugaea*) in Agricultural and Urban Habitats of Dona Ana County, New Mexico

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The Western Burrowing Owl (*Athene cunicularia hypugaea*) is native to grasslands of western North America. Habitat loss and degradation across the Great Plains is hypothesized to have caused observed population increases in urban and agricultural habitats in the south. We examined factors influencing productivity (n = 52 nests) in urbanized landscapes of Dona Ana County, NM during 2010 and 2011. We hypothesized that Burrowing Owl nest survival and success will be influenced by local and landscape variables surrounding the nest. We developed 15 *a priori* models and used Akakie Information Criterion to examine variables influencing reproduction. Based on previous research, we chose to examine the following variables: year, owl density, nearest neighbor fledging success, the interaction of owl density and nearest neighbor fledging success, percent green space, and the number of habitat patches surrounding nests. We predicted that nest survival and success will be positively influenced by Burrowing Owl density and percent green space. Nearest neighbor fledging success alone was the top model, however, four of the 15 models were competing, indicating that no one model accounted for the majority of the variation. Nearest neighbor fledging success and Burrowing Owl density were clearly the most important variables, both negatively influencing fledging success with cumulative model weights of 0.71 and 0.55, respectively. This suggests that successful nests had a lower owl density and neighboring nests tended to do poorly suggesting competition for resources prior to the onset of the monsoon season was the main factor limiting productivity.

Use of Remote Cameras for Monitoring Burrowing Owl Nesting Ecology in San Diego County

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As part of a multi-year research program to assist in the recovery of Western Burrowing Owls (BUOW; *Athene cunicularia hypugaea*) and their grassland ecosystem in San Diego County, we piloted the use of remote cameras to document BUOW nesting and foraging ecology. In the 2013 breeding season, we monitored 9 natural and 9 artificial burrow sites to examine: 1) the frequency and types of prey deliveries, 2) the frequency and types of predation events, 3) human disturbances, 4) reproductive success, 5) survivorship of marked individuals, and 6) other wildlife at/near burrows. To assist with monitoring survivorship, parental care, and reproductive success, banding of BUOW was conducted in conjunction with camera trapping. We captured, banded, and collected genetic material from over 60 BUOW and captured nearly 2 million photos during the breeding season. By comparing reproductive success across sites, we hope to gain a better understanding of local factors that may influence productivity and survival. These comparative data will be especially important for assessing the viability of establishing artificial burrows. Through this research, we hope to test the hypothesis that artificial burrows may sometimes serve as an ecological trap, attracting owls to nest in areas that expose them to greater risk of predation or do not otherwise provide sufficient resources. Here we present an overview of our methods, lessons learned, interesting findings, citizen science opportunities, and preliminary results. What has been learned in this pilot effort has substantial applicability to BUOW research in other parts of the owl’s diminishing range.