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ABSTRACT—During the 2006 and 2007 breeding seasons, we conducted a systematic survey for western burrowing owls (*Athene cunicularia hypugaea*) across the portions of California's southeastern deserts that had never been systematically surveyed for the species. We found few or no western burrowing owls in northern and eastern portions of the Mojave Desert or in the Sonoran Desert (excluding Palo Verde Valley). However, there was a substantial concentration of burrowing owls in the western Mojave Desert, which we estimated to contain ≤560 (*SE* = 268) breeding pairs. We also documented 179 breeding pairs along the banks of water-conveyance structures in Palo Verde Valley in the Sonoran Desert region. These two disjunct populations comprise a significant portion of the population of burrowing owls in California.

RESUMEN—Durante las épocas de reproducción del 2006 y 2007, se realizó un estudio sistemático de tecolotes llaneros occidentales (*Athene cunicularia hypugaea*) de las zonas de los desiertos del sudeste de California que nunca habían sido muestreados sistemáticamente para esta especie. Encontramos pocos o ningún tecolote llanero occidental ni en las partes nortes y orientales del desierto Mojave ni en el desierto Sonora (excluyendo el valle de Palo Verde). Sin embargo, encontramos una concentración notable de tecolotes llaneros en la parte occidental del desierto Mojave, que se estimó contener <560 (*SE* = 268) parejas reproductoras. Asimismo, documentamos 179 parejas de tecolotes llaneros en las orillas de las estructuras de conducción de agua en el valle Palo Verde del desierto Sonora. Estas dos poblaciones separadas de tecolotes llaneros comprenden una parte significativa de la población total de California.

The western burrowing owl (*Athene cunicularia hypugaea*) has declined in recent decades across much of its range (Wedgwood, 1978; James and Ethier, 1989; Sheffield, 1997*a*; Holroyd et al., 2001; Wellicome and Holroyd, 2001; DeSante et al., 2007), including California, where it is classified as a species of special concern (Gervais et al., 2008; Shuford and Gardali, 2008). Primary causes of the decline likely have included loss of grassland and agricultural habitats to urbanization (Trulio and Chromczak, 2007) and conversion of lands to inhospitable crops, such as orchards and vineyards (Gervais et al., 2008). Populations in Imperial Valley and in some other areas of the state, where agricultural practices permit, thrive at much higher densities than populations in natural grasslands (DeSante et al., 2004). Other suggested causes of decline include eradication of fossorial mammals (Zarn, 1974; Holroyd et al., 2001; J. V. Remsen, Jr., in litt.) and exposure to pesticides and other contaminants (Haug et al., 1993; Sheffield, 1997*b*; Gervais and Anthony, 2003). Each of these factors, and potentially others, may be important in California, which hosts one of the largest populations of western burrowing owls of any state or Canadian province (Barclay, 2007).

Excluding the desert and Great Basin regions, DeSante et al. (2007) estimated the breeding population in California was 9,266 pairs in 1993. Although burrowing owls occupy the vast deserts of southeastern California (Garrett and Dunn, 1981), estimates of size of populations for these areas based on systematic surveys have not been published. Anecdotal information indicates that burrowing owls generally are scarce in the region, particularly in easternmost portions (Garrett and Dunn, 1981), and that a substantial concentration occurs along the Colorado River in Palo Verde Valley (Gervais et al., 2008). However, quantitative, survey-based estimates of size of populations and knowledge of distributional patterns are needed for prioritizing conservation efforts in California (Burkett and Johnson, 2007).

During the breeding seasons of 2006 and 2007, as part of a larger California-wide survey (Wilkerson and Siegel, 2010), we conducted a systematic survey of portions of the deserts in southeastern California, which had not been surveyed previously. We used results of our survey to characterize patterns of distribution and abundance throughout the region and to estimate size of populations.

Materials and Methods—We divided previously unsurveyed portions of the breeding range of burrowing owls in southeastern California into four regions: northern Mojave Desert-eastern Sierra Nevada, western Mojave Desert, eastern Mojave Desert, and Sonoran Desert. We excluded Imperial and Coachella valleys because they were surveyed previously by DeSante et al. (2007). Following methods used by DeSante et al. (2007), we used ArcGIS software to divide the four regions into 5 by 5-km blocks, oriented and referenced according to the Universal Transverse Mercator (UTM) system. Surveying effort was stratified by elevational subregion because populational densities of burrowing owls generally are higher in lowland areas throughout California than in upland areas (DeSante et al., 2007). For logistical reasons, we discarded blocks that could not be accessed by roads, and then we stratified sampling effort among remaining blocks by region and subregion, randomly selecting as many blocks as we believed our field crew could survey within the time allotted in each region. We also identified additional historic breeding blocks where burrowing owls had been detected during any year beginning in 1981. Historic breeding blocks were identified by querying the California Natural Diversity Database (California Department of Fish and Game, in litt.) and consulting with knowledgeable researchers and birders with local expertise.

Boundaries of our northern Mojave Desert-eastern Sierra Nevada region corresponded to portions of Inyo and Mono counties in the Jepson areas mapped as Mojave Desert and eastern Sierra Nevada by Hickman (1993) and the California Gap Analysis Project (1998), along with a small, disjunct, but ecologically similar area southeast of Topaz Lake. We divided this region into lowland and upland subregions. Any block with ≥5% of land area <1,220 m elevation was included in the lowland subregion. Blocks with >95% of elevation >1,220 m were included in the upland subregion. The 1,830-m elevational contour was the upper limit for inclusion in the upland subregion; blocks with <5% of their area <1,830 m elevation were excluded from sampling. These elevational boundaries were somewhat higher than those established for other regions by DeSante et al. (2007), reflecting overall higher elevation of most land in eastern California.

Our western Mojave Desert region was bounded by the Transverse Range and Sierra Nevada, but it also included areas of the Kern Plateau at elevations <1,830 m. Except for inclusion of the Kern Plateau, boundaries matched those of the western portion of the Jepson area mapped as Mojave Desert by Hickman (1993) and the California Gap Analysis Project (1998). East of the Sierra Nevada, the border of Inyo County defined the northern boundary. Stratification by elevation in the western Mojave Desert region was the same as in the northern Mojave Desert-eastern Sierra Nevada region.

Our eastern Mojave Desert region was limited primarily to the eastern one-half of San Bernardino County, south of Inyo County to the Nevada-California state line. Boundaries match those of the southeastern portion of the Jepson area mapped as Mojave Desert by Hickman (1993) and the California Gap Analysis Project (1998). In southeastern San Bernardino County, from Cadiz Valley eastward, the eastern Mojave Desert region shares an irregular zig-zag border with the Sonoran Desert region to the south. Stratification by elevation in the eastern Mojave Desert region was the same as in the northern Mojave Desert-eastern Sierra Nevada region.

Boundaries of our Sonoran Desert region matched the Jepson area mapped as Sonoran Desert by Hickman (1993) and California Gap Analysis Project (1998), excluding Coachella and Imperial valleys, which bisect the region into two disjunct portions. The minimal land area in the Sonoran Desert region >1,220 m elevation was rocky and mountainous; characteristics that made it inhospitable habitat for burrowing owls. Thus, we did not survey an upland subregion in this region; any block with ≥5% land area <1,220 m elevation was included in the region.

After an intensive training session at the beginning of each field season, crew members surveyed blocks using methods developed by DeSante et al. (2007). Surveyors visually scanned all of the accessible area in their blocks at least once during morning (dawn to 1000 h) or late-afternoon (1600 h to dusk) during 1 May–30 June 2006 and 2007, when breeding burrowing owls were likely to be feeding nestlings or recently fledged young.

We provided surveyors with 1:24,000-scale topographic maps with boundaries of blocks and locations of burrowing owls known or suspected to have bred anytime beginning in 1981. Surveyors delineated extent of appropriate habitat in their block, used binoculars or spotting scopes to visually scan all areas of appropriate habitat, and plotted locations of any detections on their maps. Observers could survey habitat on foot, by automobile, or using both methods, but when surveying by automobile they were instructed to stop at least every 800 m, exit the vehicle, and scan in all directions. For each detection, surveyors provided a count of burrowing owls seen (identified to age and sex when possible) and the number of breeding pairs those individuals were believed to represent. For counts of pairs, observers were instructed to assume that lone adults had unseen mates, and represented pairs. Surveyors provided a detailed assessment of how much of each block they surveyed adequately. In some instances, this was well under 100%, due to lack of access to private property or physiographic barriers.

We estimated number of breeding pairs of burrowing owls in each subregion and region. We calculated minimum number of breeding pairs on each randomly selected block that we surveyed as the quotient of number of pairs counted divided by area of the block that was surveyed adequately. We then averaged minimum densities of populations across randomly selected blocks surveyed in each subregion. Estimates were reported with standard errors

For each subregion and region we also totaled minimum number of pairs counted, as the sum of all pairs on randomly selected blocks, all pairs on historic breeding blocks, and, in a few instances, pairs that were detected incidentally on blocks that were not officially surveyed. Because this method included data from blocks that were not randomly selected, we did not use them to extrapolate an estimate of size of population for the entire subregion or region, but rather to establish a minimum number of pairs in the subregion or region, i.e., the number of pairs actually counted.

For each subregion, we considered our best estimate of the number of pairs to be the larger of the extrapolated estimate of number of pairs, based only on results from randomly selected blocks, or the actual number of pairs counted, pooling data from randomly selected blocks and historic breeding blocks. We then summed the best estimate for each subregion to obtain best estimates of number of pairs in each region. In regions and subregions where the best estimate reflected actual number of pairs counted, or when estimated number of pairs was zero, we were unable to provide standard errors of the estimates.

RESULTS—We surveyed 38 blocks in the northern Mojave Desert-eastern Sierra Nevada region; 36 randomly selected blocks and 2 historic breeding blocks. Surveys of both random and historic breeding blocks failed to yield any burrowing owls. However, we detected one pair incidentally while traveling across an otherwise unsurveyed block ca. 5 km east of where boundaries of Kern, Inyo, and San Bernardino counties converge. Because no burrowing owl was detected in randomly selected or historic breeding blocks in this region, our random-sample-based estimates of size of populations for both lowland and upland subregions was zero. However, one pair was detected incidentally on a lowland block, so our best estimate for the lowland subregion (Table 1) is the minimum number of pairs we counted, i.e., one pair. Our best estimate for the upland subregion is zero pairs and our best estimate for number of pairs in the entire northern Mojave Desert-eastern Sierra Nevada region also was the minimum number of pairs we counted, i.e., one pair.

We surveyed 67 blocks in the western Mojave Desert region; 48 randomly selected blocks and 19 historic breeding blocks. Surveys of random blocks yielded 25 pairs and surveys of historic breeding blocks yielded 79 pairs, for a total of 94 pairs of burrowing owls detected in the region. In the 42 randomly selected, lowland blocks we surveyed, we detected 25 pairs, yielding a random-sample-based estimate of 560 ± 268 pairs throughout the lowland subregion (Table 1). This estimate was greater than the total number of pairs detected in the lowland subregion (25 pairs on randomly selected blocks plus 79 pairs on historic breeding blocks), so it serves as our best estimate for pairs in the lowland subregion. No burrowing owl was detected on randomly selected upland blocks in the region, so our best estimate for the upland subregion was zero pairs, and our estimate for the entire western Mojave Desert region was 560 ± 268 pairs. However, pairs we detected were clustered mostly in Antelope, Apple, and Lucerne valleys, where agriculture and residential areas generally were more concentrated than elsewhere in the region. Although we also detected a few pairs northward as far as Ridgecrest and eastward to Barstow, extrapolating results from these three valleys across the region as a whole may have overestimated the number of pairs in the region. Conversely, because we did not survey all blocks within the three valleys where we detected numerous pairs, and because we did detect numerous pairs on random blocks elsewhere in the region, our minimum count of 94 pairs in the region is an underestimate of the actual size of population. Actual number of pairs may be between our extrapolated best estimate of 560 pairs and the minimum count of 94 pairs.

We surveyed 45 blocks in the eastern Mojave Desert region; 43 randomly selected blocks and two historic breeding blocks. Surveys of random blocks yielded one pair of burrowing owls in the southeastern portion of the region, while surveys of historic breeding blocks yielded none, for a total of one pair detected in the region. In the 41 randomly selected lowland blocks, we located one pair of burrowing owls, yielding a random-sample-based estimate of 32 ± 32 pairs throughout the lowland subregion. Because we detected no pair on the two lowland-historic-breeding blocks, our best estimate for the lowland subregion was 32 ± 32 pairs. None was detected on the six randomly selected upland blocks in the region and there was no upland-historic-breeding block to survey, so our best estimate for the upland subregion was zero pairs. Our

Table 1—Number of blocks surveyed, number of pairs of western burrowing owls (*Athene cunicularia hypugaea*) detected, and estimates of size of populations in desert regions of southeastern California, 2006–2007.

		Random and historic breeding blocks			Random blocks only					
Region	Total area of region (km²)	Number of blocks surveyed	Km² surveyed (percentage of region)	Number of pairs detected	Number of blocks surveyed	Km² surveyed (percentage of region)	Number of pairs detected	Mean number of pairs per block (*SE*)	Estimated number of pairs (*SE*)	Best estimate of number of pairs (*SE*)
Northern Mojave Desert-eastern Sierra Nevada										
Lowland	17,731	28	432 (2.4)	1	28	431 (2.4)	0	0.00	0	1
Upland	7,826	10	153 (2.0)	0	8	103 (1.3)	0	0.00	0	0
All	25,557	38	585 (2.2)	1	36	534 (2.1)	0	0.00	0	1
Western Mojave Desert										
Lowland	23,525	61	1,362 (5.8)	94	42	902 (3.8)	25	0.60 (0.29)	560 (268)	560 (268)
Upland	1,725	6	128 (7.4)	0	6	128 (7.4)	0	0.00	0	0
All	25,250	67	1,490 (5.9)	94	48	1,030 (4.1)	25		560 (268)	560 (268)
Eastern Mojave Desert										
Lowland	31,767	42	825 (2.6)	1	40	775 (2.4)	1	0.03 (0.03)	32 (32)	32 (32)
Upland	2,037	3	55 (2.7)	0	3	55 (2.7)	0	0.00	0	0
All	33,804	45	880 (2.6)	1	43	830 (2.5)	1		32 (32)	32 (32)
Sonoran Desert										
All	18,470	47	751 (4.1)	179	31	413 (2.2)	18	0.58 (0.58)	429 (429)	179

estimate for number of pairs in the entire eastern Mojave Desert region was 32 ± 32 pairs.

We surveyed 47 blocks in the Sonoran Desert region; 31 randomly selected blocks and 16 historic breeding blocks. We considered the entire region to be lowland. Surveys of random blocks yielded 18 pairs of burrowing owls, all in one block in Palo Verde Valley, while surveys of historic breeding blocks yielded 161 pairs (distributed across 14 contiguous blocks in Palo Verde Valley), for a total of 179 pairs detected in the region. In the 31 randomly selected lowland blocks, we detected 18 pairs of burrowing owls, yielding a random-sample-based estimate of 429 ± 429 pairs throughout the Sonoran Desert region. However, we do not trust this estimate, because the entire count of pairs was within Palo Verde Valley. Because we fully surveyed all blocks that encompassed Palo Verde Valley (one was randomly selected and the others were historic breeding blocks), we considered our best estimate of the number of pairs in the Sonoran Desert region to be our minimum count of pairs in Palo Verde Valley, i.e., 179 pairs.

Discussion—Our survey of southeastern California represents the first systematic survey to assess size of populations of burrowing owls across this portion of the state. Burrowing owls were distributed heterogeneously within the study area. We detected few or none in the northern Mojave Desert-eastern Sierra Nevada region, the eastern Mojave Desert region, and the Sonoran Desert region (excluding Palo Verde Valley). However, we detected larger aggregations of burrowing owls in the western Mojave Desert region, and in one small area of the Sonoran Desert region, i.e., Palo Verde Valley.

Our count of 179 pairs in Palo Verde Valley largely corroborated anecdotal knowledge about the area (Gervais et al., 2008). In the valley, burrowing owls comprised a substantial aggregation in an area that was contained in 15 contiguous blocks. As in Imperial Valley (DeSante et al., 2004; Rosenberg and Haley, 2004), a large population of burrowing owls nest along the banks of earthen and concrete irrigation canals and other water-conveyance structures in Palo Verde Valley.

Perhaps, the most striking result of our survey was the large number of pairs that were occupying the western Mojave Desert region. Our best estimate for number of pairs in the region is comparable to number of pairs estimated to occur in the Middle Central Valley region by DeSante et al. (2007), and is exceeded in numerical importance with respect to the statewide population only by Imperial Valley and Southern Central Valley regions (DeSante et al., 2007).

Our survey method likely contained sources of error. As DeSante et al. (2007) pointed out, the inability of observers to reliably detect all burrowing owls in surveyed areas (Conway and Simon, 2003; Conway et al., 2008), particularly in desert areas with limited access, may have biased our counts toward low estimates. Perhaps, even more problematic than relatively low probability of detection, there was the possibility that detection during our study may have varied substantially across blocks and regions. Factors such as number of access roads and physiographic characteristics could have affected the proportion of pairs in a given area that we were able to detect. An additional complication is that surveyors were unable to gain access to some military installations to conduct surveys.

Even with potential sources of error, our results indicated a high level of spatial heterogeneity in populations throughout southeastern California, particularly in the western Mojave and Sonoran desert regions. This spatial heterogeneity, combined with logistical constraints that required us to sample such a vast area, suggests that both our minimum counts and our estimates of size of populations with their large standard errors should be interpreted cautiously. Nevertheless, we believe that the broad patterns in distribution and abundance that we report are meaningful for guiding conservation planning efforts and that documenting exact locations of 275 pairs of burrowing owls will provide a useful baseline for assessing future changes.

High spatial variability, especially combined with low sampling efficiency, makes precise estimates of size of populations difficult, but it may also present opportunities for conservation. If most burrowing owls in southeastern California are concentrated in a small number of relatively restricted areas, then monitoring and safeguarding them should be easier than it would be otherwise. Occupied areas can be prioritized for conservation efforts.

Although our study was not designed specifically to identify or test conservation actions, our results have some implications for conserving burrowing owls. In Palo Verde Valley, like the much larger population in Imperial Valley, burrowing owls are highly dependent on banks of irrigation canals and other water-conveyance structures for nesting. The most important actions for safeguarding the population in Palo Verde Valley would center on maintaining the existing character of these human-made structures so that they retain their attractiveness for nesting, and managing roads and canals to minimize destruction of burrows, particularly during the breeding season. In Imperial Valley, activities associated with maintenance of roads inadvertently destroyed nests, causing direct mortality of nestlings and adults, and possibly spurring dispersal of surviving adults (Caitlin and Rosenberg, 2006).

Unlike burrowing owls in Palo Verde Valley, those we detected in the western Mojave Desert generally were not associated with water-conveyance structures, which are less common in the region. Rather, breeding sites in the western Mojave Desert that we located were concentrated in or along edges of scrublands (creosotebush *Larrea tridentata*, saltbush *Atriplex*, and desert scrub), on the periphery of urban areas, and in active or fallow agricultural fields. Conservation measures for populations in the western Mojave Desert should be focused more on maintaining and enhancing quality of desert-grassland areas and reducing introduced sources of mortality on the periphery of residential and agricultural areas. Our results demonstrate that desert regions of southeastern California comprise a significant portion of the statewide population of burrowing owls.

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Literature Cited

Barclay, J. H. 2007. Foreward. Pages v–vii in Proceedings of the California burrowing owl symposium, November 2003 (J. H. Barclay, K. W. Hunting, J. L. Lincer, J. Linthicum, and T. A. Roberts, editors). Institute for Bird Populations and Albion Environmental, Inc., Point Reyes Station, California, Bird Populations Monographs 1:1–197.

Burkett, E. E., and B. S. Johnson. 2007. Development of a conservation strategy for burrowing owls in California. Pages 165–168 in Proceedings of the California burrowing owl symposium, November 2003 (J. H. Barclay, K. W. Hunting, J. L. Lincer, J. Linthicum, and T. A. Roberts, editors). Institute for Bird Populations and Albion Environmental, Inc., Point Reyes Station, California, Bird Populations Monographs 1:1–197.

Caitlin, D. H., and D. K. Rosenberg. 2006. Nest destruction increases mortality and dispersal of burrowing owls in the Imperial Valley, California. Southwestern Naturalist 51:406–409.

California Gap Analysis Project. 1998. Gap analysis of mainland California: an interactive atlas of terrestrial biodiversity and land management. University of California, Santa Barbara.

Conway, C. J., and J. Simon. 2003. Comparison of detection probability associated with burrowing owl survey methods. Journal of Wildlife Management 67:501–511.

Conway, C. J., V. Garcia, M. D. Smith, and K. Hughes. 2008. Factors affecting detection of burrowing owl nests during standardized surveys. Journal of Wildlife Management 72:688–696.

DeSante, D. F., E. D. Ruhlen, and R. Scalf. 2007. The distribution and relative abundance of burrowing owls in California during 1991–1993: evidence for a declining population and thoughts on its conservation. Pages 1–41 in Proceedings of the California burrowing owl symposium, November 2003 (J. H. Barclay, K. W. Hunting, J. L. Lincer, J. Linthicum, and T. A. Roberts, editors). Institute for Bird Populations and Albion Environmental, Inc., Point Reyes Station, California, Bird Populations Monographs 1:1–197.

Garrett, K., and J. Dunn. 1981. The birds of southern California: status and distribution. Los Angeles Audubon Society, Los Angeles, California.

Gervais, J. A., and R. G. Anthony. 2003. Chronic organochlorine contaminants, environmental variability, and the demographics of a burrowing owl population. Ecological Applications 13:1250–1262.

Gervais, J. A., D. K. Rosenberg, and L. A. Comrack. 2008. Burrowing owl (*Athene canicularia*). Pages 218–226 in California bird species of special concern: a ranked assessment of species, subspecies, and distinct populations of birds of immediate conservation concern in California (W. D. Shuford and T.

Gardali, editors). Western Field Ornithologists and California Department of Fish and Game, Studies of Western Birds 1:1–450.

Haug, E. A., B. A. Millsap, and M. S. Martell. 1993. Burrowing owl (*Athene cunicularia*). Birds of North America 61:1–18.

Hickman, J. C., editor. 1993. The Jepson manual: higher plants of California. University of California Press, Berkeley.

Holroyd, G. L., R. Rodríguez-Estrella, and S. R. Sheffield. 2001. Conservation of the burrowing owl in western North America: issues, challenges, and recommendations. Journal of Raptor Research 35:399–407.

James, P. C., and T. J. Ethier. 1989. Trends in the winter distribution and abundance of burrowing owls in North America. American Birds 43:1224–1225.

Rosenberg, D. K., and K. L. Haley. 2004. The ecology of burrowing owls in the agro-ecosystem of the Imperial Valley, California. Studies in Avian Biology 27:120–135.

Sheffield, S. R. 1997*a*. Current status, distribution, and conservation of the burrowing owl in midwestern and western North America. Pages 399–408 in Biology and conservation of owls of the Northern Hemisphere: second international symposium (J. R. Duncan, D. H. Johnson, and T. H. Nichols, editors). United States Department of Agriculture, General Technical Report NC-190:1–635.

Sheffield, S. R. 1997*b*. Owls as biomonitors of environmental health hazards. Pages 383–398 in Biology and conservation of owls of the Northern Hemisphere: second international symposium (J. R. Duncan, D. H. Johnson, and T. H. Nichols, editors). United States Department of Agriculture, General Technical Report NC-190:1–635.

Shuford, W. D., and T. Gardali, editors. 2008, California bird species of special concern: a ranked assessment of species, subspecies, and distinct populations of birds of immediate conservation concern in California. Western Field Ornithologists and California Department of Fish and Game, Studies of Western Birds 1:1–450.

Trulio, L. A., and D. A. Chromczak. 2007. Burrowing owl nesting success at urban and parkland sites in northern California. Pages 115–122 in Proceedings of the California burrowing owl symposium, November 2003 (J. H. Barclay, K. W. Hunting, J. L. Lincer, J. Linthicum, and T. A. Roberts, editors). Institute for Bird Populations and Albion Environmental, Inc., Point Reyes Station, California, Bird Populations Monographs 1:1–197.

Wedgwood, J. A. 1978. The status of the burrowing owl in Canada. Committee on the Status of Endangered Wildlife in Canada, Canadian Wildlife Service, Ottawa, Ontario, Canada.

Wellicome, T. I., and G. L. Holroyd. 2001. The second international burrowing owl symposium: background and context. Raptor Research Report 35: 269–273.

Wilkerson, R. L., and R. B. Siegel. 2010. Assessing changes in the distribution and abundance of burrowing owls in California, 1993–2007. Bird Populations 10:1–36.

Zarn, M. 1974. Burrowing owl (*Speotyto cunicularia hypugaea*). Habitat Management Series for Unique or Endangered Species, United States Bureau of Land Management, Denver, Colorado, Technical 242:1–25.

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