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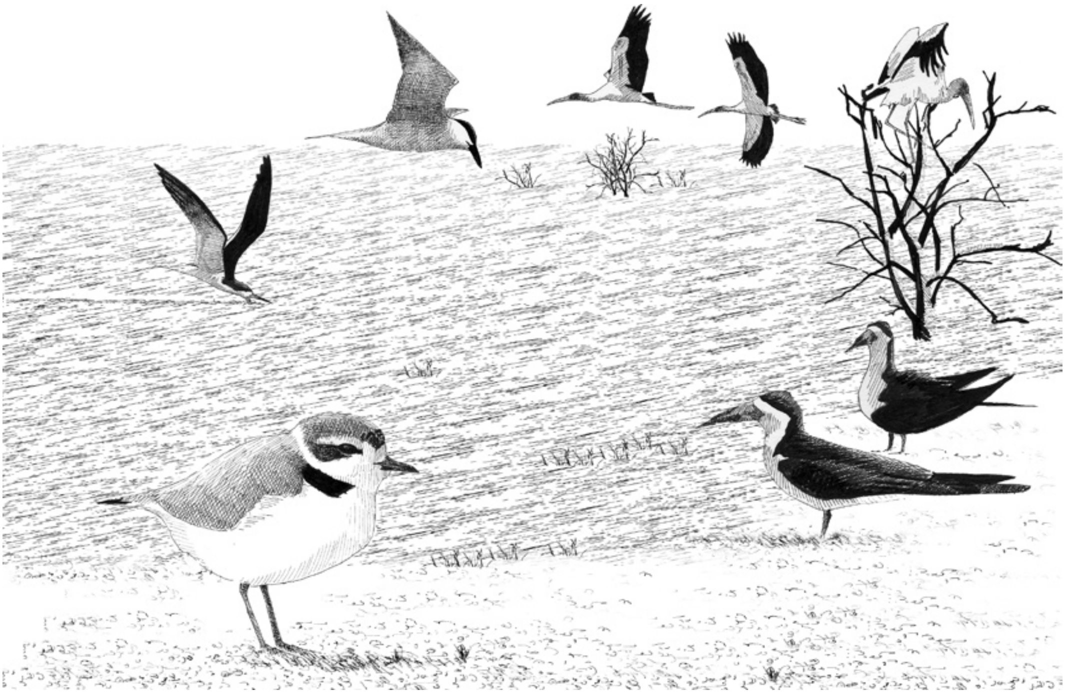
SPECIES ACCOUNTS



Andy Birch

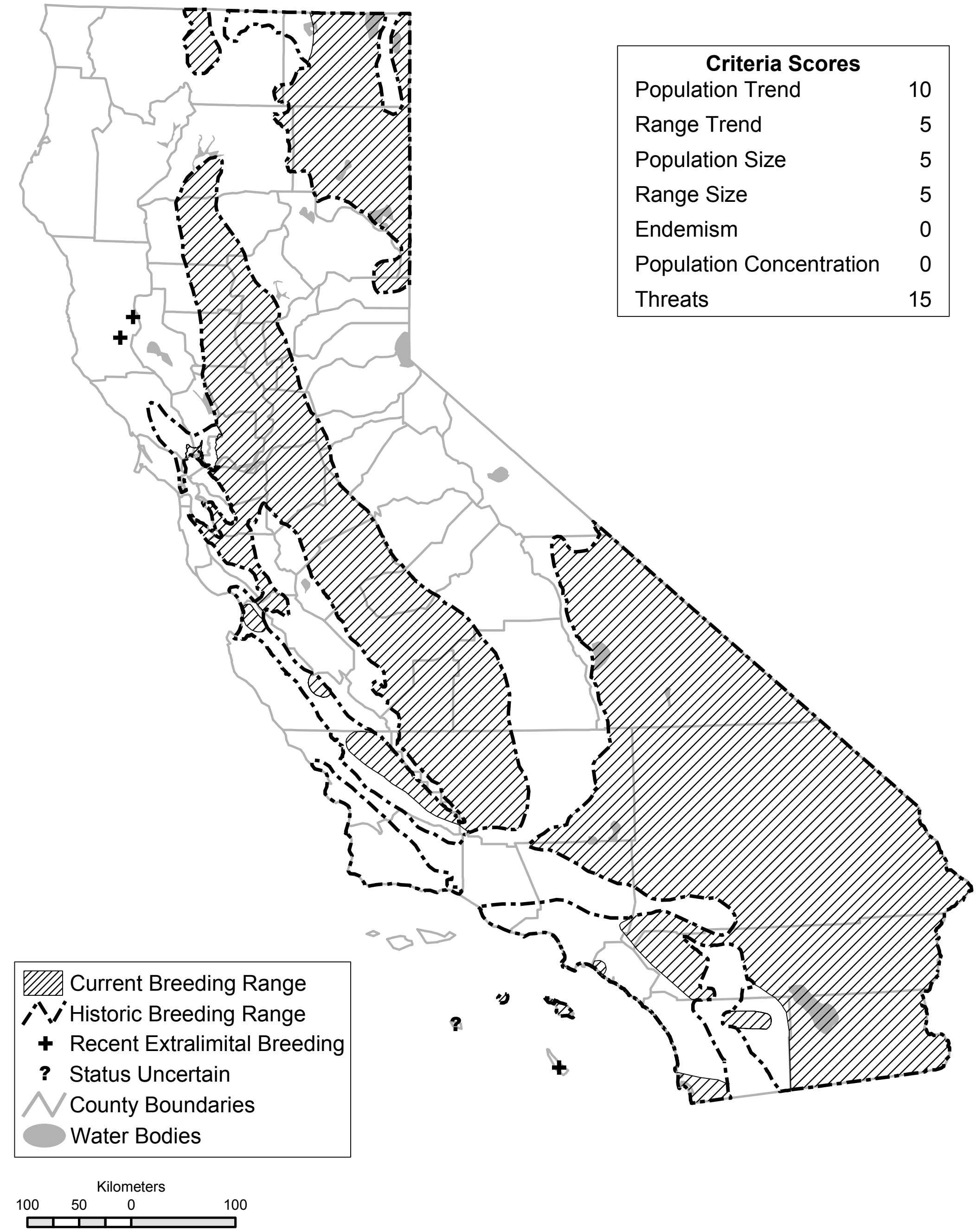
PDF of Burrowing Owl account from:

Shuford, W. D., and Gardali, T., 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. Studies of Western Birds 1. Western Field Ornithologists, Camarillo, California, and California Department of Fish and Game, Sacramento.

BURROWING OWL (*Athene cunicularia*)

Jennifer A. Gervais, Daniel K. Rosenberg, and Lyann A. Comrack

Criteria Scores	
Population Trend	10
Range Trend	5
Population Size	5
Range Size	5
Endemism	0
Population Concentration	0
Threats	15



Current and historic (ca. 1944) breeding range of the Burrowing Owl in California. Numbers have declined at least moderately overall, though they are greatly augmented in the Imperial Valley, and the range has retracted in northeastern California and along the coast. During migration and winter, more widespread in lowland areas of the state and reaches more offshore islands.

Special Concern Priority

Currently considered a Bird Species of Special Concern (breeding), priority 2. Included on both prior special concern lists (Remsen 1978, 2nd priority; CDFG 1992).

General Range and Abundance

Broadly distributed in western North America; also occurs in Florida, Central and South America, Hispaniola, Cuba, the northern Lesser Antilles, and the Bahamas (Haug et al. 1993). Two recognized subspecies in North America: *A. c. hypugaea* in the West, *A. c. floridana* in Florida and the Bahamas (Haug et al. 1993, Desmond et al. 2001). Owls in Florida and the southern portion of the western range generally are year-round residents (Haug et al. 1993), but elsewhere in North America they appear to migrate south in a leap-frog fashion (James 1992). Scant data on migration suggest that most Burrowing Owls that breed in North America winter in Mexico (G. Holroyd pers. comm.), Arizona, New Mexico, Texas, Louisiana, and California, which is considered one of the most important wintering grounds for migrants (James and Ethier 1989). A lack of genetic differentiation among migratory and resident owl populations in western North America suggests that these populations interbreed (Korfanta et al. 2005). These results are supported by recent stable isotope analyses (Duxbury 2004).

Seasonal Status in California

Year-round resident throughout much of the state. Seasonal status varies regionally, with birds retreating from higher elevations such as the Modoc Plateau in winter (Grinnell and Miller 1944). Observations of color-banded and/or radio-tagged owls demonstrate year-round residency in the Central Valley, San Francisco Bay region, Carrizo Plain, and Imperial Valley (Brenckle 1936, Coulombe 1971, Thomsen 1971, Catlin 2004, Johnson 1997b, L. Trulio et al. and D. K. Rosenberg et al. unpubl. data). Migrants from other parts of western North America may augment resident lowland populations in winter. The breeding season in California is March to August, but can begin as early as February and extend into December (Rosenberg and Haley 2004, J. A. Gervais unpubl. data).

Historic Range and Abundance in California

Grinnell and Miller (1944) described the historic range of this owl as throughout most of California and most of its islands, except the coastal counties north of Marin and mountainous areas. Noting that the species was originally common or even “abundant” in the state, they reported “large” numbers of owls still occurred in “favorable localities” but that owls were in decline in areas of human settlement. Grinnell and Wythe (1927) reported that Burrowing Owls were “fairly common in the drier, unsettled, interior parts of [the San Francisco Bay] region; most numerous in parts of Alameda, Contra Costa, and Santa Clara counties. Outside of this area has been observed sparingly” in Sonoma, Napa, Solano, and Marin counties (Grinnell and Wythe 1927). Willet (1933), also lacking quantitative information, described the species on the southern coast as a “common resident from coast to base of mountains.” In San Diego County, at least, historical descriptions suggest that the populations may have been quite extensive (Unitt 2004). The increase in abundance of owls in some agricultural environments, such as the Imperial Valley, from presettlement times likely began prior to the late 1920s, when desert country was converted to irrigated agriculture (DeSante et al. 2004, Molina and Shuford 2004). The draining of wetlands associated with European settlement in the Central Valley may also have increased owl distribution and abundance.

Recent Range and Abundance in California

The Burrowing Owl’s overall breeding range in California has changed only modestly since 1945 (see map), but the local distribution of owls across the state has changed considerably. There are three primary patterns in the current distribution. First, declines and local extirpations have been mainly

Breeding Bird Survey Statistics for California

1968–2004					1968–1979			1980–2004			All data from Sauer et al. (2005)
Trend	*P*	*n*	(95% CI)	R.A.	Trend	*P*	*n*	Trend	*P*	*n*	Credibility
5.6	0.02	32	1.1, 10.1	1.76	–0.9	0.92	19	7.1	0.11	25	High

along the central and southern coast (DeSante et al. 1997a, b; 2007), regions that are undergoing rapid urbanization. Second, sizable to very large breeding populations remain in agricultural areas in the Central and Imperial valleys, where Burrowing Owls have adapted to highly modified habitats (Coulombe 1971, Rosenberg and Haley 2004). Third, it appears that the vast majority of owls occur on private lands (DeSante et al. 1997a, 2004), largely because of the high densities in agricultural areas. These patterns will present distinct challenges and unique opportunities in the conservation of this species.

Numbers of Burrowing Owls on Breeding Bird Survey (BBS) routes in California increased significantly from 1968 to 2004 (Sauer et al. 2005). Conversely, Christmas Bird Count data, 1959–1988, show declines in midwinter numbers of Burrowing Owls in California (Sauer et al. 1996). Other recent evaluations conclude that declines have occurred in the Central Valley, San Francisco Bay region, and southern coast (DeSante et al. 1997a, 2007; Trulio 1997; Comrack and Mayer 2003). However, preliminary BBS analyses of regional patterns within California detected declines in some regions of California, but increases in the Imperial Valley (DeSante et al. 2007, C. Conway pers. comm.). Understanding the details of spatial patterns of changes in BBS data, and their limitations due to insufficient data, would help resolve the apparent inconsistencies.

Concern over declines on the coast and in urbanized areas of the Central Valley led to surveys of selected 5 x 5 km survey blocks within core areas of the state in 1992 and 1993 (DeSante et al. 1997a, b; 2007). Surveys failed to locate breeding owls in the coastal counties of Napa, Marin, San Francisco, Santa Cruz, and Ventura, and very few were located in Sonoma, San Mateo, Santa Barbara, and Orange counties. These surveys in selected blocks were not intended as a census of all owls. Many of these areas may never have supported sizable breeding populations (e.g., Grinnell and Wythe 1927), although data are generally lacking. There also appeared to be substantial reductions in numbers of breeding owls in other counties around San Francisco, San Pablo, and Suisun bays (DeSante et al. 1997a, 1997b, 2007; Klute et al. 2003). The south San Francisco Bay population, estimated at 103 breeding pairs, was considered to be declining sharply (DeSante et al. 1997a, 2007; Trulio 1997). Finally, the survey concluded that Burrowing Owls were in decline throughout the Central Valley, but this conclusion was based on mostly anecdotal data and not the actual survey (DeSante et al. 1997a). Several large populations (e.g., Naval Air Station Lemoore and Carrizo Plain National Monument) were severely underestimated or missed altogether, and previously undetected populations were also found (DeSante et al. 2007, D. K. Rosenberg et al. unpubl. data), largely due to the survey methods that often had low, but unestimated, detection probabilities (DeSante et al. 2004). In contrast, Burrowing Owls remain abundant in the Imperial Valley, where current densities in that agricultural system apparently far exceed those found in the native desert prior to agricultural conversion (DeSante et al. 2004, Rosenberg and Haley 2004).

Additional information from anecdotal sightings or multispecies surveys offer further insight into status and declines in other regions of the state as outlined below.

Northeastern California. Although its status in this region is poorly known, the species appears to be scarce and may have been so historically. To the west, a few owls are currently known from Shasta Valley, Siskiyou County, but they may have been extirpated as breeders from the Klamath Basin since the early 1990s (Summers 1993, Cull and Hall 2007, R. Ekstrom and K. Spencer fide W. D. Shuford). Burrowing Owls currently nest in small numbers in the Honey Lake basin of Lassen County and in the Plumas County portion of Sierra Valley, and they have been reported from most other large valleys in the region, including Big Valley, Lassen and Modoc counties, and at Modoc NWR and Surprise Valley in Modoc County (Cull and Hall 2007, F. Hall in litt.).

Central and southern coast. The Burrowing Owl has declined in Monterey County, with small populations remaining near Salinas and King City (Roberson 2002). It has been nearly extirpated as a breeding species from coastal San Luis Obispo, Santa Barbara, Ventura, Los Angeles, and Orange counties (Comrack and Mayer 2003); historic population sizes are not known. The San Diego region has apparently seen steady declines of owls, down from possibly sizable populations less than a century ago (Willett 1933, Unitt 2004). Elsewhere on the coastal slope, small numbers persist at scattered sites, many of which are threatened by further development. The largest numbers remaining in this region appear to be the minimum of 350 pairs known to be breeding in Riverside and San Bernardino counties, collectively (G. Short pers. comm.), followed by a lesser number in San Diego County (Unitt 2004). Sites occupied include the vicinity of San Bernardino, Chino, and Ontario, San Bernardino County; near Perris, Lakeview

(San Jacinto WA), Winchester, French Valley, Temecula, and the Pechanga Indian Reservation, Riverside County; and two military bases in San Diego, Otay Mesa, and Warner Valley, San Diego County (Unitt 2004, Calif. Nat. Diversity Database unpubl. data). Both the historic and recent status are unclear on the Channel Islands, but breeding has been documented in recent years only on Santa Barbara and Santa Catalina islands (Collins and Jones in press).

Southern deserts. Burrowing Owls occur across most of the Mojave and Colorado deserts of Inyo, eastern Kern, northern Los Angeles, San Bernardino, eastern Riverside, eastern San Diego, and Imperial counties (Miller 2003, references therein). Garrett and Dunn (1981) described the species as "quite scarce" from Inyo County south through the eastern Mojave Desert. Overall, regional numbers are low and occupied areas are widely scattered, which is likely typical for this species in desert systems.

By contrast, numbers have increased greatly with the expansion of agriculture, particularly in the Imperial Valley and apparently along the lower Colorado River, where the species was not reported prior to the advent of large-scale agriculture early in the 20th century (Rosenberg et al. 1991). An estimated 5600 pairs (95% confidence interval: 3405–7795) nested in the Imperial Valley during 1992 and 1993 (DeSante et al. 2004), and approximately 250 pairs nested in the Palo Verde Valley near the Colorado River in Riverside County during 2001–2002 (J. Kidd in litt.).

Ecological Requirements

The Burrowing Owl is primarily a grassland species, but it persists and even thrives in some landscapes highly altered by human activity (Thomsen 1971, Haug et al. 1993, Millsap 2002, Gervais et al. 2003, Rosenberg and Haley 2004). The overriding characteristics of suitable habitat appear to be burrows for roosting and nesting and relatively short vegetation with only sparse shrubs and taller vegetation (Green and Anthony 1989, Haug et al. 1993). Owls in agricultural environments nest along roadsides and water conveyance structures (open canals, ditches, drains) surrounded by crops (DeSante et al. 2004, Rosenberg and Haley 2004). Burrowing Owls often nest near and under runways and associated structures (Thomsen 1971, Gervais et al. 2003). In urban areas such as much of Santa Clara County, Burrowing Owls persist in low numbers in highly developed parcels, such as Moffett Federal Airfield, in busy urban parks, and adjacent to roads with heavy traffic (Trulio 1997, D. K. Rosenberg pers. obs.).

Nest and roost burrows of the Burrowing Owl in California are most commonly dug by ground squirrels (e.g., *Spermophilus beecheyi*; Trulio 1997, D. K. Rosenberg et al. unpubl. data), but they may use Badger (*Taxidea taxus*), Coyote (*Canis latrans*), and fox (e.g., San Joaquin Kit Fox, *Vulpes macrotis mutica*) dens or holes (Ronan 2002). Because the owls may excavate their own burrows in the soft earthen banks of the ditches and canals in the Imperial Valley (D. K. Rosenberg et al. unpubl. data), availability of burrows may not limit population size in that region. Owls in the Imperial Valley also use the small holes of Round-tailed Ground Squirrels (*Citellus tereticaudus*) and Botta's Pocket Gophers (*Thomomys bottae*) as "starts" (Coulombe 1971, Rosenberg and Haley 2004). Structures such as culverts, piles of concrete rubble, and pipes also are used as nest sites (Rosenberg et al. 1998). Nest boxes are often used by owls, and their installation may be an important management tool in California (e.g., Trulio 1995, Rosenberg et al. 1998).

The diet of Burrowing Owls in California includes a broad array of arthropods (centipedes, spiders, beetles, crickets, and grasshoppers), small rodents, birds, amphibians, reptiles, and carrion, similar to their diet rangewide (Thompson and Anderson 1988, Green et al. 1993, Plumpton and Lutz 1993, Gervais et al. 2000, York et al. 2002). Although insects dominate the diet numerically, vertebrates account for the majority of biomass in some regions (Green et al. 1993). In California, there is evidence that rodent populations, particularly those of California Voles (*Microtus californicus*), may greatly influence survival and reproductive success (Gervais and Anthony 2003, Gervais et al. 2006). Food limits the number of fledged young in some years and at some sites (Haley 2002). This is not surprising given the large clutch size (up to 14 eggs; Haug et al. 1993, Todd and Skilnick 2002).

During the breeding season, owls forage close to their burrows but have been recorded hunting up to 2.7 km away (Haug and Oliphant 1990, Gervais et al. 2003). Over 80% of foraging observations in agricultural areas of the southern San Joaquin and Imperial valleys occurred within 600 m of the nest burrow (Gervais et al. 2003, Rosenberg and Haley 2004). Home-range size is likely related to food abundance (Newton 1979), but this relationship is unclear for Burrowing Owls. Owls in Saskatchewan appeared to avoid cropland in a mixed landscape in two instances, and one owl avoided fallow land in the same study (Sissons et al. 2001); in the same region, owls avoided cropland in favor of grass-forb habitat (Haug and Oliphant 1990; but see Gervais et al. 2003 for methodological issues). Foraging owls in agricultural areas of California exhibited little or no selection for cover types; instead, foraging locations were best predicted by distance to nest (Gervais et al. 2003, Rosenberg and Haley 2004).

The Burrowing Owl is often considered a sedentary species (e.g., Thomsen 1971). A large proportion of adults show strong fidelity to their nest site from year to year, especially where resident, as in Florida (74% for females, 83% for males; Millsap and Bear 1997). In California, nest-site fidelity rates were 32%–50% in a large grassland and 57% in an agricultural environment (Ronan 2002, Catlin 2004, Catlin et al. 2005). Differences in these rates among sites may reflect differences in nest predation rates (Catlin 2004, Catlin et al. 2005). Despite the high nest fidelity rates, dispersal distances may be considerable for both juveniles (natal dispersal) and adults (post-breeding dispersal), but this also varied with location (Catlin 2004, Rosier et al. 2006). Distances of 53 km to roughly 150 km have been observed in California for adult and natal dispersal, respectively (D. K. Rosenberg and J. A. Gervais unpubl. data), despite the difficulty in detecting movements beyond the immediate study area (Koenig et al. 1996).

These large dispersal patterns likely were responsible for the lack of genetic differences among the three California populations that were analyzed for genetic structure (Korfanta et al. 2005). Although even Burrowing Owls from resident populations may disperse widely, inbreeding does occur (Johnson 1997a, Millsap and Bear 1997, D. K. Rosenberg et al. unpubl. data).

Threats

Habitat loss and degradation from rapid urbanization of farmland in the core areas of the Central and Imperial valleys is the greatest threat to Burrowing Owls in California. Ongoing urbanization in coastal regions, changes in agricultural practices, and continuing eradication of ground squirrels are also serious threats.

The importance of habitat loss is emphasized by the fact that most owl populations suffering either extirpation or drastic reduction have been in coastal counties that experienced tremendous urbanization in recent decades. The human population of the Central Valley alone is projected to reach well over 10 million by 2040; this valley is considered among the most threatened of all U.S. farmland regions (American Farmland Trust, www.farmland.org/programs/states/ca/default.asp). Loss of agricultural and other open lands will negatively affect owls. Because of their need for open habitat with low vegetation, Burrowing Owls also are unlikely to persist in agricultural lands dominated by vineyards and orchards. They nest in some of California's urban environments, but in Florida, areas with higher densities of development supported fewer owls and were correlated with lower rates of nest success (Millsap and Bear 2000). However, urban development at moderate levels appeared to benefit owls by increasing prey availability (arthropods and lizards) near homes and reducing mortality from natural causes (Millsap and Bear 2000, Millsap 2002). This pattern may hold for California, but presently this is not known.

In addition to loss of nesting burrows from extermination of ground squirrels, developed environments pose a substantial risk to Burrowing Owls from mortality caused by traffic (Klute et al. 2003, D. K. Rosenberg et al. unpubl. data). Owls nesting along roadsides or parking lots are at greatest risk, although owls foraged along roads over 1 km from the nest burrow (Gervais et al. 2003). Wind turbines are a potential population-level threat to Burrowing Owls at Altamont Pass (Thelander et al. 2003), but sites appropriate for wind development will not be located in the lowland habitats where most Burrowing Owls occur. Migrating owls may be at risk, but this must be evaluated on a case-by-case basis, as many factors influence risk (e.g., Drewitt and Langston 2006). Burrowing Owl migration routes and patterns are still poorly understood. High-voltage electrical fences around prisons have caused mortality locally in the Imperial Valley (D. K. Rosenberg et al. unpubl. data), but the implications for populations are unknown.

Pesticides may affect Burrowing Owl populations in croplands and rangelands (James and Fox 1987, James et al. 1990). In the southern San Joaquin Valley, however, there was no indication that foraging owls either selected or avoided fields recently treated for pesticides, although owls did use crops extensively for foraging (Gervais et al. 2003). Although some individuals may be affected by persistent pesticides (Gervais et al. 2000, Gervais and Catlin 2004), the owls' high densities and strong demographic rates provide evidence that pesticide impacts overall are not sufficient to offset the benefits of nesting in agricultural regions (Gervais and Anthony 2003, Rosenberg and Haley 2004, D. K. Rosenberg et al. unpubl. data). Pesticide impacts may be mediated by environmental conditions, however. Gervais and Anthony (2003) found that body burdens of DDE were associated with declines in productivity only during a year of prey scarcity. Although the proportion of the population affected was small, changes in prey abundance in the future or other stresses could modify the impact of DDE (Gervais et al. 2006).

Farming practices are likely a greater threat to Burrowing Owls in agricultural environments. Discing to control weeds in fallow fields may destroy burrows (Rosenberg and Haley 2004). Road and ditch maintenance in agricultural areas poses a threat to both owls and their nests, but these impacts can be minimized through management actions (Catlin and Rosenberg 2006). Burrowing Owls in the Imperial Valley may be affected by proposed plans to line ditches and fallow fields to increase water supplies to urban areas, and by efforts to alleviate increasing salinity in the Salton Sea (Molina and Shuford 2004).

Emerging diseases such as West Nile virus may be significant threats to Burrowing Owl populations, but few data currently exist. Given that West Nile virus is known to be particularly virulent in raptors, concern seems warranted as West Nile virus expands in California.

Management and Research Recommendations

- Develop a conservation strategy with specific population goals, desired densities, and distribution that can be modified as more information is gained. Use risk-assessment modeling to identify populations critical for regional persistence.
- Place sizable tracts of grassland under conservation easements or agreements with agricultural (grazing) operations to maintain populations through best management practices, such as the elimination or restriction of small mammal poisoning.
- Also seek conservation agreements with landowners of row-crop agriculture to encourage appropriate management of water conveyance structures, roadsides, and field margins. It will be necessary to work closely with landowners to alleviate concerns that maintaining owls on their property is a liability in terms of flexibility in land management practices necessary to maintain economic viability.
- Maintain suitable vegetation structure through mowing, revegetation with low-growing and less dense native plants, or controlled grazing, as appropriate.
- Where nesting burrows are lacking, enhance habitat by using artificial burrows or encouraging the presence of ground squirrels.
- Control off-road vehicles and unleashed pets within occupied Burrowing Owl habitat.
- Develop prescriptions that mimic natural processes and that preferably do not require ongoing management for maintaining Burrowing Owls.
- Develop guidelines for maintaining Burrowing Owls and their burrows during management of agricultural water conveyance structures.
- Assess various strategies for maintaining owl populations in urbanizing areas.
- Determine owl distribution and abundance in publicly owned grasslands and other sites of known or likely occurrence that have not yet been well characterized.
- Assess the risk Burrowing Owls pose to aircraft operations safety, and develop management guidelines for owls at airports where they occur.
- Conduct research examining the factors that attract owls, and maintain them in locations from which populations were previously extirpated. In particular, rigorously evaluate translocation to determine when, if ever, it is an effective management tool.
- Determine patterns of long-distance dispersal.
- Identify the magnitude and source of wintering populations.

Monitoring Needs

Monitoring of changes in the abundance or demographic rates of Burrowing Owls should be linked with efforts both to identify the causes of any declines and to assess the response of the population to management actions (Noon 2003). Management strategies, and thus monitoring efforts, should be region-specific to account for the varied threats each region faces. Areas of the state with declining populations for which potential causes have been identified (such as urbanization) should have priority in the design and implementation of conservation strategies, whose effectiveness should be evaluated with subsequent monitoring. Monitoring itself can be effective only when population goals have been identified and the monitoring strategy evaluated to ensure that it is sufficiently sensitive to detect population changes considered noteworthy for management.

Effective methods for estimating actual or relative abundance of this species are clearly habitat specific. For example, call surveys have been effective in extensive grasslands (Haug and Didiuk 1993, Ronan 2002, Conway and Simon 2003), whereas counts of owls along edges of farm fields from vehicles are very effective in intensive agricultural areas (Rosenberg and Haley 2004). Methods that use counts need to account for the variable probability of detection among habitats if patterns of distribution and change are to be inferred from surveys. Data from large-scale surveys such as the BBS should be critically evaluated to identify regional patterns within California and to assess the effectiveness of this monitoring approach given the often small numbers of owls detected and the inconsistent observer effort.

Acknowledgments

T. Heindel, K. Hunting, B. Johnson, and D. Roberson reviewed earlier drafts of this manuscript. G. Short (Univ. Calif. Riverside, Dept. Biol., Ctr. for Conserv. Biol.) generously shared unpublished data.

Literature Cited

Brenckle, J. F. 1936. The migration of the Western Burrowing Owl (*Speotyto cunicularia hypogaea*). Bird-Banding 7:166–168.

California Department of Fish and Game (CDFG). 1992. Bird species of special concern. Unpublished list, July 1992, Calif. Dept. Fish & Game, 1416 Ninth St., Sacramento, CA 95814.

Catlin, D. H. 2004. Factors affecting within-season and between-season breeding dispersal of Burrowing Owls in California. M.S. thesis, Oregon State Univ., Corvallis.

Catlin, D. H., and Rosenberg, D. K. 2006. Nest destruction increases mortality and dispersal of Burrowing Owls in the Imperial Valley, California. Southwest Nat. 51:406–409.

Catlin, D. H., Rosenberg, D. K., and Haley, K. L. 2005. The effects of nesting success and mate fidelity on breeding dispersal in Burrowing Owls. Can. J. Zool. 83:1574–1580.

Collins, P. W., and Jones, H. L. In press. Birds of California's Channel Islands: Their Status and Distribution. Santa Barbara Mus. Nat. Hist., Santa Barbara, CA.

Comrack, L., and Mayer, D. 2003. An evaluation of the petition to list the California population of the Western Burrowing Owl (*Athene cunicularia hypugaea*) as an endangered or threatened species. Unpublished report, Calif. Dept. Fish & Game, 4949 Viewridge Ave., San Diego, CA 92123.

Conway, C. J., and Simon, J. C. 2003. Comparison of detection probability associated with Burrowing Owl survey methods. J. Wildl. Mgmt. 67:501–511.

Coulombe, H. N. 1971. Behavior and population ecology of the Burrowing Owl, *Speotyto cunicularia*, in the Imperial Valley of California. Condor 73:162–176.

Cull, R. L., and Hall, F. 2007. Status of Burrowing Owls in northeastern California, 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, eds.), pp. 42–51. Bird Populations Monogr. 1. The Institute for Bird Populations and Albion Environmental, Inc.

DeSante, D. F., Ruhlen, E. D., Adamany, S. L., Burton, K. M., and Amin, S. 1997a. A census of Burrowing Owls in central California in 1991. Raptor Res. Rep. 9:38–48.

DeSante, D. F., Ruhlen, E. D., and Rosenberg, D. K. 1997b. The distribution and relative abundance of Burrowing Owls in California: Evidence for a declining population. Institute for Bird Populations (Contr. 58), P.O. Box 1346, Pt. Reyes Station, CA 94956.

DeSante, D. F., Ruhlen, E. D., and Rosenberg, D. K. 2004. Density and abundance of Burrowing Owls in the agricultural matrix of the Imperial Valley, California. Studies Avian Biol. 27:116–119.

DeSante, D. F., Ruhlen, E. D., and Scalf, R. 2007. The distribution and relative abundance of Burrowing Owls in California during 1991–1993: Evidence for a declining population and thoughts on its conservation, 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, eds.), pp. 1–41. Bird Populations Monogr. 1. The Institute for Bird Populations and Albion Environmental, Inc.

Desmond, M. J., Parsons, T. J., Powers, T. O, and Savidge, J. A. 2001. An initial examination of mitochondrial DNA structure in Burrowing Owl populations. J. Raptor Res. 35:274–281.

Drewitt, A. L, and Langston R. H. W. 2006. Assessing the impacts of wind farms on birds. Ibis 148:29–42.

Duxbury, J. M. 2004. Stable isotope analysis and the investigation of the migrations and dispersal of Peregrine Falcons (*Falco peregrinus*) and Burrowing Owls (*Athene cunicularia hypugaea*). Ph.D. dissertation, Univ. Alberta, Edmonton.

Garrett, K., and Dunn, J. 1981. The Birds of Southern California: Status and Distribution. Los Angeles Audubon Soc., Los Angeles.

Gervais, J. A., and Anthony, R. G. 2003. Chronic organochlorine contaminants, environmental variability, and demographics of a Burrowing Owl population. Ecol. Applications 13:1250–1262.

Gervais, J. A., and Catlin, D. H. 2004. Temporal patterns of DDE in Burrowing Owl eggs from the Imperial Valley, California. Southwest Nat. 49:509–512.

Gervais, J. A., Hunter, C. M., and Anthony, R. G. 2006. Interactive effects of prey and *p,p'*DDE on Burrowing Owl population dynamics. Ecol. Applications 16:666–677.

Gervais, J. A., Rosenberg, D. K., and Anthony, R. G. 2003. Space use and pesticide exposure risk of male Burrowing Owls in an agricultural landscape. J. Wildl. Mgmt. 67:156–165.

Gervais, J. A., Rosenberg, D. K., Fry, D. M., Trulio, L., and Sturm, K. K. 2000. Burrowing Owls and agricultural pesticides: Evaluation of residues and risks for three populations in California. Environ. Toxicol. and Chem. 19:337–343.

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

Green, G. A., Fitzner, R. E., Anthony, R. G., and Rogers, L. E. 1993. Comparative diets of Burrowing Owls in Oregon and Washington. Northwest Sci. 67:88–93.

Grinnell, J., and Miller, A. H. 1944. The distribution of the birds of California. Pac. Coast Avifauna 27.

Grinnell, J., and Wythe, M. W. 1927. Directory to the bird-life of the San Francisco Bay region. Pac. Coast Avifauna 18.

Haley, K. L. 2002. The role of food limitation and predation on reproductive success of Burrowing Owls in southern California. M.S. thesis, Oregon State Univ., Corvallis.

Haug, E. A., and Didiuk, A. B. 1993. Use of recorded calls to detect Burrowing Owls. J. Field Ornithol. 64:188–194.

Haug, E. A., Millsap, B. A., and Martell, M. S. 1993. Burrowing Owl (*Speotyto cunicularia*), in The Birds of North America (A. Poole and F. Gill, eds.), no. 61. Acad. Nat. Sci., Philadelphia.

Haug, E. A., and Oliphant, L. W. 1990. Movements, activity patterns, and habitat use of Burrowing Owls in Saskatchewan. J. Wildl. Mgmt. 54:27–35.

James, P. C. 1992. Where do Canadian Burrowing Owls spend the winter? Blue Jay 50:93–95.

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

James, P. C., and Fox, G. A. 1987. Effects of some insecticides on productivity of Burrowing Owls. Blue Jay 45:65–71.

James, P. C., Fox, G. A., and Ethier, T. J. 1990. Is the operational use of strychnine to control ground squirrels detrimental to Burrowing Owls? J. Raptor Res. 24:120–123.

Johnson, B. S. 1997a. Characterization of population and family genetics of the Burrowing Owl by DNA fingerprinting with pV47-2. Raptor Res. Rep. 9:58–63.

Johnson, B. S. 1997b. Demography and population dynamics of the Burrowing Owl. Raptor Res. Rep. 9:28–33.

Klute, D. S., Ayers, A. W., Green, M. T., Howe, W. H., Jones, S. L., Shaffer, J. A., Sheffield, S. R., and Zimmerman, T. S. 2003. Status assessment and conservation plan for the Western Burrowing Owl in the United States. Biological Tech. Publ. FWS/BTP-R6001-2003, U.S. Fish & Wildl. Serv., Washington, DC. Available at http://library.fws.gov/BTP/westernburrowingowl03.pdf.

Koenig, W. D., Van Vuren, D. D., and Hooge, P. N. 1996. Detectability, philopatry, and the distribution of dispersal distances in vertebrates. Trends Ecol. and Evol. 11:514–517.

Korfanta, N. M., McDonald, D. B., Glenn, T. C., and Handel, C. M. 2005. Burrowing Owl (*Athene cunicularia*) population genetics: A comparison of North American forms and migratory habits. Auk 122:464–478.

Miller, J. 2003. Petition to the State of California Fish and Game Commission and supporting information for listing the California population of the Western Burrowing Owl (*Athene cunicularia hypugaea*) as an endangered or threatened species under the California Endangered Species Act. Available from Ctr. Biol. Diversity, 1095 Market St., Suite 511, San Francisco, CA 94103 or at www.biologicaldiversity.org/swcbd/species/b-owl/index.html.

Millsap, B. A. 2002. Survival of Florida Burrowing Owls along an urban-development gradient. J. Raptor Res. 36:3–10.

Millsap, B. A., and Bear, C. 1997. Territory fidelity, mate fidelity, and dispersal in an urban-nesting population of Florida Burrowing Owls. Raptor Res. Rep. 9:91–98.

Millsap, B. A., and Bear, C. 2000. Density and reproduction of Burrowing Owls along an urban development gradient. J. Wildl. Mgmt. 64:33–41.

Molina, K. C., and Shuford, W. D. 2004. Introduction. Studies Avian Biol. 27:1–11.

Newton, I. 1979. Population Ecology of Raptors. T&AD Poyser Ltd., London.

Noon, B. R. 2003. Conceptual issues in monitoring ecological resources, in Monitoring Ecosystems: Interdisciplinary Approaches for Evaluating Ecoregional Initiatives (D. E. Busch and J. C. Trexler, eds.), pp. 27–72. Island Press, Washington, DC.

Plumpton, D. L., and Lutz, R. S. 1993. Prey selection and food habits of Burrowing Owls in Colorado. Great Basin Nat. 53:299–304.

Remsen, J. V., Jr. 1978. Bird species of special concern in California: An annotated list of declining or vulnerable bird species. Nongame Wildl. Invest., Wildl. Mgmt. Branch Admin. Rep. 78-1, Calif. Dept. Fish & Game, 1416 Ninth St., Sacramento, CA 95814.

Roberson, D. 2002. Monterey Birds, 2nd ed. Monterey Peninsula Audubon Soc., Carmel, CA.

Ronan, N. A. 2002. Habitat selection, reproductive success, and site fidelity of Burrowing Owls in a grassland ecosystem. M.S. thesis, Oregon State Univ., Corvallis.

Rosenberg, D. K., and Haley, K. L. 2004. The ecology of Burrowing Owls in the agroecosystem of the Imperial Valley, California. Studies Avian Biol. 27:120–135.

Rosenberg, D. K., Gervais, J. A., Ober, H., and DeSante, D. S. 1998. An adaptive management plan for the Burrowing Owl population at Naval Air Station Lemoore, California. Publication 95, Institute for Bird Populations, P.O. Box 1346, Pt. Reyes Station, CA 94956.

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

Rosier, J. R., Ronan, N. A., and Rosenberg, D. K. 2006. Post-breeding dispersal of Burrowing Owls in an extensive California grassland. Am. Midland Nat. 155:162–167.

Sauer, J. R., Hines, J. E., and Fallon, J. 2005. The North American Breeding Bird Survey, results and analysis 1966–2004, version 2005.2. USGS Patuxent Wildl. Res. Ctr., Laurel, MD. Available at www.mbr-pwrc.usgs.gov/bbs/bbs.html.

Sauer, J. R., Schwartz, S., and Hoover, B. 1996. The Christmas Bird Count Home Page, version 95.1. Patuxent Wildl. Res. Ctr., Laurel, MD. Available at www.mbr-pwrc.usgs.gov/bbs/cbc.html.

Sissons, R. A., Scalise, K. L., and Wellicome, T. I. 2001. Nocturnal foraging and habitat use by male Burrowing Owls in a heavily cultivated region of southern Saskatchewan. J. Raptor Res. 35:304–309.

Summers, S. D. 1993. A birder's guide to the Klamath Basin. Klamath Basin Audubon Soc., Klamath Falls, OR.

Thelander, C. G., Smallwood, K. S., and Rugge, L. 2003. Bird risk behaviors and fatalities at the Altamont Pass Wind Resource Area. Report NREL/SR 500-33829, National Renewable Energy Laboratory, 1617 Cole Blvd., Golden, CO 80401-3393. Available at www.nrel.gov/docs/fy04osti/33829.pdf.

Thomsen, L. 1971. Behavior and ecology of Burrowing Owls on the Oakland Municipal Airport. Condor 73:177–192.

Thompson, C. D., and Anderson, S. H. 1988. Foraging behavior and food habits of Burrowing Owls in Wyoming. Prairie Nat. 20:23–28.

Todd, L. D., and Skilnick, J. 2002. Large clutch size of a Burrowing Owl, *Athene cunicularia*, found in Saskatchewan. Can. Field-Nat. 116:307–308.

Trulio, L. 1995. Passive relocation: A method to preserve Burrowing Owls on disturbed sites. J. Field Ornithol. 66:99–106.

Trulio, L. 1997. Burrowing owl demography and habitat use at two urban sites in Santa Clara County, California. Raptor Res. Rep. 9:84–89.

Unitt, P. 2004. San Diego County bird atlas. Proc. San Diego Soc. Nat. Hist. 39.

Willett, G. 1933. A revised list of the birds of southwestern California. Pac. Coast Avifauna 21.

York, M., Rosenberg, D. K., and Sturm, K. K. 2002. Diet and food-niche breadth of Burrowing Owls (*Athene cunicularia*) in the Imperial Valley, California. W. North Am. Nat. 62:280–287.