BURROWING OWL

Athene cunicularia
CDFG: Special Concern
USFWS: None

Species Account

Background

Much of the information below was adapted from a burrowing owl species account prepared by Jack Barclay of Albion Environmental, Inc. (Barclay 2001). Other major references include the California state-listing petition (CBD et al. 2003), Trulio (2000), and Zarn (1974). Burrowing owls use a variety of natural, uncultivated, and agricultural habitats, any of which can support owls depending on the availability of burrows for cover and nesting and the presence of prey. As such, this conservation strategy is applicable to all agricultural lands within the County, the Valley Floor Grassland and Vernal Pool Natural Community, and the grasslands and oak savanna habitat within the Inner Coast Range.

Status and Description. The burrowing owl was designated as a California Bird Species of Special Concern (BSSC) in 1979 (Remsen 1978). In the revised BSSC list, burrowing owl is designated as a Second Priority species (Shuford and Gardali 2008). In April 2003, several conservation organizations submitted a formal petition to the California Fish and Game Commission (Commission) to list the species as either state threatened or endangered (CBD et al. 2003). Using a CDFG report recommending that the species not be listed (CDFG 2003), the Commission formally rejected the petition on December 4, 2003.

Burrowing owls range from approximately 230 to 280 millimeters in height (Trulio 2000) with a brown and white mottled coloration. Chicks less than three months old have a completely buffy breast and a white collar. The average adult weight is 150 grams (Zarn 1974) with male owls weighing slightly more than females. For the first month after chicks emerge from their burrows, owls weigh approximately one-half to two thirds as much as an adult (Trulio 2000).

Range. Burrowing owls are broadly distributed in western North America, and also occur in Florida, Central and South America, Hispaniola, Cuba, the northern Lesser Antilles, and the Bahamas (Haug et al. 1993). There are two recognized subspecies in North America, *Athene cunicularia hypugaea* in the west, and *Athene cunicularia floridana* in Florida and the Bahamas (Haug et al. 1993). Owls in Florida and the southern portion of the western range 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 suggests that most burrowing owls that breed in North America winter in Mexico, Arizona, New Mexico, Texas, Louisiana and California, which is considered one of the most important wintering grounds for migrants (James and Ethier 1989).

The historical range of burrowing owls in California was described by Grinnell and Miller (1944) as "suitable areas (treeless and level) almost throughout the state, from the Oregon line east of the Siskiyou mountains south to the Mexican border, and from the Nevada border and Colorado River west to the ocean shore; includes practically all islands from the Farallones south." Historically, burrowing owls have been found to reach maximum abundances in wide, lowland, interior valley bottoms and in flat coastal lowlands (Grinnell and Miller 1944). Surveys by DeSante and Ruhlen (1995) found that 92 percent of the breeding owls located throughout California occurred in such lowland areas, generally below 60-300 meters (197-984 feet) in elevation.

The burrowing owl's overall breeding range in California has changed only modestly since 1945, but the local distribution of owls across the state has changed considerably. Recent trends include declines and local extirpations due to urbanization along the central and southern coast, sizable remnant populations in agricultural areas in the Central and Imperial Valleys, and the occurrence of majority of burrowing owl populations on private agricultural lands (Shuford and Gardali 2008).

Population Estimates and Trends. Burrowing owls have been declining throughout their range in the western United States and Canada during the last 60 years (Grinnell and Miller 1944, Zarn 1974, James and Espie 1997). Throughout the statewide census area, nearly 60 percent of owl breeding groups known to have existed during the 1980's had disappeared by the early 1990's (DeSante and Ruhlen 1995). This decline has been attributed to habitat destruction, particularly grassland conversion, and the eradication and control of burrowing mammals (Haug et al. 1993, Zarn 1974).

The Institute for Bird Populations (IBP) completed a census of California's burrowing owl population (exclusive of the Modoc Plateau and Mojave Desert) from 1991 to 1993 (DeSante and Ruhlen 1995). They estimated a population of 9,266 breeding pairs of owls in California with 71 percent of the state population located in the Imperial Valley, 24 percent in the Central Valley (including Solano County), and 1.8 percent in the Bay Area. They reported that burrowing owls had been extirpated as a breeding species during the last 10-15 years from several counties, including Napa, Marin, San Francisco, Santa Cruz, Ventura, and coastal San Luis Obispo (DeSante and Ruhlen 1995). Only a few breeding pairs exist within Sonoma, Santa Barbara, Orange, coastal Monterey, and San Mateo counties (DeSante and Ruhlen 1995). Most of the recorded owl locations in the San Francisco Bay Area (approximately 170 pairs) are located in the South and East Bay between Palo Alto and the Fremont-Newark area (Trulio 2000).

IBP conducted another statewide burrowing owl census in 2006-2007 and estimated a population of 8,128 (SE = 2,391) pairs, which was 10.9 percent lower than the previous 1991-1993 estimate but the difference was not statistically significant.(Wilkerson and Siegel 2010). The distribution of burrowing owls across California remained relatively unchanged since the 1991-1993 survey, although large aggregations were newly discovered in the Palo Verde Valley and western Mojave Desert region (Wilkerson and Siegel 2010).

Occurrence in the Plan Area. Although no systematic county-wide surveys for burrowing owls have been conducted, the results of the above-mentioned IBP statewide surveys as well as an independent survey of burrowing owls in Yolo and Solano Counties (Widdicombe 2007) provide some information on population size and distribution within the Plan Area. During the 2006-2007 IBP statewide survey, 66 burrowing owl pairs were estimated to occur in 27 5-km x 5-km survey blocks in Solano County that were assigned to the Middle Central Valley Region (Wilkerson and Siegel 2010,

Figure 3). Within 20 of these blocks that were surveyed in both the 1991-1993 and 2006-2007 survey efforts, 107 pairs were estimated to occur in 1991-1993 and 57 were estimated to occur in 2006-2007 (Wilkerson and Siegel 2010, Figure 3). In his survey of 14 sites in Solano County[1] between 2000 and 2005, Widdicombe (2007) detected between 4 (2004) and 24 (2001) burrowing owl breeding pairs, with 11 pairs detected per year on average. Most of these pairs were found in the areas around Dixon, Davis, Woodland, and Rio Vista; the areas around Vacaville and Fairfield were only checked cursorily. Most sites supported only one to four pairs in a given year and contained derelict horse corrals, rubble heaps, irrigation canals, and other artificial structures that provide cover for owls.

Most of the remaining burrowing owl occurrence information is based on incidental observations and limited survey efforts (e.g., CNDDB, anecdotal records, consultant reports for small parcels). There are 91 records of burrowing owls in Solano County within the CNDDB (CDFG 2012), and 20 of these represent confirmed sightings from the last ten years (i.e., since 2002). The majority of these records are from the agricultural lands east and southeast of Dixon, in the northeastern portion of the county. Within these agricultural areas, potential nest burrows are located along ditch and canal banks, railroad rights-of ways, and other set-aside areas where ground squirrel burrows or debris piles provide suitable cover. Burrowing owls may also occur within urban areas in vacant lots, weedy fields, and utility, railroad, and road/highway rights-of-ways. Many of the existing and proposed reserves within the Valley Floor Grassland and Vernal Pool Natural Community, such as the proposed Muzzy and Gridley Mitigation Banks, also currently support burrowing owls.

Narrative Conceptual Model

This section provides a preliminary narrative conceptual model for burrowing owls in Solano County. The model is primarily based on previously published information on ecology, life history, and threats to the statewide population (e.g., literature, other HCPs, etc.). Much of the ecological and life history information was adapted from a burrowing owl species summary prepared by Jack Barclay of Albion Environmental, Inc. (Barclay 2001). Following concepts developed by Atkinson et al. (2004), the model also describes pressures affecting the breeding population. Pressures affecting the wintering population are essentially the same as those affecting the breeding population (minus threats to nest burrows). Pressures are agents that either promote or inhibit change in the state of the environment (Atkinson et al. 2004).

Life Cycle and Biology.

Breeding Biology. Burrowing owls nest solitarily or in loose colonies containing four to ten pairs (Zarn 1974). Burrowing owls are primarily monogamous, but likely do not pair for life (Martin 1973). In California, the breeding season, defined as the period from pair bonding to the independence of young, generally runs from February to August. Peak breeding activity occurs from April through July (Thomsen 1971). Adults begin pair formation and courtship in February or early March, when adult males attempt to attract a mate. After pair formation, females lay eggs (clutch size varies from 6 to as much as 12 eggs) in selected natal burrows and incubate for 28-30 days. Females perform all incubation and brooding while males forage and bring food to the female. After hatching, young remain underground for 2-4 weeks, after which they emerge from the burrow. Young are able to fly short distances approximately one month after emergence, and

[1] Two sites were only surveyed in 2005 and one site was surveyed in only 2004 and 2005. The remaining sites were surveyed all six years.

may use nearby satellite burrows if the natal burrow becomes too crowded. Adults continue to feed the young for six to eight weeks after emergence. Young remain in the vicinity of the natal burrow until mid-September, when they molt into adult plumage and disperse to find their own burrows.

Diet and Foraging Habits. The diet of burrowing owls is highly variable. The most common food items are large insects and small rodents. Common food items include voles (*Lagurus* spp., *Microtus* spp.), mice (*Peromyscus* spp., *Mus* spp., *Reithrodontomys* spp., *Zapus* spp.), pocket mice (*Perognathus* spp.), pocket gophers (*Thomomys* spp.), young ground squirrels, beetles, grasshoppers, crickets, reptiles, amphibians, small birds, fish, and crustaceans (Zarn 1974). The European earwig (*Forificula auriculata*) was a large component of pellets collected from a site in Santa Clara County and is likely to be a major component of the diet of burrowing owls (LSA obs.). Foraging primarily occurs at night. Owls hunt both on the ground and by hovering and diving in the air. In their study in Canada, Haug and Oliphant (1990) found that burrowing owls have an average home range size of 593 acres (2.4 square kilometers) and that 95 percent of their time is spent within 1979 feet (600 meters) of their burrows. In a more recent study in the Central Valley of California (Naval Air Station Lemoore), Gervais et al. (2003) found that home range sizes of male owls during the nesting season were highly variable within but not between years. Their results also suggested that owls concentrate foraging efforts within 1979 feet (600 meters) of the nest burrow, as was observed in Canada (Haug and Oliphant 1990) and southern California (Rosenberg and Haley 2004).

Habitat Associations. Burrowing owls have been observed using a variety of habitats, including open prairie, grasslands, open shrub-steppe, agricultural areas, irrigation ditches, and vacant lots and fields within urban areas (Butts 1971, Coulombe 1971, Trulio 2000). The majority of California's burrowing owls are found in wide, flat lowland valleys, basins, and coastal plains below 200 feet elevation (DeSante and Ruhlen 1995) where they are closely associated with California ground squirrels (*Spermophilus beecheyi*). Burrowing owls also occur in human-altered and disturbed environments such as grazing lands and around the margins of agricultural fields, airport infields, edges of athletic fields and golf courses, in irrigation canal banks, and vacant lots (Thomsen 1971, Zarn 1974).

In general, three habitat attributes are required for a site to support burrowing owls: (1) open, well-drained terrain, (2) short, sparse vegetation, and most importantly, (3) underground burrows. At sites where squirrels or natural burrows are absent, owls may use debris piles or other man-made structures (e.g., culverts, drainage pipes) for cover while dispersing or looking for more suitable habitat.

Vegetation. Burrowing owls prefer open areas with short vegetation that allow visibility of approaching predators (Zarn 1974) or contain elevated perches for the same purpose (Green 1983). Low-growing vegetation may also provide hiding sites for young owls (MacCracken et al. 1985) and increase hunting efficiency (Johnsgard 1988). Green (1983) found that owls in Oregon avoided habitat with vegetation that impaired the owls' horizontal visibility and did not provide elevated perches. In Oklahoma, Butts (1973) reported that owls occupied areas where vegetation was 4 inches or less. At Moffett Federal Airfield in Santa Clara County, occupied burrowing owl habitat contained 44-57 percent cover while the average cover in unoccupied fields was 85 percent (Trulio 1994, cited in Barclay 2001). Vegetation height averaged 5.6 inches directly around burrows in occupied habitat versus 10.4 inches in unoccupied fields (Trulio 1994, cited in Barclay 2001). Coulombe (1971) noted that burrowing owls abandoned their burrows when vegetation grew too thick or high.

Burrows. As mentioned above, burrows are the most important component of suitable habitat for burrowing owls because they provide security for nesting and shelter from predators and weather (Barclay 2001). Indeed, the presence of California ground squirrels may be the single most important determinant of whether burrowing owls use a given site. In California, nest and roost burrows of the burrowing owl are most commonly dug by ground squirrels, but they may use badger (*Taxidea taxus*), coyote (*Canis latrans*), and fox (*Vulpes macrotis mustica*) dens or holes (Ronan 2002), as well as structures such as culverts, pipes, concrete rubble and nest boxes (Rosenberg et al. 1998). In the Imperial Valley, burrowing owls may excavate their own burrows in the soft earthen banks of ditches and canals (Rosenberg et al. unpubl. data). At Moffett Federal Airfield, Trulio (1994, cited in Barclay 2001) reported an average burrow density of 63 burrows/acre in fields where owls nested. Burrow density was much higher around active nests where the average burrow density was approximately 200 burrows/acre in a 24-foot radius around nests (Trulio 1994, cited in Barclay 2001). In fields not occupied by owls for 5 years, the average burrow density was 7 burrows/acre. Winchell (1994, cited in Barclay 2001) observed 136 burrowing owls using 224 separate burrows, 56 of which contained nests, showing that owls use more than one burrow within their home range.

Other studies have noted that it is common for juveniles to use satellite burrows farther away from the nest site as they begin to fly and disperse (Zarn 1974, King and Belthoff 2001). Ronan (2002) found that burrowing owl families would move away from a nest burrow if their satellite burrows were experimentally removed, suggesting that nearby satellite burrow availability is an important factor in nest site selection.

Habitats within the Plan Area that support burrowing owls include grasslands, earthen levees and berms, irrigation ditch and canal banks, urban vacant lots, railroad right-of-ways, and margins of airports, golf courses, and roads. Existing occurrence information suggests that burrowing owls in Solano County are primarily associated with agricultural lands. However, the primary *natural* communities in which burrowing owls are thought to occur are valley floor grassland, and to a lesser extent, upland.

Movements and Dispersal. Migration in California burrowing owls is variable and appears to be correlated with latitude and altitude (Barclay 2001). Many owls remain resident throughout the year in their breeding locales (especially in central and southern California) while some apparently migrate or disperse in the fall (Coulombe 1971, Haug et al. 1993). Owls breeding in northern California and at higher altitudes (e.g., Modoc Plateau) generally move south during the winter (Grinnell and Miller 1944, Zeiner et al. 1990). Thomsen (1971) reported that owls stayed on their breeding grounds in Oakland during the winter and remained in their burrows in the daytime. Several years of owl monitoring at Moffett Federal Airfield (Trulio 1994, cited in Barclay 2001) and San Jose International Airport (Barclay 2001) show that the number of owls observed declines during the fall and winter months beginning in October and lasting through April. However, it is unclear whether owls actually leave these areas during the winter or whether they are simply less conspicuous as suggested by Thomsen (1971) and Coulombe (1971).

Recoveries of burrowing owls banded in California are another source of information about the nature of owl migration and dispersal. The U.S. Fish and Wildlife Service Bird Banding Laboratory records (as of 2001) contained 90 encounters of burrowing owls banded in California or banded elsewhere and found in California (Harman and Barclay 2003). Sixty-two percent of these were encountered in the same area (i.e., the same 10-minute block of longitude and latitude) where they were banded (Harman and Barclay 2003). Only two owls banded in California have been reported outside the state: an owl banded in Orange County was found dead in Mexico and an owl banded in October in the Los Angeles Basin was encountered the following March in Nevada. Four owls banded elsewhere have been encountered in California: two banded near Boise, Idaho, one in Washington, and one in British Columbia (Harman and Barclay 2003).

Fledgling burrowing owls often disperse from their natal area in the fall, but sometimes remain with their parents through the winter (Trulio 2000). In southwestern Idaho, fledglings remained within natal areas for an average of 58 days post-hatching before moving permanently beyond 300 meters (King and Belthoff 2001). On average, owls dispersed on July 27, approximately four weeks after fledging (King and Belthoff 2001). As with most bird species (Koenig et al. 2000), natal dispersal patterns in burrowing owls are poorly understood. Wellicome et al. (1997) reported a natal dispersal distance up to 300 km (186 miles) in a migratory population in Canada. Millsap and Bear (1997) reported a median natal dispersal distance of between 0.4-1.1 km (0.2-0.7 mile) in a Florida population, and Rosenberg and Haley (2004) reported a similar median distance (1.5 km [0.9 mile]) in the Imperial Valley of California. However, Rosenberg and Haley (2004) suspect that they severely underestimated natal dispersal, and state that better understanding of natal dispersal of burrowing owls is dependent on addressing general problems in the estimation of natal dispersal (e.g., Koenig et al. 2000).

Site Fidelity. Burrowing owls exhibit strong site fidelity and tend to return to nest in the same areas year after year (Martin 1973, Zarn 1974). In a New Mexico owl population, Martin (1973) found all nest burrows occupied during 1970 and 1971 had been occupied in previous years. In Oregon, Green (1983) found an average of 76 percent of nest burrows were occupied the next year, but the reuse rate varied by soil type. At Moffett Airfield, 74 percent of occupied burrows were reoccupied between 1992 and 1994 (Trulio 1994, cited in Barclay 2001). Owls at Moffett used many of the same or nearby burrows year after year. Forty-two (42) different burrows were used by owls in this study. Seven (17 percent) were used all 3 years and 24 (57 percent) were used only two of the three years. In Rosenberg and Haley's (2004) Imperial Valley study, over 85 percent of adult owls of known sex observed in two successive years nested within 400 m (984 feet) of their previous year's nest.

Burrowing owls that have been intentionally relocated have generally shown strong site fidelity to the sites from which they were moved. Feeney (1997) summarized the results of 14 relocations involving 104 owls that were relocated from 1-150 miles at different times of the year for various reasons. Owls tended to remain at or return to their original sites when the "relocation" consisted of closing occupied burrows (i.e., eviction). Owls transported to relocation sites tended to disappear from these sites shortly after release. Delevoryas (1997) reported on the active relocation of five pairs of owls at the beginning of the breeding season (February) in Santa Clara County. Four pairs of owls relocated 19 miles, kept in aviaries, and released in March, nested on the relocation site. Two of the relocated pairs successfully raised young. Three females that experienced failed nesting attempts returned to the capture site. Six owls remained on the relocation site for one year, two were present two years later, and at least one owl was observed on the site four years later. Failure to maintain habitat in appropriate condition for burrowing owls may have contributed to owls dispersing from relocation sites (Delevoryas 1997).

Land Use Practices. The land use practices or primary pressures that directly affect burrowing owls in Solano County are urbanization, intensive agriculture, cultivated grassland/dry-farming, and livestock grazing.

Urbanization. Urbanization results in the direct loss of both nesting and foraging habitat for burrowing owls. Increased urbanization and associated infrastructure (i.e., roads) also results in habitat fragmentation (see discussion below).

Intensive Agriculture. Intensive agriculture in itself (i.e., growing of crops) does not likely pose a severe threat to burrowing owl populations. On the contrary, existing occurrence information from the County and other studies in California (Gervais et al. 2003, Rosenberg and Haley 2004) suggest that owls do well in agricultural landscapes. However, several management activities associated with agricultural areas (e.g., rodent control, levee maintenance, pesticide use) have the potential to negatively affect owls and are discussed below.

Cultivated Grassland/Dry-land Farming. Similar to intensive agriculture, dry-land farming as a land use does not pose a threat to burrowing owl populations. However, two management activities associated with this land use, rodent control and disking, have the potential to negatively affect owls (see below).

Livestock Grazing. With the proper timing and management regimes, livestock grazing can actually benefit burrowing owls by keeping vegetation height low, thereby creating ideal habitat conditions for owls (assuming suitable burrows are also present).

Consequences of the Land Use Practices. The consequences of the above land use practices (i.e., secondary pressures) on burrowing owls in Solano County include:

Direct Habitat Loss. Conversion of natural grassland communities and agricultural fields to residential and commercial development results in a permanent loss of both nesting (i.e., burrow complexes) and foraging (i.e., open grasslands and fields) habitat for burrowing owls. Landscapes that once provided a source of prey (i.e., insects and small mammals) and structurally suitable vegetation communities become biologically unproductive when they are paved or built upon. Ornamental plantings and landscaping provide little value to burrowing owls.

Habitat Fragmentation. Habitat fragmentation due to urbanization and associated infrastructure (e.g., roads) results in isolation of breeding pairs, reducing connectivity between subpopulations and potentially stability of the region-wide population. Pairs within small, isolated habitat fragments (e.g., urban vacant lots) surrounded by development are more vulnerable to predation by non-native predators (i.e., house cats) and disturbance by humans than those that nest in agricultural areas or large areas of grassland. Fragmentation also lowers foraging efficiency by increasing the distance that adults must travel to find food for their mate and young, possibly resulting in reduced reproductive success.

Rodent Control. Rodent control programs along irrigation canals and levees eliminate or substantially reduce ground squirrel populations, reducing the availability of nest burrows for owls. Furthermore, by maintaining land that would otherwise be suitable owl nesting habitat free of squirrels and burrows, rodent control programs result in reduced colonization opportunities for dispersing owls. As a result, the reproductive potential of the regional burrowing owl population is limited. Lastly, rodent control methods (e.g., fumigation) could result in the direct mortality of owls if occupied burrows are sprayed.

Pesticide Use. Insecticide use in agricultural areas has the potential to adversely impact burrowing owls, although there is still uncertainty regarding the susceptibility of owls to pesticides at the population level (Gervais et al. 2003). At Naval Air Station Lemoore southwest of Fresno, 12 percent of radio-marked owls were detected foraging in crop fields when pesticides were still potent, although none died after doing so (Gervais et al. 2003). Also, the contaminant DDE (or p,p'-Dichlorodiphenyldichloroethylene, frequently written as p,p-DDE) was found in all collected eggs, but did not result in reproductive failure; however, higher concentrations of contaminants combined with reduced rodent biomass in the diet were related to reduced productivity. Gervais (2003) suggested that contaminants may be entering the population through immigration and that adverse effects are limited to years of low rodent abundance.

At the individual scale, owls are susceptible to commonly-used carbamate (e.g., carbofuran, aldicarb) and organophosphate (e.g., chlorpyrifos, diazinon) pesticides, which are known to be highly toxic to wildlife (Mineau et al. 1999). Most compounds in these categories are used as insecticides during insect outbreaks that have the potential to cause considerable crop damage. Since owls consume insects as a major portion of their diet, widespread applications of insecticides pose a significant threat. Impacts can be direct (e.g., pesticides sprayed directly over burrows) or indirect (i.e., owls consume contaminated insects).

Levee Maintenance. Routine maintenance activities along irrigation canals and levees could disturb and/or destroy nest burrows. Vehicle traffic along and grading of maintenance roads could result in burrow collapse (Rosenberg and Haley 2004), and noises associated with maintenance activities may disturb pairs nesting nearby.

Disking or Tilling. Fall disking or tilling of dry-land pastures or cultivated grasslands may destroy rodent burrows, trapping and killing owls as a result. Disking of vacant lots within urban areas for fire control also has the potential to kill owls if no pre-activity surveys are conducted, particularly in the breeding season.

Vehicular Collisions. The tendency for owls to forage and perch along roads at night (Bent 1938) makes them particularly vulnerable to vehicular collisions (Haug et al. 1993, CBD et al. 2003). Several researchers have cited vehicle strikes as a significant source of mortality in their study population (Konrad and Gilmer 1984, Millsap and Bear 1988, Haug and Oliphant 1987, all cited in Haug et al. 1993).

Predation. Urbanization results in increased densities of non-native predators such as domestic dogs and cats and red fox, which have been identified in several reports as burrowing owl predators (Thomsen 1971, Martin 1973, Haug et al. 1993). Aside from land use effects, predation by natural predators is another pressure on burrowing owl populations. Natural predators include snakes, great horned owls, barn owls, red-tailed hawks, northern harriers, and medium-sized mammals that can enter burrows and consume eggs or young (e.g., badger, raccoon, coyote).

Flooding. Although not a result of land use practices, flood events destroy nest burrows, drowning juveniles as well as adults. For example, flooding of the Jones Tract in the San Joaquin Delta on June 3, 2004 resulted in the destruction of 20 burrowing owl nests and the drowning of approximately 120 juveniles (R. Cull, September 9, 2004 meeting of California Burrowing Owl Consortium; unreferenced).

Data Gaps, Uncertainties and Assumptions. Probably the most tenuous assumption of current burrowing owl policy is that owls that are evicted (i.e., "passively relocated") from sites to accommodate urban development are able to find nearby habitat and breed successfully. This uncertainty is particularly relevant to owls occupying small, isolated habitat fragments surrounded by existing development. In these situations, owls are often excluded from occupied burrows even when the nearest habitat may be over a mile (or further) away. Since owls are not a listed species, CDFG does not have a legal precedent for requiring that developers fund studies (e.g., color banding or radio telemetry) of dispersal and survival of evicted birds. As a result, there is virtually no published information on the effectiveness of passive relocation efforts. Currently the only study on passively-relocated owls is being conducted by CDFG as part of their Resource Assessment Program (CDFG 2004b). Of 36 owls that were caught from four development sites around Sacramento and fitted with radio transmitters in 2002 and 2003, 14 survived and 16 died (most from unknown causes), with 6 owls (all juveniles) recorded as "missing" (CDFG 2004b).

Another uncertainty related to owls in isolated habitat patches is the type and minimum extent of development that constitutes a movement barrier between occupied patches and nearby foraging areas. Owls have been observed in small (i.e., 1 acre) urban lots surrounded by development, and are presumably able to fly through or above inhospitable urban areas to suitable foraging habitat. However, little is known about the maximum distance owls are able to fly from their nest sites in urban settings (i.e., what is the minimum distance between nest sites and foraging areas at which owls can no longer persist in isolated habitat patches?). Type of development between nest sites and foraging areas (e.g., high-density housing vs. parks) is another landscape factor that likely influences owl movement patterns, but no studies of this have been conducted. In general, studies of burrowing owl habitat relationships in urbanized areas are lacking and many of our assumptions about the ability of owls to persist in these settings may be invalid.

Little is known about the amount of habitat required to support a breeding pair of owls. Currently, CDFG mitigation policy for burrowing owls is based on the acquisition or preservation of 6.5 acres of suitable habitat for every pair or unpaired resident bird that is displaced by development. This amount (which equals a 300-foot radius around an occupied burrow) was defined by the California Burrowing Owl Consortium (CBOC) as the amount of habitat estimated to be a threshold where significant impacts should be considered when defining impacts during CEQA project review (CBOC 1997). It was <u>not</u> purported to be the amount of habitat needed to support a pair of owls, nor was it meant to be used as a way to manage for a sustainable population of owls. As such, there is some uncertainty over how much habitat a burrowing owl pair needs to persist in a given area. In reality, the amount of space required by a pair of burrowing owls (i.e., home range size) is highly variable both statewide and within a given region, and is dependent on factors such as prey availability, reproductive success (i.e., energy demand), and landscape characteristics that affect the distribution of resources (Newton 1979, Kenward 1982, Haug and Oliphaunt 1990, Rosenberg and Haley 2004). Various home range size estimates have been published in the literature: 35 to 1186 acres (mean = 593) in Canada (Haug and Oliphant 1990), 467 acres (mean estimate) in the Central Valley (Gervais et al. 2003), and 111 ± 45 or 456 ± 161 acres in the Imperial Valley, depending on the type of telemetry analysis used (Rosenberg and Haley 2004). Rosenberg and Haley (2004) postulate that sampling variation may be responsible for much of the observed differences in estimated home range size, and that this deserves further attention for estimation of home range sizes in general.

Current Management and Monitoring Practices. *The California Bird Species of Special Concern* (Shuford and Gardali 2008) contains management and research recommendations for the burrowing owl. These include: develop a conservation strategy with population, density and distribution goals; place sizable tracts of grassland under conservation easements; seek conservation agreements with landowners of row-crop agriculture to encourage management beneficial to the species; maintain suitable vegetation structure through mowing, low-growing species, etc.; supplement areas where burrows are lacking with artificial burrows or encourage ground squirrel presence; control off-road vehicles and off-leash pets in suitable habitat; develop guidelines for maintenance of the species; assess strategies for maintenance of the species in urban areas; determine owl distribution in public grasslands; assess the risk the owls pose to aircraft safety; conduct research on habitat suitability, dispersal and the magnitude and source of wintering populations.

There are currently no coordinated management practices or monitoring for burrowing owls within Solano County. The primary management generally results from CEQA analysis of development projects and associated passive relocation techniques that are implemented to varying degrees in order to comply with Migratory Bird Treaty Act and California Fish and Game Code requirements to avoid destruction or disturbance to active raptor nests.

Key Monitoring and Adaptive Management Issues from Conceptual Model. Burrowing owls are dependent on shelter provided by burrows of fossorial mammals such as California ground squirrels or man-made shelters formed by piles of rubble or large rocks, drain pipes, or other materials. Key pressures on burrowing owl populations are the reduction of burrows associated with ground squirrel control and the inherent conflicts with ground squirrels, agriculture, and the need to maintain the integrity of canals, levees, and other earthen structures.

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