BURROWING OWL NESTING SUCCESS AT URBAN AND PARKLAND SITES IN NORTHERN CALIFORNIA

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Abstract. From 1998 to 2004, we recorded nest numbers, success, density, and productivity rates of Burrowing Owls *(Athene cunicularia)* living in an urban setting at the south end of the San Francisco Bay. We compared these measures for birds nesting in two different land use types, urban and parkland sites. There was no significant difference between urban and parkland sites in the percent of nests that were successful (t = 1.30, df = 12, p = 0.215) (*urban nest mean* = 51%, n = 7; *parkland nest mean* = 45%, n = 7) or for the mean number of young per successful nest (t = -1.45, df = 86, p = 0.150) (*urban nest mean* = 3.04 young/nest, n = 75; *parkland nest mean* = 3.51 young/nest, n = 39). However, the number of active nests in the urban sites declined significantly over the study period (r = -0.85, p = 0.015, n = 7), while at parkland sites active nest numbers showed no significant change. Nests at urban sites were more vulnerable to human impacts than those in parkland areas. Urban sites will require better management to sustain owl populations.

Key Words: Athene cunicularia, Burrowing Owl, California, nest success rates, productivity rates, population status.

Grassland ecosystems have declined in extent and biological diversity in western North America during the past few decades (Knopf 1994). In California, where less than 10% of Central Valley grasslands remain today, these habitats have largely been reduced to small fragments, usually surrounded by extensive agriculture and/or urbanization (Knopf 1994). This fragmentation has resulted in the decline of many grassland species; including Loggerhead Shrikes (*Lanius ludovicianus*), Western Meadowlarks (*Sturnella neglicta*), and Burrowing Owls (Knopf 1995). Habitat destruction and population declines have contributed to the listing of the Western Burrowing Owl (*A. c. hypugaea*) as a Species of Special Concern in California (Remsen 1978) and a National Bird of Conservation Concern (US Fish and Wildlife Service 2002).

The Western Burrowing Owl is a bird of prairie grasslands found west of the Mississippi, north into Canada, and south into Mexico. The Burrowing Owl is the world's only owl species that lives and nests underground. It usually lives in "towns" with colonial rodents such as ground squirrels (*Spermophilus spp*.) and prairie dogs (*Cynomys spp.*) and appropriates burrows dug by these rodents. While it is a neotropical migratory species, the Burrowing Owl has both wintering and breeding populations in California (Haug et al. 1993). California supports a substantial portion of the Western Burrowing Owl population (James and Espie 1997).

Over the past 40 years, owl numbers have dropped throughout most of the species' range (James and Ethier 1989, Haug et al. 1993). Although some areas, such as the Imperial Valley, have experienced population increases due to habitat conversion (DeSante et al. 2004), many areas of California are losing Burrowing Owls (DeSante et al. 1997). A study by the Institute for Bird Populations indicated that the Burrowing Owl population in the San Francisco Bay Area and parts of Central California declined by 50% in 10 years between 1983 and 1993 (DeSante et al. 1997). A 2002 survey of 111 city-owned or privately-owned sites in the south San Francisco Bay Area where owls were recorded between 1981-1988 showed that 66% of these occupied sites had been lost to urban development (Trulio 2003). Since this species occurs in urban settings, we must understand how successful Burrowing Owls are in urban landscapes if we are to sustain their populations.

Trulio (1997) characterized population size, habitat characteristics, and distribution of Burrowing Owls at the south end of the San Francisco Bay. We provide information on nest numbers, success, density, and productivity in an urban setting applicable to managing the small, sensitive South Bay population, which is threatened by intensive development.

We address the question: Is there a significant difference in nest and reproductive rate measures between parkland and urban land use types?

STUDY AREA

The South San Francisco Bay study area is located in Santa Clara County, California, approximately 64 km southeast of the city of San Francisco. The study area included approximately 49.2 sq km (4920 ha) of land north of US Highway 101 and south of the southern-most San Francisco Bay salt ponds and marshes at the edge of the San Francisco Bay. The area is bordered by San Francisquito Creek to the west and the Guadalupe River to the east. The entire study area is dominated by the urbanized landscape of Silicon Valley. Closed landfills and open grasslands border the south end of the Bay; urban developments with some open fields cover the rest of the area. During the study, Burrowing Owl habitat was confined to fragments of grassland habitat within and adjacent to the urban matrix and included sites such as golf courses and airports.

The South San Francisco Bay region, which includes Santa Clara and Alameda Counties, supported a population of approximately 125 pairs of Burrowing Owls in the late 1990s (DeSante et al. 1997, Trulio 2003). The South Bay study area, which included only a portion of the owl's South Bay range, had approximately 50 pairs of owls during this study. We documented owls on seven major habitat patches, or sites, in the study area. We divided these sites into two land use categories: parkland sites, which are areas managed for wildlife protection and recreation, and urban sites, patches not managed specifically for wildlife habitat. The three parkland sites at Byxbee Park, Shoreline Park, and Sunnyvale Baylands Park/Landfill are recreational settings of open, non-native grassland habitat on the fringe between urbanization and wetlands. The four urban sites include NASA Ames Research Center (Moffett Field), Mission College, Tasman Drive, and Agnews Developmental Center, all of which consisted of fragmented parcels of non-native grassland habitat located within urban land uses.

METHODS

We collected data from 1998 to 2004 and conducted fieldwork each year between 1 April and 1 August. Methods followed the protocols developed by Rosenberg and Haley (2004). In April of each year, we visited all burrows occupied in previous years at least once to evaluate the structure of the burrow and check for owl activity. We located new, potentially active nests using walk-through transect surveys (Rosenberg and Haley 2004).

We visited potential nests at least once a week to determine if they were active. An active nest was defined by a pair of owls observed at the burrow. A single owl denoted an active burrow, but not a nest. If, after three to four observations we did not see an owl pair at a potential nest site, we did not include it as a nest. We used GPS units to record Universal Transverse Mercator (UTM) coordinates (NAD83 map datum) for every active nest. Observers used binoculars (10 X 50) and spotting scopes (15-45 X 60) mounted on tripods, and window mounts in cars, to identify active burrows.

Nest success was determined when ≥1 young ≥14 days old were observed. A nest was considered to have failed if, by 15 July: (1) we never observed young, (2) we observed young <14 days old, but never observed them subsequently, or (3) there was evidence that an active nest burrow was disturbed or destroyed.

Active nests located by 15 May were used in the standardized productivity estimate, a measure of reproductive rate (Gorman, et al. 2003). We searched for new broods approximately once a week. Each active nest was observed for at least 15 min until 14- to 21-day old young were observed. Young were aged as per Priest (1997).

When young were observed, we completed a series of five 30-min nest watches within a span of seven days. Observations were performed from at least 30 m, except for a few nests where visibility was obstructed. The maximum number of young observed during the five 30-min nest watches was used as the productivity estimate for that nest. We performed these standardized productivity procedures from 1999 to 2004.

An IKONOS satellite image (taken in March 2000 by the Ikonos-2 satellite) was used to develop land use classifications using ERDAS IMAGE 8.6. We used ArcGIS 8.0 to map the study area and estimate site areas. We used t-tests to compare the percent of successful nests each year in urban areas and parklands, and to compare young per nest for all nests at urban and parkland sites (compiled for all years). Correlation analyses were used to test the significance of changes in nest numbers over time.

RESULTS

We studied 356 nests over seven years, 257 in urban sites and 99 in parkland areas. We found a 34% decline in the number of nests in the study area during the study period, from a high of 64 in 1999 to a low of 42 in 2003 (Table 1), which was significant (r = -0.88, p = 0.009, n = 7). The decline in overall nest numbers was due to a significant loss of nests in urban land use areas ($r = -0.85$, $p = 0.015$, $n = 7$); nest numbers at parkland sites remained relatively constant ($r = 0.27$, $p = 0.557$, $n = 7$) (Fig. 1).

TABLE 1. Burrowing Owl nest numbers, 1998-2004.

Year	Nests	Successful Nests
1998	56	24
1999	64	27
2000	53	28
2001	49	24
2002	49	22
2003	42	24
2004	43	22
Total	356	171
Average	51	24

Despite the decline in nests, the number of successful nests remained relatively constant, averaging 24 per year over the seven-year period ($r = 0.60$, $p = 0.150$, $n = 7$) (Table 1). The percentage of nests that were successful each year at both urban and parkland sites varied from year to year. Over seven years, an average of 51% of urban nests and 45% of parkland nests produced young; comparing the yearly averages of percent successful nests showed no significant difference between the two land use types ($t = 1.30$, $df = 12$, $p = 0.215$).

Nest density, averaged over seven years at urban sites, was 3.3 nests per sq km in a total area of 11.1 sq km (Table 2). Nest density calculated for grassland only at urban sites was 8.2 nests per sq km over 4.5 sq km. For parkland sites, we found 2.6 nests per sq km in a total area of 5.4 sq km. If only the area of grassland at these subsites is considered, the density was 5.2 nests per sq km in 2.7 sq km of grassland.

TABLE 2. Burrowing Owl nest densities (nests/sq km) in urban and parkland sites, 1998-2004.

Year	Urban Sites[a]	Parkland Sites[b]
1998	4.2	1.6
1999	4.5	2.8
2000	3.1	3.3
2001	3.1	2.7
2002	3.0	2.9
2003	2.3	2.9
2004	2.9	2.0
Average	3.3	2.6

[a]Total area=11.1 sq km
[b]Total area=5.4 sq km

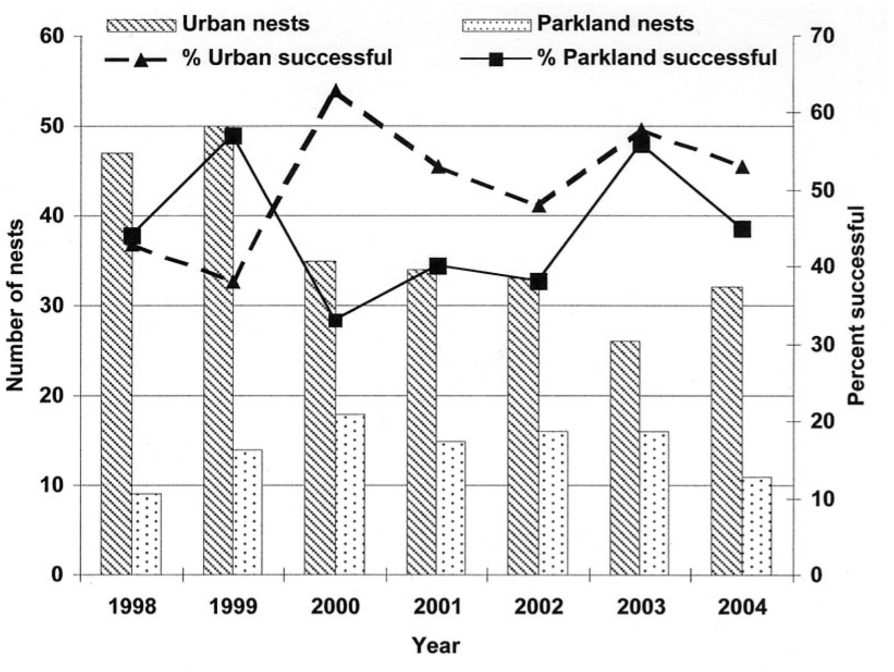

FIGURE 1. Total number of urban and parkland Burrowing Owl nests by year (bars) and the percent that were successful (lines).

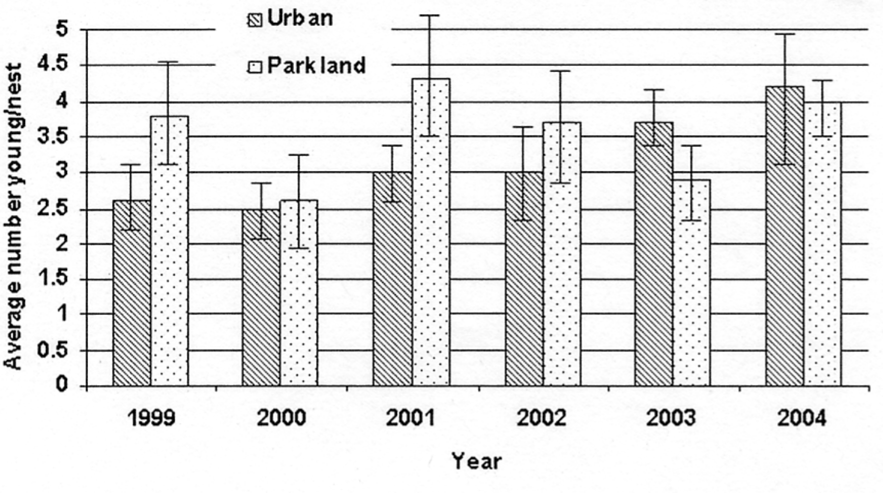

FIGURE 2. Average number of Burrowing Owl young per successful nest (with standard error bars) at urban and parkland sites by year.

The number of young, as averaged over six years for successful and failed nests combined, showed no significant difference in productivity between the two land uses (*urban mean* = 1.5 young/nest, $n = 151$; *parkland mean* = 2.0, $n = 70$) ($t = -1.53$, $df = 219$, $p = 0.127$). When considering only successful nests, there was no significant difference in young per nest, compiled for all years, between nests in urban areas (*mean* = 3.04 young/nest, $n = 75$) and parkland area (*mean* = 3.51 young/nest, $n = 39$; $t = -1.45$, $df = 86$, p = 0.150). Productivity varied from year to year (Fig. 2), but comparing the number of young per successful nest each year for urban and parkland sites showed no significant differences, as the standard errors overlapped (Fig. 2).

DISCUSSION

One might expect owls to reproduce at higher rates on the parkland sites than the urban sites, because parkland areas are managed for wildlife. However, our data showed mixed results. There was no significant difference between the two land uses in average percentage of successful nests per year, number of young per successful and failed nests, or number of young produced per successful nest. It appears that the factors affecting nest success and nestling numbers are operating at a regional level, and are not different for the two land use types.

Nest success rates for the South Bay, which averaged 51% for urban sites and 45% for parklands, were low compared to other Burrowing Owl populations. For example, Barclay (this volume) reported an 80% nesting success rate at the Mineta San Jose International Airport, adjacent to the study site. And, at the Oakland Airport, also near the study site, Thomsen (1971) found 88% and 53% of nests produced young in 1965 and 1966, respectively. A 70% success rate for nesting females in the Imperial Valley was reported by Catlin et al. (2005). Haug (1985) found nest success rates of between 51% and 64% per year in Sasketchewan. In central Oregon, Holmes et al. (2003) found that between 50% and 67% of nests produced young.

Productivity rates (number of young per nest) are very difficult to compare between studies due to methodology differences, such as varying effort and differences in nestling counting methods (Gorman et al. 2003). However, Gorman found that the maximum number of young counted in five 30-minute observations (the method used in this study and by Rosenberg and Haley [2004] in California's Imperial Valley) gave a useful relative estimate of productivity. The productivity of South Bay owls was 3.2 young per successful nest, a bit higher than Imperial Valley owls, which averaged 2.5 young per successful nest (Rosenberg and Haley 2004). As in the South Bay, productivity in the Imperial Valley varied widely between years (Rosenberg and Haley 2004).

We do not know what landscape or local factors might be influencing nest success and productivity in the South Bay region, but predation as well as prey availability, abundance, and quality are likely to be central factors (Rosenberg and Haley 2004). We are currently analyzing data on pellet contents to determine the owls' diets in urban and parkland habitat, which may provide insight into nest success and productivity results. While we have not quantified predator abundance, it seems that nest and nestling predators in the South Bay, including hawks, skunks (*Mephistis mephistis*), snakes, feral cats, and non-native red foxes (*Vulpes vulpes*), are common to both urban and parkland sites. Human disturbance is also a factor at both urban and parkland sites. Urban development, California ground squirrel (*Spermophilus beecheyi*) killing, random nest disturbance, and dogs are common disturbance factors at urban sites. The parkland sites also experienced some construction disturbance related to subsurface infrastructure, such as pipeline replacements, and random nest disturbance. Recreationists were more common in the parklands. Some parklands also allowed dogs, which contributed to nest disturbance. Recreation is a well-documented disturbance factor that can have negative impacts on nesting birds (Holmes et al. 1993, Knight and Cole 1991).

It is interesting to note that, no matter what the overall number of nests from year to year, approximately the same number of nests each year were successful. This consistency in nest success number suggests that factors throughout the region are holding successful nest numbers at a relatively constant level. Prey base, predation rates, and human disturbance are likely factors limiting nest success.

Nest density was one measure that differed between land use types, with parkland subsites having lower nest densities than urban subsites. Since the denser conditions at urban sites were not accompanied by significantly lower nest success or productivity compared to parkland sites, these data suggest that Burrowing Owls do well in suburban landscapes. Work by Wesemann and Rowe (1985) and Millsap and Bear (2000) support this finding, to a point. For example, Wesemann and Rowe (1985) found that the density of Florida Burrowing Owl (*A. c. floridana*) nests increased with increasing suburban development until approximately 60% of the land was developed. When vacant land dropped to 40% or less, owl numbers per ha began to drop also. Changes in nest density followed the abundance of prey, in particular, anole lizards (*Anolis* spp). Millsap (2002) found that, while Burrowing Owls in urban Florida benefited from high prey densities around homes, nest failures and declines in young fledged at successful nests in heavily developed areas offset the benefits of more prey. South Bay habitats had relatively low densities compared to Florida at 6.9 nests/sq km (Millsap and Bear 2000) and the Salton Sea at 8.3 nests/sq km (Rosenberg and Haley 2004), a California region with very high densities. Both parkland and urban sites in the South Bay might realize increased nest density if the prey base improved (Haley 2001).

Another parameter that differed by land use type was the average number of active nests per year, a measure that showed a significant decline in urban areas. Specifically, the Tasman Drive and Mission College subsites were responsible for this decline (LAT unpublished data). Nest loss was due primarily to urban development, a significant factor in nest loss in urban Santa Clara County (Trulio 2003). Current mitigation agreements for development projects do not require the replacement of destroyed nests within the study area nor require the preservation of foraging habitat (Trulio 1998). Thus, nests and foraging habitat destroyed at these sites were permanently lost. Construction disturbances at parkland sites were related to subsurface infrastructure work and did not result in permanent loss of foraging habitat. In cases where nests were destroyed at parkland sites, voluntary mitigation using artificial nests and the adequate area of remaining habitat were enough to compensate for nest loss.

CONSERVATION IMPLICATIONS

As a result of our findings, we recommend the following conservation measures to protect and enhance owl numbers and productivity in the South Bay region:

Collect data on the prey base and diet of Burrowing Owls at parkland and urban sites to determine if density, productivity, and/or successful nests per year are prey limited.

Enhance owl habitat by improving conditions for high quality prey.

Protect owl nests and foraging habitat in both parkland and urban sites. Mitigate on-site or within the South Bay region for nests lost to human activities.

Protect ground squirrels in owl nesting habitat.

Control non-native predators such as feral cats and the non-native red fox.

Assist the California Department of Fish and Game in developing legislation designed to prohibit destruction of burrows outside the nesting season and require mitigation for direct and indirect habitat loss; strengthen enforcement and penalties for violations of state (Fish and Game Code section 3503.5) and federal regulations (i.e., Migratory Bird Treaty Act of 1918, as amended) that protect birds and their nests.

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