BURROWING OWL NEST SUCCESS AND BURROW LONGEVITY IN NORTH CENTRAL OREGON

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BURROWING OWL NEST SUCCESS AND BURROW LONGEVITY IN NORTH CENTRAL OREGON

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ABSTRACT.—We studied nest success, burrow longevity, and rates of burrow reuse for a migratory population of Burrowing Owl (*Athene cunicularia*) in north central Oregon from 1995 to 1997. Nest success varied annually from 50% to 67%. Principal causes of nest failure were desertion (26%) and depredation by badgers (*Taxidea taxus*; 13%). Reuse of available nest and satellite burrows in subsequent years was 87% in 1996 and 57% in 1997. Reuse was highest at burrows in sandy soils, which may indicate that nest-site availability is a limiting factor in sandier soil types. Trampling by livestock resulted in the loss of 24% of all burrows between one season and the next, and natural erosion resulted in closure of 17%. Both causes of burrow failure occurred more frequently in soils with a sand component due to their friable nature. We recommend that habitat used by livestock be evaluated for use by Burrowing Owls, that occupied areas be managed to minimize destruction of burrows by livestock, and that predator-control efforts be revised to exclude mortality of badgers.

Key words: Burrowing Owl, Athene cunicularia, *nesting success, shrubsteppe, livestock, Oregon, trampling.*

The Burrowing Owl is a species of conservation concern throughout much of its range in western North America (James and Epsie 1997, Sheffield 1997, Holroyd et al. 2001). It has been extirpated as a breeding species from British Columbia since 1980 (Haug et al. 1993) and has declined recently at a rate of approximately 20% a year in the prairie region of southern Alberta and Saskatchewan (Holroyd et al. 2001, Skeel et al. 2001). Currently there is no federal regulatory designation in the U.S., although the U.S. Fish and Wildlife Service included the Burrowing Owl on a list of regional priority conservation species in the midwestern and western U.S. (U.S. Fish and Wildlife Service 2002). In contrast to monitoring programs in Canada and the Midwest, Breeding Bird Survey data for the Columbia Plateau indicate a significantly increasing population, although the estimate is considered imprecise (Sauer et al. 2001). Due in part to this increasing trend and their widespread breeding distribution, Burrowing Owls in the Columbia Plateau were given a relatively low score in a species assessment and prioritization process recently completed by Partners in Flight (total score of 16; Panjabi et al. 2001).

Impacts of human activity and land use on reproductive success and habitat use of this species vary. In Florida, mowing, livestock grazing (Ligon 1963), and wetland drainage (Millsap 1996) helped expand the species' range by increasing the availability of suitable habitat. Intensive agriculture can reduce available nesting habitat and result in increased depredation of nests (Haug 1985), but it has also been shown to provide foraging habitat (Rich 1986). Control of burrowing mammals including badgers (*Taxidea taxus*), which provide Burrowing Owl nest sites (Butts 1973), and agricultural pesticides, which kill Burrowing Owl prey (James and Fox 1987), also have been implicated in Burrowing Owl population declines.

In general, these owls prefer open, sparsely vegetated, relatively flat grasslands rather than shrubby habitats or those with dense or tall grass (MacKracken et al. 1985, Rich 1986, Green and Anthony 1989, Plumpton and Lutz 1993). Because of this habitat preference, one could assume that some grazing by livestock would increase habitat suitability in areas of taller vegetation. Studies evaluating the effects of livestock grazing on habitat use, however, particularly in shrubsteppe habitats, suggest a

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mixed response by Burrowing Owls (Saab et al. 1995). Green and Anthony (1989) reported reduced vulnerability to badger depredation at nests lined with cattle dung (because dung covered the owl scent) and suggested provisioning nesting areas with fresh cattle dung where it is not already available (Green and Anthony 1997). While it is known that migratory Burrowing Owls reuse nest sites from one year to the next (Rich 1984, Lutz and Plumpton 1999), there is no information on the impacts of livestock trampling on burrow longevity or nesting success. Our objectives were to determine nest success, survival of burrows between years, badger burrow availability, and rates of burrow reuse for a population of migratory Burrowing Owls nesting in shrubsteppe habitat in north central Oregon. Specifically, we tested whether there were differences in nest success between soil types or years and whether there were soil-type differences in burrow reuse, destruction of burrows by natural erosion, and destruction of burrows by livestock.

STUDY SITE

The study was conducted in Morrow County, north central Oregon, on the 19,000-ha Naval Weapons Systems Training Facility (NWSTF), Boardman. Topography ranges from flat to undulating with elevations from 120 m to 275 m. Terraces with gentle slopes of 2% to 10% typify most of the study area, although these terraces graduate into rounded hillsides and valleys with slopes of 5% to 20% at the southern end of the study area. Soils grade from a Quincy-Koehler association at the northern end, to predominantly Sagehill-Taunton, and then to deep Warden soils at the southern end of the facility (McClelland and Bedell 1987). Average annual precipitation in the area is approximately 22 cm (Ruffner 1978), mostly occurring from November through May. Summers are hot and dry with maximum temperatures exceeding 40°C.

Climax vegetation at the site during our study was within the *Artemisia/Agropyron* (now *Pseudoroegnaria*), *Artemesia/Stipa* (now *Hesperostipa*), or *Purshia/Stipa* associations (Franklin and Dyrness 1988). However, climax communities were rare and patchily distributed due to a history of livestock grazing, frequent fires from military activities and lightning strikes, and invasive plants, especially the exotic cheatgrass (*Bromus tectorum*). Shrubs included big sagebrush (*Artemisia tridentata*), antelope bitterbrush (*Purshia tridentata*), gray rabbitbrush (*Chrysothamnus nauseosus*), and green rabbitbrush (*C. vicidiflorus*). Important grasses included cheatgrass, Sandberg's bluegrass (*Poa sandbergii*), needle-and-thread (*Hesperostipa comata*), and bluebunch wheatgrass (*Pseudoroegnaria spicata*). Bitterbrush was sparse and restricted to sandy soils at the northern end of the study area, and sagebrush communities were restricted to the southern half. The central area was a mosaic of needle-and-thread, rabbitbrush shrublands, and extensive open areas dominated by cheatgrass. Widespread and locally abundant forbs included scurf pea (*Psolarea lanceolata*), hairy plantain (*Plantago patogonica*), hairy goldenaster (*Chrysopsis villosa*), and tumble mustard (*Sysimbrium altissimum*).

Livestock used the study area from January or early February to late May or early June at an annual stocking rate of approximately 0.20 AUM (animal unit month—1 adult cow and 1 calf or 5 sheep per month) per ha. Approximately 720 of the total 3470 AUMs were allocated on the southern half of the study area to sheep. Pastures were of varying size and valley bottoms were used more than uplands and slopes, resulting in a mosaic of grazing intensities.

METHODS

We thoroughly searched approximately 2000 ha of the study area early (April) and late (June) in the season to locate a representative sample of nesting Burrowing Owls. In addition, we located nests when carrying out other field surveys. When a nest was located, we searched the immediate area for neighboring pairs (Green and Anthony 1989). Because previous work in north central Oregon showed that Burrowing Owls avoid dense rabbitbrush shrublands for nesting (Green and Anthony 1989), we did not search extensively in larger patches of that habitat.

We checked nests from a distance of 20 m to 200 m once every 3–10 days. We identified nest sites and determined outcomes following methods outlined in Green and Anthony (1989). In summary, we used the length of known occupancy and behaviors that coincided with egg laying, incubation, and brooding (Coulombe 1971, Martin 1973) to determine if nesting occurred. We considered a nesting attempt successful when young reached flight stage (6 weeks of age). Unsuccessful nests were those destroyed or deserted after eggs had been laid. Desertion, defined as abandonment of a nest occupied by eggs or nestlings, was indicated by a lack of fresh owl tracks, prey, and sign of disturbance. Tracks and evidence of fresh digging from badgers or coyotes (*Canis latrans*) indicated when nests had been preyed upon by those species. We intensively searched the area within 300 m of deserted nest burrows to determine if the owls had shifted sites as described by Henny and Blus (1981).

We uniquely numbered all burrows used by owls, marking each with a small metal tag anchored to the ground approximately 4 m from the entrance. We classified soil type around each burrow into 1 of 3 classifications that generally followed the north-to-south gradient: loamy sand, sandy loam, and silty loam. Individual burrows were tracked from one season to the next and their status (open, closed naturally, closed due to trampling) was assessed each spring during late April to early May. Two burrows located on roadcuts that were destroyed by grading equipment were excluded from analyses of burrow availability and reuse. In total, 44 burrows (both nest and satellite) used in 1995 were tracked for the duration of the study. Fifty-six additional burrows used in 1996 were tracked through summer 1997.

In April 1996 and 1997 we surveyed 915 ha of the study area to record burrow use and density. This area was composed almost entirely of grassland dominated by cheatgrass and Sandberg's bluegrass, with intermittent areas of rabbitbrush. The area also included approximately 80 ha of bitterbrush and 35 ha of sagebrush. We divided the area into plots of various sizes and systematically searched each with 2 to 6 observers spaced 20–60 m apart, depending on vegetation density. Observers doubled back upon reaching the predetermined boundary and searched a parallel swath of habitat. Wire flags were used to mark the edge of each pass to ensure complete coverage. Burrows were marked with a shoe print just outside the entrance to prevent double counting. Each burrow detected was classified as open or closed based on visual inspection of the entrance and tunnel. Open burrows were those with an opening of at least 5 cm and presumably could be re-excavated by owls. We further classified closed burrows as naturally closed when the entrance was completely silted in, or trampled when the tunnel had been collapsed as a result of trampling by cattle. Badger activity was noted if burrows were freshly dug or contained tracks.

We tested for differences in nest success, burrow survival, natural closure rates, and trampling rates among soil types using a Pearson chi-square test. Fisher's exact test was used to examine differences in reoccupancy of nests based on success the previous year. We used ANOVA to examine significance and interaction of factors potentially influencing reuse, including success the previous year, soil type, and calendar year. We set statistical significance at the conventional $P < 0.05$ level.

RESULTS

We monitored 99 nesting attempts between 1995 and 1997. Although not all pairs used satellite burrows, some nests were associated with as many as 6 additional burrows within 50 m of the nest. It was not uncommon for a nest burrow one year to be used as a satellite burrow the following year or vice versa. A total of 148 unique burrows, used either as satellites or nests, were monitored for at least 1 nesting season.

NEST SUCCESS.—The proportion of nests fledging young ranged from 50% to 67% during the study but did not differ significantly among years (Table 1; Pearson $\chi^2_{(2)} = 2.37$, $P = 0.31$). Desertion was the principal cause of nest failure, and depredation was important only in 1997 (Table 1). Badgers were responsible for 12 of 13 depredated nests and coyote for 1. Trampling of burrows by livestock resulted in failure of 4 active nests over the course of the study. Nest success across years was 43% ($n = 35$) in loamy sand, 71% ($n = 28$) in sandy loam, and 58% ($n = 36$) in silty loam. Differences were not significant (Pearson $\chi^2_{(2)} = 5.24$, $P = 0.073$).

BURROW SURVIVAL AND REUSE.—Combining data from 1996 and 1997, we found that the proportion of burrows surviving from one season to the next varied significantly among soil types (Table 2A; Pearson $\chi^2_{(2)} = 33.986$, $P < 0.001$). Burrows in sandy loam were twice as likely as those in the sandiest soils (loamy sand) to survive from one season to the next, and burrows in silty loam were 3 times as

TABLE 1. Nest success and causes of nest failure for Burrowing Owls in north central Oregon (1995–1997).

Year	n	Successful nests n (%)	Deserted nests n (%)	Depredated nests n (%)	Trampled nests n (%)
1995	29	15 (52)	12 (41)	1 (3)	1 (3)
1996	36	24 (67)	8 (22)	1 (3)	3 (8)
1997	34	17 (50)	6 (18)	11 (32)	0 (0)
1995–1997	99	56 (57)	26 (26)	13 (13)	4 (4)

TABLE 2. Number of burrows used by Burrowing Owls in the previous year that were (A) open, (B) naturally closed, and (C) closed as a result of trampling by livestock at the beginning of the 1996 and 1997 breeding season in each soil type. Percentages are expressed as the percent of all burrows within each soil type and year.

	Soil type n (% within soil type and year)			
	Loamy sand	Sandy loam	Silty loam	Total
(A) Open burrows				
1996	10 (37)	6 (67)	8 (100)	24 (54)
1997	5 (23)	10 (59)	32 (86)	47 (61)
1996–1997	15 (30)	16 (61)	40 (89)	71 (59)
(B) Naturally closed burrows				
1996	9 (33)	0 (0)	0 (0)	9 (20)
1997	6 (26)	4 (23)	2 (5)	12 (16)
1996–1997	15 (30)	4 (26)	2 (4)	21 (17)
(C) Trampled burrows				
1996	8 (30)	3 (33)	0 (0)	11 (25)
1997	12 (52)	3 (18)	3 (8)	18 (23)
1996–1997	20 (40)	6 (22)	3 (3)	29 (24)

likely. The proportion of burrows that failed due to natural closure (Table 2B; Pearson $\chi^2_{(2)} = 10.874$, $P = 0.004$) and through trampling by livestock (Table 2C; Pearson $\chi^2_{(2)} = 15.909$, $P < 0.001$) also followed this soil type gradient, with burrows in sandier soils most likely to fail due to either cause.

Overall, burrows in sandy loam soils were reused most frequently, burrows in loamy sand less, and burrows in silty loam the least (Table 3). A 3-way ANOVA of burrow reuse with soil type, year, and success of burrow in previous year was highly significant ($F = 5.67$, $P = 0.0016$), but it had a relatively low coefficient of determination (adjusted $r^2 = 0.22$), indicating much unexplained variation. Rates of reuse for available burrows differed significantly among soil types ($P = 0.0102$) but not between years ($P = 0.0649$) nor based on success in previous years ($P = 0.0798$). No interaction terms were significant ($P > 0.6$). Successful nest burrows that remained available were used again as nests (as opposed to not used or used as satellites) more frequently (78%, n = 23) than those that had failed (44%, n = 9; Fisher's exact test, $P = 0.011$).

BURROW ABUNDANCE.—Burrow abundance varied several-fold between the 2 years that we conducted widespread surveys. We documented 44.9 and 124.8 open burrows per 100 ha in 1996 and 1997, respectively. Of these, relatively few showed signs of recent badger activity in 1996 (14.5%), but badger activity increased dramatically in 1997 when fresh burrows accounted for 52.3% of all open burrows. Numbers of recently closed burrows, as indicated by a lack of cheatgrass and other vegetation on the disturbed soil, were also variable between years, increasing from 32.1 per 100 ha in 1996 to 134.2 per 100 ha in 1997. The percentage of closed burrows attributed to trampling by livestock was similar between 1996 (57%) and 1997 (61%).

DISCUSSION

NESTING SUCCESS.—Nest success during this study (57%, n = 99) was similar to the 53%

TABLE 3. Rates of reuse by Burrowing Owls for available burrows within each soil type (1996–1997).

	Soil type *n* (%)			
	Loamy sand	Sandy loam	Silty loam	Total
Reused in 1996	10 (100)	6 (100)	8 (62)	24 (87)
Reused in 1997	5 (60)	10 (90)	32 (47)	47 (57)
Total 1996–1997	15 (87)	16 (94)	40 (50)	71 (67)

(n = 139) reported from the same area by Green and Anthony (1989). Depredation of nests, minimal in 1995 and 1996, increased dramatically in 1997. This corresponds with an increase in badger activity on the study area in 1997, as evidenced by a greater than threefold increase in the number of freshly dug burrows documented on extensive surveys. Badgers are the principal predator of Burrowing Owl nests in the Columbia Basin (Green and Anthony 1989), and so this relationship was not unexpected. As badger populations fluctuate, Burrowing Owls may experience years of reduced productivity during periods of high badger abundance, but they also may benefit from the residual effect of increased burrow availability when badger populations again decline. Annual rates of nest desertion in this study were variable (18–41%), but not dissimilar to the 30–35% reported from the same general area in 1980 (Green and Anthony 1989).

BURROW SURVIVAL AND REUSE.—The friable nature of sandy soils resulted in relatively high rates of burrow failure due both to natural erosion and trampling of the burrow entrance or tunnel by cattle (Table 2). Lower trampling rates at burrows in silty loam may be attributable to several factors. Structural stability of burrows in this soil type was greater, and burrows were therefore less likely to fail when stepped on by cattle. Burrows in this soil have the potential to remain open for many years as evidenced by several we observed in areas protected from livestock whose antiquity was confirmed by the presence of well-developed cryptobiotic soil crusts at the entrance (Belnap 1993). An additional consideration is that sheep comprised approximately 40% of the AUMs allocated to areas with loamy and sandy loam soils. Because of their lighter weight, sheep would be less likely to collapse a burrow. The absence of sheep in the parts of our study area classified as loamy sand introduces an unfortunate bias when examining the influence of soil type on trampling rates. However, relative rates of trampling among soil types mirror those of natural closures. We believe this lends support to our conclusion that observed differences in burrow failure are related to soil texture as opposed to variations in livestock management.

In this study reuse of nest and satellite burrows was greater at sites with sandy than loamy soils. We suggest that high rates of nest site reuse and decreased longevity of burrows could indicate that suitable nest locations are a limiting factor in areas of sandy soils. Although we do not know if the same individuals occupied the sites we monitored from one year to the next, nests in our study were more likely to be used again if they had been successful the previous year. Lutz and Plumpton (1999) found owls that switched burrows produced fewer young the preceding season than those that reused a nest site, indicating a similar relationship between reuse and productivity. Destruction of nest burrows forces owls to relocate, which may also impact productivity. Botelho and Arrowood (1998) reported that owls in a partially migratory population that had switched burrow type between years (cliff versus ground) produced fewer nestlings in their new location than their former and suggested there is some advantage to experience with a nest site.

BURROW AVAILABILITY.—Trampling by livestock resulted in a substantial reduction in the number of open badger burrows, especially in areas of sandy soils. This widespread reduction in badger burrows across the landscape may have several effects on populations of Burrowing Owls. First, evidence suggests that breeding density is related to density of available nest sites. Plumpton and Lutz (1993) found that in 1 of 2 years studied, owls selected nest burrows in areas that contained greater burrow density than what was available in the surrounding landscape. Desmond et al. (2000)

demonstrated a decline in Burrowing Owl densities with declining densities of prairie dog burrows, speculating that there may be a time lag in the response of owls to changes in burrow density. Second, additional burrows near the nest allow owls to distribute young among several locations and may reduce the likelihood of losing an entire brood to a predator. As brood protectors, extra escape burrows may be important to young foraging in the vicinity of the natal burrow prior to dispersal (Haug et al. 1993). Burrows are also important to juveniles during post-fledging dispersal. Juvenile owls were observed in Idaho using an average of 5.1 burrows in approximately 40 days after first leaving their natal burrow (King and Belthoff 2001).

MANAGEMENT CONSIDERATIONS.—Burrowing Owl nest sites tended to be reused if they remained available from one year to the next. In friable soils livestock trampling was a primary cause of burrow failure and resulted in reduced availability of burrows overall. We suggest rangelands with sandy soils be monitored for Burrowing Owl use and destruction of burrows by livestock. Where damage to burrows is occurring, changes should be made in stocking rates, duration, and/or season of grazing. Where owls are deemed a high priority for management, the cessation of livestock grazing may be warranted for a period of time sufficient to increase burrow densities.

United States Department of Agriculture (USDA) Animal Damage Control (now Wildlife Services) trapped and killed badgers along with coyotes (the primary target species) at our study area throughout the 1980s. Approximately 6 badgers were removed annually from the NWSTF until this practice was discontinued in 1992 due to concerns over impacts to local badger and Burrowing Owl populations (KBL personal observation). Information obtained from the USDA suggests this practice is still widespread on other rangelands. Wildlife Services removed an average of 148 badgers per year in the state of Oregon between 1996 and 2000 (U.S. Department of Agriculture 2002). The majority of these animals were killed after being caught in leg-hold traps, perhaps incidentally to coyote-control efforts. However, an average of 13 were shot each year during the same period, indicating a targeted effort. The link between fossorial mammals and Burrowing Owls has been widely recognized. Conservation of badgers and other burrow-providers is therefore of utmost importance (Wellicome and Holroyd 2001). We recommend revision of predator-control efforts to prevent incidental or targeted badger mortality.

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