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BURROWING OWLS AND DEVELOPMENT: SHORT-DISTANCE NEST BURROW RELOCATION TO MINIMIZE CONSTRUCTION IMPACTS

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ABSTRACT.—During June–July 1998, we used a combination of active and passive relocation to move five Burrowing Owl (*Athene cunicularia*) nests in artificial burrow systems (ABS) that faced destruction by development in southwestern Idaho. Regulatory agencies agreed that relocation of the nest burrows would allow construction to proceed and provide an opportunity to determine the efficacy of moving occupied Burrowing Owl nests as a mitigation technique. Relocated nests contained one to five nestlings, ranging in age from 27–45 d. ABS (plastic chamber and tunnel), wooden perches, and dependent young were relocated (active relocation) to adjacent areas that contained natural vegetation; adults were not moved but were expected to travel the short distances to new burrow locations on their own (passive relocation). Access to natural burrows near original nest locations was restricted where possible. Relocation distances averaged 153 m and ranged from 72–258 m. Because terrain was flat, new nest locations generally were within view of original burrow locations. Relocations were successful at two of five nests. For two other nests, both adults and young returned to the vicinity of the original nest and occupied natural burrows 1 d after relocation. Owls from the fifth nest were not detected following burrow relocation and presumably vacated the immediate vicinity of the construction.

KEY WORDS: *Burrowing Owl;* Athene cunicularia; *nest relocation; artificial burrow system; active relocation; passive relocation; mitigation technique.*

Búhos Cavadores y desarrollo: redisposición de las cuevas nido a corta distancia papa minimizar los impactos de la construcción

RESUMEN.—Durante Junio–Julio 1998, usamos una combinación de reubicación activa y pasiva para mover 5 nidos de Búho Cavador (*Athene cunicularia*) a sistemas de cuevas artificiales (ABSs), estos nidos estaban a punto de ser destruidos por el desarrollo en el sudoeste de Idaho. Las agencias reguladoras estuvieron de acuerdo que la redisposición de los nidos cueva debería permitir proseguir la construcción y proveer una oportunidad para determinar la eficacia de mover nidos ocupados de Búho Cavador como una alternativa de mitigación. Los nidos reubicados contenían de uno a cinco polluelos, con edades entre 27–45 d. Los ABSs (cámara y túnel plásticos), perchas de madera, y los jóvenes nidícolas fueron reubicados (reubicación activa) a áreas adyacentes que contenían vegetación natural; los adultos no fueron movidos pero se esperaba que recorrieran por su propia cuenta las cortas distancias a los nuevos sitios de las cuevas (reubicación pasiva). El acceso a las cuevas naturales cerca de los sitios de los nidos originales fue restringido a donde quiera que fue posible. Las distancias a la reubicación promediaron 153 m en un rango de 72–258 m. Debido a que el terreno era plano, las nuevas ubicaciones de los nidos generalmente estaban a la vista desde los sitios de las cuevas originales. La reubicación fue exitosa en dos de los cinco nidos. Para los otros dos nidos, ambos adultos y el joven retornaron a la vecindad del nido original y ocuparon cuevas naturales 1 día después de la reubicación. No se detecto que los búhos del quinto nido siguieran la reubicación de la cueva y presumiblemente se dispersaron de la vecindad inmediata de la construcción.

[Traducción de Victor Vanegas y César Márquez]

Burrowing Owl (*Athene cunicularia*) populations are declining throughout much of their range in North America (De Smet 1997, James and Espie 1997, Sheffield 1997). Human disturbances, such as elimination of burrowing mammals, use of pesticides and herbicides, and conversion of grasslands to agricultural or urban areas, are factors contributing to the decline in Burrowing Owl num-

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bers (Zarn 1974, Haug et al. 1993). Anthropogenic habitat change is continually displacing owls, forcing them from previous seasons' nesting areas, reducing prey abundance and foraging areas, and potentially limiting opportunities for breeding. Although regulations protect the owls, situations where Burrowing Owls and land uses conflict continue to arise.

To minimize direct impacts resulting from habitat conversion for agriculture or development, mitigation efforts often attempt to provide Burrowing Owls with suitable habitat near areas scheduled for development. Once mitigation land is established near an impact area, owls are either evicted (i.e., passive relocation) or actively relocated (Trulio 1995, Feeney 1997). Passive relocation usually occurs in the nonbreeding season or immediately before the breeding season commences. Under this scenario, owls are excluded from available natural burrows in areas slated for development and are forced to seek alternate burrows in nearby habitat outside the areas directly affected by construction. Active relocation entails: 1) capturing owls and moving them to suitable habitat, which is generally well removed from the original site; and 2) releasing the owls at a new site, often after a period of acclimation in temporary aviaries. To replenish or reintroduce populations, Burrowing Owls also have been translocated into areas where suitable habitat remained but natural populations had declined or were extirpated (Martell 1990, Dyer 1991). Translocation projects require active capture and transport of adults and juveniles from breeding areas and then release in establishment sites.

The efficacy of these mitigation techniques (active relocation, passive relocation, and translocation) has varied. Most relocation projects resulted in fewer breeding pairs of Burrowing Owls at the mitigation site than at the original site, and translocation projects generally have failed to produce self-sustaining populations. Investigators attribute the limited success of management efforts to: 1) strong site tenacity exhibited by Burrowing Owls, and 2) potential risks associated with forcing owls to move into unfamiliar and perhaps less preferable habitats (Trulio 1995, Delevoryas 1997, Feeney 1997). Further research on methods of Burrowing Owl relocation and translocation may lead to an increase in the success of these techniques.

In this study, we examined the responses of Burrowing Owl families to short-distance nest burrow relocation. We predicted that nest-site fidelity would be overcome through parental responses to their offspring, thus eliminating the need to capture and relocate adults.

We conducted this research in response to the planned destruction of a 130-ha field, in which five pairs of Burrowing Owls nested in 1998. Each artificial burrow system (ABS) contained a pair of adults and their dependent fledglings, which were still closely associated with their nest burrow. Before young were ready to leave their natal area (i.e., flight skills improving, but still dependent on adults), the field became a borrow pit for construction of a wastewater treatment facility; ultimately, the site will function as an effluent field in which alfalfa and other cover crops are grown. To allow the project to proceed, state and federal regulatory agencies agreed that the situation offered an opportunity to examine the feasibility of relocation of Burrowing Owl nest burrows to minimize construction impacts. We decided that nest burrows would be relocated to the periphery of the construction project, into a buffer strip surrounding the field. Burrow relocations would allow construction to continue without costly delays that would result from waiting until the owls migrated from the construction area after the breeding season.

This study provides data on relocation of ABS occupied by Burrowing Owls to determine if passive adult and active fledgling relocation is a feasible mitigation technique to avoid or reduce direct impacts from construction or other anthropogenic pressures.

METHODS

Study Area. Five Burrowing Owl nests were located approximately 3 km south of Kuna, Ada County, which is 32 km southwest of Boise, Idaho and <23 km north of the Snake River Canyon. Topography was flat to rolling, and elevations ranged from 841–896 m. Rock outcrops and a few isolated buttes (e.g., Kuna Butte, elevation 896 m) exist in the region. Annual temperatures range from −20 to +45°C, and annual precipitation typically averages <20 cm (NOAA 1985).

The study area was once a typical shrub-steppe community dominated by big sagebrush (*Artemisia tridentata wyomingensis*, Hironaka et al. 1983). Range fires and other disturbances have converted much of the surrounding shrublands to exotic grasslands dominated by cheatgrass (*Bromus tectorum*) and tumble mustard (*Sisymbrium altissimum*). The area contained a few homes, several large dairy farms, paved and gravel roads, and irrigated agricultural fields that grew primarily alfalfa, mint, and sugar beets. Irrigated agricultural fields bordered the northern, eastern, and southern sides of the field that was scheduled for construction, and a two-lane highway bordered

the field's western edge. Previously excavated badger (*Taxidea taxus*) burrows were abundant throughout the study area and served as nest and shelter sites for Burrowing Owls (King 1996, King and Belthoff 2001).

Fledgling Data. Before moving nest burrows, we estimated the age of juveniles based on feather growth (Landry 1979) and the estimated hatching date of the brood (±1 d, Smith 1999). For individual recognition in the field, each owl received one United States Geological Survey aluminum leg band and a unique combination of three plastic color bands (National Band and Tag Co., Newport, KY).

Nest Relocation. Each of the five nest burrows were in ABS deployed as part of another study (Smith 1999, Smith and Belthoff 2001) in 1997 (Nos. 1, 3, and 5) and in 1998 (Nos. 2 and 4). Therefore, active relocation of nests and juveniles was relatively simple when compared with moving nests from natural burrows. This project occurred during the latter part of the nesting cycle; thus, we expected adult owls to move the short distance from the original nest area to the relocation site (i.e., passive relocation). However, nest burrows and fledglings were physically moved (i.e., active relocation) to sites outside the impacted area.

All five nests were relocated to a buffer strip between 25 June–9 July 1998. The buffer strip was along the western and southern borders of the field, was approximately 25 m wide, and was the nearest habitat with natural vegetation suitable for ABS placement (Fig. 1). We selected new nest locations that were as close as possible to the original nest location in areas deemed to provide sufficient space and habitat for owls. New sites generally were no closer to neighboring nests than were original sites (except for Nos. 3 and 5; Table 1) and, in each case, new nest locations were within view of original nests. After site selection, we: 1) dug holes to place relocated ABS, 2) removed all fledglings from their nest chambers, 3) removed each ABS intact (i.e., the chamber and tunnel), 4) buried each ABS at the new location with the same orientation as the original burrows, and 5) returned juveniles to nest chambers. We also moved the wooden perches from the original sites to the new sites to lure adult owls, who used the perches for roosting. Each ABS was encircled with highly-visible flagging to reduce chances that construction personnel would inadvertently disturb the new sites. To determine the fate of each relocated nest, we monitored relocation areas (via spotting scope from a vehicle as far away as possible) each day after relocation for 2 wk, and at least three times/wk thereafter until the date that migration normally commenced.

Burrowing Owls exhibit strong site attachment behavior (Trulio 1995, Delevoryas 1997, Feeney 1997), so we were aware that some owls might return to their original nest locations after the nest burrow was removed. To minimize this possibility, we first placed Owl Exclusionary Devices (OED) at natural burrows near the original nest site. Each OED consisted of a 0.5-m section of perforated plastic drainage pipe and a piece of transparent Plexiglas® attached to a hinge at one end of the pipe. Once placed at the entrance to a natural burrow, OED allowed any owls that were underground to exit but prevented owls from taking up residence at such burrows. We also

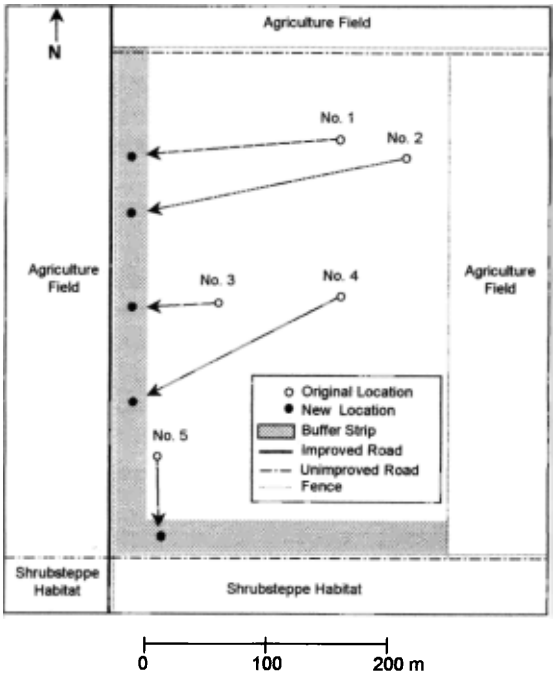

Figure 1. Original and new locations of artificial burrow systems relocated to minimize construction impacts on Burrowing Owl nests in southwestern Idaho, 1998. Numbers indicate nest burrows and their associated young that were relocated to a buffer strip along the western and southern border of the field; adults were not captured but were expected to locate the new sites on their own. The entire field (except the buffer strip) was leveled by machinery soon after all nests were relocated.

attempted to coordinate relocations such that original nest areas would be destroyed shortly after nest burrows were moved, thus reducing the likelihood that owls would return to original nest locations.

Upon relocating each ABS, we measured the distance (to nearest 0.5 m) and direction from the original nest location to its new site. We considered a relocation successful if the owl family took up residence at its new location and remained until dispersal or migration. Unsuccessful relocations occurred when owl families returned to their original nest areas or immediately disappeared from the study area; dispersal from natal areas at this young age is not characteristic of Burrowing Owls (King 1996, King and Belthoff 2001).

RESULTS

Fledgling Data. At the time of relocation, the number of juveniles at each ABS varied from one to five, ranging from 27–45 d post-hatch (Table 1). These young had developed modest to good flight capabilities, but they still depended on parental

Table 1. Information on Burrowing Owl young, relocation measurements, and apparent fates of relocated nests. Juveniles and artificial nest burrows were relocated during the 1998 breeding season to minimize construction impacts in Ada County, Idaho.

Nest	Number of Young	Age (d) of Young[a]	Relocation Date	Distance Moved (m)	Nearest Nest Before (m)	Nearest Nest After (m)	Fate
No. 1	2	39–40	25 June	174	55	55	Accepted new site
No. 2	4	38–39	25 June	258	55	55	Site tenacity
No. 3	5	35–38	7 July	79	102	85	Disappeared
No 4	1	27	9 July	183	102	85	Site tenacity
No. 5	3	44–45	7 July	72.5	290	271	Accepted new site

[a] Estimated based on morphological development and estimated hatching dates. Young >28 d are considered fledglings.

care and remained associated with natal burrows. We captured and relocated all juveniles within each ABS except at No. 5 where, upon our approach to the nest, one fledgling flew ca. 25 m away. At No. 1, both young were captured and relocated, but immediately after being relocated one juvenile flew across the two-lane highway in the opposite direction of the original site.

Nest Relocation. Relocation distances averaged 153 m, ranging from 72.5–258 m, and four of the five nests were moved in a westerly direction (Table 1; Fig. 1). Overall, two families accepted their relocation sites (40%), two families (40%) returned to the vicinity of their original nest burrows, and one family (20%) disappeared from the field (Table 1). All family members from Nos. 1 and 5 were observed at their new sites 1 d after relocation, and both adults and fledglings from each family used their new sites for several weeks until they disappeared. In contrast, two families (Nos. 2 and 4) did not remain in the relocation areas. Instead, 1 d after relocation, family groups from these nests were observed at natural burrows <20 m away from their original nest burrows. The adult male from No. 4 began using the perch, and possibly the ABS, at the new site approximately 10 d after relocation, but his young and his mate remained near the original nest. Fates of birds from these nests are unknown, except for the female from No. 2 (see below). We believe family No. 3 moved from the immediate vicinity of both the original nest and the relocated burrow, even though this nest was moved only 79 m from the original site. After moving this ABS and all five fledglings, no members of the family were observed again at the original or relocation sites, or in nearby areas that contained suitable habitat for Burrowing Owls. The fates of the members of this family were also unknown, except for the male from No. 3 (see below). Finally, within the period of our study, dates of relocation events did not appear to be related to relocation outcomes (Table 1).

In 1999, two adults returned to the area and fledged young successfully from ABS that had been relocated to the buffer strip in 1998. The adult female that nested in No. 2 in 1998 (an unsuccessful relocation) nested at the relocated No. 2 ABS in 1999. The male that nested at No. 3 in 1998 (also an unsuccessful relocation) nested at the relocated No. 5 ABS. This represented a 20% return rate (by sex, and overall) for adults affected by construction in this field in 1998. During 1999, we observed none of the 15 fledglings from 1998 nests, despite continued work in the area.

DISCUSSION

Burrowing Owls typically remain within 50–100 m of their nest or satellite burrows during daylight hours (Haug and Oliphant 1990) and exhibit strong nest-site tenacity, even after a site has been disturbed (Zarn 1974, Feency 1997). Because Burrowing Owls commonly use burrows in close proximity to their nest burrows for roosting, escape cover, and other activities (Zarn 1974, Haug et al. 1993), relocated nests should be in close proximity to the original nest burrow (Trulio 1995). For successful relocations in our study (Nos. 1 and 5), burrows were generally closer to their original sites than were those relocations considered unsuccessful (Nos. 2–4). However, three of five relocation distances were greater than the 100-m maximum distance that Trulio (1995, 1997) recommended

for passive relocation techniques. Because shorter relocations generally were more successful, distance also may have been a relevant factor in the type of relocations we employed. However, as No. 3 family members were relocated only 79 m and apparently disappeared from the study area, other factors besides distance must play a role in relocation success.

Burrowing Owls commonly return to the same or nearby nest burrows year after year (Thomsen 1971, Rich 1984, Botelho and Arrowood 1998). For the relocations that we considered to be successful (Nos. 1 and 5), banding information from our study area showed that both adult males and one adult female bred successfully in the same field during the previous (1997) breeding season. Such experience could have made these owls more familiar with relocation areas and led to their increased willingness to accept new sites. For the three relocations we considered unsuccessful (Nos. 2–4), one adult male was known to have nested in this field during 1997, and the family dispersed from the field immediately following relocation. Ages and previous breeding experiences were unknown for the two remaining pairs, as these birds were not banded before they entered the 1998 breeding season. Nonetheless, familiarity with this field may have influenced whether a family accepted their relocation site, returned to the original nest area, or dispersed from the area.

Although immediate success was realized for two relocations, long-term success of relocations and their effects on Burrowing Owls are also important. In 1999, one female and one male returned to the buffer strip to nest (both had new mates). Of the two remaining ABS, one was occupied by a pair of unmarked owls and the other was unoccupied. The fifth ABS was destroyed during the nonbreeding season. Return rates for females on the impacted area were similar to female return rates over the entire area (20% vs. 24%, respectively) for 1997–98, but were lower for males on the impacted area than over the entire area (20% vs. 44%, respectively, J. Belthoff and B. Smith unpubl. data). We failed to detect any of the juveniles from this study in the impacted field or in surrounding areas during 1999. However, this is not surprising because only 15 juveniles were associated with this field, and first-year return rates are very low (<4% of banded individuals during 1997–98) for birds in our area (J. Belthoff and B. Smith unpubl. data). Nonetheless, the subsequent return and successful nesting of two adults to the impacted site in 1999 suggested that our methods provided both immediate and longer-term success for some of the owls involved.

Other factors also may have affected the owls' willingness to accept new sites. Unfamiliar disturbances (e.g., traffic) could have caused the owls to reject the new sites (Feeney 1997). Both Nos. 2 and 4 (unsuccessful relocations) were relocated from relatively quiet portions of the field to <25 m from a busy road (Fig. 1). Given surrounding land use and destruction of the field, the placement of each relocated nest was restricted to the buffer strip because it offered the nearest "suitable" habitat Also, we were unable to have the original nest areas destroyed immediately because of inclement weather (i.e., destruction of sections of the field did not occur on planned dates). These delays, or our inability to locate all natural burrows near original nest locations to place OED, potentially allowed two families (Nos. 2 and 4) to return to natural burrows near their original nest areas.

Finally, for the two successful relocations (Nos. 1 and 5), one juvenile from each nest either was not captured or escaped during the relocation process. At the time of relocation, juveniles from successful nests also were older than those from unsuccessful nests. It is not clear if or why these factors would affect the tendency for families to remain in the relocation area. Possibly, separation of family members led to increased rate of contact vocalizations by juveniles, which lured adults to the new site more readily, or the older individuals were more visible because of increased activity (i.e., practice flights, perching, hunting) around the relocation site.

Our results indicated that short-distance relocation of occupied nests was successful under some circumstances, although the factors associated with success remained unclear. Regardless, the relocations we performed avoided the almost certain death of many young owls that would have resulted from construction. Because this was a small study (five nests), success rates for the techniques described here should be quantified in much larger studies before such relocations are considered viable options. Additionally, whether the techniques we examined would relate also to owls nesting in natural burrows (the most likely situation faced in many areas) remains unknown. Currently, we recommend that these techniques be used only when no alternatives exist. Postponing mitigation and construction activities until the nonbreeding sea-

son (i.e., after dispersal and/or migration occurs), as well as compensating for any habitat loss or degradation, would be the preferred approach to reduce impacts on Burrowing Owls. If mitigation activities cannot be avoided, original nest areas should be destroyed immediately after moving the owls so they cannot return to the original burrow, or any other burrow, in the impacted area (Trulio 1995). Finally, it remains unknown whether actively relocating adults with their dependent young would affect success rates of short-distance relocations. If the stress of capture on owls is not severe, it seems reasonable that including adults would increase relocation success. However, it may be difficult to capture adults late in the nesting cycle, so timing of the relocation would be important. Therefore, passive relocation of adults and active relocation of fledglings may encourage adult Burrowing Owls to overcome nest-burrow tenacity and inhabit new burrows to care for young when relocations are over short distances.

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LITERATURE CITED

BOTELHO, E.S. AND P.C. ARROWOOD. 1998. The effect of burrow site use on the reproductive success of a partially migratory population of western Burrowing Owls (*Speotyto cunicularia hypugaea*). *J. Raptor Res.* 32: 233–240.

DE SMET, K.D. 1997. Burrowing Owl (*Speotyto cunicularia*) monitoring and management activities in Manitoba, 1987–1996. Pages 123–130 *in* J.R. Duncan, D.H. Johnson, and T.H. Nicholls [EDS.], Biology and conservation of owls of the northern hemisphere: proceedings of the second international owl symposium. USDA Gen. Tech. Rep. NC-190, St. Paul, MN U.S.A.

DELEVORYAS, P. 1997. Relocation of Burrowing Owls during courtship period. Pages 138–144 *in* J.L. Lincer and K. Steenhof [EDS.], The Burrowing Owl, its biology and management including the proceedings of the first international Burrowing Owl symposium. J. Raptor Res. Report 9.

DYER, O. 1991. Reintroductions of Burrowing Owls (*Athene cunicularia*) to the South Okanagan Valley, British Columbia (1983–1988). Pages 231–235 *in* G.L. Holroyd, G. Burns, and H.C. Smith [EDS.], Proceedings of the second endangered species and prairie conservation workshop. Nat. Hist. Occasional Paper No. 15 Provincial Mus. of Alberta, AB Canada.

FEENEY, L.R. 1997. Burrowing Owl site tenacity associated with relocation efforts. Pages 132–137 *in* J.L. Lincer and K. Steenhof [EDS.], The Burrowing Owl, its biology and management including the proceedings of the first international Burrowing Owl symposium J Raptor Res. Report 9.

HAUG, E.A. AND L.W. OLIPHANT. 1990. Movements, activity patterns, and habitat use of Burrowing Owls in Saskatchewan. *J. Wildl. Manage.* 54:27–35.

———, B.A. MILLSAP, AND M.S. MARTELL. 1993. Burrowing Owl (*Speotyto cunicularia*). *In* A. Poole and F. Gill [EDS.], The birds of North America, No. 61. The Academy of Natural Sciences, Philadelphia, PA and American Ornithologists' Union, Washington, DC U.S.A.

HIRONAKA, M., M.A. FOSBERG, AND A.H. WINWARD. 1983. Sagebrush-grass habitat types of southern Idaho Univ. of Idaho Forest, Wildlife, and Range Experiment Station, Bull. No. 35, Moscow, ID U.S.A.

JAMES, P.C. AND R.H.M. ESPIE. 1997. Current status of the Burrowing Owl in North America: an agency survey. Pages 3–5 *in* J.L. Lincer and K. Steenhof [EDS.], The Burrowing Owl, its biology and management including the proceedings of the first international Burrowing Owl symposium. J. Raptor Res. Report 9.

KING, R.A. 1996. Post-fledging dispersal and behavioral ecology of Burrowing Owls in southwestern Idaho M.S. thesis, Boise State Univ., Boise, ID U.S.A.

——— AND J.R. BELTHOFF. 2001. Post-fledgling dispersal of Burrowing Owls in southwestern Idaho: characteristics of movements and use of satellite burrows. *Condor* 103:118–126.

LANDRY, R.E. 1979. Growth and development of the Burrowing Owl. M.S. thesis, California State Univ., Long Beach, CA U.S.A.

MARTELL, M.S. 1990. Reintroduction of Burrowing Owls into Minnesota: a feasibility study. M.S. thesis, Univ of Minnesota, Minneapolis, MN U.S.A.

NOAA (NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION). 1985. Climates of the states: 1951–1980 Vol. 1, 3rd Ed.

RICH, T. 1984. Monitoring Burrowing Owl populations: implications of burrow re-use. *Wildl. Soc. Bull.* 12:178–180.

SHEFFIELD, S.R. 1997. Current status, distribution, and conservation of the Burrowing Owl (*Speotyto cunicularia*) in midwestern and western North America. Pages 399–407 *in* J.R. Duncan, D.H. Johnson, and T.H. Nicholls [EDS.], Biology and conservation of owls of the northern hemisphere: proceedings of the second

international owl symposium. USDA Gen. Tech. Rep. NC-190, St. Paul, MN U.S.A.

SMITH, B.W. 1999. Nest-site selection, ectoparasites, and mitigation techniques: studies of Burrowing Owls and artificial burrow systems in southwestern Idaho. M.S. thesis, Boise State Univ., Boise, ID U.S.A.

——— AND J.R. BELTHOFF. 2001. Effects of nest dimensions on use of artificial burrow systems by Burrowing Owls. *J. Wildl. Manage.* 65:318–326.

THOMSEN, L. 1971. Behavior and ecology of Burrowing Owls on the Oakland municipal airport. *Condor* 73: 177–192.

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

———. 1997. Strategies for protecting western Burrowing Owls (*Speotyto cunicularia hypugaea*) from human activities. Pages 461–465 *in* J.R. Duncan, D.H. Johnson, and T.H. Nicholls [EDS.], Biology and conservation of owls of the northern hemisphere: proceedings of the second international owl symposium. USDA Gen. Tech. Rep. NC-190, St. Paul, MN U.S.A.

ZARN, M. 1974. Burrowing Owl (*Speotyto cunicularia hypugaea*). Habitat management series for unique or endangered species. USDI Bureau of Land Mgmt. Tech Rep. T/N-250, Denver, CO U.S.A.