

APPENDIX D
SPECIES ACCOUNT: BURROWING OWL

WESTERN BURROWING OWL (*Athene cunicularia hypugaea*)

Species Status

In 1994, the Burrowing Owl¹ was included on the Category 2 list of species to be considered for federal listing by the USFWS. Since Category 2 designation was discontinued in 1996, the Burrowing Owl has not had legal status under the ESA. It is, however, listed in many U.S. states – including listings as endangered in Minnesota and Iowa, threatened in Colorado, and species of special concern in Washington, Oregon, California, Montana, Wyoming, Idaho, North Dakota, South Dakota, Utah and Oklahoma. The Western Burrowing Owl is a USFWS Non-game Avian Species of Management Concern (USFWS 1995), a sensitive species in Regions 1 and 2 of the U.S. Forest Service, and a CITES Appendix II species (Ehrlich et al. 1992). Mexico lists the Burrowing Owl as threatened and Canada changed its rank from threatened to endangered in 1995 (Commission for Environmental Cooperation 2000). The Commission for Environmental Cooperation, established under the North American Free Trade Agreement, has identified the Burrowing Owl as a priority grassland species for conservation action. The Colorado Natural Heritage Program ranks the Burrowing Owl G4/S4B (the species is apparently secure globally and in Colorado, but breeding birds may be rare in parts of the range) (CNHP 2003).

The BBS did not detect statistically significant trends for the Burrowing Owl survey-wide from 1966 to 1999, nor for the U.S. or Colorado. Oklahoma, Wyoming, Saskatchewan and Canada over-all showed significant declines, while Nevada, the Western BBS Region and Region 1 of the USFWS showed significant increases. Breeding Bird Survey trend information, however, should be interpreted with care. Of the 50 regions for which BBS data are reported, 32 regions (including Colorado) have a red credibility rating (important deficiency in the data) and 16 regions have a yellow rating (deficiency in the data) (Sauer et al. 2001).

Andrews and Righter (1992) report the species declining in Colorado, with complete or near extirpation in some areas. Along the front range of Colorado, Burrowing Owls have largely disappeared from much of their historic range (Jones 1998). Workers for the Colorado Breeding Bird Atlas (Jones 1998) found breeding Burrowing Owls almost exclusively in eastern Colorado, despite once having been more widespread throughout the state. DeSante and George (1994) suggested that Burrowing Owl populations in six U.S. states and Canadian provinces (including Colorado) have dropped by more than 50% over the last 100 years.

Description and Taxonomy

The Burrowing Owl is a comparatively small owl (approximately 8-10 in) distinguished by its long legs (National Geographic Society 1987; Gillihan and Hutchings 2000). This bird has a round head, no ear tufts, white spotting on brown wings and back, and dark barring on light brown breast and belly (Gillihan and Hutchings 2000). It has white margins around yellow eyes, a white throat patch and a pale-colored beak (Anderson et al. 2001).

The Burrowing Owl was described in 1782. It was originally named *Strix cunicularia*, and then moved to the genus *Speyota* and finally *Athene* (Clark et al. 1997; AOU 1998). There are two subspecies recognized in North America: *A. c. hypugaea* (western Burrowing Owl); and *A. c. floridana* (Florida Burrowing Owl). The Florida Burrowing Owl is restricted to the state of Florida. The Western Burrowing Owl occurs in western North America, from southern Canada (Manitoba to southeast British Columbia) to Panama (Haug et al. 1993).

¹ In this document, 'Burrowing Owl' refers to the Western Burrowing Owl only.

Historical and Current Distribution

The Burrowing Owl is distributed discontinuously throughout the western grasslands of North America. Historically it ranged from Alberta, Saskatchewan, Manitoba and southeastern British Columbia south to Panama (Haug et al. 1993). In the U.S., the Burrowing Owl breeds in all western states east to the Dakotas and south to Texas. The Burrowing Owl has been nearly extirpated from its former breeding range in western Minnesota, most areas east of the Missouri River in North Dakota, eastern Nebraska and Oklahoma, eastern and central Kansas, large areas around San Francisco in California, and the Rogue Valley in Oregon (Anderson et al. 2001). Burrowing Owls were extirpated from British Columbia in the early 1980's, but starting in 1983 were released there, with 13 birds returning in 1992 (Haug et al. 1993). It now appears, however, that the Burrowing Owl has been extirpated from its former range in British Columbia and Manitoba, as well as from northern portions of its former range in Saskatchewan and Alberta (Wellicome 1997; Anderson et al. 2001). This species could be extirpated from Canada entirely within a few decades (Wellicome and Haug 1995; Paige 1998; Anderson et al. 2001).

In Colorado, the Burrowing Owl is considered locally uncommon to fairly common on the eastern plains and rare to uncommon in mountain parks and on the western slope (Andrews and Righter 1992). The Colorado Breeding Bird Atlas documented breeding primarily throughout the eastern plains, but also in the Grand Valley and in very few blocks in extreme southwestern Colorado, North Park, and the San Luis Valley (Jones 1998). Burrowing Owls no longer occur in much of their historic range along the urban front range (Jones 1998). Major populations are found at the Rocky Mountain Arsenal in Adams County, and in Baca, Bent, Cheyenne, Crowley, Kit Carson, Kiowa, Lincoln, Logan, Morgan, Otero, Prowers, Pueblo, Weld and Yuma counties (Anderson et al. 2001).

Birds winter primarily in the southern part of their range, although occasional winter records occur as far north as Montana (Haug et al. 1993). Andrews and Righter (1992) report six winter records on the eastern plains of Colorado. The Christmas Bird Count (CBC) suggests that most wintering birds are found in California, Arizona, New Mexico, Texas and Mexico (James and Ethier 1989; Anderson et al. 2001); they are also found in lower numbers in Oklahoma, Kansas and other states further north (Anderson et al. 2001).

Life History and Habitat

Breeding habitat

The Burrowing Owl is a grassland specialist that is dependent on the presence of fossorial mammals. Burrowing Owls use well-drained, flat to gently sloping grassland habitats with sparse vegetation (usually less than four inches high) and a relatively large proportion of bare ground (Pezzolesi 1994; Gillihan and Hutchings 2000; Dechant et al. 2001). This species nests in underground burrows in grasslands and grazed pastures, as well as other dry, open habitats such as shrublands, deserts and grassy urban areas (including golf courses, airports, cemeteries, vacant lots, road rights-of-way) (Haug et al. 1993; Jones 1998; Dechant et al. 2001). Semi-desert shrublands are rarely used (Andrews and Righter 1992). Green (1993) found that nest sites were characterized by 40% - 50% bare ground where prey is abundant. A study area in Oregon with vegetation taller than five cm suggested that observation perches were required (Green and Anthony 1989; Anderson et al. 2001). According to studies in Colorado where vegetation was less than eight cm, observation perches were not used (Green and Anthony 1989), or were farther away from nests than would have been expected by chance (Plumpton and Lutz 1991; Plumpton 1992; Anderson et al. 2001).

In Colorado, over 70% of sightings by Breeding Bird Atlasers were in shortgrass prairie (Jones 1998). Jones (1998) stated that the Burrowing Owl in eastern Colorado favors prairie dog colonies, but did not specify how many observations were made in prairie dog colonies as opposed to other shortgrass habitats.

The Burrowing Owl is capable of excavating its own burrows if the soils are sandy, but most often use holes excavated by other animals (especially rodents). The Burrowing Owl on the Great Plains is not known to excavate its own burrows (Salt and Wilk 1958; Bent 1961; Berdan and Linder 1973; Stewart 1975; Desmond 1991; Haug et al. 1993; Stockrahm 1995; Desmond and Savidge 1996, 1998, 1999; Sidle et al. 1998; Dechant et al. 2001). The presence of burrows for nesting appears to be a critical component of Burrowing Owl habitat (Thomsen 1971; Martin 1973; Zarn 1974; Wedgwood 1978; Haug 1985; Haug et al. 1993). In the Great Plains, the Burrowing Owl is primarily associated with prairie dogs (Jones 1998; Paige 1998). Across its range, the Burrowing Owl uses burrows of various mammals, including the black-tailed prairie dog (*Cynomys ludovicianus*), American badger (*Taxidea taxus*), ground squirrel (*Spermophilus* spp.), white-tailed (*C. leucurus*) and Gunnison's (*C. gunnisoni*) prairie dog, yellow-bellied marmot (*Marmota flaviventris*), skunk (*Mephitis* spp.), squirrel (*Citellus* spp.), fox (*Vulpes* spp.) and woodchuck (*M. monax*), among others (Dechant et al. 2001).

The Burrowing Owl forages in a variety of habitats, ranging from the low structure plant communities of prairie dog colonies where it forages for insects, to areas of taller plant cover (rights-of-way and native grasslands) where small mammal prey is likely to be more abundant (Wellicome 1994). Generally, it uses shortgrass habitat typical of prairie dog colonies for nesting and roosting, and forages over areas of taller vegetation (at least 12 in) (Gillihan and Hutchings 2000; Dechant et al. 2001).

Use of Prairie Dog Towns

In eastern Colorado, the Burrowing Owl is usually found associated with black-tailed prairie dog colonies (Andrews and Righter 1992; Jones 1998). Black-tailed prairie dog colonies provide burrows for nesting and perching mounds, and the low vegetation structure provides a clear view of terrestrial predators (Jones 1998). In western Nebraska, 85% of Burrowing Owl nests occurred in prairie dog colonies (Desmond 1991). In the Oklahoma panhandle, 66% of nests occurred in prairie dog colonies, which comprised less than 20% of available habitat (Butts 1973; Butts and Lewis 1982).

Although the Burrowing Owl has been documented in relatively inactive prairie dog colonies (Bent 1961; MacCracken et al. 1984), Pezolesi (1994) found that all nesting attempts in north-central Colorado were in active colonies. Burrowing Owls inhabiting larger colonies with higher densities of black-tailed prairie dogs were more likely to return to nest in subsequent years, and have higher rates of nest success and lower rates of nest depredation than Burrowing Owls inhabiting smaller colonies, or colonies with fewer black-tailed prairie dogs (Butts 1973; Desmond and Savidge 1996, 1998, 1999; Toombs 1997; Dechant et al. 2001). In western Nebraska, the size of prairie dog colonies was positively correlated with fledging success rates (Desmond 1991). On the Buffalo Gap National Grassland, reproductive success of the Burrowing Owl improved with increasing prairie dog colony size (Greibel 2000). Hughes (1993) found that black-tailed prairie dog colonies in northeastern Colorado having Burrowing Owls ranged in size from 1.9 to 167.6 ha, with >50% of the burrows active in 26 out of 27 colonies.

The Burrowing Owl does not use all available and apparently suitable habitat. Active prairie dog or ground squirrel colonies that were not used by the Burrowing Owl have been identified in virtually all states within its current range, including Colorado (Plumpton and Lutz 1993b; Anderson et al. 2001). Studies attempting to quantify the difference between used and unused colonies have failed to identify any parameters that are consistent over multiple years (Anderson et al. 2001). In Colorado, black-tailed prairie dog colonies containing Burrowing Owl nests had higher densities of burrows than did those not containing nests (Plumpton 1992; Plumpton and Lutz 1993b; Dechant et al. 2001). In 1993, Hughes found that the density of the Burrowing Owl in black-tailed prairie dog colonies in northeastern Colorado was positively related to the percentage of active burrows (Hughes 1993; Dechant et al. 2001), with 2.85 owls/ha in colonies with over 90% active burrows compared to 0.57 owls/ha in colonies with 70-80% active burrows. Toombs

(1997) found higher means for total burrow density, active burrow density and percent active burrows in black-tailed prairie dog towns with Burrowing Owl nests than in black-tailed prairie dog towns without Burrowing Owl nests. In Nebraska, Burrowing Owl density in black-tailed prairie dog colonies was negatively correlated with the density of inactive burrows (Desmond 1991) and positively correlated with density of active burrows (Desmond et al. 2000).

Nests are sometimes concentrated near the edges of prairie dog colonies (Butts 1973; Desmond et al. 1995; Toombs 1997; Anderson et al. 2001). Burrowing Owls nesting near the edge of a prairie dog colony may benefit from increased perch availability, higher insect populations and closer proximity of foraging areas (Butts 1973; Rich 1986; Dechant et al. 2001).

When a prairie dog colony is eradicated or greatly reduced, the vegetation in the colony grows taller than the Burrowing Owl will tolerate and the burrows begin to deteriorate. Under these circumstances, the Burrowing Owl will abandon its nest burrows (Grant 1965; Butts 1973; MacCracken et al. 1985; Plumpton and Lutz 1993b). Black-tailed prairie dog colonies in Oklahoma became unsuitable for the Burrowing Owl within one to three years after abandonment, because of the encroachment of dense vegetation (Butts 1973). While mowing can be used to control the growth of vegetation after prairie dogs have been eliminated, prairie dogs may be required to maintain long-term suitability of burrows for the Burrowing Owl (MacCracken et al. 1985; Dechant et al. 2001). Biddle (1996) offered anecdotal evidence that black-tailed prairie dog towns only recently vacated, but still containing suitable burrows, did not contain the Burrowing Owl. She noted that one black-tailed prairie dog town in Logan County, Colorado, did not have black-tailed prairie dogs or Burrowing Owls in 1994, but that both breeding Burrowing Owls and black-tailed prairie dogs were present in 1995 (Anderson et al. 2001).

Use of Cultivated Fields

Olendorff (1973) found that the Burrowing Owl was uncommon in cultivated land in northcentral Colorado. Plumpton and Lutz (1993b) found that nest burrows in cultivated land in Colorado were closer to roads, further away from perches and had more bare ground and shorter grasses/forbs than non-nest burrows. A study in Alberta, Canada, found that all nest sites were in native pasture and no nest sites occurred in re-seeded pasture or cultivated lands (Clayton and Schmutz 1999; Dechant et al. 2001). This same study further found the majority of roost sites were in native pasture. The Burrowing Owl nesting in cropland probably experiences nest failure during cultivation (Haug et al. 1993; Dechant et al. 2001). Gleason (1978) found that seven out of nine nests were adjacent to alfalfa fields in an agricultural region of southern Idaho. Nesting near cultivated fields may be due to higher prey populations and closer foraging areas (Butts 1973; Rich 1986; Dechant et al. 2001).

Wintering and Migration Habitat

No specific information on wintering and migration habitat is available. Habitat used during these times is presumed to be similar to breeding habitat (Haug et al. 1993; Anderson et al. 2001).

Reproduction

The Burrowing Owl arrives on its breeding grounds in the Great Plains around mid-March (Haug et al. 1993) to early April, and remains until September (Bent 1961; Grant 1965; Maher 1974; Wedgwood 1976; Gleason 1978; Haug 1985; Ratcliff 1986; Haug and Oliphant 1990; De Smet 1992; Dechant et al. 2001). In Colorado, breeding season safe dates are April 21 to August 10 (Nelson 1993; Yanishevsky and Petring-Rupp 1998). Pair formation usually occurs by April (Grant 1965; Butts 1973), followed by nest site selection. Average clutch size is 6.5 within a range of 4-12 (Haug et al. 1993). Incubation lasts 28-30 days (Coulombe 1971; Thomsen 1971; Haug et al. 1993). The female incubates the eggs (Coulombe 1971; Thomsen 1971; Haug et al. 1993), while the male provides food during the incubation and early nestling stages (Haug et al.

1993; Anderson et al. 2001). Females are rarely active above ground during egg laying and incubation (Butts and Lewis 1982; Yanishevsky and Petring-Rupp 1998).

The Burrowing Owl averages three to five nestlings per brood. The young appear above ground approximately two weeks after hatching (Johnsgard 1988), can run and forage (assisted by the female) at three to four weeks (Martin 1973) and achieve sustained flight by six weeks. Once the young reach three to four weeks of age, families may move to satellite burrows every 10-15 days (Haug et al. 1993; Dechant et al. 2001), possibly to reduce predation (Desmond and Savidge 1998) or avoid nest parasites (Dechant et al. 2001). They remain a family group until the young begin to disperse to nearby burrows in the early fall (Haug et al. 1993; Dechant et al. 2001).

The Burrowing Owl typically begins breeding at one year of age; some females may either not breed the first year after hatching, or breed in a different locale the first year and then return to their natal site to breed in the second year (Lutz and Plumpton 1999). One brood is produced per year (Haug et al. 1993), but birds may re-nest if the first nest is lost early in the season (Thomsen 1971; Butts 1973; Wedgwood 1976; Haug et al. 1993). There are no records of second broods (Haug et al. 1993). Reproductive success may be limited by the availability and abundance of small mammal prey (Wellcome 1998).

Average fledging rates are from two to five young per burrow (Johnsgard 1988), but as many as ten fledglings have been reported at one burrow (Jones 1998). Annual reproductive success ranges from 33% to 100% in the U.S. (Thomsen 1971; Haug et al. 1993), and from 45% to 97% in Canada (Hjertaas et al. 1995; Anderson et al. 2001). Fledging rates for the Burrowing Owl are high relative to rates for other small owls and may reflect the advantage of nesting underground as much as a need to compensate for high post-fledging mortality (Johnsgard 1988). Pezolesi (1994) found that, of 326 birds banded at the Rocky Mountain Arsenal in Colorado in 1991 and 1992, only 28 returned to nest in 1992 or 1993.

Colonial nesting has been reported for this species (Ehrlich et al. 1988) and may reduce predation risks as Burrowing Owls may alert one another to threats (Desmond 1991; Desmond et al. 1995). Jones (1998), however, suggests this may be a recently developed behavior reflecting a scarcity of nest sites as much as a lack of territoriality. In northeastern Colorado, Hughes (1993) found that pairs breeding in large black-tailed prairie dog colonies nested further apart than did pairs nesting in small colonies.

The Burrowing Owl exhibits a moderate to high level of site fidelity, not only to general breeding areas, but also sometimes to prairie dog colonies or even nest burrows (Anderson et al. 2001). Martin (1973 in Pezolesi 1994) found that every male reused the same burrow it had previously used, unless the original burrow was destroyed (in which case, a burrow in close proximity was chosen). The Burrowing Owl typically reuses traditional nesting areas, but not necessarily the same burrows (Haug et al. 1993; Dechant et al. 2001). The highest documented annual return rate was 39% for adults in Colorado, compared to 5% return rate for chicks (Plumpton and Lutz 1993b). Plumpton and Lutz (1993b) found 90% of prairie dog towns and 20% of nesting burrows in their Colorado study area were reused between 1990 and 1991, and 66% of returning adults reused the same prairie dog town as the previous year. The Burrowing Owl is more likely to reuse burrows and nest sites if it reproduced successfully the previous year (Haug et al. 1993). Pezolesi (1994) found 84% of returning individuals had successful nests the previous year, compared to 16% of returning individuals with unsuccessful nests the previous year. No such difference was found between sexes or age classes, but males had a return rate almost three times the return rate of females (Pezolesi 1994). Observations of lag time in response to declines in the density of active prairie dog burrows (Desmond and Savidge 1998) may indicate a strong nest site fidelity (Paige 1998).

Diet and Foraging

The Burrowing Owl is an opportunistic feeder, subsisting largely on insects, small rodents, amphibians, reptiles, and on occasion, small birds (Haug et al. 1993). In general, more vertebrates are taken in winter and more invertebrates are taken in summer (Errington and Bennet 1935; Butts 1973; Green 1983; Tyler 1983; Haug 1985; MacCracken et al. 1985; Haug et al. 1993). Common prey in northeastern Colorado included ground and dung beetles, crickets, short-horned grasshoppers, deer mice, meadow voles and cottontail rabbits (Zarn 1974; Yanishevsky and Petring-Rupp 1998). Invertebrates constitute the major prey item (92% in Colorado) (Marti 1974), but represent low biomass by weight (Haug et al. 1993) compared to vertebrates, which may be the more important prey item (Wesemann and Rowe 1987; Pezolesi 1994; Yanishevsky and Petring-Rupp 1998). The deer mouse was the most important prey species at the Rocky Mountain Arsenal in Colorado (Plumpton 1992; Plumpton and Lutz 1993). Mammals are taken in proportion to their availability (Green 1983; Haug et al. 1993). In northern Colorado, arthropods are consumed disproportionately with respect to their abundance (Plumpton 1992; Plumpton and Lutz 1993; Dechant et al. 2001). Invertebrates may be especially important when mammal abundance is low (LeClerc 1990; Yanishevsky and Petring-Rupp 1998).

Researchers note that pellets may not be reliable indicators of food habits (Thomsen 1971; Haug 1985). Grant (1965) observed the Burrowing Owl taking at least as many amphibians as mammals, but found only mammal remains in pellets.

The Burrowing Owl forages in native grassland, cropland and pasture, prairie dog colonies, fallow fields and other areas that are sparsely vegetated (Butts and Lewis 1982; Thompson and Anderson 1988; Desmond 1991; Haug et al. 1993; Wellicome 1994; Dechant et al. 2001). Areas with vegetation less than one m tall are avoided (Haug and Oliphant 1990; Wellicome 1994). During the nesting season the Burrowing Owl is active throughout the day and night, hunting insects when it is light and rodents at night (Bent 1938; Marti 1974; Plumpton 1992; Plumpton and Lutz 1993). Feeding areas are not defended (Haug et al. 1993).

Survivorship and Mortality

The oldest known Burrowing Owl was eight years, eight months old (Kennard 1975; Clapp et al. 1983; Anderson et al. 2001). Minimum survival rates (based on return rates of banded adults) in Canada range from 29% to 58% (Haug et al. 1993). These rates are considered minimum because migrating Burrowing Owls may change breeding locations between years. A non-migrating population in California showed survival rates of 30% for juveniles and 81% for adults (based on banded adults) (Thomsen 1971). Butts (1973) estimated an annual mortality rate in Oklahoma of 62% for young and adults combined. Clayton and Schmutz (1997) found that adult females had a mean survival of 0.83, compared to 0.46 for adult males and 0.48 for juveniles, with mortality occurring after fledging when activity around the nest peaked.

Causes of death in breeding areas include predation, vehicle collisions, human disturbance (especially from agricultural activities, construction and shooting), toxic chemicals (either direct mortality or loss of prey) and weather (severe hail) (Haug 1985; Haug et al. 1993). Known and suspected predators include the badger (*Taxidea taxus*), domestic and feral cat and dog, opossum (*Dedelphis virginiana*), weasel (*Mustela* spp.), skunk (*Mephitis* spp.), coyote (*Canis latrans*), bobcat (*Lynx rufus*), snake, Swainson's Hawk (*Buteo swainsoni*), Ferruginous Hawk (*B. regalis*), Merlin (*Falco columbarius*), Prairie Falcon (*F. mexicanus*), Peregrine Falcon (*F. peregrinus*), Great Horned Owl (*Bubo virginianus*), Red-tailed Hawk (*B. jamaicensis*), Cooper's Hawk (*Accipiter cooperii*), Northern Harrier (*Circus cyaneus*) and American Crow (*Corvus brachyrhynchos*) (Bent 1938; Butts 1973; Martin 1973; Zarn 1974; Wedgwood 1978; Evans 1982; Green 1983; Konrad and Gilmer 1984; Haug 1985; Millsap and Bear 1988; Martell 1990; Desmond 1991; Haug et al. 1993; Low and Leupin 1998; Yanishevsky and Petring-Rupp 1998; Anderson et al. 2001). The badger is considered a major predator (Haug et al. 1993). Desmond

and Savidge (1998) observed higher rates of predation by the badger in prairie dog colonies that had a lower density of prairie dogs.

Vehicle collisions are considered a serious cause of mortality in some locations because the Burrowing Owl tends to sit and hunt on roads at night (Bent 1938; Ratcliff 1987; Haug et al. 1993). Researchers have reported three of five known deaths (Konrad and Gilmer 1984), 25% of known mortality (Millsap and Bear 1988), and 37% of Burrowing Owl remains (Haug and Oliphant 1987) at their study sites, all attributed to vehicle collisions.

Abundance

James and Espie (1997) estimated the total U.S. population as 20,000 – 200,000 breeding pairs, and the Colorado population as 1,000 – 10,000 breeding pairs. The Rocky Mountain Bird Observatory documented 468 Burrowing Owl colonies and 2,675 individuals in eastern Colorado in 1999 (Hutchings et al. 1999).

Area Requirements

In general, the Burrowing Owl remains close to nest burrows during the day and forages farther away at night (Haug 1985; Haug and Oliphant 1990; Dechant et al. 2001). Grant (1965) found nest area requirements ranged between 4.1 and 7.3 ha in the northern part of the U.S. breeding range. Thompson (1984) found the average diurnal range in Wyoming to be 3.5 ha. Mean home range size for males in Canada was 2.41 km² (0.9 mi²), within a range of 0.14 km² (0.05 mi²) to 4.81 km² (2 mi²). These values were considered minimum size for breeding home range. Birds with larger home ranges fledged more young, while birds with smaller home ranges lost most or all of their young to predators (Haug and Oliphant 1990).

Average territory size has been estimated at 1.98 acres, within a range of 0.1 acres to 4.0 acres (Thomsen 1971; Zarn 1974). Haug and Oliphant (1990) found that defense of territories is largely limited to the immediate area around the nest burrow, with 95% of all movements occurring within 600 m of the nest burrow.

Distance between nest burrows ranges from <14 m (Ross 1974) to 900 m (Gleason 1978). Green and Anthony (1989) found that the mean nearest-neighbor distance differed between successful and deserted nests. For pairs of nests with <60 m between, both nests out of two pairs were abandoned; at distances of 60 to 110 m, at least one of two nests was abandoned for nine pairs; at distances of >110 m, only 14% of 21 pairs of nests resulted in the abandonment of at least one of the two nests. The mean distance between nests on black-tailed prairie dog colonies in north-central Colorado was 101 m (Plumpton 1992).

Burrowing Owls sometimes cluster their nests within prairie dog colonies (Butts 1973; Desmond 1991; Desmond et al. 1995, 2000; Desmond and Savidge 1996), perhaps to reduce the risk of predation by making it easier to warn one another when predators approach (Dechant et al. 2001). In Nebraska, Burrowing Owls nesting in prairie dog colonies >35 ha had a mean nearest-neighbor distance of 125 m, with nests in clusters, whereas Burrowing Owls nesting in colonies <35 ha had a mean nearest-neighbor distance of 105 m with nests randomly distributed (Desmond 1991; Desmond et al. 1995; Desmond and Savidge 1996).

Dispersal distances for juveniles in Canada ranged from 984 ft to 16.4 mi, with females dispersing shorter distances than males (Yanishevsky and Petring-Rupp 1998).

Migration

Very little is known about Burrowing Owl migration, but most Burrowing Owls in North America, including Colorado, are considered migratory (Bailey and Niedrach 1965; Andrews and Righter 1992; Haug et al. 1993). Most Burrowing Owls breeding in the northern U.S. and Canada are

believed to migrate south during September and October, and to return north in March and April (Haug et al. 1993). The Burrowing Owl is believed to be non-migratory in southern California, but migratory in northern California (Thomsen 1971; Haug et al. 1993).

Patterns of migration are not well understood. Burrowing Owls banded in the extreme western U.S. migrated south along the coast (Haug et al. 1993). Burrowing Owls banded in the northern Great Plains migrated through Nebraska and Kansas to Oklahoma, Missouri, Texas and points south (Haug et al. 1993). Burrowing Owls banded in the central U.S. mountains and plains (including Colorado) migrated through (or to) Oklahoma, Arkansas, Texas and Mexico (Haug et al. 1993). James (1992) suggested that Burrowing Owls from Canada migrate further south than do Burrowing Owls in the U.S.

Reasons for Decline

Decline of the Burrowing Owl is primarily attributed to loss of habitat as populations of prairie dogs and ground squirrels decline due to control and eradication efforts, and as prairies are converted to cropland, urban uses, and pastures with taller, non-native grasses (Grant 1965; Konrad and Gilmer 1984; Ratcliff 1986; Haug et al. 1993; Dundas and Jensen 1995; Sheffield 1997; Barclay et al. 1998; Rodriguez-Estrella et al. 1998; Anderson et al. 2001; Dechant et al. 2001). An estimated 98% of native prairie has been altered or converted to other uses. This intensification of land use has resulted in loss and fragmentation of nesting habitat. These activities are expected to continue (Ostlie et al. 1997).

Decline of Burrowing Mammals

In many areas, including Colorado, the fate of the Burrowing Owl is tied to that of active black-tailed prairie dog colonies. The elimination of burrowing rodents (prairie dogs and ground squirrels) has been identified as the primary factor in Burrowing Owl declines (Butts and Lewis 1982; Evans 1982; Ratcliff 1986; Pezolesi 1994; Desmond and Savidge 1996, 1998, 1999; Toombs 1997; Barclay et al. 1998; Dechant et al. 2001). Loss of prairie dog colonies through poisoning and plague outbreaks has eliminated nest sites (Butts 1973; Jones 1998) and may reduce reproductive success of the Burrowing Owl. A 63% decline in Burrowing Owl numbers in Nebraska over a seven-year period was associated with prairie dog control activities and subsequent declines in prairie dog densities (Desmond and Savidge 1998; Desmond et al. 2000). Reproductive success of the Burrowing Owl was positively correlated, and predation was negatively correlated, with density of prairie dogs (Dechant et al. 2001). Butts (1973) documented a 71% decline in an Oklahoma breeding population of Burrowing Owls after the prairie dog colony they occupied was treated with sodium fluoroacetate.

Control of prairie dogs can result in direct mortality to the Burrowing Owl as well. Ingestion of as little as one prey item poisoned by a rodenticide has been shown to cause mortality in many different owl species (Sheffield 1997b; Anderson et al. 2001). The Burrowing Owl is known to scavenge dead prey and is highly susceptible to secondary poisoning (Sheffield 1997b; Anderson et al. 2001). In addition, the tendency for the Burrowing Owl to stand at burrow entrances makes them susceptible to shooting (Marti and Marks 1989; Yanishevsky and Petring-Rupp 1998). At one study site in Oklahoma, 66% of the known mortality was due to shooting (Butts 1973). Wedgwood (1978) documented three colonies that were completely destroyed by shooting.

Almost 80% of eastern Colorado's prairie dog colonies occur on private land (EDAW 2000). Due to ongoing control and eradication efforts, it is likely that prairie dog colonies on private land will tend to be small, and therefore will not offer the higher quality nesting habitat that large colonies and complexes provide.

Agriculture

Haug (1985) noted that intensive agriculture led to loss of nesting sites and foraging habitat, and creation of sub-optimal nesting habitat. In addition, conversion of native grassland to cropland may have other impacts beyond direct loss of habitat. According to Wellicome and Haug (1995), cultivation of grassland habitat and increased tree cover on native prairies have resulted in increased numbers of other mammalian and avian species that prey on the Burrowing Owl. In addition, higher post-fledging mortality due to collisions with vehicles has been documented in agricultural landscapes compared to unfragmented rangeland (Clayton and Schmutz 1997; Paige 1998).

Agricultural operations also expose the Burrowing Owl to the toxic effects of pesticides (Haug et al. 1993). Pesticide use targeting the large insects on which the Burrowing Owl depends during the nesting season (grasshoppers, crickets and beetles) depletes the prey base and may impact reproduction. The Burrowing Owl has been observed foraging for insects on ground littered with poison grains (Butts 1973; James et al. 1990). The Burrowing Owl in pastures treated with strychnine-coated grain weighed less than those in control pastures, suggesting either a sub-lethal effect on the birds themselves, or reduction in prey availability (James et al. 1990). James and Fox (1987) observed a 54% reduction in young per nest after carbofuran (an insecticide used to control agricultural pests) was sprayed within 50 m of nest burrows. They attributed this reduction in productivity to direct toxicity. An 83% reduction in brood size and an 82% reduction in nest success were observed when the same insecticide was sprayed directly over nest burrows (James and Fox 1987; Fox et al. 1989). The granular form of carbofuran is banned in the U.S. and Canada, but the liquid form is certified for specific uses in both countries (Dechant et al. 2001).

Fragmentation

The Burrowing Owl appears to be sensitive to fragmentation and isolation of habitat. Warnock and James (1997) documented larger home range sizes in fragmented landscapes. Fragmentation and isolation of habitat may reduce the chances that unpaired Burrowing Owls will find mates (Haug et al. 1993; Sheffield 1997; Paige 1998). In Canada, the Burrowing Owl chose the highest quality sites (suitable soils, presence of burrowing mammals and proximity to other occupied sites) in a fragmented landscape over the largest or least fragmented habitat patches (Warnock 1997; Warnock and James 1997). Crowding into smaller habitat patches could lead to increased competition for food, reduced nest success and increased nest abandonment (Green and Anthony 1989; Warnock and James 1997). Paige (1998) found that Burrowing Owl persistence for more than four years increased at sites that had more neighboring occupied sites, more continuity with natural habitats within 20 km, and less patch edge. Fragmentation and isolation of habitat patches may also result in decline or local extirpation of prairie dog colonies if dispersal and colonization is hampered (Benedict et al. 1996).

Rangeland Management

The Burrowing Owl prefers grasslands of low structure typical of grazed grasslands (MacCracken et al. 1985). Cessation or drastic reduction of grazing, either through loss of prairie dogs or removal of native ungulates or domestic livestock, can negatively impact the Burrowing Owl. In Saskatchewan and Alberta, the Burrowing Owl nested in pastures with shorter vegetation than occurred in randomly chosen pastures and preferred native or tame pastures over cultivated land (Clayton 1997). In North Dakota, the Burrowing Owl nested in moderately or heavily grazed mixed-grass pastures, but not in hayed or lightly grazed mixed-grass pastures (Kantrud 1981). In Colorado, Montana, Nebraska, North Dakota, South Dakota and Wyoming, optimal habitat occurred in heavily grazed areas (Kantrud and Kologiski 1982). In Oklahoma, grazing of taller grasses may attract burrowing mammals, resulting in increased nest site availability (Butts 1973). Declines of Burrowing Owls in North Dakota may be attributable to reduction in sheep grazing (Anderson et al. 2001).

In addition, availability of horse or cow manure for nest lining may be important, possibly to mask odors and reduce predation (Martin 1973; Green and Anthony 1989; Desmond et al. 1997; Dechant et al. 2001). In Oregon, 72% of successful nests (n=32) were lined with manure, but only 13% of depredated nests (n=15) were lined (Dechant et al. 2001).

Urban Development

The Burrowing Owl no longer occurs in much of the area it formerly occupied along the urban corridor of Colorado's front range (Jones 1998). Millsap and Bear (1988) found that reproductive success is reduced significantly on sites where home construction occurred compared to sites adjacent to construction or absent construction. Thomsen (1971) reported that humans caused 65% of observed damage to burrows and domestic dogs caused 20% of burrow damage on a municipal airport site. It was noted that the dogs elicited a frenzied defense.

LITERATURE CITED

- American Ornithologists' Union. 1998. Check-list of North American Birds. Seventh edition. American Ornithologists' Union, Washington, D.C.
- Anderson, S.H., L.W. Ayers, J.A. Dechant, M.T. Green, W.H. Howe, S.L. Jones, D.S. Klute, D.K. Rosenberg, S.R. Sheffield, and T.S. Zimmerman. 2001. Status Assessment and Conservation Plan for the Western Burrowing Owl in the United States. Administrative Report. U.S. Department of the Interior, Fish and Wildlife Service, Denver, Colorado.
- Andrews, J.N. and R. Righter. 1992. Colorado Birds: A Reference to Their Distribution and Habitat. Denver Museum of Natural History, Denver, Colorado. 442pp.
- Bailey, A.M. and R.J. Niedrach. 1965. Birds of Colorado. Denver Museum of Natural History. 2 vols. 895pp.
- Barclay, J., C. Bean, D. Plumpton, B. Walton, and the California Burrowing Owl Consortium. 1998. Burrowing Owl conservation in California: issues and challenges. Page 7 *in* Abstracts of the Second International Burrowing Owl Symposium, Ogden, Utah.
- Benedict, R.A., P.W. Freeman, and H.H. Genoways. 1996. Prairie legacies – mammals. Pp. 149-167 *in* F.B. Samson and F.L. Knopf, eds. Prairie Conservation: Preserving North America's Most Endangered Ecosystem. Island Press, Covelo, California. 339pp.
- Bent, A.C. 1938. Life histories of North American birds of prey. U.S. Natl. Mus. Bull. No. 170.
- Bent, A.C. 1961. Life Histories of North American Birds of Prey, part 2. Dover Publications, Inc., New York. 482pp.
- Berdan, C.A. and R.L. Linder. 1973. Burrowing Owls in Mellette County, South Dakota. South Dakota Bird Notes 26:26-29.
- Biddle, P.G. 1996. Do landuse patterns influence Burrowing Owl nest site selection in northeastern Colorado? M.S. Thesis, Colorado State University, Fort Collins. 45pp.
- Butts, K.O. 1973. Life history and habitat requirements of Burrowing Owls in western Oklahoma. M.S. Thesis, Oklahoma State University, Stillwater.
- Butts, K.O. and J.C. Lewis. 1982. The importance of prairie dog towns to Burrowing Owls in Oklahoma. Proceedings of the Oklahoma Academy of Science 62:46-52.
- Clapp, R.J., M.K. Klimkiewicz, and A.G. Fitcher. 1983. Longevity records of North American birds: columbidae through paridae. Journal of Field Ornithology 54:123-137.
- Clark, R.J., J.L. Lincer, and J.S. Clark. 1997. Appendix A: A bibliography on the Burrowing Owl (*Speotyto cunicularia*). Pp. 145-170 *in* J. Lincer and K. Steenhof, eds. The Burrowing Owl, its biology and management including the proceedings of the First International Burrowing Owl Symposium. Raptor Research Report Number 9.
- Clayton, K.M. 1997. Post-fledging ecology of Burrowing Owls in Alberta and Saskatchewan: dispersal, survival, habitat use, and diet. M.S. Thesis, University of Saskatchewan, Saskatoon. 66pp.

- Clayton, K.M. and J.K. Schmutz. 1997. Burrowing Owl (*Speotyto cunicularia*) survival in prairie Canada. Pp. 107-110 in J.R. Duncan, D.H. Johnson, and T.H. Nicholls, eds. Biology and conservation of owls of the Northern Hemisphere. USDA Forest Service General Technical Report NC-190. North Central Forest Experiment Station, St. Paul, Minnesota.
- Clayton, K.M. and J.K. Schmutz. 1999. Is the decline of Burrowing Owls *Speotyto cunicularia* in prairie Canada linked to changes in Great Plains ecosystems? *Bird Conservation International* 9:163-185.
- Colorado Natural Heritage Program. 2003. Biological and Conservation Datasystem. Element Tracking Database. Colorado State University, Fort Collins, Colorado.
- Commission for Environmental Cooperation. 2000. Biodiversity conservation: conservation of migratory and transboundary species (2.2.4). Species of common conservation concern in North America, working draft of the Commission for Environmental Cooperation.
- Coulombe, H.N. 1971. Behavior and population ecology of the Burrowing Owl, *Speotyto cunicularia*, in the Imperial Valley of California. *Condor* 73:162-176.
- De Smet, K.D. 1992. Manitoba's threatened and endangered grassland birds: 1991 update and five-year summary. Report No. 92-93. Manitoba Department of Natural Resources, Winnipeg. 77pp.
- Dechant, J.A., M.L. Sondreal, D.H. Johnson, L.D. Igl, C.M. Goldade, P.A. Rabie, and B.R. Euliss. 2001. Effects of management practices on grassland birds: Burrowing Owl. Northern Prairie Wildlife Research Center, Jamestown, North Dakota. Northern Prairie Wildlife Research Center Home Page.
<http://www.npwrc.usgs.gov/resource/literatr/grasbird/buow/buow.htm>.
- DeSante, D.F. and T.L. George. 1994. Population trends in the landbirds of western North America. *Studies in Avian Biology* 15:173-190.
- Desmond, M.J. 1991. Ecological aspects of Burrowing Owl nesting strategies in the Nebraska panhandle. M.S. Thesis: University of Nebraska, Lincoln. 114pp.
- Desmond, M.J. and J.A. Savidge. 1996. Factors influencing Burrowing Owl (*Speotyto cunicularia*) nest densities and numbers in western Nebraska. *American Midland Naturalist* 136:143-148.
- Desmond, M.J. and J.A. Savidge. 1998. Burrowing Owl conservation in the Great Plains. Page 9 in *Abstracts of the Second International Burrowing Owl Symposium*, Ogden, Utah.
- Desmond, M.J. and J.A. Savidge. 1999. Satellite burrow use by Burrowing Owl chicks and its influence on nest fate. In P.D. Vickery and J.R. Herkert, eds. *Ecology and conservation of grassland birds in the western hemisphere*. *Studies in Avian Biology* 19.
- Desmond, M.J., J.A. Savidge, and K.M. Eskridge. 1997. Prairie partners. *Nebraskaland* 75:16-25.
- Desmond, M.J., J.A. Savidge, and K.M. Eskridge. 2000. Correlations between Burrowing Owl and black-tailed prairie dog declines: a 7-year analysis. *Journal of Wildlife Management* 64:1067-1075.
- Desmond, M.J., J.A. Savidge, and T.F. Seibert. 1995. Spatial patterns of Burrowing Owl (*Speotyto cunicularia*) nests within black-tailed prairie dog (*Cynomys ludovicianus*) towns. *Canadian Journal of Zoology* 73:1375-1379.

- Dundas, H. and J. Jensen. 1995. Burrowing Owl status and conservation. *Bird Trends* 4:21-22.
- EDAW. 2000. Black-tailed prairie dog study of eastern Colorado. Unpublished report prepared for Colorado Department of Natural Resources, Denver. 43pp.
- Ehrlich, P.R., D.S. Dobkin, and D. Wheye. 1988. *The Birder's Handbook*. Simon and Schuster, New York. 785pp.
- Ehrlich, P.R., D.S. Dobkin, and D. Wheye. 1992. *Birds in Jeopardy*. Stanford University Press, Stanford. 259 pp.
- Errington, P.L. and L.J. Bennett. 1935. Food habits of Burrowing Owls in northwestern Iowa. *Wilson Bull.* 47:125-128.
- Evans, D.L. 1982. Status reports on twelve raptors. U.S. Fish and Wildlife Service Special Scientific Report No. 238.
- Fox, G.A., P. Mineau, B. Collins, and P.C. James. 1989. The impact of the insecticide carbofuran (Furadan 480F) on the Burrowing Owl in Canada. Technical Report Series No. 72. Canadian Wildlife Service, Ottawa. 21pp.
- Gillihan, S.C. and S.W. Hutchings. 2000. Best management practices for shortgrass prairie birds: a landowner's guide. Rocky Mountain Bird Observatory, Brighton, Colorado. 33pp.
- Gleason, R.S. 1978. Aspects of the breeding biology of Burrowing Owls in southeastern Idaho. M.S. Thesis, University of Idaho, Moscow. 47pp.
- Grant, R.A. 1965. The Burrowing Owl in Minnesota. *Loon* 37:2-17.
- Green, G.A. 1983. Ecology of breeding Burrowing Owls in the Columbia Basin, Oregon. M.S. Thesis, Oregon State University, Corvallis.
- Green, G.A. 1993. Ecological considerations for management of breeding Burrowing Owls in the Columbia Basin. *J. Raptor Res.* 27:60.
- Green, G.A. and R.G. Anthony. 1989. Nesting success and habitat relationships of Burrowing Owls in the Columbia Basin, Oregon. *Condor* 91:347-354.
- Greibel, R.L. 2000. Ecological and physiological factors affecting nesting success of Burrowing Owls in Buffalo Gap National Grassland. M.S. Thesis, University of Nebraska, Lincoln.
- Haug, E.A. 1985. Observations on the breeding ecology of Burrowing Owls in Saskatchewan. M.S. Thesis, University of Saskatchewan, Saskatoon.
- Haug, E.A., 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, and The American Ornithologists' Union, Washington, D.C.
- Haug, E.A. and L.W. Oliphant. 1987. Breeding biology of Burrowing Owls in Saskatchewan. Pp. 269-271 in G.L. Holroyd, W.B. McGillivray, P.H.R. Stephney, D.M. Ealey, G.C. Trottier, and K.E. Eberhart, eds. *Endangered species in the Prairie Provinces*. Provincial Museum of Alberta Occasional Paper No. 9.
- Haug, E.A. and L.W. Oliphant. 1990. Movements, activity patterns, and habitat use of Burrowing Owls in Saskatchewan. *Journal of Wildlife Management* 54:27-35.

- Hjertaas, D., S. Brechtel, K. De Smet, O. Dyer, E. Haug, G. Holroyd, P. James, and J. Schmutz. 1995. National recovery plan for the Burrowing Owl. Report No. 13. Ottawa: Recovery of Nationally Endangered Wildlife Committee. 33pp.
- Hughes, A.J. 1993. Breeding density and habitat preference of the Burrowing Owl in northeastern Colorado. M.S. Thesis, Colorado State University, Fort Collins.
- Hutchings, S., M. Carter, E. Atkinson, T. VerCauteren, C. Finley, S. Gillihan, and J. Nosedal. 1999. Prairie Partners: promoting stewardship in shortgrass prairie. Unpublished report. Rocky Mountain Bird Observatory, Brighton, Colorado.
- James, P.C. 1992. Operation Burrowing Owl in Saskatchewan: the first five years. Abstract, Burrowing Owl Symposium. 1992 Raptor Res. Found. Ann. Meeting, Seattle, Washington.
- James, P.C. and R.H.M. Espie. 1997. Current status of the Burrowing Owl in North America: an agency survey. Pp. 3-5 *in* J. Lincer and K. Steenhof, eds. The Burrowing Owl, its biology and management including the Proceedings of the First International Burrowing Owl Symposium. Raptor Research Report No. 9.
- James, P.C. and T.J. Ethier. 1989. Trends in the winter distribution and abundance of Burrowing Owls in North America. *Am. Birds* 43:1224-1225.
- James, P.C. and G.A. Fox. 1987. Effects of some insecticides on productivity of Burrowing Owls. *Blue Jay* 45:65-71.
- James, P.C., G.A. Fox, and T.J. Ethier. 1990. Is the operational use of strychnine to control ground squirrels detrimental to Burrowing Owls? *Journal of Raptor Research* 24:120-123.
- Johnsgard, P.A. 1988. North American owls. Biology and natural history. Smithsonian Inst. Press, Washington, D.C.
- Jones, S.R. 1998. Burrowing Owl. Pp. 220-221 *in* Kingery, H.E., ed. Colorado Breeding Bird Atlas. Colorado Bird Atlas Partnership, Denver, Colorado. 636pp.
- Kantrud, H.A. 1981. Grazing intensity effects on the breeding avifauna of North Dakota native grasslands. *Canadian Field Naturalist* 95:404-417.
- Kantrud, H.A. and R.L. Kologiski. 1982. Effects of soils and grazing on breeding birds of uncultivated upland grasslands of the northern Great Plains. U.S. Fish and Wildlife Service. Wildlife Research Report 15. Washington, D.C. 33pp.
- Kennard, J.H. 1975. Longevity records of North American birds. *Bird-Banding* 46:55-73.
- Konrad, P.M. and D.S. Gilmer. 1984. Observations on the nesting ecology of Burrowing Owls in central North Dakota. *Prairie Naturalist* 16:129-130.
- LeClerc, M.G. 1990. Food niche relationships of sympatric raptors in western Utah, electrophoretic identification of raptor pellets, diet and nesting success of Burrowing Owls following aerial pesticide application in Utah, winter behavior and habitat selection of four raptor species in west-central Utah. PhD. Thesis, Brigham Young University. 61pp.
- Low, D. and E.E. Leupin. 1998. An assessment of the Burrowing Owl re-introduction in the Thompson/Nicola region of British Columbia: a summary report (1992-1997). Page 17 *in* Abstracts of the Second International Burrowing Owl Symposium, Ogden, Utah.

- Lutz, R.S. and D.L. Plumpton. 1999. Philopatry and nest site reuse by Burrowing Owls: implications for productivity. *Journal of Raptor Research* 33:149-153.
- MacCracken, J.G., D.W. Uresk, and R.M.Hansen. 1984. Burrowing Owl nesting habitat use in Conata Basin, South Dakota. Abstracts of the Society for Range Management 37th Annual Meeting, Rapid City, South Dakota.
- MacCracken, J.G., D.W. Uresk, and R.M. Hansen. 1985. Vegetation and soils of Burrowing Owl nest sites in Conata Basin, South Dakota. *Condor* 87:152-154.
- Maher, W.J. 1974. Matador Project: Birds II. Avifauna of the Matador area. Canadian Committee for the International Biological Programme, Matador Project Technical Report 58. University of Saskatchewan, Saskatoon. 31pp.
- Martell, M.S. 1990. Reintroduction of Burrowing Owls into Minnesota: a feasibility study. M.S. Thesis, University of Minnesota, Minneapolis.
- Marti, C.D. 1974. Feeding ecology of four sympatric owls. *Condor* 76:45-61.
- Marti, C.D. and J.S. Marks. 1989. Medium-sized owls. Pp. 124-133 *in* Western Raptor Management Symposium and Workshop.
- Martin, D.J. 1973. Selected aspects of Burrowing Owl ecology and behaviour. *Condor* 75:446-456.
- Millsap, B.A. and C. Bear. 1988. Cape Coral Burrowing Owl population monitoring. Annual performance report, Florida Game and Freshwater Fish Comm., Tallahassee.
- National Geographic Society. 1987. Field Guide to the Birds of North America. Second edition. Washington, D.C. 464pp.
- Nelson, D. 1993. Colorado breeding bird atlas. Denver Museum of Natural History, Denver. 27pp.
- Olendorff, R.R. 1973. The ecology of the nesting birds of prey of northeastern Colorado. U.S. International Biological Program, Grassland Biome Technical Report 211. Colorado State University, Fort Collins. 233 pp.
- Ostlie, W.R., R.E. Schneider, J.M. Aldrich, T.M. Faust, R.L.B. McKim, and S.J. Chaplin. 1997. The status of biodiversity in the Great Plains. The Nature Conservancy, Arlington, Virginia.
- Paige, C. 1998. Species Management Abstract: Western Burrowing Owl (*Athene cunicularia hypugaea*). The Nature Conservancy, Wings of the Americas Program, Arlington, Virginia. 18pp.
- Pezzolesi, L.S.W. 1994. The western Burrowing Owl: increasing prairie dog abundance, foraging theory, and nest site fidelity. M.S. Thesis, Texas Tech University, Lubbock.
- Plumpton, D.L. 1992. Aspects of nest site selection and habitat use by Burrowing Owls at the Rocky Mountain Arsenal, Colorado. M.S. Thesis, Texas Tech University, Lubbock.
- Plumpton, D.L. and R.S. Lutz. 1991. Nest site selection by Burrowing Owls in Colorado. *Journal of Raptor Research* 25:158-159.
- Plumpton, D.L. and R.S. Lutz. 1993. Prey selection and food habits of Burrowing Owls in Colorado. *Great Basin Naturalist* 53:299-304.

- Plumpton, D.L. and R.S. Lutz. 1993b. Nesting habitat use by Burrowing Owls in Colorado. *Journal of Raptor Research* 27:175-179.
- Ratcliff, B.D. 1986. The Manitoba Burrowing Owl survey, 1982-1984. *Blue Jay* 44:31-37.
- Ratcliff, B.D. 1987. Manitoba Burrowing Owl survey 1982-1984. Report 87-15. Manitoba Nat. Res., Winnipeg.
- Rich, T. 1986. Habitat and nest-site selection by Burrowing Owls in the sagebrush steppe of Idaho. *Journal of Wildlife Management* 50:548-555.
- Rodriguez-Estrella, R., F. Chavez Ramirez, and G.L. Holroyd. 1998. Current knowledge of the Burrowing Owl in Mexico: what is needed for a conservation plan? Abstract and notes. Second International Burrowing Owl Symposium, Ogden, Utah.
- Ross, P.V. 1974. Ecology and behavior of a dense colony of Burrowing Owls in the Texas Panhandle. M.S. Thesis, West Texas State University, Canyon.
- Salt, W.R. and A.L. Wilk. 1958. The birds of Alberta. Department of Economic Affairs, Edmonton, Alberta. 295pp.
- Sauer, J. R., J. E. Hines, and J. Fallon. 2001. The North American Breeding Bird Survey, Results and Analysis 1966 - 2000. Version 2001.2, [USGS Patuxent Wildlife Research Center](http://www.mbr-pwrc.usgs.gov/bbs/bbs.html), Laurel, Maryland. <http://www.mbr-pwrc.usgs.gov/bbs/bbs.html>.
- Sheffield, S.R. 1997. Current status, distribution, and conservation of the Burrowing Owl (*Speotyto cunicularia*) in Midwestern North America. Pp. 399-407 in J.R. Duncan, D. Johnson, and T.H. Nicholls, eds. *Biology and conservation of owls of the Northern Hemisphere*. USDA Forest Service, General Technical Report NC-190. North Central Forest Experiment Station, St. Paul, Minnesota.
- Sheffield, S.R. 1997b. Owls as biomonitors of environmental health hazards. Pp. 383-398 in *Biology and conservation of owls of the North Hemisphere*. USDA Forest Service, General Technical Report NC-190.
- Sidele, J.G., M. Ball, T. Byer, J. Chynoweth, G. Foli, R. Hodorff, G. Moravek, R. Peterson, and D. Svingen. 1998. Occurrence of Burrowing Owls on Great Plains National Grasslands. Page 22 in *Abstracts of the Second International Burrowing Owl Symposium*, Ogden, Utah.
- Stewart, R.E. 1975. Breeding birds of North Dakota. Tri-College Center for Environmental Studies, Fargo. 295pp.
- Stockrahm, D.M.B. 1995. Distribution of the Burrowing Owl (*Athene cunicularia*) in Billings County, North Dakota. Unpublished report. Moorhead State University, Moorhead, Minnesota. 40pp.
- Thompson, C.D. 1984. Selected aspects of Burrowing Owl ecology in central Wyoming. MS. Thesis, University of Wyoming, Laramie. 45pp.
- Thompson, C.D. and S.H. Anderson. 1988. Foraging behavior and food habits of Burrowing Owls in Wyoming. *Prairie Naturalist* 20:23-28.
- Thomsen, L. 1971. Behavior and ecology of Burrowing Owls on the Oakland Municipal Airport. *Condor* 73:177-192.

- Toombs, T.P. 1997. Burrowing Owl nest-site selection in relation to soil texture and prairie dog colony attributes. M.S. Thesis, Colorado State University, Fort Collins. 73pp.
- Tyler, J.D. 1983. Notes on Burrowing Owl food habits in Oklahoma. *Southwest Naturalist* 28:100-102.
- U.S. Fish and Wildlife Service. 1995. Migratory nongame birds of management concern in the United States: the 1995 list. Migratory Bird Management Office, Washington, D.C.
- Warnock, R. 1997. Is habitat fragmentation a factor in the decline of the Burrowing Owl in Saskatchewan? *Blue Jay* 55:222-228.
- Warnock, R.G. and P.C. James. 1997. Habitat fragmentation and Burrowing Owls (*Speotyto cunicularia*) in Saskatchewan. Pp. 477-486 in J.R. Duncan, D.H. Johnson, and T.H. Nicholls, eds. *Biology and conservation of owls of the Northern Hemisphere: Second International Symposium*. USDA Forest Service General Technical Report NC-190, North Central Forest Experiment Station, St. Paul, Minnesota.
- Wedgwood, J.A. 1976. Burrowing Owl in south-central Saskatchewan. *Blue Jay* 34:26-44.
- Wedgwood, J.A. 1978. The status of the Burrowing Owl in Canada. A report prepared for the Committee on the Status of Endangered Wildlife in Canada. Canadian Wildlife Service, Ottawa, Ontario.
- Wellicome, T.I. 1994. Taverner award recipient's report: Is reproduction in Burrowing Owls limited by food supply? *Picoides* 7:9-10.
- Wellicome, T.I. 1997. Status of the Burrowing Owl (*Speotyto cunicularia hypugaea*) in Alberta. Wildlife Status Report No. 11. Alberta Environmental Protection, Wildlife Management Division, Edmonton.
- Wellicome, T.I. 1998. Can we manage reproductive output in Burrowing Owls by managing their prey? Abstract and notes. Second International Burrowing Owl Symposium, Odgen, Utah.
- Wellicome, T.I. and E.A. Haug. 1995. Second update of status report on the Burrowing Owl (*Speotyto cunicularia*) in Canada. Committee on the Status of Endangered Wildlife in Canada, Canadian Wildlife Service, Environment Canada, Ottawa, Ontario.
- Wesemann, T. and M. Rowe. 1987. Factors influencing the distribution and abundance of Burrowing Owls in Cape Coral, Florida. Pp. 129-137 in L.W. Adams and D.L. Leedy, eds. *Integrating man and nature in the metropolitan environment*. Natl. Inst. Urban Wildl., Columbia, Maryland.
- Yanishevsky, R. and S. Petring-Rupp. 1998. Management of breeding habitat for selected bird species in Colorado. Colorado Division of Wildlife, Denver. 791pp.
- Zarn, M. 1974. Burrowing Owl, Report No. 11. Habitat management series for unique or endangered species. U.S. Department of the Interior, Bureau of Land Management, Denver, Colorado. 25pp.