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DEMOGRAPHY AND DISTRIBUTION OF THE BURROWING OWL IN FLORIDA

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Abstract.—Herein I describe the demographic characteristics and distribution of the Burrowing Owl (*Athene cunicularia*) in Florida. I censused owls in 62 counties between 15 April and 14 August 1999 and recorded 2,509 Burrowing Owls (1,757 adults, 752 young) at 946 territories. These included means of 1.9 adults, 2.4 young, and 1.5 burrows per territory. Non-breeding adults represented 8.2% of adults. I re-censused sites in Punta Gorda in 2000 and burrow reuse was 66.7%. Fifty Burrowing Owl territories were in agricultural habitats, 896 in urban habitats. The largest number of territories, 458 (51.1%), had burrows on vacant residential lots; 408 of these were in southwest Florida. In southeast Florida, the largest numbers of territories were at airports, parks, ball fields, and schools. As human densities increase in southwest Florida, owl territories may be limited to airports, parks, ball fields, and schools as they are now in southeast Florida. In peninsular Florida, Burrowing Owls were spottily distributed from Madison County in the north to Monroe County in the south. I recorded a small disjunct population in Okaloosa County. Adult Burrowing Owl density in peninsular Florida was 0.014 adults per km^2. Highest densities occurred in urban coastal regions of south Florida. Although the Burrowing Owl may be colonizing man-made habitats, these habitats may represent "ecological traps" the species is not fully adapted to cope with.

In Florida, the Burrowing Owl (*Athene cunicularia*) was historically associated with prairie habitats (Howell 1932). In the 1890s, colonies of 200 to 300 Burrowing Owls were described on the Kissimmee Prairie (Nicholson 1954). During the 1900s, the Burrowing Owl expanded its northern and southern ranges (Sprunt 1938, Neill 1954, Ligon 1963, Courser 1979). These authors also documented the owl's use of man-made habitats such as pastures, airports, along roads, and heavily cleared areas. A range expansion is generally considered

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healthy. However, if a species' density declines in its original range and populations are concentrated along the edge of its expanded range, population fragmentation may be occurring. In the 1950s, Nicholson (1954) reported a decline in owl populations on the Kissimmee Prairie. Extensive development and the Burrowing Owl's reliance on transient man-made habitats pose a threat to the species (Millsap 1996) and it was listed as a "Species of Special Concern" by the Florida Fish and Wildlife Conservation Commission (FFWCC) in 1979 (Wood 2001).

The most extensive survey of the owl's distribution is included in the unpublished Florida Breeding Bird Atlas (FBBA). Confirmed breeding records for the Burrowing Owl include sites on 159 of the 1,028 United States Geological Survey 7.5 minute topographic maps (Kale et al. 1992). In comparison, other prairie species such as the Crested Caracara (*Caracara plancus*) and Grasshopper Sparrow (*Ammodramus savannarum*) were found breeding in 42 and five of the topographic maps, respectively. The Burrowing Owl's distribution was described as being local and spotty, depending on suitable available habitat, throughout a wide area of Florida (Kale et al. 1992).

My goals were to map the current Florida range of the Burrowing Owl and to describe its demography including population size, distribution, density, and characteristics related to its capacity to expand or decline. I determined regional owl densities and evaluated use of ephemeral man-made habitats to assess the species' vulnerability in the face of development.

Survey Sites and Methodology

During the 1991 breeding season, DeSante et al. (1997) evaluated two methods of censusing Burrowing Owls in a 20-county region in California. Using the first method they censused owls in random stratified blocks and found 96 pairs of owls. Using the second method they censused random blocks and nonrandom blocks where Burrowing Owls had bred in the past and found 336 pairs of owls; 308 of the pairs occurred at historic breeding sites. Because the use of past breeding sites provided the most accurate count, I used historic and current Burrowing Owl sites as center-points for my censuses. Since median natal dispersal distance of female and male owls in Cape Coral, Florida, was 1,116 m and 414 m (Millsap and Bear 1997), I censused circular areas with a minimum radius of 1.5 km extending from a historic or current center-point.

Prior to conducting the census, I reviewed (1) data from 407 FFWCC take permits issued between 1988 and 1998, (2) 296 FBBA field cards for sites recorded between 1986 and 1990, (3) Florida Natural Areas Inventory's database with 99 owl sites documented between 1975 and 1997, and (4) FFWCC's Wild Bird Observation database with 85 sites recorded between 1987 and 1993. I also solicited information while giving presentations to Audubon Society chapters, in newsletters, through a web site, from regional FFWCC offices, and from other researchers.

I censused 1,035 historic and current Burrowing Owl sites in 62 Florida counties between 15 April and 14 August 1999. I chose this census period because (1) it coincided with the peak of the breeding season when adult owls are most visible, (2) it would allow me to collect data on both adults and young, and (3) it preceded the onset of nocturnal

behavior associated with raptor migration (Haug et al. 1993). Franklin, Liberty, Leon, Baker, and Columbia counties were not censused as they lacked suitable owl habitat and historic owl records. I censused sites in Punta Gorda, Florida, in 1999 and 2000 to obtain data on burrow reuse. Most sites, such as pastures and airports, had open grassy areas with few or no trees.

I censused sites, at least once, between 08:00 and 20:00. If I saw no owls, but molted feathers, prey remains, or feces suggested they were present, I revisited the site. I conducted roadside surveys and used county maps, topographic maps, and DeLorme Street Atlas, a computer map program, to determine the census route for each site. Census stops were made every 0.16 km to provide visual overlap between stops. If vegetation obstructed the view 0.16 km from the last stop, the next stop was made at the first point where the view was no longer obstructed. Census stops continued for a minimum of 1.5 km in all accessible directions or until no suitable owl habitat, open grassy areas with few or no trees, was visible. However, roadside surveys are biased and only provide counts of individuals visible from a road (Bibby et al. 1992). Roadside surveys also result in limited coverage in areas that have few roads. In order to reduce biases associated with roadside surveys, I conducted walking surveys along the perimeter and in the interior of sites where property owners permitted access. Fifty-two volunteers assisted with the census. I established one census team in each county and personally led each team to ensure consistency in reporting.

I located owls by playing a recording of the male Burrowing Owl's primary call and scanning the landscape with binoculars and a 50-mm telescope with an 18 to 36× zoom eyepiece. A tape of the Florida subspecies' call was played for a minimum of six minutes per census stop. I used a Garmin GPS 12 unit to determine the longitude and latitude of each territory. Burrowing Owls do not defend feeding territories; they only defend nest burrows (Haug et al. 1993). I defined a territory as a burrow or site where breeding adults or young were observed or as a potential breeding site where single adults were observed.

Results

Demographic Characteristics

I recorded Burrowing Owls (1,757 adults, 752 young; Table 1) at 946 territories. The largest number of adult owls was recorded in southwest Florida (Table 1). The mean number of adults per territory was 1.9 and ranged from 1.7 in the panhandle to 1.9 in northwest Florida (Table 1). Mean number of adults per territory was not significantly different among regions (ANOVA $F = 1.25$, $df = 6$ and 939, $P > 0.05$). Single adults were observed at 144 (15.26%) territories. Breeding pairs were observed at 796 (84.32%) territories and three breeding adults were observed at four (0.42%) territories.

I observed young Burrowing Owls at 314 territories (Table 1). The largest numbers of young were recorded in southwest Florida (Table 1). Mean number of young per breeding territory was 2.4 (range: 1.9 in south central region to 3.0 in panhandle; Table 1). The largest number of young owls ($n = 428$) was observed between 16 and 31 May 1999. I observed single fledglings at 90 (28.6%) territories, two at 89 (28.3%), three at 76 (24.2%), four at 42 (13.4%), five at 14 (4.5%), and six at three (1.0%).

Table 1. Numbers of Burrowing Owls recorded per territory in Florida, 15 April-14 August 1999.

Region	No. of territories with adults	No. of adult owls	No. of adults/territory (Mean ± S.D.)	No. of territories with young	No. of young owls	No. of young/territory (Mean ± S.D.)	Total owls recorded
Southeast	306	563	1.8 ± 0.4	53	123	2.2 ± 1.2	686
South Central	36	67	1.9 ± 0.4	10	19	1.9 ± 0.7	86
Southwest[a]	503	946	1.9 ± 0.3	216	530	2.5 ± 1.2	1476
Northeast	14	26	1.9 ± 0.4	6	14	2.3 ± 0.8	40
North Central[b]	57	99	1.8 ± 0.5	17	34	2.0 ± 1.2	133
Northwest	23	44	1.9 ± 0.5	10	26	2.6 ± 1.5	70
Panhandle	7	12	1.7 ± 0.5	2	6	3.0 ± 2.8	18
Totals	946	1757	1.9 ± 0.4	314	752	2.4 ± 1.2	2509

[a]Includes one site censused after the census date.
[b]Includes two sites censused after the census date.

The mean number of burrows per territory was 1.5. Most territories (580; 61.31%) had a single burrow. Two burrows occurred at 241 (25.48%) territories, three at 93 (9.83%), four or more burrows at 25 (2.64%) territories. Seven (0.74%) territories lacked a burrow.

In Punta Gorda in 1999, I found 21 active Burrowing Owl territories with 38 adult owls; in 2000, I found 22 active territories with 42 adult owls. In 2000 the same burrows were occupied in 14 (66.7%) of the original 21 territories and seven (33.3%) territories had gone inactive. One active territory in 2000 was undetected during the 1999 census. Two active territories in 2000 were active prior to 1999 but were inactive in 1999. Five (22.7%) new territories, in areas that did not have owls previously, were recorded during the 2000 breeding-season.

Habitat Use

Most territories (n = 896; Fig. 1) were in urban areas, with a smaller number in agricultural habitats (n = 50). I found no owls in native habitats. In northwest, southeast, and south-central Florida most territories were on airports (n = 8, 110, 22, respectively). Territories in north-central Florida were equally split between airports (n = 16) and residential nature preserves (n = 16). Most Burrowing Owl territories in southwest Florida were on vacant residential lots (n = 408).

A chi-square contingency table revealed that burrows in the southeast and southwest regions were not similarly distributed among man-

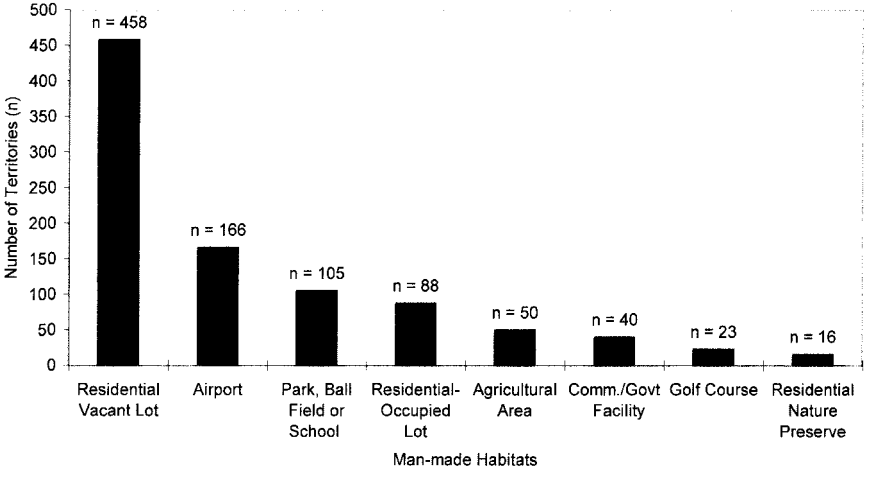

Figure 1. Man-made habitats surrounding burrows at Burrowing Owl territories censused in Florida, 15 April-14 August 1999. A residential nature preserve is a tract of land set aside for Burrowing Owls and other protected species in a planned urban development.

made habitats (χ^2 = 443.48, df = 5, P < 0.005). Territories in southeast Florida represented 37% of the total territories in southeast and southwest Florida. Therefore, 37% of the burrows in each man-made habitat would be expected to occur in southeast Florida (Fig. 2a). However, 92% of the burrows at airports and 90% of the burrows at parks, ball fields, and schools occurred in the southeast region (Fig. 2a). Territories in southwest Florida represented 63% of the total territories in both regions and 63% of the burrows in each habitat would be expected to occur in southwest Florida (Fig. 2b). Only 8% of the burrows at airports and 10% of burrows at parks, ball fields, and schools were in this region (Fig. 2b). In comparison, 91% of the burrows located on vacant residential lots were found in southwest Florida (Fig. 2b).

Distribution and Density

I recorded Burrowing Owls in 32 counties (Fig. 3). The five counties with the largest numbers of adult owls were Lee (n = 813), Broward (n = 357), Palm Beach (n = 159), Dade (n = 52), and Charlotte (n = 38). In peninsular Florida, Burrowing Owls were spottily distributed from Madison County in the north to Monroe County in the south. A small disjunct population with seven territories was found at Eglin Air Force Base, Okaloosa County. No active territories were found at the previously recorded disjunct population in Duval County.

The largest number of territories (n = 503) was in southwest Florida in Lee, Charlotte, Collier, and Hillsborough counties (Fig. 3). Burrowing Owl territories were not uniformly distributed through the peninsula based on the percent of land area in each region (χ^2 = 2046.1, df = 5, P < 0.001). Based on land area, the largest number of Burrowing Owl territories in south Florida was expected to occur in the south-central region. However, this region had the smallest number of territories (n = 36) in south Florida. The smallest number of owl territories in south Florida was expected to occur in the southwest region, which had the largest number of territories, 503 territories. In north Florida, the largest number of territories was expected to occur in northeast Florida; however, the north-central region had the largest number of territories. In south Florida, the largest numbers of Burrowing Owl territories were found in the urban coastal regions. In contrast, the largest number of territories in north Florida was in the interior of the state.

The number of adult Burrowing Owls per km^2 in peninsular Florida was 0.014 (Table 2). The highest density of adult owls, 0.065 adults per km^2, was in southwest Florida (Table 2). The density of adult owls in southwest Florida was 2.3 times higher than the density of adults (0.028 adults per km^2) in southeast Florida. The highest density of adult owls in southwest Florida was 65.0 times higher than the lowest density of adults found in northeast Florida (0.001 adults per km^2). The

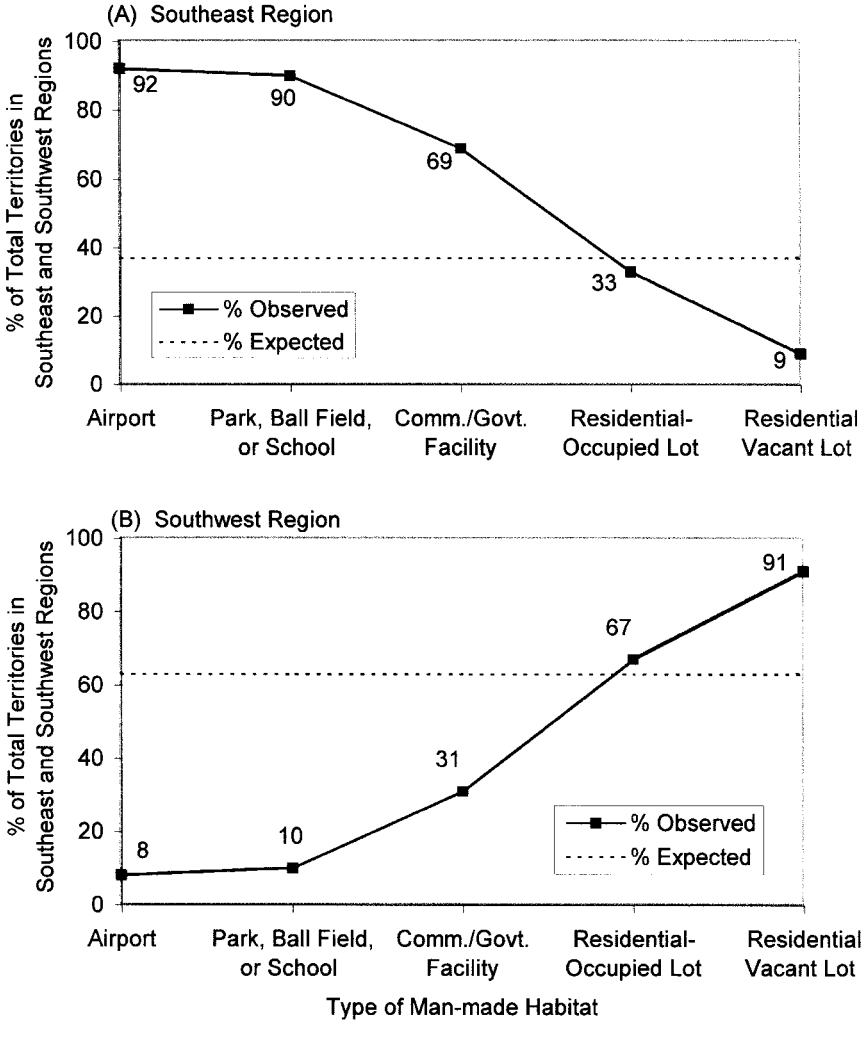

Figure 2. Percent of observed Burrowing Owl territories versus expected territories based on man-made habitats surrounding burrows in southeast and southwest Florida, 15 April-14 August 1999. See Figure 3 for limits of regions.

density of Burrowing Owl territories in peninsular Florida was 0.007 territories per km^2 (Table 2). The highest density of territories was in southwest Florida and the lowest density was in northeast Florida (Table 2). When densities were calculated for the entire north and south Florida areas, adult Burrowing Owl density in south Florida (0.026 adults per km^2) was 8.7 times higher than in north Florida (0.003 adults per km^2). Lee County had the highest density of adult Burrow-

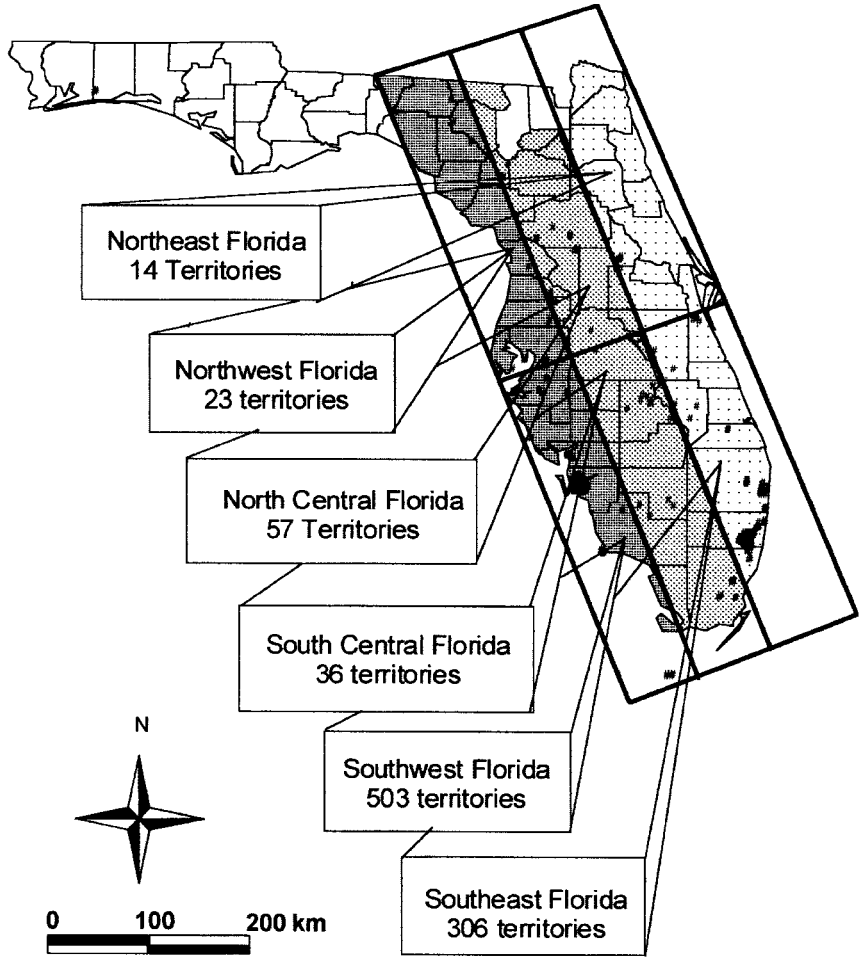

Figure 3. Number of Burrowing Owl territories recorded in peninsular Florida, 15 April-14 August 1999. Black dots represent the location of owl territories. Due to the scale of the map, some dots represent more than one territory. For example, 416 territories were located in Cape Coral, Lee County.

ing Owls, 0.391 adults per km^2. Broward County had the second highest density, 0.114 adults per km^2, and Palm Beach County had the third highest density, 0.031 adults per km^2.

DISCUSSION

DEMOGRAPHIC CHARACTERISTICS

The low mean number of adult Burrowing Owls found in the panhandle may have been influenced by the sample size (n = 7 territories),

Table 2. Density of adult Burrowing Owls and territories recorded in peninsular Florida, 15 April-14 August 1999.

Region[a]	Area (km^2)	No. of adults	No. of adults per km^2	No. of territories	No. of territories per km^2
Southeast	19,915.71	563	0.028	306	0.015
South Central	27,231.55	67	0.003	36	0.001
Southwest[b]	14,593.27	946	0.065	503	0.035
Northeast	22,439.19	26	0.001	14	0.001
North Central[c]	21,815.05	99	0.005	57	0.003
Northwest	20,359.37	44	0.002	23	0.001
Totals	126,354.14	1,745	0.014	939	0.007

[a]See Figure 3 for limits of regions.
[b]Includes one site censused after the census date.
[c]Includes two sites censused after the census date.

while the high mean found in northwest Florida was impacted by two territories with three adults. Occasional polygyny has been observed in Burrowing Owls in Saskatchewan, Canada (Haug et al. 1993). Using DNA fingerprinting, Johnson (1997) confirmed polygynous matings at two of 20 breeding territories in Davis, California. I observed polygynous groups at 0.42% of the territories. Single non-breeding adults represented 8.2% of the adult population. Population turnover is usually rapid in small, short-lived birds like the Burrowing Owl and ensures non-breeding populations remain small (Newton 1998).

Millsap and Bear (1988) recorded 1.7 and 2.0 fledglings per breeding territory in Cape Coral, Florida, in 1987 and 1988. The mean fledging date was 24 May in both years. Mealey (1997) recorded means of 2.37, 2.46, and 2.73 fledglings per territory on his study sites in Dade and Broward counties in 1988, 1989, and 1990, with the largest number of owls in May of each year. Because a minimum of one visit was made per site in my census, it is possible young were not observed at territories breeding late in the season in south Florida or early in the season in north Florida. However, when young were observed, I spent additional time at each site to ensure all young were included in the census. The mean number of young I observed was similar to the means recorded by Mealey (1997) and higher than those recorded by Millsap and Bear (1988). The high regional means I recorded in northwest Florida and the Panhandle were recorded in July and August and may indicate a later breeding peak in the northwestern areas of the state.

Burrowing Owls prefer nesting in areas with a high density of burrows and hypotheses suggest multiple burrows protect owls from avian predators or provide escape burrows for young (Haug et al. 1993). Like the Bald Eagle (*Haliaeetus leucocephalus*) which constructs alternate

nests, multiple burrows may provide an alternate nest site in the event a burrow is destroyed. In 924 Bald Eagle territories, the mean number of nests per territory was 1.5 (Stalmaster 1987). No burrows were found at seven Burrowing Owl territories and eggs were laid above ground at four territories. No young were produced at these sites due to egg predation. If alternate burrows had been present, nests might have been successful. Burrow reuse in Punta Gorda was higher than burrow reuse (60.0%) recorded by Mealy (1997). Higher burrow reuse in my study may have been positively influenced by maintenance activities. Prior to the breeding season in Punta Gorda, vegetation obstructing burrow entrances was removed and signs identifying burrows as protected nesting sites were replaced.

Habitat Use

The low number of territories found in natural and agricultural habitats may be influenced by several factors. First, fewer reports on owl sites in remote natural and agricultural areas were received prior to the census than on highly visible urban sites. Second, roadside surveys do not provide the same level of coverage in natural or agricultural habitats as they do in urban habitats (Bibby et al. 1992). Most pastures had one road along a border, while subdivisons had numerous roads in their interior and along borders. It is probable that active Burrowing Owl territories were missed during my census in areas that could not be viewed from a road and where access for walking surveys was not permitted by property owners. However, coverage may not be the only factor influencing the low number of owls observed in these habitats. I conducted walking surveys in a subset of natural and agricultural sites; the maximum number of adults I recorded was five. Population viability analysis suggests small owl populations ($n < 5$ adults) have a 57.5% probability of extinction within 100 years (Bowen 2000). Large owl populations ($n \geq 30$ adults) have a less than 2.0% probability of extinction provided there are no changes in the habitat's carrying capacity (Bowen 2000). Finally, habitat loss and agricultural land-use changes may have impacted some sites. Central Florida was once estimated to have 830,000 ha of dry prairie habitat; in 1995, dry prairie had declined to an estimated 156,000 ha (Shriver and Vickery 1999). Additionally, the number of cattle and calf operations in Florida declined from 17,321 in 1987 to 15,522 in 1992 (Floyd 1997). Two property owners and one birder confirmed owls had occurred in three pastures planted with slash pine. The most likely explanation for lack of owls at these three sites was habitat change resulting from conversion of pastures to silviculture.

I recorded the largest number of territories on residential vacant lots. Millsap and Bear (2000) found that (1) nest failures due to human causes increased with increasing development, (2) the number of

young fledged per nest decreased as human development exceeded 60%, and (3) owls nesting in sodded lawns on occupied lots fledged fewer young than those nesting in vacant lots. My results and those of Millsap and Bear (2000) suggest the Burrowing Owl faces serious challenges in developing areas. If productivity decreases as vacant lots are converted to occupied lots, owl populations in southwest Florida will probably decline.

Burrowing Owls in southeast and southwest Florida were not similarly distributed across man-made habitats. In 1997, an estimated 2,427,500 people lived in Dade and Broward counties, a density of 76,300 individuals per square-mile (Floyd 1998). In contrast, Lee, Charlotte, and Collier counties were estimated to have 725,500 individuals, a density of 20,600 individuals per square-mile (Floyd 1998). Where human densities are high in southeast Florida, Burrowing Owls occurred in the last available habitat patches with large expanses of open grass. The largest populations occurred at airports; 77 adults were found at Fort Lauderdale Executive Airport, and 63 adults at Pompano Airport in Broward County. Parks, ball fields, and schools only supported small populations. The largest number of adults recorded at a ball field was 13 at Sunrise Park, Broward County. Florida Atlantic University, larger than most neighborhood schools, had 19 adults, the largest number of adults found at a school. Usually, only one to two pairs of owls were found at schools. The United States Department of Agriculture is testing methods to reduce birdstrikes. If airport habitat patches are eliminated, the size of Burrowing Owl populations in southeast Florida may be significantly reduced. Finally, as human densities increase in southwest Florida, owls in the region may be limited to man-made habitat patches in a pattern similar to those observed in southeast Florida. This pattern was seen in one heavily developed area of Cape Coral where owls had occurred along Pelican Boulevard, between Gleason and Mohawk parkways. In 1999, the area was almost fully developed; one territory was found on a residential lot and three territories occurred at Pelican Elementary School.

Distribution and Density

The FBBA (Kale et al. 1992) recorded Burrowing Owls in a large area of south-central Florida. Although I found owls in a large area of this region, the population density in the region was low in comparison to densities recorded in the coastal regions of southeast and southwest Florida. Courser (1979) identified owl sites as far north as Suwannee and Duval counties. The FBBA (Kale et al. 1992) recorded a probable breeding site in Madison County and a confirmed breeding site in Duval County. I recorded a pair of owls in Madison County; however, I did not find Burrowing Owls in Duval County. The lack of owls in Duval

County may have resulted from habitat changes associated with land use changes. Owls had occurred at Imeson Industrial Park, a former military air base, in Jacksonville. The FBBA (Kale et al. 1992) did not include a record of Burrowing Owls in Okaloosa County. I recorded a small disjunct population (12 adults and six young) on a bombing range at Eglin Air Force Base, Okaloosa County. This site was not confirmed as a breeding site until 1993, one year after work was completed on the FBBA (Stevenson and Anderson 1994).

In 1991, DeSante et al. (1997) recorded 672 adult Burrowing Owls in 20 California counties. The Burrowing Owl density was 0.016 adults per km^2 and was higher than the density I recorded in peninsular Florida. Observation time and area coverage may have influenced the difference in densities between my study and the California study (Bibby et al. 1992). The California study covered 21,713 km^2 per month while my census covered 31,588 km^2 per month.

It is possible Florida's Burrowing Owl populations are not as stable as once believed. In 1992, the Burrowing Owl in California was listed as declining with an estimated 1,000-10,000 pairs; the Burrowing Owl in Florida was listed as stable with 1,000-10,000 pairs (James and Espie 1997). In 1987, 1,000 pairs of owls were estimated to occur in Cape Coral, Florida (Millsap 1996). In 1999, 416 territories with 782 adult owls were recorded in Cape Coral.

The Burrowing Owl represents a paradox in species conservation. With the largest densities occurring in the most rapidly developing regions of Florida, the owl appears to be adapting to anthropogenic environments. However, the Burrowing Owl's reliance on ephemeral man-made habitats may ultimately impact its numbers. These habitats may function as "ecological traps" which provide vegetative cues suggesting good nest sites, but result in smaller clutch sizes and increased rates of predation (Gates and Gysel 1978). These man-made habitats may not be representative of the niche the species evolved in and it may be poorly adapted to coping with increased predation or similar pressures (Gates and Gysel 1978). The extirpation of Burrowing Owl colonies at the University of South Florida, Hillsborough County, and Imeson Industrial Park, Duval County, suggests Burrowing Owl populations in man-made environments are at risk. The presence of owls in a man-made habitat is probably most indicative of efforts to colonize new habitats. True adaptation would be reflected in long-term increases in Burrowing Owl clutch sizes, fledgling success, and survival rates in response to the ecological pressures exerted by man-made habitats.

Knowledge of Burrowing Owl densities at regional and county levels could provide insight for future monitoring efforts. Lee, Broward, and Palm Beach counties in southwest and southeast Florida had the highest Burrowing Owl densities. Establishment of annual censuses in these

areas and long-term regional breeding studies may provide further insight into the Burrowing Owl's adaptive abilities. Although wildlife management is seldom applied to urban environments, its application at airports, ball fields, and schools may provide the best opportunity to preserve a species that has come to rely on urban environments.

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