Metapopulation Dynamics of a Burrowing Owl (*Speotyto cunicularia*) Population in Colorado

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Abstract.—We banded 555 Burrowing Owls (*Speotyto cunicularia*) either as adults (after hatch year; AHY) or as young of the year (hatch year; HY) and used capture-recapture models to estimate survival and recapture rates and Leslie matrix models to project population growth over time at the 6,900-ha Rocky Mountain Arsenal National Wildlife Refuge (RMANWR), Colorado from 1990-1994. We found survival rates for AHY could be pooled across sexes and that survival varied by year. Survival for AHY birds between 1990-1991 was 0.71 and averaged 0.18 for the period 1991-1994 ($P = 0.06$). Survival for HY birds was lower (0.12) the first year of life than succeeding years ($\bar{x} = 0.62$, $P = 0.0006$). We modeled populations on the Refuge as a combination of birds using 'good' and one of two types of 'fair' habitats. In all models, the proportion of birds that used the good habitat was not critical to population persistence. Our models suggest that RMANWR could act as a source if the population used the combination of good and an 'increasing' fair habitat. Our model also suggests that number of pairs using RMANWR decline (5-20 percent) when we used good habitat combined with 'average' fair habitat.

Burrowing Owls (*Speotyto cunicularia*) are a species of concern throughout much of their range in the United States (Rich 1984) and Canada (Ratcliff 1986, Johnsgard 1988). Eradication of burrowing mammals that provide nest sites for Burrowing Owls (Butts 1973, Zarn 1974) and habitat loss to development by humans (Zarn 1974) are principal factors suspected in owl population declines. In Colorado, migratory Burrowing Owls depend chiefly on black-tailed prairie dogs (*Cynomys ludovicianus*) for nesting burrows, and often return to nesting areas used previously (Plumpton and Lutz 1993b). Philopatry by marked Burrowing Owls (Martin 1973), and nest site fidelity by populations (Gleason 1978, Rich 1984) have been identified as traits of Burrowing Owls.

We investigated survival and reproductive performance in a migratory population of Burrowing Owls. Our objectives were to determine: (1) age class and gender-specific survival rates and; (2) to model population trajectories using our estimates of these vital statistics.

MATERIALS AND METHODS

Study Area

We studied Burrowing Owls on the Rocky Mountain Arsenal National Wildlife Refuge (RMANWR) 16 km from Denver, Colorado, in southwestern Adams County. This 6,900-ha area is vegetated primarily by weedy forbs, cheatgrass (*Bromus tectorum*), and perennial grasses. Shrubs include yucca (*Yucca* spp.), sand sagebrush (*Artemisia filifolia*), and rubber rabbitbrush (*Chrysothamnus nauseosus*) that occur in patches throughout the area. Cottonwood (*Populus sargentii*) and willow (*Salix* spp.) occur along riparian areas and where planted. Black-tailed prairie dog colonies were present throughout the area, and provided the sole nesting habitat of Burrowing Owls.

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Capture And Banding

We captured and banded Burrowing Owls during the breeding seasons (1 April - 31 July) from 1990-1994. We used primarily Sherman and Tomahawk traps to capture nesting Burrowing Owls and their young (Plumpton and Lutz 1992, 1993a). We banded owls with visual identification (VID) color-anodized aluminum legbands engraved with unique alpha/numeric combinations (Acraft Sign and Nameplate Co., Ltd., Edmonton, Alberta, Canada) and classified owls as either hatch year (HY) or adult (after hatch year; AHY) based on size and plumage. We surveyed the study site daily during the breeding season to locate nest burrows, count young, and trap owls. Our surveys consisted of driving roads and using spotting scopes mounted on vehicle windows to identify nesting and previously banded Burrowing Owls. We also traversed prairie dog towns on foot, inspecting burrows for signs of occupancy by Burrowing Owls (whitewash, castings, and prey remains). We defined mated pairs as those that used a single burrow and attempted to nest, and successful nesting attempts as those where ≥1 young was fledged (Steenhof 1987). We estimated brood size as the maximum number of young seen at each burrow prior to fledging.

Survival

We used capture-recapture models and methods (Burnham and Anderson 1992, Lebreton et al. 1992) to estimate survival (Φ) and recapture (p) probabilities. We followed notation of Lebreton et al. (1992). In our most general model for AHY owls, we varied survival and recapture probabilities by time (t), sex (s), and/or age (a). For HY birds, we varied Φ and p by t and/or a. We used goodness-of-fit tests in RELEASE (Burnham et al. 1987) to evaluate pooling across groups (e.g., t, a, s) for further analyses and SURGE 4.1 (Pradel et al. 1990) for model building. We used Akaike's Information Criterion (AIC) (Burnham and Anderson 1992) to select parsimonious models, and likelihood-ratio tests (LRT) to determine significance between general and reduced models. We tested the hypotheses that group survival rates within AHY and HY were similar using chi-square tests (Sauer and Williams 1989). Our survival rates should be interpreted as apparent survival rates because we have no estimate of dispersal in this population.

Model

We used a stage-structured Leslie matrix (Leslie 1945) where the first two stages corresponded to annual age classes to project population growth for a population of 35 pairs over 50 years. We modeled demographic parameters using a normal distribution to account for stochasticity. We investigated the influence of habitat quality on population trajectories by modeling population growth in two types of habitat, good and fair. We used maximum values for our parameters to describe the dynamics in the good habitat. We defined fair habitat in two different ways. In one approach, we used average values for our parameters. We refer to this as 'average' fair conditions. In another approach to fair habitat, we manipulated AHY survival (within the range of our estimates) until we generated a lambda of > 1.0. We refer to this as 'increasing' fair conditions. Additionally, we modeled population trajectories when 2 percent and 33 percent of individuals in the population occupied good habitat.

RESULTS AND DISCUSSION

We banded 555 Burrowing Owls (table 1); this provided 4 consecutive years of potential return to RMANWR (1991-1994) involving 514 individuals (those banded before 1994). During all nesting years (1990-1994), 202 of 334 nesting adults (60 percent) were known individuals. We estimate that this population fledged 585 owlets from 1990-1993; we banded 369 (63 percent) of these owlets.

Survival

We did not have sufficient data to use goodness-of-fit tests in RELEASE; we did build reduced models in SURGE. Adult male and female survival and recapture rates did not vary (survival: $X^2 = 3.978$, 2 df, $P = 0.137$, recapture: $X^2 = 2.887$, 2 df, $P = 0.236$), so we pooled the sexes for analyses (table 1) and modeling. Our most reduced model for AHY revealed that adult survival was high in 1991 (71 percent) and averaged 18 percent in subsequent years ($X^2 = 3.4$, 1 df, $P = 0.06$). We found annual survival for owls banded during HY varied by age. For owls banded during HY, survival the first year of life average 12 percent and then increased to an average of 62 percent for the remaining years ($X^2 = 11.79$, 1 df, $P = 0.0006$).

Table 1.—Estimates of annual survival (Φ) and recapture (p) probabilities for Burrowing Owls captured at Rocky Mountain Arsenal National Wildlife Refuge, Colorado, 1990-1994.

Age[1]	**Model**[2]	**Group**[3]	**Φ**	**SE**[4]	**p**	**SE**
AHY	(Φ_{t}, p)	1990-1991	0.71	0.28	0.49	0.19
		1991-1994	0.18	0.06	0.49	0.19
HY	(Φ_{2a}, p)	age, 1-2 yr	0.12	0.04	0.35	0.13
		age, >2 yr	0.62	0.14	0.35	0.13

[1] Age at banding was either after hatch year (AHY) or hatch year (HY).
[2] We present estimates from the reduced models produced in SURGE.
[3] Group parameters were either time, 1990-1994, or age since capture.
[4] Standard Error.

Model

We used weighted averages to estimate AHY survival (0.37) and used 0.12 as an estimate of survival for HY birds. When we used these estimates of survival and an average of 3.5 fledglings/pair, this population had lambda of 0.79. When we used an average fecundity of 3.5 and 0.12 for HY survival, we found that AHY survival of 0.59 was the lower limit to maintain a population with lambda > 1.0. This estimate of AHY survival was within the range of our estimates, 0.18-0.71.

Some pairs were very successful at rearing young. We saw females return to the same nest site to breed after they had fledged an average of 4.2 young. We incorporated this phenomenon into our model by using this rate to describe fecundity in 'good' habitat. We defined the other parameters in good habitat as HY survival of 0.12, and AHY survival of 0.71 (maximum) to yield a lambda of 1.21. We defined fair habitat in two ways: (a) 'average'-fecundity of 3.5, HY survival of 0.12, AHY survival of 0.37 which resulted in a lambda of 0.79 or (b) 'increasing'-fecundity of 3.5, HY survival of 0.37, AHY survival of 0.59 which resulted in a lambda of 1.01.

In all combinations of good and fair habitat, we found population persistence (fig. 1). Our models resulted in RMANWR acting as a source population (Pulliam 1988) when we used combinations of good and 'increasing' fair habitat and indicated a decline over the 50 year time period when we modeled populations using good and 'average' fair habitat. The decline from year 1 to year 50 was approximately 20 percent when 2 percent of the population used the good habitat and 5 percent when 33 percent of the population used the good habitat.

We suggest that biologists continue to mark individuals so that demographic parameters can be better estimated. For this marking program to be useful, biologists must mark a high proportion of the population and trap each year so that enough owls are recaptured to reliably estimate survival rates. We urge biologists to continue to explore the relationships between owl social factors and productivity (Plumpton and Lutz 1994) and the relationships between burrowing owl productivity and prairie dog abundance and density (Plumpton and Lutz 1993b).

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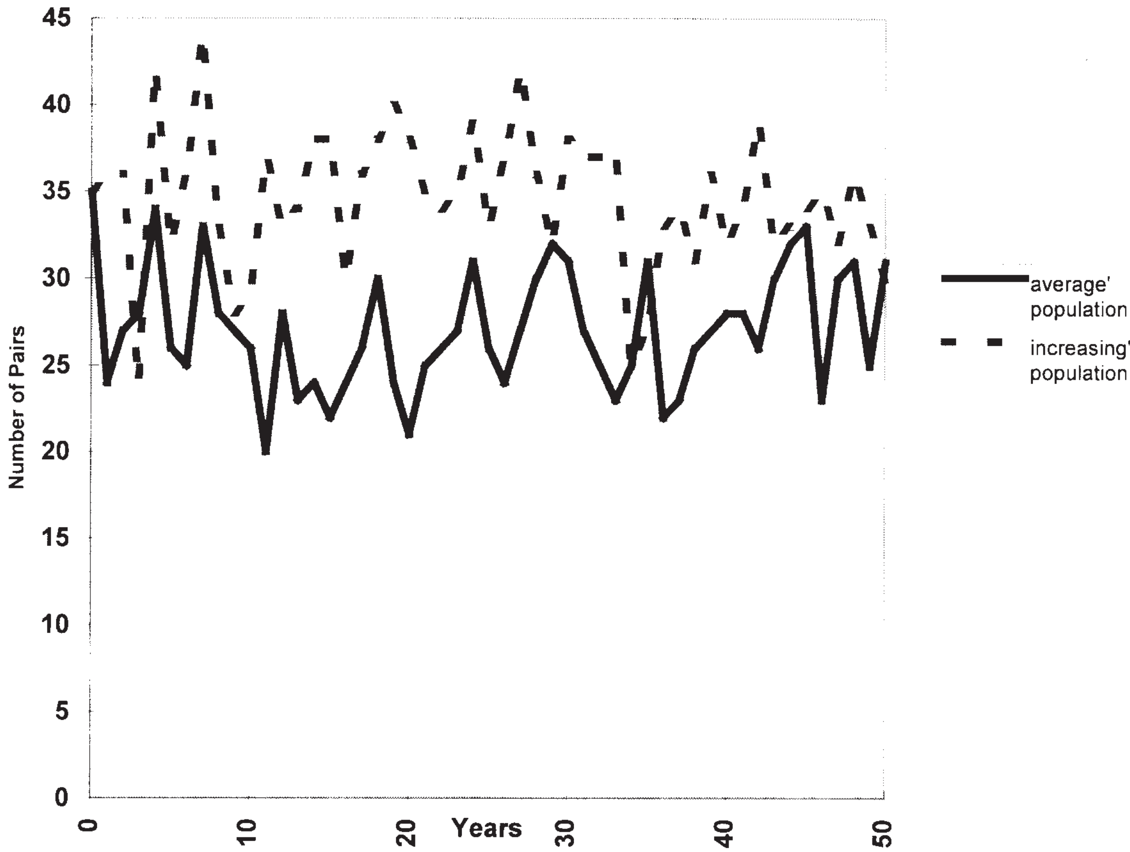

Figure 1.—Burrowing Owl (Speotyto cunicularia) population projections using two types of fair habitat, increasing and average at Rocky Mountain Arsenal National Wildlife Refuge, Colorado.

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