

ridges and drainages. Spotted owl telemetry studies and intensive surveys began in 1987 and 1990, respectively, on a 160 mi<sup>2</sup> portion of this study area (old Sierra study area). In 1994, surveys were expanded to include an additional 103 mi<sup>2</sup> (new Sierra study area; Steger *et al.* 1999). Juvenile survival rate was not calculated using data from this study area. Instead, the juvenile survival rate from the San Bernardino study area (0.328) was used to approximate the Sierra study area's juvenile survival rate.

Using survey data from 1990 to 2000 and the projection matrix method, the annual rate of population change was estimated for the old Sierra study area (1987 to 2000) and both old and new Sierra study areas combined (1987 to 2000). Annual rates of population change for the old Sierra and combined Sierra study areas were 0.897 and 0.901, respectively. These estimates were significantly less than that of a stationary population, and suggested that the territorial female owl population declined about 10 percent annually from 1987 to 2000. For an 11 year period (1990 to 2000), this translates to a population decline of around 60 percent. For the old Sierra study area during 1991 to 2000 (1990 was not examined as survey guidelines were not yet established on the study area), actual owl numbers seemed to corroborate a decline, albeit the drop in numbers was less severe than 60 percent. Owl abundance in 1991 and 2000 were 69 and 55, respectively. These numbers represent a 20 percent decrease, although the accuracy of the count numbers is unknown. The new Sierra study area also showed a decline: actual owl numbers dropped from 37 in 1994 to 29 in 2000.

The meta-analysis for this study area included 11 years of sampling (1990 to 2000) and encompassed 137 mi<sup>2</sup>. The mean  $\lambda$  estimate for this study area was less than 1.0 (0.961), but was not statistically different from that of a stationary population ( $\lambda = 1.0$ ). Annual  $\lambda$  estimates showed a weak (nonsignificant) decline, and adult apparent survival showed no substantive variation or trends through time. The Sierra study showed a negative trend in fecundity, which could have been driven by a high reproduction year early in the study.

Although the mean  $\lambda$  was statistically stationary using Pradel's methodology, actual numbers of owls declined; the projection matrix approach showed a decline; there was a negative trend in fecundity; and there was a weak, nonsignificant decline in annual  $\lambda$  estimates (using Pradel's method). It

appears that a decline in this study area is possible, but the use of a surrogate juvenile survival rate introduced a bias of unknown proportion, and thus, the magnitude of a possible decline remains uncertain.

**Sequoia and Kings Canyon Study Area**—The Sequoia and Kings Canyon study area encompassed approximately 130 mi<sup>2</sup> of land in Fresno and Tulare counties. The majority of the area was located in the Sequoia and Kings Canyon National Parks. Small segments of the study area include the Kings River watershed, but most of the study area was in the Kaweah River watershed (Franklin *et al.* 2002). Surveys in this study area cover 11 years of field sampling (1990 to 2000), but useful data exist from a previous demographic study that began in 1988 (Steger *et al.* 2000). Demographic surveys were conducted on 130 mi<sup>2</sup> of land in this area, and methods for calculating  $\lambda$  were identical to those used for the Sierra study area. The annual rate of population growth using the projection matrix method was estimated to be 0.973, suggesting a decline of 2.7 percent per year. Statistical testing found that  $\lambda$  was not significantly less than 1.0. Actual owl counts during the study period seemed to indicate that the population might be growing, but again, the accuracy of such numbers is uncertain. Owl abundance in 1990 and 2000 were 54 and 64, respectively.

The meta-analysis for the Sequoia and Kings Canyon study area covered 132 mi<sup>2</sup> during 1991 to 2000. The resulting mean  $\lambda$  estimate was 0.984, but was not statistically different from that of a stationary population. A significant quadratic trend (decline, then increase) was detected for annual  $\lambda$  estimates, but adult apparent survival showed no substantive variation or trends through time. A linear trend could not be identified in fecundity estimates, as fecundity was highly variable through time. Apparent survival for the Sequoia and Kings Canyon study area was significantly higher (0.877) than that of the other study areas combined (0.819).

Lambda estimates using the projection matrix approach and Pradel's method suggest stationary population trends, and actual owl numbers do not show declines. Trend in annual  $\lambda$  estimates also does not show a decline, and apparent survival in this study area was higher than all other study areas examined in this finding. Based on these results, and considering the inclusion of the juvenile survival rate from another study area, we cannot conclude that this population is declining.

**San Bernardino Study Area**—The San Bernardino study area was located entirely within the San Bernardino National Forest, and comprised all suitable habitat for spotted owls within the mountains. Surveys covering approximately 200 mi<sup>2</sup> (Big Bear study area) began in 1987, but were expanded in 1989 to cover the entire San Bernardino Mountain range (approximately 730 mi<sup>2</sup>; San Bernardino Mountains study area; Gutiérrez *et al.* 1999). This study area was unique in that it exists in southern California as a relatively isolated population (Gutiérrez and Pritchard 1990, LaHaye *et al.* 1994). Higher elevations in the study area contained forested habitat suitable for spotted owls, while lowland areas of unsuitable desert scrub and chaparral habitats surrounded and isolated the higher peaks (Noon and McKelvey 1992). Early projection matrix studies using four, five, and six years of data estimated significant annual declines during years between 1987 and 1993 ( $\lambda = 0.769, 0.827$  and  $0.860$ , respectively; LaHaye *et al.* 1992, Noon *et al.* 1992, LaHaye *et al.* 1994). The annual rate of population change for the most recent report we possess was estimated to be 0.91 based on 11 years of data (1988 to 1998; LaHaye *et al.* 1999). This estimate was significantly less than that of a stationary population, and suggested that the territorial female owl population declined nine percent annually from 1988 to 1998. Over the 11-year study period, this rate of decline would translate to a loss of over 60 percent of the population.

Although all forested habitat within the San Bernardino Mountains study area (including unoccupied habitat) was surveyed (Gutiérrez 2001), survey effort increased during the study period. In 1989, 532 total surveys were conducted, whereas in 1998, 1,185 total surveys were conducted (LaHaye *et al.* 1999). This change in survey effort could cause the number of owls observed in any year to be a function of the survey effort instead of an actual trend in numbers. Thus, there is a high likelihood that an assessment of actual owl numbers through time could be biased, and may not accurately represent the true population size in any given year.

The meta-analysis for this study area included 8 years of sampling (1991 to 1998) and encompassed 730 mi<sup>2</sup>. The mean  $\lambda$  estimate for this study area was less than 1.0 (0.978), but was not statistically different from that of a stationary population ( $\lambda = 1.0$ ). Examination of annual  $\lambda$  estimates showed a weak (nonsignificant) decline, and as with all other study areas, adult apparent survival showed no