

corroborative data and analyses before concluding that a population is declining. Our following discussion of the results from each of the five study areas will include evaluation of potential error in the lambda estimate that might result from these factors.

More recently, the data from the five study areas were reanalyzed using another statistical method. In 2001, owl researchers from the five California spotted owl study areas, timber industry consultants, and stakeholders met with experts in population analyses to conduct a meta-analysis of the available data (Franklin *et al.* 2002). The term meta-analysis refers to the combined analysis of data collected from numerous studies to increase sample size and investigate relationships that would be difficult to assess with data from an individual study. A draft report authored by 15 participants (Franklin *et al.* 2002) summarized the results of the five-day meta-analysis workshop and subsequent analysis.

It is our understanding that, as of the publication of this finding, peer review comments have been received by the authors of the meta-analysis, but the incorporation of peer review comments by the authors has not been completed. Thus, the meta-analysis manuscript remains a draft. We have examined the draft meta-analysis document, the comments of prominent peer reviewers, and solicited comments from the authors regarding our conclusions herein. We regard the draft meta-analysis as the best available science on the subject, but as stated above, we have not relied solely on this analysis in developing our conclusions regarding population trend.

The meta-analysis of adult survival was based on female and male adult capture histories for the five study areas, but fecundity was estimated for each study area separately because differences existed in field sampling protocols. To eliminate a possible bias in projection matrix estimates of λ due to inaccurate rates of survival (resulting from unknown emigration rates), a new technique was used to calculate λ , called the "temporal symmetry capture-recapture model" (Pradel 1996). Pradel's method calculates the rate of change in population size between two successive years using mark-recapture histories for each owl, and since this technique calculates annual estimates, λ can change each year. In contrast, the projection matrix method calculates an average λ estimate for the period of study using a population's average birth and death rates. Pradel's measure applies to subadult and adult territorial owls, and incorporates birth, death,

emigration, and immigration rates. Estimates of juvenile survival are unnecessary because movement of spotted owls into and out of the study area is considered in changes of owl numbers over time.

While Pradel's λ accounts for permanent emigration of juveniles, it doesn't provide insight as to the root cause of a population's rate of change. For example, if $\lambda = 1.0$, indicating a stable population, it is impossible to know if the stability is a result of immigration or new recruits from births, which prevents inferences about the health of the local population (Franklin *et al.* 2002). Thus, it is important that trends in survival and fecundity rates be examined concurrently with assessments of λ . Pradel's λ provides information as to whether owls are being replaced from within or outside the study area, and not solely whether they are replacing themselves, which is the goal of the projection matrix approach. Because the Pradel method provides an estimate of one λ for each year, the annual λ estimates can themselves be assessed for trends, and a mean estimate can be calculated for the period of study.

Franklin *et al.* (2002) applied the Pradel method to each of the five individual study areas, and conducted a combined meta-analysis of the results from the four study areas (Lassen, Eldorado, Sierra, and Sequoia / Kings Canyon) that lie in the Sierra Nevada. The following discussion details the results of the earlier projection matrix analyses and reports of basic count data for each study area, and compares those results with the new results derived using the Pradel method, as reported by the draft. Following the discussion of individual areas, we will describe the results of the meta-analysis of the four combined Sierra Nevada study areas.

Since survey areas changed throughout the course of some studies, only those areas (within larger study areas) that received surveys from start to finish were included in the new analysis, and only years that received consistent survey effort were used in the analysis (Lassen study area [490 mi²]: 1992 to 2000; Eldorado study area [137 mi²]: 1990 to 2000; Sierra study area [137 mi²]: 1990 to 2000; Sequoia and Kings Canyon study area [132 mi²]: 1991 to 2000; San Bernardino study area [730 mi²]: 1991 to 1998).

In this review, we primarily used the most recent report or published article for each area, although we reference earlier reports to clarify apparent changes in results for a given area. We summarize the results below.

Lassen Study Area—The Lassen study area encompassed approximately 850 mi² in northeastern California, the majority of which was located in the Lassen National Forest. Small segments of the study area included the Plumas National Forest, private timber lands, Lassen Volcanic National Park, and Bureau of Land Management land. According to Blakesley and Noon (*in litt.* 2003), four lines of evidence suggest that the Lassen population has been decreasing. However, this information, received very recently, could not be fully evaluated. The most recent publication for this study area (Blakesley *et al.* 2001) covered 10 years of field sampling (1990 to 1999), during which the annual rate of population change was estimated to be 0.910 using the projection matrix method. This estimate was significantly less than that of a stationary population ($\lambda = 1.0$), and suggested that the territorial female owl population (those females that occupy and defend a habitat area) declined 9 percent annually from 1990 to 1999. Blakesley *et al.* (2001) inferred that if the conditions present during their study remained constant into the future, and if the true rate of change were as low as 4 percent instead of the estimated 9 percent, that the population would decline by one-half within 20 years. Such forecasting beyond the period of data collection is unreliable, and the accuracy of this projection is likely biased, as conditions are unlikely to remain constant for 20 years (Burnham *et al.* 1996, Raphael *et al.* 1996, Noon *et al.* 1992).

We were unable to compare the estimated value of λ to the observed numbers of territorial adults in this study, because the survey area increased over time. However, from the estimated growth rate of 0.910, we can conclude that over 50 percent of the population would be lost by the end of the study. According to Blakesley and Noon (*in litt.* 2003), within 68 territories surveyed consistently from 1993 to 2001, the number of female owls declined from 56 to 37. This suggests a decline of 5 percent annually, which is not statistically different from the 9 percent decline estimated above. A potentially large source of error arises from unknown rates of juvenile and adult emigration. Blakesley *et al.* (2001) suggested that while incorrect juvenile emigration rates may have resulted in a survival estimate biased low, the magnitude of the bias was probably small. For the Lassen population to demonstrate a stationary trend during the study period (given that all other vital rates were accurate, including an