

reproductive output were positively correlated with the proportion of habitat surrounding each nest that was selected by the owls throughout the Sierra Nevada, as described by Gutiérrez *et al.* (1992). Nest success was positively associated with the presence of large trees within the nest stand.

Verner *et al.* (1992b) reported that about 75 percent of the California spotted owls in the Sierra Nevada occurred in areas where the northern flying squirrel was the primary prey species. Northern flying squirrels have been shown to be most common in larger stands of mature forests (Williams *et al.* 1992). Flying squirrels typically use older mature forest because they provide suitable nest sites, including snags, and abundant sources of food including arboreal lichens and truffles, which are associated with an abundance of soil organic matter and decaying logs (Verner *et al.* 1992b). In second-growth forests in Oregon, northern flying squirrels were found in younger forests if large snags and down logs remained from earlier stands (Carey and Peeler 1995). Thus, past selection harvest that removed the largest trees and snags probably did not favor northern flying squirrels, and, therefore, probably had negative effects on foraging by California spotted owls.

Blakesley (2002a, pers. comm. 2002) studied California spotted owls in an area where northern flying squirrels (*Glaucomys sabrinus*) comprised 70 to 80 percent of prey taken. She found that both survival and reproductive output were positively related to the proportion of the home range that was comprised of habitat selected by owls. Furthermore, site occupancy and reproductive output were negatively associated with the amount of non-habitat (non-forest and areas dominated by small trees and/or very low canopy cover).

In areas where the primary prey consists of dusky-footed woodrats, effects of timber harvest, either by selection or small patch cuts, may have been less severe on spotted owl prey. Dusky-footed woodrats are more abundant in shrubby areas than in areas with little shrub understory (Williams *et al.* 1992), so this forage species may persist in harvested areas, at least at the lower elevations where it is more common. Franklin *et al.* (2000), who studied demographic performance of northern spotted owls in an area of northwestern California where dusky-footed woodrats were the primary prey, reported that adult owls with access to larger blocks of suitable forested habitat had slightly lower mortality rates, but those with home ranges that were more

patchy with more openings had slightly higher fecundity (number of young produced per breeding female). A landscape pattern with some small patches of other habitats dispersed within and around a main patch of old forest appeared to provide the optimum balance in promoting both high fecundity and high survival. It seems likely that California spotted owls would have similar responses in the minority of their range where dusky-footed woodrats are the primary prey and thus may be less affected by habitat modification in those areas.

According to McKelvey and Johnston (1992), clear-cutting was the predominant harvest method on Sierran national forests only from 1983 through 1987. In areas where clear-cutting occurred during those years, and perhaps also where catastrophic fire has eliminated forested habitat, it may be reasonable to evaluate impacts based on studies of the effects of clear-cutting on the similar northern spotted owl. Bart (1995b) examined the relationship between amount of a northern spotted owl pair's home range that is suitable habitat and productivity and survivorship of owls. In Bart's (1995b) study area, habitat remaining after harvest was either of good quality (*i.e.*, remaining old growth) or very poor quality unsuitable for extensive use by owls (clear cuts). That analysis suggested that removing any suitable habitat within the vicinity of the nest tends to reduce productivity and survivorship of resident owls. Bart concluded that replacement rate reproduction might occur when 30 to 50 percent suitable habitat is retained within an owl's home range. However, he also noted that productivity and survivorship declined steadily below 80 percent suitable habitat and advised that northern spotted owl habitat should not be reduced to perceived thresholds in all instances or viability could be compromised. The primary form of habitat modification in the Bart (1995b) analysis area was clear-cutting. Therefore, these results may only have limited application to the California spotted owl, because much of the range of the California spotted owl has been selectively harvested. The selection harvest practiced in the Sierra is believed to have lowered habitat quality by removing large trees and snags, but it may not have rendered habitat completely unsuitable (USFS 2001a). Thus, the degree of impact of past selection harvest practices on California spotted owls remains unclear.

Spotted owl distribution in the Sierra Nevada is generally continuous and of uniform density within the historic

range. However, several "areas of concern" were identified in Beck and Gould (1992). These are areas where densities of spotted owls are low, local populations are isolated, or distribution of habitat or owls is not continuous or is restricted because of past timber harvest, fire, and natural breaks in habitat. Areas of concern might be important if the range of the spotted owl begins to shrink. Beck and Gould (1992) identified 16 areas distributed throughout the range where there are gaps that delineate discontinuities in owl distribution (no habitat exists or there is a bottleneck) and 19 areas where concern relates to low population density, fragmented habitat, or loss of habitat due to fire.

The USFS (2001a) further cautioned that management in at least nine of these areas of concern in the Sierra Nevada could have disproportionate impacts to spotted owls without special management consideration. USFS noted that areas of concern that fall within checkerboard ownerships (blocks of private land interspersed with Federal lands) or fragmented habitats warranted special attention. Final management direction selected by the USFS-modified alternative 8 (USFS 2001b) included objectives for the amounts of habitat within each owl home range to provide for replacement rate reproduction.

#### Demographic Analysis

As one of the most intensively studied birds in the United States, the spotted owl has been the focus of research for well over two decades. Many sophisticated statistical techniques for estimating population trends have been developed and refined using data from the northern spotted owl, and the state of information for the California subspecies has benefitted accordingly. Across the range of the California spotted owl, five study areas (Lassen, Eldorado, Sierra, Sequoia-Kings Canyon, and San Bernardino), totaling about 2,200 square miles, have been established to examine the subspecies' population status. This research serves as a valuable resource for evaluating whether or not listing under the ESA may be warranted. In this section, we offer a synopsis and evaluation of the most current research on California spotted owl population trends. Because analytical techniques for assessing population status are complex, it is necessary to discuss the techniques, the studies, and their conclusions in some detail.

Several analytical methods have been applied to the analysis of population trend in spotted owls, and each method carries certain strengths and