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III. Biological Data for Species Covered by the HCP

A. Northern Spotted Owl

Species Ecology/Literature Review

INTRODUCTION

The northern spotted owl (*Strix occidentals caurina*) occurs in the Pacific coastal region from British Columbia to Marin County, California. Research during the past two decades indicates that spotted owls are strongly associated in much of their range with late successional and old-growth forest habitats. The spotted owl also occurs in some younger forest types where the structural attributes of older forests are present. The U.S. Fish and Wildlife Service listed the spotted owl as a threatened species in June 1990, based on the reduction of the owl's preferred habitat throughout its range (Federal Register v. 55, p. 26114-94). The state of Washington has listed the northern spotted owl as endangered.

The federal Northern Spotted Owl Recovery Team (hereafter referred to as the Recovery Team; for a description of its purposes, see the section in chapter II on the Final Draft Recovery Plan for the Northern Spotted Owl) adopted a modified version of the physiographic provinces described in Franklin and Dyrness (1973) to describe the range of the northern spotted owl. Physiographic provinces are defined by the physical and environmental factors that influence ecological characteristics of the landscape. This section will refer to the Recovery Team provinces for descriptive purposes. (See Map III.1.)

There is a separate discussion on ecology and threats to population for the northern spotted owl on the Olympic Peninsula because a separate conservation strategy is proposed for spotted owls in the Olympic Experimental State Forest Planning Unit on the west side of the Olympic Peninsula and the majority of knowledge of spotted owl ecology and population biology in Washington derives from studies conducted on the Olympic Peninsula. The objectives of that discussion are to review and discuss life history, population ecology, and threats to population persistence of the spotted owl as they relate to its conservation in the Olympic Experimental State Forest.

PHYSICAL CHARACTERISTICS AND BEHAVIOR

The northern spotted owl is a medium-size dark brown owl that has round to elliptical white spots on the head, white mottling on the body and abdomen, and white bars on the tail (Johnsgard 1988). It can be distinguished from other owls by its dark brown eyes surrounded by lighter brown facial disks. It differs from a close relative, the barred owl (*Strix varia*), by the presence of spots on the head and chest as compared to the vertical barring on the chest of barred owls.

Age and Sex Characteristics

Spotted owls have an average life span of eight years (Thomas et al. 1990). Juvenile spotted owls (age one day to five months) can be distinguished from older owls by the presence of pale brown downy feathers (Forsman 1981). As juveniles grow, the amount of down plumage decreases. At approximately five months, juveniles acquire adult-like plumage, but they have white, sharp-tipped tail feathers (Forsman 1981). Subadults between the ages of one and two years retain a downy tuft at the tip of their still-white tail feathers; the tuft is lost sometime after the first year (Moen et al. 1991). Spotted owls are considered adults at 27 months, at which time their tail feathers become rounded and mottled brown.

The easiest way to distinguish males and females is by voice, since their plumage is very similar (Forsman et al. 1984). Male vocalizations are generally lower pitched than female vocalizations. There is also a difference in size, with females being larger than males (reverse sexual dimorphism) (Blakesley et al. 1990 p. 323).

Foraging

Northern spotted owls are adapted to nocturnal hunting through exceptionally good eyesight and hearing and through modified feathers that facilitate silent flight (USDI 1992b p. 18). Spotted owls hunt opportunistically during the day. Typical hunting behavior consists of perching on a branch and locating potential prey by sight or sound, then pouncing on and capturing prey with their talons (USDI 1992b p. 18).

Spotted owls rely on small mammals for most of their diet, although they also eat birds and insects. Significant prey species in terms of biomass (weight) and frequency of capture are flying squirrels (*Glaucomis sabrinus*), wood rats (*Neotoma fuscipies* and *N. cinera*), mice (*Peromyscus* spp.), red tree voles (*Arborimus longicadus*), and rabbits (*Sylvilagus* spp.). Red-back voles (*Clerthrionomys californicus*) can be important south of the Columbia River (Forsman et al. 1984; Thomas et al. 1990; Carey et al. 1992). Two or three small mammal species generally comprise the majority of prey biomass for spotted owls in an area (Solis 1983; Forsman et al. 1984). On the Olympic Peninsula, however, Carey et al. (1992) found that spotted owls depend primarily on flying squirrels. Regional variation in diet is apparently based on habitat and distributional limits of the prey species (Forsman et al. 1984; Thomas et al. 1990, Appendix J; Carey et al. 1992).

Reproduction

Spotted owls form long-term pair bonds. Reproductive activity begins in the late winter when pairs begin to roost together on a regular basis. Commitment to nesting depends on the condition of the female, ability of the male to obtain sufficient food, and availability and abundance of prey. Spotted owls nest in existing structures such as cavities, broken tree tops, or platforms. (See section on habitat characteristics below.) Eggs are laid during early spring. Clutch size in spotted owls is small — one to two eggs is normal. Occasionally a female will lay three eggs. The female incubates the eggs for approximately 30 days, during which time the male's primary responsibility is to provide her with food (Forsman et al. 1984).

Owlets remain in the nest for three to five weeks after hatching (USDI 1992b p. 31). They typically leave before they are able to fly by hopping onto adjacent branches or the ground. Juvenile owls depend on their parents for food until they disperse in September or October. Dispersal of the young signals the end of the reproductive cycle (Gutierrez et al. 1985; Miller and Meslow 1985; Miller 1989). Members of a pair then separate for the winter.

During nesting season, a reproductively active pair of spotted owls defends a functional territory through vocalizations and visual displays. Breeding owls, especially males, are more likely to respond to actual or mimicked owl calls than are non-breeding or single birds (Thomas et al. 1990). A functional territory is the area where habitat conditions are sufficient for survival and reproductive replacement of the pair. Territories are thought to be smaller than home ranges, though the exact relationship is not known (USDI 1992b p. 20).

Nesting Success

Reproductive success for spotted owls varies widely by geographic region and over time (Forsman et al. 1984; Gutierrez et al. 1984; Carey 1985; Franklin et al. 1990; Lutz 1992; LeHaye et al. 1992). Initiation of nesting varies from 40 to 60 percent of pairs (Federal Register, v. 55, p. 7). Success of nesting within a population of sampled individuals can vary from 0 to 100 percent (USDI 1992b p. 31).

Survival

Survival rates for juvenile owls vary, but generally are low (Gutierrez et al. 1985; Miller 1989). Juveniles are vulnerable to predation and starvation during dispersal due to lack of cover when travelling in open areas, inexperience at evading predators, and inexperience in obtaining food (Forsman et al. 1984; Miller 1989). Survival rates for subadults and adults are generally higher than for juveniles. Burnham et al. (1994) summarized survival rates for spotted owls from 11 study sites in California, Oregon, and Washington. Survival rates are estimated from capture/recapture studies of banded animals (Burnham et al. 1987; Lebreton et al. 1992). Estimated mean annual juvenile survival rates for the 11 study areas was 0.258 (standard error[1], se = 0.36) and ranged from 0 to 0.418. Mean annual survival rates for adult spotted owls was 0.844 (se = 0.005) and ranged from 0.821 to 0.868 (Burnham et al. 1994 p. 16).

Home Range

Home range for a species is generally defined as the area used by the animal and to which it exhibits fidelity (USDI 1992b p. 26). Spotted owl home range sizes vary geographically. Median annual home ranges in Washington are largest on the Olympic Peninsula at 14,232 acres (Hanson et al. 1993 p. 19). The Final Draft Recovery Plan reported median annual home ranges in the eastern Cascades and western Cascades provinces as 7,124 acres and 6,657 acres respectively (USDI 1992b p. 27). Hanson et al. (1993) reported median annual home ranges of 6,609 acres and 8,205 acres for the eastern and western Washington Cascades respectively. The smallest observed home range in Washington is 2,969 acres in the western Washington Cascades (Hanson et al. 1993 p. 20).

Gutierrez (in USDI 1992b) summarized the generalizations that can be derived from recent studies about home range characteristics. First, initial observations by Forsman (1980) about the large size of spotted owl home ranges have been confirmed. Second, there is a large degree of overlap between members of the same pair (Forsman et al. 1984; Solis and Gutierrez 1990) and less overlap among adjacent pairs. Carey (1985) speculated that the degree of home range overlap can be affected by forest fragmentation in the landscape. Later research confirmed this hypothesis (Carey et al. 1992). Third, there is much geographic variation in home range size (Thomas et al. 1990; Carey et al. 1992). Fourth, home range size increases as the amount of old-growth forest in the home range decreases

[1]Standard error (se) is a measure of variability. A larger standard error indicates greater variability. Standard error generally decreases with larger sample size.

(Forsman et al. 1984; Carey 1985; Thrailkill and Meslow 1990). Data about the amount of late successional habitat in annual home ranges summarized by Hanson et al. (1993) corroborated this finding for the Olympic Peninsula but not for the western Washington Cascades.

In addition to the above studies on home range characteristics, Lehmkhul and Raphael (1993) found that most measures of spotted owl habitat patterns (total amount, patch size, measures of fragmentation) in home ranges were similar to patterns found in 8,035-acre circles around owl activity centers on the Olympic Peninsula. Measures were less similar for 2,008-acre circles and for 18,080-acre circles. Lehmkhul and Raphael also suggest that 8,035-acre circles contain habitat that is in smaller, more isolated patches than actual home ranges and that circles will more closely approximate home ranges where habitat is distributed across the landscape in regular patterns (Lehmkuhl and Raphael 1993 p. 312).

The variables responsible for geographic differences in home range size are not well understood. Many factors, such as food availability, interspecific competition, and amount and arrangement of suitable habitat, probably contribute to observed variation in home range size (USDI 1992b p. 26).

Dispersal

Juvenile spotted owls must disperse from their parents' home range to establish their own home range and engage in reproductive activity. Adults may also disperse to new home ranges if they have been displaced by logging or by a competing barred owl or if the other member of a pair has died. The dynamics of adult dispersal are much less understood than for juveniles. Successful dispersal of juvenile and displaced adult spotted owls is an important mechanism for recolonizing unoccupied habitat and replacing breeding members of the population, which, in turn, are important for population recovery and maintenance (Thomas et al. 1990 p. 303).

Researchers have used radio telemetry to study patterns of juvenile owl dispersal in Oregon and California. Dispersal generally begins between mid-September and mid-October, and direction of dispersal from the nest area appears to be random (Gutierrez et al. 1985; Miller 1989). Straight-line travel distance for the first autumn was between 9 and 30 miles (Gutierrez et al. 1985; Miller 1989). Guitierrez et al. (in USDI 1992b p. 34) used reobserved banded owls to determine dispersal distance for juveniles that survived to establish their own territories. These distances averaged 4 miles for juvenile males and 12 miles for juvenile females.

Radio-telemetry data for dispersing juveniles in Washington was collected in 1991 and 1992, and comes from three studies, one each on the Olympic Peninsula, the Wenatchee National Forest in the eastern Washington Cascades and the Yakama Indian Reservation. Mean dispersal distance for juveniles on the Olympic Peninsula was 15 miles (number in sample size, $n = 31$, $se = 1.22$), maximum distance 36 miles (Washington Forest Practices Board 1995 p. 23). In the eastern Cascades, mean distance was 15.1 miles ($n = 80$, $se = 1.22$), and maximum distance was 76 miles. On the Yakama Indian Reservation, mean dispersal distance was 22.2 miles ($n = 7$, $se = 5.29$), and maximum dispersal distance was 54 miles (Washington Forest Practices Board 1995 p. 23).

Knowledge of dispersal behavior and habitat is crucial for designing conservation strategies for the spotted owl (Thomas et al. 1990). The distance between areas of suitable nesting, roosting, and foraging habitat should not exceed the distance that most successfully dispersed juveniles are known to have traveled (Thomas et al. 1990). The structure of dispersal habitat is discussed below.

Interspecific Relationships

The spotted owl's main competitor for resources is the barred owl. Barred owls have colonized the Cascade Range and Olympic Mountains in the past 50 years, probably in response to forest fragmentation across the landscape. Barred owls have been reported to be dominant in their interactions with spotted owls and have displaced spotted owls from nests at some sites (USDA 1988; Hamer et al. 1989). Where spotted owls and barred owls co-exist, barred owls reduce the amount of habitat available to spotted owls by using similar structures for nests and pursuing some of the same prey.

Hybridization (breeding between different but related species) is occurring between spotted owls and barred owls. Hamer et al. (1994) reported that a hybrid owl successfully reproduced with a barred owl in at least two breeding seasons. Hybridization appears to be a rare occurrence, given the proportion of known hybrids to known breeding pairs of spotted owls. If hybridization were to become more extensive, however, the genetic integrity of the spotted owl population could be threatened (Thomas et al. 1993; Hamer et al. 1994).

The main predators of spotted owls are thought to be great horned owls (*Bubo virginianus)* and northern goshawks (*Accipiter gentilis)* (Forsman et al. 1984; Miller 1989; USDI 1992b). Spotted owls are known to nest in goshawk territories and to defend their nests against goshawk attacks (USDI 1992b p.21). Great horned owls appear to occupy more fragmented habitats than do spotted owls (Fredrickson et al. 1990; Johnson 1993) and thus probably prey more frequently on spotted owls when the latter's habitat becomes more fragmented or when juvenile spotted owls are dispersing through younger, more open forests (Forsman et al. 1984). The Recovery Team reported that 40 percent of 91 adult or subadult owls and 25 percent of 60 juvenile owls that were radio marked and then died between 1975 and 1991 were killed by other birds (USDI 1992b p. 46).

HABITAT CHARACTERISTICS AND SELECTION

Spotted owls use a variety of forest types and stand structures for nesting, roosting, and foraging throughout their range. Forest types include Douglas fir, western hemlock, mixed conifer, mixed evergreen, redwood, mixed Douglas fir and hardwood, evergreen hardwood, ponderosa pine, and western red cedar.

Spotted owls use existing structures for nests. Nesting habitat is generally found in mature and old-growth stands and contains a high degree of structural complexity. (See discussion below.) In older forests, spotted owls select cavities or broken-top trees more frequently than platforms (mistletoe brooms, abandoned raptor and gray squirrel nests, and debris accumulations) (Forsman et al. 1984; LaHaye 1988). In younger forests, they tend to use platforms more frequently (LaHaye 1988; Buchanan 1991).

Roosting habitat has characteristics similar to nesting habitat, i.e., high canopy closure, a multi-layered canopy, and large diameter trees. In the summer, spotted owls roost in shady spots and near streams. The multi-layered canopy helps owls regulate body temperature by providing various microclimates vertically throughout the canopy (Forsman 1980; Barrows 1981; Solis 1983; Forsman et al. 1984).

Foraging appears to occur in more varied habitat conditions than does nesting and roosting (Thomas et al. 1990). Within these variations however, foraging habitat is still characterized by high canopy closure and complex structure (USDI 1992b p. 24).

Current understanding of characteristics of suitable spotted owl habitat is derived from several types of studies. Bart and Earnst (1992) divide these studies into the following categories:

(1) structural characteristics of utilized habitat,
(2) amount and distribution of suitable habitat within home ranges,
(3) habitat selection for roosting and foraging,
(4) abundance of spotted owls in different habitats,
(5) demographic rates of spotted owls in different habitats, and
(6) studies of different resources needed by spotted owls.

Descriptions of habitat characteristics are best used in combination with correlational studies that determine habitat preference and the survivability of owls in different habitat types, and with functional studies that determine the specific resources of value to spotted owls in their preferred habitats. Any of these types of information in isolation gives an incomplete picture of habitat suitability (Bart and Earnst *in* USDI 1992b, Appendix B, p. 26). Thomas et al. (1990) provide a comprehensive review of spotted owl habitat studies; Bart and Earnst (1992) review new information made available since that 1990 study. The following summary discussion is derived primarily from Bart and Earnst (1992) and Thomas et al. (1990). More recent literature is also discussed.

Structural Characteristics

Spotted owls use sites with a high average canopy cover (greater than 70 percent) and which contain large live trees, down logs and snags (Thomas et al. 1990; Buchanan 1991; Hanson et al. 1993; North 1993). In studies that quantified structural characteristics, the average number of trees that have a specific diameter at breast height (dbh) was consistent, while the number of trees decreased as dbh class increased. Fewer large trees occurred in the eastern Washington Cascades province, eastern California Cascades province and in the western part of the California Cascades province than in other parts of the spotted owl range (Bart and Earnst 1992 p. 38).

Studies summarized in USDI 1992b that compared structural characteristics of utilized sites with those of old-growth forests found average snag density was similar for both. Average values for tree density, snag density, and canopy closure were similar in nesting, roosting, and foraging habitats. Spotted owls use stands dominated by conifers, with hardwood understories present in California, but largely absent in Washington and Oregon. Bart and Earnst (1992) caution that average values should be taken as that and not as a description of each site. Variations in canopy cover, numbers of large trees and snags, and composition of the understory occur in habitat actually used by spotted owls.

Amount of Habitat in Home Ranges

The large size of spotted owl pair home ranges and the amount of late seral stage forest the owls require account for the controversial character of spotted owl conservation. Thomas et al. (1990) summarized the amounts of old-growth and mature forest in spotted owl pair home ranges. (Because there can be extreme outlyers, calculating the median acreage has been found to be more reliable than considering average sizes.) Median acreages of mature and old-growth forest in the Olympic Peninsula and western Cascade province spotted owl home ranges are 4,579 and 3,281 respectively. Hanson et al. (1993) reported the median amount of late successional habitat in spotted owl pair home ranges as 3,827 acres on the Olympic Peninsula and 3,586 acres in the western Washington Cascades. In the eastern Washington Cascades, the median amount of suitable habitat in home ranges was 3,248 acres (Hanson et al. 1993). The median amount of mature and old-growth forest in home ranges varies from 615 acres in the Klamath province to 4,579 acres in the Olympic Peninsula province. Median amounts of old growth in home ranges were less than 1,000 acres in only two studies. Variation also occurred within provinces (Thomas et al. 1990 p. 195; Hanson et al. 1993).

Bart and Earnst (1992 p. 40) point out that the large variation in the amounts of late successional forest within home ranges poses problems for determining what habitat and how much to maintain around individual nest sites to allow for successful replacement of spotted owl pairs. Given that the large cluster reserve concept (Thomas et al. 1990; USDI 1992a and b; FEMAT 1993) is the approach that will be applied on federal lands (USDA and USDI 1994b), how much habitat to conserve around site centers is an issue for land owners and managers attempting to avoid take on nonfederal land by protecting individual nest sites. Some of the uncertainty could be resolved through additional studies that combine estimates of home-range size and amount of old growth within them with analyses of stand structure, viability assessments, and analyses of the functional components of preferred habitat within the home range (Bart and Earnst 1992 p. 41).

Habitat Selection

Gutierrez (in USDI 1992b p. 22-23) discusses habitat use versus selection and preference. Habitat use is determined by observation of an animal in a certain habitat type without defining the context of the observation. Habitat selection is the choice of a habitat or habitats directly available to the animal. Habitat preference is the choice of habitat or habitats that the animal would make if all habitat types were available to it. Several studies have shown that spotted owls select mature and old-growth habitat with a concomitant selection against young stands (Forsman 1980; Carey et al. 1990, 1992; Blakesley et al. 1992).

Several recent studies confirm earlier hypotheses that spotted owls select older stands that have a high degree of structural complexity for their nesting habitat. Most nests located on public land have been found in mature and old-growth forests (Forsman et al. 1984; LaHaye 1988). The proportion of late seral stage forests surrounding nests has been found to be significantly greater than in surrounding random sites in the area (Meyer et al. 1990; Ripple et al. 1991). Lehmkuhl and Raphael (1993) found that spotted owl pair locations had significantly more habitat composed of primarily late successional forest than did random sites. LaHaye (1988) and Buchanan (1991) found that nests were located in stands whose structure was more complex than that of the surrounding areas. Buchanan et al. (1993) also found that nest trees in the eastern Washington Cascades were significantly older than trees at randomly selected sites. These studies suggest that spotted owls select nesting habitat with certain characteristics.

An exception to the generally old age of nesting habitat occurs in eastern Washington where spotted owl nest sites are found in stands that are younger than nest stands in other parts of the spotted owl's range, including western Washington. Buchanan et al. (1995) found that the median age of forest stands in more than half of the 85 nest sites located for their study was 130 years. Median age of actual nest trees in their study area was 137 years (Buchanan et al. 1993). They concluded that the difference in age of the stands and trees between western and eastern Washington was due to regional differences in patterns of disturbance, climate, and tree growth (Buchanan et al. 1993 p. 5).

Spotted owl nest sites have been found in younger managed stands on private land. These sites tend to be in areas where there was some previous uneven-aged management or in areas with rapid tree growth that facilitates habitat development in a relatively short period. Nest sites on managed land retain some structural characteristics of old growth (Thomas et al. 1990). Gutierrez (in USDI 1992b p. 23) pointed out that (1) the health of spotted owl populations found on private ownerships cannot be ascertained because no critical demographic studies have been completed on them, and (2) the presence of breeding owls alone in managed stands does not establish that such habitat is capable of supporting a self-sustaining population.

Thomas et al. (1990) reviewed the literature about selection of habitat for roosting and foraging. Old-growth stands were consistently preferred for both activities in Washington and Oregon west of the crest of the Cascade range. Young stands, pole stands and other stands were consistently avoided. Selection of mature stands was varied. Most studies defined old growth as stands older than 200 years and mature stands as 80-200 years old and containing few canopy layers.

Bart and Earnst (1992) have summarized more recent data. They concluded that the criteria for habitat selection are less clear in California and in the Oregon portion of the Klamath province than in other areas. While Thomas et al. (1990) found that young forests (less than 80 years) were avoided by 55 percent of spotted owls and selected by only 3 percent, Blakesley et al. (1992) and Zabel et al. (1991) found no tendency for owls to avoid stands in the 11- to 21-inch dbh size class (roughly equivalent to the "young" category in Thomas et al. 1990). Blakesley et al. (1992) noted, however, that the small-size class stands in their study areas were produced by natural processes and contained diverse composition and complex structure. Thus selection rates may not apply to even-age managed stands of a similar size class (USDI 1992b, Appendix B, p. 42).

Abundance of Spotted Owls in Different Habitats

Thomas et al. (1990) found that spotted owl density increased with the amount of old growth in a landscape or study plot. Density was very low in landscapes dominated by stands that were 80 years old or less and that lacked old-growth characteristics. Thomas et al. (1990) also recognized studies that indicated the potential for suitable habitat to develop faster in coastal California redwood and mixed Douglas fir forests than in other portions of the spotted owl's range and that more research is necessary in this area. Bart and Forsman (1992) found on both a landscape scale (5,000 - 171,000 acres) and a home range scale (1,000-acre plots) that spotted owl density was significantly higher for areas with greater than 60 percent older forest than for areas with less than 20 percent older forest.

Demographic Rates in Different Habitats

Results of studies analyzing the relation between demographic rates and the amount of old growth in spotted owl nesting territories indicate that the proportion of territories with pairs and reproductive success declined as the amount of old growth declined (Thomas et al. 1990). Bart and Earnst

(1992 p. 47-49) analyzed data from Meyer's and Johnson's unpublished data and found that persistence of spotted owl pairs in territories increased with the amount of forest more than 120 years old. Persistence was defined as the "probability that an owl present in a circle at the start of a year would be found at that site the next year, given that the site was revisited the following year." The authors took persistence as a surrogate measure for adult survival. These results further corroborate the above-mentioned findings of Thomas et al. (1990) on spotted owl density. In contrast, however, Irwin and Fleming (1994) found no correlation between occupancy rates or reproductive success and the amount of late successional habitat within 2.1 miles of spotted owl nests in the eastern Washington Cascades.

In summary, descriptions of habitat used for nesting, roosting, and foraging have shown that these activities take place in older forest; correlational studies have shown that spotted owls prefer older stands for roosting and foraging. Some, though not all, studies have shown that reproductive success is higher for pairs that have more old growth in their home ranges; spotted owl density and adult persistence has also been demonstrated as correlated with increasing amounts of old growth (Bart and Earnst 1992 p. 26).

Dispersal Habitat

In order to disperse successfully, juvenile spotted owls need both sufficient cover to avoid predators and opportunities for foraging. Dispersal habitat as a category distinct from nesting, roosting, and foraging habitat is necessary, given the extent to which older forest habitat has been reduced and fragmented throughout the spotted owl's range. Evidence suggests that juveniles prefer mature and old-growth forests for roosting (Miller 1989) and that risk of predation during dispersal is high in open and fragmented landscapes (Forsman et al. 1984; Johnson 1993). In the current landscape, large areas exist between patches of suitable nesting, roosting, and foraging habitat that juvenile spotted owls need to cross to establish new territories. For the demographic and genetic stability of small sub-populations, juveniles must be able to move between clusters of territories; to do this, they also need to cross large areas of younger forests between large late successional habitat reserves (USDA and USDI 1994b).

The concept of dispersal habitat was first proposed in the Interagency Scientific Committee's report called A Conservation Strategy for the Northern Spotted Owl (Thomas et al. 1990). The idea of establishing specific stand conditions over a large area to facilitate movement of juvenile and non-territorial adults between areas of suitable nesting, roosting, and foraging habitat is based on radio-telemetry data that suggests juvenile owls disperse in random directions (Miller 1989). Thus linear, directional corridors are unlikely to be useful. The Interagency Scientific Committee's report recommended that forested federal lands between designated Habitat Conservation Areas be managed such that 50 percent of every quarter township have forest stands in which trees have an average dbh of 11 inches and at least a 40 percent canopy closure. (This is commonly referred to as the 50-11-40 rule.) The committee proposed this set of specific guidelines as a management hypothesis with the clear understanding that further research was necessary to establish its effectiveness (Thomas et al. 1990, Appendix R). No definitive research on spotted owl dispersal habitat has been published since this recommendation.

POPULATION VIABILITY AND DYNAMICS

Questions of how many spotted owl pairs and how much habitat are sufficient to prevent the species from going extinct are at the center of policy debates and conservation planning involving the northern spotted owl. Addressing these questions involves studies of population dynamics — how birth and death rates contribute to changes in size of the population over time. An understanding of population dynamics can then be used to analyze how large a population needs to be, and how its habitat needs to be distributed across landscapes, to persist over time. This is known as population viability analysis.

A viable population is one that is of sufficient size and distribution to be able to persist for a long period of time in the face of demographic variations, random events that influence the genetic structure of the population, and fluctuations in environmental conditions, including catastrophic events (Meffe and Carroll 1994). The northern spotted owl population currently exists in small sub-population units that are separated in some portions of its range by large areas of unsuitable habitat. The rate at which dispersing juveniles move among these small sub-populations to add to local breeding populations influences the overall likelihood that the whole population will persist. This is called metapopulation dynamics. Metapopulation dynamics are often influenced by the distribution of high quality habitat over the landscape. Areas of lower-quality habitat may function as sinks — areas that need regular immigration of individuals from other sub-populations to survive. Areas of higher quality nesting, roosting, and foraging habitat can often serve as source populations that are self-maintaining and that provide emigrants to sink areas (Harrison 1991; Meffe and Carroll 1994). Viability analyses for spotted owls attempt to take these dynamics into account.

Population modeling also requires data on demographic trends. Studies of recapture or re-observance of banded owls are used to estimate survival rates of juveniles, subadults, and adults (Burnham et al. 1987; Lebreton et al. 1992). These estimates combined with data on the number of females produced by breeding pairs (fecundity) can be analyzed to assess population trends (Anderson and Burnham 1992; Burnham et al. 1994). (For a discussion of the results of recent demographic analyses, see section below on status of and threats to the spotted owl.) Estimates of demographic trends can be used to get a picture of the current situation, but they cannot be used to project population trends into the future (Burnham et al. 1994; USDA and USDI 1994b, Appendix J3). Mathematical and spatial simulation models enhance population viability analyses (USDA and USDI 1994b, Appendix J3, p. 7).

Viability analyses for the spotted owl have used mathematical demographic-based models that do not take spatial arrangement of habitat and territories into account (Lande 1987, 1988), as well as map-based, spatially explicit simulation models (Doak 1989; Lamberson et al. 1992; McKelvey et al. 1993; Holthausen et al. 1994; Lamberson et al. 1994; Raphael et al. 1994).

Modeling efforts have led to several important insights about the factors influencing viability of spotted owl populations[2]. Lande (1987, 1988) used a non-spatial model of dispersal and territory occupancy to estimate the minimum amount of habitat needed to sustain a population of northern spotted owls in a large region. He concluded that if the total landscape (all ownerships) contained less than 21 percent suitable habitat, the population would eventually become extinct. Results from later models that incorporated spatial factors also concluded that sharp thresholds exist in the amount of nesting, roosting, and foraging habitat needed to support a viable spotted owl population (Doak 1989; Lamberson et al. 1992; Carroll and Lamberson 1993).

[2]For a discussion of the differences among these models, see Lamberson et al. (1994) and Appendix J3 in USDA and USDI 1994a.

The analysis by Lamberson et al. (1992) also indicated that another threshold response may occur if population density became too low. When territories become too sparse, the ability of spotted owls to find mates theoretically becomes an insurmountable barrier to maintaining replacement levels of reproduction.

McKelvey et al. (1993) and Lamberson et al. (1994) concluded that in addition to the overall amount of suitable nesting, roosting, and foraging habitat, spatial arrangement of habitat is a very important factor in influencing the persistence of spotted owl populations. These modeling efforts demonstrated that arranging suitable habitat to support large clusters of owls (20-25 pairs) rather than a dispersed arrangement of single territories increased population stability and reduced the potential impacts of random demographic events.

The model described by McKelvey et al. (1993) allows the effects of different management scenarios to be simulated over time. Raphael et al. (1994) used this model to compare the relative differences in effects on spotted owl populations of three alternatives described in the federal Supplemental Environmental Impact Statement (SEIS) on Management of Habitat for Late-Successional and Old Growth Forest Related Species within the Range of the Northern Spotted Owl. They demonstrated that population sizes and occupancy rates that resulted from their model runs were sensitive to assumptions made about juvenile, subadult, and adult survival rates used to set parameters for the model. One set of assumptions or "rule sets" resulted in declining populations for all scenarios modeled (No Cut, SEIS Alternative 1, SEIS Alterative 7, and SEIS Alternative 9, the preferred alternative); use of the other two rule sets resulted in populations that declined and then stabilized. The differences in actual alternatives were swamped by the use of different assumed survival rates for spotted owls (USDA and USDI 1994a, Appendix J3). The fact that results varied depending on assumed demographic rates indicates the need for solid demographic data to use as input in these models in order to achieve more realistic outcomes.

While spotted owl biologists have increased the ability of models to incorporate more realistic assumptions (Lamberson et al. 1994), the results of such models should not be viewed as real predictions of spotted owl population behavior. Holthausen et al. (1994) caution that results of their modeling experiment on the Olympic Peninsula should be viewed as "repeatable projections of sets of assumptions" (p. 45). In USDA and USDI (1994a), the authors view models as "one tool in evaluating wildlife populations and habitat, and do not replace sound professional judgement in decision making" (USDA and USDI 1994a, Appendix J3).

STATUS AND THREATS

The northern spotted owl currently inhabits areas within most of its historic range. However, its distribution has changed markedly from hypothesized historical distributions due to removal or alteration of nesting, roosting, and foraging habitat. Booth (1991) has estimated that more than 80 percent of the old growth that existed prior to European settlement of the Pacific Northwest had been logged by the early 1980s. While not all old growth is suitable habitat, this represents a substantial loss of potential suitable nesting, roosting, and foraging habitat. The Interagency Team responsible for writing the Environmental Impact Statement for the President's Forest Plan estimates that there are 7.4 million acres of suitable habitat left on federal lands throughout the spotted owl's entire range (USDA and USDI 1994a p. 214).

Spotted owl populations are sparse and small in British Columbia, the Oregon Coast Range, the western Washington lowlands province, and other low elevation areas. Local populations have been extirpated from the Puget Trough and Willamette Valley due to habitat loss from urbanization, logging, and agricultural development. Most of the remaining habitat occurs at mid to high elevations (between 2,500 and 5,000 feet) and on federal land.

There are approximately 4.1 million acres of potentially suitable spotted owl habitat on all ownerships in Washington. Approximately 490,000 acres of this is on DNR-managed lands (DNR GIS 1995).

The federal Northern Spotted Owl Recovery Team reported that there are approximately 3,602 known spotted owl pairs in Washington, Oregon, and northern California as of 1992 (USDI 1992 p. 39). Population estimates have been updated for the Olympic Peninsula (Holthausen et al. 1994) (see later discussion on spotted owls on the Olympic Peninsula), but similar efforts have not been undertaken in the rest of the spotted owl's range. The true population size is unknown. There are currently 354 spotted owl site centers that are either on or have a median home range radius (Hanson et al. 1993) that includes DNR-managed lands (WDFW Non-game Database May 1995a).

The Recovery Team identified 10 threats to existing populations of spotted owls. The severity of each threat varies by physiographic province. The most significant factor contributing to the overall decline of the species is loss of nesting, roosting, and foraging habitat to clear-cutting and other even-aged harvest methods (Thomas et al. 1990). Habitat loss also ranks as the most severe future threat to the spotted owl (USDI 1992a p. 41). The following description of threats has been condensed from the Final Draft Recovery Plan for the Northern Spotted Owl (USDI 1992a p. 41-48) and from the Report of the Scientific Analysis Team (Thomas et al. 1993).

Limited Habitat

Limited habitat poses a threat to spotted owls because productivity levels and occupancy decrease in areas with low proportions of suitable nesting, roosting, and foraging habitat (Bart and Forsman 1992). Areas with less than 20 percent habitat cover do not provide spotted owls with suitable habitat. The Recovery Team considered limited habitat to be a severe threat in provinces that had about or less than 20 percent suitable habitat by area. The northern portion of western Washington Cascades province and the entire western Washington lowlands province fell into this category. A moderate threat exists in provinces with 20 to 60 percent suitable habitat coverage. The rest of the Washington provinces fell into this category.

Population Decline

Rates of population decline are measured by analyzing birth and death rates (see USDI 1992b p. 44 and Appendix C; Thomas et al. 1993) or by using population density studies that examine actual changes in territorial owls per unit area over time (USDA 1992b p. 15). Anderson and Burnham (1992) summarized the results from a demographic analysis from five sites distributed throughout the spotted owl's range. The results indicated that female territorial spotted owls were declining at rates of between 6 and 16 percent per year at individual study sites. The average was 10 percent per year (Anderson and Burnham 1992). A demographic meta-analysis of the complete data set showed that, in addition to populations decreasing at individual study sites, female survival rates were declining at an increasing rate (Anderson and Burnham 1992).

The federal Scientific Analysis Team (Thomas et al. 1993) reported that the Anderson and Burnham (1992) study may have overestimated rates of population decline by assuming that undetected emigrants were dead when they may actually have been alive. The Scientific Analysis Team used a population density method to estimate rates of population decline from 12 study sites. They concluded the overall rate of decline to be 3.2 percent (Thomas et al. 1993 p. 180). Density studies are thought to result in underestimates of rates of population decline. The Scientific Analysis Team (Thomas et al. 1993) concluded that the real annual rates of population decline were somewhere between the results reported in both studies (p. 192).

At the prompting of a group of 14 scientists concerned with the viability of the northern spotted owl, the Clinton Administration directed Anderson, Burnham, and White (Burnham et al. 1994) to conduct an intensive analysis of all existing demographic data, which included new data since Anderson and Burnham's 1992 report. More than 50 specialists undertook the analysis during a 12-day workshop in December 1993 at Fort Collins, Colorado. They analyzed capture-recapture data from 1985-1993 for 11 large study areas. They used estimates of average age-specific survival probabilities and fecundity rates to calculate rates of population change. They estimated the population to be declining at a rate of 4.5 percent per year and found that the rate of population loss is accelerating. They also found that annual survival probabilities for adult females have declined significantly in the six study areas for which they had more than six years of banding data as well as in the other five areas for which they had shorter term records. They concluded that the population of resident territorial female owls is declining at both a biologically and statistically significant rate. This analysis was corrected for undetected emigrants, thus lessening potential underestimations of survival rates.

The discussion of the meaning of the results of this analysis is under way in the scientific community. Bart (1995) argues that Burnham et al. (1994) still underestimate juvenile and adult survival rates by not considering that spotted owls could move to portions of study areas that are inaccessible to researchers and thus go undetected. Holthausen et al. (1994) incorporate unpublished updated data for juvenile emigration from Forsman et al. in their estimates of annual vital rates on the Olympic Peninsula, which results in an estimated annual juvenile survival rate of 0.612 and estimated annual rate of population change of 1.058. Without this readjustment, the estimated rate of annual population change is 0.955. Holthausen et al. (1994) cite Forsman's caution that this adjusted juvenile emigration rate is based on data from only 35 owls and from only two years of study. Estimation of vital rates thus remains inexact and uncertain.

The Recovery Team ranked population decline as a moderate threat in the western Washington Cascades (north and south) and on the Olympic Peninsula. They considered population decline to be a severe threat in the western Washington lowlands and an unknown threat in the eastern Cascades (USDI 1992b p. 42).

Small Populations

Small populations of plants and animals are vulnerable to extinction through random fluctuations in environmental conditions (environmental stochasticity) and in age and sex structure of populations (demographic stochasticity) (USDI 1992b). Small populations can also suffer loss of genetic diversity, which reduces general fitness of the population (USDI 1992b).

The Recovery Team (1992b) considered small populations to be a severe threat in the northern portion of the western Washington Cascades, the Olympic Peninsula, and the western Washington lowlands and a moderate threat in the southern portion of the western and eastern Washington Cascades.

Distributions of Habitats and Populations

Local spotted owl populations and habitat can be unevenly distributed across the landscape. Clusters of spotted owl pairs can become isolated when surrounded by unsuitable habitat. These local populations then are vulnerable to the same fluctuations described above for small populations. Where clusters of spotted owls or patches of suitable habitat are separated by more than 12 miles of poor habitat, persistence of the clusters becomes increasingly unlikely (USDI 1992b p. 45).

Sparse population and lack of habitat distribution is considered a severe threat in the eastern Washington Cascades, western Washington Cascades (northern portion), and western Washington lowlands provinces; they are a a moderate threat in the southern portion of the western Washington Cascades and on the Olympic Peninsula (USDI 1992b p. 42).

Province Isolation

If provinces are separated by physical barriers or lack of suitable habitat, genetic interchange between sub-populations may be blocked. Isolated populations are also vulnerable to genetic, environmental, and demographic fluctuations. Immigration of a few individual spotted owls per generation is necessary for a local population to maintain genetic diversity. A higher rate of immigration may be necessary to counteract demographic imbalance (USDA 1992b).

The Recovery Team identified province isolation as a severe threat in the western Washington Cascades (north), Olympic Peninsula, and the western Washington lowlands provinces, and as a moderate threat in the eastern Cascades and the western Washington Cascades (south) (USDI 1992b). Subsequent analysis by Holthausen et al. (1994) suggests that province isolation may not be as severe a threat to the spotted owl population on the Olympic Peninsula as was previously thought.

Predation

The great horned owl, northern goshawk, red-tailed hawk, and common raven are documented predators of the northern spotted owl. Great horned owls are the most common predator (Miller 1989). This species occurs more frequently in highly fragmented landscapes than does the spotted owl (Anthony and Cummins 1989; Hamer et al. 1989; Johnson 1993). Thus predation by great horned owls is more of a problem in fragmented landscapes than in areas with relatively intact forest cover. Barred owls are starting to share the same range with spotted owls and tend to be dominant in spotted owl/barred owl interactions (Hamer 1988). While barred owls are not a direct predator, they have displaced spotted owls in some areas and are decreasing the amount of habitat available to spotted owls (USDA 1988; Hamer et al. 1989).

The Recovery Team did not feel there was enough information to assess the severity of the predation threat in either the eastern or western Washington Cascades (north and south). They considered predation to be a severe threat in the western Washington lowlands and a moderate threat on the Olympic Peninsula.

Vulnerability to Natural Disturbances

In an unfragmented landscape with abundant suitable habitat, loss of habitat from natural disturbance is generally not a threat to population viability. Given the highly fragmented pattern and reduced amount of the remaining suitable habitat, loss of habitat from fire, windthrow, or insect and disease infestation can pose a significant threat to spotted owls in certain areas. The Recovery Team determined that natural disturbance is a severe threat in the eastern Washington Cascades, a moderate threat in the Olympic Peninsula, and a low threat in the western Washington Cascades (USDI 1992b).

Spotted Owls on the Olympic Peninsula

LIFE HISTORY

Aspects of spotted owl life history that have been well-studied on the Olympic Peninsula and are important to the HCP proposal include reproduction, dispersal of juveniles, and survivorship of both adults and juveniles.

Reproduction

Average annual fecundity rates (numbers of female fledglings produced per female) of adult owls from 11 geographically distinct areas varied from 0.231 to 0.565; the median value was 0.323 (Burnham et al. 1994). Annual fecundity in the Olympic Peninsula study area was 0.380, or 0.76 young per pair per year. There is considerable annual variation in reproductive effort within and among sub-populations of spotted owls, and among individual owl pairs within years. For example, Forsman et al. (1984) observed nesting in 16-89 percent (mean = 62 percent) of pairs during a five-year study in Oregon. Annual variation in fecundity in seven geographically distinct areas with at least five years of study ranged from 0.3-13.4 percent (coefficient of variation, median = 5.6 percent, see Thomas et al. 1993, Table 4-3). Annual variation in fecundity of the Olympic Peninsula sub-population was third highest, c.v. = 10.2 percent. Reproductive rates of spotted owls on the Olympic Peninsula thus seem to be consistent with those observed elsewhere in the species' range, but annual variability in reproduction is relatively high.

Dispersal of Juveniles

Spotted owls leave their natal territories after their first summer. This dispersal appears to be innate (Howard 1960), and may function to maintain the species' distribution in available habitat and maintain genetic diversity among sub-populations (Howard 1960; Greenwood and Harvey 1982). Early studies of dispersing juvenile spotted owls used backpack-mounted radio-transmitters (Forsman et al. 1984; Gutierrez et al. 1985; Miller 1989) or relied on re-observations of owls banded as fledglings (Forsman 1992a) to track their movements and survival. These studies provided information on the directions and distances of movement, habitat associations, and survival. However, there is evidence that the relatively large, backpack-mounted radio-tags influenced survival (Paton et al. 1991) and reproduction (Paton et al. 1991; Foster et al. 1992) of adult owls (with the inference that they may have influenced behavior and survival of juveniles as well), and that emigration of banded owls from study areas causes underestimates of survival (Forsman 1992a). A discussion of juvenile survival is presented in the subsequent section on survivorship.

Dispersing juvenile owls in three study areas from the 1991 (Miller et al. 1992) and 1992 cohorts (Forsman 1992b) were radio-tagged with much smaller transmitters mounted on their tail feathers (a new system with presumably less effect on their behavior). These studies are beginning to provide important, additional information on habitat relationships, dispersal distances, rates of emigration, and survival probabilities. Data from these studies consist of relocations, estimated by triangulation, that were obtained at approximately weekly intervals mostly during the daytime, with less frequent, direct observations. They are probably suitable for descriptions of the general areas traversed and used by dispersing juveniles and descriptions of roost-sites but not for evaluating habitat use for foraging. Analyses are in progress, but it appears that the general trend is for dispersing juveniles to attempt to settle, at least temporarily, in areas that provide good habitat for nesting, foraging, and roosting by adult owls. Further analyses of these data may provide better insights as to cover types that provide habitat for dispersing spotted owls.

Preliminary estimates of first-year dispersal distances (15.12±0.98 miles) of 111 juveniles from the Olympic Peninsula and the east slope of the Cascades Range are similar to those reported by earlier radio-telemetry studies (Gutierrez et al. 1985; Miller 1989). Dispersal distances for 31 juveniles on the Olympic Peninsula ranged from 5.39 to 36.20 miles, and averaged 15.05±1.58 miles. In the four known cases of dispersal to and/or from DNR land in the Olympic Experimental State Forest, owls banded as fledglings were recaptured 9, 14, 18, and 30 miles from their natal sites as adult or subadult members of pairs.

Survivorship

Survival rates are estimated based on annual re-observation of banded spotted owls. Simulation modeling suggests that the survival rate of adult females is the aspect of spotted owl life history that most strongly influences rates of population change (Noon and Biles 1990). Estimates of adult female survival probabilities average 0.844±0.005 across the spotted owl's range, and 0.862±0.017 for the Olympic Peninsula sub-population (Burnham et al. 1994). While their meta-analysis of survival rates across the range of the spotted owl indicated that survival rates were declining, they found that these rates did not change during the study on the Olympic Peninsula. Survival rates for males may be higher; Forsman (1992b) estimated annual survival probabilities for Olympic Peninsula males at 0.893±0.026 for the period 1987-1992.

Estimates of both range-wide and Olympic Peninsula survival probabilities for juvenile birds are much lower (0.258±0.036 and 0.245±0.064 respectively; Burnham et al. 1994). However, those estimates are based solely on re-observations of birds banded as fledglings and are negatively biased because some juveniles emigrate from the study area or to non-monitored sites within the study area and are thus unavailable for re-observation (Burnham et al. 1994; Holthausen et al. 1994; Bart 1995a).

Burnham et al. (1994) used the average emigration rate (0.316±0.053) of 76 juvenile spotted owls that were monitored with radio-telemetry and survived one year to adjust their overall estimate of juvenile survival (averaged over all 11 study areas) to 0.377±0.060. But their analysis did not account for emigration of juveniles to non-monitored sites within the study area (Bart 1995a). Bart (1995b, Table 5) simulated juvenile dispersal to estimate a 21 percent rate of dispersal to non-monitored sites across those study areas and further adjust the juvenile survival estimate of Burnham et al. (1994) to 0.48 (Bart 1995a). Furthermore, Burnham et al. (1994) argued that they did not have area-specific estimates of emigration rates and thus could not derive area-specific, adjusted juvenile survival rates. But the emigration rate they used was derived by averaging over two study areas in which the estimates differ markedly (13/57 = 0.228 Roseburg, Oregon; 11/19 = 0.579 Olympic Peninsula; Burnham et al. 1994). These areas are profoundly different in the degree to which spotted owls are able to disperse from them to areas inaccessible to normal re-observation techniques. Roseburg is entirely commercial forest lands, accessible by road throughout, and surrounded mostly by other study areas. In contrast, almost half of the spotted owl habitat on the Olympic Peninsula study area is in Olympic National Park, which is nearly roadless and extremely difficult to survey for owls. No other study areas border the Olympic Peninsula. Thus, while Holthausen et al. (1994) correctly note that the area-specific emigration and adjusted juvenile survival estimates should be viewed with caution because few data (they studied 35 owls over two years, one of which had an exceptionally mild winter that may have favored juvenile survival) were used to derive them, there are some data and sound logic with which to develop an estimate of emigration (both within and outside of the study area) specific to the Olympic Peninsula. Holthausen et al. (1994) used data additional to that reported by Burnham et al. (1994) to estimate the emigration rate for the Olympics at 0.600±0.083. This results in an adjusted juvenile survival rate of 0.612±0.204, over two times the unadjusted estimate of Burnham et al. (1994). While neither this estimate of juvenile survival in the Olympics, nor Bart's (1995a) metapopulation estimate are conclusive, they suggest that survival rates may be substantially higher than the metapopulation estimate reported by Burnham et al. (1994).

POPULATION ECOLOGY

Trends in the population of spotted owls are extremely important to management decisions relevant to conservation of spotted owl habitat. Thus, analyses and interpretations of ongoing studies of spotted owl populations are closely scrutinized and are subject to considerable controversy. The review and discussion under the subheading Population Decline of these analyses, interpretations, and disagreements provides a good, general overview. A more detailed summary and discussion of findings from the Olympic Peninsula follows.

Population Estimates

The most up-to-date and rigorous estimate of the number of spotted owl pairs on the Olympic Peninsula was provided by Holthausen et al. (1994). They used three sources of data for their estimate: extrapolations from the Washington Department of Fish and Wildlife non-game database for DNR-managed, private, and tribal lands, a nearly complete inventory of territorial owls; extrapolations from nearly complete inventories of territorial owls conducted by the U.S. Forest Service PNW Research Station since 1987 in the Olympic National Forest (Forsman 1992a); and estimates of density for the Olympic National Park based on extrapolating from the density of territories located in randomly selected sample areas (Seaman et al. 1992). The density estimates for the park are the results of preliminary analyses, and await another year of fieldwork and further statistical analysis to refine the point estimate and develop confidence intervals for the estimate. Holthausen et al. (1994) used two sets of assumptions to develop two estimates for the numbers of spotted owl pairs on the Olympic Peninsula: a lower estimate derived by adding the known pairs (and, at least for DNR-managed lands, sites at which pairs had been observed in the past) on DNR-managed and Olympic National Forest lands to the estimated numbers in the Olympic National Park; and a higher estimate derived by adding the known pairs and other sites where spotted owls had been located but pairs not documented on national forest and DNR-managed lands to the estimated numbers in the park. They estimated 282 or 321 pairs of spotted owls on the Olympic Peninsula. These numbers are substantially higher than previously estimated; for example, Thomas et al. (1990) estimated a population of 177 pairs: 40 in the Olympic National Park (Table C2), 131 in the Olympic National Forest (W-38 in Table Q6), and six on state and private lands (W-37, 38 in Table Q6).

Population Trends

Burnham et al. (1994) used the estimates of survival and productivity reviewed above to estimate the rate of change in the population of resident female owls on the Olympic Peninsula. Changes in the population of resident female owls ultimately equate to those of the entire population because the resident females produce the juveniles that maintain the population. They estimated the annual rate of population change (±) for the Olympic Peninsula, using unadjusted estimates of juvenile survival, as 0.9472±0.0255 or an annual loss of 3-8 percent of the resident females (significantly less than ± = 1, a stable population). Their adjusted estimate of juvenile survival results in an estimate of ± = 0.9894, or an annual loss of 1 percent of the resident females (significance needs to be calculated). Holthausen et al. (1994) estimated ± = 1.058±0.065, or an annual change ranging from a 1 percent loss to a 12 percent increase (not significantly different from ± = 1), using their Olympic Peninsula-specific adjustment of juvenile survival rates. They advise that this estimate be interpreted with caution for the reasons noted in the discussions of juvenile survival.

THREATS TO POPULATION PERSISTENCE

This section reviews and discusses recent thoughts on significant threats to the viability of spotted owls on the Olympic Peninsula. Two original discussions are reviewed and compared, that of the interdisciplinary Northern Spotted Owl Recovery Team appointed by the Secretary of the Interior in February 1991 (USDI 1992a) and that of the Reanalysis Team (Holthausen et al. 1994), a team of U.S. Forest Service and National Biological Survey scientists. This review is important because the HCP proposal for the Olympic Experimental State Forest attempts to address the threats identified and discussed in those original reports.

Threats to Owls on the Olympic Peninsula

The Recovery Team (USDI 1992a) identified low population levels, poor population distribution, habitat loss, population isolation, and natural disturbances as major threats to owls on the Olympic Peninsula. Their estimate of population size was 200±25 pairs. They characterized the current distribution of spotted owls as a "doughnut", with owls largely restricted to the mid-elevation forests on mainly federal lands. Over half of the area of the northwestern Olympic Peninsula, 712,000 acres (Table III.1), is in younger forest cover or other open conditions; the great majority of this cover-type is the result of harvests of older forests within the past 40 years. The Recovery Team expected habitat loss to continue at high rates under management regimes then in use. Isolation of the Olympic Peninsula population from other reproductive owls can place the population at risk of extinction or inbreeding if catastrophic or stochastic events caused it to decline severely. Catastrophic fire and/or wind were predicted under a worst-case scenario to reduce the habitat capability up to 30 percent over 100 years (USDI 1992a).

Holthausen et al. (1994) used simulation analyses and other techniques to evaluate the risks to owls on the Olympic Peninsula, and they presented different interpretations of those risks than did the Recovery Team (USDI

Table III.1: Estimates of forest cover types on lands of different ownerships in the Olympic Experimental State Forest area, July 1991

Land cover estimated by supervised classification of Landsat Thematic Mapper scenes taken July 1991 (WDFW 1994c). Land ownership estimated from DNR's digital public lands map (DNR GIS 1995).

Landowner	Cover type	Total area (acres)	Percent of area[1]	Percent of cover type[2]
Olympic National Park	late seral[3]	216,137	16.5	59.1
	mid-seral[4]	16,298	1.2	18.7
	other[5]	143,857	11.0	16.8
Olympic National Forest	late seral	66,325	5.0	18.1
	mid-seral	15,434	1.2	17.7
	other	93,294	7.1	10.9
DNR-managed lands	late seral	52,150	4.0	14.3
in the OESF	mid-seral	20,990	1.6	24.1
	other	197,974	15.1	23.1
Other[6]	late seral	30,983	2.4	8.4
	mid-seral	34,293	2.6	39.4
	other	421,558	32.1	49.2
Total		**1,309,293**	**100**	

[1] The area within the cover type within the ownership class, divided by the total area described.

[2] The area within the cover type within the ownership class, divided by the total area within the cover type.

[3] Late-seral forests include old growth and large sawtimber.

[4] Mid-seral forests include small sawtimber.

[5] Other land cover includes pole, sapling, open canopy/mixed conifer, open areas (clearcuts, high-elevation barrens, towns, etc), water, cloud/shadow cover.

[6] Other lands include all private ownerships, tribal lands, DNR-managed lands outside the OESF.

1992a). They estimated a population size of 282 or 321 pairs, substantially greater than the estimate of the Recovery Team. Their evaluations of risk to the population posed by the spatial and ecological distribution of habitat generally concurred with those of the Recovery Team. Their simulations showed that maintaining all current habitat on all nonfederal lands on the peninsula increased the predicted numbers of pairs occupying sites on both federal and nonfederal lands by about 20 percent over simulations based on no nonfederal habitat, and they concluded that it was unlikely that owls would occupy coastal lowland forests in the Olympic Experimental State Forest area without habitat on nonfederal land.

The current plans for management of the Olympic National Forest have established large reserves in which owl habitat will be maintained and/or restored (USDA and USDI 1994b). In light of these management plans for federal lands, Holthausen et al. (1994) concluded that "...it is likely, but not assured, that a stable population would be maintained on portions of the Olympic National Forest and the core area of the national park in the absence of any nonfederal contribution of habitat." They also analyzed the potential impacts of establishing a significant (370,500 acres of high-quality habitat) connecting corridor between the southern Cascades and the Olympic Peninsula. They concluded that habitat conditions on the Olympic Peninsula were the most important factor determining the stability of the sub-population; in other words, isolation of the sub-population is not as serious a threat as the Recovery Team (USDI 1992a) thought.

Holthausen et al. (1994) evaluated the effects of a worst-case fire by simulating a complete loss of habitat in portions of the eastern and northern Olympic Peninsula that are at high risk of large-scale fires (33 percent of federal land on the peninsula, Holthausen et al. 1994, Figure 5). Their analyses suggested that the total area managed for habitat on federal lands is large enough that an otherwise stable population of spotted owls would be robust to a disturbance of this scale. They discussed but did not analyze the effects of a large-scale windstorm on the western peninsula in combination with the simulated fire loss. They concluded that such a scenario would cause significantly greater impacts to the peninsula owl population, but that the combination was extremely unlikely.

DNR's Survey Data

DNR's spotted owl surveys identify the distribution and presence of northern spotted owls on the landscape and reduce the possibility of violating the Endangered Species Act. Surveys also provide information on the patterns of spotted owl use on both local and statewide scales.

HISTORY

From 1985 through 1987, DNR personnel participated with the Washington Department of Wildlife and Olympic National Park staffs in surveying selected portions of Olympic National Park and DNR's Hoh-Clearwater Block on the Olympic Peninsula. In 1988 and 1989, DNR again conducted surveys on the Hoh-Clearwater Block. The results of these surveys were compiled into a report titled 1988-1989 Hoh-Clearwater Spotted Owl Inventory Project (Anthony and Cummins 1989).

In 1990, inventory surveys were continued in the Hoh-Clearwater Block and were also conducted in the Columbia River Gorge area of southwest Washington.

In 1991, DNR developed an agency protocol for surveying for spotted owls based on draft survey guidelines from the U.S. Fish and Wildlife Service. In the same year, DNR began surveying areas surrounding planned management activities in all DNR regions within the range of the spotted owl.

In 1992, the U.S. Fish and Wildlife Service endorsed the Protocol for Surveying Proposed Management Activities that May Impact Northern Spotted Owls (hereafter referred to as the USFWS Protocol). From 1992 through 1995, DNR conducted surveys according to the USFWS Protocol.

METHODS

The USFWS Protocol includes the Northern Spotted Owl Survey Protocol, which DNR follows strictly with the following EXCEPTIONS:

(1) Prior to the 1994 survey season, DNR surveyed all suitable spotted owl habitat located within a 2.2-mile radius around management activities west of Interstate Highway 5, including the Olympic Peninsula and southwest Washington; elsewhere in the state, DNR surveyed all suitable habitat within a 1.8-mile radius. In 1994, the U.S. Fish and Wildlife Service increased the 2.2-mile radius to 2.7 miles; however, the 1.8-mile radius stayed the same. The 1.8-mile and 2.7-mile radii are based on radio telemetry data showing that spotted owls have larger territories in some parts of the state than in others. In addition, DNR surveys an extra 0.1 mile (1.9 and 2.8 respectively) to allow for management activities that move slightly during the planning stages.

(2) The USFWS Protocol for Spot Calling requires projecting taped calls through a megaphone from predetermined locations (or stations) for 10 minutes per station. DNR has extended this time to 12 minutes per station so as to detect spotted owls that may be slow to respond.

(3) Some surveys may contain spotted owl habitat that cannot be accessed because of difficult terrain or inability to cross private ownership. When these situations arise, DNR and the Washington Department of Fish and Wildlife review each restriction to determine if surveys in the rest of the area will still provide reliable information about spotted owls on the landscape. Because access issues are not addressed in the USFWS Protocol, these restrictions necessitate a protocol departure. In most situations, additional survey efforts compensate for inaccessible habitat by adding extra stations along the edges of the restricted lands, extending calling to 20 minutes instead of 12, and, depending on the amount and shape of the inaccessible habitat, conducting as many as three extra visits within a 0.5- or 1.0-mile wide buffer around the area. These activities can be considered "reasonably consistent" with the USFWS Protocol Standards.

DATA REVIEW

Prior to 1993, the Washington Department of Wildlife reviewed DNR spotted owl surveys on a case-by-case basis as requested by DNR. In 1993, when DNR's spotted owl survey program was expanded significantly, the Washington Department of Fish and Wildlife indicated that DNR should conduct its own data review. DNR established a data review section in its Forest Resources Division, which reviews and evaluates spotted owl surveys using the Washington Department of Fish and Wildlife's Guidelines for Reviewing Spotted Owl Surveys (WDFW 1994a) to determine if individual surveys are reasonably consistent with the USFWS Protocol.

RESULTS

DNR's survey effort has gradually increased, from 53,000 acres of habitat surveyed in 1988 and 1989 to 329,000 acres surveyed in 1993 and 1994.

The Washington Department of Fish and Wildlife tracks all spotted owl detections and uses this information to locate site centers. As of the end of the 1995 survey season, there was a total of 344 site centers on or affecting DNR-managed lands (using the owl circle radii as defined in the USFWS Protocol). (See Table III.2.) Most of these site centers were classified as status 1 (providing habitat for a pair). However, three site centers have been changed to historic status (formerly occupied) according to Washington Department of Fish and Wildlife criteria because surveys for three consecutive years have failed to detect spotted owls at these sites.

Table III.2: Northern spotted owl site centers on or affecting DNR-managed lands as of the end of the 1995 survey season

(Source: WDFW Non-game database October 1995 for site centers; DNR GIS April 1995 for land base)

Status 1 - Pair status	217
Status 2 - Two owls, status unknown	11
Status 3 - Resident single owl	50
Status 4 - Status unknown	63
Status 5 - Historic status (formerly occupied)	3
Total site centers	**344**