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Title: A PRELIMINARY INVESTIGATION OF THE SPOTTED OWL IN OREGON

Abstract approved: E. Charles Meslow

Between 1970 and 1974, data were collected on the distribution and biology of the spotted owl (Strix occidentalis) in Oregon. One-hundred and sixteen pairs and seven single birds were located. Spotted owls occurred throughout the mountains of western Oregon and on the east slope of the Cascade Range at least as far east as Badger Butte, Hood River County; Abbot Butte, Jefferson County; and Swan Lake Point, Klamath County. The upper elevational limits of the species increased from about 1,350 meters in northern Oregon to 1,770 meters in southern Oregon. Although spotted owls were not uncommon in some areas, evidence indicated that the population was declining as a result of habitat loss.

A total of 2,647 prey items were identified from 42 pairs of owls. Prey species included 29 mammals, 20 birds, 2 reptiles, a crayfish, a terrestrial snail, and 26 genera of insects. Mammalian prey comprised over 90 percent of the biomass consumed. The flying squirrel (Glaucomys sabrinus) was the principal prey species (13-48

percent of total biomass consumed), except in dry forest areas, where wood rats (Neotoma fuscipes and N. cinerea) became most important (7-78 percent of total biomass). Other important prey included snowshoe hares (Lepus americanus), red tree voles (Phenacomys longicaudus), deer mice (Peromyscus maniculatus), western red-backed voles (Clethrionomys occidentalis), Mazama pocket gophers (Thomomys mazama), pikas (Ochotona princeps), and small birds. Predation on showshoe hares, gophers, moles, and insects was heaviest during the late spring and summer months. Spotted owls foraged primarily at night, and often captured arboreal animals (squirrels, wood rats, and tree voles) by grabbing them from limbs or tree trunks.

Eighteen spotted owl nests were located, including 13 in cavities in living old-growth conifers, three in clumps of deformed limbs caused by dwarfmistletoes (Arceuthobium spp.), and two in platform nests constructed by other species. Nest height above ground ranged from 19.8-55.2 meters. Owls added no materials to their nests except small amounts of molted down. The mean date of clutch initiation for 15 nests was 29 March (range 9 March - 19 April). As egg-laying neared, adult activities (vocalization, copulation, courtship feeding, roosting) became increasingly centered around nest trees, and several days before they laid eggs, females began to roost inside their nest cavities. Incubation, which lasted approximately

30 days, was performed entirely by females. Males fed females during this period. Owlets fledged at 34-36 days of age (between early May and mid-June), and were fed by their parents until late September. At fledging, owlets were weak fliers, and often fell from their nests to the ground. When this occurred, they regained safe perches in trees or low bushes by climbing. Forty-eight nesting attempts were observed (38 successful). Total number of young fledged was 63. Mean number of young fledged per successful nest was 1.61 (range 1-3). The percentage of pairs attempting to nest ranged from 89 percent in 1972, to 16 percent in 1973, and 46 percent in 1974. I suspected, but did not verify, that the low numbers of breeding pairs in some years reflected a decline in prey numbers. Percent of nesting pairs which fledged young was 92 in 1972, 40 in 1973, and 72 in 1974. A principal cause of nest failure in all years was nest desertion during early stages of nesting. In 1972, juvenile mortality between fledging and the end of August was 35 percent. Predation was suspected as the principal cause of mortality, but several young were killed when the fell from nests, and two young died in their nest.

Most broods did not move far from their nests until they began dispersal in September or October. Of 14 broods checked in late August, 5 were within 160 meters of their nests, 5 were 170-250 meters from their nests, and 2 had moved 487 and 670 meters, respectively.

Two broods could not be relocated, but had moved 1,050 and 365 meters, respectively, when last seen in July.

Owlets underwent two molts during their first summer; the white natal down was replaced by the downy mesoptile plumage before owlets fledged. Replacement of the mesoptile plumage by the first winter plumage then occurred over a 4-month period and was complete by the end of September or early October. In the latter plumage owlets were nearly indistinguishable from adults.

Of 123 sites where spotted owls were located, 117 (95 percent) where characterized by unharvested old-growth conifer forests. Two pairs occupied old-growth forests which had been partially logged about 30 years previous, and three occupied second-growth forests which contained minor old-growth components. The multilayered structure of old-growth stands provided owls with large trees for nests and winter roosts, small shaded summer roost trees, and a closed canopy (canopy closure ranged from 53-86 percent at nest sites). Owls occurred in most coniferous associations found in western Oregon and the Cascades, with the exception of subalpine forests, open ponderosa pine (Pinus ponderosa) forests and lodgepole pine (Pinus contorta) forests.

Owls showed a slight preference ($\chi^2 = P < .01$) for nests located on north or east exposures, possibly because trees there were usually larger and forests were denser than on south or west

exposures. Fifteen of 18 nests were within 400 meters of permanent water (range = 15-1,417 meters). Sources of water utilized by all 18 pairs consisted of small perennial streams or springs.

Timber harvest occurred or was scheduled in 52 percent of the owl habitats located during the study. In most cases, timber harvest within an occupied habitat did not drive the owls completely out of the area, because only small portions of extensive forest areas were harvested. When portions of small forest areas (less than about 80 hectares) were harvested, however, owls often disappeared from these areas. Two pairs located in old-growth forests which had been subjected to very light overstory removal indicated that, under some circumstances, owls could tolerate this type of harvest activity. Clear-cut harvest, however, eliminated roosting, nesting and most foraging in the affected areas.

A Preliminary Investigation of the Spotted Owl in Oregon

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Typed by Clover Redfern for Eric Forsman

In memory of Howard Morgan Wight

Who loved all things wild and free

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A PRELIMINARY INVESTIGATION OF THE SPOTTED OWL IN OREGON

INTRODUCTION

This study of the spotted owl (Strix occidentalis) was designed to determine its status in Oregon and to obtain information on which to base its management. The spotted owl is a medium-sized owl inhabiting the forested mountains of western North America. It was first described by Xantus (1859), but because of its nocturnal habits and preference for dense forests, it has been seen infrequently, and little is known about its natural history. It is generally considered rare or uncommon, but census data are unavailable for most areas.

In Oregon and Washington, the spotted owl occupies forests which account for approximately one-fourth of the softwood produced annually in the United States (Wall 1972:1). There is a strong emphasis on timber production in the region, and during the last century, management practices that favor young fast-growing forests have steadily reduced the area of mature and old-growth forests. The effects of these practices on spotted owls have not been evaluated. Because it was feared that the reduction in area of old-growth forests by logging was causing concurrent declines in spotted owl populations in Oregon, Washington, and northern California, the species was listed in the 1973 edition of Threatened Wildlife of the United States (U.S. Fish and Wildlife Service 1973).

In 1969 and 1970, I began part-time research on the spotted owl in Oregon. Full-time research was begun in 1972, with financial support from the USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. During 1972 and 1973, I spent 8 months each year (March-October) locating spotted owls and collecting data on their ecology. In 1974, field work was limited to 4 months (March-June).

Research Objectives

Specific objectives were:

(1) Determine the range and numerical status of the spotted owl in Oregon.

(2) Describe habitats utilized by spotted owls in Oregon.

(3) Investigate the reproductive biology of the spotted owl.

(4) Investigate the food habits of spotted owls and compare food habits in different habitat types.

Species Description

The spotted owl is a medium-sized, dark brown, round-headed owl with irregular white spots on the back of the head and neck, and on the back (Frontispiece). The breast and abdomen are brown, barred with irregular rows of wide tawny-white blotches. The brownish facial disks are large and round with indistinct concentric circles of

darker brown around each eye. The irises are dark brown, appearing black from any distance beyond a few feet. Remiges and rectrices are dark brown, barred with lighter brown and white. Adults exhibit reversed sexual size dimorphism; males average about 582 grams (range = 518-694), females 637 grams (range = 548-760) (Earhart and Johnson 1970). Body length is from 405- to 483-mm, wing length, 295- to 317-mm (Earhart and Johnson 1970, Dawson 1923). Total wing span has been listed as 1067-1143 mm (Walker 1974, Robbins et al. 1966).

In most areas where it occurs, the spotted owl is the only large forest owl with dark eyes. It superficially resembles the barred owl (Strix varia), but the ranges of the two species do not overlap except in southwestern British Columbia and possibly Mexico (A.L. Taylor and E.D. Forsman, in press; Campbell 1973, Grass 1971, Friedmann et al. 1950). The barred owl is slightly larger, is grayish-brown, and is streaked vertically on the lower breast and abdomen (Robbins et al. 1966).

Unlike other large owls within their range, spotted owls are unafraid of man. They can usually be approached within a few feet before they fly, and have occasionally been captured by hand or killed with sticks (Ligon 1926, Peyton 1910). Miller (1974) was able to feed a wild spotted owl from her hand.

Taxonomy

The spotted owl is one of 11 species belonging to the genus Strix, family Strigidae (Burton 1973). Two other congeneric species occur in North America, the barred and great gray owls. Owls in this genus are round-headed, and most are nocturnal forest-dwelling species.

Based on differences in plumage coloration and geographical distribution, three subspecies of S. occidentalis are recognized by the American Ornothologists' Union (1957) (Fig. 1):

California spotted owl (S. o. occidentalis) Xantus (1859)

Northern spotted owl (S. o. caurina) Merriam (1898)

Mexican spotted owl (S. o. lucida) Nelson (1903)

Although three subspecies are recognized, subspecific relationships are confused. Oberholser (1915) compared a number of skins of S. o. occidentalis with a single skin of S. o. caurina and found overlap in characteristics used to separate the two subspecies. Because S. o. occidentalis had subspecies priority, he advocated combining the northern and California subspecies as S. o. occidentalis. Oberholser also found that light and dark color phases may occur in the same areas. This further confused subspecific relationships, because plumage darkness was used by some authors to separate the subspecies (Nelson 1903, Merriam 1898).

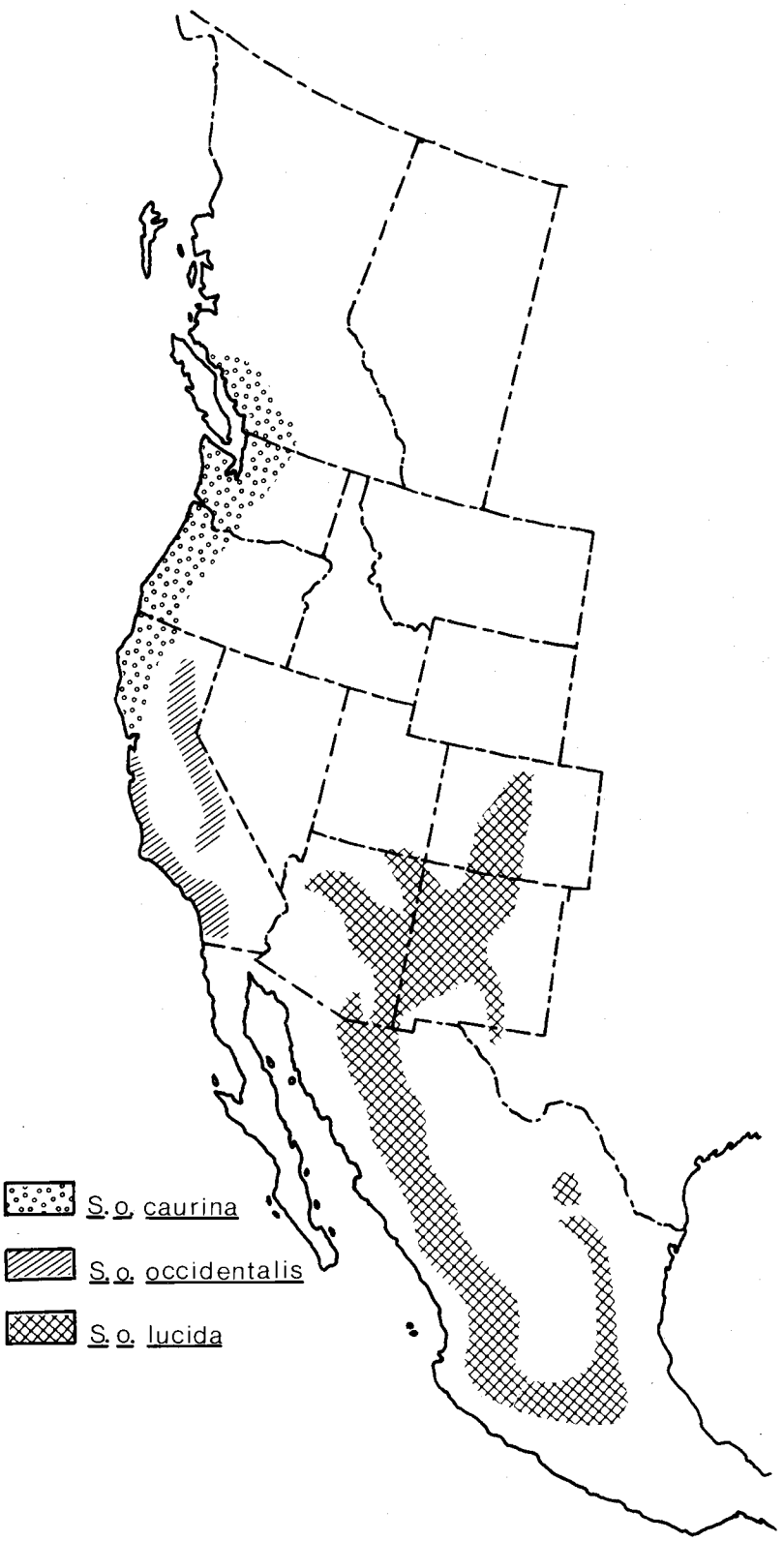


Fig. 1. Distribution of the three subspecies of Strix occidentalis in North America. The distribution of S. o. lucida in northern Colorado and in Mexico is somewhat hypothetical, as only scattered records are available from those areas.

G.I. Gould (1974, unpublished report, California Dept. Fish and Game) demonstrated that little, if any, geographical separation existed between S. o. caurina and S. o. occidentalis in California, where the two subspecies were formerly believed to be widely separated (Grinnell and Miller 1944). If the distribution of the two subspecies is continuous in California, it is possible that morphological differences are clinal. Therefore, I consider the taxonomy of the species unresolved. To avoid confusion, I followed the nomenclature of the A.O.U., which recognizes S. o. caurina as the subspecies present in the Oregon study area.

Distribution

The spotted owl is found from southwestern British Columbia (north to Alta Lake, east to Hope and Manning Park) southward through western Washington and Oregon and the mountains of California to northern Mexico (Fig. 1). It also occurs in the high mountains of eastern Arizona and New Mexico north to southern Utah and north-central Colorado, and east to the Guadalupe Mountains of west Texas (Guiguet 1970, A.O.U. Check-list 1957, Bent 1938). In Mexico, local populations apparently exist in the pine-oak woodlands of the Sierra Madre Mountains at least as far south as Mount Tancitaro in the state of Michoacan (Freidman et al. 1950, Nelson 1903).

There are two records of spotted owls seen in the Glacier National Park area of Montana (Hoffmann et al. 1959, Weydemeyer 1927). However, Hoffman (1973, personal communication), says the 1959 record was an error; the bird photographed was a barred, not a spotted owl. Shea (1974) reported the barred owl a regular permanent resident of the Glacier Park area, but found no spotted owls there. Weydemeyer's (1927) report was not documented by specimens or photographs and is questionable.

History of Discovery

The first record of the spotted owl was a specimen collected in 1858 near Fort Tejon in the Sierra Nevada Mountains of southern California (Xantus 1859). A nesting bird collected near Tucson, Arizona in 1872 constituted the second specimen and the first breeding record for the species (Bendire 1892). As ornithological activity increased in the early 1900's, this supposedly rare owl was diligently sought by collectors, and specimens and eggs were taken regularly in California, Arizona and New Mexico. Most nests found in those states were located in holes in cliffs or in low cavities in hardwoods (Bent 1938, Ligon 1926, Dickey 1914, Peyton 1910, Dunn 1901).

Published information on the distribution and biology of the spotted owl in the Pacific Northwest (Oregon, Washington, British Columbia) is limited (Guiguet 1970, Smith 1963, Jewett et al. 1953,

Gabrielson and Jewett 1940). It was first recorded as a resident of the region when Rhoads (1893) reported two specimens collected near Tacoma, Washington. Brooks (1900) listed specimens from southwestern British Columbia, and V. Bailey (1909, unpublished report, U.S. Fish and Wildlife Service, Patuxent, Maryland) recorded a bird near Gold Beach, Curry County, Oregon, tentatively establishing the species as a resident along the entire Northwest coast. There have been seven reports of nesting: Oregon (Crowell and Nehls 1970, Gabrielson and Jewett 1940); Washington (Slipp 1946, G.G. Cantwell, 1919, unpublished report, U.S. Fish and Wildlife Service, Patuxent, Maryland; Bowles 1910); and British Columbia (Smith 1963, Laing 1942). Several of these records were poorly documented, and in at least one case (Bowles 1910) the species identity was not clearly determined. The only verified location of a nest was reported by Gabrielson and Jewett (1940), but the nest was not described. Population estimates are conjectural.

Except for papers by Marshall (1942, 1957) and Smith (1963), most information on the food habits of spotted owls consisted of reports on the stomach contents of individual specimens (Earhart and Johnson 1970, Maser 1965, Jewett et al. 1953, Bent 1938, Huey 1932, Ligon 1926, Balmer 1924, G.G. Cantwell, 1919, unpublished report, U.S. Fish and Wildlife Service, Patuxent, Maryland; Dickey 1914, Daggett 1913, Richardson 1906). Preliminary data from the

Northwest indicated that the flying squirrel (Glaucomys sabrinus) was the most important prey taken, but that deer mice (Peyomyscus maniculatus), bats, pikas (Ochotona princeps), small birds, and insects were also important prey (Smith 1963, Marshall 1942). Ligon (1926) found wood rat (Neotoma spp.) remains in nearly every spotted owl stomach he examined in New Mexico. Marshall (1957) and Dicky (1914) also mentioned predation upon wood rats in the southwestern United States.

Spotted owls have been the subject of little research since Bent (1938) summarized earlier work. Marshall (1942, 1957) described territories occupied by spotted owls and listed food habits data for S. o. caurina, S. o. occidentalis, and S. o. lucida in Oregon, California and Arizona. Smith (1963) listed a breeding record and food habits data for a pair of S. o. caurina in British Columbia, and Miller (1974) described 7 years of observations of a nesting pair of S. o. occidentalis. G.I. Gould (1974, unpublished report, California Dept. Fish and Game) described the distribution and abundance of the spotted owl in California.

THE STUDY AREA

The study area included the western one-third of Oregon, from the eastern foothills of the Cascade Range to the coast (Fig. 2). With the exception of the lowland interior valleys, this area is characterized by rugged mountains covered by extensive coniferous forests. Limited work was also done in the Gearhart, Warner, Ochoco, Wallowa, and Blue Mountains east of the Cascades. The following description of the study area climate and vegetation is summarized from Franklin and Dyrness (1973).

The study area was divided into three subregions: (1) the Coast Range and west slope of the Cascades, characterized by mild, wet winters and relatively dry summers, (2) the Siskiyou Mountains in southwestern Oregon, characterized by cool, dry winters and hot, dry summers, and (3) the east slope of the Cascades, characterized by cool winters and warm, dry summers. Elevation ranged from sea-level to 3,452 meters, although most of the area was below 1,500 meters.

Vegetation of the Coast Range and west slope of the Cascades is characterized by extensive forests of subclimax Douglas-fir (Pseudotsuga menziesii), and western hemlock (Tsuga heterophyla) that have been modified to varying degrees by logging, fire, and agriculture. In some areas, particularly the Coast Range and inland

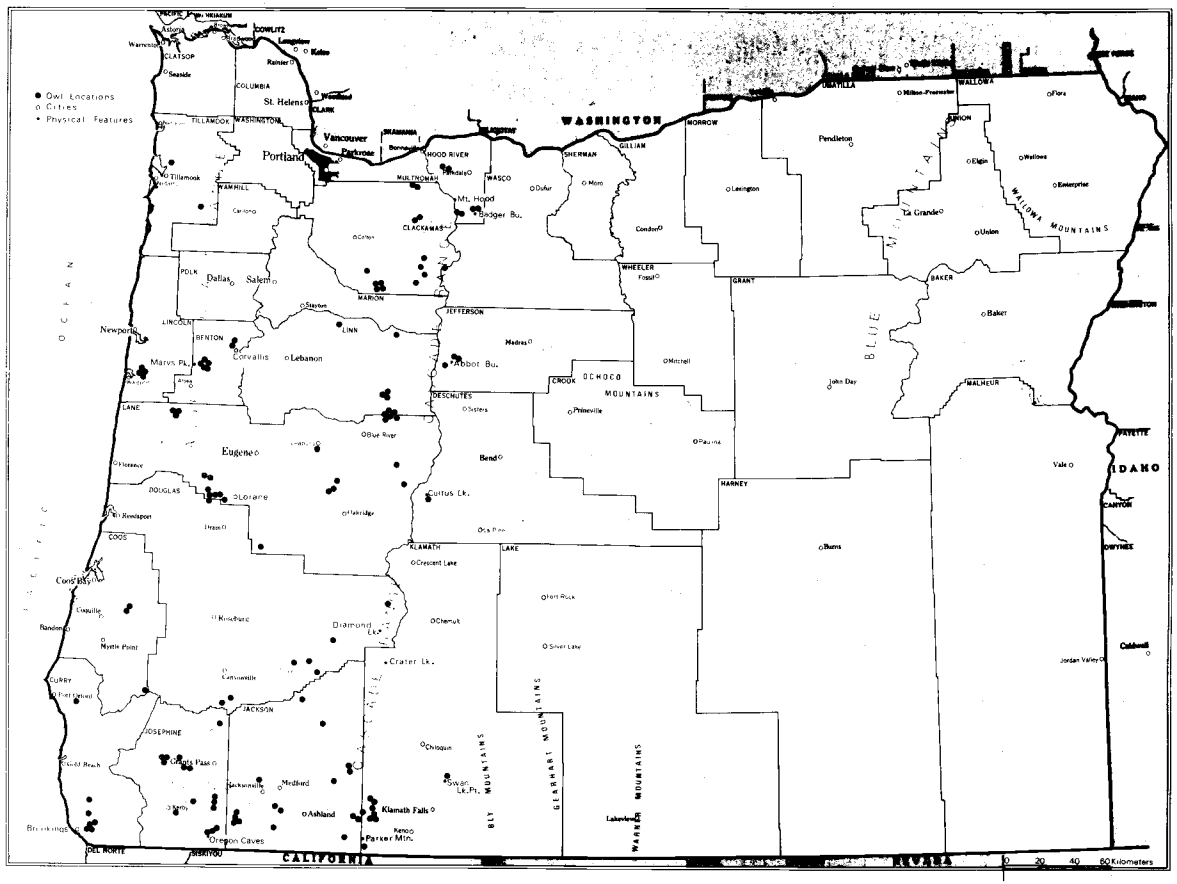


Fig. 2. Outline map of Oregon indicating location of cities, counties, and some physical features. Locations of 116 pairs of spotted owls and 7 single spotted owls found during the study are also shown.

valley foothills, this modification has been extreme, and mature forests have been largely replaced by second-growth Douglas-fir or early herb-shrub succession.

In the Mixed Evergreen and Mixed Conifer Zones in the Siskiyou Mountains and southern Cascade Range, Douglas-fir dominates mixed stands of sugar pine (Pinus lambertiana), ponderosa pine (P. ponderosa), incense cedar (Libocedrus decurrens), white fir (Abies concolor), grand fir (A. grandis) and associated evergreen broad-leaved trees such as tanoak (Lithocarpus densiflorus), Pacific madrone (Arbutus menziesii), canyon live oak (Quercus chrysolepis), California laurel (Umbellularia californica), and golden chinkapin (Castanopsis chrysophylla). Between 1,400 and 1,800 meters in this area, the Mixed Conifer and Mixed Evergreen Zones intergrade with the White Fir Zone, which is characterized by stands of mature or old-growth white fir and Douglas-fir. At its upper elevational limits, this Zone merges with the Shasta Red Fir (Abies magnifica shastensis) Zone, and mixed stands of white fir, Shasta red fir, Douglas-fir, sugar pine, and western white pine (Pinus monticola) are common.

The east slope of the Cascades is characterized by a zone of grand fir and Douglas-fir at mid-elevations, which is bordered at its lower limits by forests of ponderosa pine or lodgepole pine (Pinus contorta), and, at its upper limits, by subalpine forests of silver fir (Abies amabilis), subalpine fir (A. lasiocarpa), Shasta red fir, or

mountain hemlock (Tsuga mertensiana). Minor components of ponderosa pine, lodgepole pine, incense cedar, and western larch (Larix occidentalis) are commonly found in forests of grand fir and Douglas-fir.

METHODS AND MATERIALS

Definitions of Terms

In following sections, habitat refers to the forest environment in which pairs of owls roosted, nested, and obtained food. The territory is the area defended by mated pairs of spotted owls against intrusion by other spotted owls. The nest site includes the nest tree and the forested area within 100 meters of the nest tree. Canopy closure is an estimate or direct measurement of the percent of sky obscured by overhead vegetation. Canopy density refers to the amount of space filled by vegetation within the area subtended by the canopy. Second-growth designates any tree or forest less than 100 years old, and mature designates any tree or forest 100-200 years old. An old-growth tree is any tree over 200 years old, and an old-growth forest is any closed-canopy forest in which trees over 200 years old are present at densities greater than eight per hectare (most commonly 10-38 per hectare in Oregon). An uneven-aged forest is one in which several age classes of trees are present, resulting in a multilayered canopy. In western Oregon, overstory trees in uneven-aged associations are most commonly old-growth conifers, especially Douglas-fir, and if they fit the above criteria, I referred to them as old-growth stands. Undisturbed refers to forests that have never been logged and have not been burned by ground fires within the last 40 years or crown fires

within the last 200. Hi-grading refers to the outdated logging method of harvesting only the most commercially valuable large trees (variable numbers of mature and old-growth trees were left standing and many understory trees were not cut).

Location of Owls

Vocal imitation of spoted owl calls was the principal method used to locate owls. Spotted owls are highly territorial and respond to the call of an intruding spotted owl by flying towards the intruder, calling loudly. At night they will fly long distances to challenge an intruder on their territories. During the day, they usually challenge intruders vocally from their roosts but are reluctant to fly far.

In conjunction with calling, two survey methods were used: (1) verification of cooperator sightings (reports of spotted owls from other observers) and (2) road transects, which involved driving or walking forest roads at night, stopping to call frequently until owls responded. Cooperator sightings were usually checked first by a daytime visit to the area where owls have been reported; if the owls were not located, night calling was used. After getting a response at night, I located nests and roosts by calling in the same areas on foot during the day.

To avoid counting the same pair twice during night surveys, I usually moved approximately 1 kilometer from the point of a response

before calling again. Even then, it was often difficult to interpret pair distributions correctly because owls often followed me for long distances or because members of individual pairs sometimes responded from widely separated areas on their territories. These relationships were usually clarified by relocating pairs many times, allowing more refined delineation of territory size and shape.

Spotted owl response to calls was variable, depending upon season, weather, and reproductive status. With persistent searching, however, they could usually be located at all seasons. Response was best on clear calm nights between February and September. Response on windy, rainy nights was poor, and response during fall and winter was usually less intense than during spring and summer. As I became familiar with individual pairs, I could locate them most easily by checking roosts and nests that were used year after year.

Survey areas were selected to determine the distribution of the spotted owl in Oregon, and to reaffirm the presence of owls in areas of historical occurrence. When possible, cooperator sightings were used as starting points in surveying new areas. Most survey work was done in old-growth forests because: (1) with one exception, all pairs reported by cooperators were in habitats of this type, and (2) my experience was that spotted owls generally occurred in the densest, most mature forests. Clear-cuts were scattered through nearly all forests surveyed on the west side of the Cascades, and were

surveyed concurrent with the forest areas. Second-growth forests occurring along road transects were included in surveys. Most surveys were conducted on federal lands because I received only one cooperator report for private lands, and because most private forests had been harvested within the last 40 years.

Habitat Analysis

In all habitats occupied by spotted owls, I recorded species composition of overstory and understory trees, forest age and area, canopy closure, topographic features, distance of nest trees from water, and history of fire or logging. Fire history was determined by examining trunks of larger trees for presence of fire scars, and by measuring the age of understory trees that had grown since the last fires. Canopy closure was estimated visually at four points within each habitat; all points were then averaged to determine a mean for each habitat. Measurement of closure was made by walking a randomly selected number of steps (from random numbers table) away from nest trees or roost trees along north, south, east, and west compass bearings. At the point of measurement, canopy closure was determined by estimating the amount of sky obscured by foliage directly overhead. Age of trees was determined from core samples. Age of overstory trees too large for core sampling was estimated by counting growth rings of similar trees which had been felled along

roads or in timber sales within the habitat areas. Habitat area was calculated by on-the-ground reconnaissance and by measurements taken from aerial photos by polar planimeter. Slope and exposure were determined with Abney Level and compass.

Food Habits

Regular collections of pellets were made at spotted owl roost and nest areas between 1970 and 1973. Data were also gathered from observations of food brought to young, collections of discarded prey remains, and collections of prey remains from nests. Prey species in pellets were identified from skulls, bones of the appendicular skeleton, fur, feathers, or scales. Insects were identified from mandibles, head capsules, leg parts, or fragments of the elytra, abdomen, or thorax. Numerical abundance of prey items was determined by counting skulls or pairs of jaws of the smaller vertebrates and by counting skulls or piecing together skeletons of larger mammals. Insect numbers were determined from head capsules, mandible parts, leg parts, or elytra pairs.

Biomass of each prey species in the diet was determined by multiplying numbers of individuals times mean prey weight (mean prey weights are listed in Appendix 3). Biomass contribution of larger mammals, particularly hares and rabbits, was calculated by piecing together skeletons, because remains of the same animal often

occurred in several pellets. Because most rabbits and hares taken were juveniles or subadults, weighing 150-600 grams, a mean weight of 350 grams was used to estimate biomass of these animals. When a large hare was encountered in a pellet, its weight was estimated according to bone size.

Breeding Biology

During the incubation and brooding periods, male spotted owls usually roosted near their nest trees during the day; this was the principal key to location of nest trees. After locating a solitary male, I called loudly and persistently in the area around his roost until the female became aroused and left the nest cavity. She was then watched until her return to the nest.

With one exception, climbing of nest trees was restricted to the brooding period and to the period after young left the nest. Small nest trees were climbed with climbing irons and a flip rope. Larger trees were climbed with Jumar Ascenders after rigging them with 11 mm climbing ropes (Fig. 3). Ropes were placed in position by shooting lines over limbs in nest trees with a bow equipped with a fish-hunting spool. After the initial ascent, light nylon lines were left in place in nest trees so climbing ropes could be hoisted whenever a tree was climbed again. Because of their height, some nest trees could be rigged only part way up with the bow and arrow, and in these instances

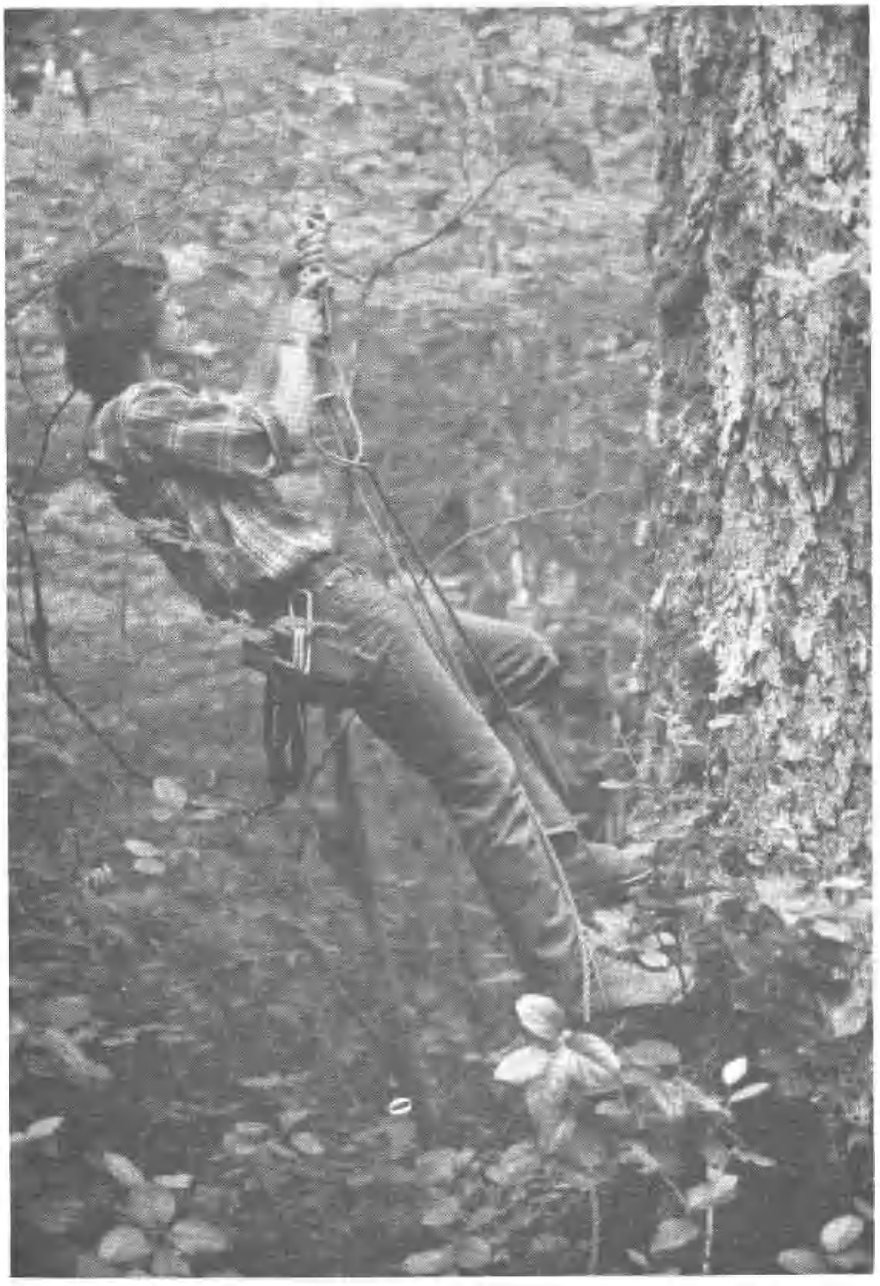


Fig. 3. Climbing a nest tree with a climbing rope and Jumar Ascenders. The climber stands in rope stirrups attached to Jumars and slides Jumars up the rope.

bolting techniques similar to those used by rock climbers were used to proceed the rest of the way up the tree (see Denison 1973 for a description of this method).

Nesting pairs were observed from the time nests were located until the young began to disperse in September or October. After owlets left the nest, they were relocated on subsequent visits by calling or by following trails of feces, prey remains and molted feathers. They usually responded to my imitations of adult calls by begging (see Vocalizations) or by flying toward me, thus revealing their location. This method became less effective during late summer when owlets ceased to beg as readily. I made brief visits to nests at 1- to 14-day intervals, and less frequently, spent continuous 1- to 6-hours periods observing individual nests. Records were kept with the 24-hour system and Pacific Standard Time.

Observations on development, behavior and molt were also made on a spotted owl taken as a nestling in May 1970 and held in captivity during the study.

OREGON DISTRIBUTION AND ABUNDANCE

Historical Synopsis

Records of the spotted owl in Oregon prior to 1970 included 18 specimens and 10 sight records (Appendices 1 and 2). The first state record was of a bird heard calling near Gold Beach, Curry County, in 1909 (V. Bailey, 1909, unpublished report, U.S. Fish and Wildlife Service, Patuxent, Maryland), and the first specimen was collected near Kerby, Josephine County on 24 March 1912 (unpublished record, Appendix 1). Based on limited data, Gabrielson and Jewett (1940:348) called the species a "Permanent resident west of [the] Cascades." The easternmost records were from the upper North Santiam River, Linn County (Marshall 1942), Diamond Lake, Douglas County (Crowell and Nehls 1966), and 16 miles west of Keno, Klamath County (Crowell and Nehls 1968). The latter record was the first indication that the species might be a resident on the east slope of the Cascade Range. Although there is a nesting record (Gabrielson and Jewett 1940) and a specimen record (Appendix 1) for Jackson County, Browning (1975) did not list the spotted owl as a resident there.

Current Distribution

Spotted owls located during the study included 116 pairs and 7 single birds (Fig. 2). All but two of the single birds were believed to

have been paired individuals that were roosting or foraging away from their mates when located. Thirty-four locations resulted from cooperator reports which I later verified and 28 were reported by experienced observers but were not verified by me. Specimens collected included two birds hit by automobiles, one bird which died of starvation, and a juvenile bird which died when it became tangled in a piece of string.

These records indicate that the spotted owl occurs throughout the mountains of western Oregon and on the east slope of the Cascade Range at least as far east as Badger Butte, Hood River County; Abbot Butte, Jefferson County; and Swan Lake Point, Klamath County. The eastern periphery of the range appears to coincide with the eastern limits of the Grand Fir Zone on the east slope of the Cascades but extends slightly east of the Cascades in southern Oregon, where nearly continuous forests of white fir, Douglas-fir, and ponderosa pine extend eastward to the Bly, Gearhart, and Warner Mountains. Spotted owls were not located in the latter two ranges, but survey work there was limited to four nights. There are several recent records of spotted owls in the Warner Mountains of California near Alturas, Modoc County, 48 kilometers south of the Oregon border (G.I. Gould, 1974, unpublished report, California Dept. Fish and Game).

There are no historical records of spotted owls in the Ochoco, Blue, or Wallowa Mountains in eastern Oregon. Three surveys were

conducted there but no owls were located. The apparent absence of spotted owls from these mountains is surprising because they contain habitat similar to that occupied by spotted owls on the east slope of the Cascades. Perhaps the physical separation that exists between these mountains and the Cascades has precluded dispersal into eastern Oregon. Considering the ability of the spotted owl to populate isolated ranges in the southwestern United States, however, this explanation is unsatisfactory.

The Coast Range

In the northern Coast Range (Clatsop, Columbia, Tillamook and Washington Counties), where most forests had been extensively clear-cut or burned during the last 100 years, the spotted owl was extremely uncommon. Only two pairs were located in that area during five survey nights. Farther south, old-growth forests were more extensive and spotted owls were more abundant. Generally, owls were restricted to remaining old-growth forests on lands administered by the Forest Service (USFS) and Bureau of Land Management (BLM) and to state lands and municipal watersheds which had not been subjected to intensive timber harvest. In a particularly large concentration of old-growth on the Corvallis Municipal Watershed, Benton County, four pairs were located in an area of roughly 39 square kilometers. In the southern Coast Range, where every other section was privately

owned, the distribution of spotted owls followed the checker-board distribution of BLM ownership; private sections were largely cutover, whereas some BLM sections contained the remaining tracts of old-growth inhabited by spotted owls. On one such area west of Lorane, Lane County, six pairs were located in an area of one township (93 square kilometers). This concentration, and the one in the Corvallis Watershed appeared greater than average density in the Coast Range; in areas where private holdings were extensive or where old-growth forests on federal lands had been depleted, densities averaged less than two pairs per township. Owls were located in this region at elevations ranging from 25 meters above sea level near Tillamook, Tillamook County, to 838 meters on Mary's Peak, Benton County.

The Siskiyou Mountains

Spotted owls were found in old-growth forests throughout this region. As in the Coast Range, the distribution was influenced by historical patterns of fire and logging. Much of the area was in alternate-section ownership, and owls were restricted primarily to uncut BLM sections or to old-growth forests on the Siskiyou National Forest. Densities of three to four pairs per township were not uncommon on federal lands but no owls were located on private lands. Spotted owl locations in this region ranged from 25 meters above sea

level near the coast in Curry County, to 1,460 meters near Oregon Caves, Josephine County.

The Cascade Range

On the west slope and in the southern Cascades, densities of three to four pairs per township were common on federal lands. The highest density recorded was five pairs in 32 square kilometers on the H.J. Andrews Experimental Forest, Lane County. Only three pairs were located on private lands.

On the east slope of the Cascade Range, spotted owls were locally distributed in the Grand Fir Zone along the midslope region. Owls were not found in ponderosa or lodgepole pine forests or in stunted subalpine forests, although elements of these forest types frequently intergraded with the midslope forests occupied by spotted owls. Owls appeared to be most abundant on the east slope in the northern Cascades (Hood River County and western Wasco County), where seven pairs were located. Only four pairs of owls were located on the east slope of the central Cascades (Jefferson and Deschutes Counties).

A single bird was photographed near Swan Lake Point, 14 kilometers east of Klamath Lake, Klamath County (T. Williams, 1974, personal communication), but the bird's status was unknown and it could not be relocated. This was the only spotted owl recorded east

of the Cascades. More intensive surveys in the region east of Klamath Lake, Klamath County, will probably produce more owl locations, but the scarcity of reports from that area indicated that spotted owls were uncommon there.

The upper elevational range limits of the spotted owl in the Cascades increased from about 1,350 meters in Hood River County (northern Cascades), to 1,770 meters in Klamath County (southern Cascades). These limits coincided generally with the transition from forests of Douglas-fir, white fir (grand fir) or Shasta red fir to subalpine forests with smaller trees, more open canopies, and harsher winters.

Apparent Population Trends

I surveyed eight areas where spotted owls were observed or collected prior to 1950. Owls were located in only three of these areas. All of the areas where owls could not be relocated had been harvested or burned since the previous records. Data were inadequate to evaluate historical abundance, but the above results indicated that the population had declined as a result of habitat loss. This conclusion was supported by my observations of the effects of timber harvest on spotted owls (see Habitat Disturbance).

FOOD HABITS

Prey species taken by spotted owls during 1970, 1972, and 1973 included 29 mammals, 20 birds, 2 reptiles, a crayfish, a terrestrial snail, and 26 genera of insects (Tables 1-8). A total of 2,647 prey items were identified from 42 pairs of owls, including 14 pairs in the Coast Range, 8 in southwestern Oregon, and 20 in the Cascades (Fig. 4). Because of the size of the study area and the variety of vegetative types involved, I analyzed food habits data from different vegetative types separately. Nearly all data were collected between 1 March and 15 October. Although a few pellets collected each spring had been cast during winter months, winter food habits were largely uninvestigated.

Food habits of spotted owls from different areas of the state varied, particularly when data from the moist coniferous forests of the Coast Range and western Cascades were compared with data from the dry forests of southwestern Oregon. Differences in prey species composition probably reflected differences in composition of the prey base but, no doubt reflected differential susceptibility to predation in different habitat types as well.

I detected several basic patterns from the data in Tables 1-8:

1. Mammalian prey comprised over 90 percent of the total biomass consumed by spotted owls in all areas studied. The

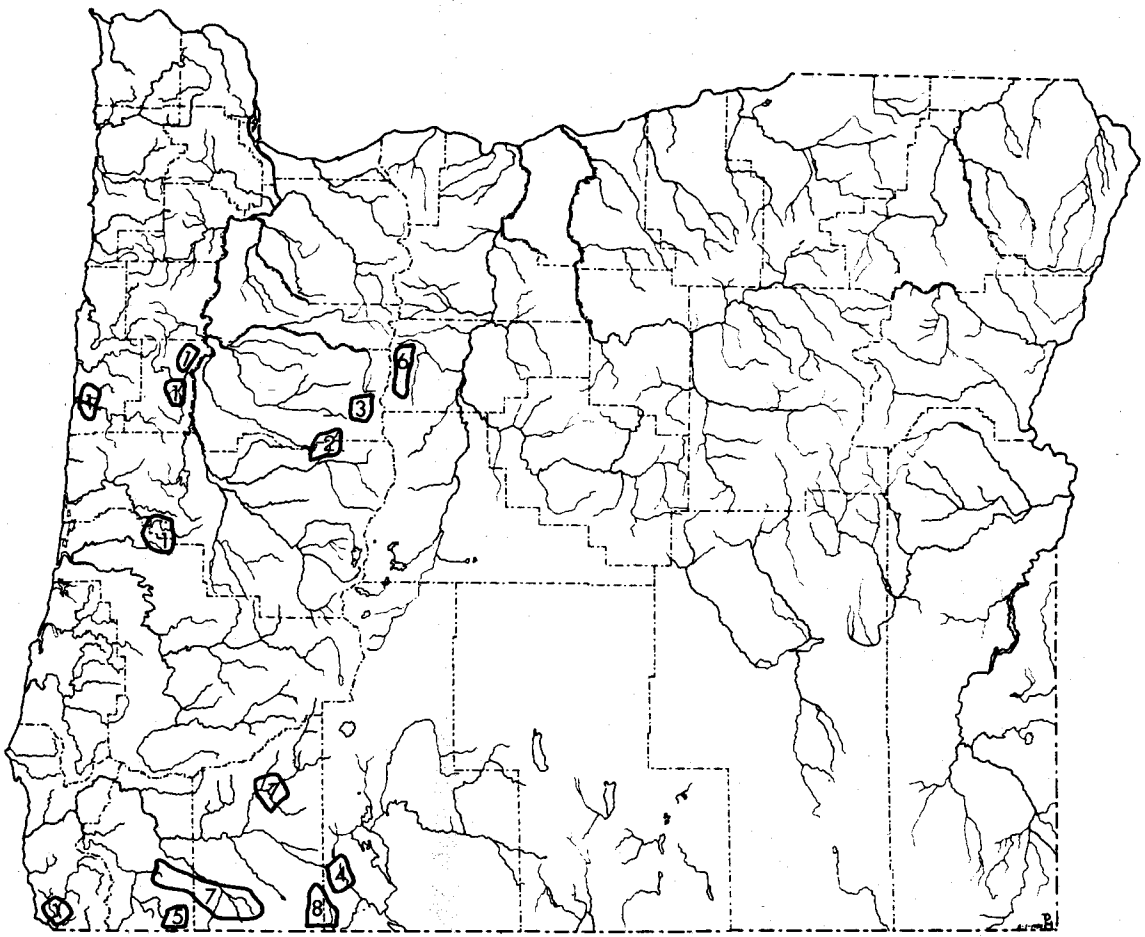


Fig. 4. General location of areas where data on food habits of spotted owls were collected in Oregon during 1970, 1972, and 1973. Numbers inside closed circles indicate which table should be consulted for each area (see Tables 1-8).

Table 1. Prey occurrence in percent numbers and percent biomass for 14 pairs of spotted owls in the Oregon Coast Range (Fig. 4).[a]

Prey Species[b]	Percent Numbers (n=1, 437 prey items)	Percent of Total Biomass (n=102, 408 grams)
Mammals		
Glaucomys sabrinus	25.56	41.09
Phenacomys longicaudus	30.61	11.60
Neotoma spp. (mostly N. cinerea)	5.49	20.50
Lagomorph[c]	1.8	8.88
Peromyscus maniculatus	12.94	3.99
Clethrionomys occidentalis	4.24	1.35
Tamiasciurus douglasii	0.69	2.03
Microtus oregoni	1.32	0.35
Sorex spp.	1.73	0.24
Other mammals	4.45	3.72
Birds		
Small owls	1.18	1.46
Oreortyx pictus	0.13	0.47
Dendragapus obscurus (juveniles)	0.20	1.07
Other birds	4.23	2.95
Insects	4.73	0.07
Miscellaneous	0.70	0.14
Total	100.00	100.00

[a] Years of data collection were 1970, 1972, 1973. Principal habitat types were old-growth associations of Douglas-fir, western hemlock and western redcedar. Elevations ranged from 25 to 490 meters.

[b] Prey not specifically identified in the table included Neotoma fuscipes, Lepus americanus, Sylvilagus bachmani, Scapanus orarius, Eutamias townsendii, Mustela erminea, Lasionycterus noctivagans, Neurotrichus gibbsii, Aplodontia rufa, Microtus townsendii, Sorex trowbridgii, Sorex pacificus, Sorex vagrans, Sorex spp., unidentified mammals, Aegolius acadicus, Glaucidium gnoma, Otus asio, Hesperiphona vespertina, Certhia familiaris, Turdus migratorius, Junco oreganus, Sphyrapicus varius, Coloptes cafer, Cyanocitta stelleri, Parus rufescens, Ixoreus naevius, Regulus satrapa, unidentified birds, Thamnophis spp., Sceloporus occidentalis, Pacifastacus spp., Ergates spiculatus, Pleocoma dubitalis, Pterostichus lama, Pterostichus herculaneus, Panscorpus spp., Plectrura spinicauda, Dyslobus lecontei, Centrodera spurca, Camponotus spp., Chlorochroa spp., Scaphinotus marginatus, Sinodendron rugosum, Omus californicus, Dyslobus spp., Hymenoptera spp., Orthoptera spp., unidentified insects, unidentified spiders, and Haplotrema vancouverense.

[c] Mostly Lepus americanus but may have included a few individuals of Sylvilagus bachmani.

Table 2. Prey occurrence in the diet of seven pairs of spotted owls on the west slope of the Cascade Range below 975 meters elevation (Fig. 4).[a/]

Prey Species[b/]	Percent Numbers (n=215 prey items)	Percent of Total Biomass (n=16,051 grams)
Mammals		
Glaucomys sabrinus	27.80	42.64
Lepus americanus	4.17	19.62
Thomomys mazama	5.09	5.99
Neotoma cinerea	1.85	6.60
Phenacomys longicaudus	12.50	4.54
Peromyscus maniculatus	14.35	4.25
Microtus richardsoni	1.39	1.31
Clethrionomys occidentalis	3.70	1.13
Sorex spp.	4.63	0.63
Other mammals	12.96	9.73
Birds		
Cyanocitta stelleri	0.92	1.33
Otus asio	0.46	0.88
Other birds	2.78	0.96
Insects	6.48	0.08
Miscellaneous	0.92	0.31
Total	100.00	100.00

[a/] Years of data collection were 1972, 1973. Principal habitat types were old-growth associations of Douglas-fir, western hemlock and western redcedar.

[b/] Prey not specifically identified in the table included *Microtus oregoni*, *Sorex trowbridgii*, *Sorex benderii*, *Sorex pacificus*, *Scapanus orarius*, *Tamiasciurus douglasii*, *Eutamias townsendii*, *Mustela erminea*, *Ochotona princeps*, *Neurotrichus gibbsii*, *Zapus trinotatus*, unidentified mammals, *Sphyrapicus varius*, unidentified small birds, *Thamnophis* spp., unidentified vertebrates, *Ergates spiculatus*, *Cyphoderris* spp., *Camponotus* spp., *Pterostichus lama*, *Pterostichus amethystinus*, *Arhopalus productus*, *Polyphylla decemlineata*, and unidentified insects.

Table 3. Prey occurrence in the diet of three pairs of spotted owls on the west slope of the Cascade Range between 975 and 1,400 meters elevation (Fig. 4).[a/]

Prey Species[b/]	Percent Numbers (n=196 prey items)	Percent of Total Biomass (n=10,625 grams)
Mammals		
Glaucomys sabrinus	12.78	27.00
Lepus americanus	2.55	16.36
Thomomys mazama	9.18	14.74
Neotoma cinerea	1.53	7.48
Clethrionomys occidentalis	14.28	5.98
Ochotona princeps	2.04	5.93
Microtus richardsoni	3.57	4.61
Phenacomys longicaudus	4.59	2.30
Peromyscus maniculatus	2.55	1.03
Eutamias townsendii	1.53	2.26
Other mammals	10.20	8.55
Birds		
Ixoreus naevius	0.51	0.75
Other birds	2.55	1.41
Reptiles		
Thamnophis spp.	0.51	0.47
Insects (mostly *Cyphoderris* spp.)	31.63	1.13
Total	100.00	100.00

[a/] Years of data collection were 1970, 1972, 1973. Principal habitat types were old-growth associations of Douglas-fir, western hemlock, and silver fir.

[b/] Prey not specifically identified in the table included *Microtus oregoni*, *Zapus trinotatus*, *Tamiasciurus douglasii*, *Sorex palustris*, *Sorex trowbridgii*, *Sorex obscurus*, *Sorex* spp., unidentified mammals, unidentified small birds, *Dysmichohermes disjunctus*, *Prionus californicus*, *Ctenicera* spp., *Camponotus* spp., *Ortholeptura valida*, and *Ceruchus striatus*.

Table 4. Prey occurrence in the diet of four pairs of spotted owls at high elevations (1,460-1,700 meters) in Klamath County in the southern Oregon Cascade Range (Fig. 4).[a/]

Prey Species[b/]	Percent Numbers (n=131 prey items)	Percent of Total Biomass (n=11,828 grams)
Mammals		
Glaucomys sabrinus	38.19	48.61
Neotoma cinerea	8.39	24.31
Lepus americanus	2.29	8.88
Clethrionomys occidentalis	22.90	5.75
Peromyscus maniculatus	4.58	1.11
Other mammals	9.92	3.25
Birds		
Dendragopus obscurus	0.76	4.23
Other birds	5.34	3.77
Insects	7.63	0.09
Total	100.00	100.00

[a/] Years of data collection were 1972, 1973. Principal habitat types were old-growth associations of white fir, Shasta red fir, Douglas-fir, and ponderosa pine.

[b/] Prey not specifically identified in the table included *Microtus oregoni*, *Microtus montanus*, *Thomomys mazama*, *Eutamias townsendii*, *Neurotrichus gibbsii*, *Sorex* spp., unidentified mammals, *Coloptes cafer*, *Cyanocitta stelleri*, *Piranga ludoviciana*, *Dendrocopus albolarvatus*, unidentified small birds, *Cyphoderris* spp., *Ergates spiculatus*, *Camponotus* spp., *Monochamus oregonensis*, *Ortholeptura* spp., and unidentified insects.

Table 5. Prey occurrence in the diet of one pair of spotted owls in the Siskiyou Mountains near Oregon Caves National Monument, Josephine County (Fig. 4).[a/]

Prey Species[b/]	Percent Numbers (n=71 prey items)	Percent of Total Biomass (n=4,706 grams)
Mammals		
Glaucomys sabrinus	24.02	41.59
Neotoma cinerea	4.22	16.89
Clethrionomys occidentalis	38.02	13.00
Thomomys mazama	7.04	9.24
Phenacomys longicaudus	12.67	5.16
Lepus americanus	1.40	7.42
Peromyscus maniculatus	4.22	1.40
Eutamias townsendii	1.40	1.69
Birds		
Cyanocitta stelleri	1.40	2.27
Other birds	2.81	1.27
Insects	2.81	0.06
Total	100.00	100.00

[a/] Year of data collection was 1973. Habitat was an old-growth association of Douglas-fir, grand fir, and Shasta red fir at 1,380 meters elevation.

[b/] Prey not specifically identified in the table included unidentified small birds, *Ergates spiculatus*, and *Cryptocercus punctulatus*.

Table 6. Prey occurrence in the diet of three pairs of spotted owls on the east slope of the Cascade Range in Jefferson County (Fig. 4).[a/]

Prey Species[b/]	Percent Numbers (n=256 prey items)	Percent of Total Biomass (n=21,148 grams)
Mammals		
Neotoma cinerea	8.26	26.32
Lepus americanus	5.07	24.12
Glaucomys sabrinus	12.10	16.86
Thomomys mazama	4.29	4.54
Peromyscus maniculatus	14.84	3.95
Eutamias townsendii	3.12	3.04
Scapanus orarius	4.29	2.77
Clethrionomys occidentalis	5.07	1.40
Other mammals	11.33	10.29
Birds		
Aegolius acadicus	0.78	0.77
Asio otus	0.39	1.24
Other birds	5.46	4.27
Insects[c/]	25.00	0.43
Total	100.00	100.00

[a/] Years of data collection were 1970, 1972, 1973. Principal habitat types were old-growth associations of Douglas-fir, grand fir, and ponderosa pine. Elevations ranged from 975 to 1,340 meters.

[b/] Prey not specifically identified in the table included *Microtus oregoni*, *Microtus richardsoni*, *Phenacomys intermedius*, *Tamiasciurus douglasii*, *Ochotona princeps*, *Sorex trowbridgii*, *Sorex* spp., *Neurotrichus gibbsii*, *Mustela frenata*, unidentified mammals, *Cyanocitta stelleri*, *Coloptes cafer*, *Sphyrapicus varius*, *Picoides arcticus*, unidentified small birds, *Centrodera spurca*, *Pterostichus neobrunneus*, *Bolboceras obesus*, *Primacma serrata*, *Orthoptera* spp., *Dyslobus* spp., *Camponotus* spp., *Acmaeops* spp., *Formica fusca*, *Cyphoderris* spp., and *Ergates spiculatus*.

[c/] Mostly *Cyphoderris* spp., and *Ergates* spiculatus.

Table 7. Prey occurrence in the diet of seven pairs of spotted owls in the eastern Siskiyou Mountains (Fig. 4).[a/]

Prey Species[b/]	Percent Numbers (n=188 prey items)	Percent of Total Biomass (n=28,049 grams)
Mammals		
Neotoma spp. (mostly N. fuscipes)	40.48	72.37
Glaucomys sabrinus	16.48	12.71
Sylvilagus bachmanni	2.65	6.24
Phenacomys longicaudus	8.51	1.54
Clethrionomys occidentalis	6.91	1.05
Scapanus orarius	1.59	0.57
Sorex trowbridgii	2.13	0.14
Other mammals	5.85	2.27
Birds		
Glaucidium gnoma	0.53	0.24
Other birds	5.84	1.75
Insects	1.59	0.02
Total	100.00	100.00

[a/] Years of data collection were 1972, 1973. Principal habitat types were old-growth mixed conifer associations dominated by Douglas-fir. Elevations ranged from 490 to 915 meters.

[b/] Prey not specifically identified in the table included Microtus oregoni, Microtus townsendii, Eutamias townsendii, Neurotrichus gibbsii, Neotoma cinerea, unidentified mammals, Cyanocitta stelleri, Ixoreus naevius, Certhia familiaris, unidentified small birds, Ergates spiculatus, and Okanagana spp.

Table 8. Prey occurrence in the diet of three pairs of spotted owls in the southern Cascade Range near Parker Mountain, Klamath County (Fig. 4).[a/]

Prey Species[b/]	Percent Numbers (n=152 prey items)	Percent of Total Biomass (n=19,535 grams)
Mammals		
Neotoma spp. (mostly *N. cinerea*)	26.32	54.69
Glaucomys sabrinus	19.74	17.66
Lepus americanus	4.60	12.54
Thomomys mazama	4.60	3.13
Peromyscus maniculatus	13.16	2.25
Eutamias townsendii	1.97	1.23
Clethrionomys occidentalis	5.92	1.04
Other mammals	4.60	2.20
Birds		
Oreortyx pictus	0.66	1.25
Otus asio	0.66	0.73
Aegolius acadicus	0.66	0.42
Other birds	6.58	2.77
Insects	10.53	0.09
Total	100.00	100.00

[a/] Years of data collection were 1972, 1973. Principal habitat types were old-growth mixed conifer associations of Douglas-fir, white fir, ponderosa pine and incense cedar. Elevations ranged from 1,160 to 1,585 meters.

[b/] Prey not specifically identified in the table included *Neotoma fuscipes*, *Sorex trowbridgii*, *Microtus* spp., unidentified mammals, *Ixoreus naevius*, *Cyanocitta stelleri*, *Dendrocopus villosus*, *Piranga ludoviciana*, unidentified birds, *Cyphoderris* spp., *Ergates spiculatus*, *Okanagana* spp., *Camponotus* spp., *Cryptocercus punctulatus*, unidentified insects.

remainder was comprised of birds, insects, and an occasional reptile. Smith (1963) and Marshall (1942) also found that mammals were the principle prey of spotted owls in the Pacific Northwest. Although insects were sometimes numerically important during the summer months (Table 3), they contributed less than 2 percent of the total biomass consumed.

2. In associations of Douglas-fir and western hemlock or in true fir associations (grand fir, white fir, silver fir, Shasta red fir) in the northern half of the study area and at higher elevations in the southern half, the flying squirrel was the principal prey species (27-48 percent of total biomass) (Tables 1-4). Other important prey in these areas, included bushy-tailed wood rats (Neotoma cinerea), red tree voles (Phenacomys longicaudus), snowshoe hares (Lepus americanus), Mazama pocket gophers (Thomomys mazama), small birds, western red-backed voles (Clethrionomys occidentalis) and deer mice.
3. In forests characterized by broad-leaved evergreen trees or by dry-site conifers such as incense cedar, the dusky-footed wood rat (Neotoma fuscipes) or the bushy-tailed wood rat replaced the flying squirrel as the principal prey species (26-78 percent of total biomass) (Tables 6-8).

4. Predation upon strictly terrestrial mammals, particularly western red-backed voles, Mazama pocket gophers, and snowshoe hares increased at higher elevations in forests characterized by heavy winter snowpacks and low herbaceous ground cover (Tables 3-5).
5. Although small terrestrial species (deer mice, western red-backed voles, and shrews (Sorex spp.) were more abundant in forests occupied by spotted owls, the owls appeared to prey selectively upon larger, arboreal or semi-arboreal species (flying squirrels, wood rats and, in many cases, red tree voles) (Tables 1-8).

Seasonal Changes in Predation

The size of the study area and the remoteness of most pairs of owls made regular pellet collection difficult, particularly at elevations above 1,000 meters, where winter snowpacks made some pairs inaccessible until late May or early June. This complicated the seasonal analyses of predation, since I was faced with difficulties in aging pellets collected at infrequent intervals (sometimes once annually). For this reason, seasonal analyses were made on only five pairs from which regular collections were made (Tables 9-10).

Predation upon hares, rabbits, pocket gophers, coast moles (Scapanus orarius), and insects was seasonal. Because the most

Table 9. Seasonal variation in prey species occurrence in the diet of three pairs of spotted owls on the east slope of the Cascade Range in Jefferson County. [a]

Prey Species	Percent Numbers (1 February - 31 May) (n=58 prey items)	Percent Numbers (1 June - 1 October) (n=198 prey items)
Mammals		
Glaucomys sabrinus	19.0	10.1
Peromyscus maniculatus	15.6	14.6
Clethrionomys occidentalis	20.8	0.5
Lepus americanus	3.4	5.6
Neotoma cinerea	8.6	8.8
Scapanus orarius	3.4	4.5
Thomomys mazama	1.7	5.1
Tamiasciurus douglasii	1.7	0.5
Eutamias townsendii	1.7	3.5
Other mammals	8.6	11.1
Small birds	5.2	7.1
Insects	10.3	29.3
Total	100.00	100.00

[a] Data compiled from 1970, 1972, 1973. Major habitat types were old-growth associations of Douglas-fir, grand fir, and ponderosa pine. Elevation 1,036-1,400 meters.

Table 10. Seasonal variation in prey species occurrence in the diet of two pairs of spotted owls in the Coast Range near Corvallis, Benton County. [a]

Prey Species	Percent Numbers (1 February - 31 May) (n=178 prey items)	Percent Numbers (1 June - 1 October) (n=198 prey items)
Mammals		
Glaucomys sabrinus	33.6	29.3
Arborimus longicaudus	26.4	21.2
Peromyscus maniculatus	23.6	19.7
Clethrionomys occidentalis	4.5	4.5
Lepus americanus	0.6	5.6
Neotoma cinerea	1.7	7.6
Sorex sp.	1.7	1.5
Other mammals	5.6	7.6
Small birds	0.6	0.5
Insects	1.7	2.0
Miscellaneous	0	0.5
Total	100.00	100.00

[a] Data compiled from 1972 and 1973. Major habitat types were old-growth associations of Douglas-fir, western hemlock, and western redcedar. Elevation 225-490 meters.

noticeable changes in dietary composition occurred in late May and early June, I partitioned the data into segments collected before and after 31 May (Tables 9-10). Variability in predation appeared to be due to at least three factors: (1) seasonal production of large numbers of easily captured young, (2) melting of winter snowpacks, which influenced prey activities or susceptibility to predation, and (3) surface activity by burrowing mammals, related to foraging activities or dispersal.

Predation on snowshoe hares was mostly restricted to juveniles weighing 150-600 grams, taken between 1 June and early September, when large numbers of young hares were available as prey. Snowshoe hares in Oregon produce two to three litters annually, between mid-May and early August (Black 1965).

Predation upon brush rabbits was uncommon, but one pair of owls in the eastern Siskiyou Mountains (Table 7) fed heavily upon juvenile brush rabbits during July and August 1973.

The Mazama pocket gopher was taken in large numbers only between July and September, when the ground in the high Cascades was clear of snow, and presumably when gopher numbers were highest (Table 9).

Only a few pairs of owls on the east slope of the Cascade Range preyed heavily upon moles (Table 6), and then only between mid-April and the end of June, with a peak about 20 June. This pattern is not

apparent in Table 9 because pellet collections were divided in the middle of the period when moles were taken regularly. The upsurge in predation upon these normally subterranean mammals was probably a response to above-ground dispersal of juvenile moles at night. Giger (1965) found that barn owls (Tyto alba) near Tillamook, Tillamook County, took moles in large numbers only between May and July, with a peak in June; he attributed this increase in predation to surface dispersal of juvenile moles. He also found that barn owls did not eat many of the moles they caught. This behavior was characteristic of spotted owls also; in several nest areas I found decomposed mole carcasses that had been dropped by the owls.

Predation upon insects occurred primarily in late spring, summer, and fall, when insects were most active. Insects taken most commonly included a large arboreal cricket (Cyphoderris spp.), and several species of large beetles (Pterosticus spp., Ergates spiculatus). Cyphoderris was heard regularly in the Cascades during the summer, usually stridulating from trees or low shrubs after nightfall. Marshall (1942) also found Cyphoderris common in the diet of spotted owls in the western Oregon Cascades.

Seasonal shifts in predation upon a species were sometimes seen in one area but not in another. Whether these shifts reflected actual seasonal changes or were simply a result of small sample size was unclear. Examples included a distinct decrease in predation on

western red-backed voles during the summer on the east slope of the Cascades which was not observed in the Coast Range, and an increase in predation on bushy-tailed wood rats during the summer in the Coast Range that was not observed on the east slope of the Cascade Range (Tables 9-10).

In England, Southern (1954) found that ephemeral crops of young rabbits, moles, and insects which became available about halfway through the nestling period provided tawny owls with a new prey resource at a time when other prey populations (mice and voles) reached annual lows. He suggested that nesting by tawny owls was timed to make optimum use of the new prey resource. In Oregon, the sudden availability of juvenile snowshoe hares, gophers, and moles in late May and early June (when young spotted owls were 15-35 days old) closely resembled the relationship between timing of nesting and increased prey abundance noted by Southern.

Foraging Behavior

Two spotted owl attacks on chickarees (Tamiasciurus douglasii), that illustrate what I believe is the most common method of capturing arboreal prey, are described below.

1. At 1530 on 13 June, a male spotted owl was perched about 9 meters up in a small fir. From this perch, he suddenly launched into a gliding dive towards a chickaree that had been

sitting quietly in a small fir sapling about 9 meters away. The owl hit the squirrel with its feet, knocked it from its perch, and then fluttered to the ground with the squirrel in its talons. On the ground, it killed the squirrel, and then flew into a large fir with the squirrel held in one foot.

2. At dawn (0500) on 15 July a chickaree began to climb about on the trunk of a large Douglas-fir about 25 meters from a male spotted owl perched in a small oak. The owl watched it intently for several seconds and then launched into a downhill glide towards it. At the last second, the squirrel ran behind the trunk and the owl missed it. The owl then verred off and returned to its perch.

Predation upon more strictly terrestrial forms such as red-backed voles, deer mice, Mazama pocket gophers, and shrews occurred in a more conventional fashion, as illustrated by a kill observed on 14 July.

At 1725 I was sitting about 30 meters from a female spotted owl when she suddenly glided downhill about 20 meters and caught a vole from the top of a fallen log. Before making this kill, the owl had been perched about 8 meters up in a fir, and had been staring at the area where she caught the vole. Contact with the vole was made with one foot, and the owl's momentum carried her past the log. Without stopping, and with the vole in her grasp, she flew into a small tree.

The vole was alive when the owl reached her perch, but the owl stared at is for several seconds before killing it with her beak.

These observations, and observations of other spotted owls during periods of crepuscular activity, indicated that they hunted primarily by sitting quietly on elevated perches and diving upon their prey. Arboreal prey were frequently taken by "snatching" them from tree trunks or limbs, stunning them sufficiently so they could be carried to a perch or to the ground, where they were killed.

Timing of Foraging Activity

As indicated by the preponderance of nocturnal species in the diet (Tables 1-8), spotted owls foraged primarily after late twilight or darkness. As described previously, however, when owls observed a diurnal prey in their roost areas, they often attempted to capture it. I believe this explained the presence of diurnal squirrels [chickarees and chipmunks (Eutamias spp.)] in the diet. Although most birds were probably taken at night, woodpeckers must have been taken during the day since they normally roosted in cavities at night. Miller (1974) reported that a female spotted owl with young sometimes foraged during the day, but the extent of diurnal foraging was not described. Except for the instances of opportunistic predation in roost areas cited, I observed little diurnal foraging.

Feeding Behavior

Spotted owls generally ate the heads of prey first, a behavioral trait also reported for the screech owl, saw-whet owl, boreal (Tengmalm's) owl (Aegolius funereus), and Eurasian pygmy owl (Glaucidium passerinum) (Walker 1974, Catling 1972, Mikkola 1970, Collins 1963, Mumford and Zusi 1958). After eating the head, owls sometimes swallowed the remains of smaller vertebrate prey intact, but prey larger than deer mice were usually partially dismembered.

I frequently found the discarded stomachs of prey under spotted owl feeding perches and observed adults or fledged owlets discarding prey stomachs. Typically, after tearing into the peritoneal cavity of their prey, owls pinned the prey under one foot and tugged at the intestinal tract with their beaks until the stomach and part of the intestine was severed. The severed portion was then dropped and the rest of the viscera were eaten. Owls rarely ate the stomachs of prey larger than voles, but did eat the stomachs of many smaller prey that were swallowed nearly entire. However, my captive spotted owl sometimes removed the stomachs from prey as small as deer mice and sparrow-sized birds. Collins (1963) reported that saw-whet owls removed the stomach and part of the intestine from their prey.

Adult spotted owls frequently discarded the tails of squirrels and wood rats, and I found these under their feeding perches. Owlets, however, were less predictable and sometimes swallowed these

appendages. Miller (1974) reported similar behavior by young spotted owls.

Food Storage

Spotted owls regularly stored excess food and retrieved it later (Fig. 5). This was observed most commonly when adults were caring for fledged young. When owlets became hungry during the day and begged, adults often flew off momentarily and returned with partially eaten prey which had been hidden nearby. Large prey such as squirrels and wood rats were stored more frequently than small prey. As owlets became older, they sometimes stored prey in their roost trees. Prey remains were most frequently stored on large, mossy limbs and occasionally on the ground under fallen logs or bent-over trees. Only fresh kills were stored, and if a kill was not consumed within about 24 hours, it was abandoned. The dessicated carcasses of abandoned prey were sometimes found hanging over limbs in roost areas.

Huey (1913:229) first observed food storage by a spotted owl but did not know if the stored prey animal had simply died "lying crosswise on a large limb," or had been killed by the spotted owl perched next to it. Miller (1974) also reported food storage by spotted owls. Other owls reported to store food include boreal, saw-whet, and screech owls (McQueen 1975, personal communication, Catling 1972, Collins 1963, Mumford and Zusi 1958).

Fig. 5. Food storage. Hindquarters of a bushy-tailed wood rat hidden on the ground under the trunk of a small tree near a spotted owl roost.

BREEDING BIOLOGY

I located 18 spotted owl nests and observed 48 nesting attempts (38 successful). Location of the nest tree was known in 21 attempts. The other 27 attempts involved broods located after they fledged. I was in most cases able to follow adults and fledged young through the summer, relocating them on periodic visits by calling.

Summary of the Annual Cycle

Adults selected nest sites in late February or March, often returning to a traditional nest tree. As egg-laying neared, vocalization, copulation, and courtship feeding became increasingly centered around nest trees. Eggs were laid in March or early April. Incubation and brooding were done entirely by females. Males fed females at the nest during this period and roosted near their nests during the day. The young fledged between early May and mid-June, approximately 64-66 days after the eggs were laid. Adults began the annual molt in April or early May.

After fledging, owlets were cared for by their parents until September (or later). Adults roosted with their owlets during the day until early August; then, with increasing frequency, owlets began to roost alone. Most adults completed the molt by early October. Between mid-September and mid-October, at about 145 days of age,

owlets completed the molt into the first winter plumage, which was nearly indistinguishable from that of adults. At this stage they became independent of the adults and began to disperse from their parent's territories.

Limited data for the winter period (November-February) indicated that paired adults wandered widely within their territories, roosting together infrequently. By February, pairs began to roost together with increasing regularity.

Nest Trees

The 18 nests located included 13 in cavities, 3 in clumps of deformed limbs caused by parasitic dwarfmistletoes (Arceuthobium spp.), and 2 in platform nests constructed by other species. In the humid forests of the Coast Range and western Cascades, all 10 nests located were in cavities. In drier forests on the east slope of the Cascades and in the Siskiyou Mountains, cavities were also used, but use of other nest types increased.

All cavity nests were located in the hollow boles of living old-growth conifers with broken tops and secondary crowns (Figs. 7,8). Twelve were in Douglas-fir and one in a white fir. Typically, nest cavities were located inside the tops of hollow tree trunks 19-55 meters above the ground (Table 11). Owls entered cavities through the tops of broken trunks (11 nests) or through large holes in trunks where

Fig. 6. Spotted owl nest cavity in the broken top of an old-growth Douglas-fir. Note secondary top issuing from left side of trunk.

Fig. 7. View from above into the interior of a spotted owl nest cavity in the broken top of an old-growth Douglas-fir. Nest floor is composed of an accumulation of fir needles, rotted wood, and small twigs. Projecting into the cavity at the top of the picture are hardened cores of old limbs, a common feature in nest cavities.

Table 11. Dimensions of 18 spotted owl nests.

Measurement	No. in Sample	Range	Mean
Cavity nests (n = 13)			
Height above ground	13	19.81-55.17 m	33.47 m
Cavity depth	10	0-121.9 cm	38.3
Cavity diameters	10	27.9 x 33.0-76.2 x 78.7 cm	46.2 x 54.1 cm
Entrance width	10	15.2-55.9 cm	31.0 cm
Tree diameter at breast height	13	116.8-201.9 cm	153.7 cm
Tree diameter at nest height	10	57.1-104.1 cm	82.0 cm
Total tree height	11	30.17-61.57 m	42.21 m
Bole height	13	10.97-24.38 m	17.25 m
Tree age	13	220-380	---
No. secondary tops	10	1-8	4
Dwarfmistletoe nests (n = 3)			
Height above ground	3	21.94-26.21 m	23.47 m
Platform diameters	3	48.3 x 60.9-60.9 x 73.7 cm	64.3 x 52.3 cm
Tree diameter at breast height	3	60.2-76.2 cm	68.6 cm
Tree diameter at nest height	1	55.9 cm	---
Total tree height	3	38.71-42.06 m	40.23 m
Bole height	3	6.71-13.72 m	11.37 m
Tree age	3	140-182	164 years
Open platform nests (n = 2)			
Height above ground	2	22.86-24.38 m	23.62 m
Platform diameters	-	---	---
Tree diameter at breast height	2	106.7-152.4 cm	129.5 cm
Tree diameter at nest height	-	---	---
Total tree height	2	36.58 m	36.58 m
Bole height	1	15.24 m	---
Tree age	2	250 +	250 +

limbs had broken off (2 nests). Most nest cavities appeared to have been formed when parasitic fungi (Fomes spp., etc.) weakened the tops of old trees; the tops were then broken off by the wind, exposing the hollow trunks. Since tops did not break out evenly, most nest cavities were characterized by large splinters of old trunk projecting 0.5-4 meters above the nest (Fig. 7). Secondary crowns consisted of large limbs which grew upward in response to increased sunlight after the original tops broke off (Fig. 7). They eventually overtopped the broken trunks, forming new tops. Secondary crowns protected nest cavities from sunlight, rain, and snow, and provided perches that owls used as they entered or left their nests. Cavity floors were filled with natural accumulations of rotted wood and, frequently, many conifer needles and small twigs which had fallen into the cavities (Fig. 8). Owls hollowed out shallow depressions in the debris in which to lay their eggs. Contrary to Bendire's (1892) belief that spotted owls built their own nest, the owls I observed added nothing to their nests except small amounts of molted down.

Three nests were located in abnormally dense clumps of limbs in Douglas-fir trees, caused by parasitic dwarfmistletoes (Table 11). These dense clumps, referred to as "brooms" or "witches brooms," formed growths 1-2 meters in diameter, encircling trunks of infected trees. Owls nested on solid platforms that developed inside the brooms when falling conifer needles and small twigs were trapped by

the dense limbs. In two cases, squirrels or wood rats had previously used the platforms as feeding sites, adding to the debris. These nests were protected from the elements by limbs growing completely around and over the platforms. Ligon (1926) described a spotted owl nest in a dwarfmistletoe broom in New Mexico.

Only one pair of owls used nests constructed entirely by another species (Table 11). In 1973, a pair in southwestern Oregon nested in a large dilapidated stick nest that appeared to have been constructed by goshawks (Accipiter gentilis) or dusky-footed wood rats. The nest appeared very old, and rested against the trunk of an old-growth Douglas-fir on a large limb that forked in several directions. Overhanging limbs and the leaning trunk of the tree sheltered the nest from above. For unknown reasons, this nest failed in 1973, when the young were several weeks old.

The following year the same pair nested in what appeared to be a wood rat nest in an old-growth Douglas-fir 25 meters from the previous nest. Like the previous nest it was constructed of small twigs and rested against the trunk on a clump of large limbs. It was sheltered by a large deformed limb about 50 cm above the platform. The young were killed when they fell from the nest at about 20 days of age.

Vocalizations

Because vocalizations are referred to frequently in the discussion of breeding behavior, I described below the more common calls given, with my interpretation of their meaning.

Calls given by spotted owls included hoots, whistles, and loud barking calls, as well as bill popping sounds (also see Burton 1973, Bent 1938). Calls of females were higher pitched than those of males, making sex identification possible. The accuracy of this method for determining sex of spotted owls was confirmed on numerous occasions when behavioral differences could also be noted. With the exception of copulatory calls and food calls, all call variations were given by both sexes, though some were given more frequently by one sex than another.

Location Call: This is the hooting call most frequently described in the literature. It was given by both sexes in a variety of situations and seemed to function as a general location call and as an announcement of territory. It most commonly had four notes in a series: Hoo---hoo-hoo----hoo! Variation in this basic pattern was almost endless, but common variants were: (1) Hoo-hoo---hoo! (2) Hoo---hoo-hoo----hoo, hoo-hoo---hoo! (3) Hoo-hoo-hoo-hoo-hoo-hoo---hoo-hoo----hoo!

Agitated Location Call: This call was a variation of the Location Call given in situations of apparent sexual or aggressive excitement. Both sexes gave this call in repelling intruders from their territories. Both sexes, but especially males, gave this call during copulatory sequences. The call began like the Location Call, but was more intense and ended in a sharp, barked ow! note. Variants included: (1) Hoo---hoo-hoo---ow!, hoo-hoo---ow! (2) Hoo-hoo---ow!, hoo-hoo---ow! (3) Hoo---hoo-hoowa--ow!, hoo-hoowa---ow!.

Nest Call: This call was most commonly given by males after they had flown into their nest trees following copulation. It was a steady series of low hoots, sometimes carried on for several minutes or more with only minor breaks: Hu-hu-hu-hu-hu-hu-hu-hu-hu-hu-hu, etc. Females gave this call while perched inside their nest cavities. It was heard infrequently in other situations.

Contact Call: This call, which was given most frequently by females, is the whistle call frequently mentioned in the literature (Bent 1938). Given at low intensity, it apparently served to maintain contact between the female and her mate or young. It was a hollow whistle ending with an upward inflection: Weee-et! or Cooo-weep!

Agitated Contact Call: In situations of apparent aggressive excitement, such as intrusion of an unfamiliar spotted owl into a territory, the Contact Call was frequently given loudly and repeatedly,

mounting to a near shriek. It sometimes began with a raspy series of whistled notes that gradually increased in volume and clarity until each note became a loud, emphatic shriek: Kre--ick! (pause) kre-ick! (pause) kre-ick! (pause) kre-eet! etc. This call was most commonly given by females.

Scolding Bark: This call usually had a crowlike quality. It was a loud ow!-ow!-ow!-ow!-ow!-ow! series, frequently introduced by an emphatic Waa!. It sometimes resembled Wah!-wah!-wah!-wah!-wah!. During territorial encounters this call was given most frequently by females. It also appeared to be a long-distance contact call between paired birds.

Chitter: This call consisted of a rapid series of low chittering notes. It was given by adults or owlets when they were handled, apparently indicating fear or irritation. It was also occasionally given at low intensity by adults when they engaged in preening each other. It was given at high intensity by females during copulation.

Female Copulatory Call: This call was slightly variable but the basic pattern consisted of rapid chittering notes as the female was mounted which graded into a high-pitched, wheezy, prolonged whistled note as copulation occurred. The call ceased as the male dismounted.

Male Copulatory Call: Male copulatory calls were often an excited mixture of Location Calls and Agitated Location Calls given as the male flew to the female and mounted. Occasionally, however,

a steady series of emphatic single hoots was given during copulation: Hoo!-hoo!-hoo!-hoo!-hoo!. This was usually followed by Agitated Location Calls as the male dismounted and flew away.

Male Food Call: When males arrived near their nests or fledged young with food, they usually announced their presence with the Location Call. Some males had a distinct variation of the Location Call reserved for this occasion. It was identical with the Location Call except that the last note was given in a subdued fashion, almost quietly.

Female Begging Call: This call was occasionally given by females after males arrived near their nests with food and gave the Food Call. It was a low series of persistent hollow whistles with a cooing quality: Whee, whee, whee, whee, whee, etc.

Warning Call: This call was sometimes given when birds were approached by a predator. It was a single low uhh! or whu!.

Owlet Begging Call: Although owlets occasionally gave the Chitter or a low uhh! sound similar to the Adult Warning Call, the only call they gave regularly during their first summer was a begging call. This was a sibilant, high-pitched, prolonged whistled note, given persistently when they were hungry. Like the adult Contact Call, it ended with an upward inflection: Sweeeeet! etc. I could easily induce owlets to beg by imitating the call of an adult near them. The begging call was not loud, but could be heard at a considerable distance.

Conversation Calls: These were the "cooing" calls mentioned by Peyton (1910:122). They consisted of a variety of low whistles and cooing sounds given at close range between adults. Conversation Calls were given in many contexts, most commonly when paired adults were roosting together.

Timing of Nesting

The mean date of clutch initiation for 15 nests (calculated by backdating from the dates owlets fledged) was 29 March (range 9 March-19 April. I found no relationship between elevation and timing of clutch initiation, but there were differences between different geographical areas. Spotted owls in southwestern Oregon in 1972, for instance, nested 1-2 weeks earlier than those in the Coast Range and western Cascades, and 3-4 weeks earlier than pairs on the east slope of the Cascades. I received one report of a recently fledged brood of spotted owls observed on 28 April 1970 near Colton, Clackamas County (Crowell and Nehls 1970). I did not verify this sighting, but, if correct, it would indicate that eggs were laid in late February, an extremely early date.

Timing of nesting in Oregon did not differ appreciably from dates given by Bent (1938) for southern California. He listed 15 records of eggs observed or collected between 1 March and 10 May. Eight of the records fell within the periods 27 March to 1 April,

"indicating the height of the season" (Bent 1938:207).

Reproductive Behavior of Adults

As the breeding season approached, the activities of nesting pairs became increasingly centered around their nest trees, and several days prior to egg-laying, females began roosting in their nest cavities. Following copulations at night, both sexes (particularly males) called from nest trees.

Concurrent with concentration of activities around nest sites and initiation of reproductive behavior was a gradual shift of the primary foraging role to the male. Females spent more time near their nest sites at night, while males began to provide them with food. I did not determine exactly when males began feeding females, but the pattern was firmly established prior to egg-laying. Southern (1970) indicated that courtship feeding of females by male tawny owls began in January or February, 1-2 months before eggs were laid.

Pair Relations Prior to Egg Laying

On 23 March 1974, I found a pair roosting 140 meters from the nest they had used in 1972. This was the only pair studied intensively during the period prior to egg-laying and, unless otherwise indicated, the following discussion is drawn from this pair.

Copulation: Between 24 March and 12 April, 14 evenings were spent observing the pair from about 1730 hours (about one hour before darkness) until 2000-2100 hours. Copulation was observed on 10 evenings (Table 12). The maximum number of copulations observed per observation period was two and minimum time between successive copulations was 43 minutes. There was little variation in the manner in which copulation was performed; a typical sequence, recorded on 29 March, is described below.

Table 12. Number of copulations by one pair of spotted owls on 14 observer evenings between 24 March and 12 April.[a/]

Date:	March				April									
	24	25	28	29	1	2	3	4	5	7	8	9	10	12
No. copulations	2	1	1	2	2	1	0	0	0	1	0	0	1	1

[a/] Observation periods were from approximately 1730 (dusk) until 2000-2100. Observations during the full night period would undoubtedly have yielded a higher number of copulations.

At 1750 I entered the nest area and found the female roosting 40 meters from the nest tree. The male was roosting 20 meters from the female in a small fir. At 1805 (early twilight) the female began to give the Contact Call quietly every 15-30 seconds. The male was silent but began to watch the female. At 1809 he flew towards the female, giving Agitated Location Calls, hovered over her momentarily, and then mounted her, changing to the steady male Copulatory Call as

he did so. During copulation, which lasted 3-4 seconds, the female perched cross-wise on her roost limb and gave the Copulation Call. The male arched his wings over his back and fluttered them rapidly. When copulation was completed, the male flew away toward the nest tree, giving Agitated Location Calls. The female resumed the Contact Call after several minutes of silence.

The female completed her clutch of two eggs sometime between 8 and 12 April. After 12 April the pair ceased to copulate altogether.

Calling From the Nest Tree: After copulation, the male usually flew into the nest tree and perched on a limb just outside the nest cavity, giving the Nest Call. The female either became silent or perched near the nest tree, giving the Contact Call. On 29 March she flew into the cavity shortly after the male had ceased to call from the nest tree and had flown off to forage. When the male returned 30 minutes later and gave the Agitated Location Call near the nest, the female began to utter the Nest Call from inside the cavity. She then left the cavity and copulation followed.

Use of Nest Cavities as Day Roosts: On 4 April, at least 2 days before she laid the first egg, the female began roosting in her nest cavity during the day. I did not climb to the nest during this period but could see the female in the cavity by climbing an adjacent tree. During the first 2 days she roosted in the cavity, I always found her perched upright, looking out of the cavity. On the evening of 6 April

she was lying flat in typical incubation posture, and I suspected she was about to lay or had already laid the first egg. At another nest, a female roosted on a limb beside her nest cavity for several days prior to laying. Before females began roosting in their nest cavities, males usually roosted near them during the day, although frequently in separate trees.

Discussion: Like spotted owls, female little owls (Athene noctua), elf owls (Micrathene whitneyi), and spotted screech owls (Otus trichopsis) emit a shrill shrieking or whistling sound during copulation, and males beat their wings rapidly (Ligon 1968, Haverschmidt 1946).

Other owls in which males call from potential nest sites include the tawny owl, elf owl, little owl, Tengmalm's (boreal) owl, Eurasian pygmy owl, and common scops owl (Otus scops) (Ligon 1968, Konig 1965, Jansson 1964, Haverschmidt 1946). Ligon (1968) found that male elf owls called from within their nest cavities and females followed them inside. He interpreted this behavior as an attempt by males to entice females into nest cavities. The male spotted owl I observed did not enter the nest cavity while calling. He usually perched on a limb about 1 meter from the cavity.

Ligon (1968) found that female elf owls began roosting in their nest cavities 1-2 weeks before laying eggs. This behavior appeared to condition males to feed females at their nests and to prepare

females for the long period of incubation and brooding. Except for females in the nesting season, I never saw spotted owls roosting in cavities. Preferred roosts were on limbs in the dense foliage of trees.

Pair Roles During Incubation

Incubation was performed entirely by females, and once incubation was underway, nearly all foraging was by males. Females usually left their nests for 10-20 minutes at dusk, but their activities during this period appeared limited to preening, casting and defecating. Males typically roosted near their nest trees during the day and began foraging by late twilight. Before leaving to forage, males often gave several Location Calls near their nests. Females responded by calling from their nests or by leaving their nests and joining their mates for several minutes.

When returning to nest sites with food, males announced their presence by giving several Location Calls or Food Calls from nearby trees. Females responded by leaving their cavities and giving Begging Calls or Contact Calls until food was exchanged. Exchanges occurred in trees adjacent to nest trees or on limbs near nest cavities.

Pair Roles During the Nestling Period

By 12 May, all but the latest clutches had hatched. During the first 2 weeks of the nestling period, females brooded their young almost constantly, leaving their nests for only brief periods during the night. Foraging appeared to be entirely by males. When the young were 2-3 weeks old, females began spending progressively longer periods away from their nests at night. By the time owlets were 3-5 weeks old, females sometimes left them for 1-3 hours on warm nights. I assumed they were foraging during these absences, but could not verify this assumption. Both sexes carried prey into nest cavities during this period, but males were not observed feeding nestlings; they passed the food to their females and the females fed the young.

During the day, females roosted in their nest cavities with their young even after they ceased to brood them regularly. Three to 6 days before their young fledged, however, most females began roosting outside their nest cavities during the day. They typically roosted within 60 meters of their nests, occasionally giving the Contact Call. This call appeared to function in maintaining contact with the young in the nest. During the latter half of the nestling period some males began roosting away from their nests during the day, visiting them only at night to deliver food.

Nest Defense

Although Bent (1938), Ligon (1926), and Dickey (1914) stated that spotted owls were docile around their nests, I found them very aggressive. Nearly every time I climbed a nest tree I was attacked repeatedly, and several times when I approached fledged young on the ground I was attacked. Owls usually attacked by flying past me and raking with their talons. At most nests both adults participated in nest defense, but females were usually most aggressive. Smith (1963) also mentioned being hit by a spotted owl when he approached its young. On one occasion I watched a female spotted owl defend her nest against two ravens (Corvus corax) (see Natural Enemies).

Percent of Population Attempting to Nest

The percentage of the study population that nested during 1972, 1973, and 1974 varied markedly (Table 13). Why some pairs refrained from breeding each year was unknown, although I suspected that this may have been a reaction to fluctuating prey populations. A direct relationship between percentage of pairs nesting and prey abundance has been documented for several other owl species (Rusch et al. 1972, Southern 1970, Craighead and Craighead 1956).

Table 13. Brood size, productivity, and nest success of spotted owls in Oregon between 1972 and 1974. Percentages in parentheses.

	1972	1973	1974
Number of pairs checked for nesting	28	31	37
Number of pairs attempting to nest	25 (89.3)	5 (16.1)	17 (45.9)
Number of nesting pairs fledging young	23 (92.0)	2 (40.0)	13 (72.0)
Broods of 1 fledged	8 (33.3)	1 (50.0)	7 (46.0)
Broods of 2 fledged	12 (54.2)	1 (50.0)	6 (44.0)
Broods of 3 fledged	3 (12.5)	0	0
Total number of young fledged	41	3	19
Mean number of young produced per successful nest	1.87	1.50	1.46
Mean number of young produced per nesting attempt	1.72	0.60	1.11

Brood Size

I did not directly determine clutch sizes, but relied on the numbers of young fledged as an index of minimum clutch size (Table 13). In 1972, broods of one or two were most common, but three broods of three were recorded. During 1973 and 1974, broods of one or two were about equally common but no broods of three were observed. Mean number of young fledged per successful nest during the 3 years was 1.61, indicating an average clutch of two. Bent (1938:204) reported that "The spotted owl lays two or three eggs,

usually only two, and very rarely four. . . ." I observed no broods of four.

Nest Success

Nest success was high in 1972, dropped sharply in 1973, and rose again in 1974 (Table 13). A principal cause of nest failure in all years was nest desertion during the early stages of nesting. Several times, pairs arrived at their nest sites, and the females were observed entering their nest cavities; then unexplainably, all nesting activities ceased and the owls left their immediate nest areas. Whether these females laid eggs or simply roosted in their nest cavities for a time before foregoing nesting was unclear. In England, Southern (1970) found that during years of low prey abundance tawny owls frequently behaved as if they intended to nest, but never actually laid eggs and eventually abandoned their nests.

Other causes of nest failure included at least one nest (probably two) that failed when the young fell from the nest at 2-3 weeks of age. The young in another nest died at 4 weeks of age and one nest failed when the incubating female disappeared.

Development and Behavior of Nestlings

At hatching, owlets were covered by pure white natal down, and their eyes were closed. Until their eyes opened 5 to 9 days later,

they were relatively inactive. Between 10 and 20 days of age, the mesoptile plumage, which was pale brown and barred, began to replace the natal down on their wings, backs, and tops of their heads. At this age, owlets sat up and became active. They gave Begging Calls from nests, especially when adults called or were visible. They also snapped their beaks when I visited their nests and gave quiet Chittering Calls when handled or otherwise disturbed. Replacement of the natal down by the mesoptile down was nearly complete when owlets left the nest at 34-36 days of age (Fig. 9). Growth of remiges and rectrices during the latter half of the nestling period was rapid and owlets became increasingly active. Several days before they fledged, some owlets climbed on limbs outside their nest cavities. Others peered at me from nest entrances but apparently did not venture out of their nests until they fledged.

Fledging and Climbing

Most broods fledged between 15 May and 24 June. At fledging, the young were weak fliers; some were essentially flightless. As a result, many young ended up on the ground below nests or on low perches to which they climbed after falling to the ground. They were clumsy but persistent climbers and could climb almost any tree trunk with rough bark or small limbs to reach an elevated perch. A typical instance of fledging, observed on 26 May, is described below.

I arrived at a nest site at dusk (2000 hours) and found the female roosting 45 meters from the nest tree, giving the Contact Call quietly every 10-20 seconds. Two owlets were begging from the nest cavity, 43 meters up in a Douglas-fir, and a third was perched on a dead limb just outside the cavity. The latter owlet was begging loudly, and after a moment it jumped from its perch and fluttered vertically downward about 10 meters before grabbing a small limb with its feet. For a moment it hung upside down from the limb, but then by flapping its wings vigorously, it righted itself. At 2012 the second owlet flew clumsily to a limb outside the cavity, and the third appeared in the cavity entrance. All were begging loudly in response to the female's continued utterance of the Contact Call. The owlet in the cavity soon jumped to some small limbs near the cavity and then fell vertically about 12 meters, bouncing off several limbs before it was able to grab one with its feet. It hung upside down for some time, looking down at the ground, and then fell again, this time to a small limb about 3 meters lower, where it righted itself. After each owlet fell (or jumped) several more times, they reached temporarily secure perches in small trees below the nest tree. I left the area at 2130. When I returned the next day, two of the owlets were perched within 1.5 meters of the ground and the third was perched 10 meters up in a tree. The two owlets near the ground could barely fly. All were in good condition. Five days later, I found them roosting together

4 meters up in a vine maple (Acer circinatum), 100 meters from the nest tree.

Other strigids that leave their nests before they are fully capable of flight include the tawny owl, barred owl, great gray owl, and Ural owl (Strix uralensis) (Dunstan and Sample 1972, Hoglund and Lansgren 1968, Dement'ev et al. 1951). This behavior may be due to the inability of nestlings to exercise their wings within cramped nest cavities (Dunstan and Sample 1972). The fact that the young of great gray owls (which most frequently nest on open platforms) also leave their nests before they can fly (Hoglund and Lansgren 1968) seems to contradict this explanation. Hoglund and Lansgren (1968) suggested that young great gray owls left their nests early because they became increasingly uncomfortable as the season advanced and the sun began to shine more directly into nests. This explanation hardly seemed to apply to spotted owls, as they were usually protected from sunlight by nest cavities.

Young spotted owls climbed sloping tree trunks by walking up them, a maneuver that was accompanied by a great deal of wing flapping if climbing became difficult. To climb vertical tree trunks, owlets first grapsed the rough bark with their talons and then gripped a flake of bark or a small limb with their beaks to maintain balance. Then, by alternately walking upwards and grasping with their beaks, they proceeded upwards. While moving, owlets flapped their wings,

but when the stopped to rest, they draped their wings against the tree trunks. This assisted owlets in holding themselves in place. Dunstan and Sample (1972) described identical method of climbing by young barred owls, and reported that juvenile great horned owls and screech owls were also good climbers. Although Hoglund and Lansgren (1968) did not observe young great gray owls in the act of climbing, they suspected the owlets were good climbers.

According to Dunstan and Sample (1972), young barred owls sometimes continued to roost on the ground for several weeks after leaving their nests and after they developed flight. This was not the case with young spotted owls. All but the weakest owlets were able to get off the ground within 3 days after fledging; they did not roost on the ground thereafter. However, they frequently roosted only 1-3 meters aboveground.

THE POST-NESTING PERIOD

Adult Attendance of Fledglings

During the first 2 weeks after the young fledged, the female and frequently the male, roosted with them during the day. Males appeared to do most of the foraging during this period, but only infrequently fed their young. Instead, they brought food to their females, who in turn fed the young. Two to 3 weeks after owlets fledged, a change was noted in adult roles. Instead of giving prey to females, males began to take it directly to their owlets.

As owlets grew stronger, adults tended to roost further away from then during the day. By mid-July, adults often roosted 50-200 meters from their young, and by mid-August most adults no longer roosted near their owlets. During late summer I occasionally found them roosting up to 1.5 km from their young. Most males were less consistent than females in roosting near their young during the day. Table 14 illustrates the gradual shift from almost constant daytime attendance of owlets just after fledging to infrequent daytime attendance by late August. Although adults did not often roost with their owlets during late summer, they continued to feed them until late August or September.

Table 14. Record of adult presence near owlets during the day after the young fledged (in percent of total observations).

	Both Adults Present	Female Only Present	Male Only Present	Both Absent	Total Observations
20 May - 30 Jun	36	36	7	21	14
1 July - 31 July	46	42	8	4	24
1 Aug - 15 Aug	8	8	8	75	12
16 Aug - 31 Aug	0	8	0	92	13
1 Sept - 22 Sept	0	22	0	78	9

Development of the Young After Fledging

Behavioral Development

Although not able to fly well at fledging, owlets gained strength rapidly, and after only a week were able to hop clumsily about in their roost trees, grabbing at pieces of moss or small twigs with their beaks or talons and toying with them. When hungry, the gave the Begging Call persistently, especially if an adult with food was in sight or if an adult called nearby. Their movements during this early period consisted of short, clumsy flights between adjacent perches. When they were unsuccessful in flying from one perch to another and ended up on the ground, as often happened, owlets regained elevated perches by climbing.

Two weeks after fledging, owlets were able to fly upward into perches. Flight was still clumsy, however, and owlets frequently

landed on the ground after misjudging the distance to a perch. With increased mobility they began to make longer forays around their nest areas at night.

Three to 4 weeks after fledging, owlets began to exhibit behavior which resembled clumsy hunting attempts. This consisted of pouncing on leaves, twigs, pieces of moss, or crawling insects, and tearing them to pieces. Insects captured in this manner were sometimes eaten. These mock captures were clumsy at first but became increasingly coordinated. Miller (1974) described similar behavior by young spotted owls. Although adults usually tore up prey for them, owlets were now capable of holding and tearing up prey on their own.

By mid-July or Early August most owlets became proficient at pouncing on relatively immobile objects. They still relied primarily upon their parents for food, however. At night they remained in the vicinity of their roost areas until an adult returned with food, then flew towards the adult, begging loudly. Owlets were now given whole prey which they tore up themselves. I saw no evidence to indicate that young spotted owls accompanied their parents while the latter were foraging.

Owlets continued to beg for food through August, but by early September, the more advanced broods became increasingly quiet. Broods of late nesters continued to beg until the end of September if I called near them, and I suspected that these owlets were still fed

occasionally by their parents. After owlets ceased to beg in the fall, they sometimes flew in overhead silently and watched me when I called in their roost areas. By this time they were nearly self-sufficient hunters.

Plumage Development

Like most other strigids, juvenile spotted owls have three basic plumages in their first summer. The white natal down was replaced by the downy mesoptile plumage while the young were still in the nest. Replacement of the mesoptile plumage by the first winter plumage began at age 47-56 days and was completed by the end of September or early October (Figs. 8-14 and Table 15). During the mesoptile molt all feathers but remiges and rectrices were replaced. Owlets in their first winter plumage were indistinguishable from adults, except that they had ragged, downy tips on their rectrices, which persisted into the winter (Fig. 13). Tips of adults rectrices were smooth and rounded.

Movements of Owlets During Their First Summer

After fledging, broods remained near their nests for 2-3 weeks. Thereafter, they began to make longer movements each night, but these movements were erratic, and most broods did not venture far from their nests. Some broods moved away from and then back toward

Fig. 8. 17 June. Owlet ten days after fledging and 42-46 days old.

Fig. 9. 16 July. Owlet approximately 44 days after fledging and 76 days old. All but two greater coverts molted.

Fig. 10. 17 July. Owlet approximately 54 days after fledging and 85 days old. Top of head, neck, and breast still entirely covered by mesoptile down.

Fig. 11. 17 July. Owlet approximately 58 days after fledging and 90 days old. First-winter breast feathers begin to emerge along sides of upper breast at the level of the bend in the folded wing.

Fig. 12. 31 August. Owlet approximately 76 days after fledging and 110 days old. Nape and back of head still covered by mesoptile down.

Fig. 13. 23 August. Owlet approximately 85 days after fledging and 119 days old. Note appearance of first winter feathers on nape. Ragged, downy tips of rectrices are characteristic of first-winter juvenile.

Fig. 14. Owlet at about 120-130 days of age on 3 September. Replacement of mesoptiles complete except for a narrow band across nape and sides of head.

Table 15. Plumage development of juvenile spotted owls after fledging (15 May to 30 September).

Number of Days After Fledging	Approximate Age in Days	Developmental Stage
0-10	35-46	(Brood variability 15 May to 24 June)[a/] Covered by buff-brown mesoptile down, owlets fledged when about 34-36 days old. Natal down clung to the tips of mesoptiles, giving owlets a fuzzy appearance. Mesoptiles on head and wing converts grew rapidly, complete by end of period. Facial disks were small and dark brownish-black. Irises dark brown, pupils pale watery blue. Beak greenish-blue, cere pink (Fig. 8).
11-20	47-56	(Var. 8 June to 5 July) Owlets began ecdysis of mesoptiles from wing coverts, breast, and abdomen. Rictals began to grow over base of cere. Remiges and rectrices grew rapidly. Facial disks developed rapidly, developing buff-brown lateral margins.
21-31	57-67	(Var. 15 June to 14 July) First winter lesser and middle wing coverts developed rapidly. Ecdysis of mesoptile greater wing coverts and some middle coverts continued. Ecdysis of mesoptiles from back, nape, and from outer edge of facial disks began (Fig. 9).
32-45	68-82	(Var. 30 June to 24 July) First winter feathers on back emerged rapidly. Ecdysis of mesoptiles from top of head, nape, and borders of facial disks occurred rapidly. Facial disks were nearly adult size (Fig. 10).

Table 15. Continued.

Number of Days After Fledging	Approximate Age in Days	Developmental Stage
46-57	83-93	(Var. 12 July to 10 August) First winter breast feathers became visible at level of the bend in the folded wing, forming patches on each side of the breast (Fig. 11). Facial disks were nearly complete. Ecdysis of last greater wing coverts occurred. A few mesoptile scapulars (axilars ?) were still unmolted. The head was still covered by mesoptile down, but rapidly developing contour feathers could be seen by spreading the mesoptiles with the fingers.
58-84	94-120	(Var. 25 July to 10 September) Molt of back and wings completed. Facial disks appeared essentially complete. Lateral patches of new breast feathers merged across upper breast, leaving a small amount of mesoptile down on abdomen. Feathers on nape and between facial disks on top of head developing rapidly (Figs. 12, 13). A broad band of mesoptile down still crossed the back and sides of the head.
58-110	212-145	(Var. 26 August to 22 September) Replacement of mesoptiles completed except for small unmolted patches of mesoptiles on the sides of the head and in a narrow line across the back of the head (Fig. 14).
111-131	135-155	(Var. 10 September to 15 October) Molt completed. Owlets were now indistinguishable from adults except for "cottony" tips on rectrices.

[a] Indicates approximate dates at which broods of early or late nesting pairs reached the same stage in development.

their nests, while others took a wandering course away from their nests. A few broods remained near their nests for the entire summer. Of 14 broods checked in late August, 5 were within 160 meters of their nests, 5 were 170-250 meters from their nests, and 2 had moved 487 and 670 meters, respectively. Two broods could not be located. One of the broods not located had moved 1.05 kilometers from their nest when last seen on 29 July. The other unlocated brood had moved 365 meters when last seen on 7 July. Of the 12 broods located in August, at least 5 were still within 200 meters of their nests in early September.

Two instances in which broods moved long distances from their nests (487 and 670 meters) occurred where goshawks (Accipiter gentilis) nested close to spotted owl nests. It appeared that these pairs of owls "led" their young away from the goshawk nests.

Dispersal

Spotted owl broods remained together until at least September of early October. Thereafter, I was unable to follow their movements.

Juvenile Mortality After Fledging

Of 29 owlets observed from the time they fledged in 1972, only 19 were alive at the end of August, a loss of 35 percent. Most mortality occurred between late July and the end of August, when

owlets had attained a degree of independence and were alone much of the time. During June and early July when newly fledged owlets were attended by adults, mortality was low. Cause of mortality was determined in only one case when an owlet was killed by a great horned owl. In other instances, owlets simply disappeared and were assumed dead. I suspected predation as the cause of mortality in most instances because owlets appeared otherwise healthy shortly before they disappeared.

NATURAL ENEMIES

On 30 August 1972 I found the remains of a juvenile spotted owl scattered under one of its usual roost trees. Mixed with the plucked feathers of the owlet were several molted feathers of a great horned owl. Nearby, I found a large owl pellet containing the feet of the owlet. I concluded that the owlet was killed by a great horned owl. In several other instances when owlets disappeared, I suspected, but could not verify, great horned owls as the cause of mortality. I saw no predation on adult spotted owls by great horned owls, and did not believe it occurred often, as many pairs of spotted owls existed in close proximity to great horned owls.

The goshawk and Cooper's hawk (Accipiter cooperii) may prey on spotted owls, as indicated by the following observations. At 1133 hours on 6 July 1972 an owlet was being fed by its male parent, and was begging loudly. The adult female owl was roosting about 15 meters away. A chipmunk suddenly gave an alarm call nearby, followed by the low Warning Call of the female spotted owl. The male and owlet "froze," and seconds later, an adult female Cooper's hawk appeared, flying rapidly toward the owlet. Before the hawk reached the owlet, the male spotted owl flew from his perch and intercepted it. I could not see whether the owl hit the hawk, but the hawk veered off and flew away.

Cooper's and sharp-shinned hawks (Accipiter striatus) appeared too small to capture adult spotted owls, although they frequently harassed them. I observed one instance in which an adult male Cooper's hawk repeatedly dived at, and hit, an adult male spotted owl. Both Cooper's and sharp-shinned hawks frequently scolded me when I called spotted owls during the day. Miller (1974:142) observed harassment of a juvenile spotted owl by an immature Cooper's hawk.

In eight instances, spotted owls nested within 400 meters of active goshawk nests, and, in one case, nests of the two species were only 125 meters apart. Thirty-two other pairs of spotted owls occupied territories within the foraging areas of goshawks. Despite the close proximity of their nest sites and areas of activity, neither I nor Richard Reynolds (1975, personal communication), who studied goshawks within my study area, observed predation on spotted owls by goshawks. Twice, when adult spotted owls responded to my calls during the day, adult goshawks flew into the owl roost areas, apparently looking for the owls. The owls ceased calling and remained nearly motionless until the goshawks left. I suspected goshawks were capable of preying on spotted owls, but that the secretive nature of the owls during the day allowed them to avoid detection.

When I called spotted owls during the day, ravens frequently scolded me. On one occasion, a pair of ravens harassed a female owl near her nest; while trying to locate her mate, I had accidentally

called the female out of her nest cavity, and when she left the nest she was attacked by the ravens and a pair of Steller's jays. The ravens landed on limbs near the nest, and the owl immediately returned to the nest tree, scolding and diving at the ravens. I became concerned that I might have placed the nest in jeopardy, and yelled at the ravens, which then flew away. The female returned to her nest cavity.

When a male spotted owl responded to my calls during the day, an adult red-tailed hawk (Buteo jamaicensis) flew into the roost area and began searching for the owl. The owl became silent, and the hawk eventually left. Miller (1974:142) described a similar interaction.

Many species of small birds were observed mobbing spotted owls during the day, and at night, saw-whet, pygmy, and screech owls often scolded when spotted owls called.

Two owls were intentionally killed or injured by humans during the study, and two were killed when hit by automobiles. An owlet that became entangled in a piece of cotton string apparently died of exhaustion or exposure. The string had been suspended above the ground during a timber sale layout.

HABITAT

The spotted owl is a forest owl. It is dependent upon mammals and birds which occupy forest environments for its food, capturing much of its prey in the forest canopy. The forest also provides the owl with nests and with a protective environment in which to roost and raise its young. Outside of this environment it is unable to exist, much less nest. Questions perplexing forest managers and researchers are (1) what are the specific habitat requirements of the spotted owl, and (2) how adaptable is it to intensively managed forests? These questions are addressed in the following sections.

Vegetative Characteristics of Habitats

Forest Age and Structure

Examination of forests inhabited by spotted owls indicated that the structure of forest vegetation was particularly important in habitat selection. Of 123 pairs located, 117 (95 percent) occupied undisturbed old-growth conifer associations. Two pairs occupied partially logged old-growth forests and three occupied second-growth forests with minor old-growth components.

Old-Growth Associations: Age of old-growth trees in occupied habitats ranged from about 220 to 600 years. Although there was wide variation in forest age, all old-growth habitats were characterized by

similar structure, in particular, uneven-aged, multilayered canopies. Canopies usually consisted of an overstory layer of old-growth trees and large mature trees that blended with one or two lower layers of second-growth trees (Figs. 15, 16). Although individual canopy layers varied in density, composite canopy closure was moderate to high (50-90 percent closure). This structure provided the owls with a relatively dense forest environment in which individual foliage layers were not so dense as to impede flight through the canopy.

Although structure and species composition were affected by natural succession, the multilayered structure of most old-growth forests occupied by spotted owls was partially caused by wildfires. Before the advent of fire control in the early 1900's, wildfires periodically burned most of Oregon's forests (Franklin and Dyrness 1973). Ground fires, which killed only the less resistant understory trees, were common. As a result, many present old-growth forests in western Oregon and the Cascades consist of large Douglas-fir overstory trees with fire-scarred trunks and understories of 60- to 180-year-old trees regenerated since the last ground fires. Understory trees are usually shade-tolerant species, such as western hemlock.

Old-growth habitats were also characterized by moderate to high incidence of diseased or damaged trees, including snags, fallen trees, trees with broken tops, and trees with fungal or dwarfmistletoe

infections. Old trees were most commonly afflicted with broken tops and parasitic infections, and were the principle source of nests utilized by the owls.

Ground layer vegetation in spotted owl habitats varied from almost none to dense herb-shrub layers up to 1.5 meters high. This variability indicated ground layer vegetative structure had little influence in habitat selection.

Disturbed Forests: Of five pairs located in atypical habitats, two occupied forests that had been hi-graded (see p. 15) about 30 years previous. These stands had developed closed, uneven-aged, multilayered canopies, that were structurally similar to undisturbed old-growth forests except that old-growth overstory trees were reduced in numbers. Pairs occupying these sites nested successfully.

Two pairs occupied forests which were mosaics of old second-growth and undisturbed old-growth. In both instances, the total area in second-growth equaled or exceeded that in old-growth. In one case, a pair located near Hebo, Tillamook County, occupied two adjacent 6-hectare pockets of undisturbed old-growth surrounded by several square kilometers of 80-year-old second-growth. Fire-scarred old-growth trees were scattered through the second-growth at densities below two per hectare. The principal roost area was in one of the old-growth islands, but the nest was not located.

The second pair, found near Parkdale, Hood River County, occupied a 40 hectare stand of 70-year-old second-growth Douglas-fir and western hemlock that bordered an equal area of undisturbed old-growth Douglas-fir and western hemlock. The second-growth portion regenerated after a crown fire in the late 1800's, and consisted of a 70 percent closed canopy with an open understory. The owls were roosting in the second-growth when located. I visited this site only once.

A fifth pair, located near Corvallis, Benton County, occupied a predominantly second-growth forest of 70- to 90-year-old Douglas-fir. The nest tree, an old-growth Douglas-fir, was in a stand of 40- to 92-centimeter dbh (diameter at breast height) Douglas-fir having a 70 percent closed canopy. Scattered through the forest were large old-growth Douglas-fir with fire-scarred trunks. Density of old-growth trees was less than two per hectare, except at the nest site where there was a cluster of four large trees. Most old-growth trees had broken tops and were contained within the second-growth canopy or protruded only slightly above. The owls in this habitat nested only once in the 3 years I observed them (1972-1974) and failed in that effort. When not nesting, they often roosted in a hi-graded stand of old-growth Douglas-fir about 1.2 kilometers from their nest.

Vegetative Species Composition

Coast Range: Twenty-three of 26 pairs located in the Coast Range occupied habitats dominated by subclimax associations of old-growth Douglas-fir, western hemlock, and western red cedar. In 22 of these habitats, old-growth Douglas-fir was the most numerous overstory tree, but mature western hemlock and western red cedar were usually scattered through the Douglas-fir overstories. The exception was a stand of old-growth western hemlock that contained only scattered old-growth Douglas-fir. Fifty- to 80-year-old western hemlock dominated most understories but other common species were western redcedar (Thuja plicata), western yew (Taxus brevifolia), bigleaf maple (Acer macrophyllum), Pacific dogwood (Cornus nuttallii), Douglas-fir, golden chinkapin, grand fir, and on mesic sites, red alder (Alnus rubra).

One pair, found in the Coast Range, 8 kilometers east of Tillamook, Tillamook County, occupied an old-growth association of Douglas-fir and sitka spruce with a dense understory of western hemlock and sitka spruce. Old-growth Douglas-fir and spruce (178-228 cm dbh), were equally represented. This was the only owl habitat in which sitka spruce was an overstory co-dominant. There are old records of spotted owls in sitka spruce and western hemlock along the coast (Gabrielson and Jewett 1940) but most of these areas have been clear-cut or burned.

In the foothills of the Coast Range near Corvallis, Benton County, two pairs were located in mixed forests of Douglas-fir and grand fir. One pair occupied a predominantly second-growth habitat, the other, a hi-graded habitat (see p. 15). The nest site of the latter pair consisted of a multilayered stand of scattered old-growth Douglas-fir and grand fir with an understory of grand fir, Douglas-fir, bigleaf maple, western yew and Pacific madrone. Overstory trees represented two age-classes, old-growth trees over 200 years old, and slightly small trees about 160 years old.

West Slope of the Cascade Range--North of Crater Lake: All 29 pairs located in this region occupied old-growth associations of Douglas-fir, western hemlock, and usually western redcedar. Most sites were characterized by overstories dominated by old-growth Douglas-fir with minor components of mature or old-growth western hemlock and western redcedar. Old-growth trees on most sites had fire-scarred trunks. Understories were dominated by 40- to 100-year-old western hemlock but included variable amounts of Douglas-fir, western yew, vine maple, western redcedar, Pacific dogwood, and bigleaf maple. On a few sites, mature trees and saplings of white pine or sugar pine were present in low densities and one site included areas of mature Engelmann spruce (Picea engelmannii) mixed with western hemlock. Three habitats at 1,000-1,350 meters elevation on the South Santiam Pass, Linn County, contained scattered mature

silver fir (Abies amabilis) in their old-growth Douglas-fir overstories; second-growth silver fir was also scattered through the predominantly western hemlock understories.

East Slope of the Cascade Range--North of Crater Lake:

Habitats in this region were divided into four vegetative types.

Type 1: In western Hood River County, five pairs were located in forests dominated by old-growth Douglas-fir and scattered western hemlock with scattered stems of mature grand fir, silver fir, noble fir, or western white pine. At higher elevations, grand fir became less common and silver fir or noble fir more common (Fig. 15). Understory trees consisted of second-growth western hemlock, grand fir, silver fir, Douglas-fir, and western white pine in various combinations. On one mesic site, western redcedar and Engelmann spruce were important understory trees. Ground layer vegetation consisted of low herbaceous species and scattered shrubs.

Type 2: At 1,040 meters elevation near the headwaters of the Metolius River, Jefferson County, one pair was located in an old-growth association of Douglas-fir, ponderosa pine, and incense cedar, with a dense understory of 85-year-old Douglas-fir and grand fir. Old trees had fire-scarred trunks and the old-growth Douglas-fir was heavily dwarfmistletoe infected. Herbaceous ground cover was 1-5 percent. The nest cavity was in an old-growth Douglas-fir.

Fig. 15. Spotted owl nest area in an uneven-aged stand of Douglas-fir and western hemlock at 975 meters elevation on the east slope of Mount Hood near Parkdale, Hood River County. Understory is predominantly western hemlock and Pacific silver fir, with scattered noble fir and western white pine.

Type 3: On a more mezic site, 4.8 kilometers from the pair in Type 2, a pair was located in a stand of old-growth Douglas-fir, ponderosa pine, and western larch. The Douglas-fir was heavily infected with dwarfmistletoe and many older trees were dead. The site was characterized by many small springs and creeks, and in the wet areas second-growth western hemlock, western yew, Engelmann spruce, western larch, and western white pine were present. The majority of the understory, however, was comprised of 85- to 100-year-old grand fir. The nest was in a large dwarfmistletoe broom.

Type 4: Three pairs located between 1,240 and 1,520 meters on the east slope of the central Cascades occupied old-growth associations of Douglas-fir, grand fir, and silver fir, with scattered old-growth ponderosa pine. Other overstory trees present in variable numbers included western white pine, mountain hemlock, and Shasta red fir. Understory trees included combinations of grand fir, silver fir, Shasta red fir, Douglas-fir, mountain hemlock, western white pine, and occasionally, ponderosa pine, lodgepole pine, or knobcone pine (Pinus attenuata). Ground cover consisted principally of low herbs and shrubs. These habitats represented the highest elevations at which spotted owls were located on the east slope of the central Cascades.

Southern Cascade Range--South of Crater Lake: Sixteen pairs were located in this region which included the Oregon Cascades south

of Crater Lake, between Klamath Falls, Klamath County on the east and Medford, Jackson County on the west. Habitats were divided into two major vegetative types.

Type 1: At high elevations (1,200-1,770 meters) in western Klamath County and eastern Jackson County, eight pairs were located in old-growth associations of white fir, with variable amounts of old-growth Douglas-fir and Shasta red fir. Douglas-fir comprised 0-44 percent of the overstory trees on these sites but, with one exception, was uncommon in stand understories. Shasta red fir was a minor forest component at lower elevations but became increasingly common above 1,500 meters. Ponderosa pine was uncommon in five of the eight habitats, but was common on xeric south exposures in the other three. White pine was a scattered overstory and understory tree on most sites, and old-growth incense cedar was sometimes present on south exposures. Understories were dominated by 50- to 90-year-old white fir, but included various mixtures of Douglas-fir, Shasta red fir, ponderosa pine, western white pine, sugar pine, western yew, incense cedar, and golden chinkapin. Old-growth trees on all sites were fire-scarred. Ground layer vegetation consisted mainly of low herbaceous species. Three nests were located in this area, two in treetop cavities, and one in a dwarfmistletoe broom.

Type 2: At elevations between 700 and 1,280 meters in the southern Cascades seven pairs were located in old-growth mixed

conifer forests characterized by overstories of Douglas-fir, with variable amounts of incense cedar, white fir, sugar pine, and ponderosa pine. Understories were dominated by 50- to 120-year-old white fir and Douglas-fir but included mixtures of incense cedar, California black oak (Quercus kelloggii), western white pine, sugar pine, bigleaf maple, western yew, Pacific madrone, and Pacific dogwood.

Siskiyou Mountains: Habitats of 30 pairs located in this region were divided into three major vegetative types.

Type 1: Of 23 pairs located in the eastern Siskiyou Mountains, 20 occupied old-growth, mixed conifer forests between 300 and 1,220 meters elevation. Old-growth Douglas-fir was dominant in all mixed conifer habitats, but associated overstory species included incense cedar, ponderosa pine, sugar pine, and on mesic sites, Port-Orford-cedar (Chamaecyparis lawsoniana). Old-growth trees on most sites had fire-scarred trunks. Understory trees were generally 50-90 years old, and consisted of mixtures of Douglas-fir, grand fir, incense cedar, western yew, Pacific madrone, canyon live oak, California black oak, and bigleaf maple.

Type 2: Three pairs, located between 1,060 and 1,400 meters elevation near Oregon Caves, Josephine County, occupied forests resembling those of the White Fir Zone in the southern Cascades. Stands consisted of mixed associations of old-growth Douglas-fir,

Fig. 16. Spotted owl habitat in an uneven-aged mixed conifer stand at 457 meters elevation in the Siskiyou Mountains 13 kilometers west of Medford, Jackson County. Overstory is old-growth Douglas-fir. Understory is Douglas-fir, incense cedar, white fir, and western yew. A principal roost used by the owls was the small western yew at right center.

white fir, and Shasta red fir, and, occasionally, Port-Orford-cedar. Old-growth Douglas-fir and white fir dominated overstories at lower elevations, but above 1,340-1,400 meters, Shasta red fir became increasingly common. Principal understory tree species were second-growth grand fir, Shasta red fir, Douglas-fir, and Port-Orford-cedar.

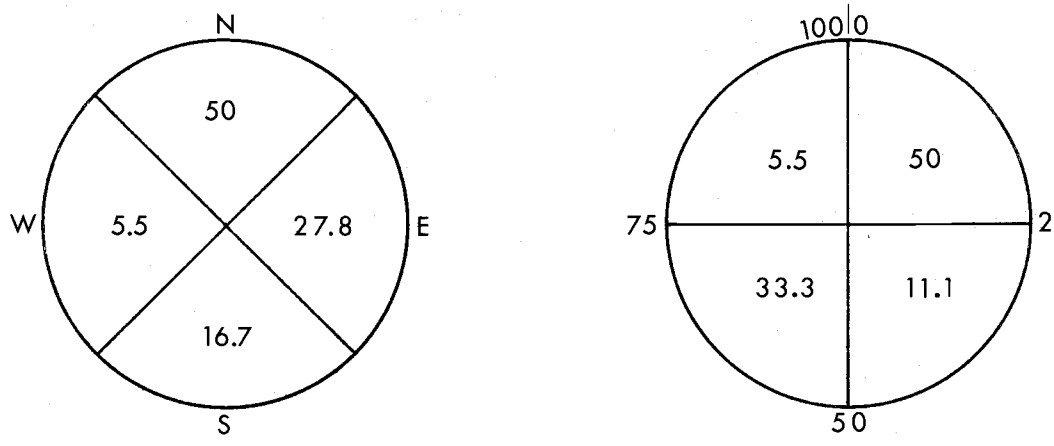
Type 3: Seven pairs located near the coast, at the western edge of the Siskiyou Mountains, occupied forests dominated by old-growth Douglas-fir. Two sites were characterized by minor components of old-growth coast redwood (Sequoia sempervirens) and mature western hemlock. Old-growth trees in all habitats were fire-scarred and understory trees averaged 60-80 years old. Principal understory trees were tanoak and California laurel, but western hemlock, bigleaf maple, and red alder were common on mesic sites. On dry south exposures and ridgetops, Pacific madrone and golden chinkapin sometimes formed dense thickets. Herb and shrub layers were generally dense.

Characteristics of Nest Sites

Exposure and Slope

Spotted owls showed slight preference ($\chi^2 = P < .01$) for nest sites on north or east exposures, probably because trees there were

usually larger and forests were denser than on south or southwest exposures (Fig. 17A). Such forests best satisfied their need for large nest trees and for shade during the summer. Spotted owls did not appear to tolerate high temperatures well; wild birds began gular flutter at ambient temperatures as low as 29 C, and above 32-33 C they showed definite signs of heat stress (gular flutter, panting, compression of body feathers, roosting with the wings held away from the body and with the legs exposed).



A. Exposure B. Percent slope

Fig. 17. Exposure and slope at 18 spotted owl nest sites located in Oregon. Numbers inside circles indicate percent of nests in each category.

Because most of western Oregon was mountainous, and because flat, accessible areas had been most intensively logged or developed, most owls existed in mountainous areas. Of 123 pairs, only 13 (11 percent) occupied areas of flat or undulating terrain with low hills. Twenty-nine pairs (23 percent) occupied areas of moderate relief where most slopes were less than 60 percent (average about 45 percent). Eighty-one pairs (66 percent) occupied mountainous terrain characterized by rugged drainage systems. Slopes in these areas reached 80-100 percent but averaged 50-70 percent. Nest trees were located on slopes ranging from 1-78 percent (Fig. 17B). Of 14 nests on slopes greater than 10 percent, 10 were less than halfway up the slope, 3 were one-half to two-thirds way up the slope, and 1 was near the top of a broad ridge top.

Water

Most nest sites and summer roost areas were located close to water, usually a small creek or spring (Table 16). It was not clear whether this reflected selection for a nearby source of drinking and bathing water or for the larger trees and denser forests usually associated with water. I observed spotted owls drinking from small springs and streams on several occasions, and twice saw owls bathing in shallow pools. Occasionally, I found molted feathers floating in small pools where owls had bathed. Miller (1974) and Ronald Nussbaum (1972,

personal communication) also observed spotted owls bathing. My captive owl drank and bathed at irregular intervals. It appears, therefore, that if water is not absolutely required by spotted owls, it is at least preferred.

Table 16. Distance between 18 spotted owl nests and the nearest source of permanent water.

Distance From Water (in meters)	Number of Nests
0-50	5
50-100	2
100-200	6
200-300	2
485	1
975	1
1,420	1
Total	18

Three nests located over 400 meters from permanent water (Table 16) were in areas characterized by heavy winter snowpacks and brief periods in April or May when surface runoff was present. After the runoff, available water was limited to the distances given in Table 16. These pairs visited the areas where water was available in the late summer, but their less mobile owlets were without water until they dispersed in late September or October. This had no apparent effect upon the owlets. Sources of permanent water utilized by all 18 pairs consisted of small perennial streams or springs.

Streams were often reduced to small trickling pools in late summer.

Forest Structure

The principal requirement in nest site selection appeared to be the presence of an acceptable nest tree, in which the nest did not project above the surrounding canopy. Canopy closure at 18 nest sites ranged from 53 to 86 percent. Fifteen nests were over 180 meters from the nearest large opening in the forest; the other three were 90-150 meters from the forest edge.

Characteristics of Roost Areas

Spotted owls roosted at different levels in the forest canopy during different seasons. This appeared to be a reaction to changes in weather conditions. During summer, they roosted low in the understory, where they were shaded from the sun. On hot days they often roosted only 1-5 meters off the ground, frequently near water. Typical warm-weather roosts were in second-growth trees with many limbs. Preferred perches were often located where limbs of several trees intertwined, creating a shady roost (Fig. 16, p. 100). Tree species most commonly used as warm-weather roosts included western yew, western redcedar, incense cedar, western hemlock, canyon live oak, California black oak, Pacific madrone, bigleaf maple, tanoak, California laurel, Douglas-fir, grand fir, white fir, and

Port-Orford-cedar. Owls roosting near the ground sometimes perched on bent-over vine maple trees or other woody shrubs.

During wet weather, owls roosted higher in the canopy, often in old-growth Douglas-fir with large limbs or dense deformities caused by dwarfmistletoe. Typically, owls perched 15-45 meters aboveground, close against the trunks of large trees, and under a protective screen of overhanging limbs. In this type of roost, they remained dry, even when the forest understory was soaked by rainfall.

HABITAT DISTURBANCE

Reactions to Man's Presence

Unless physically abused, spotted owls were little affected by man's presence. They were exceptionally tame and showed little concern when approached closely. Human presence around nest sites did not seem to affect the owls adversely unless incubating or brooding females were kept from their nests for inordinate periods.

Reactions to Roads and Related Structures

Logging roads passed through the habitats of many pairs, and two pairs occupied territories bisected by a major highway. These roads seemed to have little effect upon the owls. High speed traffic did create a hazard, however; two adults were struck and killed by automobiles. Owls abandoned nest or roost sites that were harvested during road construction.

Reactions to Timber Harvest

Timber harvest and related activities accounted for most habitat loss. Timber harvest either occurred or was scheduled in approximately half of the habitats occupied by spotted owls (Table 17). The rate of harvest in habitats located without aid of cooperator reports exceeded that in habitats located as a result of cooperator reports

(Table 17). These differences were caused by differences in the method of location and in the amount of time different habitats were under observation. Most pairs that I located were found in 1970 and 1972. Cooperator locations increased between late 1972 and 1974; most were received in 1973 and 1974. Therefore, most sites I located were observed for 2-4 years and planned timber sales had 2-4 years in which to be harvested. Most sites located by cooperators were observed only 1-3 years and most were located during timber sale layout, 2-3 years prior to harvest. The end results were similar; 49 percent of the habitats I located were affected by timber harvest or were scheduled for harvest within 3 years. The corresponding figure for the 62 habitats reported by cooperators was 54 percent.

Table 17. Record of harvest activities in 123 habitats occupied by spotted owls during 1970-1974 in Oregon. Pairs located without aid of cooperator reports are listed in column one. Pairs located as a result of cooperator reports are listed in column two.

Harvest Category	Independent Locations (n = 61)	Cooperator Locations (n = 62)
Harvest plans undetermined	15 (25%)	14 (23%)
No immediate harvest planned	16 (26%)	14 (23%)
Major harvest planned in area[a/]	11 (18%) } 49%	30 (48%) } 54%
Major harvest occurred in area	19 (31%) }	4 (6%) }
Total	61 (100%)	62 (100%)

[a/] Major harvest refers to any harvest involving a nest site or principal area of activity (principal roost areas, suspected nest sites), or any harvest involving more than 25 percent of the existing forested habitat.

The effects of logging upon spotted owls depended on (1) type of harvest, (2) amount of undisturbed forest left after harvest, (3) placement of the harvest unit relative to areas utilized by the owls, and (4) individual site differences. The last factor was nearly impossible to quantify because individual site differences included a myriad of interactions between owls and their environment.

Harvest of a portion of the timber within a habitat did not, in most instances, completely eliminate the owls from the area, as only parts of large habitats were logged. In a 160-hectare stand of old-growth, for instance, a single 12-hectare clear-cut often had no observable effect upon a pair of owls except to cause them to concentrate their activities in the remaining uncut habitat. If, however, the clear-cut coincided with a nest area or principal roost area, reactions were more pronounced (Table 18). Harvest within forest habitats less than about 80 hectares in area had serious effects (Table 18).

Clear-cutting in all cases eliminated roosting or nesting in the harvested areas. Overstory removal appeared to have less traumatic effects on spotted owls than clear-cutting; in several instances when light overstory removal was completed on part of occupied habitats, owls still foraged and roosted in the disturbed areas. Heavy overstory removal, which resulted in widely-spaced trees and open canopies, destroyed sites for nesting or roosting. I surveyed several such areas and located no owls in them.

Table 18. Responses of seven pairs of spotted owls to timber harvest within their habitats.

Site No.	Area of Old-Growth Forest Habitat Before Harvest (hectares)	Number of Years Observed	Type and Area of Harvest Unit (hectares)	Nest Area Harvested	Roost Areas Harvested	Response of Owls	Record of Nesting After Harvest
1	80	5 (5)[a]	CC (12)[b] and DS (16)	yes	yes	Disappeared	No[c]
2	80	3 (2)	CC (44)	yes	yes	Disappeared	No
3	80	3 (3)	CC (12)	unknown	yes	Disappeared	No
4	240	3 (2)	CC (44)	no	yes	Disappeared	No
5	80	3 (2)	OR (65)	yes	yes	Apparently left area	No
6	645	5 (3)	OR (283)	unknown	yes	Shifted area of activity into unharvested portion	1, 3[d]
7	125	3 (3)	CC (12)	no	unknown	No noticeable response	1, 2

[a] Figure in parentheses indicates number of years each site was observed after harvest occurred.

[b] CC = clear-cut; OR = overstory removal; DS = deadfall salvage (removal of down and dead trees).

[c] No = no nesting.

[d] Numbers 1, 2, 3 indicate whether birds nested in the first, second, or third breeding season following harvest.

Another aspect of timber harvest which may be detrimental to spotted owls is the invasion of logged areas by great horned owls. The great horned owl was a predator of juvenile spotted owls, and proximity of the two species probably increased the likelihood of predation on young spotted owls.

MANAGEMENT

Projections indicate that by the year 2000, 80-90 percent of the timber on federal lands in Oregon will be converted to forests less than 200 years old (Anon. 1963:99). Where old-growth has already been greatly reduced, such as in the Coast Range, conversion will undoubtedly be completed before 2000. Most private holdings have already been converted to second-growth. After conversion, average rotation ages (age at which forests will be periodically harvested) of 56-77 years on private lands and 75-80 years on federal lands are anticipated (Anon. 1963:96). These forest management practices make few allowances for species such as the spotted owl, which require large cavities or diseases trees for nesting, and which appear to have a strong preference for multilayered forests. It appears, therefore, that some modification of current forest management practices is desirable if viable populations of these species are to be preserved.

Existing Preserved Areas

There are several areas in Oregon that are currently exempt from timber harvest and that might be considered preserved spotted owl habitat. My evaluation of these areas follows.

Wilderness Areas and Roadless Areas

Most wilderness and roadless areas contain little spotted owl habitat. They are high elevation areas characterized by subalpine or timberline vegetation. Some, like the Mt. Jefferson and Three Sisters Wilderness Areas, contain narrow strips of potential spotted owl habitat around their margins, but this is a small percentage of the total area. Two pairs were located inside the Mt. Jefferson Wilderness boundary on the east slope of the Cascades. The habitat of one pair was entirely within the wilderness while the other was principally outside the wilderness. Although little spotted owl habitat occurs in wilderness or roadless areas, the possibility exists of extending boundaries to include such habitat.

National Parks and Monuments

These include Crater Lake National Park (64, 869 hectares) and the Oregon Caves National Monument (188.5 hectares). Like the wilderness areas, much of Crater Lake National Park is covered by subalpine forests. I did not survey this area, but there is one record of a bird heard calling near the west boundary of the park (Farner 1952). I located one pair in the Oregon Caves National Monument, but the main roost area and probable nest site were 60 meters outside the monument boundary; that area was marked for overstory removal in 1974.

Federal Research Natural Areas

There are eight Research Natural Areas in western Oregon and the Cascades which may provide habitat for spotted owls (Table 19). For descriptions of these areas see Franklin et al. (1972). Five of these areas are less than 240 hectares, but might provide adequate habitat for one pair each.

Table 19. Federal Research Natural Areas in Oregon containing potential spotted owl habitat.

Name	Area (hectares)	Forest Type
Abbott Creek	1,052	Mixed conifer
Ashland	569	Ponderosa pine - Douglas-fir
Bull Run	142	Noble fir - silver fir - mountain hemlock
Bagby	226	Douglas-fir - western hemlock
Cherry Creek	239	Douglas-fir - western hemlock
Coquille River Falls	202	Douglas-fir - Port Orford cedar
Port Orford Cedar	454	Douglas-fir - Port Orford cedar
Wheeler Creek	135	Douglas-fir - coast redwood

I surveyed three of the most promising areas (Cherry Creek, Bagby, Wheeler Creek), locating one pair in the Cherry Creek Natural Area. No owls were found in the other two areas, but several pairs were found in adjacent public forests.

State, County, and Municipal Parks

With few exceptions these were small, and most contained unsuitable habitat. Silver Creek Falls State Park, Marion County, contained a small stand of mature forest, but I did not find spotted owls there, possibly because the park has been isolated from other mature forests.

Management Suggestions

Information gathered during this study provides some basic insights into the habitat requirements of spotted owls. Many questions remain unanswered, however. Two informational gaps are (1) how large are areas utilized by spotted owls for foraging, and (2) do spotted owls prefer specific forest types for foraging? Until these questions are answered it is difficult to develop a general management plan for spotted owls. Because of this impasse, I present some interim management suggestions; I hope these will aid managers in dealing with individual management problems.

Short-Term Management for Individual Pairs

Principal objectives should be to maintain uneven-aged old-growth forests on sites where spotted owls occur. Clear-cutting and overstory removal should be avoided in isolated forest habitats of

limited area (less than about 80 hectares). If overstory removal is conducted in stands occupied by spotted owls, dense patches should be left around nest and roost areas and around small springs or streams. Scattered large trees with broken tops or with dwarfmistletoe brooms should be left as potential nest trees.

Because individual pairs did not nest every year, location of nest trees often required 1- to 2-year periods. For this reason, decisions as to what portion of a habitat to preserve cannot always be based on location of nest sites. In such cases, the following may prove helpful:

(1) If owls are observed near small streams or springs in heavily-forested ravines or canyons, preserved areas should be centered on these physiographic features.

(2) If dense mature forests are present but do not coincide with physiographic features such as stream bottoms or ravines, then preserved areas should include stands of timber which meet the other requirements of the owls (i.e., old broken-topped trees, trees infected by dwarfmistletoe, dense understory roost trees, and a dense canopy).

(3) Owlets located between May and August, are often still within 350 meters of their nests. Although some broods move farther from the nest area during late summer, location of a brood is usually a clue to general location of the nest.

(4) Where pairs occupy small islands of old-growth forests in predominantly second-growth stands, as much old-growth as possible should be preserved.

Long-Term Management

To avoid population declines, management on some sites should be initiated to reverse the trend towards young, even-aged forests. This could be accomplished by:

(1) Longer Rotation Periods. This practice would maintain old-growth forests scattered throughout the public lands. Where clear-cutting is the principal harvest method this could be accomplished by managing some stands on 300-400 year rotations. These should be allowed to develop closed canopies, dense understories, old-growth overstories, and at least some diseased and damaged trees. Where overstory removal is the principal method of harvest, a similar plan might be undertaken, or overstory removal might be conducted on some sites at infrequent intervals.

(2) Management Preserves. Low-elevation, old-growth preserves could be established in areas of known concentrations of spotted owls, and used simultaneously as wildlife areas, research areas, and recreation areas. Preserves might coincide with roadless areas but should not be

restricted to areas which meet "roadless" or "wilderness" classifications. Most remaining spotted owl habitat in the Coast Range did not meet roadless area standards as it consisted of scattered blocks of old-growth in heavily roaded areas.

Areas managed or preserved for spotted owls will also provide habitat for other species of plants and animals which comprise the old-growth community. Such communities are becoming increasingly rare, and are, therefore, becoming important as research and recreation areas, as well as sanctuaries. Without old-growth coniferous forests, numerous species can be expected to decline in numbers, perhaps to the point of acquiring rare or endangered status.

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APPENDICES

Appendix 1. Eighteen specimens of Strix occidentalis caurina collected in Oregon prior to 1970.

Location	Year	No. Birds	Authority	Reference or Repository
Kerby, Josephine Co.	1912	1	Bowles, J.H.	U.C.L.A. Museum Zoology
Netarts, Tillamook Co.	1914	1	Jewett, S.G.	Condor 18(2):74-80
Ocean View, Tillamook Co.	1914	1	Gabrielson and Jewett	Birds of Oregon 1940
Oswego, Clackamas Co.	1914	1	Jewett and Gabrielson	Pacific Coast Avifauna No. 19
Near Portland, Multnomah Co.	unknown	2	Jewett and Gabrielson	Pacific Coast Avifauna No. 19
Scio, Linn Co.	1924	1	Prill, A.	Wilson Bull. 40(2):112
Trail, Jackson Co.	1925	1	Gabrielson and Jewett	Birds of Oregon 1940
Near Mercer, Lane Co.	1925	1	Dowell, O. Jr.	OSU Museum Nat. Hist.
Near Mercer, Lane Co.	1930	1	Dowell, R.	OSU Museum Nat. Hist.
Prospect, Jackson Co.	1930	1	Unknown	Mus. Vert. Zool., U.C. Berkeley
Tillamook, Tillamook Co.	1940	1	Walker, A.	OSU Museum Nat. Hist.
Depoe Bay, Lincoln Co.	1940	1	Braly, J.C.	OSU Museum Nat. Hist. Col.
North Santiam R., Linn Co.	1941	3	Marshall, J.T. Jr.	Condor 44(2):66-67
Near Corvallis, Benton Co.	1965	1	Maser, C.	Murrelet 46(3):46
Near Diamond Lake, Douglas Co.	1966	1	Hicks, J.	Audubon Field Notes 20(3):451

Appendix 2. Nine records of Strix occidentalis caurina in Oregon prior to 1970, not supported by specimens.

Location	Year	No. Birds	Authority	Reference
Gold Beach, Curry Co.	1909	1	Bailey, V.	Unpubl. Field Report[a/]
Eugene, Lane Co.	1914	1	Bailey, V.	Unpubl. Field Report[a/]
Corvallis, Benton Co.	1918	1	Gabrielson and Jewett	Birds of Oregon 1940
Mercer, Lane Co.	1920	1	Gabrielson and Jewett	Birds of Oregon 1940
West of Crater Lk., Klamath Co.	1934	1	Farner, D.S.	Birds of Crater Lake 1952
Dundee, Yamhill Co.	1937	1	Decker, W.	Condor 39(3):132
Oakridge, Lane Co. (25 mi. South)	1950	1	Greathouse, T.E.	Unpubl. Field Report[a/]
West of Keno, Klamath Co.	1967	2	Beal, R.	Audubon Fld. Notes 22(1):82
West of Carlton, Yamhill Co.	1968	1	Knight, G.	Audubon Fld. Notes 23(1):98

[a/] Available upon request from U.S. Fish and Wildlife Service, Patuxent, Maryland.

Appendix 3. Weights of prey species used to compute biomass consumed by spotted owls.

Species	Number of Specimens	Mean Weight (grams)	Source
Mammals			
Aplodontia rufa	--	400[a]	estimated juvenile wt.
Lepus americanus	--	350[a]	estimated mean juvenile wt.
Sylvilagus bachmani	--	350[a]	estimated mean juvenile wt.
Neotoma fuscipes	42	269	C. Maser unpublished
Neotoma cinerea	24	265	C. Maser unpublished
Tamiasciurus douglasii	61	208	C. Maser unpublished
Mustela frenata	-	200[a]	estimated mean juvenile wt.
Ochotona princeps	11	158	C. Maser unpublished
Glaucomys sabrinus	33	115	C. Maser unpublished; OSU[b]
Thomomys mazama	24	87	C. Maser unpublished
Eutamias townsendi	48	80	C. Maser unpublished
Microtus richardsoni	27	70	C. Maser unpublished
Scapanus orarius	34	53	C. Maser unpublished
Mustela erminea	8	41	OSU[b]
Microtus townsendi	20	54	OSU[b]
Phenacomys intermedius	10	27	C. Maser unpublished
Arborimus longicaudus	17	27	C. Maser unpublished
Peromyscus maniculatus	98	22	C. Maser unpublished
Clethrionomys californicus	66	23	C. Maser unpublished
Zapus trinotatus	10	24	OSU[b]
Microtus oregoni	90	19	C. Maser unpublished
Sorex bendiri	42	18	C. Maser unpublished
Sorex palustris	6	11	C. Maser unpublished
Neurotrichus gibbsii	31	9	C. Maser unpublished
Sorex pacificus	79	12	C. Maser unpublished
Sorex vagrans	99	5	C. Maser unpublished
Sorex trowbridgii	92	5	C. Maser unpublished
Sorex obscurus	7	9	C. Maser unpublished
Lasionycterus noctivagans	7	10	C. Maser unpublished
Squirrel-size mammal	--	100	estimated average
Unidentified mouse or vole	--	25	estimated average
Unidentified shrew	--	10	estimated average
Birds			
Dendragapus obscurus	--	500[a]	estimated mean juvenile wt.
Asio otus	66	262	Earhart and Johnson (1970)
Oreortyx pictus	?	244	Kilgore (1971)
Coloptes cafer	?	149	Kilgore (1971)
Otus asio	-	140	estimated
Cyanocitta stelleri	?	107	Kilgore (1971)
Aegolius acadicus	45	83	Earhart and Johnson (1970)
Turdus migratorius	?	81	Kilgore (1971)
Ixoreus naevius	?	79	Point Reyes Bird Observatory[c]
Dendrocopus villosus	?	70	Kilgore (1971)

Appendix 3. Continued.

Species	Number of Specimens	Mean Weight (grams)	Source
Glaucidium gnoma	52	67	Earhart and Johnson (1970)
Hesperiphona vespertina	?	64	Kilgore (1971)
Sphyrapicus varius	?	46	Kilgore (1971)
Piranga ludoviciana	?	31	Kilgore (1971)
Parus rufescens	?	10	estimated
Junco oreganus	?	18	Kilgore (1971)
Certhia familiaris	?	8	Kilgore (1971)
Regulus satrapa	?	6	Kilgore (1971)
Small owl	--	90	estimated average
Small birds	--	30	estimated average
Medium-sized birds	--	70	estimated average
Reptiles			
Thamnophis spp.	?	50	R. Nussbaum unpublished
Sceloporus occidentalis	?	10	R. Nussbaum unpublished
Crustaceans			
Pacifastacus spp.	--	20	estimated
Insects			
Dysmicohermes disjunctus	--	2	estimated
Cryptocercus punctulatus	--	1	estimated
Cyphoderris spp.	--	2	estimated
Ergates spiculatus	--	2	estimated
All other insects	--	0.5	estimated
Spiders			
Family unknown	--	0.5	estimated
Gastropods			
Haplotremea vancouverense	--	2	estimated

[a] Weights listed are for the estimated mean weight of juveniles taken by owls. Weights of the few adults taken were estimated on an individual basis, according to size of skeletal fragments.

[b] Specimens in Oregon State University collections, collected in Oregon.

[c] Unpublished data from records at Point Reyes Bird Observatory, California.