Conservation Implications of a Multi-scale Study of Flammulated Owl (*Otus flammeolus*) Habitat Use in the Northern Rocky Mountains, USA

Vita Wright
USGS

Sallie J. Hejl
USDA Forest Service

Richard L. Hutto
University of Montana - Missoula, hutto@mso.umt.edu

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Abstract.—Our multi-scale analysis of Flammulated Owl (*Otus flammeolus*) habitat use in the northern Rocky Mountains indicates some landscapes may be unsuitable for this species. As a result, there may be less habitat available for Flammulated Owls than thought based on the results of microhabitat studies. Thus, we suggest Flammulated Owl habitat conservation measures be based on the results of landscape-level, as well as microhabitat studies. Habitat conservation and restoration efforts in the ponderosa pine ecosystem should retain large trees, large snags, understory tree thickets, and grassland openings within landscapes that contain an abundance of suitable forest types.

Effective conservation strategies cannot be designed without understanding the distributions of rare species. Bird distributions are heavily dependent on habitat distribution (reviews in Cody 1985), partly because populations are limited by the availability of suitable habitat. Thus, identifying and maintaining adequate amounts of suitable habitat are critical to supporting population sizes and structures necessary for long-term species viability.

Flammulated Owls (*Otus flammeolus*) in the central Rocky Mountains (Hayward 1986, Reynolds and Linkhart 1992) and Blue Mountains (Bull *et al.* 1990) predominantly nest and forage in old-growth ponderosa pine (*Pinus ponderosa*) forests, suggesting the species depends on the ponderosa pine ecosystem for population viability in some geographic areas. This ecosystem has been heavily altered by past forest management in the northern Rocky Mountains. Specifically, the removal of overstory ponderosa pine since the early 1900's and nearly a century of fire suppression have led to the replacement of most old-growth ponderosa pine forests by younger forests with a greater proportion of Douglas-fir (*Pseudotsuga menziesii* var. *glauca*) than ponderosa pine (Habeck 1990). Clearcut logging and subsequent reforestation have converted many older stands of ponderosa pine/Douglas-fir forest to young structurally-simple ponderosa pine stands (Wright and Bailey 1982).

Fire scar evidence in the northern Rocky Mountains indicates that ponderosa pine forests burned approximately every 1-30 years prior to fire suppression, preventing contiguous understory development and, thus, maintaining relatively open ponderosa pine stands (Arno 1988, Habeck 1990). In old forests that retain a ponderosa pine overstory, a century of fire exclusion has permitted development of a more contiguous dense Douglas-fir understory (Mutch *et al.* 1993). USDA Forest Service personnel entrusted with the management of national forests in the northern Rocky Mountains are currently investigating techniques to remove understory Douglas-fir and return pre-European-settlement fire regimes to ponderosa pine ecosystems (Mutch *et al.* 1993). National Forests such as the Bitterroot and Lolo National Forests in west-central Montana are proposing to restore old-growth ponderosa pine forests by removing Douglas-fir from mixed ponderosa pine/Douglas-fir stands to increase the proportion of ponderosa pine trees relative to Douglas-fir, and to thin the Douglas-fir understory. Alteration of forest conditions

[1] Wildlife Biologist, USGS, Biological Resources Division, Science Center, Glacier National Park, West Glacier, MT 59936; Research Wildlife Biologist, USDA Forest Service, Intermountain Research Station, P.O. Box 8089, Missoula, MT 59807; Professor, Division of Biological Sciences, University of Montana, Missoula, MT 59812, respectively.

can be expected to change the bird communities inhabiting ponderosa pine/Douglas-fir forests. Because Flammulated Owls in Colorado, Oregon, and Montana nest predominantly in old ponderosa pine/Douglas-fir forests (Bull et al. 1990, Goggans 1986, Reynolds and Linkhart 1992), this species may be affected by proposed ponderosa pine ecosystem restoration activities, such as mechanical tree removal and prescribed burning.

Because old-growth ponderosa pine is rarer in the northern Rocky Mountains than it was historically, and little is known about the local Flammulated Owl distribution and habitat use, the USDA Forest Service has listed the Flammulated Owl as a sensitive species in the Northern Region (USDA 1994). It is also listed as a sensitive species by the USDA Forest Service in the Rocky Mountain, Southwestern, and Intermountain Regions, and receives special management consideration in the States of Montana, Idaho, Oregon, and Washington (Verner 1994).

We conducted a multi-scale analysis of Flammulated Owl habitat use, as part of the USDA Forest Service Bitterroot Ecosystem Management and Research Project (BEMRP) in west-central Montana, USA. BEMRP consisted of an interdisciplinary (wildlife and fisheries biologists, silviculturalists, landscape ecologists, fire ecologists, sociologists) group of researchers and managers, many of whom conducted studies to assess approaches to manage and restore the ponderosa pine ecosystem in the northern Rocky Mountains. Detailed methodology and results of the BEMRP Flammulated Owl habitat use study are reported elsewhere (Wright 1996).

In this paper, we use the results of our multi-scale Flammulated Owl habitat use study and a literature review to address conservation implications of (1) the Flammulated Owl relationship to landscape composition that we observed, and (2) the potential microhabitat (stand-level) effects of proposed ponderosa pine restoration activities on Flammulated Owl habitat.

STUDY AREA

We conducted the BEMRP study of Flammulated Owl habitat use in the low elevation ponderosa pine/Douglas-fir forest zone of the Bitterroot and Sapphire Mountains around the Bitterroot Valley, in west-central Montana (fig. 1). With the exception of a strip of cottonwood (Populus trichocarpa) and ponderosa pine forest along the Bitterroot River, the Bitterroot Valley bottom is nonforested. With increasing elevation, the predominantly urban and agricultural land in the valley bottom grade into grassland (e.g., Agropyron spicatum, Festuca idahoensis, Festuca scabrella, Balsamorhiza sagittata, Bromis tectorum, Centauria maculosa) and xeric shrubland (e.g., Purshia tridentata, Artemesia spp., Cercocarpus ledifolius), and then forested land. Low elevation ridge tops and south-facing slopes in the study area are generally characterized by a mosaic of xeric grassland, xeric shrubland, and relatively low canopy cover ponderosa pine/Douglas-fir forest with a xeric grassland understory, whereas low elevation north-facing slopes and shallow draws contain more contiguous Douglas-fir forest with a moister understory (e.g., Physocarpus malvaceus, Symphoricarpos albus, Calamagrostis rubescens). At higher elevations, ponderosa pine/Douglas-fir forests in the study area are replaced by higher canopy cover Douglas-fir forest, or Douglas-fir/western larch (Larix occidentalis) forest, with a mesic understory (e.g., Vaccinium spp., Linnaea borealis, Arctostaphylos uva-ursi). Mesic forests containing lodgepole pine (Pinus contorta), subalpine fir (Abies lasiocarpa), and Englemann spruce (Picea engelmanni) occur above approximately 1,950 m elevation. The highest elevation forest zone is composed of alpine larch (Larix lyallii), subalpine fir, and whitebark pine (Pinus albicaulis).

Most of the forest in the study area occurs on public land and is managed by the National Forest System (fig. 2). The study area consists of three management zones: (1) unharvested, higher-elevation forest in the Selway-Bitterroot Wilderness area, (2) forest predominantly managed for timber production on National Forest land outside the wilderness, and (3) forest often managed for timber production on private land. Historic timber management outside the wilderness, where most of the ponderosa pine/Douglas-fir forest occurs, has created a variety of even- and uneven-aged harvested forest stands. Even-aged timber management, particularly along the eastern front of the Bitterroot Valley, has created young to mature, single-storied stands of ponderosa pine without large ponderosa pine trees or

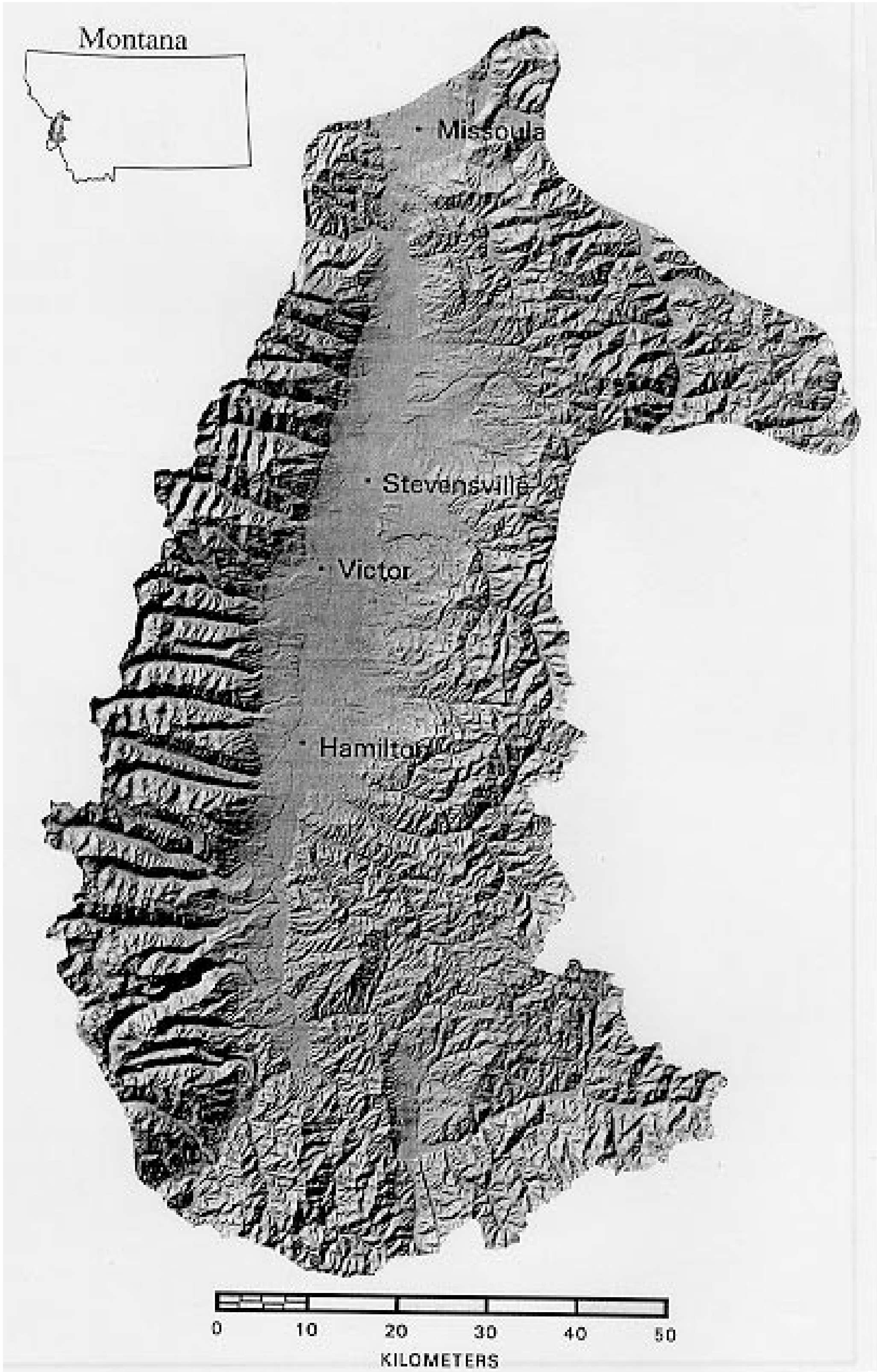

Figure 1.—Study area location and topography, west-central Montana, USA.

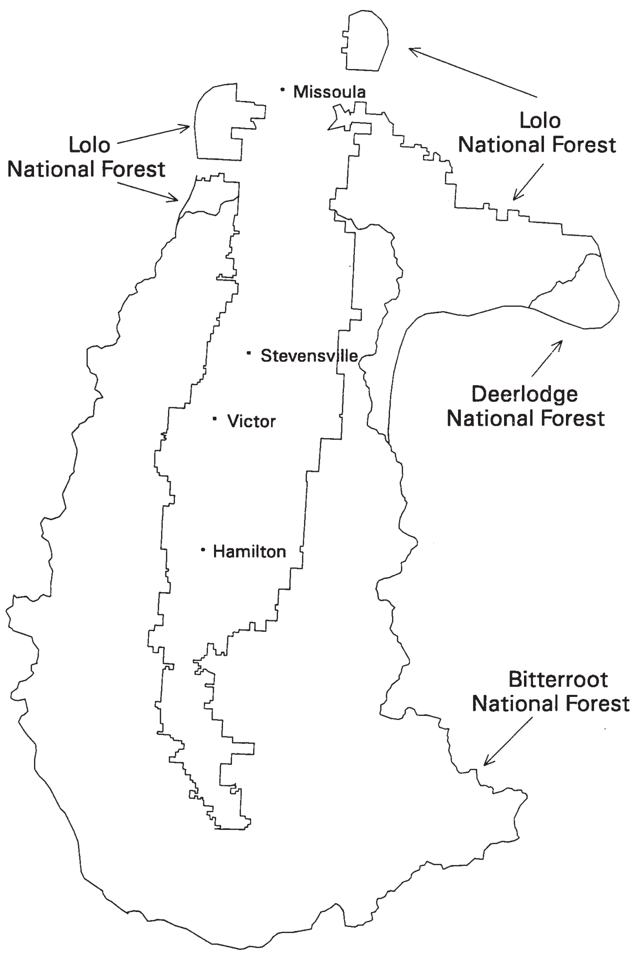

Figure 2.—Location of National Forest land within the study area, west-central Montana, USA.

snags. Uneven-aged management has lead to the presence of multi-storied stands throughout the study area, with varying numbers of large ponderosa pine, Douglas-fir trees, and snags.

SUMMARY OF BEMRP FLAMMULATED OWL STUDY

During the multi-scale BEMRP study of Flammulated Owl habitat use, we used tape playback surveys to sample and describe the distribution of Flammulated Owls in a 656,317-ha study area. After describing the owl distribution, we analyzed habitat use at four spatial scales, comparing used and unused habitat by measuring forest stand composition and structural variables within the traditional microhabitat scale of 11.3-m-radius plots, and by quantifying landscape composition at three larger spatial scales: (1) estimated home range around microhabitat plots, (2) surveyed area around transects, and (3) topographically- and geologically-delineated landtype polygons within the study area. For the three landscape scales, we used a vegetative cover-type classification of Landsat TM data with a 2-ha resolution to quantify landscape composition (Redmond et al. 1996).

Results of the microhabitat analyses were similar to those reported for previous studies. Flammulated Owls used mature and old-growth ponderosa pine/Douglas-fir forest stands disproportionately more than young ponderosa pine/Douglas-fir or other coniferous forest types. Still, we did not detect owls at 48 percent of the plots that contained these suitable microhabitat cover types. We refer to plots without owl detections as unoccupied. Many of the unoccupied plots had similar stand structure to occupied plots, but occurred in landscapes with a lower proportion of low/moderate canopy closure (< 70 percent cover) ponderosa pine/Douglas-fir forest than landscapes containing occupied plots. When analyses included only plots that occurred in occupied landscapes, those with a relatively high proportion of suitable forest, a greater proportion of suitable microhabitat plots were occupied (fig. 3). Thus, we hypothesize that some points, though suitable at the local scale, might not

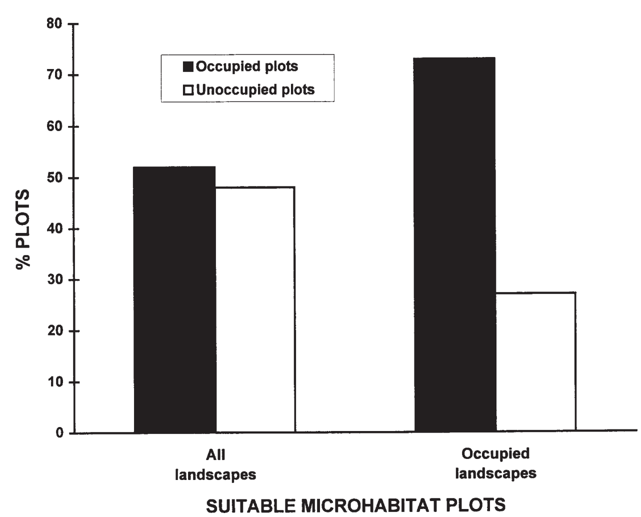

Figure 3.—Percent of suitable microhabitat (i.e., old-growth and mature ponderosa pine/Douglas-fir) plots occupied in all landscapes, compared to percent of suitable microhabitat plots occupied only in landscapes occupied by Flammulated Owls (Otus flammeolus), west-central Montana, USA.

have been occupied because they occurred in unsuitable landscapes (Wright 1996). Because Flammulated Owls often occur in association with other Flammulated Owls, this may be related to social requirements, such as mate selection; or, selecting landscapes with an abundance of ponderosa pine/Douglas-fir forest may increase the chance of finding suitable nest sites. Assuming we measured the critical microhabitat attributes, these results help explain why Flammulated Owls are often absent from sites that appear to contain suitable microhabitat, and have patchy distributions.

CONSERVATION IMPLICATIONS

Where to Manage/Conserve Habitat

Within the geographic range of ponderosa pine, managers often identify old-growth ponderosa pine stands as potential Flammulated Owl habitat. These stands are targeted for management actions thought to benefit Flammulated Owls, under the assumption that all old-growth ponderosa pine stands are suitable habitat. Two consequences of this assumption are: (1) if all old-growth ponderosa pine stands are not suitable for Flammulated Owls, there is less habitat available than we think, and (2) habitat conservation and restoration efforts may be wasted if they occur in ponderosa pine forest stands that are not, or do not have the potential to become, suitable habitat.

Flammulated Owls in the BEMRP study area did not occupy all ponderosa pine stand types. Instead, they occupied stands that occurred within landscapes containing a greater proportion of low canopy cover ponderosa pine/Douglas-fir forest than landscapes around unoccupied stands. Of the occupied landscapes, Flammulated Owl densities were greater in landscapes with more older ponderosa pine/Douglas-fir forest. The mean nearest-neighbor distance we observed (552 m) between owls on transects with an abundance of old forest was three times closer than on transects in landscapes with an abundance of young forest. This is probably because suitable stands were farther apart in landscapes dominated by young forest. Thus, Flammulated Owls in the BEMRP study area used landscapes with an abundance of ponderosa pine/Douglas-fir forest, and had greater densities in landscapes with an abundance of older ponderosa pine/Douglas-fir forest.

Even within suitable landscapes, all ponderosa pine forest types in the BEMRP study area were not occupied. For instance, we never detected Flammulated Owls in mesic old-growth ponderosa pine stands with a Vaccinium understory. Thus, within suitable landscapes, it may be most effective to conserve and restore stand structural characteristics within suitable habitat types (e.g., xeric ponderosa pine/Douglas-fir stands in our study area), rather than within any stand containing ponderosa pine trees.

While Flammulated Owls in the BEMRP study area appeared to use only suitable forest stands that occurred in suitable landscapes, specific results of the study might have been different if we had defined landscape size differently, conducted the study during a period with different bird densities, or used a vegetative cover-type classification developed with a different unit of resolution. Due to the large number of studies that have found similar associations between Flammulated Owls and microhabitat structural characteristics, microhabitat results may be more broadly extrapolated than the landscape results. Though additional studies should be conducted to confirm specific landscape associations, the BEMRP study supported the idea that landscape context is important when defining suitable habitat for Flammulated Owls.

If the landscape associations identified during the BEMRP study apply elsewhere, querying broad-scale Geographic Information System (GIS) databases for landscapes with an abundance of suitable forest types, may be a useful tool for identifying potentially occupied areas. Identifying landscapes with a high likelihood of occupancy can increase the efficiency of conducting surveys to describe local Flammulated Owl distributions. These queries can also be used to estimate the distribution of currently suitable habitat, recognizing that large areas of ponderosa pine/Douglas-fir forest may be more likely to contain Flammulated Owls than small stands of this forest type.

Geographic Information System queries based on the results of broad-scale studies, such as the BEMRP study described here, can also be used to predict landscapes with past and future Flammulated Owl habitat. For example, areas with an abundance of young ponderosa pine/Douglas-fir forest may represent past habitat that could be managed as potential *future habitat. The recruitment of old ponderosa pine/Douglas-fir forest may be most beneficial for Flammulated Owls in areas such as the eastern front of the Bitterroot Mountains, which contain an abundance of ponderosa pine/Douglas-fir forest, but where most of the old-growth ponderosa pine/Douglas-fir forest has been replaced by young, structurally-simple forest stands. BEMRP managers and researchers are currently trying to determine the best method to accomplish this on the Bitterroot National Forest.*

Stand Structure

While landscape analyses can help identify suitable landscapes for a species, it is still necessary to maintain suitable microhabitat within suitable landscapes. For example, the regional decline of the Siberian Tit (Parus cinctus), a cavity nester of Finland's old-growth forests, was the result of intensive forest management that removed large trees and snags at the microhabitat scale (Virkkala 1991). Similarly, Flammulated Owls that settle in suitable landscapes cannot nest unless there are suitable snags or large trees with nest cavities, as well as other necessary microhabitat features.

Cover Type

Results of the BEMRP study were similar to those reported in previous studies conducted at the microhabitat scale within the geographic and elevational range of ponderosa pine (reviewed in McCallum 1994). Based on vegetation samples taken at the microhabitat scale in our study, Flammulated Owls used old-growth and mature ponderosa pine/Douglas-fir forest more than young ponderosa pine/Douglas-fir or other coniferous forest types. Sample plots near occupied points contained more large (> 38 cm diameter, measured 1.4 m above ground) trees and snags than those near unoccupied points.

Similarly, Flammulated Owls in the northern and central Rocky Mountains (Hayward 1986, Reynolds and Linkhart 1992) and in the Blue Mountains (Bull et al. 1990) used predominantly old-growth ponderosa pine forests as nesting and foraging habitat, rather than other old-growth coniferous forest types or young dense stands of Douglas-fir/blue spruce (Reynolds and Linkhart 1987). Occupied habitat in a New Mexico study area (McCallum and Gehlbach 1988) was also located in stands with large ponderosa pine and Douglas-fir or grand fir (> 50 cm d.b.h.) and large-diameter snags with suitable cavities. In a southern British Columbia study area at the extreme northern edge of the Flammulated Owl range, Howie and Ritcey (1987) found Flammulated Owls associated with older open Douglas-fir forests. Regardless of the differences in tree species composition, Howie and Ritcey (1987) agreed with others (Bull 1990, Reynolds and Linkhart 1992) that Flammulated Owls prefer older forests. Atkinson and Atkinson (1990) also found most owls in Douglas-fir habitat types on the Salmon National Forest in Idaho, with structure similar to that described by Howie and Ritcey (1987) in British Columbia.

Large Ponderosa Pine and Douglas-Fir Trees

Large ponderosa pine and Douglas-fir trees are important components of Flammulated Owl habitat for a variety of reasons, including the provision of early-season foraging substrates. Flammulated Owls eat primarily noctuid moths early in the breeding season, and orthopterans later (Goggans 1986, Reynolds and Linkhart 1987). Four times as many lepidopteran species (including noctuids) in a Colorado study area were associated with ponderosa pine and Douglas-fir than with other western conifer species (Reynolds and Linkhart 1987), and most arthropods captured in the Colorado study were in Douglas-fir (61 percent) and ponderosa pine (19 percent) trees with a mean age of 199 years. Early-season prey are most frequently captured by hawk-gleaning inside tree crowns and hover-gleaning from the outer conifer needles (Reynolds and Linkhart 1987). Reynolds and Linkhart (1987) suggested that large open tree crowns, such as those found in large ponderosa pine trees, were used for tree-crown foraging tactics such as hawk-gleaning and hover-gleaning. This is similar to other insectivorous forest bird species that select specific tree species to facilitate maneuvering while foraging (Robinson and Holmes 1984, Vander Werf 1993).

In addition to providing foraging substrates, old ponderosa pine and Douglas-fir trees are often used for song perches and roost sites (Reynolds and Linkhart 1992, Wright 1996), and decadent portions of old trees provide nest sites (see next section). Eighty-two percent of the song trees we observed during the BEMRP habitat-use study were ponderosa pine, possibly because ponderosa pine was often the largest tree species present in occupied stands. Additionally, Flammulated Owls in northeastern Oregon roosted in ponderosa pine more than any other tree species (Goggans 1986).

Flammulated Owls use both large ponderosa pine and Douglas-fir trees within the ponderosa pine/Douglas-fir forest type (Reynolds and Linkhart 1992), and sometimes nest in old-growth Douglas-fir stands (Howie and Ritcey 1987, Powers et al. 1996). Thus, where ponderosa pine is absent or rare, large Douglas-fir trees may provide nest, roost, song, and foraging substrates. Because there are fewer ponderosa pine old-growth trees in the northern Rocky Mountains than there were historically, it may be necessary to retain large Douglas-fir, in addition to large ponderosa pine trees, as song trees, foraging trees, and for large snag recruitment. Thus, selective logging that removes large ponderosa pine or Douglas-fir trees would be expected to decrease the availability of early-season feeding sites, song and roost sites, and trees for snag recruitment in areas already limited in large snag abundance. Without studying reproductive success relative to large tree density to gather information on habitat quality, it may be risky to selectively harvest large ponderosa pine or Douglas-fir trees or snags from current habitat.

Selective Tree Harvest

The distribution and abundance of many bird species, including the Flammulated Owl, change with forest habitat alteration. Flammulated Owls do not occur in recently clearcut forests (Howie and Ritcey 1987), and their abundances have declined following this type of timber harvest (Franzreb and Ohmart 1978, Marshall 1957, Phillips et al. 1964). However, Flammulated Owls were present in approximately half of the selectively-logged microhabitat plots in the BEMRP study area. Occupied selectively-logged stands contained large residual trees and snags, similar to stands described by Hasenyager et al. (1979) and Bloom (1983), who also reported nests in partially logged forests with large residual trees. In a heavily managed study area in British Columbia (Howie and Ritcey 1987), most owls occurred in mature and old stands of Douglas-fir that had been selectively harvested 2-3 decades prior to the surveys. These multi-storied stands contained 35-65 percent overstory canopy closure composed of Douglas-fir and ponderosa pine, a Douglas-fir understory, and a sparse shrub layer. Occupied plots in selectively-logged stands in our study area contained fewer large (> 38 cm diameter) stumps than selectively-logged stands around unoccupied plots, indicating owls used stands that had been harvested less intensively.

The evidence is clear that Flammulated Owls occupy, and sometimes nest in, selectively-logged stands. However, inferences about habitat quality, such as comparing unlogged and selectively-logged sites should be saved for studies that incorporate measures of reproductive success and survivorship. Presence/absence data provide valuable information about which habitats are completely unsuitable; however, it is inappropriate to assume equal habitat quality among all occupied areas (Van Horne 1983). For instance, two forest types may appear suitable based on occupancy data, but reproductive or survivorship data could indicate one type provides higher-quality habitat than another. Thus, our results provide information about which microhabitat and landscape conditions were completely unsuitable in our study area, rather than information about the relative habitat quality of occupied areas.

Large Snags

Flammulated Owls are obligate cavity nesters, dependent on Pileated Woodpeckers (*Dryocopus pileatus*), Northern Flickers (*Colaptes auratus*), and sapsuckers (*Sphyrapicus* spp.) to excavate suitable nest cavities (Bull et al. 1990, Powers et al. 1996). These woodpecker species excavate cavities in large snags or decadent portions of large live trees. Thus, large snags provide important nesting substrates for Flammulated Owls. Of 33 nests in northeastern Oregon, mean nest tree d.b.h. was 72 cm (Bull et al. 1990). Ninety-one percent of the nests found by Bull et al. (1990), and 80 percent of 20 nests found by Goggans (1986) were in snags. Additionally, 85 percent of 20 nests in Oregon were in ponderosa pine (Goggans 1986). Most nests observed by Goggans (1986) were ponderosa pine snags, indicating that ponderosa pine snags may be especially important to Flammulated Owls. Thus, selective logging within this forest type that harvests "high-risk" ponderosa pine, trees that are expected to die soon, could remove trees critical to the recruitment of future Flammulated Owl nest trees.

Major Flammulated Owl nest competitors were presumed to be Abert's squirrels (Sciurus aberti) and Northern Flickers in New Mexico (McCallum and Gehlbach 1988), and flying squirrels (Glaucomys sabrinus) and red squirrels (Tamiasciurus hudsonicus) in British Columbia (Cannings and Cannings 1982). Because Flammulated Owls nest later than resident forest owls, they might also be excluded from nest cavities by resident owls such as the Northern Saw-whet (Aegolius acadicus) and Northern Pygmy (Glaucidium gnoma) Owls. Thus, nest sites may be especially limited if snag densities are low. The abundance of snags and decadent trees was low in our study area, with more than a single large snag evident within 1 ha of only 35 percent of the microhabitat plots. This was probably due to past forest management practices. Managers on the Bitterroot National Forest in the 1950's and 1960's actively removed snags that were thought to be ignition points for lightning strikes, and firewood cutters still often remove large snags. The single unroaded transect in ponderosa pine/Douglas-fir forest in our study area had greater snag densities than roaded transects in this forest type.

Habitat Type

While Flammulated Owls used older ponderosa pine/Douglas-fir stands in the BEMRP study area, they did not use all types of old ponderosa pine/Douglas-fir forest. We assigned habitat type categories to plots based on relative site moisture, as indicated predominantly by understory vegetation composition (Pfister et al. 1977). In the BEMRP study, Flammulated Owls occupied stands with dry habitat types. Owls were positively associated with dry-site indicator species such as Balsamorhizza sagitatta, and were never found in stands with moist-site plants such as Salix spp. and Vaccinium spp. The use of xeric ponderosa pine/Douglas-fir forest may be related to food availability; dry openings appear to be important structural elements for Flammulated Owl foraging. These structural elements may limit the types of forest this species inhabits because many coniferous forest types in the northern Rocky Mountains do not contain dry openings.

In a USDA Forest Service summary of habitat types used by Flammulated Owls (J. Taylor, Wildlife Biologist, Idaho Panhandle National Forest) on the Idaho Panhandle, Kootenai, and Payette National Forests in northern Idaho and northwestern Montana, 63 percent of the detections were in xeric ponderosa pine/Douglas-fir habitat types, and 37 percent were in habitat types that were more mesic than sites used in our study area. Douglas-fir, a tree species used by Flammulated Owls, is often the dominant species in seral stands for all the mesic habitat types Flammulated Owls were reported in by the Forest Service summary; however, these habitat types contain moist-site understory plants rather than the xeric grassland understory used by Flammulated Owls in our study area. Owls in those areas might have been solicited through tape playbacks from adjacent xeric stands, or they might use more mesic habitat types in the moister landscapes of northern Idaho and northwestern Montana.

Thus, specific results of our study may not be applicable in regions with different habitats, including areas with aspen or areas without xeric ponderosa pine/Douglas-fir forest. Two types of ponderosa pine forest that existed in our study area were not surveyed during our study. Old-growth ponderosa pine forests occur along many south-facing slopes in the Bitterroot Mountains. These slopes were too steep and rocky to safely traverse at night, and the creek noise from spring runoff was too loud to survey these areas from gentler slopes high above the canyons. The understory vegetation on these slopes was sparse, and may represent lower quality foraging habitat than under the more contiguous ponderosa pine forests that occur on gentler slopes. Additionally, Flammulated Owls in the southeastern region of the study area used home ranges with a lower slope gradient, and it is possible these slopes are too steep to be suitable. Thus, forests on these south-facing slopes represent a different, unsurveyed habitat type that may or may not be suitable. Ponderosa pine also occurred in association with black cottonwood along terraces of the Bitterroot River (Habeck 1990). Based on the presence of cottonwoods, which often have an abundance of cavities, such forests would be expected to contain an abundance of suitable nest trees. Most of these terraces in the study area occur on private land, and many of the large ponderosa pine were removed when the land was settled in the early 1900's (Habeck 1990). Intact examples of this forest type along the Bitterroot River were rare and were not surveyed for Flammulated Owls. Thus, our study results are not applicable to these forest types.

Understory Vegetation

There was no significant difference in the amount of understory Douglas-fir in occupied and unoccupied plots in the BEMRP study in west-central Montana. However, other researchers have noted the importance of understory thickets to Flammulated Owls. For instance, while stands of dense young trees in New Mexico or Oregon (Bull 1990, McCallum and Gehlbach 1988) were not suitable as nest sites, thickets of dense vegetation were present near all nests, and were used for roosting and singing in New Mexico (McCallum and Gehlbach 1988). Reynolds and Linkhart (1992) also observed males singing within dense clumps of foliage, and Flammulated Owls in eastern Oregon predominantly roosted in dense stands with > 50 percent canopy cover. Mean stem density in roost sites observed by Goggans (1986) was 2,016 trees/ha (SD = 1,378, n = 31, range 509-5,346), with mean basal area of 129 m^2 (SD = 48.5, n = 31, range 21-239). Flammulated Owl use of dense forest thickets was also recorded by Bull and Anderson (1978) and Marcot and Hill (1980).

Because Flammulated Owls use both ponderosa pine and Douglas-fir dominated forest types, the recent floristic change in many ponderosa pine forests to predominantly Douglas-fir might not be expected to affect Flammulated Owl occupancy of stands. However, there are no data on reproductive success in the two forest types. The change in forest structure, from a low canopy cover forest with openings and patchy understory thickets, to a contiguous high canopy forest with fewer openings, might decrease food availability for Flammulated Owls. Densities of orthopteran prey in grassland are greater than in forest, and ponderosa pine/Douglas-fir forests with open canopies have greater food availability than continuous forests (Goggans 1986). For instance, based on insect window trap stations in eastern Oregon, 2.7 times as many prey items occurred in ponderosa pine/Douglas-fir forest, and 8.7 times as many prey items occurred in grassland, than in mixed conifer forest (Goggans 1986). Thus, stands with dense understories probably contain less prey, and hinder foraging maneuverability (Goggans 1986).

While the elimination of some understory forest would be expected to maintain the grassland openings used by foraging owls, management activities that eliminate all understory Douglas-fir may remove thickets important for roosting and singing, for drop-pounce foraging perches, and for predator protection cover. Flammulated Owls roosted an average of 53 m from nests during the nesting period, and < 20 m from nests prior to juvenile fledging; therefore, Goggans (1986) suggested that suitable nest-sites may include patches of dense forest for roosting, as well as openings for foraging.

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