Part 10
Appendices

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Appendix A-List of Common and Scientific Names Used in This Volume[a]

Common name	Scientific name
INSECTS	
Western spruce budworm	*Choristoneura occidentalis*
REPTILES	
Lizards	
Northern alligator lizard	*Elgaria coerulea*
Sagebrush lizard	*Sceloporus graciosus*
Southern alligator lizard	*Elgaria multicarinata*
Western fence lizard	*Sceloporus occidentalis*
Western skink	*Eumeces skiltonianus*
Snakes	
California mountain kingsnake	*Lampropeltis zonata*
Common garter snake	*Thamnophis sirtalis*
Northwestern garter snake	*Thamnophis ordinoides*
Racer	*Coluber constrictor*
Ringneck snake	*Diadophis punctatus*
Rubber boa	*Charina bottae*
Sharptail snake	*Contia tenuis*
Western aquatic garter snake	*Thamnophis couchii*
Western rattlesnake	*Crotalus viridis*
Western terrestrial garter snake	*Thamnophis elegans*
Turtles	
Western pond turtle	*Clemmys marmorata*

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Common name	Scientific name
AMPHIBIANS	
Mole Salamanders	
Long-toed salamander	*Ambystoma macrodactylum*
Northwestern salamander	*Ambystoma gracile*
Giant and Olympic Salamanders	
Cope's giant salamander	*Dicamptodon copei*
Olympic salamander	*Rhyacotriton olympicus*
Pacific giant salamander	*Dicamptodon tenebrosus*[b]
Rocky Mountain giant salamander	*Dicamptodon atterimus*[b]
Lungless Salamanders	
Arboreal salamander	*Aneides lugubris*
Black salamander	*Aneides flavipunctatus*
California slender salamander	*Batrachoceps attenuatus*
Clouded salamander	*Aneides ferreus*
Del Norte salamander	*Plethodon elongatus*
Dunn's salamander	*Plethodon dunni*
Ensatina	*Ensatina eschscholtzii*
Larch Mountain salamander	*Plethodon larselli*
Oregon slender salamander	*Batrachoceps wrightii*
Plethodontid salamanders	(lungless or woodland salamanders in the family Plethodontidae, including *Aneides* spp., *Batrachoceps* spp., *Ensatina eschscholtzii,* and *Plethodon* spp.)
Redback salamander	*Plethodon cinereus*
Siskiyou Mountains salamander	*Plethodon stormi*
Van Dyke's salamander	*Plethodon vandykei*
Western redback salamander	*Plethodon vehiculum*
Woodland salamanders	(see plethodontid salamanders)
Newts	
Roughskin newt	*Taricha granulosa*
Frogs	
Cascades frog	*Rana cascadae*
Foothill yellow-legged frog	*Rana boylii*
Pacific treefrog	*Hyla regilla*
Red-legged frog	*Rana aurora*
Tailed frog	*Ascaphus truei*
Toads	
Western toad	*Bufo boreas*
MAMMALS	
Shrews	
Marsh shrew	*Sorex bendirii*[C]
Masked shrew	*Sorex cinereus*
Montane shrew	*Sorex monticolus*[d]
Pacific shrew	*Sorex pacificus*
Trowbridge's shrew	*Sorex trowbridgii*
Vagrant shrew	*Sorex vagrans*
Water shrew	*Sorex palustris*

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Common name	Scientific name
Moles	
Coast mole	*Scapanus orarius*
Shrew-mole	*Neurotrichus gibbsii*
Townsend's mole	*Scapanus townsendii*
Bats	
Big brown bat	*Eptesicus fuscus*
California myotis	*Myotis californicus*
European pipistrelle	*Pipistrellus pipistrellus*
Fringed myotis	*Myotis thysanodes*
Hoary bat	*Lasiurus cinereus*
Keen's myotis	*Myotis keenii*
Little brown myotis	*Myotis lucifugus*
Long-eared myotis	*Myotis evotis*
Long-legged myotis	*Myotis volans*
Silver-haired bat	*Lasionycterus noctivagans*
Townsend's big-eared bat	*Plecotus townsendii*
Western small-footed myotis	*Myotis ciliolabrum*
Yuma myotis	*Myotis yumanensis*
Rabbits and Pikas	
Pika	*Ochotona princeps*
Squirrels and Chipmunks	
Douglas' squirrel	*Tamiasciurus douglasii*
Northern flying squirrel	*Glaucomys sabrinus*
Townsend's chipmunk	*Tamias townsendii*[e]
Western gray squirrel	*Sciurus griseus*
Yellow-pine chipmunk	*Tamias amoenus*
Pocket Gophers	
Botta's pocket gopher	*Thomomys bottae*
Northern pocket gopher	*Thomomys talpoides*
Western pocket gopher	*Thomomys mazama*
Mice, Rats, and Voles	
Black rat	*Rattus rattus*
Bushy-tailed woodrat	*Neotoma cinerea*
California vole	*Microtus calijornicus*
Creeping vole	*Microtus oregoni*
Deer mouse	*Peromyscus maniculatus*
Dusky-footed woodrat	*Neotoma fuscipes*
Forest deer mouse	*Peromyscus oreas*[f]
Heather vole	*Phenacomys intermedius*
Long-tailed vole	*Microtus longicaudus*
Montane vole	*Microtus montanus*
Pinon mouse	*Peromyscus truei*
Red-backed voles	*Clethrionomys spp.*
Red tree vole	*Arborimus longicaudus*[8]
Southern red-backed vole	*Clethrionomys gapperi*
Townsend's vole	*Microtus townsendii*

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Common name	Scientific name
Mice, Rats, and Voles--continued	
Water vole	*Microtus richardsoni*
Western red-backed vole	*Clethrionomys californicus*
White-footed mouse	*Arborimus albipesi*
Jumping Mice	
Pacific jumping mouse	*Zapus trinotatus*
Western jumping mouse	*Zapus princeps*
Carnivores	
Coyote	*Canis latrans*
Ermine	*Mustela erminea*
Fisher	*Martes pennanti*
Grizzly bear	*Ursus arctos*
Marten	*Martes americana*
Wolf	*Canis lupus*
Ungulates	
Elk	*Cervus elaphus*
Mountain goat	*Oreamnos americanus*
Mule deer	*Odocoileus hemionus*
White-tailed deer	*Odocoileus virginianus*
BIRDS	
Swans, Geese, and Ducks	
Bufflehead	*Bucephala albeola*
Barrow's goldeneye	*Bucephala islandica*
Common merganser	*Mergus merganser*
Hooded merganser	*Lophodytes cucullatus*
Wood duck	*Aix sponsa*
Hawks and Vultures	
Bald eagle	*Haliaeetus leucocephalus*
Cooper's hawk	*Accipiter cooperii*
Northern goshawk	*Accipiter gentilis*
Red-shouldered hawk	*Buteo linneatus*
Sharp-shinned hawk	*Accipiter striatus*
Turkey vulture	*Cathartes aura*
Grouse and Quail	
Blue grouse	*Dendragapus obscura*
California quail	*Callipepla californica*
Capercaillie	*Tetrao urogallus*
Mountain quail	*Oreortyx pictus*
Ruffed grouse	*Bonasa umbellus*
Murrelets	
Marbled murrelet	*Brachyramphus marmoratus*
Pigeons and Doves	
Band-tailed pigeon	*Columba fasciata*
Mourning dove	*Zenaida macroura*

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Common name	Scientific name
Owls	
Barred owl	*Strix varia*
Flammulated owl	*Otus flammeolus*
Northern pygmy-owl	*Glaucidium gnoma*
Northern saw-whet owl	*Aegolius acadicus*
Northern spotted owl	*Strix occidentalis caurina*
Western screech-owl	*Otus kennicottii*
Hummingbirds and Swifts	
Allen's hummingbird	*Selasphorus sasin*
Anna's hummingbird	*Calypte anna*
Rufous hummingbird	*Selasphorus rufus*
Vaux's swift	*Chaetura vauxi*
Kingfishers	
Belted kingfisher	*Ceryle alcyon*
Woodpeckers	
Acorn woodpecker	*Melanerpes formicivorus*
Downy woodpecker	*Picoides pubescens*
Hairy woodpecker	*Picoides villosus*
Ivory-billed woodpecker	*Campephilus principalis*
Northern flicker	*Colaptes auratus*
Pileated woodpecker	*Dryocopus pileatus*
Red-breasted sapsucker	*Sphyrapicus ruber*
Red-cockaded woodpecker	*Picoides borealis*
White-headed woodpecker	*Picoides albolarvatus*
Flycatchers	
Ash-throated flycatcher	*Myiarchus cinerascens*
Dusky flycatcher	*Empidonax oberholseri*
Hammond's flycatcher	*Empidonax hammondi*
Olive-sided flycatcher	*Contopus borealis*
Western flycatcher	*Epidonax difficilis*
Western wood-pewee	*Contopus sordidulus*
Jays, Crows, and Ravens	
American crow	*Corvus brachyrhynchos*
Common raven	*Corvus corax*
Gray jay	*Perisorius canadensis*
Scrub jay	*Aphelocoma coerulescens*
S teller's jay	*Cyanocitta stelleri*
Chickadees, Nuthatches, and Creepers	
Black-capped chickadee	*Parus atricapillus*
Brown creeper	*Certhia americana*
Brown-headed nuthatch	*Sitta pusilla*
Chestnut-backed chickadee	*Parus rufescens*
Mountain chickadee	*Parus gambeli*
Red-breasted nuthatch	*Sitta canadensis*
White-breasted nuthatch	*Sitta carolinensis*

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Common name	Scientific name
Wrens	
Bewick's wren	*Thryomanes bewickii*
House wren	*Troglodytes aedon*
Winter wren	*Troglodytes troglodytes*
Kinglets	
Golden-crowned kinglet	*Regulus satrapa*
Ruby-crowned kinglet	*Regulus calendula*
Thrushes	
American robin	*Turdus migratorius*
Hermit thrush	*Catharus guttatus*
Swainson's thrush	*Catharus ustulatus*
Townsend's solitaire	*Myadestes townsendi*
Varied thrush	*Ixoreus naevius*
Bushtits and Wrentits	
Bushtit	*Psaltriparus minimus*
Wrentit	*Chamaea fasciata*
Vireos	
Hutton's vireo	*Vireo huttoni*
Solitary vireo	*Vireo solitarius*
Warbling vireo	*Vireo gilvus*
Wood Warblers	
Bachman's warbler	*Vermivora bachmanii*
Black-throated gray warbler	*Dendroica nigrescens*
Golden-winged warbler	*Vermivora chrysoptera*
Hermit warbler	*Dendroica occidentalis*
McGillivray's warbler	*Oporornis tolmiei*
Nashville warbler	*Vermivora ruficapilla*
Orange-crowned warbler	*Vermivora celata*
Swainson's warbler	*Lymnothlypis swainsonii*
Townsend's warbler	*Dendroica townsendi*
Wilson's warbler	*Wilsonia pusilla*
Yellow-rumped warbler	*Dendroica coronata*
Tanagers	
Western tanager	*Piranga ludoviciana*
Sparrows	
Bachman's sparrow	*Aimophila aestivalis*
Chipping sparrow	*Spizella passerina*
Dark-eyed junco	*Junco hyemalis*
Fox sparrow	*Passerella iliaca*
Lazuli bunting	*Passerina amoena*
Rufous-sided towhee	*Pipilo erythrothalmus*
Song sparrow	*Melospiza melodia*

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Common name	Scientific name
Blackbirds, Cowbirds, and Orioles	
Brown-headed cowbird	*Molothrus ater*
Northern oriole	*Icterus galbula*
Red-winged blackbird	*Agelaius phoeniceus*
White-winged crossbill	*Loxia leucoptera*
Finches	
Black-headed grosbeak	*Pheucticus melanocephalus*
Evening grosbeak	*Coccothraustes vespertinus*
Pine siskin	*Carduelis pinus*
Purple finch	*Carpodacus purpureus*
Red crossbill	*Loxia curvirostra*
White-winged crossbill	*Loxia leucoptera*
CONIFEROUS TREES (SOFTWOODS)	
Yews	
Pacific yew	*Taxus brevifolia*
Pines	
Jeffrey pine	*Pinus jeffreyi*
Knobcone pine	*Pinus attenuata*
Lodgepole pine	*Pinus contorta*
Pinyon pine	*Pinus edulis*
Ponderosa pine	*Pinus ponderosa*
Sugar pine	*Pinus lambertiana*
Western white pine	*Pinus monticola*
Spruces	
Black spruce	*Picea mariana*
Engelmann spruce	*Picea engelmannii*
Sitka spruce	*Picea sitchensis*
White spruce	*Picea glauca*
Hemlocks	
Mountain hemlock	*Tsuga mertensiana*
Western hemlock	*Tsuga heterophylla*
True Firs	
California red fir	*Abies magnijiica*
Grand fir	*Abies grandis*
Noble fir	*Abies procera*
Pacific silver fir	*Abies amabilis*
Subalpine fir	*Abies lasiocarpa*
True firs	*Abies spp.*
White fir	*Abies concolor*
Douglas-firs	
Douglas-fir	*Pseudotsuga menziesii*
Redwoods	
Redwood	*Sequoia sempervirens*

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Common name	Scientific name
Cedars	
Alaska-cedar	*Chamaecyparis nootkatensis*
Incense-cedar	*Libocedrus decurrens*
Port-Orford-cedar	*Chamaecyparis lawsoniana*
Western redcedar	*Thuja plicata*
FLOWERING TREES (HARDWOODS)	
Bigleaf maple	*Acer macrophyllum*
Bitter cherry	*Prunus emarginata*
Black cottonwood	*Populus trichocarpa*
California black oak	*Quercus kelloggii*
California-laurel	*Umbellularia californica*
Canyon live oak	*Quercus chrysolepis*
Cascara buckthom	*Rhamnus purshiana*
Golden chinkapin	*Castanopsis chrysophylla*
Oregon ash	*Fraxinus lattfolia*
Oregon white oak	*Quercus garryana*
Pacific dogwood	*Cornus nuttallii*
Pacific madrone	*Arbutus menziesii*
Red alder	*Alnus rubra*
Scouler willow	*Salix scouleri*
Tanoak	*Lithocarpus densiflorus*
Vine maple	*Acer circinatum*
SHRUBS AND HERBS	
Alaska huckleberry	*Vaccinium alaskaense*
Blackberry	*Rubus spp.*
California hazel	*Corylus cornuta*
Canadian thistle	*Cirsium arvense*
Common pipsissiwa	*Chimaphila umbellata*
Dwarf rose	*Rosa gymnocarpa*
Fireweed	*Epilobium spp.*
Hedge-nettle	*Stachys cooleyae*
Huckleberry	*Vaccinium spp.*
Little pipsissiwa	*Chimaphila menziesii*
Ocean-spray	*Holodiscus discolor*
Oregongrape	*Berberis nervosa*
Oregon oxalis	*Oxalis oregana*
Pacific rhododendron	*Rhododendron macrophyllum*
Pinesap	*Hypopitys monotropa*
Red huckleberry	*Vaccinium parvifolium*
Salal	*Gaultheria shallon*
Salmonberry	*Rubus spectabilis*
Thimbleberry	*Rubus parviflorus*
Thin-leaved huckleberry	*Vaccinium membranaceum*
Twinflower	*Linnaea borealis*
FERNS	
Bracken fern	*Pteridium aquilinum*
Swordfem	*Polystichum munitum*

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Common name	Scientific name
FUNGI	
Red-brown butt rot	*Phaeolus schweinitzii*
White pine blister rust	*Cronartium ribicola*

[a] Except as noted below, common and scientific names follow Collins 1990 for amphibians and reptiles, Jones and others 1986 for mammals, American Ornithologists' Union 1983 for birds, and Hitchcock and Cronquist 1973 plants.

[b] Formerly ***D.** ensatus;* species' revisions based on Good (1989).

[c] Also known as Pacific water shrew.

[d] Also known as dusky shrew.

[e] Proposed revision of Townsend's chipmunk into four species including the Siskiyou chipmunk *(Tamias siskiyou)* is not recognized.

[f] Also known as Columbian mouse.

[g] Inclusion of the red tree vole and white-footed vole in the genus Phenacomys is not recognized.

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Appendix B-Abstracts of Poster Presentations at the Symposium on "Old-Growth Douglas-Fir Forests: Wildlife Communities, and Habitat Relationships," Held in Portland, Oregon, on 29-31 March 1989

Old-Growth Ecology and Management

Structure and Dynamics of Old-Growth Temperate Rainforests in Coastal Alaska

Paul Alaback, USDA Forest Service

The cool temperate forests in coastal Alaska share many species in common with both the montane and coastal floras of the Pacific Northwest, but they have evolved under extreme conditions of cool temperatures and heavy year-round rainfall. In south-central Alaska, hemlock-dominated forests have been in the area for only a few thousand years and tend to have more abundant spruce seedlings than do upland forests of southeastern Alaska. Compared to the Northwest, the growing season climate is much shorter, cooler, and wetter. This climate leads to rapid soil formation, leaching, and, in the absence of disturbance, bog formation. Larger canopy openings are required to give the same degree of release for hemlock seedlings. Huckleberry dominates the understory of most upland sites because of high shade tolerance and heavy seed production. The abundance of other herbs is related to canopy disturbances-usually windthrow. Dense growth of young trees after catastrophic disturbance shades out understory plants for as much as 100 to 150 years. In the Pacific Northwest, by contrast, this lasts 50 years or less, perhaps because of greater radiation through the forest canopy. Many wildlife species are thought to depend on the open, structurally diverse old-growth forests. The mosaic of forest and soil conditions and recent glacial history makes the south coast of Alaska ideal for studies of forest development in the face of rapid climatic change and of landscape patterns in relation to wildlife populations.

Growth and Mortality in a 450-Year-Old Forest: Trends During Four Decades for Douglas-fir, Western Hemlock, and Associated Species

Dean S. DeBell, USDA Forest Service, and Jerry F. Franklin, University of Washington

Resource managers are faced with decisions about the fate of existing old-growth stands and the future role of old growth in long-term plans for managing forests. Information on what has happened since 1947 in a 450-year-old stand at Thornton T. Munger Research Natural Area is useful background for such decisions. Growth and mortality were measured at 6-year intervals from 1947 to 1983 in a 478-ha old-growth stand in southwestern Washington. Principal tree species were

Douglas-fir, western hemlock, Pacific silver fir, western redcedar, and western white pine. They comprised 59,27,6,6, and 1 percent, respectively, of the total cubic volume (372 m^3) in 1947. Gross volume growth averaged 6.2 m^3 per hectare per year, and mortality averaged 6.0 m per hectare per year. Net growth was therefore minimal, and total stand volume remained nearly constant for 36 years. Changes are occurring, however, in stand characteristics and species importance. Douglas-fir, which accounted for only one-third of the gross growth and nearly one-half of the mortality, is losing dominance to western hemlock, which provided nearly one-half the gross growth and only 28 percent of the mortality. Pacific silver fir increased in importance in the lower canopy and was 60 percent of the ingrowth. Although such changes may be relatively slow, they indicate that characteristics or functions of old-growth stands cannot be guaranteed in perpetuity by simply preserving existing tracts. Information is needed on how silvicultural practices might enhance development of desired attributes in younger, managed forests.

Patterns of Variation in Snag Populations on the Mt. Hood National Forest

Christopher Topik, Nancy M. Diaz, and Timothy J. Brady, USDA Forest Service

The functional roles of snags in the forest ecosystem depend on their decay condition, size, and abundance. Effective management of the snag resource requires knowledge of both the general and habitat-specific patterns of variation in these attributes. Survey data for plots from unmanaged westside (western hemlock zone) and eastside (ponderosa pine, Douglas-fir, and grand fir zones) stands greater than 60 years old were compared, to characterize the patterns of variation in snag populations in the Mount Hood National Forest.

Two general statements emerge from the data: the patterns of variation in condition, size, and abundance of snag populations are, at most, only weakly correlated with successional status; and the density of large snags ($\geq$ 50 cm in d.b.h., $\geq$ 15 m height) is essentially uniform throughout the habitats sampled. The results suggest several habitat-specific observations as well: eastside stands contain substantially lower snag densities than those west of the Cascade Crest: and although no trend in snag densities is discernible among decay-classes for westside stands, the distribution for eastside stands is biased towards a greater representation of hard snags. The data presented here suggest that snag-management policy should remain flexible so that it can be modified in light of habitat-specific characteristics of snag populations.

The Status of Old-Growth Forests in Six National Forests of the Pacific Northwest

Peter H. Morrison, The Wilderness Society

The amount of old-growth forest remaining in the Pacific Northwest has been the subject of increasing controversy. In 1988, The Wilderness Society undertook a project to determine the amount of old-growth forest remaining on six National Forests: Mount Baker-Snoqualmie, Olympic, Gifford Pinchot, Mount Hood, Willamette, and Siskiyou. The study used the interim definition established by the Old-Growth Definition Task Group as a basis for the inventory. USDA Forest Service timber inventories were analyzed to determine forest characteristics. Inventory-plot status was updated using Forest Service records and aerial overflights. The acreage of old-growth forests and other mature forest types was determined by use of plot expansion factors. The results of the study indicate that considerably less old-growth forest exists than the acreage reported for old-growth forest in National Forest management plans. The Wilderness Society analysis indicated 461 538 ha of old-growth forest remain on the six Forests studied. This compares to 1 029 555 ha reported in Forest Service draft plans. The major reason for this discrepancy is the inclusion of all forest stands with trees over 53 cm in d.b.h. in the Forest Service estimate and the more stringent criteria of the interim old-growth definition. Some of the discrepancy is due to more recent updating of the status of old-growth forests in The Wilderness Society study. The landscape context of the remaining old growth was also assessed in this study. Over 38 percent of the remaining old growth exists in stands that are less than 32 ha or within 120 m of a road or clearcut. Old-growth fragmentation is particularly severe on some National Forests, such as the Gifford Pinchot where over 68 percent of the remaining old growth is within 120 m of a road or clearcut or in stands less than 32 ha. At current harvest rates, unfragmented old growth will virtually disappear in a few years on such Forests.

Rain Chemistry and Buffering in an Old-Growth Rainforest

Ted B. Thomas, Jonathon J. Rhodes, and Robert L. Edmonds, University of Washington

The Olympic Peninsula and the forest lands of the Hoh River Valley provide an ideal setting for characterizing wet deposition into clean ecosystems. Long-term ecosystem monitoring provides an indication of environmental change from inputs of atmospheric pollutants. An old-growth (650 years) forested watershed at West Twin Creek in the Hoh Valley of Olympic National Park was chosen by the National Acid Precipitation Assessment Program for long-term intensive watershed study. The objective of the program is to investigate rainfall chemistry and watershed processes that may affect surface-water chemistry. The abundant rainfall (3500 mm) of the Hoh

Valley comes directly off the Pacific Ocean and is virtually unimpacted by industrial pollution. Rainfall chemistry of the Hoh Valley has been examined on a gradient from the Pacific Ocean to 30 km inland. H^+, SO_4^{2-}, and NO_3^- ion concentration varied significantly over the 30-km transect; pH increased and SO_4^{2-} and NO_3^- concentration decreased. The long-term mean pH for precipitation in the Hoh Valley is 5.3. Interception of rainfall by old-growth forest canopies and tree boles may acidify solutions to as low as pH = 4.0 (throughfall and stemflow ranged from 4.0-5.1). Stemflow and throughfall solutions were more concentrated for H^+, PO_4^{3-}, and cations than rain, Organic acids expressed as dissolved organic carbon were most concentrated in stemflow and highly correlated with charge balance deficit. Soil and bedrock weathering reactions buffered soil solutions and appear to be the dominant controls on streamflow chemistry. West Twin Creek surface waters have been consistently greater than pH = 7.0, and dominated by HCO_3^-, SO_4^{2-}, Ca^{2+}, and Mg^{2+}. Monitoring rain chemistry and characterizing ecosystem processes that affect ion transfers within old-growth forests are important. These studies provide a baseline to evaluate changes in forest health and surface water quality.

Northeast Cascades Recreation Strategy Research Needs

E.L. Burr, Mazama, Washington

The objective of wilderness management to maintain the natural forest renewal processes requires baseline data related to fire, avalanche, grazing, browsing, endangered species, spraying, fuelwood gathering, logging, and interagency boundary discontinuities. Research funding is too often narrowly focused and has been largely reactive, forced by crises with western spruce budworms, mountain goats, mule deer, grizzly bears, ski development, and spotted owls. Research that anticipates management needs by probability and priority is necessary to minimize social-resource management conflicts. The first research priority for the east side should be the definition of old-growth forests, then the ecological effects of fire and spotted owl management. Questions about grizzly bears as an old-growth-dependent species need to be addressed. Court injunctions threaten to shackle forest management unless research becomes more relevent.

Forest Fragmentation and Landscape Ecology

A Comparison of Three Methods of Estimating Fractal Dimension as a Measure of Fragmentation of Old-Growth Habitat Using a GIS

Kenneth R. Dixon, Timothy A. Young, K. Lea Knutson, James R. Eby, and Harriet L. Allen, Washington Department of Wildlife

Landsat MSS data were used to classify spotted owl old-growth habitat in western Washington. Habitat fragmentation was measured using the fractal dimension of Mandelbrot. Three different methods of calculation (length of trail, relation of area to perimeter, and Korcak empirical relation for islands) produced three different estimates. Each method may have advantages over the others, depending on scale and application.

Minimum Fragmentation Landscape Design

Miles Hemstrom, Steve Eubanks, and Karen Geary, USDA Forest Service

The spatial placement of harvest units across a landscape greatly influences the resulting kinds and qualities of stand conditions present. Because the distribution of stand age-classes developed by timber harvest influences harvest options beyond one rotation, the pattern imposed on the landscape during the initial rotation tends to be self perpetuating. The staggered-setting approach, typically used to disperse harvest impacts across the landscape, results in the maximum rate of fragmentation of remaining unharvested stands. When the landscape is half cut over, the remaining patches are the same size as the harvest units. Edge effects, which extend into remaining stands for some distance, may render all the remaining unharvested stands unsuitable as habitat for interior species.

An alternative harvest regime, based on maintaining large unharvested stands and associated travel corridors as long as possible, was developed for an area of the Blue River Ranger District. This minimum fragmentation alternative is based on the same rate of decadal timber harvest as the staggered-setting approach and can be implemented given existing management regulations. Both alternatives were analyzed in a geographic information system. Minimum fragmentation designs are being considered for most new timber sales on the Blue River Ranger District.

Monitoring Biodiversity With Permanent Plots-Landscape, Stand Structure, and Understory Species

Janet L. Ohmann and Charles L. Bolsinger, USDA Forest Service

Permanent plots are useful for monitoring biological diversity and wildlife habitat across the forested landscape. Forest Inventory and Analysis conducts a continuing multiresource inventory of non-Federal forest lands in Washington, Oregon, and California. Plots, established on a systematic grid, consist of five sample points over about 20 ha. Live and standing dead trees and understory vegetation are measured, and area descriptors such as aspect, slope, elevation, and disturbance history are recorded. Plot data in western Oregon indicate that 82 percent of the non-Federal timberland is in a mid-successional stage, and only 1 percent qualifies as old growth. Estimates of old-growth area vary by definition: in western Oregon, only 8 percent of stands over 100 years old meet an ecological definition of old growth, while several stands younger than 100 years qualify. Snag density increases with forest succession, from 1 ha in very young stands to 7.1 in old growth. In southwest Washington, permanent plots show that within 10 to 25 years after clearcutting, Douglas-fir and western hemlock make up a slightly larger portion of new stands, western redcedar has been reduced markedly, and other tree species have changed little. Average shrub cover decreased slightly after logging, but number of shrub species increased. Groundcover in forbs increased slightly after logging, but number of species nearly doubled, including several pioneer species such as Canadian thistle, fireweed, and hedge-nettle. In conclusion, Forest Inventory data show that intensive management of non-Federal timberland has reduced structural diversity across the landscape as well as on specific sites, but has increased diversity as measured by number of plant species (although species proportions have changed). These changes have implications for diversity of wildlife communities as well as for long-term management for other resources. This information should be useful to planners, policy makers, and others concerned about the effects of land management on both public and private lands.

Spotted Owl

Banding as a Management Tool: The Case of the Northern Spotted Owl

Robin R. Bown and Joseph B. Lint, USDI Bureau of Land Management

Since 1985, biologists have banded 216 adult, 37 subadult, and 107 juvenile spotted owls with USDI Fish and Wildlife Service colored leg bands on the Roseburg District of BLM. Intensive efforts to observe and band birds each year allow the biologists to define stable sites, detect changes in occupancy over time, and document movements of the nest areas. By identifying individual owls, the biologists gather demographic information including site and mate fidelity, survival, replacement, and movements. Birds banded as subadults or juveniles provide age-specific information on survival, reproduction, site fidelity, and movements. Of 116 adults banded on 68 stable territories, 74 percent were observed after 1 year, compared to 45 percent of 11 subadults. To date, 28 banded birds have been replaced by new birds, including three complete pairs. Three adult females have moved from existing sites and paired with an established male on another site. Six of the 69 juveniles banded in 1986 and 1987 have been encountered. Long-term banding information will permit us to calculate the demographic values for population analyses and viability assessment, as well as to determine a relative measure of habitat quality based on the occupation and reproductive history of sites.

Spotted Owl Monitoring in Washington and Oregon

Kathleen A. O'Halloran, A. Grant Gunderson, and Richard S. Holthausen, USDA Forest Service

The goal of Pacific Northwest Region spotted owl habitat management is to ensure the viability of spotted owls on Forest Service lands as mandated by the regulations implementing the National Forest Management Act of 1976 (36 CFR 219). To determine if spotted owl populations in spotted owl habitat areas (SOHAs) are stable, 11 Forests conducted monitoring with standardized procedures. In 1987, 405 ha SOHAs were monitored. The regional average for nonreserved SOHAs with any owls (singles and pairs) was 89 percent, and 80 percent of the reserved SOHAs had owls; 46 percent of the nonreserved SOHAs had pairs, and 30 percent of the reserved SOHAs had pairs. In 1988, SOHAs were designated primarily on nonreserved lands, and size varied from 405 to 1093 ha, depending on the physiographic province. The 1988 regional average for SOHAs with any owls was 91 percent, with 56 percent having pairs. To examine general population trends, random sample areas (RSAs) were monitored for spotted owls. In 1987, 116 RSAs of 1822 ha were monitored; 73 percent had owls, with 26 percent having owl pairs. Because of interpretation and implementation problems, RSAs were reduced to 405 ha. In 1988 also, RSAs were established and monitored on reserved lands; 57 percent of the nonreserved RSAs had owls and 15 percent had owl pairs. For reserved RSAs, 38 percent had owls and 17 percent had owl pairs. Monitoring of these areas will continue on a stratified basis. Within 5 years, trend information from the SOHA and RSA monitoring will be evaluated to determine if the Forest Service's spotted owl management strategy is working.

Ecology of Spotted Owls on the Olympic Peninsula, Washington

Eric D. Forsman, Stan G. Sovern, and Duane Aubuchon, USDA Forest Service

Twenty-one spotted owls were radio-tagged on the west side of the Olympic Peninsula in 1987-88 and observed for periods ranging from 7 to 19 months. Home ranges of individuals varied from 1367 to 13 475 ha. Home ranges expanded considerably during winter, with few individuals wandering extensively into areas up to 22 km from the center of summer activity. Color banding of the 21 radio-tagged owls and an additional sample of 46 owls that were not radio-tagged indicated an approximate adult survival rate of 0.94 during the first year of the study, Reproduction during 1987 was poor, with only 9 percent of the population producing young. In 1988,36 percent of the population produced young. In a

360 km^2 intensive study area on the west side of the peninsula, density of owls was 0.064 owls per km^2, which is less than half the density reported in studies in Oregon and northern California.

Spotted Owl Home Ranges in Five Landscapes

Scott P. Horton, Andrew B. Carey, Janice A. Reid, and **Robert** B. Horn, USDA Forest Service

Spotted owl home ranges in the Pacific Northwest are typically large and primarily composed of late-successional forests. Home-range size and composition may vary with landscape composition and pattern, but few data are available for such comparisons. We obtained over 7000 relocations on members of 23 pairs of radio-tagged spotted owls, between 1 September 1987 and 31 August 1988, in five study areas in southwestern Oregon. Pair ranges (medians) were 1567 and 2864 ha, respectively, in old-growth dominated (five pairs) and mosaic-patterned (four pairs) Douglas-fir study areas; 571 and 1648 ha, respectively, in old-growth dominated (three pairs) and mosaic (five pairs) mixed-conifer areas; and 1662 ha in a mosaic, mixed-evergreen (six pairs) area. Pair ranges were composed of an average of 65 percent and 47 percent late-successional forest in homogeneous and mosaic-patterned landscapes, respectively. All but 1 of the 46 owls selected late-successional stands for foraging, based on their availability within the owls' ranges. Other types of stands were used either in proportion to their availability or avoided. Both landscape composition and pattern appeared to influence home-range sizes. Pair home ranges were smaller in the mixed-conifer/evergreen forest zone than in the Douglas-fir zone in landscapes of similar pattern. And pair home ranges were smaller in homogeneous, old-growth dominated landscapes than in mosaic-patterned landscapes in similar forest zones.

Temporal Variation in Spotted Owl Home Ranges

Kevin C. Peeler, Andrew B. Carey, J.H. Guetterman, and Peter J. Loschl, USDA Forest Service

Spotted owls are known to have large home ranges, however little is known of how these home ranges change over time. Our objective is to report the seasonal, yearly, and cumulative home ranges of four adult spotted owls that were followed for about 2.5 years, Three male and 1 female spotted owls were radio-tagged in the spring of 1986 in the southern Oregon Coast Range. The owls were relocated every other night and on one day during the 5-day work week, for an average of 377 fixes per owl over 2.5 years. We estimated home ranges using the minimum convex polygon method for each individual for two or three breeding seasons (March through August), two nonbreeding seasons (September through February), two l-year periods (September through August), and for the entire 2.5-year period. Breeding season home ranges averaged 802 ha (n = 11, SE = 118). Nonbreeding season home ranges averaged 1566 ha (n = 8, SE = 305). Yearly home ranges averaged 1715 ha (n = 8, SE = 283). The 2.5-year cumulative home range averaged 2,454 ha (n = 4, SE = 554). Yearly home range size averaged 73 percent of the 2.5-year cumulative home range (n = 8, SE = 7). Although four individuals is a small sample, spotted owl home ranges appear to increase over time.

Diet of Spotted Owls on the Olympic Peninsula, Washington and the Roseburg District of the Bureau of Land Management

Eric D. Forsman, Ivy Otto, and Andrew B. Carey, USDA Forest Service

Between May 1987 and November 1988, 884 prey were identified from pellets of spotted owls on the Olympic Peninsula. The northern flying squirrel was 64 percent and 42 percent of the diet on the west side of the Peninsula, respectively. Bushy-tailed woodrats and southern red-backed voles were important prey on the east side of the Peninsula but were rare in the diet of owls on the west side. Deer mice were common in the diet on all study areas. Most predation on snowshoe hares consisted of small juveniles captured between April and September. In both 1987 and 1988, small juvenile flying squirrels were largely absent from the diet except during September-November. This suggested that flying squirrels on the Peninsula produced only one litter per year in July or August, and that the young squirrels began to forage outside their natal nests in September. Diets of male and female spotted owls did not differ significantly either in terms of composition or mean prey size. On the Roseburg Study Area, the diet of spotted owls in five different geographic areas was compared. The main difference noted among areas was that woodrats tended to predominate in drier mixed-conifer and mixed-evergreen forest types, but flying squirrels predominated in the diet in more humid forests of Douglas-fir.

Roosting Habits of the Spotted Owl in the Oregon Coast Range

Christopher C. Foster, Joseph A. Bums, and Andrew B. Carey, USDA Forest Service

Radio-telemetry studies of the spotted owl have been conducted in the Oregon Coast Range since 1986. Site characteristics have been recorded for 772 diurnal roost locations in three vegetation zones (western hemlock, mixed conifer, and mixed evergreen) and five stand types (sapling, pole, young, mature, and old-growth). Old-growth stands in all vegetation zones were preferred as roost locations. Owls selected for northeast-facing slopes and tended to roost on the northeast side of the tree. Slope and perch aspects did not vary significantly with season. Owls roosted predominantly in Douglas-fir. Roost heights were inversely related to ambient temperature in winter. Overhead perch protection averaged 75 percent. Old growth offers the northern spotted owl the variety of roost conditions necessary to survive in a varying climate.

Spotted Owl Prey Studies

Red Tree Voles in the Oregon Coast Ranges

Anne-Marie Gillesberg and Andrew B. Carey, USDA Forest Service

Red tree voles are of interest because of their restricted geographical distribution, preference for old growth, and as an important food item for the spotted owl. To manage for viable populations of the spotted owl, we need to describe the ecology of its prey base in greater detail. Several techniques have been used in an attempt to estimate the abundance of red tree voles. Because nest surveys and trapping efforts in the Oregon Cascades and Coast Range proved largely unsuccessful, we explored an alternative technique: searching felled trees. The Bureau of Land Management assesses the value of timber in old-growth stands by felling trees and examining them for defects (a procedure known as 3P sampling). We examined 93 felled trees from four 3P samples for evidence of red tree voles. We found 117 pieces of nest material and described their composition. Smaller nests usually consisted solely of resin ducts and fecal material, but larger nests contained, in addition to resin ducts, conifer needles, twigs, lichen, feces, and other organic matter. Nests were found in hollow limbs and broken tops, resting on branches or situated against the boles of the sample trees. Nests were most often within the lower one-third of the canopy, and larger trees (>100 cm in d.b.h.) were preferred over smaller trees. We concluded that searching a sample of felled trees, in conjunction with 3P sampling (or thinnings), can be an effective method of determining the relative abundance of red tree vole nests and investigating potential dependency of this species on old-growth forests.

Woodrat Abundance in Forests of the Southern Oregon Coast Range

G. Scott Center, Bruce R. Casler, and Andrew B. Carey, USDA Forest Service

Abundance patterns of dusky-footed woodrats and bushy-tailed woodrats were described as part of a spotted owl prey-base study in southwest Oregon. Exploratory live-trapping was conducted in Douglas-fir and mixed-conifer forests in seral stages ranging from recently cut to old growth (>200 years). Forty-five sites were sampled: six stages in mixed-conifer forests and five stages in Douglas-fir forests. Abundance of both woodrat species was higher in mixed-conifer forests than in Douglas-fir forests. Both species were locally abundant in mixed-conifer old growth; only the bushy-tailed woodrat occurred in Douglas-fir old growth. Both bushy-tailed woodrats and dusky-footed woodrats were abundant in riparian zones. Dusky-footed woodrats were abundant in sapling-pole, young (<80 years), and in disturbed portions of old stands (>80 years) where dense regrowth occurred in the mixed-conifer forests. The percentage of ground cover of fine and coarse litter shows a significant positive relationship to dusky-footed woodrat abundance. Dusky-footed woodrats built shelters (“middens”) of coarse woody debris. Bushy-tailed woodrats appeared to use cavities in trees or crevices in rocks, which might explain their association with old growth (where snags are abundant), and riparian zones, where rocks are exposed and deciduous trees provide additional cavities.

Flying Squirrel Abundance in Young and Old-Growth Forests of the Pacific Northwest

Brian L. Biswell and Andrew B. Carey, USDA Forest Service

Northern flying squirrel abundance was determined in stands representative of the home ranges of spotted owls, particularly young and old-growth Douglas-fir forests in the Oregon Coast Range and climax western hemlock and young western hemlock and Douglas-fir forests on the Olympic Peninsula, WA. Live-trapping was conducted during 1985-88 in 18 Coast Range sites: 8 young, 3 mature, and 7 old-growth. Fourteen Olympic Peninsula sites were trapped twice during 1987-88: 8 young and 6 climax. Trapping was conducted during spring and fall in the Coast Range. Trapping was conducted only in fall in the Olympics. Flying squirrel densities in old stands in the Coast Range were 0.1 to 4.8 (averaging 1.8) animals per hectare and 0.3 to 2.0 (averaging 0.9) animals per hectare in young stands. Fall flying squirrel densities on the Olympic Peninsula were 0.0 to 0.8 (averaging 0.3) animals per hectare in climax stands and 0.0 to 1.2 (averaging 0.4) animals per hectare in young stands. No significant difference in flying squirrel abundance was found between young and climax forests on the Olympic Peninsula. Densities were 2 times greater in old stands than in young stands in the Coast Range. Young stands averaged 2.3-times higher densities in the Coast Range than in the Olympics and 6-times higher densities in old-growth Douglas-fir than in climax western hemlock.

Comparison of Small Mammal Abundance in Climax and Young Forests of the Olympic Peninsula, Washington

Brian L. Biswell, John Boulanger, and Andrew B. Carey, USDA Forest Service

Small mammal abundances in climax western hemlock stands on the Olympic Peninsula of Washington were compared to young stands as part of a spotted owl prey-base study. The focus of the study was to determine the abundance patterns of deer mice and southern red-backed voles. An index to abundance was obtained by using snap-trap transects in 14 stands. Trapping was conducted during the summers of 1987 and 1988. Sampled stands were classified as climax (250 years) or young (40-90 years and regenerated after logging or wind storms). Transects consisted of two lines of 25 stations, 15 m apart. Two Museum Special snaptraps were placed at each station and checked for 4 nights. Young and climax stands were paired by geographic areas for analysis. Capture rates between paired stands were compared by using Wilcoxon's signed-ranks test. Twelve species of small mammals were caught, Trowbridge's shrew, red-backed vole, and deer mice were most abundant. The numbers of species trapped were nearly equal between stand types. Deer mice were more abundant ($P = 0.058$) in climax stands than in young stands. The abundance of red-backed voles did not differ between stand types ($P = 0.46$). Deer mice decreased between 1987 and 1988, but red-backed voles increased ($P = 0.003$). Our results document the preference of deer mice for climax forests, and the high variability of small mammal abundance.

Increasing the Carrying Capacity of Second-Growth Stands for Flying Squirrels With the Use of Nest Boxes

J.W. Witt, U.S. Department of the Interior, Bureau of Land Management

Three experimental and three control areas were established in second-growth Douglas-fir stands in western Oregon. Nest boxes were installed in the experimental areas at a density of about 2.8 boxes per hectare. The mean adult-trapping success and densities of adult northern flying squirrel were estimated using an arboreal live-trapping grid. The estimates were compared between and within their respective areas, and compared with similar estimates from an old-growth grid established in the Coast Range. Nest-box use and occupancy were examined in the second-growth stands and in an old-growth nest-box grid. The mean adult density in the experimental grids, using the boundary-strip technique, was 0.80 squirrels per ha with a range of 0.29 to 1.54; the mean density in the control areas was 0.39 squirrels per ha, with a range of 0.08 to 0.81. Two-way analysis of variance with replication (ANOVA Model I) indicated a significant difference (P c 0.005) between the treatment and the control, and the density estimates between treatment areas was also significantly different ($P < 0.0005$). The mean density estimates in spring from the experimental areas were not significantly different from the old-growth mean, but a mean density estimate in the fall derived from two of the three experimental areas indicated a significant difference between the second growth and the old growth ($P < 0.05$), with the old growth being larger. Although the response to the nest boxes was variable, the results are consistent in that they demonstrate that the carrying capacity of second-growth habitat can be increased with the use of nest boxes.

Management implications of the study: if the target species is the northern flying squirrel, then nest boxes are an appropriate and useful management tool; as to managing the northern spotted owl-by contributing to its prey base, next boxes are a supplemental tool but not a surrogate for old growth.

Flying Squirrel Live-Trapping Success

Janelle G. Corn, U.S. Department of the Interior, Fish and Wildlife Service, and Joseph Witt, U.S. Department of the Interior, Bureau of Land Management

The northern flying squirrel is an important component of old-growth forests in the Pacific Northwest. It is the primary prey of the spotted owl and may be an important part of the forest nutrient cycle. Variations in flying squirrel live-trapping success were examined in an old-growth Douglas-fir forest stand in Oregon's Coast Range to determine whether microhabitat and trap placement affect capture rates. The results of three trapping periods over 2 years were used to identify a subset of trap sites with good or poor squirrel capture rates. Forest structural and compositional features were measured within 5 m of each trap, and trap-placement features were described at each trap. Variables selected for measurement were thought to relate to proximity to squirrel foraging or resting areas, protection for squirrels from predators, and reduced invasion of traps by other small mammals. Few measured variables were correlated with trap success. The few correlations between trap-site features and capture rates indicate that flying squirrel trap-success is not influenced by conditions existing at or very near the trap, and that these features will not confound large-scale patterns of habitat use.

Marbled Murrelet

The Marbled Murrelet in Western Oregon: A Summary of Current Knowledge

S. Kim Nelson, Oregon State University

The marbled murrelet is a small robin-sized seabird that inhabits near-shore coastal waters and inland older-aged (80 years) coniferous forests of the Pacific Northwest. Despite this alcid's frequent and widespread occurrence along the Pacific coast, little is known about their inland distribution and specific habitat preferences. A total of 14 nests of this species have been recorded in its entire range; 9 on the ground or in rock cavities in tundra habitats, and 5 on moss-covered branches or broken tops of large conifer trees in forested habitats. In western Oregon, the marbled murrelet is known to occur at 42 inland locations, up to 47 km from the ocean; however, no nests have been found. These inland sightings occurred primarily in mature (80-200 years) and old-growth (>200 years) forests of the central Coast Range that included large conifer trees with moss-covered branches. Although exact use (nesting, roosting, or incidental) of these inland sites has not been determined, older forests with specific vegetation characteristics may be required for marbled murrelet nesting habitat. Conflict with timber management practices may develop because some inland sites where murrelets were located are scheduled for harvest within the next 10 years.

Geographic Distribution of the Marbled Murrelet in California at Inland Sites

Peter W.C. Paton and C. John Ralph, USDA Forest Service

The marbled mm-relet is an inhabitant of the coastal old-growth redwood forests of the northern half of California, yet little is known of its ecology away from the ocean. During the summer of 1988, we conducted a series of systematic surveys to quantify the distribution of the murrelet at inland sites from the Oregon border south to Monterey Bay. We identified old-growth and mature forests as potential habitat using remote-sensing techniques developed by Larry Fox of Humboldt State University. We then conducted transects, quantifying the relative abundance of murrelet activity, their behavior, and various vegetative aspects of the stands. Transects consisted of 8 to 12 stations spaced 250 m to 1 km apart, with each station surveyed for 10 minutes. The survey period extended from 45 minutes before to 90 minutes after sunrise. Each transect was surveyed at least twice during the 1988 field season. A total of 283 morning censuses were conducted on 127 transects, with murrelets detected on 53 percent (66) of the transects. In addition, stationary counts at fixed stations were conducted on 37 mornings and 31 evenings. Eighty percent of the murrelet detections occurred from 30 minutes before to 30 minutes after sunrise. Morning censuses had 5 to 6 times more detections than evening censuses at the same fixed station during the same 24-hour period. About 25 percent of the detections were visual observations, the rest were only heard. Flock size was small, single birds and pairs accounted for 80 percent of all detections. Bird distribution was patchy and restricted to the old-growth, redwood-dominated forests of Del Norte, Humboldt, San Mateo, and Santa Cruz Counties. No birds were detected in Mendocino, Sonoma, or Marin Counties, with the exception of one possible detection in Mendocino County. Areas with the highest activity were the Redwood State and National Parks within 25 km of the coast, although birds were detected 39 km inland at Grizzly Creek Redwoods State Park in Humboldt County.

Forest Birds

Does Habitat Heterogeneity Matter to Breeding Birds in Natural Douglas-fir Forests?

Andrew J. *Hansen*, Oregon State University, and Barry R. Noon and Kathryn L. Purcell, USDA Forest Service

We studied the influence of fine-scale habitat heterogeneity on bird community structure in a natural Douglas-fir forest to determine if habitat specialists are less common here than in other types of forests and if the size of microhabitat patches influences their suitability as habitat. Vegetation and birds were sampled in spring 1987 along 80-m wide, continuous-belt transects totaling 4 km in length. The data were analyzed at scales of resolution of 800, 1600, 3200, and 6400 m^2.

Principal components analyses revealed that 2 of 10 bird species (20 percent) used nonrandom subsets of the habitat in the study area. This proportion of habitat "specialists" was slightly less than the 29 percent found in a comparable study in a northern hardwood forest. Also, 20 percent of our species showed significantly different densities in forest gaps and in patches of closed forest. The comparable figure from four studies in other biomes is 16 to 45 percent.

Relative density of one bird species was positively associated with increasing area of suitable microhabitats. A group of species used large patches of unsuitable habitat less than they used small patches of unsuitable habitat.

Our findings support the hypothesis that birds specializing on specific microhabitats are generally less common in Douglas-fir forests than in other types of forest. Nonetheless, microhabitat diversity and spatial patterning are important habitat components for some birds in Douglas-fir forests.

The Effects of Forest Management on Cavity-Nesting Birds in Northwestern Washington

Jill E. Zarnowitz, Oregon Department of Fish and Wildlife

I studied the population characteristics and nest-site preferences of cavity-nesting birds in the Olympic National Forest of northwestern Washington. I characterized breeding populations in four different forest successional stages, from clearcuts to old growth, where either high or low densities of snags occurred. I described active cavity nests for 11 bird species. Species richness, densities, and diversities of cavity-nesting birds were greater in the plots with high snag densities (snag plots) than those with low snag densities (clean plots). Cavity-nesting bird populations increased with increasing densities of snags. Active cavity-nesters were 5 times more numerous on snag plots than clean plots. Hairy woodpeckers, a primary cavity-nester, selected western hemlock snags for nest sites. In contrast, broken-topped Douglas-fir snags were preferred by secondary cavity-nesters. The average diameter at breast height (d.b.h.) for active nest trees was substantially greater than the mean d.b.h. for sampled snags in the Forest. Low snag density appears to be a limiting factor for breeding cavity-nesting populations. Management recommendations for cavity-nesting birds in the Forest are discussed.

Significance of Old-Growth Forest for the Capercaillie

Pekka Helle and Harto Linden, Finnish Game and Fisheries Research Institute

The capercaillie, a Palearctic grouse species, inhabits old conifer stands, especially during winter and lekking season. Its well-documented population decline in Fennoscandia during past decades is associated with modem industrial forestry.

Two studies from Finland dealing with habitat distribution and stand characteristics of capercaillie leks are described. In northern Finland close to the Arctic Circle, the lekking stands did not differ from randomly selected stands in the 1950s. In the 1980s, when forestry had considerably altered stand structure, lekking stands were older, larger, and had a higher timber volume than random stands. Mean stand age and timber volume significantly decreased when moving away from the lek center, relatively evenly up to a distance of 4 km, to which distance adjacent areas were assessed.

A southern Finnish study based on topographic maps showed that the proportion of forest distinctly decreased with increasing distance from the lek center, up to a distance of 1 to 1.5 km. The data suggest that, in optimum habitats, a fine-grained mosaic of habitat patches is advantageous, but in marginal habitats, a coarse-grained habitat configuration is better. The results are discussed in terms of forestry planning, landscape ecology, and grain-size concepts.

Habitat Use of Cavity-Nesting Birds, Oregon Coast Range

S. Kim Nelson, Oregon State University

The availability of suitable standing dead trees or snags is known to influence cavity-nesting bird populations. Current snag-management practices on Federal lands may not be providing the appropriate number or distribution of snags to meet requirements of cavity-nesting birds. This study was undertaken to describe the nest-tree and nest-site characteristics of cavity-nesting birds in unmanaged old-growth, mature, and young forests, and to provide management recommendations. I found 277 active nests of 9 cavity-nesting species. No differences were found among species in their nest-tree or nest-site preferences. In general, all species preferred to nest in Douglas-fir snags >50 cm in diameter (d.b.h.) and >21 m in height. Large, tall snags were used significantly more than available in all stand ages. Cavity-nesting birds also selected hard snags with more bark and branches compared to available snags, and nested in snag patches with dense midstory and understory cover. Current snag management policies include retaining or creating snags, and retaining live green-tree replacements in clearcuts. These snags and trees will provide feeding habitat for all cavity-nesting birds, but not nesting habitat for species tied to the forest interior. Management practices should be modified to provide snags in all stages of managed forests, and retain or create snag habitat islands that include large (>50 cm in d.b.h.), tall snags, large green-tree replacements, and intact midstory and understory vegetation layers.

Comparative Foraging Ecology of Hammond's and Western Flycatchers in Northwestern California

Howard F. Sakai, Barry R. Noon, and C. John Ralph, USDA Forest Service

Stand structure and vegetation composition of old Douglas-fir forests in northern California and the Pacific Northwest are constantly being subjected to modifications from natural and human-caused disturbances. Effects of these habitat modifications, and conversion of old to young forests, on foraging site selection of breeding flycatchers has not been quantified and is relatively unknown. Foraging behaviors of Hammond's and western flycatchers in different-aged Douglas-fir stands were studied in northwestern California during the breeding seasons of 1984-85. Habitat characteristics of foraging sites were compared within species across stand ages and between species independent of stand age. Tree-structure characteristics, visual obstruction of perches, and foliage density at different heights best differentiated the two species among different foraging sites. Comparisons between species indicated that Hammond's differ from western flycatchers by perching and foraging higher, and choosing taller and larger diameter trees. Use of foraging sites varied within a species according to structural features associated with the different-aged stands. Comparisons within stand age-class showed that Hammond's foraged on fewer plant species than western flycatchers. Both species generally did not select forage tree species according to their availability in a stand.

Other Wildlife

Arthropods in Old Growth: Sensitive Environmental Indicators

Andrew R. Moldenke and John D. Lattin, Oregon State University

In all ecosystems, the species-rich arthropods regulate numerous critical biologic transformations and confer stability on the total system. A forest ecosystem has structure, and animal and plant species respond to this structure spatially and seasonally. This structure changes geographically as well as with succession. Invertebrates function in the food webs that involve every plant and animal in the forest, Current research focuses on old growth of the H.J. Andrews Experimental Forest.

Soil arthropods play important roles in the breakdown of litter, cycling of nutrients, and dispersal of microbial inocula. Pacific Northwest old-growth soils typically maintain nearly 200 arthropod species per square foot at any time of the year (5- to 8-year-old clearcuts have yet to recover to one-tenth that diversity). These species-rich assemblages respond predictably to changes in slope face and succession with strong turnover in individual species abundance. Soil arthropod studies indicate that fundamental ecological processes (for example, herbivore populations, parasitoids, microbial grazers) are differentially keyed to advancing successional seres. The composition of an individual series of samples can thus predict the type of forest association they were collected from. Thus, soil arthropods demonstrate promise to be used as "biologic probes" of biodiversity, disturbance, and edge effects caused by habitat fragmentation.

Ecology of Marten in the Pacific Northwest: Technique Evaluation

Lawrence L.C. Jones, Leonard F. Ruggiero, and James K. Swingle, USDA Forest Service

The marten, once widespread and abundant in boreal forests, has been extirpated from much of its former range by trapping and habitat alteration. Although the marten is a Management Indicator Species on many National Forests in Oregon and Washington, published studies on the ecology of marten in the Pacific Northwest are virtually nonexistent. The purpose of this pilot study is twofold: to identify techniques that might prove helpful to management biologists for monitoring marten, and to determine which techniques will be both feasible and effective for use in future studies of marten ecology.

Four census techniques are currently being evaluated: hair traps (winter), track plates (winter, fall), track counts in snow (winter), and live-trapping (summer, fall). The success rate of our modified hair traps and track plates was low: 2 and 6 detections for 410 and 286 sample-nights, respectively, during the winter! Live-trapping does not appear to be a feasible technique in our study area because only one marten was captured for every 221 corrected trap-nights. Snow track counts yielded 41 sets of tracks or runways in 30 search-days, making this the most successful and cost-effective technique to determine patterns of abundance for marten in the Pacific Northwest.

Logging on Old-Growth Mule Deer Winter Range

Harold M. Armleder and Rick J. Dawson, Ministry of Forests, British Columbia

Douglas-fir is an important component of the timber supply in the Cariboo Forest Region of British Columbia. A significant amount of old-growth Douglas-fir is located on mule deer winter range. Douglas-fir is an essential component of winter habitat providing deer with food and shelter. Common types of logging do not preserve these winter-range values. Eight years of research on mule deer habitat relationships has resulted in the development of an integrated management system designed especially for winter range. Managers apply the system by using procedures for assessing the current status of a winter range and determining prescriptions that will maintain habitat values. A major component of the system is a specialized method of low-volume selective logging that involves removing only about 20 percent of the merchantable volume of a stand. Trained loggers select trees to cut according to criteria developed especially for winter range. The objective is to maintain and promote a healthy stand of trees in all size- and age-classes, including a significant component of large, old trees. Two user-oriented publications that aid in implementing the system are highlighted.

Historic, Present, and Future Abundance of Terrestrial Vertebrates in Northwestern California

Martin G. Raphael and Bruce G. Marcot, USDA Forest Service

Douglas-fir forest covers over 1 million ha in northern California and has been heavily harvested over the last 30 years. Because of logging, old-growth stands have been reduced to 50 percent of their historic acreage and may ultimately be reduced to 10 to 15 percent. Based on extensive field surveys, we estimated the relative abundance of 115 terrestrial vertebrate species in clearcuts, young forest stands, and mature stands. We also estimated historic, present, and future acreages of these seral stages. We then estimated relative population sizes of each vertebrate species at each period to predict long-term effects of timber harvest on populations. We project that future populations of 17 species will have declined >50 percent from historic populations; an equal number will likely increase by >50 percent. Species associated with early-seral vegetation are currently at peak abundance and will decline, but species most strongly associated with mature forest have declined and will continue to do so. None of the species will be pushed to extinction, unless fragmentation effects are so severe that patch sizes of suitable habitat are too small and too widely dispersed to support viable populations.

Another trend is increased abundance among species of southern affinity and decreased abundance among species of boreal affinity. Increasers tend to be widespread and associated with a wide variety of habitats; decreasers tend to occupy restricted ranges and a narrow range of habitats. Therefore, even though numbers of increasers and decreasers are equal, the effects of old-growth reduction are not neutral.

Occurrence of Old-Growth-Related Wildlife Species in Non-Old-Growth Habitats

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During the summer of 1988, I studied the occurrence of three old-growth-related wildlife species-spotted owls, marbled murrelets, and fishers-in habitats generally considered unsuitable for the species. The study was conducted on lands of the Pacific Lumber Company in Northern California's Humboldt County. Owls were surveyed on 24 transects using methods developed by the USDA Forest Service. Fishers were surveyed with sooted track stations placed in different timber types and by monitoring tracks in the dust of logging roads, skid trails, and landings. Marbled mm-relets were surveyed in five major drainages on Pacific Lumber property by sampling techniques developed by the Pacific Seabird Group and the USDA Forest Service. Twenty-two owls were located on 16 transects. Owls were found in 40 vegetative complexes, of which 9 (22 percent) can be classified as old growth. The remainder (78 percent) may be classified as either second-growth stands or residual stands (stands containing scattered large trees and smaller second-growth trees). Coastal weather influence and timber-growing conditions may account for the presence of owls in a diversity of habitat types not suitable in other regions of their range. Marbled murrelets were found in four of the five drainages I sampled. The common factor associated with the presence of murrelets was large conifers (2127 cm in d.b.h.) comprising at least 25 25 percent of the overstory. Only one fisher was located-in a second-growth redwood-Douglas-fir stand containing trees 100 cm in d.b.h.

Old-Growth Forest Management (Slide Presentation)

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The objective of this presentation is to define old-growth forests and describe the benefits and values derived from them, their role in the natural system, and why their management is so controversial. The 15-minute slide-tape program attempts to build common ground to discuss a critical planning and management issue in the Pacific Northwest. With a look at the results of current ecological research, the four structural features (snags, large live trees, fallen trees, and multilayered forest) are discussed. Perspectives, attitudes, values, and benefits derived from them are discussed to share differing management objectives. Finally, the importance of citizen input in the planning process is highlighted.

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