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Terrestrial Forest Ecosystem Assessment

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Descriptions of Terrestrial Forest Ecosystems

Overview of Biological Communities and Ownership Patterns for Each Physiographic Province

The area addressed in this report is the range of the northern spotted owl within the United States, which includes western Washington, western Oregon, and northwestern California south to Marin County. With the exception of some lowland interior valleys and coastal plains, this area is dominated by mountainous terrain and coniferous forests.

The range of the northern spotted owl within the United States encompasses approximately 57 million acres, of which 24.3 million acres (43 percent) is federal land (Table 4-1). Of the federal lands, 19.5 million acres are administered by the U.S. Forest Service, 2.7 million acres are administered by the U.S. Bureau of Land Management, and 2.0 million acres are administered by the U.S. National Park Service (Table 4-1). Other federal lands within the range of the owl include military installations and national wildlife refuges.

Table 4-1. Estimated total land acres within the range of the northern spotted owl by agency or ownership and physiographic province.

State/ Physiographic Province	Acres by Ownership				
	U.S. Forest Service	Bureau of Land Management*	National Park Service	Other Federal	Non-Federal
Washington					
Eastern Cascades	3,329,000	0	137,200	6,000	2,210,000
Western Cascades	2,957,000	0	760,200	4,400	2,428,300
Western Lowlands	0	0	1,700	124,700	6,343,900
Olympic Peninsula	628,000	0	889,400	1,500	1,512,200
Total:	**6,914,000**	**0**	**1,788,500**	**136,600**	**12,494,900**
Oregon					
Klamath	1,284,800	821,200	200	0	1,894,200
Eastern Cascades	1,431,800	48,400	77,200	100	767,500
Western Cascades	3,724,600	666,300	86,800	500	2,161,700
Coast Range	618,600	776,300	100	1,700	4,374,400
Willamette Valley	0	16,800	0	8,700	2,632,600
Total:	**7,059,800**	**2,329,000**	**164,300**	**11,000**	**11,830,400**
California					
Coast Range	70,100	219,900	77,500	20,600	5,302,300
Klamath	4,358,200	101,600	0	0	1,621,100
Cascades	998,500	10,400	0	0	1,493,300
Total:	**5,426,800**	**331,900**	**77,500**	**20,600**	**8,416,700**
Three-State Total:	**19,400,600**	**2,660,900**	**2,030,300**	**168,200**	**32,742,000**

*** No acres tallied for Bureau of Land Management in Washington due to the dispersed nature of the ownership.**

Lands administered by the U.S. Forest Service are widely distributed within the range of the northern spotted owl. In contrast, Bureau of Land Management lands within the range of the owl are largely concentrated in western Oregon. Because of historical land grants, lands administered by the Bureau of Land Management in western Oregon tend to be distributed in a checkerboard pattern of alternating square-mile sections of federal and private land. In contrast, lands administered by the U.S. Forest Service tend to be more contiguous, with fewer inclusions of private land.

Some portions of the range of the owl contain little federal land. Most notable in this regard are the northern Coast Range Province in Oregon, the western Washington lowlands, and most of the coastal mountains of northern California. Nonfederal lands within the range of the owl include a variety of privately owned lands and areas owned and administered by state governments. Private lands include a multitude of small holdings and extensive areas owned by large timber companies. Indian reservations cover significant portions of the range of the owl, especially in the Olympic Peninsula, Eastern Cascades, and Klamath Provinces.

The Northern Spotted Owl Recovery Team (USDI 1992c) divided the range of the spotted owl into 12 provinces based on differences in vegetation, soils, geologic history, climate, land ownership, and political boundaries (Figure 2-5). The physiographic provinces (also referred to as "provinces") incorporate physical, biological and environmental factors that shape broad-scale landscapes. Physiographic provinces reflect differences in geology (e.g., uplift rates, and recent volcanism, tectonic disruption) and climate (e.g., precipitation, temperature, and glaciation). These factors result in broad-scale differences in soil development and natural plant communities. Within each province, variable characteristics of rock stability affect steepness of local slopes, soil texture, soil thickness, drainage patterns, landforms, and erosional processes. Thus, physiographic provinces have utility in the description of both terrestrial and aquatic ecosystems (see Aquatic Ecosystem Assessment Appendix A for more detail). Rates of harvest and natural disturbance have varied tremendously among the 12 different provinces, depending on land ownership patterns, topography, climate, soils, and proximity to centers of human population. As a result, some provinces, such as the Oregon Coast Ranges and Western Washington Lowlands, contain little remaining late- successional/old-growth forest, whereas other provinces, such as the Oregon Cascades, still retain extensive areas of such forests. These patterns have been described in detail elsewhere (e.g., Franklin and Dyrness 1973; Thomas et al. 1990; Ruggiero et al. 1991; USDI 1992a, b, c) and will only be briefly summarized here.

Olympic Peninsula

The Olympic Peninsula Province in northwestern Washington is a mountainous region bounded on three sides by water and on the fourth side by an extensive region of cutover state and private lands (the Western Washington Lowlands). Vegetation on the peninsula includes temperate rain forests of western hemlock, western red cedar, and Sitka spruce on the western slopes of the Olympic Mountains and forests of Douglas-fir and western hemlock in the rain shadow on the east side of the peninsula (Henderson et al. 1989). This province is occupied by a number of vertebrate species associated with late-successional/old-growth forests, including northern spotted owls, goshawks, American marten, and marbled murrelets. Although only a few nests have been found, large numbers of marbled murrelets are resident offshore and apparently nest on the peninsula. A dark race of the northern goshawk occurs on the peninsula and may represent a unique subspecies.

The Olympic National Park occupies the interior of the Olympic Peninsula. It is surrounded by the Olympic National Forest, which is surrounded by extensive areas of private land, Indian reservations, and state owned lands. Much of the Olympic National Park consists of high-elevation forests and subalpine areas. However, lowland valleys within the park contain significant areas of late-successional/old-growth forest.

The Olympic National Forest is characterized by a fragmented mixture of clearcuts, young plantations, and natural forests ranging from young stands to stands in excess of 2,000 years old.

The southern edge of the National Forest includes the Shelton Sustained Yield Unit which was largely clearcut between 1960 and 1985. The National Forest includes several small wilderness areas on the east slope of the Olympic Range adjacent to the National Park. Most private lands, state lands, and Indian reservation lands on the peninsula have been clearcut within the last 80 years. Some of the private lands are now being clearcut for the second time.

Western Washington Lowlands

The Western Washington Lowlands Province includes the Puget Sound area and all of western Washington south of the Olympic Peninsula and west of the Cascades Range. This area is largely in state and private ownership and has been almost entirely clearcut within the last 80 years. It is now dominated by a mixture of recent clearcuts and young stands on cutover areas. Forests on cutover areas are dominated by even-aged mixtures of Douglas-fir, western hemlock, and red alder. This province also includes extensive agricultural and metropolitan areas.

Western Washington and Oregon Cascades

The Western Washington and Western Oregon Cascades Provinces include the entire west slope of the Cascades Ranges in Oregon and Washington. This region is dominated by humid forests of Douglas-fir and western hemlock at mid-to-low elevations and forests of silver fir and mountain hemlock at higher elevations. At the southern end of the Western Oregon Cascades, forests of Douglas-fir and western hemlock are largely replaced by mixed conifer forests of Douglas-fir, grand fir, and incense cedar. Land ownerships include a mixture of private and state lands, National Forests, and National Parks. The Bureau of Land Management has extensive holdings in the Western Oregon Cascades Province. Private and state lands within this area are mostly cutover, whereas Forest Service and Bureau of Land Management lands still include significant areas (albeit highly fragmented) of late-successional/old-growth forest. Although some National Parks and wilderness areas within this region include significant areas of mid-elevation late-successional/old-growth forest, most are dominated by high elevation areas of montane and subalpine vegetation. A large proportion of the known spotted owl population in Washington and Oregon occurs in the Western Cascades. In Washington, old forests on federal lands in the Western Cascades are also important nesting habitat for marbled murrelets.

Eastern Washington and Oregon Cascades

The Eastern Cascades Provinces in Washington and Oregon include the east slope of the Cascades Range from the Okanogan Highlands of northern Washington south to the California border. This region is dominated by mixed-conifer forests and ponderosa pine forests at mid to lower elevations and by true fir forests at higher elevations. Land ownership patterns include a mixture of Forest Service, private, state, Indian, National Park Service and Bureau of Land Management lands. Forests in this region are highly fragmented due to logging and a variety of natural factors (poor soils, high fire frequencies, high elevations).

Before the development of modern methods of fire suppression, wildfire played a major role in shaping the forests of this region. Fire suppression efforts in the last 60 years have resulted in significant fuel accumulations in some areas and shifts in tree species composition. These changes may have made forests more susceptible to catastrophic fires and to epidemic attacks of insects and diseases. Any plan to protect late-successional/old-growth forests in this area must include

considerable attention to fire management and to the stability of forest stands.

Oregon Coast Range

The Oregon Coast Range Province includes the coastal mountains of western Oregon from the Columbia River south to the Middle Fork of the Coquille River. This area is dominated by forests of Douglas-fir, western hemlock, and western red cedar, with a narrow band of Sitka spruce along the coastal headlands. The southern half of the province includes a mixture of private, Forest Service, and Bureau of Land Management lands. The northern half is largely in private and state ownership. Heavy logging and a number of extensive wildfires during the last century have eliminated most late-successional/old-growth forests in the northern half of the province. Older forests in the southern half of the province are highly fragmented, especially on Bureau of Land Management lands, which are typically intermixed with cutover private lands in a checkerboard pattern of alternating square-mile sections.

Before the advent of fire suppression, the Coast Range Province was subject to frequent fires caused by lightning. As a result, many of the remaining natural forests consist of a mosaic of mature stands and remnant patches of old-growth trees. Because it is heavily cutover and relatively isolated from other forested areas, the Coast Range Province has been identified as an area of concern for spotted owls, marbled murrelets, and anadromous fish.

Willamette Valley

The Willamette Valley Province includes the lowland valley area between the Coast Range and Cascades Provinces in western Oregon. This area was originally covered by of a mosaic of lowland coniferous and deciduous forests and native prairie grasslands. It was mostly cleared in the 1800's and early 1900's and converted to farmland, residential areas and metropolitan areas. Land ownership is largely private.

Oregon and California Klamath

The Klamath Provinces of Oregon and California include much of southwestern Oregon and northwestern California. This area is dominated by mixed conifer and mixed conifer/hardwood forests. Land ownerships include a mixture of Forest Service, Bureau of Land Management, private, and state lands. Forests are highly fragmented by natural factors (poor soils, dry climate, wildfires) and timber harvest. Historically, much of the harvest in this area has been selective cutting rather than clearcutting. As a result, many stands that were logged in the early 1900's include a mixture of old trees left after harvest and younger trees that regenerated after harvest.

Much of the area within the Klamath Provinces is characterized by high fire frequencies. Any plan to protect late-successional/old-growth forests in these areas must include careful consideration of the role of fire in management of ecosystems.

California Coast Range

The California Coast Range Province includes the coastal strip that extends from the Oregon border south to Marin County, California. This area is dominated by redwood forests and mixed forests of

Douglas-fir and hardwoods. Most of the area is privately owned, but Forest Service lands, Bureau of Land Management lands, and state and federal parks are also present. This area includes the coastal fog belt where the last remaining stands of old-growth redwoods occur. Considerable numbers of spotted owls occur on private lands in the area. This is an important nesting area for marbled murrelets.

California Cascades

The California Cascades Province includes the extreme southern end of the Cascades Range, which extends into California. Forests in this region are dominated by mixed conifer or ponderosa pine associations on relatively dry sites. Ownership is mixed with some areas of consolidated Forest Service lands and some areas of intermixed Forest Service and private lands. Forests are highly fragmented due to natural factors and harvest activities. As in a number of other provinces, fire plays an important role in the California Cascades in maintaining fire-adapted pine communities. Because of fire suppression, mixed conifer communities have increased, gradually replacing stands that were dominated by pine. If the objective is to manage a portion of the landscape in fire-dependent old forests, then management must include understory thinning and understory burning.

Current Forest Conditions

Allocation of Federal Lands

Federal lands within the range of the owl include 20.5 million acres that are considered capable of growing forests (Table 4-2). The other 3.8 million acres of federal land includes high elevation nonforest areas and other nonforest types. Of the 20.5 million forest acres on federal lands, 5.7 million (28 percent) are Congressionally Withdrawn Areas, primarily Wilderness and National Parks (Table 4-2). Another 3.3 million acres (16 percent) are Administratively Withdrawn Areas, set aside by the managing agencies. Administrative withdrawals are designated for a variety of reasons, including protection of fragile soils or watersheds, protection of sites unsuited for tree growth, protection of wildlife or fish, recreation values, and scenic values. Administratively Withdrawn Areas are not necessarily off limits to timber harvest, but rates of harvest are frequently greatly reduced in such areas. These administrative withdrawals are subject to modification when agencies revise their current management plans.

Table 4-2. Estimated total federal acres and federal forest acres in Congressionally Withdrawn Areas and Administratively Withdrawn Areas in the range of the northern spotted owl, by state and by physiographic province.

State/ Physiographic Province	Federal Land Acres			Federal Forest Acres*		
	Total	Congressionally Withdrawn Areas	Administratively Withdrwan Areas	Total	Congressionally Withdrawn Areas	Administratively Withdrwan Areas
Washington						
Eastern Cascades	3,472,400	1,473,800	586,100	2,498,100	986,800	409,400
Western Cascades	3,721,700	1,749,400	630,300	3,083,200	1,377,900	531,500
Western Lowlands	126,300	1,700	0	1,700	1,700	0
Olympic Peninsula	1,518,800	976,700	45,400	1,440,200	960,100	43,200
Total:	**8,839,200**	**4,201,600**	**1,261,800**	**7,023,200**	**3,326,500**	**984,100**
Oregon						
Klamath	2,106,200	259,100	333,500	1,939,300	223,300	300,500
Eastern Cascades	1,557,400	425,200	320,400	1,444,500	379,300	288,200
Western Cascades	4,478,200	721,800	545,300	4,219,200	661,100	516,200
Coast Range	1,396,800	22,100	73,600	1,331,500	22,100	47,100
Willamette Valley	25,600	0	200	16,000	0	200
Total:	**9,564,200**	**1,428,200**	**1,273,000**	**8,950,500**	**1,285,800**	**1,152,200**
California						
Coast Range	388,200	94,700	96,500	198,500	90,200	45,400
Klamath	4,459,900	1,214,300	1,203,100	3,553,600	955,800	957,700
Cascades	1,009,200	44,300	211,000	732,200	18,200	144,600
Total:	**5,857,300**	**1,353,300**	**1,510,600**	**4,484,300**	**1,064,200**	**1,147,700**
Three-State Total:	**24,260,700**	**6,983,100**	**4,045,400**	**20,458,00**	**5,676,500**	**3,284,000**

*** Acre values for Forest Service, Bureau of Land Management, and National Park Service administered lands only.**

Amounts of Late-Successional Conifer Forest on Federal Lands

We categorized vegetation on federal lands within the range of the owl into broad structural classes based on stand inventory data and satellite imagery (see section on Sources For Information on Forest Conditions). These structural classes were:

Small conifer--Stands dominated by small conifer trees ranging from 9 to 21 inches diameter at breast height. Exceptions were in eastern Washington and on the Mendocino National Forest in northern California where this structural class included trees from 9-15.9 inches diameter at breast height. This category also included stands with scattered large overstory trees that provide some old-forest characteristics.

Medium/large single-storied conifer--Stands dominated by conifer trees that were at least 21 inches diameter at breast height, and characterized by only a single canopy layer. Exceptions were in the Eastern Cascades Province of Washington and on the Mendocino National Forest in northern California where this structural class included trees that were at least 16 inches diameter at breast height. Stands in this structural class satisfy the definition of late-successional.

Medium/large multistoried conifer--Stands dominated by conifer trees that were at least 21 inches diameter at breast height, and characterized by a multistoried canopy. Exceptions were in the Eastern Cascades Province of Washington and on the Mendocino National Forest in northern California where this structural class included trees that were at least 16 inches diameter at breast height. Stands in this structural class include the majority of old-growth forests.

Forests on federal lands within the range of the northern spotted owl currently include approximately 4.5 million

acres of multistoried, medium/large conifer forest, 4.0 million acres of single-storied medium/large coniferous forest, and 5.8 million acres of small, single story conifers (Table 4-3). Over half of the medium/large coniferous forests occur at relatively high altitudes (over 4,000 feet) (Table 4-4).

Of the 8.5 million acres of medium/large conifer forest on federal lands within the range of the northern spotted owl, 2.4 million acres (28 percent) are Congressionally Withdrawn Areas, and 1.6 million acres (19 percent) are Administratively Withdrawn Areas (Table 4-3). An undetermined proportion of the medium/large conifer forests in both Congressionally Withdrawn and Administratively Withdrawn Areas are high-elevation forests that are not occupied by spotted owls. Although the latter stand types may not be important to spotted owls, they are important habitat for a variety of plants and animals that occupy late-successional high-elevation forests.

Table 4-3. Current estimated late-successional conifer forest on federal lands in the range of the northern spotted owl by total acres, acres in Congressionally Withdrawn Areas, and in Administratively Withdrawn Areas by state and physiographic province.

State/ Physiographic Province	Total			Portion in Congressionally Withdran Ares			Portion in Administratively Withdrawn Areas		
	Small Conifer single story*	Medium/Large Conifer** Single Story	Medium/Large Conifer** Multi-Story	Small Conifer single story*	Medium/Large Conifer** Single Story	Medium/Large Conifer** Multi-Story	Small Conifer single story*	Medium/Large Conifer** Single Story	Medium/Large Conifer** Multi Story
Washington									
Eastern Cascades	830,100	515,500	432,200	286,000	183,700	217,700	164,400	74,600	68,600
Western Cascades	1,009,000	676,000	515,700	373,000	309,600	209,000	175,500	112,800	143,900
Western Lowlands	0	0	0	0	0	0	0	0	0
Olympic Peninsula	485,800	47,400	446,700	274,300	23,000	327,700	17,800	3,00	16,600
Total:	**2,324,900**	**1,238,900**	**1,394,600**	**933,300**	**516,300**	**754,400**	**357,700**	**190,400**	**229,100**
Oregon									
Klamath	596,200	207,500	489,500	98,100	19,400	50,900	104,400	30,500	75,700
Eastern Cascades	968,900	207,00	81,100	250,700	68,400	22,200	203,100	49,100	16,900
Western Cascades	1,165100	997,900	921,200	279,400	231,900	102,200	189,900	125,200	122,600
Coast Range	526,100	209,300	140,500	18,900	2,600	400	19,400	9,700	10,900
Willamette Valley	4,300	1,300	800	0	0	0	0	0	100
Total:	**3,260,600**	**1,623,000**	**1,633,100**	**647,100**	**322,300**	**175,700**	**516,800**	**214,500**	**226,200**
California									
Coast Range	4,700	25,800	9,800	300	2,700	2,200	2,100	9,600	3,800
Klamath	140,300	963,200	1,303,900	37,100	304,500	368,000	28,800	214,500	462,600
Cascades	38,500	181,500	157,100	1,800	4,700	0	1,400	40,100	34,400
Total:	**183,500**	**1,170,500**	**1,470,800**	**39,200**	**311,900**	**370,200**	**32,300**	**264,200**	**500,800**
Three-State Total:	**5,769,000**	**4,032,400**	**4,498,500**	**1,619,600**	**1,150,500**	**1,300,300**	**906,800**	**669,100**	**956,100**

* Stands generally characterized by trees 9.0 - 20.9 inches in diameter at breats height (dbh) - only a portion of these acres are late-successional forest.

** Stands generally characterized by trees 21.0 inches in diameter at breast height (dbh) or larger.

Significant portions of Congressionally and Administratively Withdrawn Areas are covered by relatively young forest. Of the 5.7 million forest acres in Congressionally Withdrawn Areas, for example, 1.6 million acres (28 percent) are in single story stands of small conifers (Table 4-3). This does not include additional acres that are covered by forests of trees smaller than 9 inches in diameter. The considerable acreage of small forests within

Congressionally Withdrawn Areas reflects a long history of fire and other natural disturbances as well as factors such as poor soils and high elevations, which tend to suppress tree growth.

Table 4-4. Acres of conifer forest on federal lands within the range of the northern spotted owl, by structural class and 2,000 foot elevation band.

State	Class [a]	Elevation Bands in Thousands of Feet					Grand Total
		0-2	2-4	4-6	6-8	8-16	
California	Small Conifer	1,107	53,115	92,635	35,766	830	183,452
	Med/Lrg Single Story Conifer	38,651	373,899	593,551	161,755	2,648	1,170,503
	Med/Lrg Multi Story Conifer	63,074	547,075	612,955	243,996	3,636	1,470,737
Oregon	Small Conifer	594,183	1,060,440	1,124,502	479,338	2,134	3,260,598
	Med/Lrg Single Story Conifer	228,347	665,003	559,959	169,541	40	1,622,889
	Med/Lrg Multi Story Conifer	261,939	784,828	523,403	62,837	40	1,633,045
Washington	Small Conifer	191,079	1,009,064	902,202	222,458	79	2,324,883
	Med/Lrg Single Story Conifer	33,750	435,668	692,746	76,669	0	1,238,833
	Med/Lrg Multi Story Conifer	147,252	593,195	618,172	36,042	0	1,394,661
3 State Total	**Small Conifer**	**786,369**	**2,122,619**	**2,119,339**	**737,562**	**3,043**	**5,768,932**
	Med/Lrg Single Story Conifer	**300,747**	**1,474,570**	**1,846,256**	**407,965**	**2,687**	**4,032,226**
	Med/Lrg Multi Story Conifer	**472,264**	**1,925,098**	**1,754,530**	**342,876**	**3,675**	**4,498,443**

a - **Small Conifer** - Stands dominated by small conifer trees ranging from 9 to 21 inches in diameter at breats height.
Medium/Large Single Storied Conifer - Stands dominated by conifer trees that are at least 21 inches in diameter at breats height, and characterized by only a single canopy layer.
Medium/Large Multistoried Conifer - Stands dominated by conifer trees that are at least 21 inches in diameter at breast height, and characterized by a multistoried canopy.

Patterns of Spatial Distribution

As described in the earlier descriptions of physiographic provinces, most late-successional and old-growth forests within the range of the northern spotted owl have been harvested from private and state lands. Late-successional/old-growth stands that remain on private and state lands tend to typically occur in small patches surrounded by cutover areas and young stands. In areas where little federal land is present, such as the western Washington lowlands, old-growth forests have been largely eliminated by harvest.

On federal lands, late-successional/old-growth forests are typically highly fragmented by harvested areas and stands of younger trees. Late-successional/old-growth forests in Congressionally Withdrawn Areas tend to occur in larger blocks than in other areas, but even in the withdrawn areas, there is considerable natural fragmentation of older stands due to historic disturbance patterns and poor growth conditions.

Terrestrial Species of Special Political, Legal, and Biological Interest

Northern Spotted Owl

The northern spotted owl is a medium-sized forest owl that occurs along the Pacific Coast from southwestern British Columbia to central California. Studies of the owl during the last 20 years have shown it to be strongly associated with late-successional/old-growth forests throughout much of its range. In northern California and on the east slope of the Cascades in Washington, the spotted owl also occurs in some types of relatively young forest, especially where those forests are structurally similar to late-successional/old-growth forests.

Northern spotted owls nest in cavities or platforms in trees and feed on a variety of forest mammals, birds, and insects. They are long-lived, territorial birds, often spending their entire adult life in the same territory. In good habitat, pairs are typically spaced about 1-2 miles apart.

Data summarized by the U.S. Department of the Interior Spotted Owl Recovery Team indicated that spotted owls were located at approximately 4,600 sites in the years 1987-1991, including confirmed pairs at 3,602 sites (Table 4-5), and single owls at approximately 1,000 sites (Thomas et al. 1993). The actual population is undoubtedly larger than the number of individuals confirmed because a significant portion of the range of the owl has yet to be adequately surveyed (USDI 1992c, Thomas et al. 1993). Although the majority of spotted owls occur on federal lands, significant numbers do occur on nonfederal lands, especially in northwestern California.

Legal status. The northern spotted owl was federally listed as a threatened species in 1990 (USDI Fish and Wildlife Service 1990a, b). The listing was based primarily on the fact that the preferred habitat of the owl was declining throughout its range. The lack of clear regulatory mechanisms that would ensure the retention of adequate habitat for the owl also figured in the listing. The northern spotted owl is listed as "endangered" by the state of Washington, "threatened" by the state of Oregon, and as a "species of special concern" by the state of California.

Existing recommendations. Early attempts to manage spotted owls focused on protection of habitat for individual pairs or clusters of two to three pairs scattered across the forest landscape on federal lands (Oregon Endangered Species Task Force 1977; Oregon-Washington Interagency Spotted Owl Subcommittee 1981). This approach was abandoned when it became apparent that single pairs or small clusters of two to three pairs occupying widely spaced areas would be unlikely to persist.

Table 4-5. Known and inferred number of pairs of spotted owls located during a five-year period on all lands in Washington, Oregon, California. These are detected pairs only; numbers do not represent total population size.

Landowner or Agency	Owl Pairs Withdrawn[b]	Non-Withdrawn[c]	Totals
FS, Washington	61	425	486 [d]
FS, Oregon	83	1,081	1,164 [d]
FS, California	38	433	471 [d]
BLM, Oregon	1	607	608 [d]
BLM, Washington	0	22	22 [d]
NPS, Washington	64	0	64 [d]
NPS, Oregon	8	0	8 [e]
NPS, California	2	0	2 [d]
Indian lands, Washington	0	32	32 [e]
Indian lands, Oregon	0	36	36 [e]
Indian lands, California	0	37	37 [e]
FWS, Washington	0	0	0 [e]
FWS, Oregon	0	0	0 [e]
WDNR, Washington	0	43	43 [e]
WDW, Washington	0	1	1 [e]
State parks, Washington	0	0	0 [e]
Cities of Seattle, and ODF, Oregon	0	24	24 [e]
State parks, Oregon	2	0	2 [e]
Counties and cities, Oregon	1	0	1 [e]
CDF, California	0	4	4 [d]
State parks, California	0	10	10 [d]
BLM/TNC, California	0	0	0 [d]
NAS, California	0	0	0 [d]
Private, Washington	0	45	45 [d]
Private, Oregon	0	128	128 [d]
Private, California	0	414	414 [d]
	260	**3,342**	**3,602**

a - Information obtained from landowners, land managers, or state wildlife agencies.
b - Withdrawn from tibmer harvest (e.g., wilderness, national park, research natural area).
c - Owl pairs on land not withdrawn from timber harvest.
d - Fiver year survey period - 1987 to 1991.
e - Fiver year survey period - 1988 to 1992.

WDNR - Washington Department of Natural Resources
ODF - Oregon Department of Forestry
TNC - The Nature Conservancy
WDW - Washington Department of Wildlife
CDF - California Department of Forestry and Fire Protection
NAS - National Audubon Society

An alternative approach, initially published by Thomas et al. (1990) and more recently supported by the U.S. Department of the Interior Spotted Owl Recovery Team (USDI 1992c), was to manage for a network of "Habitat Conservation Areas", each of which was large enough to support 20 or more pairs of owls. Smaller Habitat Conservation Areas were permissible in areas where the 20 pair target was not achievable. To ensure that owls could disperse among Habitat Conservation Areas, Thomas et al. (1990) recommended that distances between Habitat Conservation Areas should not exceed 12 miles. This approach, often referred to as a "metapopulation" approach, has received considerable support from conservation biologists and ecologists as a viable alternative to a "save it all" approach to northern spotted owl management. Although this strategy would allow a considerable decline in the owl population, Thomas et al. (1990) argued that the population within the Habitat Conservation Areas would eventually stabilize as the forest stands regenerated on cutover areas within the Habitat Conservation Areas.

Marbled Murrelet

The marbled murrelet is a small seabird somewhat larger than a robin. The North American subspecies of the marbled murrelet ranges from the Aleutian Archipelago in Alaska south to central California. Marbled murrelets are unique among alcids in their choice of nesting habitat. Except for the treeless tundra portions of their range and possibly a portion of the Prince William Sound area in Alaska, marbled murrelets nest exclusively in trees. Some nest sites are located considerable distances inland from saltwater; marbled murrelets have recently been detected up to 52 miles inland in Washington State (T. Hamer, personal communication).

Many aspects of the life history of marbled murrelets are poorly understood. However, it is believed that they are much like other alcids, which are relatively long-lived and which first breed at about 3 to 4 years of age (Gaston 1992). They may not breed every year. A single egg is laid and incubated by both adults in alternating 24-hour shifts for approximately 28 days. After hatching, the adults leave the chick unattended except for feeding visits. The chick is cryptically colored and remains in the nest approximately 30-35 days before flying to the ocean.

Marbled murrelets are associated with late-successional/old-growth forests throughout most of their range. Although only 54 marbled murrelet nests have been found in North America, 44 of those nests, including all 22 found in Washington, Oregon, and California, are in forests with old-growth characteristics. Nests in trees are typically on top of a large limb or other broad surface, such as thick moss or branch deformations generated by disease or past damage to the nest tree, or on platforms created where two branches come together. Most nests are directly under overhanging branches. It is believed that overhanging branches over nests may reduce detection by predators and provide protection from harsh weather. Because marbled murrelets are seabirds, and thus depend on the ocean for food, nesting habitat must be available within flight distance of a marine environment.

Historical data on the population size of marbled murrelets is largely anecdotal. In the early 1900's marbled murrelets were frequently described in the literature as being common or even abundant in areas that now support low numbers of murrelets. Estimated population sizes in the 1980's were 5,000 individuals in Washington (Speich et al. 1992), 2,000-3,000 individuals in Oregon (Nelson et al. 1992; Strong et al. 1993), and 2,000-3,000 individuals in California (Carter and Erickson 1992). The Oregon, Washington, and California populations are currently being recensused using improved techniques.

Loss of late successional/old-growth forest has reduced the number of nest sites available to marbled murrelets and may be the cause of several gaps in their inland distribution (Carter and Erickson 1992; Sowls et al. 1980; K. Nelson, personal communication 1993). A major concern is that continued loss of nesting habitat and increasing isolation of the remaining breeding colonies could adversely effect long-term population stability.

High failure rates of marbled murrelet nests in trees has led some to hypothesize that fragmentation of nest stands may cause murrelets to be more susceptible to predation. Predation appears to be the major source of mortality for nestling marbled murrelets. Success rates of nests in trees is only 27 percent, and 54 percent of the nests that fail do so as a result of predation (K. Nelson, personal communication 1993). One theory is that the primary predators on nestling murrelets (jays, ravens, and crows) may be more abundant along forest edges, or may be able to more easily detect nests along edges.

The apparent low reproductive success and recruitment of young birds into the breeding population are major concerns. Surveys in California have shown that only 1-2 percent of marbled murrelets observed on the water each year are newly fledged birds (C. J. Ralph, personal communication 1993). Recent counts of newly fledged birds along the coast of Oregon led to an estimate of 1.1-2.7 percent juvenile birds (Strong et al. 1993); shore-based counts ranged from 1.0-4.5 percent juvenile murrelets over a 5-year period (Nelson and Hardin, in press). Because juvenile birds experience the highest rates of mortality in alcids (Nettleship and Birkhead 1985), rates of recruitment to the breeding population may be substantially lower than inferences drawn from counts of newly fledged birds. Even given the long life expectancy of alcids, newly fledged young: adult ratios appear low. Because of adult longevity, population declines may lag behind declines in reproduction and not be readily

detected and not associated with causative factors.

Legal status. The marbled murrelet was federally listed in 1992 as a threatened species in Washington, Oregon, and California (USDI Fish and Wildlife Service 1992). The listing was based on the loss of nesting habitat (late-successional/old-growth forests) and, to a lesser extent, on the threat from gill-net mortality and the potential of catastrophic mortality from oil spills. Under existing state laws, the marbled murrelet is listed as sensitive in Oregon by the Oregon Department of Fish and Wildlife and a candidate for listing by the Washington Department of Wildlife (the candidate category includes species that are currently under review for possible state listing as endangered, threatened, or sensitive). In California, the marbled murrelet was listed as a state endangered species in 1991 by the California Department of Fish and Game.

A Marbled Murrelet Recovery Team was established by the U.S. Fish and Wildlife Service in February 1993 to develop a recovery plan for the species. A draft recovery plan is anticipated in late 1993 or early 1994, with a final plan due 6-12 months later. The recovery plan will address all aspects of the life history of the marbled murrelet, including the nesting habitat conditions throughout the range (regardless of ownership) and potential impacts in the marine environment (e.g., gill-net mortality, oil spills).

Existing recommendations. In 1990, prior to the listing of the marbled murrelet, an interagency team, with both research and management expertise, developed a set of interim management guidelines for marbled murrelet conservation in Washington, Oregon, and California. The latest draft was completed in August 1991. To date, there has been no adoption or recognition of these interim guidelines.

Thomas et al. (1993) recommended interim protection of all habitat that was suitable for nesting by marbled murrelets on federal lands within 35 miles of the coast in California and southern Oregon, and 50 miles of the coast in Washington and northern Oregon. They further recommended that additional "recruitment habitat" be protected, equal to 50 percent of the amount of suitable habitat outside of Category 1 and 2 Habitat Conservation Areas (as described in Thomas et al. 1990). These guidelines were intended to be interim, pending completion of a recovery plan for the marbled murrelet. The Thomas et al. (1993) guidelines have not been formally accepted by any federal agencies.

Both the U.S. Forest Service and Bureau of Land Management require that proposed timber sales in suitable murrelet habitat be surveyed for marbled murrelets and that consultation with the U.S. Fish and Wildlife Service be initiated for all actions that may affect marbled murrelets. Beyond that, neither agency has adopted specific management guidelines for protection of marbled murrelets.

Other Threatened or Endangered Species

The Final Draft Recovery Plan for the Northern Spotted Owl (USDI 1992c) reviewed other species that might be influenced by the plan. This review included threatened or endangered species, candidates for federal listing, sensitive species or species of special concern in any one of the three states, and species associated with late-successional forests. Of 668 species that were considered in the recovery plan, eight are listed federally as threatened or endangered, 162 are candidates for federal listing, 27 are listed as threatened or endangered by one or more of three states within the range of the northern spotted owl, and 144 are sensitive species or species of special concern in at least one state. Of the species considered, 482 are associated with late successional forests. In addition, the list of 28 fish species includes numerous stocks that are at risk and may become candidates for listing in the future. The large number of candidates for federal listing, species of special concern, and those associated with late-successional forests emphasizes the need for an ecosystem-based strategy to conserve biological diversity. In addition, the large number of riparian associates and the many fish stocks that are considered at risk emphasize the importance of protecting and restoring riparian areas in any such strategy.

The eight threatened or endangered species include four birds, two mammals, one stock of chinook salmon, and one plant found in coniferous forests in the Pacific Northwest. Other species within the range of the northern spotted owl are federally listed but are not included here because they are principally associated with habitats other than coniferous forests. The species included on the list of threatened or endangered species found in coniferous forests are the grizzly bear, gray wolf, bald eagle, marbled murrelet, peregrine falcon, northern spotted owl, Sacramento River winter chinook salmon, and McDonald's rock-cress. A brief description of the legal status, existing management recommendations (i.e., recovery plans), and important biological considerations of six of these species is presented below. Similar information was presented for northern spotted owls and marbled murrelets in previous sections.

Grizzly Bear

The grizzly bear is federally listed as threatened and state listed as endangered in Washington. It has been extirpated in Oregon and California and is found only in the northern Cascade Mountains of Washington. This population of grizzly bears was not included in the original listing of the grizzly bears in the Intermountain States, so there is currently no recovery plan for the population in Washington. Recovery planning by the Fish and Wildlife Service for the population of the species in the North Cascades of Washington is currently under way.

Grizzly bears are not closely associated with late-successional forests, but inhabit vast, diverse, and remote mountainous areas away from human disturbance. They use a variety of vegetation types and forest successional stages for foraging and other life functions. These habitats include open areas such as lowland wet meadows and marshes, shrub fields, high-elevation sedge or heath meadows, and stream floodplains. Forested areas are used for resting and hiding cover as well as for foraging.

Gray Wolf

The gray wolf is federally listed as endangered and is listed as endangered by the state of Washington. It has been extirpated from Oregon and California and is found only in the northern Cascade Mountains of Washington. The North Cascades population of gray wolves was not included in the initial federal listing of the species in the Intermountain States. Therefore, there is no recovery plan for the species in Washington. The recovery plan for gray wolves is being revised by the Fish and Wildlife Service to include the population in Washington.

Like the grizzly bear, the gray wolf is not closely associated with late successional forests within the range of the northern spotted owl. Forested and open habitats supporting ungulate populations, their major prey, are the primary requirements of the gray wolf. Areas that support small-mammal populations are important seasonally. Human-induced mortality is the major limiting factor to the survival of the species throughout its range. Wolf predation on livestock can cause conflicts with humans, and misconceptions about wolves have led to indiscriminate shooting.

Bald Eagle

The bald eagle is listed federally as threatened in Washington and Oregon and endangered in California. Breeding and wintering populations occur in all three states. The Pacific Bald Eagle Recovery Plan (USDI Fish and Wildlife Service 1986) covers the management recommendations for the species in the Pacific Northwest.

Prey of the bald eagle consists primarily of fish during the breeding season and waterfowl or carrion during the fall and winter. As a result, the species forages over water for most of its prey items. However, bald eagles nest (and roost communally -- usually during winter) in forested habitats, and these areas are in old-growth forests or forests that possess components of old-growth forests. Nesting and roosting areas are considered essential habitat features for the species. The Pacific Bald Eagle Recovery Plan recognizes the importance of older forests for nesting and roosting, and timber harvest is restricted in such areas.

Peregrine Falcon

The peregrine falcon is listed federally as endangered in all three states. Both breeding and wintering populations occur in all three states. The Pacific States Recovery Plan for the Peregrine covers the recommendations for management for the species.

The peregrine falcon is not closely associated with late- successional forests, but it often nests on cliffs that are situated among coniferous forests in the Pacific Northwest. It also forages in and around coniferous forests, and its prey base is quite diverse, with most of the prey associated with openings around forested areas. Pesticides, particularly DDT, were a major factor in the initial decline of this species. Populations of the species have increased in some areas of North America since DDT was banned and a large scale reintroduction program was initiated. However, populations in the Pacific Northwest have not reached recovery levels.

Sacramento River Chinook Salmon

This stock of chinook salmon is listed as threatened throughout this river system. A recovery plan for this stock of fish has been completed and is under the jurisdiction of the National Marine Fisheries Service.

The major spawning areas for this species occur outside of coniferous forests. Before the construction of Shasta Reservoir, this stock of salmon spawned throughout the upper tributaries of the Sacramento River. Forest management practices along the tributaries to the west of the mainstem below the reservoir could have an influence on the species. The major factors that affect the stock are probably the allocation of water flows on the river, withdrawal of water for irrigation, and harvesting of the fish at sea.

MacDonald's Rock-Cress

MacDonald's rock-cress was listed federally as endangered in 1978 (USDI 1978), and a recovery plan was completed in 1984 (USDI 1984). Specimens from Oregon, which were previously considered MacDonald's rock-cress, have been determined to be a separate and undescribed species. Therefore, both taxa are significantly more rare than originally considered (J. Nelson May 11, 1993, U.S. Forest Service, personal communication).

MacDonald's rock-cress occurs on barren or shrub-covered, rocky, and serpentine soils associated with Jeffrey pine woodlands, which range from 3,500 to 4,000 feet in elevation in Del Norte and Mendocino Counties, California (Matthews et al. 1990). These soils do not typically produce stands of commercial timber due to the sparse tree cover and low site productivity. However, salvage sales and related activities plus development of rock quarries for roads present potential threats to this

species (Foster 1992). Mining of nickel-rich soils has posed the greatest threat to the species and was the primary concern cited in the original listing (USDI 1978).

Other Species Associated with Late-Successional and Old-Growth Forests

Literally thousands of species occupy late-successional and old-growth forests of the Pacific Northwest. Several previous efforts attempted to account for the effects of various forest management plans on these species. The Final Draft of the Recovery Plan for the Northern Spotted Owl (USDI 1992c) discussed 640 terrestrial species within the range of the northern spotted owl that were old-forest associates or threatened, endangered, or candidate species. The Scientific Analysis Team (Thomas et al. 1993) assessed the effects of various forest management options on 667 species, including 555 terrestrial species and 112 at risk fish stocks or species.

In the current assessment, we reviewed and updated the list of species associated with old forests. Criteria based on those developed by Thomas et al. (1993) were used for this effort (see section on identification of species closely-associated with late-successional forests). The number of species identified is greater than that shown by Thomas et al. because of new information and because this report focuses on all federal late-successional forests within the range of the northern spotted owl rather than just the old-growth component on National Forests. A total of 1,098 terrestrial species (not counting arthropods) are identified as closely associated with late-successional forests on federal lands. The number of species in each species group follows:

Species Associated with Late-Successional and Old-Growth Forests

Vasular Plants	29
Lichens	
Aquatic	3
Riparian	9
Bryophytes	
Aquatic	3
Splash Zone	5
Floodplain	13
Mollusks	
Freshwater Snails	54
Freshwater Clams	3
Ampibians	
Salamanders	12
Frongs	1
Birds	38
Mammals	18
Bats	11
Total	**199**

In addition to this list of species, we recognized and reviewed 15 functional groups of arthropods that may include as many as 7,000 individual species closely associated with late-successional forests. Information on all these

species and groups, and the effects of proposed management plans on them, is presented in the section on the effects of options on terrestrial ecosystems. (No reptile species was identified as closely associated with late-successional forests.)

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Development of Terrestrial Options

Terrestrial Reserves: Late-Successional Reserves and Managed Late-Successional Areas

Habitat areas -- often referred to as "conservation areas" or, for this report, Late-Successional Reserves -- have been key components of most spotted owl and late-successional forest management strategies developed in the Pacific Northwest in the last decade. Thomas et al. (1990), the Final Draft Recovery Plan for the Northern Spotted Owl (USDI 1992c), Johnson et al. (1991), and Thomas et al. (1993) all recommended large blocks of federal land that encompass late-successional forests to serve as habitat areas. Although habitat areas from these plans were variously named, the objective of each plan was to provide areas where habitat would occur in amounts and arrangements capable of supporting multiple, reproductive pairs of spotted owls and other species associated with old-growth forests.

We used the conservation areas or Reserves from the above mentioned works to develop options. We briefly describe the biological rationale for, and criteria used to delineate the Reserves and Managed Late-Successional Areas of each of the plans.

Conservation areas of the Interagency Scientific Committee's Strategy and the Final Draft Recovery Plan for the Northern Spotted Owl

Conservation areas recommended by Thomas et al. (1990) and the Final Draft Recovery Plan (USDI 1992c) were designed to support multiple pairs of northern spotted owls. Empirical data from studies of other bird species and modeling results indicate that habitat patches or areas capable of supporting fewer than 15 breeding pairs have a low probability of successfully supporting the expected numbers of pairs through time. Fluctuations in birth and death rates or stochastic events are more likely to cause populations in such areas to "wink out," causing local extirpations. This information led the Interagency Scientific Committee

(Thomas et al. 1990), and later the Northern Spotted Owl Recovery Team (USDI 1992c), to prescribe conservation areas large enough to support at least 20 pairs of spotted owls. Where lack of federal land or limitations in the amount of spotted owl habitat made it impossible to delineate 20-pair conservation areas, smaller areas were prescribed.

Principles of conservation biology and common sense also indicate that conservation areas should be located in a network system so that individuals of the species can successfully move (disperse) among such areas. Successful dispersal is necessary for recolonization of areas where habitat may be temporarily lost and it provides for maintenance of genetic diversity. The conservation areas of Thomas et al. (1990) and the Final Draft Recovery Plan (USDI 1992c) were spaced so as to accommodate dispersal of spotted owls. The conservation areas capable of supporting at least 20 pairs of spotted owls were to be no more than 12 miles apart, and those capable of supporting fewer than 20 pairs were to be no more than 7 miles apart. The 12-mile distance was within the dispersal radius of about two-thirds of the spotted owls observed in studies.

Thomas et al. (1990) and the Final Draft Recovery Plan (USDI 1992c) suggested that the successful movement by spotted owls would be increased if federal lands between the conservation areas (known as the forest Matrix) provided spotted owls with forage areas and cover from predation. To facilitate successful movement, the plans prescribed the 50-11-40 rule. This rule is described in the discussion on standards and guidelines. The 50-11-40 prescription is intended to provide a forested condition in the Matrix sufficient to sustain dispersing owls between conservation areas.

The following criteria were used to delineate the conservation areas:

> Conservation areas are to include 20 known pairs of spotted owls when possible.
>
> Conservation areas are to be widely distributed throughout the range of the northern spotted owl to provide redundancy in the network.
>
> Each conservation area is to be within the prescribed dispersal distance of at least two other conservation areas--again to provide

redundancy in the network, and to increase the probability of successful movement by owls among the areas.

Conservation areas are to be as circular as possible because this shape minimizes edge and maximizes interior forest conditions. Forest interior conditions are believed to be important to spotted owl survival. Because ownership patterns and actual terrain within the northern spotted owl range make it impossible to delineate circular conservation areas, the plans delineated large blocky conservation areas that mostly tended to be square or rectangular shaped.

As much as possible, conservation areas are to be identified using wilderness areas and other land allocations where no timber harvest is planned.

Conservation areas are to be distributed so forests at various elevations and in various ecological zones are included. The plans placed particular emphasis on delineated conservation areas in the lower elevational forest lands, which are generally more biologically productive than forests at higher elevations.

In the Final Draft Recovery Plan (USDI 1992c), the conservation areas were adjusted to include known locations of other species associated with late-successional forests.

Reserves from Johnson et al. 1991

The report of the Scientific Panel on Late-Successional Forest Ecosystems (Johnson et al. 1991) identified large geographic areas the panel called "reserves." These Reserves were analogous to our Late-Successional Reserves and were identified primarily on the basis of locations of late-successional forests. Late-successional forests include mature forest stands greater than 80 years old, stands of mixed age (mature and old-growth forests), and old-growth forests.

The areas mapped as Reserves were aggregations of late-successional and old-growth forest stands that were categorized into three groups based on ecological significance. These categories were (1) most significant (LS/OG1), (2) significant (LS/OG2), and (3) remaining late-successional/old-growth forests (LS/OG3). The following characteristics of an area gave it ecological significance:

> Large contiguous blocks of forest that maximize the area of forest with interior forest conditions.
>
> A location that is key to the design of an interconnected system or network of late-successional conservation areas.
>
> Presence of classic old-growth forest as defined in Forest Service Research Note PNW-447 (Old-Growth Definition Task Force 1986).
>
> Areas of late-successional forests on lands with higher site productivity (generally lower elevation) that are believed to have greater biological diversity than late-successional forests at higher elevations.
>
> Areas with known or likely occurrence of spotted owls, marbled murrelets, or other species associated with late-successional forests.

In addition to the late-successional forest areas (LS/OG), Johnson et al. (1991) identified areas known as "owl additions" that, in combination with the LS/OG1s, would meet the criteria for spotted owl conservation areas from Thomas et al. (1990). The owl additions in combination with the LS/OG1 areas formed Reserves under some alternatives identified by Johnson et al. (1991).

Conservation Areas from the Scientific Analysis Team Report

Thomas et al. (1993) identified conservation areas beginning with either those of the Interagency Scientific Committee (Thomas et al. 1990) or the Final Draft Recovery Plan for the Northern Spotted Owl (USDI 1992c). The biological rationale for these areas was described above. Other terrestrial conservation areas that result from the application of mitigation steps offered in Thomas et al. (1993) are:

> Conservation areas resulting from protection of forest stands occupied by rare and locally endemic species closely associated with old-growth forests (at least 17 species).
>
> Conservation areas resulting from the protection of other species found in the upland forest Matrix (Del Norte salamander and great gray owl).

The small conservation areas that would result from protection of rare and locally endemic species and the Del Norte salamander and great gray owl are needed because significant numbers in such species, within the range of the northern spotted owl, occur outside the other larger conservation areas.

Recommendations of the Marbled Murrelet Working Team

The current effort incorporates recommendations from a marbled murrelet working team which were used in most options. The marbled murrelet working team assessed the network of Reserves from each of the three plans described above. The working team identified a minimum Late-Successional Reserve network on federal forest land they believed was necessary for an option to have a high probability of providing marbled murrelet nesting habitat in adequate amounts and arrangements to support viable populations. The working team identified two zones based on observed use and expected occupancy by marbled murrelets. Zone 1 extends 10 to 40 miles inland from the marine environments, depending on

geographic area. The majority of murrelet occupied sites and sightings occur in this zone. Distances vary by geographic region, as follows:

Washington - Marine environments to 40 miles inland.

Oregon - Marine environments to 35 miles inland.

California at the Oregon border - Marine environments to 35 miles inland; thence southward maintaining a distance of 35 miles inland to a point of intersection with the Klamath River. The eastern boundary of zone 1 then follows the Klamath River southward to a point where it is 25 miles from the marine environments (near the town of Orleans, California); from that point, zone 1 extends southward with the eastern boundary remaining 25 miles inland until a point near the town of Ukiah, California. From Ukiah the eastern boundary of zone 1 then follows Route 253 to a point where it is 10 miles from marine environments; thence the eastern boundary of zone 1 extends southward, remaining 10 miles inland, to the southern end of the range of the northern spotted owl.

Zone 2 includes areas further inland from the eastern boundary of zone 1, and is characterized by relatively low numbers of murrelet sightings, partially a function of few inventories. Specific distances for zone 2 by geographic area are as follows:

Washington - from the eastern boundary of zone 1 (40 miles inland) to 55 miles inland from marine environments.

Oregon - from the eastern boundary of zone 1 (35 miles inland) to 50 miles inland from marine environments.

California - from the eastern boundary of zone 1 to 45 miles inland from marine environments to a point where the eastern boundary of zone 2 intersects with California Highway 175. At this point the southern boundary of zone 2 follows Highway 175 until it intersects with zone 1, where it ends.

In zone 1, the working team determined that a Late-Successional Reserve network should consist of the most significant late-successional forest areas (LS/OG1s), the significant late-successional forest areas (LS/OG2s), and the owl additions (or equivalent area) from Johnson et al. (1991). In addition to the network of Late-Successional Reserves, the murrelet team recommended surveys (to an accepted protocol) and protection of all sites occupied by murrelets in zones 1 and 2, regardless of whether they were in a Reserve or not. Occupied forest stands are to be protected as follows:

1. The contiguous stand within 0.5 mile of the occupied site will be protected from cutting.

2. Forest stands within 0.5 mile of the occupied site that are currently not suitable as nesting habitat, but will likely develop into such habitat within 25 years (100 years old) and are contiguous to the occupied forest stand, will be protected from cutting.

Protection of forest stands occupied by marbled murrelets in both zones 1 and 2 creates additional small Late-Successional Reserves including younger forests that will grow and develop into suitable nesting habitat for marbled murrelets.

Standards and Guidelines for Vegetative Management

In addition to standards and guidelines we developed for this report, we used other standards and guidelines derived from earlier plans proposed for the management

of federal forest lands. Brief descriptions of four sets of standards and guidelines for vegetation management that we used follow:

The first set, standards and guidelines from the Scientific Panel on Late-Successional Forest Ecosystems (Johnson et al. 1991), provided for management of the late successional/old growth forest areas (LS/OG), called "reserves" in that report, and for areas between the reserves, or the forest Matrix. Standards and guidelines for the Reserve restricted the cutting of trees to precommercial silvicultural treatments of young stands. Timber sales that had already been awarded were exempted from this prohibition.

Johnson et al. (1991) also proposed options for the management of the forest Matrix. In this report, the Forest Ecosystem Management Assessment Team used two of the Matrix options from Johnson et al. (1991):

> Forest Matrix Management Option A - This option was designed to augment the standards and guidelines that were in effect under forest plans of the federal agencies. The 50 11 40 rule developed by Thomas et al. (1990) was included with an additional provision to increase the retention of old growth structural components left after logging to provide structure in the forested environments. The 50 11 40 rule called for at least 50 percent of the forest stands on federal lands in a quarter township to be at least 11 inches in diameter at breast height and for such stands to have a canopy closure of at least 40 percent. The intent of the 50-11-40 rule was to provide for conditions that would facilitate successful movement of spotted owls among reserves. The prescription for retention of old growth forest structural components consisted of leaving six large green trees, two large snags (standing dead trees), and two large logs per acre after logging.
>
> Forest Matrix Management Option C - This option is identical to option A but further stipulates that at least 10 percent of the forest outside Wilderness Areas and the proposed Reserves was to be older than 180 years. The remaining forest stands in the Matrix were to be managed using an area-control timber harvest strategy to achieve 180-year timber harvest rotations. At most, 1/18th of the area remaining in the Matrix would be cut per decade.

Standards and guidelines proposed by Johnson et al. (1991: 26) for the protection of watersheds and fish habitat include: (1) 180-year timber harvest rotations in "Key Watersheds" identified for their high water quality and the presence of species and stocks of fish considered to be at risk, and (2) riparian buffer zones. Riparian buffers of varying width were prescribed depending on the type of stream or wetland. There was to be no cutting of timber in the buffers and livestock grazing was to be curtailed to promote the reestablishment of riparian vegetation. A road improvement and reduction program was also to be implemented.

A second set of standards and guidelines we used was contained in the Final Draft Recovery Plan for the Northern Spotted Owl (USDI 1992c). This plan provided direction for the management of vegetation in the recommended conservation areas and the intervening federal forest lands -- the Matrix. Several categories of conservation areas were proposed, with variations in the standards and guidelines for each type. Descriptions of the standards and guidelines follow:

> Designated conservation areas - Standards and guidelines for these areas have several key objectives (USDI 1992c: 64 75). They allow natural successional processes to continue in areas currently suitable as spotted owl habitat, and they focus silvicultural activities on developing suitable habitat for spotted owls in areas that are currently unsuitable. Salvage of dead trees is allowed where it will not retard development of suitable habitat. Standards and guidelines also provide for treatment of some forest stands within some of the conservation areas to reduce risk of large scale disturbances. In some situations, these may include stands that are currently suitable owl habitat. The Recovery Plan indicates that a management plan for each designated conservation area should be completed prior to implementation of silvicultural activity in that conservation area.
>
> Reserved pair areas - Standards and guidelines for management of vegetation within this category of conservation area are the same as those for the designated conservation areas (USDI 1992c: 86).
>
> Managed pair areas - In this category of conservation area, the objective of the standards and guidelines is to always maintain an acreage of suitable habitat equal to the median amount observed in

> home ranges of pairs of spotted owls in each physiographic province (USDI 1992c: 86). A wider application of silvicultural activities designed to reduce the risk of large scale disturbances is permitted in managed pair areas.
>
> Residual habitat areas - These conservation areas incorporate 100 acres of suitable spotted owl habitat as close as possible to the nest site or activity center of a pair of spotted owls or a single, territorial spotted owl. Timber management is not appropriate in the residual habitat areas, and adjacent management should be designed to reduce risk of natural disturbance.
>
> Matrix management - The Draft Final Recovery Plan for spotted owls prescribed the 50 11 40 rule as a standard and guideline for management of vegetation outside the conservation areas.

The third set we drew from, the report of the Scientific Analysis Team (Thomas et al. 1993), provided standards and guidelines associated with several major components of a strategy that was developed to provide for species associated with old growth forests within the range of the northern spotted owl using a step wise approach. The standards and guidelines used within this report follow:

> Standards and guidelines for riparian habitat conservation areas (Thomas et al. 1993: 447 458) include the establishment of interim riparian buffers of varying widths for different categories of streams, lakes, and wetlands. Buffers for riparian areas vary from a minimum of 300 feet (on each side of the stream) for fish bearing streams and lakes, to a minimum of 150 feet on each side of perennial streams without fish, and around ponds, reservoirs, and wetlands greater than 1 acre, to at least 100 feet on seasonally flowing streams or wetlands less than 1 acre. The riparian buffers are interim until watershed analyses are completed that may reduce or increase the widths of the buffers in some areas (see Aquatic Ecosystem Assessment, for a description of watershed analysis). Vegetation management in the buffers would be limited to removal of hazard trees, silvicultural activities that create conditions needed to attain riparian objectives, and some limited salvage of dead trees following large catastrophic events. "Key Watersheds" identified by Thomas et al. (1993: 449)

are delineated using the same criteria as those used by Johnson et al. (1991). However, under the standards and guidelines of the Scientific Analysis Team, Key Watersheds are used to establish priority areas for completing watershed analyses and restoration work rather than as areas where there would be extended timber harvest rotation as under Johnson et al. (1991).

Standards and guidelines for protection of rare and locally endemic species (Thomas et al. 1993: 291 295) include inventories in areas where activities are planned that could disturb or destroy habitat occupied by such species. Sites occupied by rare and locally endemic species would be protected when located.

Standards and guidelines for the protection of habitat for other species in the upland Matrix (Thomas et al. 1993: 295 299) consist of (1) conducting surveys and protecting sites occupied by Del Norte salamanders; (2) retaining a greater numbers of snags and green trees within the range of the white headed woodpecker, black backed woodpecker, pygmy nuthatch, and flammulated owl; (3) providing buffers around meadows and natural openings within the range of the great gray owl; (4) completing the habitat capability model for fisher and American marten by the National Forests in California and retaining all management requirement areas for martens on National Forests and in Oregon and Washington; (5) regulatory closure of kill trapping of martens in Oregon and Washington where the range of the American marten overlaps with that of the fisher (to avoid accidental kill trapping of fishers); (6) developing site specific timber harvest, roading, and fire management plans in the range of the lynx to improve conditions for lynx.

The Forest Ecosystem Management Assessment Team developed additional standards and guidelines for some options. The bases for these standards and guidelines are presented in the section on Ecological Principles for Management of Late-Successional Forests.

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Ecological Principles For Management of Late-Successional Forests

Ecological Principles For Management of Late-Successional Forests: The Basis For Standards And Guidelines

In this section we provide the rationale for management of Late-Successional Reserves and Matrix lands, and the development of terrestrial standards and guidelines. A similar discussion of the aquatic/riparian system is found in Aquatic Ecosystem Assessment. Specific terrestrial standards and guidelines used to develop the options are presented in Option Development and Description.

Standards and guidelines provide objectives and rules for management under different options evaluated by the Forest Ecosystem Management Assessment Team. All of the options have the same general goal: maintain late-successional species and ecosystems on federal lands while providing for social and economic needs. Late-successional forests are those forest seral stages that include mature and old-growth age classes (Thomas et al. 1993:510). The options differ in means used to reach that goal and the degree of certainty that the goal will be met.

For all options, standards and guidelines are intended to provide guidance during the early phase of implementation. However, forest ecosystems are quite variable throughout the Pacific Northwest and site-specific knowledge of ecosystems is best interpreted and applied by resource specialists familiar with local conditions. These specialists will aid in refining the standards and guidelines over time to adapt to specific planning areas and incorporate new information and improved understanding of ecosystems. A process by which standards and guidelines could be modified is described in Implementation and Adaptive Management. Oversight groups would be responsible for interpretation of guidelines provided by any selected option, as well as review and approval of proposed modifications.

An important goal of forest management on the federal lands is to maintain biological diversity associated with native species and ecosystems in accordance with environmental laws and regulations. To meet this goal, the federal lands are viewed as an ecologically interdependent mosaic of ecosystems that is stratified into Congressionally Withdrawn Areas, Late-Successional Reserves, and Matrix.

In Late-Successional Reserves, standards and guidelines are designed to maintain late-successional forest ecosystems and protect them from loss to large-scale fire, insect and disease epidemics, and major human impacts. The intent is to maintain natural ecosystem processes such as gap dynamics, natural regeneration, pathogenic fungal activity, insect herbivore, and low-intensity fire. In some options, standards and guidelines encourage the use of silvicultural practices to accelerate the development of overstocked young plantations into stands with old forest characteristics, and to reduce the risk that Late-Successional Reserves will be severely impacted by large-scale disturbances and unacceptable loss of habitat.

The Matrix is an integral part of the conservation strategy included in all options. Production of timber and other commodities is an important objective for the Matrix. However, management must ensure that the forests in the Matrix provide for connectivity between Late-Successional Reserves and provide habitat for a variety of organisms associated with both late-successional and younger forests, and that ecosystem productivity is maintained. Standards and guidelines for the Matrix are designed to provide for important ecological functions such as dispersal of organisms, carryover of some species from one stand to the next, and maintenance of ecologically valuable structural components such as down logs, snags, and large trees. The Matrix will also provide for ecologically diverse early-successional conditions.

General Ecological Basis for Forest Management

Most options contain provisions to manage young forests to maintain or accelerate the development of attributes that are characteristic of late-successional forests, namely: (1) structure and composition, (2) ecological processes, and (3) ecosystem functions.

Structure and Composition

The structure and composition of late-successional and old-growth forest ecosystems has been detailed in numerous publications (e.g., Franklin et al. 1981; Spies and Franklin 1988; Spies and Franklin 1991). Franklin et al. (1981) identified four major structural attributes of old-growth Douglas-fir forests: live old-growth trees, standing dead trees (snags), fallen trees or logs on land, and logs in streams. Additional important elements typically include multiple canopy layers, smaller understory trees, canopy gaps, and patchy understory (Spies et al. 1990). Structural characteristics of old forests vary with vegetation type, disturbance regime, and developmental stage. For example, in many Douglas-fir stands in western Oregon and Washington the mature phase of stand development begins around 80 years with relatively large live and dead trees (Spies and Franklin in press), although multiple canopy layers may not yet be well developed. In some forest types subject to frequent, low-intensity fire, such as ponderosa pine, the late-successional and old-growth stages typically have relatively open understories and relatively few large fallen trees in comparison with more moist Douglas-fir/western hemlock types. We recognize that as structural and compositional characteristics of old forests vary among physiographic provinces, so necessarily will standards and guidelines intended to promote the desired conditions.

Ecological Processes

Ecological processes include those natural changes that are central to the development and maintenance of late-successional and old-growth forest ecosystems. Although the processes that created the current late-successional and old-growth ecosystems are not completely understood, we do know that they include:

(1) tree growth and maturation, (2) death and decay of large trees, (3) low to moderate intensity disturbances (e.g., fire, wind, insects, and disease) that create canopy openings or gaps in the various strata of vegetation, (4) establishment of trees beneath the maturing overstory trees either in gaps or under the canopy, and (5) closing of canopy gaps by lateral canopy growth or growth of understory trees. These processes result in forests moving through different stages of late-successional/old-growth conditions that may span 80 to 1,000 years for forests dominated by long-lived species.

Several authors have described these stages (Bormann and Likens 1979; Oliver 1981; Peet and Christensen 1987) and Spies and Franklin (in press) have expanded the descriptions to include the protracted nature of stand development in forests dominated by long-lived trees such as Douglas-fir. Following stand-replacement disturbance, these stages can be described as (1) establishment, (2) thinning, (3) maturation, (4) transition, and (5) shifting-gap.

The maturation stage (3) is characterized by a slowed rate of height growth and crown expansion. Heavy limbs begin to form and gaps between crowns become larger and more stable or expand from insect and pathogen mortality. Large dead and fallen trees begin to accumulate, and the understory may be characterized by seedlings and saplings of shade-tolerant tree species. In Douglas-fir stands west of the Cascades, this stage typically begins between 80 and 140 years, depending on site conditions and stand history.

During the transition stage (4), the original cohort of overstory trees approaches its maximum height and diameter and growth is slow. Tree crowns become

more open and irregular in shape and contain heavy limbs, Broken, dead, and decaying portions of tree crowns are common. Old trees become relatively resistant to low to moderate intensity fire, and depending on species, crown bases are high above the understory and bark is relatively thick. During this stage, understory trees form multiple canopy layers, coarse woody debris accumulates to relatively high levels, and low to moderate intensity disturbances from insects, disease, wind, and fire create patchy openings and accumulations of standing dead trees. These disturbances also frequently promote establishment or advancement of understory trees that eventually fill the holes in the canopy. In Douglas-fir stands west of the Cascades, this stage begins between 150 to 250 years and may last for an additional 300 to 600 years depending on site conditions and species.

The shifting-gap stage begins when the last of the original cohort of overstory old-growth trees dies and all trees in the canopy have established following smaller gap-type disturbances of various types. Forests in the last two stages (4 and 5) of development actually contain all of the stand developmental stages in a relatively fine-grained mosaic of smaller stands. The later three stages (3, 4, and 5) embody the late-successional/old-growth conditions that are the focus of this report.

Some of the stand developmental processes, such as tree growth and mortality, and understory establishment, can be accelerated through silvicultural manipulations. Most options provide for the acceleration of these processes in younger stands. Other processes such as maturation of tree crowns, thickening of bark, and decay of tree boles are not readily accelerated through silviculture. Because of our limited knowledge of late-successional and old-

growth processes and lack of silvicultural experience in old stands, it is by no means certain that we can create old-growth ecosystem conditions.

Most of the current late-successional and old-growth stands developed from natural regeneration following wildfire that occurred during the last 500 to 600 years and covered large areas--frequently many thousands of acres. Although these fires were large, they were patchy and left many areas of unburned or lightly burned forest. The natural regime of patchy fires that leave an abundance of large dead trees and lesser amounts of scattered live trees, as individuals and in patches, is the basis for silvicultural methods such as retention of green trees as individuals and in patches.

In some cases, however, natural reburns occurred, resulting in relatively little carryover of live trees as a legacy from the old-growth condition. Where considerable live and dead material was left following fires, young stands contained many old-growth structures and presumably old-growth-associated organisms, including organisms associated with coarse woody debris on the forest floor.

Large fires and relatively long fire return intervals in the moist northern and western physiographic provinces resulted in periods during which landscapes contained large areas of relatively unbroken forest cover. In the warmer, drier physiographic provinces (e.g., Eastern Cascades and Klamath Provinces), fire is more frequent, less intense, and more a part of the internal dynamics of what is typically considered a stand (e.g., tens to hundreds of acres). In the drier provinces, fire control and timber harvest have decreased the abundance of some types of old-growth, such as ponderosa pine, that are dependent on frequent, low-intensity fires. Other types of late-

successional forest that are less fire resistant or are less desirable for harvest have become more widely distributed. In these areas, the potential for stand replacement wildfires has increased, resulting in a higher risk to the stability of current stands reserved for late-successional species.

At a landscape-scale and over long periods, stand replacing wildfires have an important role in resetting successional processes and developing new areas of late-successional forests to replace those lost through succession or disturbance. Silvicultural practices, designed to imitate natural processes may be able to reset succession to achieve stand and landscape level goals. This type of silviculture holds promise to meet a variety of ecosystem objectives, however we have very little experience in applying silviculture for late-successional objectives. Until we gain more experience and knowledge about active management to produce late-successional ecosystems, sustaining late-successional ecosystems in the landscape will be best accomplished through retention of existing areas of late-successional forest. Given the relatively low remaining proportion of late-successional ecosystem in the landscape at the present time, these older forests should be protected from fire and other "resetting" disturbances.

Ecosystem Functions

Late-successional ecosystems perform several ecological functions that appear to be lacking, or less well developed, in younger natural forests and managed plantations. These functions include buffering of microclimate during seasonal climatic extremes (Chen et al. 1993), producing food for those consumer organisms which occupy late-successional

forests (Ure and Maser 1982; Huff et al. 1991), storing carbon (Harmon et al. 1990), nutrient and hydrological cycling (Franklin and Spies 1991), and providing sources of arthropod predators and organisms beneficial to other ecosystems or successional stages (Schowalter 1989). Old-growth ecosystems appear to be highly retentive of nutrients (Sollins et al. 1980) and low in soil erosion potential (Swanson et al. 1982a) although differences in these functions between stand developmental stages may not be large when canopy closure has occurred. Tall, deep canopies of late-successional forests can intercept more moisture from clouds and fog than young plantations (Harr 1982).

Categories of Late-Successional Forest Conservation Areas

Any plan that does not maintain a strong network of existing old-forest ecosystems risks losing known and unknown biodiversity associated with old forests. Therefore, all management options include Reserves designed to maintain and enhance late-successional forests. Although their size, distribution, and management varies among options, these Reserves include two general categories, as follows.

Late-Successional Reserves

These Reserves represent a strong network of existing old forests that are retained in their natural condition, with natural processes such as fire allowed to function to the extent possible. These Reserves are designed to serve several functions. First, they provide a distribution, quantity, and quality of old-forest habitat sufficient to avoid foreclosure of future management options. Second, they provide habitat for viable, well-distributed populations of species including the northern spotted owl and marbled murrelet that are

associated with late-successional forests. Third, they will help ensure that the full range of late-successional biodiversity will be conserved. Currently, Reserves contain significant areas dominated by early successional communities. However, late-successional communities and associated species will become more abundant as younger stands mature.

Late-successional forest communities are the result of a unique interaction of disturbance, regeneration, succession, and climate that probably can never be created with management. At present, we do not even fully understand the structure, species composition, and function of these forests. The best we can hope to accomplish through silviculture is to at least partially restore or accelerate the development of some of the structural and compositional features of such forests. Because they will be regenerated by different processes during a different period from that of the existing late-successional forests, it is highly likely that silviculturally created stands will look and function differently from current old stands that developed over the last 1,000 years. Consequently, conserving a network of natural old-growth stands is imperative for preserving biodiversity into the future.

Most options allow management of stands within Late-Successional Reserves to maintain, or accelerate the development of, late-successional forest conditions. In general, management would be limited to young stands, removal of hazard trees, and salvage of limited amounts of dead trees after fires, windstorms, or insect-caused mortality.

A variety of areas currently remaining unmapped would be managed as Late-Successional Reserves. These areas include LS/OG3s (Johnson et al. 1991) and murrelet sites within the Matrix. Options 1-6, 9

and 10 included protection for murrelets and assumed that sites occupied by murrelets would be retained as Late-Successional Reserves once they were identified and mapped. LS/OG3s were retained as Late-Successional Reserves under option 1, were at least partially retained under options 3 and 4, and were released for harvest under other options. Where the LS/OG3 areas were retained as Late-Successional Reserves, the intent was to further strengthen the network and diversity of late-successional forest. We assumed that all of these areas would be mapped during the planning and implementation process for the selected option.

Managed Late-Successional Areas

We assume that all late-successional forests will, at one time or another in the future, be subjected to ecological disturbance such as fire, wind, insects, or disease. Given this assumption, we believe it is reasonable to initiate silvicultural experiments that are likely to produce stands that are similar in structure to existing old stands. While these replacement stands may never be duplicates of existing old stands, we hypothesize that they will provide for most of the species and processes that occur in natural stands and will be adapted to current and future climate.

We proposed some options that allow management in some Reserves so that managers and researchers will experiment and gain experience with a more dynamic approach to maintenance of older forests on the landscape, while at the same time extracting some wood products. Research, monitoring, and adaptive management will have to occur simultaneously if we are going to understand how well we can expect to duplicate late-successional forest conditions within

managed forest landscapes.

Some options examined by the Forest Ecosystem Management Assessment Team contained provisions for timber harvest through the use of long rotations in some Late-Successional Reserves. The objective of long rotations is to re-create, to the extent possible, the structural and compositional features of late-successional forests. Some of these features include: (1) multispecies and multilayered assemblages of trees, (2) moderate to high accumulations of large logs and snags, (3) moderate to high canopy closure, (4) moderate to high numbers of trees with physical imperfections such as cavities, broken tops, and large deformed limbs, and (5) moderate to high accumulations of fungi, lichens, and bryophytes. Although they may not be duplicates of existing old forests, we do believe that in the long term these stands could provide adequate habitat for some species.

Role of Silviculture

Silviculture is the art and science of managing forest stands to provide or maintain structures, species composition, and growth rates that contribute to forest management goals. Silvicultural practices will vary considerably throughout the Pacific Northwest because of the broad variety of forest species and ecosystems in this region. The ecosystems range from coastal temperate rain forests where fire occurs infrequently but where wind may have a major impact, to forests on dry interior sites where disturbance by natural fire and insects is common. Within specific locales the silvicultural practices will be strongly influenced by such factors as nearby residential areas, local wildlife habitat requirements, and fire management constraints.

To develop silvicultural systems, it is important to have clear

objectives for stand structure and species composition. Under most options, silviculture systems proposed for Late-Successional Reserves have two principle objectives (Tappeiner et al. 1992): (1) development of old-forest characteristics including snags, logs on the forest floor, large trees, and canopy gaps that enable establishment of multiple tree layers and diverse species composition; and (2) prevention of large-scale disturbances by fire, wind, insects, and diseases that would destroy or limit the ability of the Reserves to sustain viable forest species populations. Small-scale disturbances by these agents should continue.

Matrix objectives for silviculture should include: (1) production of commercial yields of wood, including those species such as Pacific yew and western red cedar that require extended rotations, (2) retention of moderate levels of ecologically valuable old-growth components such as snags, logs, and relatively large green trees, and (3) provision of ecologically diverse early-successional conditions.

Stand Management

Forests within Late-Successional Reserves are composed of managed stands from 2 to over 50 years of age as well as unmanaged, late-successional, and old-growth stands. The younger stands were usually established following fire or timber harvest. Some of these stands will develop old-growth characteristics without silvicultural intervention. However, current stocking and structure of some of these stands were established to produce high yields of timber, not to provide for old-growth-like forests. Consequently, silviculture can accelerate the development of young stands into multilayered stands with large trees and diverse plant species and structures that may in turn maintain or enhance species diversity.

Under most options, stand management in Late-Successional Reserves is proposed to focus on stands that have been regenerated (by clearcutting,

shelterwood, and group or single tree selection methods) following timber harvest or on stands that have been thinned. These include stands that will acquire old-growth-like characteristics more rapidly with treatment, or are prone to fire, insects, disease, wind, or other variables that would jeopardize the reserve. Depending upon stand conditions, treatments could include, but not be limited to: (1) thinning or managing the overstory to produce large trees, release advanced regeneration of conifers, hardwoods, or other plants, or to reduce risk from fire, insects, disease, or other environmental variables; (2) underplanting and limited understory vegetation control to begin development of multistory stands; (3) killing trees to make snags and logs on the forest floor; (4) reforestation; and (5) use of prescribed fire.

Tappeiner et al. (1992) discussed management of forest stands for northern spotted owl habitat, including examples of silvicultural systems and treatments that resemble natural forest disturbances. Their discussion can provide initial guidance for silvicultural treatment of young stands in Late-Successional Reserves.

Stands in the Matrix can be managed for timber and other commodity production, but they also have an important role in maintaining biodiversity. Silviculture systems for stands in the Matrix should provide for retention of old-growth ecosystem components such as large green trees, snags and down logs, and depending upon site and forest type, a diversity of species.

All options evaluated provide for retention of varying numbers of green trees following timber harvest in the Matrix, to provide a legacy bridging past and future forests. Retained green trees serve several important functions including snag recruitment, promoting multi-

storied canopies, and providing shade and suitable habitat for many organisms in the Matrix.

Options 3 and 9 call for retention of green trees in well-distributed patches as well as dispersed individuals. Patches of green trees of various sizes, ages, and species will promote species diversity and may act as refugia or centers of dispersal for many organisms including plants, fungi, lichens (Esseen et al. 1992), small vertebrates, and arthropods.

Patches of trees may also provide protection for special microsites such as seeps, wetlands, or rocky outcrops. Trees retained within riparian protection areas can contribute to retention objectives but will generally not be sufficiently dispersed across the landscape to fully satisfy these objectives.

Diversity of tree structure should be considered when selecting trees for retention. Complex canopy structure and especially leaning boles are beneficial for some lichens (Esseen et al. 1992). Trees that are asymmetrical provide a diversity of habitat substrates and often have more lichen and moss epiphytes on large lateral limbs than symmetrical trees. Location of green trees is also important (e.g., ridgelines are optimum locations for lichen dispersal).

Large logs of a variety of decay classes should be left. All down logs in advanced stages of decay (class 3-5) and significant quantities of less decayed logs (class 1-2) should be retained. Down log guidelines will differ between forests west of the Cascades and those in the Eastern Cascade or Klamath Provinces primarily because of fundamental differences in ecosystems (e.g., climate, vegetation, fire frequency and severity).

Coarse woody debris is essential for many species of

vascular plants, fungi, liverworts, mosses, and lichens, arthropods, salamanders, reptiles and small mammals. Because of drier microclimates, logs in the Matrix may be occupied by species different from those found on coarse woody debris in late-successional forests. However, these logs may provide transitional islands in successional time for the maintenance and eventual recovery of some late-successional organisms in the Matrix.

In the Matrix, levels of snags should be retained that are adequate to support viable populations of cavity nesters. Management for 40 percent of potential populations of cavity nesters may be the minimum required for viability of these species within the Matrix (Thomas et al. 1979). However, considerable research and monitoring will be required to determine actual levels of snags required to support viable populations of various species in different provinces. Snags could be created in Matrix stands if they are lacking, but there is much uncertainty concerning the efficacy of killing trees to provide snags.

Adequate numbers of large snags and green trees are especially critical for bats because they are used for maternity roosts, temporary night roosts, day roosts, and hibernacula. Large snags and green trees should be well distributed throughout the Matrix because bats compete with primary excavators and other species that use cavities. Day and night roosts are often located at different sites, and migrating bats may roost under bark in small groups. Thermal stability within a roost site is important for bats, and large snags and green trees provide that stability. Individual bat colonies may use several roosts during a season as temperature and weather conditions change. Large, down logs with loose bark may also be used by some bats for roosting.

Local information should be used to refine requirements for quantity, size, spacing, and distribution of snags and down logs. Guides for the retention of snags and down logs must be responsive to safety considerations during logging and other forest operations.

Thinning prescriptions should encourage development of diverse stands with large trees and a variety of species in the overstory and understory. Prescriptions should vary within and among stands.

Management of Disturbance Risks

Natural disturbance is an important process within late-successional forest ecosystems but humans have altered disturbance regimes. Management may be required to re-introduce natural disturbance such as fire or to minimize socially unacceptable impacts.

Fire suppression has resulted in significant increases in accumulated fuels within some forests, particularly in the Eastern Cascades Province of Washington and Oregon and in the Klamath Province of southern Oregon and northern California (Agee 1990; Deeming 1990; Kauffman 1990). At the same time, these forests may have become much more vulnerable to insects and diseases (Mitchell 1990a; Wickman 1992; Mutch et al. 1993).

In Late-Successional Reserves in the Western Cascades and coastal areas of Oregon and Washington, manipulation of natural stands to reduce fire hazard is generally not necessary (Agee and Edmonds 1992). However, fuel management may be desirable in plantations. An aggressive fire control strategy should be implemented, with emphasis on fire

detection and initial attack (Agee and Edmonds 1992). In the future, fires may be allowed to burn, at least under some conditions. However, until we have fire management plans, all fires in west-side Late-Successional Reserves should be suppressed.

In Late-Successional Reserves in the Eastern Cascades or Klamath Provinces, silviculture aimed at reducing the risk of stand-replacing fires may be appropriate. Treatments may include thinning, underburning, and establishment of fuelbreaks. With fire suppression, some forests have become quite dense and multistoried, primarily from the invasion of shade tolerant species (Tappeiner et al. 1992). Reduction in mid-level canopy layers by thinning may reduce the probability of crown fires. Also, underburning can be used to reduce fuel loads and vertical fuel continuity. Wildfires entering underburned stands generally are less severe and direct control is often possible. To be effective, underburning should be implemented over large areas (Agee and Edmonds 1992).

Fuelbreaks compartmentalize management units by creating zones of reduced fuel, which allow safe access for fire suppression crews and provide a reasonable location for control. Fuelbreaks are generally located along ridgelines with continuous fuels. Stands are manipulated to reduce continuity of canopies, boles are pruned on residual trees, and significant quantities of understory fuels are removed (Agee and Edmonds 1992). Many of these treatments may reduce the quality of habitat for late-successional organisms. Thus, managers need to seek balance in an approach that reduces risk of fire while at the same time protects large areas of fire-prone late-successional forest.

Silvicultural systems within the Matrix contribute to

management of the Late-Successional Reserves. Matrix management should reduce the risk of fire and other large-scale disturbances that would jeopardize the reserves. For example, fire and fuels management in the Matrix are compatible with management objectives for Late-Successional Reserves when they reduce the risk of fire entering the Reserves from adjacent managed lands.

Harvesting trees immediately adjacent to Late-Successional Reserves may result in increased wind damage along boundaries. In such cases, "feathering" stands within harvest units may be appropriate to reduce this risk. Local expertise will be essential in designing meaningful strategies for wind protection (Agee and Edmonds 1992).

Management After Natural Disturbance

Fire, wind, insects, and disease have greatly influenced the development of Pacific Northwest forests (Agee 1990, 1991; Kauffman 1990; Agee and Edmonds 1992). Fine-scale disturbances, generally insects or disease, include deaths of single trees or small groups of trees which result in small patches of early successional vegetation embedded in a larger portion of older forest. Coarse-scale disturbances, such as fire and wind, result in more extensive areas of early seral vegetation. Many native forest organisms have adapted to these cycles and scales of disturbance and regrowth.

Most options have provisions for management following natural disturbances in Late-Successional Reserves. Management objectives should focus on either simulating natural succession or allowing it to occur unimpeded. Direct silvicultural management will usually be more appropriate following coarse-

scale disturbances such as extensive, hot fires that kill most or all trees within a large area. Fine-scale disturbances will generally not require such management. In fact, insects, disease, and wind create small gaps in the overstory that characterize the transition and shifting-gap stages of old-growth forest development (Spies and Franklin 1989; Spies et al. 1990). The processes leading to formation of these gaps should not be impeded.

Tree mortality is an important and natural process within a forest ecosystem. Diseased and damaged trees and logs are key structural components of late-successional and old-growth forests (Franklin and Spies 1991; Spies and Franklin 1991). Accordingly, management planning for Late-Successional Reserves must acknowledge the considerable value of retaining dead and dying trees in the forest.

Salvage of dead trees has significant effects on the development of future stands and their suitability as habitat for a number of organisms. Snag removal results in long-term impacts on the forest community because large snags are not produced by the new stand until trees become large and begin to die from natural mortality (often a period of 50-100 years). Snags are used extensively by cavity nesting birds and mammals such as woodpeckers, nuthatches, chickadees, squirrels, red tree voles, and American marten (Carey et al. 1991; Gilbert and Allwine 1991a, b; Lundquist and Mariani 1991; Thomas et al. 1993). Removal of snags following disturbance can significantly reduce the carrying capacity for these species for many years.

Down logs are important components of forest ecosystems. They provide habitat for a broad array of vertebrates, invertebrates, fungi, mosses, vascular plants, and micro-organisms. Arthropods,

salamanders, reptiles, and small mammals live in or under logs; woodpeckers forage on them; vascular plants and fungi grow on rotting logs (Harmon et al. 1986, Thomas et al. 1993).

Because of the important role of dead wood in late successional and old-growth forest ecosystems, and because there is much to learn about the role of dead wood in the development of forests, only limited salvage is appropriate in Late-Successional Reserves. Salvage policies of options generally ranged from no salvage to limited salvage as permitted by the Final Draft Recovery Plan for the Northern Spotted Owl (USDI 1992c). This plan would allow removal of small-diameter snags and logs but would also require retention of snags and logs likely to persist until the new stand begins to contribute significant quantities of coarse woody debris.

Many natural disturbances do not result in complete mortality of stands. For example, recent fires in the Western Cascades of Oregon killed only 25-50 percent of trees within the areas burned (USDA 1988, 1989, 1992a, b). The surviving trees are important elements of the new stand. They provide structural diversity and a potential source of additional large snags during the development of new stands. Furthermore, trees injured by disturbance may develop cavities, deformed crowns, and limbs that are important habitat components for a variety of wildlife. Therefore, no removal of green trees should be allowed within Late-Successional Reserves unless significant human safety hazards (e.g., unstable trees adjacent to campgrounds or trails) are involved.

In many options, more extensive salvage would be allowed where fire, insects, or disease are likely to result in a significant risk to the future development of

late-successional and old-growth forests (e.g., Eastern Cascades and Klamath Provinces). The Final Draft Recovery Plan for the Northern Spotted Owl (USDI 1992c) provides for a process by which salvage guidelines can be adapted to specific conditions. A similar process should be adopted to provide guidance for management of salvage in Late-Successional Reserves.

In Matrix areas, objectives for post-disturbance management will generally be different from that for Late-Successional Reserves. Economic benefits of timber production will receive greater consideration. For example, the commercial salvage of dead trees will be less constrained, and replanting of disturbed areas will be a high priority. However, because the Matrix provides habitat and connectivity for many organisms, post disturbance management must achieve a balance between economic and ecosystem objectives. Standards and guidelines for post disturbance management were generally similar to those for timber harvest management, but restoration planning must consider local conditions and site-specific information.

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Methods for Assessing Effects of Options

Sources of Information

Information for the assessment of the effects of the options on terrestrial species and their habitats included data on forest cover types, species' geographic ranges, northern spotted owl and marbled murrelet habitat, and specific locations occupied by these two species.

Information on general forest cover types on Forest Service and National Park Service lands in Oregon and Washington was obtained through a contract with Pacific Meridian Resources Company. The cover type data were produced using a combination of 1988 and 1991 Landsat imagery and were classified into vegetation categories based on tree size and stand structure. For Forest Service lands in California, vegetation data from each of the National Forests were used to develop the forest cover type data set. No data were available for National Park Service lands in California.

Vegetation information for Bureau of Land Management lands in Oregon was compiled from forest stand description data on tree diameter classes of the dominant overstory trees. This data was developed from aerial photo interpretation and field surveys. Forest cover type data for Bureau of Land Management lands in California were derived from

the agency's Wildlife Habitat Relationships Geographic Information System theme.

To combine data from different agencies, the data were generalized to a geographic information system-based grid with a resolution of 400 by 400 meters square. Data were then reorganized to conform to the cover type categories of the Pacific Meridian Resources classification.

We obtained specific data sets for northern spotted owl and marbled murrelet habitat for lands administered by the Forest Service in the three states; the Bureau of Land Management lands in Oregon; and the National Park Service lands in Oregon and Washington. Agency field offices had previously completed the classification of spotted owl habitat for the Forest Service and Bureau of Land Management. Information on spotted owl habitat for National Parks in Oregon and Washington was derived from the Pacific Meridian Resources Landsat cover type data by the Forest Ecosystem Management Assessment Team. All medium and large conifer acres from the Landsat data that occurred under 4,000 feet elevation in Washington and under 5,500 feet in Oregon were tallied as spotted owl habitat.

The spotted owl habitat data were also used to identify marbled murrelet habitat on Forest Service lands within the range of the murrelet in Oregon and California; data specific to marbled murrelet habitat were not available for those lands. In Washington, marbled murrelet habitat was identified for National Forests and National Parks using updated 1989 Landsat data classified by Eby and Snyder (1990). Data for a portion of land in the Puget Sound not covered by the Eby and Snyder data were supplied by the Washington Department of Natural Resources

from work by Green et al. (1993). On Bureau of Land Management lands in Oregon, the team used field office classifications of forest stand data designating probable murrelet habitat. No data were available for either northern spotted owl or marbled murrelet habitat on lands administered by the Bureau of Land Management or the National Park Service in California.

Species range maps developed by Thomas et al. (1993) were refined for this effort by personnel from the Forest Service's Pacific Northwest Research Station in Olympia, Washington, for the mammal, bird, and amphibian species closely associated with late-successional forest. They were based on information derived from field guides, scientific literature, Natural Heritage Database files, state agency records and review by species authorities.

Specific location information was plotted for northern spotted owls and marbled murrelets from data compiled by the state wildlife agencies of Washington, Oregon, and California. The spotted owl location data identified points on the landscape where survey data documented nesting by a pair of owls, or continued occupancy of a location by either a pair of owls or a territorial single owl. Data were tallied for owl pairs and territorial single owls that had been verified from 1987 to 1991 for all federal lands, and from 1988 to 1992 for other ownerships where earlier surveys were incomplete or significant new data were available. The marbled murrelet location data identified sites where surveys documented murrelet activity in the canopy of a given forest stand. Data coverage included all federal lands. Occupied stands verified from 1986 through 1992 were included.

Identification of Species Closely Associated

with Late-Successional Forests

To identify plant and animal species closely associated with late-successional forests and components, we relied on (1) existing assessments and publications and (2) the advice of experts who reviewed those lists for completeness for all federal lands within the range of the northern spotted owl.

Existing assessments and publications included the Scientific Analysis Team Report of Thomas et al. (1993), who identified old-growth forest species and evaluated their likely future under planning alternatives presented in the Forest Service's Final Environmental Impact Statement on the Northern Spotted Owl (USDA Forest Service 1992). Thomas et al. (1993) identified species closely associated with old-growth forests and components of old-growth forests on National Forests within the range of the northern spotted owl. In their analysis, 667 species, species in parts of their range, and at-risk fish stocks were found to be closely associated with old-growth forests.

We adopted the process used by Thomas et al. (1993) for identifying species of plants and animals closely associated with late-successional, including old-growth, forests within the range of the northern spotted owl. In their process, Thomas et al. (1993) listed ecological information on each species and determined the association of each species with late-successional and old-growth forests by applying specific criteria. (See table IV-6). With help from species experts (see appendix IV-B and later sections on species groups), we expanded this list to account for new information and for additional plants and animals found on other federal lands within the northern spotted owl's range, particularly on National

Parks and on Bureau of Land Management Districts. In this process our working definition of late-successional, including old-growth forests included all forests in which the dominant overstory trees were at least 80 years old. This included old-growth forests as described by Spies and Franklin (1991) and Franklin and Spies (1991).

Table IV-6. Criteria for developing the list of species closely associated with late-successional and old-growth forests. Adapted from Thomas et al. (1993). A species is included in the list of species closely associated with late-successional and old-growth forests or components if it meets at least one of the following four criteria:

Criterion 1: The species is significantly more abundant (based on field study or collective professional judgment of the Forest Ecosystem Management Assessment Team) in late-successional and old-growth forest than in young forest, in any part of its range.

Criterion 2: The species shows association with late-successional and old-growth forest (may reach highest abundance there, but not necessarily statistically so), and the species requires habitat components that are contributed by late-successional and old-growth forest (based on field study or collective professional judgment of the Forest Ecosystem Management Assessment Team).

Criterion 3: The species is associated with late-successional and old-growth forest (based on field study) and is on a federal (Fish and Wildlife Service) or state threatened and endangered list, on the Fish and Wildlife Service candidate species list, Forest Service Regions 5 or 6 sensitive species list, or listed by Washington, Oregon, or California as species of special concern or sensitive species.

Criterion 4: Field data are inadequate to measure strength of association with late-successional and old-growth forest, and the

species is listed as a federal (Fish and Wildlife Service) threatened and endangered, and the Forest Ecosystem Management Assessment Team suspects that it is associated with late-successional and old-growth forest.

Methods for Assessing Effects of Options on Species

We assessed the potential effect of seven of the options on species habitat and viability in two separate rounds of expert panels. We viewed evaluations not as precise analyses of likelihoods of habitat and population conditions, but rather as judgments of knowledgeable experts.

The first panel assessment was conducted April 21 to 30, 1993, involving 67 panelists in 12 panels covering all major plant and animal taxa associated with late-successional and old-growth forest ecosystems in the Pacific Northwest.

For the first panel assessment, the rating was an assessment of the likelihood of maintaining species viability, defined as the continued persistence of the species population, well distributed throughout its historical range on federal lands within the range of the northern spotted owl over the next 100 years.

Panelists were selected from universities, the private sector, and agency management and research branches. Results from the panels were advisory to the Forest Ecosystem Management Assessment Team who made final judgments about viability effects. Other information considered in the assessment included contract reports, notes from panel discussions, panel leader’s impressions from the panel discussions, published scientific reports, empirical experience of the panel leaders, and follow-up

discussions with panel members and additional experts. Results from the first panel sessions were reviewed during the first 2 weeks in May 1993. A second round of panel evaluations was conducted in June because new options were developed, existing options were revised, and some key problems needed corrections.

The panel process was structured to elicit high quality judgments about future outcomes. We judged most of the structure of the first round of panels to be sound, so it was repeated. This included selection of species, species groupings protocols, panelist selection criteria, and information bases for Team evaluation. Major changes were made in the response scale and in emphasizing habitat as opposed to population viability.

A second round of panel evaluations was conducted in June. The Team convened this second round of panels for several reasons:

1. The option set had changed substantially in response to initial biological, economic, and sociological assessments. New options were added, and existing options had been substantially modified.

2. Panel procedures were revised to improve the interpretability of the results and to better capture the panelists' professional opinions. The scale used in the first round of panels, although biologically well founded, was a difficult instrument for interpreting option differences. In the second set of panels it was refined to allow a clear distinction between population and habitat factors; habitat was the element of concern and most directly influenced by the options.

3. The reassessment allowed a cleaner separation of biological judgments from legal or political contexts. The redesigned process focused judgment on biological events without predisposing panelists to layers of complex and possibly confusing legal and political interpretations.

4. The final reason for repaneling was to develop a response format that allowed panelists to express levels of uncertainty across options and species as a component of their likelihood judgements.

The second round of panels, consisting of three to nine biological experts, were held during June 3 to 14, 1993. Most panelists in this round had participated in the first round (appendix IV-B). All panelists who had participated in the first round were asked to participate in the second round, but some were unavailable. Panels considered differing numbers of species, ranging from one in the case of the northern spotted owl and marbled murrelet panels to more than 8,000 in the arthropod panel. Some panels with large numbers of species rated them in groups. Other panels considered geographical segments of individual species that had unique habitat requirements sensitive to the options. Seven of the 10 options were assessed by these panels. These were options 1, 3, 4, 5, 7, 8 and 9.

Panelist Selection

Panelists were selected using several criteria including technical expertise with the taxa, ecological understanding of habitat requirements, availability to attend panel sessions, and representative of a range of technical expertise across species and throughout the geographic range. Biologists were selected who could set interest group values aside to focus on the

biological assessment task. We gathered a mixture of research and management biologists, providing they met qualifications, and we tried to develop a mixture of habitat and population perspectives.

Assessment Process - Overview

The basic assessment process generally followed those described in Merkhofer (1987), McNamee and Celona (1989), Spetzler and Stael von Holstein (1975), and Cleaves (in prep) for making probabilistic judgments. The process was adapted for use in a panel setting. Our process led panelists through several generally accepted stages, including motivating panelists toward probabilistic assessment, task structuring, conditioning of assumption and background information, encoding the actual numerical judgments, and verifying the assessment results.

Motivation and structuring were handled in a 2-hour orientation that covered assessment rationale, description of the task, explanation of scale, and description of the options (see below). Conditioning occurred in a facilitated discussion of specific conditions that describe each of the four outcomes in the scale. This usually involved group agreement about the meaning of terms such as well distributed, habitat, and population, and about assumptions adopted to clarify the assessment task.

The actual rating of likelihoods was individual, followed by group display and discussion. Verification was also handled in the discussion step, as panelists explained reasons for their ratings. Final individual assessments were panelists' choices. We did not attempt to achieve a consensus rating; group interaction was used to clarify knowledge and exchange individual reasoning.

Response Scale: Outcome Component

Panelists used an outcome-based scale to assess the likelihood that habitat would support populations. We developed this scale to represent the range of possible trends and future condition of habitat on federal lands (table IV-7). Each of four outcomes, labeled A through D, describes a biological condition that is observable and mutually exclusive of the other three outcomes. Value-laden references such as high," 'good, or preferred' were avoided in the outcome descriptions. Panels discussed and refined the scale. In some panels, the outcome scale worked well without adjustment, while in others considerable discussion was necessary to clarify how the scale applied to a particular taxon.

We also instructed panelists to consider the ability of the options to buffer natural disturbances such as fire, insects, disease, and windstorms, at their historic frequencies and seventies. We could not provide data on rates of natural disturbance, but we encouraged discussion of these factors during the sessions.

We feel the scale improved on the earlier scale, but it was not a panacea. The following

areas were subject to different interpretations by different panels:

1. Treatment for rare and locally endemic species. Many of these species had small and restricted ranges ox- existed in refugia even before habitat alteration by harvesting and other activities. Some panelists tended to rate these species in outcome B or C under even the most protective options.

2. Habitat versus population outcomes. We defined the outcomes in terms of habitat ‘quality, distribution, and abundance’, but some panelists found it difficult to separate the habitat and population elements.

3. Definition of ‘well distributed.” Panelists were not uniformly clear about what “well distributed” meant for each taxon, although they concentrated their thinking on biological functions, particularly interaction. This issue was particularly confusing between outcomes A (well distributed) and B (distributed with gaps). Distinctions between B and C (occurrence in refugia) and between C and D (extirpation) were more explicit.

Table IV-7. Description of the outcomes used for rating the level of habitat support for populations.

Outcome A. Habitat is of sufficient quality, distribution, and abundance to allow the species population to stabilize, well distributed across federal lands. (Note that the concept of well distributed must be based on knowledge of the species distribution, range, and life history).

Outcome B. Habitat is of sufficient quality, distribution, and abundance to allow the species population to stabilize, but with significant gaps in the historic species distribution on federal land. These gaps cause some limitation in interactions among local populations. (Note that the significance of gaps must he judged relative to the species distribution, range, and life history, and the concept of metapopulations).

Outcome C. Habitat only allows continued species existence in refugia, with strong limitations on interactions among local populations.

Outcome D. Habitat conditions result in species extirpation from federal land.

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4. Historic versus current species distribution. Reference in our scale to “historic species distribution” in outcome A was difficult for species groups for which information is limited to the current distribution. Taken literally, the reference to historic distribution held the ratings to a high standard of requiring habitat reestablishment throughout the historic range.

5. It was difficult for panelists to project changes in bio-physical conditions over the 100 year timeframe specified.

6. Some panelists said that the 1CC-year period was not long enough for the options to express “equilibrium” conditions. These panelists considered 1CC years to be an interim checkpoint and preferred 2CC years or longer as an assessment frame.

Response Scale: Likelihood Component

We asked panelists to assign 1CC “likelihood votes” (or points) across the four outcomes in the scale. A panelist could express complete certainty in a single outcome for a species/option combination by allocating all 1CC points to a single outcome. The panelist could express uncertainty by spreading votes across the outcomes. An individual panelist could refrain from assessing a species because they simply had too little understanding to venture an informed opinion. The entire panel could also choose not to rate a species if they thought there was inadequate scientific knowledge about the species. These species were marked ‘not rated on the assessment forms, but

they were of no less concern than rated species. Discussions about the need to study and provide for these species was captured in the panel transcripts and panel leaders' reports.

We adopted the likelihood voting methodology in an effort to quantify scientific and personal uncertainty (Finkel 1990). We felt that honest expressions of how little or how much was known about species/option interactions could help us and decisionmakers better understand the issues and make more informed tradeoffs. We emphasized to panelists that the likelihoods are not probabilities in the classical notion of frequencies. They represented degrees of belief in future outcomes, expressed in a probability-like scale that could be mathematically aggregated and compared across options and species. This use of the "judgmental probabilities" is consistent with the theory and practice of decision analysis and decision science (von Winterfeldt and Edwards 1986; Howard and Matheson 1983).

Panel facilitators and leaders encouraged panelists to be candid and protected panelists' ratings from domineering personalities. The pattern of likelihood votes across the options reflected the panelist's rationale, knowledge base, and assumptions. It allowed panel leaders and panelists to detect and clarify key uncertainties and ambiguities in the option descriptions or panelist's interpretation of them.

Panel Process Mechanics

All panel assessments followed the same process flow. Panels lasted one to two days depending on the number of species being assessed. Two panels were usually combined for orientation to help standardize the process and to stimulate questions.

Each orientation consisted of the following:

1. *Welcoming statement.* We reviewed the purposes of the overall Forest Ecosystem Management Assessment Team assessment and reasons for reconvening the panels. Some panelists were suspicious that the second round of assessments was politically motivated to obtain “new’ results. Introductory remarks responded to these concerns.

2. *Orientation to the rating scale.* We presented and explained the rating scale. We defined terms and encouraged panelists to discuss their understanding of the scale. The points received particular consideration. The first was the definition of “well-distributed”. The second was the separation of federal habitat from other influences on species viability. This was discussed with reference to figure IV-1.

This diagram displays six factors that could influence species populations. These are habitat conditions on federal lands; life history characteristics of rite species; “bottleneck” periods of low habitat and population; landownership patterns and habitat conditions on nonfederal lands; habitat conditions outside the range of the northern spotted owl; and other environmental conditions caused by activities off federal lands.

For the purposes of the rating, panelists were asked to focus their assessment on habitat conditions on federal lands; life history characteristics of the species; and any bottlenecks in habitat (and population) that would occur under the option. For this assessment, they were asked to assume that the other three factors would he adequate to support a stable, well-distributed

population of the species ~f habitat on federal land was adequate to support such a population. These assumptions were relaxed later in the process when the likelihood rating had been completed. Panelists were then asked to describe the actual influence that these last three factors might have on overall population viability.

3. *Orientation to the assignment (likelihood) scale component.* We presented the likelihood scheme, its methodological rationale, and examples. The purpose of the group discussion was information exchange not consensus, and it was important to spend time in calibrating judgments, customizing the outcome definitions, and discussing the concept of likelihood points.

4. *Orientation to process/low.* We described the roles of the facilitator, panel leader, panelists, scribe and observers.

The facilitator's role was to clarify the task and the use of materials, keep the process moving and the discussions relevant to the task, stimulate thinking and interchange about the assessments, probe for consistency, biases, and misunderstandings and identify opportunities for improving the assessment process.

The scribe captured the discourse during the session, displaying the transcripts to the panel with an overhead projection from the computer screen. These transcripts were useful in clarifying and tracking points cited by panelists and supporting the later interpretations.

At times, panels were visited by members of the Supplemental Environmental Impact Statement learn

and other observers. These observers were asked to limit their involvement to occasional clarifying questions; their primary role was passive observation.

Description of the Options

We presented the seven options in a 1-hour briefing with opportunities for panelists to ask questions. In order to make the panel process workable, we assessed only seven of the 10 options (1, 3, 4, 5, 7. 8 and 9). In an attempt to emphasize the biological nature of the judgment task, only information relative to the bio-physical aspects were presented; no economic, harvest level (allowable sale quantity), or community assessment information was provided. The briefing was supplemented with visual materials provided to the panelists and displayed in the panel work area. In addition, an option expert was available to answer questions at any time during the panel assessments. Materials provided for the seven options included:

· Maps of options, color-keyed to depict spatial allocations of reserves. These 1:500,000 maps, one for each state for each option, were displayed on walls around the work area.

· Overlay maps of Key Watersheds.

· For vertebrates and vascular plants, overlay maps were available showing species ranges.

· Package of written descriptions of option components. Each option was described in a two-page summary, including details about Late-Successional Reserves, Managed Late-Successional Reserves, Riparian Reserves, Matrix management, and other standards and guidelines. For some options this

included supplementary guidelines for marbled murrelet management, and for Option 9 a two-page description of the Adaptive Management Areas. A pie chart of acreage allocations was also presented for each option except Options 8 and 9.

· Summary table of options, comparing them across the components. This table served as a bridge between the detailed descriptions and the maps and was referred to repeatedly by the panelists.

· In addition to the materials provided to describe the options, we also provided overlay maps of the ranges of vertebrates and vascular plants. For many of the other species groups, panelists supplied maps of species locations or ranges.

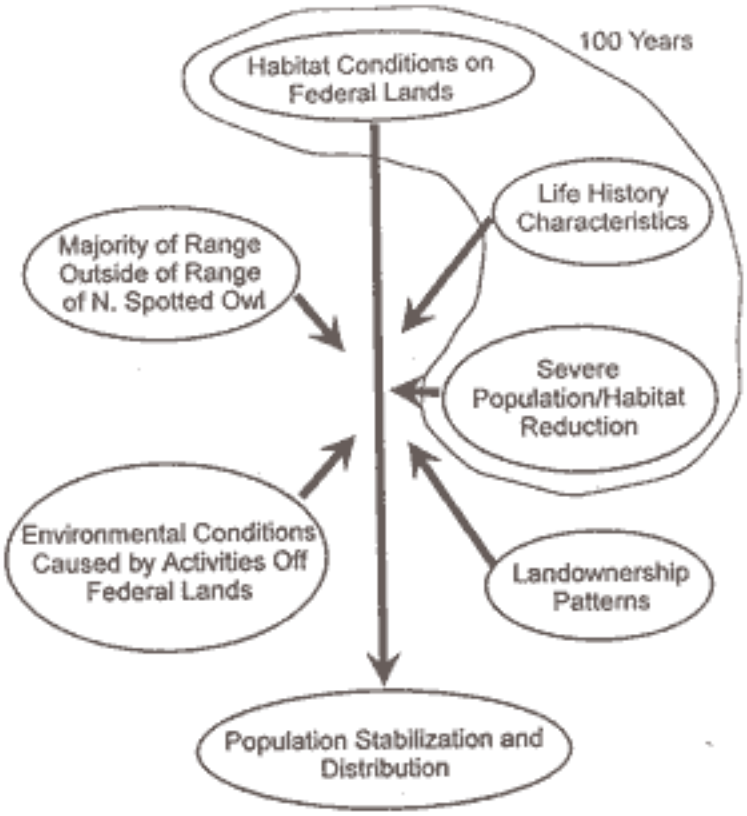

Figure IV-1. Factors that can affect a species population trend and distribution. Factors that are circled were the focus of the species' habitat assessments.

The assessment for each species or group of species proceeded according to the following steps:

1. *Present species profile.* Panelists contributed to a set of facts and assumptions that could be important in assessing the species or species group.

2. *Individuals assess species/or all options.* Panelists were provided with rating forms and allocated 100 likelihood points to outcomes for each option.

3. *Display and discuss assessments.* The facilitator recorded individual assessments on the overhead projector, and encouraged the panel to review patterns across options and across panel members. Each panelist briefly explained his/her reasoning for the rating. The facilitator encouraged discussion among panel members.

4. *Individuals review their ratings and modify as appropriate.* These final ratings were not displayed but were turned in to the panel leader.

5. *Record judgment factors.* The facilitator led the group through a prepared list of option elements (table IV-8) ("factors influencing judgment"), asking for a listing of factors that were most important in arriving at a final rating. In most cases these factors had already been introduced in the

discussion.

6. *Suggest mitigation measures.* The panels to recommended mitigation for species and options that did not provide an average of at least 80 percent likelihood of achieving outcome A. Mitigation meant relatively minor modifications that might enhance habitat conditions provided in the option. These measures did not include major changes that would have made the option more similar to another option. They could conceivably be written into standards and guidelines. Mitigations were suggested that might achieve the 80 percent level, but no attempt was made to re-evaluate the options with the measures applied.

7. *Record other influences on population viability.* The primary assessment was based on the adequacy of habitat provided on federal land. The final step was intended to look at the influence of population-level and nonfederal habitat factors on the overall success of the species. This assessment was not specific to any option. The panelists were asked to indicate which, if any, of the following factors were important: landownership patterns, species range outside the range of the spotted owl, and environmental conditions outside federal lands affecting the population. Panelists described how these factors might influence the overall species population. These discussions generally indicated that other factors would cause negative effects on populations. The discussions are captured in the sections of this chapter describing each species or group of species.

Summary and Evaluation of Panel Results

Ratings were averaged across panelists for each outcome under each option for each species. The panel leader then made the final assessment for each species,

generally accepting the outcomes of the panel. However, before accepting these as the final assessment, he or she evaluated the results to look for any obvious errors or apparent misunderstandings that might have led to illogical results. If any problems were suspected, further evaluations were done based on comparisons of panel results with

Table IV-8. Components of the options considered by the expert panels in their evaluation of habitat outcomes.

Riparian Reserves proposed for the option

Specific distances protected for different stream classes
Overall acreage of the reserves
Distribution of the reserves across the landscape
Management proposed for the reserves
Quality of habitat within the reserves

Other reserves proposed for the option

Overall acreage of the reserves
Size of the individual reserves
Location of specific reserves
Spacing of the reserves
Distribution of the reserves across the landscape
Management proposed for the reserves
Quality of habitat within the reserves

Forests in the Matrix

Overall amount of forest in the Matrix
Distribution of Matrix lands across the

landscape
Proposed management provisions of the Matrix forests

transcripts from the panel discussions, primarily to determine if results were consistent with the discussion. Panel leaders, in conjunction with other team members, could make a final assessment different from the panel results if they determined that errors or misinterpretations had occurred.

To summarize results across species among options, several different data summaries were prepared from the individual species assessments. The first summary is the total number of species that achieved each of the four outcomes with a cumulative likelihood of 80 percent or better. For each species, we calculated the cumulative score for each successive outcome from A through D. We determined the outcome where the cumulative score equaled 80 or more. For example, if a species' scores were 60, 25, 10, and S for outcomes A, B, C, and D, respectively, the species would have been tallied as achieving outcome B or better; scores of 50, 20, 20, and 10 would have been tallied as outcome C or better. We then summed the number of species that reached the 80 percent cumulative likelihood level at each of the four outcomes.

Second, we determined the likelihood that each species would reach outcome A. We classified this into five equal intervals of likelihood (0-19, 20-39, 40-59, 60-79, and 80-100). We made this determination for each species under each option and summarized the options for that group of species by counting the total number of species that fell into each level.

We compared outcomes of options by using these two kinds of summaries. The first summary -- assessing 80

percent likelihood or greater of achieving outcome A was used because it represents a relatively secure level of providing habitat, and thus a stringent criterion for comparison of options. However, there is no single such level that represents a viable population for all species and circumstances. The 80 percent level was chosen here as a point of comparison only; other levels could also he chosen for comparing options. The information on likelihoods is available and is amenable for such additional comparisons, if desired.

Methods for Assessing the Likelihood of Maintaining a Functional, interconnected Late-Successional Ecosystem

We assessed the potential effect of seven of the options on the late-successional ecosystem in two separate rounds of expert panels. The general process used follows that described for the species assessments in the section “Methods for Assessing Effects of Options on Species’.

Assessments of likelihood of maintaining a functional interconnected late-successional ecosystem were performed by a panel of five experts (see previous section for the general expert panel process). The set of outcomes used in the ecosystem assessment panel differed from the set of outcomes defined for the species panels -- an ecosystem perspective requires different evaluation criteria than a species perspective. The species assessments were based on habitats of specific organisms, while the ecosystem assessment was broader, focusing on the diversity, function, dynamics, and spatial patterns of the ~ ecosystem as a whole system. The ecosystem assessment emphasized the primary producers of the late-successional ecosystem (i.e., the vegetation) and the processes and functions associated with the quantity, quality, and dynamics of those primary producers (i.e., physical,

chemical, and biological environment, including disturbances).

The rating of late-successional ecosystems is based on three attributes that characterize the quantity and quality of the ecosystem. The attributes, which are described in detail later in this chapter, are:

1. Abundance and ecological diversity - the acreage and variety of plant communities and environments.

2. Processes and functions - the ecological actions that lead to the development and maintenance of the ecosystem and the values of the ecosystem for species and populations.

3. Connectivity - the extent to which the landscape pattern of the ecosystem provides for biological flows that sustain animal and plant populations.

Abundance and Ecological Diversity

Abundance of late-successional/old-growth communities and ecosystems refers to the total acreage of forest meeting structural, functional, or minimum age criteria based on sub-regional ecological conditions and definitions. These standards define forests corresponding to the maturation, transition, - and shifting, small gap stages of late-successional/old-growth forest development (see section on Ecological Principles for Management of Late-Successional Forests for a description of these forest development stages). In the central western Cascades these conditions are typically found in stands over 80 years of age.

Ecological diversity of late-successional forest ecosystems includes the occurrence of the full range of late-successional and old-growth stages (maturation, transition, and shifting, small gap and variants of these) that can develop following severe disturbance. Ecological diversity also includes the distribution represented in late-successional and old-growth communities (geographic, climatic, elevation, topographic, edaphic).

Outcome 1: Late-successional and old-growth ecosystem abundance and ecological diversity on federal lands is at least as high as the long-term average (see below for discussion) prior to logging and extensive fire suppression.

Long-term is defined as a period of at least 200 to 1,000 years or the time over which the full potential range of late-successional and old-growth communities and ecosystems can develop following severe disturbance. Relatively large areas (e.g., 50,000 to 100,000 acres) would still occur in which the abundance and distribution of late-successional forests are well below the regional average for long periods. However, within each physiographic province, the abundance would be at least as high as province-level long-term averages, which might be higher or lower than the regional long-term average.

Outcome 2: Late-successional and old-growth ecosystem abundance and ecological diversity on federal lands is less than the long-term average conditions (prior to logging and extensive fire-suppression) but within the typical range of conditions that occurred during previous centuries.

Abundance and distribution would be at least as high

as the long-term average of the centurial-low values (see discussion below). Ecological diversity is characterized by presence of a wide range of late-successional stages. Distribution is characterized by presence in all physiographic provinces and elevations but with larger gaps in distribution than in outcome 1.

Outcome 3: Late-successional and old-growth ecosystem abundance and ecological diversity on federal lands is considerably below the typical range of conditions that have occurred during the previous centuries but some provinces are within the range of variability.

The ecological diversity (age class diversity) may be limited to lust the younger stages of late-successional ecosystems. Late-successional and old-growth communities and ecosystems may be absent from some physiographic provinces or elevations within physiographic provinces and/or occur as scattered remnant patches within provinces.

Outcome 4: Late-successional and old-growth ecosystems are very low in abundance and may he restricted to a few physiographic provinces or elevational bands or localities within provinces.

Late-successional and old-growth communities and ecosystems are absent from most phvsiographic provinces or occur only as small remnant forest patches.

Long-term Averages and Long-term Average Lows

The long-term average regional abundance of late-successional and old-growth communities can only be approximated from a few local studies of fire history.

If we assume that the average regional natural fire rotation was about 250 years for severe fires (those removing 70 percent or more of the basal area), then 60 to 70 percent of the forest area of the region was typically dominated by late-successional and old-growth forests, depending on the age at which “mature’ forest conditions develop (assume a range of 80 to 100 years). Converting this range to a single number, 65 percent, provides an estimate of the long-term average percentage of the regional landscape covered by late-successional forest. This average percentage would certainly vary by physiographic province, with moist, northerly provinces having higher averages than drier provinces with higher fire frequencies.

Our estimate of the natural fire rotation and average coverage by late-successional forest is close to values reported in the literature (Franklin and Spies 1984; USD1 1992c). The total percentage would apply to a wide range of patch sizes, from less than 1 acre to 100,000’s of acres. Most of the total percentage (perhaps 80 percent or more) would probably have occurred as relatively large (greater than 1,000 acres) areas of connected forest.

The average of centurial-low (average of the lows that occur in 100-year periods) coverage by late-successional forest is defined as setting the lower bound of the “typical” range. There is no data from which we could estimate the average low for the preceding 10 centuries. Consequently, this value was estimated based on the subjective opinions of the ecosystem experts. We hypothesized that the average of low amounts might be about 40 percent coverage by late-successional forests, with lower values expected for individual provinces.

Processes and Function

Processes refer to ecological changes or actions that lead to the development and maintenance of late-successional and old-growth ecosystems at all spatial and temporal scales. Examples include: (1) tree establishment, maturation, and death, (2) gap formation and filling, (3) understory development, (4) small and large scale disturbances such as fire and wind, (5) decomposition, (6) nitrogen fixation, (7) canopy interception of energy and matter, and (8) energy and matter transfers between the forest and atmosphere.

Functions, in this case, refer to ecological values of the late-successional ecosystem or its components that (1) are of value to maintenance of populations of species that use these ecosystems and (2) contribute to the diversity and productivity of other ecosystems (e.g. carry over of large dead trees to early successional ecosystems, and storage of carbon in the global ecosystem). Examples include habitat for organisms, climatic buffering, soil development and maintenance of soil productivity through inputs of large woody debris, nitrogen fixation, spread of biotic and abiotic disturbance through landscapes, and source-sink in landscapes for organisms and structures.

Outcome 1: Full range of natural disturbance and vegetative development processes and ecological functions are present at all spatial scales, from microsite to large landscapes.

Outcome 2: Natural disturbance and vegetative development processes and ecological functions occur across a moderately wide range of scales hut are limited at large landscape scales through fire

suppression and limitation of areas where late-successional ecosystems can develop.

Outcome 3: Natural disturbance and vegetative development processes are limited in occurrence to stand and microsite scales. Many stands may he too small or not well-developed enough to sustain the full range of ecological processes and functions associated with late-successional and old-growth ecosystems.

Outcome 4: Natural disturbance and vegetative development processes associated with late-successional and old-growth ecosystems are extremely restricted or absent from most stands and landscapes. Most late-successional and old-growth stands are too small or not well-developed enough to sustain the full range of processes and ecological functions associated with late-successional/old-growth ecosystems.

Connectivity

Connectivity is a measure of the extent to which the landscape pattern of the late-successional/old-growth ecosystem provides for biological and ecological flows that sustain late-successional/old growth animal and plant species across the region. Connectivity does not necessarily mean that the late-successional/old-growth areas have to be physically joined in space -- many late-successional species can move (or he carried) across areas that are not in late-successional ecosystems conditions. Landscape features affecting connectivity of late-successional ecosystems are (1) distance between late--successional/old-growth areas and (2) forest conditions in areas between late-successional/old growth areas.

Outcome 1: Connectivity is very strong, characterized by relatively short distances (less than 6 miles on

average) between late-successional/old-growth areas. Smaller patches of late-successional/old-growth frequently occur. Small patches consist of riparian buffers, green tree retention patches, individual live and dead old-growth trees. The proportion of the landscape covered by late-successional/old-growth conditions of all patch sizes exceeds 0.6, a threshold when many measures of connectivity increase rapidly. At regional scales, phvsiographic provinces are connected by presence of landscapes containing areas of late-successional/old growth forests.

Outcome 2: Connectivity is strong, characterized by moderate distances (less than 12 miles on average) between large late-successional/old growth areas. Smaller patches of late-successional forest occur as described in outcome 1. At regional scales, physiographic provinces are connected by presence of landscapes containing areas of late--successional/old-growth forest. Total proportion of landscape in late-successional/old-growth conditions, including smaller patches is at least 0.5, so that the late-successional condition is still the dominant cover type.

Outcome 3: Connectivity is moderate, characterized by distances of 12-24 miles between large old-growth areas and limited occurrence of smaller patches of late-successional forest in the Matrix. The late-successional forest is at least 25 percent of the landscape, and the Matrix contains some smaller areas for dispersal habitat.

Outcome 4: Connectivity is weak, characterized by wide distances (greater than 24 miles) between old-growth areas and a Matrix in which late-successional/old-growth conditions occur as scattered remnants or are completely absent.

Overall outcome descriptions were obtained by combining the individual attribute outcomes into four overall outcomes for the ecosystem as a whole. The likelihoods of achieving overall outcomes were computed by averaging the likelihoods of individual attribute outcomes.

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Effects of Options on Terrestrial Ecosystems

Amounts of Late-Successional and Old-Growth Forests

The amounts of current late successional and old-growth forests in different land allocations were estimated for the options from various sources (see also section Sources of Information). In Washington and Oregon, the abundance and distribution of late successional forests (forests older than 80 years) were estimated from digital maps derived from satellite imagery classified by Pacific Meridian Resources under contract with the Forest Service. In this data set late-successional forests were defined as stands dominated by conifers at least 21 inches in diameter ('medium and "large" classes in tables IV-9, IV-10, IV-11) including single and multistoried stands. A "small conifer' class (9-20.9 inches in diameter) (tables IV-10, IV-1 1) contains some natural forests over 80 years old but is dominated by younger natural stands and older plantations in low to mid-elevations. On Bureau of Land Management lands in Oregon and on all lands in California, maps of forest conditions derived from air photo interpretation were used to estimate the abundance and distribution of forests dominated by conifers at least 21 inches in diameter. The estimates of late-successional forest acreages derived from these data sets have not been subjected to error analysis and ground-truthing by the Forest Ecosystem Management Assessment Team. Consequently, the estimates should he viewed only as approximations with unknown error. Some spot-checking was done by comparing maps with air photos, and no systematic error was observed.

The options are estimated to protect between 5.9 and 8.5 million acres of late-successional forests in several categories of reserves: Congressionally Withdrawn Administratively- Withdrawn, Late-Successional Reserves, and Riparian Reserves (tables IV-10, IV-1 1). This represents 69 to 100 percent of the current late-successional and old-growth forests on federal lands. The degree of protection varies by state and physiographic province and elevation, with highest percentages protected in the state of Washington and the lowest percentages protected in Oregon.

About 42 to 53 percent of the Late-Successional Reserves are currently covered by late-successional forests depending on the option (table IV-9). This illustrates that the Late--Successional Reserves were drawn around large areas containing a mixture of age classes. Option 1 has a higher percentage of late-successional forest in Late-Successional Reserves than the other options because many of its Reserves were created by drawing boundaries around small concentrations of late-successional forest (LS/OG3s of Johnson et al. 1991). The remaining area of the Reserves is covered by smaller, naturally regenerated conifers, conifer plantations, deciduous forests, younger successional stages following logging, and nonforested areas. The Late-Successional Reserves have a higher percentage of late-successional forest in them than the federal landscape as whole (table IV-9) and the Matrix lands.

Table IV-9. Acreages and percentages of forests dominated by medium and large conifer in different federal land allocations.("Total Reserve" includes Congressionally Withdrawn Areas)

Option	Total federal lands	Late-Successional Reserve	Admin. Withdrawn	Riparian Reserve	Total Reserve	Adaptive Mgt/LS Met.	Matrix
1	8,530,900	6,060,800	0	7,100	8,518,800	0	12,100
	(35%)	(53%)	-	(4%)	(40%)	-	(1%)
2	8,530,900	3,777,800	431,500	561,100	7,281,800	0	1,249,100
	(35%)	(42%)	(28%)	(28%)	(38%)	-	(26%)
3	8,530,900	3,336,000	518,100	602,000	7,310,100	396,100	1,220,800
	(35%)	(42%)	(31%)	(28%)	(37%)	(47%)	(27%)
4	8,530,900	3,553,700	453,800	851,700	7,310,400	0	1,220,500
	(35%)	(42%)	(27%)	(30%)	(37%)	-	(28%)
5	8,530,900	2,982,000	610,700	838,400	6,830,500	0	1,700,400
	(35%)	(43%)	(29%)	(32%)	(37%)	-	(30%)
6	8,530,900	3,220,500	550,900	682,500	6,904,600	0	1,626,300
	(35%)	(43%)	(30%)	(30%)	(37%)	-	(29%)

7	8,530,900	2,559,000	691,700	194,000	5,915,800	0	2,615,100
	(35%)	(43%)	(30%)	(31%)	(37%)	-	(31%)
8	8,530,900	3,220,500	550,900	451,100	6,673,200	0	1,857,700
	(35%)	(43%)	(30%)	(30%)	(37%)	-	(29%)
9	8,530,900	2,975,100	586,600	696,600	6,623,200	457,000	1,450,700
	(35%)	(42%)	(35%)	(31%)	(37%)	(31%)	(30%)
10	8,530,900	3,220,500	550,900	682,500	6,904,600	0	1,626,300
	(35%)	(43%)	(30%)	(30%)	(37%)	-	(29%)

Projections Over Time in Reserves

The proportion of late-successional forest in the Reserves is expected to increase over time under all options. The Reserves currently contain 47 to 58 percent (depending on the option) of younger natural forests and plantation forests. Over time most of these areas probably will develop late-successional characteristics through stand development processes. The future amount of late-successional/old-growth forest will depend on the frequency of large severe disturbances and the occurrence of "typical" stand developmental processes. We are unable to model future amounts of late-successional forests in the Reserves except under the simplest of assumptions (see below).

Analysis of Change for Oregon and Washington

A simulation of forest development in the Reserves was conducted starting with current conditions estimated from satellite imagery classified for the Forest Service by Pacific Meridian Resources. The simulation was applied to the following land allocations in western Oregon and Washington: Congressionally Withdrawn, Administratively Withdrawn, and Late-Successional Reserves (see fig. IV-2). The simulation was based on simple assumptions about growth from one forest cover size class into another and did not include disturbance. It did not take into account that many dense young plantations within the Reserves would probably take longer to develop late-successional conditions, or perhaps not ever develop them. A disturbance correction was applied to the growth output by assuming that 12.5 percent of the reserved areas would be subject to severe disturbance over 50 years. This translates to a 400-year natural disturbance rotation. The simulation assumed that partial fire suppression would occur, driving the natural disturbance rotation longer than the presettlement regional average of about 250 years. Under these assumptions, about 80 percent of the Reserves on average would eventually be covered by forests older than 80 years.

Effects of Options on Ecosystems

The effects of the options on the late successional ecosystem were evaluated in terms of degrees (outcomes 1-4) of ecosystem quantity and quality (abundance, diversity, processes, functions and connectivity). The outcomes were characterized in part in terms of how they compare to hypothesized long-term averages and typical ranges (See Methods for Assessment of Late Successional Ecosystem for further information). Long-term past (last 1000 years) conditions are not the only, or necessarily the best standard by which to evaluate the future late successional ecosystem. However past conditions provide a reference point for current and future conditions and an opportunity for understanding processes that lead to the development and maintenance of the current late successional ecosystem.

None of the options provides for higher than 60 percent likelihood of reaching an outcome in 100 years in which the quality and quantity (as defined by the three attributes) of the overall late successional ecosystem is as at least as high as the hypothesized long-term average condition (Outcome 1) (table TV-12). However, two of the options (3 and 4 in moist provinces) attained at least 80 percent likelihood of reaching an outcome in which the quantity and quality of the overall late-successional ecosystem falls within the hypothesized, typical long-term range of conditions (Outcomes 1 and 2) (fig. IV-3, table IV-13). The other options had a 62-77 percent likelihood or reaching outcomes 1 and 2 combined in moist provinces. No options achieved an 80 percent or higher likelihood of reaching outcome 2 or better in the dry provinces (fig. IV-3, table IV-13).

For individual attributes, none of the options achieved a likelihood of 80 percent or better for outcome 1 for any of the individual attributes (table IV-12). However, Options 1, 3, 4, 5, and 9 had at least one attribute that had an 80 percent or better likelihood of achieving outcomes 1 and 2 combined (table IV-13). For the "process and function" attribute, none of the options achieved an 80 percent or better likelihood for outcome 1 and 2 combined (table IV-13). This occurred primarily because outcomes 1 and 2 under this attribute describe a condition in which larger scale landscape disturbance processes, such as fire, follow long-term natural behavior, which we felt was unlikely. In the dry provinces, no options achieved an 80 percent or greater likelihood for outcome 1 and 2 combined for any attribute (table IV-13). In the moist provinces Options 3, 4, and 9 achieved 62-93 percent likelihood ratings for outcomes I and 2 combined under all three attributes (table IV-13). In the dry provinces, no options achieved a 60 percent or greater likelihood rating for outcomes 1 and 2 under all attributes (table IV-13).

Table IV-10. Current late-successional conifer forest on federal lands in the range of the northern spotted owl by option, by state, and by physiographic province.

	Total		Portion in Late-Successional Reserves		Portion in Administratively Withdrawn Areas		Portion in Riparian Reserves		Portion in Matrix	
State/	Small	Medium/large conifer **	Small	Medium/large conifer **	Small	Medium/large conifer **	Small	Medium/large conifer **	Small	Medium/large conifer **

Physiographic province	conifer single story *	Single story	Multi-story	conifer single story *	Single story	multi-story	conifer single story *	Single story	multi-story	conifer single story *	Single story	Multi-story	conifer single story *	Single story	Multi-story
Option 1															
Washington															
Eastern Cascades	830,100	515,500	432,200	296,800	331,800	214,600	55,700	0	0	68,900	0	0	122,800	0	0
Western Cascades	1,009,000	676,000	515,700	381,100	366,400	306,700	76,100	0	0	73,200	0	0	105,600	0	0
Western Lowlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Olympic Peninsula	485,800	47,400	446,700	143,600	24,400	119,000	1,500	0	0	33,600	0	0	32,800	0	0
Total:	**2,324,900**	**1,238,900**	**1,394,600**	**821,500**	**722,600**	**640,300**	**133,300**	**0**	**0**	**175,700**	**0**	**0**	**261,200**	**0**	**0**
Oregon															
Klamath	596,200	207,500	489,500	337,900	187,800	430,500	23,600	0	0	58,200	100	2,600	78,500	300	5,400
Eastern Cascades	968,900	207,000	81,100	370,700	138,600	56,800	75,300	0	0	75,300	0	700	197,000	0	1,500
Western Cascades	1,165,100	997,900	921,200	457,200	765,500	814,400	87,700	0	0	142,000	300	1,800	198,900	300	2,800
Coast Range	526,100	209,300	140,500	331,500	206,600	136,900	8,100	0	0	91,000	0	1,500	76,700	0	1,700
Willamette Valley	4,300	1,300	800	1,000	1,300	600	0	0	0	1,500	0	100	1,700	0	100
Total:	**3,260,600**	**1,623,000**	**1,633,100**	**1,498,300**	**1,299,800**	**1,439,200**	**194,700**	**0**	**0**	**368,000**	**400**	**6,700**	**552,800**	**600**	**11,500**
California															
Coast	4,700	25,800	9,800	3,000	23,100	7,600	100	0	0	600	0	0	700	0	0
Klamath	140,300	963,200	1,303,900	49,600	658,600	935,800	4,500	0	0	23,500	0	0	25,600	0	0
Cascades	38,500	181,500	157,100	5,500	176,700	157,100	900	0	0	12,800	0	0	17,600	0	0
Total:	**183,500**	**1,170,500**	**1,470,800**	**58,100**	**858,400**	**1,100,500**	**5,500**	**0**	**0**	**36,900**	**0**	**0**	**43,900**	**0**	**0**
Three-State Total:	**5,769,000**	**4,032,400**	**4,498,500**	**2,377,900**	**2,880,800**	**3,180,000**	**333,500**	**0**	**0**	**580,600**	**400**	**6,700**	**857,900**	**600**	**11,500**
Option 2															
Washington															
Eastern Cascades	830,100	515,500	432,200	296,800	196,700	151,000	55,700	21,800	17,600	50,400	28,300	11,500	141,200	85,100	34,400
Western Cascades	1,009,000	676,000	515,700	379,500	253,000	235,800	76,300	37,000	36,000	56,200	25,300	9,300	124,000	51,000	25,600
Western Lowlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Olympic Peninsula	485,800	47,400	446,700	142,500	21,500	112,400	1,500	100	200	28,000	1,100	2,700	39,500	1,600	3,700
Total:	**2,324,900**	**1,238,900**	**1,394,600**	**818,800**	**471,200**	**499,200**	**133,500**	**58,900**	**53,800**	**134,600**	**54,700**	**23,500**	**304,700**	**137,700**	**63,700**
Oregon															
Klamath	596,200	207,500	489,500	279,300	116,100	294,100	24,600	4,500	6,600	66,400	19,500	39,800	127,700	48,000	98,000
Eastern Cascades	968,900	207,000	81,100	368,100	76,600	45,000	75,300	18,100	2,600	54,200	6,500	2,300	220,600	37,500	9,100

Western Cascades	1,165,100	209,300	921,200	427,100	483,200	580,200	88,100	45,200	16,100	109,700	70,400	61,700	260,900	167,200	161,000
Coast Range	526,100	997,900	140,500	301,200	157,200	112,200	8,200	1,400	200	83,100	17,300	9,900	114,700	30,700	17,800
Willamette Valley	4,300	1,300	800	600	600	400	0	0	0	1,400	200	100	2,300	400	200
Total:	**3,260,600**	**1,623,000**	**1,633,100**	**1,376,300**	**833,700**	**1,031,900**	**196,200**	**69,200**	**25,500**	**314,800**	**113,900**	**113,800**	**726,200**	**283,800**	**286,100**
California															
Coast	4,700	25,800	9,800	3,000	16,100	3,000	100	1,000	1,200	400	1,600	1,000	900	4,400	2,400
Klamath	140,300	963,200	1,303,900	49,600	342,300	455,900	4,500	48,400	153,700	16,700	84,200	107,700	32,400	183,800	218,500
Cascades	38,500	181,500	157,100	5,400	84,300	40,200	900	12,300	7,500	9,000	23,600	37,100	21,500	56,500	72,200
Total:	**183,500**	**1,170,500**	**1,470,800**	**58,000**	**442,700**	**499,100**	**5,500**	**61,700**	**162,400**	**26,100**	**109,400**	**145,800**	**54,800**	**244,700**	**293,100**
Three-State Total:	**5,769,000**	**4,032,400**	**4,498,500**	**2,253,100**	**1,747,600**	**2,030,200**	**335,200**	**189,800**	**241,700**	**475,500**	**278,000**	**283,100**	**1,085,700**	**666,200**	**642,900**

State/ Physiographic province	**Total**			**Portion in Late-Successional Reserves**			**Portion in Managed Late-Successional Areas**			**Portion in Administratively Withdrawn Areas**			**Portion in Riparian Reserves**			**Portion in Matrix**		
	Small conifer single story *	Medium/large conifer ** Single story	Medium/large conifer ** Multi-story	Small conifer single story *	Medium/large conifer ** Single story	Medium/large conifer ** multi-story	Small conifer single story *	Medium/large conifer ** Single story	Medium/large conifer ** multi-story	Small conifer single story *	Medium/large conifer ** Single story	Medium/large conifer ** multi-story	Small conifer single story *	Medium/large conifer ** Single story	Medium/large conifer ** Multi-story	Small conifer single story *	Medium/large conifer ** Single story	Medium/large conifer ** Multi-story
Option 3																		
Washington																		
Eastern Cascades	830,100	515,500	432,200	323,600	216,600	160,200	0	0	0	54,200	20,100	16,200	49,900	27,200	11,600	116,400	67,800	26,500
Western Cascades	1,009,000	676,000	515,700	344,500	224,000	217,800	28,700	20,000	7,200	84,100	46,600	47,900	62,900	27,900	10,300	115,900	47,900	23,500
Western Lowlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Olympic Peninsula	485,800	47,400	446,700	143,600	21,700	113,000	0	0	0	1,500	100	200	29,100	1,200	2,600	37,400	1,400	3,300
Total:	**2,324,900**	**1,238,900**	**1,394,600**	**811,700**	**462,300**	**491,000**	**28,700**	**20,000**	**7,200**	**139,800**	**66,800**	**64,300**	**141,900**	**56,300**	**24,500**	**269,700**	**117,100**	**53,300**
Oregon																		
Klamath	596,200	207,500	489,500	228,500	96,100	249,100	43,100	16,800	40,900	33,500	8,100	11,400	66,800	20,300	40,700	126,100	47,000	96,400
Eastern Cascades	968,900	207,000	81,100	374,500	81,200	45,300	0	0	0	73,600	16,800	2,500	57,400	6,300	2,400	212,700	34,300	8,800
Western Cascades	1,165,100	997,900	921,200	303,800	345,400	438,800	104,900	120,200	128,900	106,400	62,800	28,600	120,200	77,500	71,100	250,400	160,100	151,600
Coast Range	526,100	209,300	140,500	325,400	159,300	112,900	600	300	400	8,200	1,700	200	74,100	17,200	9,900	98,900	28,100	16,800
Willamette Valley	4,300	1,300	800	500	600	400	0	100	0	0	0	0	1,400	200	100	2,300	400	200
Total:	**3,260,600**	**1,623,000**	**1,633,100**	**1,232,700**	**682,600**	**846,500**	**148,600**	**137,400**	**170,200**	**221,700**	**89,400**	**42,700**	**319,900**	**121,500**	**124,200**	**690,400**	**269,900**	**273,800**
California																		
Coast	4,700	25,800	9,800	3,000	16,100	3,700	0	0	0	100	1,000	500	500	1,900	1,300	900	4,200	2,100
Klamath	140,300	963,200	1,303,900	43,800	311,100	394,300	4,500	21,500	39,800	5,800	58,000	175,600	18,100	97,100	122,800	31,000	170,900	203,300

Cascades	38,500	181,500	157,100	5,400	84,300	44,100	0	0	0	900	12,300	7,500	9,000	23,600	35,800	21,500	56,500	69,700
Total:	**183,500**	**1,170,500**	**1,470,800**	**52,200**	**411,500**	**442,100**	**4,500**	**21,500**	**39,800**	**6,800**	**71,300**	**183,600**	**27,600**	**122,600**	**159,900**	**53,400**	**231,600**	**275,100**
Three-State Total:	**5,769,000**	**4,032,400**	**4,498,500**	**2,096,600**	**1,556,400**	**1,779,600**	**181,800**	**178,900**	**217,200**	**368,300**	**227,500**	**290,600**	**489,400**	**300,400**	**308,600**	**1,013,500**	**618,600**	**602,200**
Option 4																		
Washington																		
Eastern Cascades	830,100	515,500	432,200	312,600	206,200	158,800	0	0	0	61,800	21,200	16,800	58,200	34,900	13,400	111,500	69,500	25,600
Western Cascades	1,009,000	676,000	515,700	371,700	251,000	239,100	0	0	0	76,600	37,500	34,900	81,300	35,300	12,600	106,500	42,500	20,200
Western Lowlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Olympic Peninsula	485,800	47,400	446,700	151,000	22,100	115,100	0	0	0	1,200	100	0	30,000	1,100	2,000	29,300	1,100	1,900
Total:	**2,324,900**	**1,238,900**	**1,394,600**	**835,300**	**479,300**	**513,000**	**0**	**0**	**0**	**139,600**	**58,800**	**51,700**	**169,500**	**71,300**	**28,000**	**247,300**	**113,100**	**47,700**
Oregon																		
Klamath	596,200	207,500	489,500	248,800	109,500	274,400	0	0	0	32,100	5,800	9,900	84,500	26,700	56,500	132,600	46,200	97,800
Eastern Cascades	968,900	207,000	81,100	288,600	68,800	39,400	0	0	0	110,400	22,200	5,600	91,200	9,800	4,100	228,100	37,800	9,900
Western Cascades	1,165,100	997,900	921,200	338,900	387,800	477,200	0	0	0	102,900	53,000	24,800	182,800	134,500	124,300	261,100	190,700	192,600
Coast Range	526,100	209,300	140,500	332,600	170,500	119,600	0	0	0	8,100	1,700	200	90,200	15,700	9,300	76,300	18,700	10,900
Willamette Valley	4,300	1,300	800	500	600	400	0	0	0	0	0	0	1,800	300	200	2,000	400	200
Total:	**3,260,600**	**1,623,000**	**1,633,100**	**1,209,400**	**737,200**	**911,000**	**0**	**0**	**0**	**253,500**	**82,700**	**40,500**	**450,500**	**187,000**	**194,400**	**700,100**	**293,800**	**311,400**
California																		
Coast	4,700	25,800	9,800	3,000	17,100	4,100	0	0	0	200	1,300	200	600	1,900	1,300	500	2,700	1,900
Klamath	140,300	963,200	1,303,900	48,200	335,200	424,100	0	0	0	5,200	46,900	151,100	23,600	123,000	163,800	26,300	153,500	196,900
Cascades	38,500	181,500	157,100	6,300	88,700	44,000	0	0	0	700	12,900	7,700	12,500	31,500	49,500	17,300	43,600	55,900
Total:	**183,500**	**1,170,500**	**1,470,800**	**57,500**	**441,000**	**472,200**	**0**	**0**	**0**	**6,100**	**61,100**	**159,000**	**36,700**	**156,400**	**214,600**	**44,100**	**199,800**	**254,700**
Three-State Total:	**5,769,000**	**4,032,400**	**4,498,500**	**2,102,200**	**1,657,500**	**1,896,200**	**0**	**0**	**0**	**399,200**	**202,600**	**251,200**	**656,700**	**414,700**	**437,000**	**991,500**	**606,700**	**613,800**

State/ Physiographic province	**Total**			**Portion in Late-Successional Reserves**			**Portion in Administratively Withdrawn Areas**			**Portion in Riparian Reserves**			**Portion in Matrix**		
	Small conifer single story *	Medium/large conifer ** Single story	Medium/large conifer ** Multi-story	Small conifer single story *	Medium/large conifer ** Single story	Medium/large conifer ** multi-story	Small conifer single story *	Medium/large conifer ** Single story	Medium/large conifer ** multi-story	Small conifer single story *	Medium/large conifer ** Single story	Medium/large conifer ** Multi-story	Small conifer single story *	Medium/large conifer ** Single story	Medium/large conifer ** Multi-story
Option 5															
Washington															
Eastern Cascades	830,100	515,500	432,200	220,500	174,800	129,900	106,400	37,200	36,400	61,600	33,500	14,500	155,500	86,200	33,700

Western Cascades	1,009,000	676,000	515,700	323,100	215,600	221,200	89,600	47,800	40,800	84,000	40,000	15,300	139,200	63,000	29,400
Western Lowlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Olympic Peninsula	485,800	47,400	446,700	151,000	22,100	115,100	1,200	100	0	26,000	1,000	1,700	33,300	1,200	2,100
Total:	**2,324,900**	**1,238,900**	**1,394,600**	**694,600**	**412,500**	**466,200**	**197,200**	**85,100**	**77,200**	**171,600**	**74,500**	**31,500**	**328,000**	**150,400**	**65,200**
Oregon															
Klamath	596,200	207,500	489,500	225,600	96,300	245,800	36,200	8,300	14,700	80,600	25,300	54,500	155,700	58,200	123,600
Eastern Cascades	968,900	207,000	81,100	140,800	30,500	20,900	159,900	41,500	10,300	90,900	10,500	5,500	326,500	56,100	22,300
Western Cascades	1,165,100	997,900	921,200	214,900	250,600	320,300	127,900	72,300	52,100	176,200	147,100	141,100	366,700	296,000	305,500
Coast Range	526,100	209,300	140,500	331,700	170,300	119,400	8,100	1,700	200	71,300	13,100	7,700	96,100	21,600	12,900
Willamette Valley	4,300	1,300	800	200	400	200	0	0	100	1,500	300	200	2,600	600	300
Total:	**3,260,600**	**1,623,000**	**1,633,100**	**913,200**	**548,100**	**706,600**	**332,100**	**123,800**	**77,400**	**420,500**	**196,300**	**209,000**	**947,600**	**432,500**	**464,600**
California															
Coast	4,700	25,800	9,800	3,000	17,100	4,100	200	1,300	200	400	1,500	1,200	700	3,100	2,000
Klamath	140,300	963,200	1,303,900	36,000	267,500	384,900	8,200	62,500	161,500	21,200	118,800	144,900	37,800	209,800	244,600
Cascades	38,500	181,500	157,100	4,500	85,500	37,700	800	13,200	8,500	9,300	23,000	37,700	22,200	55,000	73,200
Total:	**183,500**	**1,170,500**	**1,470,800**	**43,500**	**370,100**	**426,700**	**9,200**	**77,000**	**170,200**	**30,900**	**143,300**	**183,800**	**60,700**	**267,900**	**319,800**
Three-State Total:	**5,769,000**	**4,032,400**	**4,498,500**	**1,651,300**	**1,330,700**	**1,599,500**	**538,500**	**285,900**	**324,800**	**623,000**	**414,100**	**424,300**	**1,336,300**	**850,800**	**849,600**

Option 6 and 10

Washington															
Eastern Cascades	830,100	515,500	432,200	249,500	168,100	135,200	73,300	29,400	21,600	57,500	33,300	14,400	163,800	101,000	43,400
Western Cascades	1,009,000	676,000	515,700	344,500	224,000	217,800	84,100	46,600	47,900	67,200	32,700	11,700	140,200	63,100	29,300
Western Lowlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Olympic Peninsula	485,800	47,400	446,700	143,600	21,700	113,000	1,500	100	200	27,600	1,100	2,400	38,900	1,500	3,400
Total:	**2,324,900**	**1,238,900**	**1,394,600**	**737,600**	**413,800**	**466,000**	**158,900**	**76,100**	**69,700**	**152,300**	**67,100**	**28,500**	**342,900**	**165,600**	**76,100**
Oregon															
Klamath	596,200	207,500	489,500	228,500	96,100	249,100	33,500	8,100	11,400	78,000	23,700	50,200	158,100	60,300	127,900
Eastern Cascades	968,900	207,000	81,100	260,300	61,100	36,400	118,700	25,700	7,300	69,000	7,600	3,000	270,200	44,200	12,400
Western Cascades	1,165,100	997,900	921,200	303,800	345,400	438,800	106,400	62,800	28,600	139,600	105,400	95,500	335,800	252,500	256,100
Coast Range	526,100	209,300	140,500	325,400	159,300	112,900	8,200	1,700	200	72,000	16,300	9,600	101,700	29,300	17,400
Willamette Valley	4,300	1,300	800	500	600	400	0	0	0	1,400	200	100	2,400	500	200
Total:	**3,260,600**	**1,623,000**	**1,633,100**	**1,118,500**	**662,500**	**837,600**	**266,800**	**98,300**	**47,500**	**360,000**	**153,200**	**158,400**	**868,200**	**386,800**	**414,000**
California															

Coast	4,700	25,800	9,800	3,000	16,100	3,700	100	1,000	500	400	1,600	1,000	900	4,400	2,400
Klamath	140,300	963,200	1,303,900	43,800	311,100	394,300	5,800	58,000	175,600	18,000	90,800	119,900	35,600	198,800	246,100
Cascades	38,500	181,500	157,100	5,000	76,300	39,100	900	16,400	7,800	9,100	24,800	37,400	21,800	59,300	72,800
Total:	**183,500**	**1,170,500**	**1,470,800**	**51,800**	**403,500**	**437,100**	**6,800**	**75,400**	**183,900**	**27,500**	**117,200**	**158,300**	**58,300**	**262,500**	**321,300**
Three-State Total:	**5,769,000**	**4,032,400**	**4,498,500**	**1,907,900**	**1,479,800**	**1,740,700**	**432,500**	**249,800**	**301,100**	**539,800**	**337,500**	**345,200**	**1,269,400**	**814,900**	**811,400**

State/ Physiographic province	**Total**			**Portion in Late-Successional Reserves**			**Portion in Administratively Withdrawn Areas**			**Portion in Riparian Reserves**			**Portion in Matrix**		
	Small conifer single story *	Medium/large conifer ** Single story	Medium/large conifer ** Multi-story	Small conifer single story *	Medium/large conifer ** Single story	Medium/large conifer ** multi-story	Small conifer single story *	Medium/large conifer ** Single story	Medium/large conifer ** multi-story	Small conifer single story *	Medium/large conifer ** Single story	Medium/large conifer ** Multi-story	Small conifer single story *	Medium/large conifer ** Single story	Medium/large conifer ** Multi-story
Option 7															
Washington															
Eastern Cascades	830,100	515,500	432,200	220,500	174,800	129,900	106,400	37,200	36,400	14,200	7,700	3,100	203,000	112,000	45,000
Western Cascades	1,009,000	676,000	515,700	299,400	200,800	199,700	97,600	54,700	52,600	19,400	9,400	3,900	219,600	101,500	50,500
Western Lowlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Olympic Peninsula	485,800	47,400	446,700	127,100	19,100	104,300	3,400	100	500	6,800	400	1,200	74,200	4,700	13,000
Total:	**2,324,900**	**1,238,900**	**1,394,600**	**647,000**	**394,700**	**433,900**	**207,400**	**92,000**	**89,500**	**40,400**	**17,500**	**8,200**	**496,800**	**218,200**	**108,500**
Oregon															
Klamath	596,200	207,500	489,500	107,100	69,600	151,600	73,300	13,500	35,500	21,300	6,700	16,400	296,300	98,400	235,000
Eastern Cascades	968,900	207,000	81,100	140,700	30,500	19,800	159,900	41,500	10,300	19,700	2,200	1,400	397,900	64,400	27,600
Western Cascades	1,165,100	997,900	921,200	211,900	245,700	316,800	127,900	72,400	52,200	37,000	31,000	28,800	508,900	416,900	421,200
Coast Range	526,100	209,300	140,500	236,100	133,200	94,500	9,100	2,800	800	20,900	5,700	3,600	241,100	65,000	41,200
Willamette Valley	4,300	1,300	800	200	100	0	0	0	100	300	100	0	3,800	1,100	600
Total:	**3,260,600**	**1,623,000**	**1,633,100**	**696,000**	**479,100**	**582,700**	**370,200**	**130,200**	**98,900**	**99,200**	**45,700**	**50,200**	**1,448,000**	**645,800**	**725,600**
California															
Coast	4,700	25,800	9,800	3,000	16,800	4,000	200	1,500	300	100	300	200	1,000	4,600	3,100
Klamath	140,300	963,200	1,303,900	33,700	244,400	300,200	8,900	68,300	189,300	4,800	25,700	32,200	55,900	320,200	414,200
Cascades	38,500	181,500	157,100	4,500	85,500	37,700	800	13,200	8,500	2,300	5,600	8,400	29,200	72,400	102,500
Total:	**183,500**	**1,170,500**	**1,470,800**	**41,200**	**346,700**	**341,900**	**9,900**	**83,000**	**198,100**	**7,200**	**31,600**	**40,800**	**86,100**	**397,200**	**519,800**
Three-State Total:	**5,769,000**	**4,032,400**	**4,498,500**	**1,384,200**	**1,220,500**	**1,358,500**	**587,500**	**305,200**	**386,500**	**146,800**	**94,800**	**99,200**	**2,030,900**	**1,261,200**	**1,353,900**

Option 8

Washington															
Eastern Cascades	830,100	515,500	432,200	249,500	168,100	135,200	73,300	29,400	21,600	37,600	21,600	9,200	183,700	112,700	48,500
Western Cascades	1,009,000	676,000	515,700	344,500	224,000	217,800	84,100	46,600	47,900	46,500	22,700	8,100	161,000	73,200	33,000
Western Lowlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Olympic Peninsula	485,800	47,400	446,700	143,600	21,700	113,000	1,500	100	200	21,900	800	1,900	44,500	1,700	3,900
Total:	**2,324,900**	**1,238,900**	**1,394,600**	**737,600**	**413,800**	**466,000**	**158,900**	**76,100**	**69,700**	**106,000**	**45,100**	**19,200**	**389,200**	**187,600**	**85,400**
Oregon															
Klamath	596,200	207,500	489,500	228,500	96,100	249,100	33,500	8,100	11,400	46,000	15,100	31,300	190,100	68,900	146,700
Eastern Cascades	968,900	207,000	81,100	260,300	61,100	36,400	118,700	25,700	7,300	41,800	4,500	1,900	297,500	47,300	13,400
Western Cascades	1,165,100	997,900	921,200	303,800	345,400	438,800	106,400	62,800	28,600	88,700	65,600	59,800	386,700	292,300	291,800
Coast Range	526,100	209,300	140,500	325,400	159,300	112,900	8,200	1,700	200	49,000	11,400	6,500	124,600	34,100	20,500
Willamette Valley	4,300	1,300	800	500	600	400	0	0	0	900	200	100	2,900	500	300
Total:	**3,260,600**	**1,623,000**	**1,633,100**	**1,118,500**	**662,500**	**837,600**	**266,800**	**98,300**	**47,500**	**226,400**	**96,800**	**99,600**	**1,001,800**	**443,100**	**472,700**
California															
Coast	4,700	25,800	9,800	3,000	16,100	3,700	100	1,000	500	300	1,000	600	1,100	5,000	2,800
Klamath	140,300	963,200	1,303,900	43,800	311,100	394,300	5,800	58,000	175,600	11,100	56,500	87,700	42,500	233,100	278,300
Cascades	38,500	181,500	157,100	5,000	76,300	39,100	900	16,400	7,800	5,900	16,000	28,600	25,000	68,100	81,600
Total:	**183,500**	**1,170,500**	**1,470,800**	**51,800**	**403,500**	**437,100**	**6,800**	**75,400**	**183,900**	**17,300**	**73,500**	**116,900**	**68,600**	**306,200**	**362,700**
Three-State Total:	**5,769,000**	**4,032,400**	**4,498,500**	**1,907,900**	**1,479,800**	**1,740,700**	**432,500**	**249,800**	**301,100**	**349,700**	**215,400**	**235,700**	**1,459,600**	**936,900**	**920,800**

State/ Physiographic province	**Total**			**Portion in Late-Successional Reserves**			**Portion in Adaptive Management Areas**			**Portion in Administratively Withdrawn Areas**			**Portion in Riparian Reserves**			**Portion in Matrix**		
	Small conifer single story *	Medium/large conifer ** Single story	Medium/large conifer ** Multi-story	Small conifer single story *	Medium/large conifer ** Single story	Medium/large conifer ** multi-story	Small conifer single story *	Medium/large conifer ** Single story	Medium/large conifer ** multi-story	Small conifer single story *	Medium/large conifer ** Single story	Medium/large conifer ** multi-story	Small conifer single story *	Medium/large conifer ** Single story	Medium/large conifer ** Multi-story	Small conifer single story *	Medium/large conifer ** Single story	Medium/large conifer ** Multi-story
Option 9																		
Washington																		
Eastern Cascades	830,100	515,500	432,200	266,700	172,100	116,300	5,600	14,000	19,000	69,000	25,000	29,800	64,300	35,300	15,500	138,500	85,400	34,000
Western Cascades	1,009,000	676,000	515,700	291,500	193,700	208,200	81,100	44,500	39,600	68,000	34,400	23,900	70,600	35,000	11,500	124,700	58,800	23,500
Western Lowlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Olympic Peninsula	485,800	47,400	446,700	130,300	21,700	114,400	81,000	2,600	4,600	0	0	0	100	0	0	100	0	0

Total:	**2,324,900**	**1,238,900**	**1,394,600**	**688,500**	**387,500**	**438,900**	**167,700**	**61,100**	**63,200**	**137,000**	**59,400**	**53,700**	**135,000**	**70,300**	**27,000**	**263,300**	**144,200**	**57,500**
Oregon																		
Klamath	596,200	207,500	489,500	186,800	86,500	214,200	99,000	24,700	35,300	26,300	3,400	13,400	73,600	23,400	56,600	112,300	50,200	119,100
Eastern Cascades	968,900	207,000	81,100	238,000	59,000	25,600	0	0	0	122,000	25,100	9,100	80,400	8,800	4,900	277,800	45,700	19,300
Western Cascades	1,165,100	997,900	921,200	257,100	291,900	387,500	31,600	54,800	55,000	117,300	66,200	37,500	149,300	111,300	95,000	330,500	241,800	244,100
Coast Range	526,100	209,300	140,500	300,200	129,800	90,800	69,400	33,500	17,300	6,500	1,700	200	53,800	14,800	11,200	77,300	26,800	20,600
Willamette Valley	4,300	1,300	800	200	200	0	0	0	0	0	0	100	1,500	400	200	2,500	700	400
Total:	**3,260,600**	**1,623,000**	**1,633,100**	**982,300**	**567,400**	**718,100**	**200,000**	**113,000**	**107,600**	**272,100**	**96,400**	**60,300**	**358,600**	**158,700**	**167,900**	**800,400**	**365,200**	**403,500**
California																		
Coast	4,700	25,800	9,800	3,000	17,100	3,800	0	0	0	200	1,400	600	400	1,500	1,200	700	3,100	2,000
Klamath	140,300	963,200	1,303,900	45,200	307,700	397,600	12,300	84,500	27,600	3,400	47,500	159,900	16,500	83,000	130,600	25,900	136,000	220,200
Cascades	38,500	181,500	157,100	6,700	91,300	45,700	0	0	0	1,000	14000	7,500	8,500	21,100	35,300	20,500	50,400	68,600
Total:	**183,500**	**1,170,500**	**1,470,800**	**54,900**	**416,100**	**447,100**	**12,300**	**84,500**	**27,600**	**4,600**	**62,900**	**168,000**	**25,400**	**105,600**	**167,100**	**47,100**	**189,500**	**290,800**
Three-State Total:	**5,769,000**	**4,032,400**	**4,498,500**	**1,725,700**	**1,371,000**	**1,604,100**	**380,000**	**258,600**	**198,400**	**413,700**	**218,700**	**282,000**	**519,000**	**334,600**	**362,000**	**1,110,800**	**698,900**	**751,800**

*Stands generally characterized by trees 9.0 - 29.0 inches in diameter at breast height (dbh)
* Stands generally characterized by trees 21.0 inches in diameter at breast height (dbh) or larger

Table IV-11. Existing acres of federal forest by cover type by land allocation for each option by state within the range of the northern spotted owl.

		Conifer dominated				**Hardwood dominated**		
				Medium/large conifer				
Option/allocation/state	Grass/ shrub	Seedling, sapling, poles	Small conifer single story	Single story	Multi story	Small	Medium	Large
Congressionally Withdrawn Areas								
Washington	31,200	257,300	933,300	516,300	754,400	13,600	0	0
Oregon	4,100	55,200	647,000	322,200	175,700	8,900	0	0
California	28,100	16,200	39,100	312 000	370,200	3 700	10,000	6,100
Total:	**63400**	**328700**	**1619400**	**838500**	**1300300**	**22500**	**10000**	**6100**
Option 1								
Late-Successional Reserves								
Washington	180,600	384,500	821,500	122,500	640,300	3,100	600	0

Oregon	116,500	947,600	1,498,200	1,299,700	1,439,300	44,500	200	0
California	71,300	149,400	58,000	858,500	1,100,500	31,100	27,300	15,800
Total:	**368,400**	**1,481,500**	**2,377,700**	**2,280,700**	**3,180,100**	**78,700**	**28,100**	**15,800**
Administratively Withdrawn Areas								
Washington	23,800	79,600	133,200	0	0	500	0	0
Oregon	6,700	36,000	194,600	0	0	1,000	0	0
California	28,100	27,600	5,400	0	0	3,600	8,100	5,200
Total:	**58,600**	**143,200**	**333,200**	**0**	**0**	**5,100**	**8,100**	**5,200**
Option 2								
Late-Successional Reserves								
Washington	180,300	382,600	818,700	471,200	499,300	3,000	600	0
Oregon	114,700	932,900	1,376,300	833,700	1,031,800	42,000	100	0
California	71,300	149,400	58,000	442,700	499,100	31,100	27,300	15,800
Total:	**366,300**	**1,464,900**	**2,253,000**	**1,747,600**	**2,030,200**	**76,100**	**28,000**	**15,800**
Administratively Withdrawn Areas								
Washington	23,800	79,700	133,400	58,900	53,800	500	0	0
Oregon	6,800	36,200	196,200	69,200	25,500	1,100	0	0
California	28,100	27,600	5,400	61,700	162,400	3,600	8,100	5,200
Total:	**58,700**	**143,500**	**335,000**	**189,800**	**241,700**	**5,200**	**8,100**	**5,200**
Option 3								
Late-Successional Reserves								
Washington	179,000	371,100	811,700	462,300	491,000	3,100	600	0
Oregon	92,800	771,300	1,232,700	682,500	846,500	43,100	100	0
California	64,500	137,300	52,100	411,500	442,000	30,700	26,000	14,700
Total:	**336,300**	**1,279,700**	**2,096,500**	**1,556,300**	**1,779,500**	**76,900**	**26,700**	**14,700**
Managed Late-successional Areas								
Washington	5,300	17,900	28,700	20,000	7,200	0	0	0
Oregon	20,600	155,100	148,700	137,300	170,100	600	0	0
California	3,200	10,300	4,500	21,500	39,800	200	900	600

Total:	**29,100**	**183,300**	**181,900**	**178,800**	**217,100**	**800**	**900**	**600**
Administratively Withdrawn Areas								
Washington	25,900	83,700	139,700	66,700	64,200	500	0	0
Oregon	9,100	47,700	221,800	89,400	42,600	1,100	0	0
California	31,700	29,700	6,800	71,300	183,600	3,800	8,500	5,700
Total:	**66,700**	**161,100**	**368,300**	**227,400**	**290,400**	**5,400**	**8,500**	**5,700**

		Conifer dominated				**Hardwood dominated**		
	Grass/	Seedling,	Small	Medium/large conifer				
Option/allocation/state	shrub	sapling, poles	conifer single story	Single story	Multi story	Small	Medium	Large
Congressionally Withdrawn Areas								
Washington	31,200	257,300	933,300	516,300	754,400	13,600	0	0
Oregon	4,100	55,200	647,000	322,200	175,700	8,900	0	0
California	28,100	16,200	39,100	312,000	370,200	3,700	10,000	6,100
Total:	**63,400**	**328,700**	**1,619,400**	**1,150,500**	**1,300,300**	**26,200**	**10,000**	**6,100**

Option 4

Late-Successional Reserves*								
Washington	190,300	400,500	835,300	479,300	512,900	3,000	600	0
Oregon	95,700	862,000	1,209,400	737,200	911,100	43,700	100	0
California	62,500	145,800	57,500	441,100	472,300	32,800	15,300	13,200
Total:	**348,500**	**1,408,300**	**2,102,200**	**1,657,600**	**1,896,300**	**79,500**	**16,000**	**13,200**
Administratively Withdrawn Areas								
Washington	16,800	75,200	139,500	58,800	51,700	400	0	0
Oregon	10,200	41,900	253,600	82,700	40,400	1,100	0	0
California	37,100	24,900	6,100	61,200	159,000	4,900	11,000	7,600
Total:	**64,100**	**142,000**	**399,200**	**202,700**	**251,100**	**6,400**	**11,000**	**7,600**

Option 5

Late-Successional Reserves*								
Washington	169,300	345,200	694,600	412,600	466,300	2,600	500	0
Oregon	72,000	700,400	913,300	548,000	706,500	43,200	100	0
California	59,500	130,100	43,600	370,100	426,700	32,200	13,500	11,700
Total:	**300,800**	**1,175,700**	**1,651,500**	**1,330,700**	**1,599,500**	**78,000**	**14,100**	**11,700**
Administratively Withdrawn Areas								
Washington	21,200	89,700	197,200	85,100	77,300	500	0	0
Oregon	13,600	56,500	332,100	123,900	77,300	1,100	0	0
California	38,500	27,700	9,200	77,000	170,300	5,200	11,100	8,500
Total:	**73,300**	**173,900**	**538,500**	**286,000**	**324,900**	**6,800**	**11,100**	**8,500**

Option 6 and 10**

Late-Successional Reserves								
Washington	166,500	348,300	737,500	413,800	466,000	3,100	600	0
Oregon	89,600	762,000	1,118,500	662,400	837,500	43,000	100	0
California	64,500	135,700	51,700	403,500	431,100	30,700	13,500	14,700
Total:	**320,600**	**1,246,000**	**1,907,700**	**1,479,700**	**1,734,600**	**76,800**	**14,200**	**14,700**
Administratively Withdrawn Areas								
Washington	26,600	86,900	158,900	76,100	69,600	500	0	0
Oregon	10,700	48,100	266,900	98,300	47,400	1,100	0	0
California	31,700	29,700	6,800	75,300	183,900	3,800	11,200	5,700
Total:	**69,000**	**164,700**	**432,600**	**249,700**	**300,900**	**5,400**	**11,200**	**5,700**

		Conifer dominated				**Hardwood dominated**		
			Small	Medium/large conifer				
Option/allocation/state	Grass/ shrub	Seedling, sapling, poles	conifer single story	Single story	Multi story	Small	Medium	Large
Congressionally Withdrawn Areas								
Washington	31,200	257,300	933,300	516,300	754,400	13,600	0	0
Oregon	4,100	55,200	647,000	322,200	175,700	8,900	0	0
California	28,100	16,200	39,100	312,000	370,200	3,700	10,000	6,100

Total:	**63,400**	**328,700**	**1,619,400**	**1,150,500**	**1,300,300**	**26,200**	**10,000**	**6,100**

Option 7

Late-Successional Reserves*								
Washington	157,200	313,100	647,000	394,800	434,000	1,500	500	0
Oregon	55,200	559,800	696,000	479,000	582,800	17,000	100	0
California	58,800	110,300	41,200	346,700	341,800	32,100	12,200	11,700
Total:	**271,200**	**983,200**	**1,384,200**	**1,220,500**	**1,358,600**	**50,600**	**12,800**	**11,700**
Administratively Withdrawn Areas								
Washington	22,100	96,700	207,400	92,000	89,500	700	0	0
Oregon	16,400	79,100	370,300	130,200	98,800	5,000	0	0
California	38,700	33,100	9,900	82,900	198,200	5,400	11,400	8,500
Total:	**77,200**	**208,900**	**587,600**	**305,100**	**386,500**	**11,100**	**11,400**	**8,500**

Option 8

Late-Successional Reserves								
Washington	166,500	348,300	737,500	413,800	466,000	3,100	600	0
Oregon	89,600	762,000	1,118,500	662,400	837,500	43,000	100	0
California	64,500	135,700	51,700	403,500	437,100	30,700	13,500	14,700
Total:	**320,600**	**1,246,000**	**1,907,700**	**1,479,700**	**1,740,600**	**76,800**	**14,200**	**14,700**
Administratively Withdrawn Areas								
Washington	26,600	86,900	158,900	76,100	69,600	500	0	0
Oregon	10,700	48,100	266,900	98,300	47,400	1,100	0	0
California	31,700	29,700	6,800	75,300	183,900	3,800	11,200	5,700
Total:	**69,000**	**164,700**	**432,600**	**249,700**	**300,900**	**5,400**	**11,200**	**5,700**

Option 9

Late-Successional Reserves								
Washington	155,600	313,900	688,600	387,500	438,900	2,500	700	0
Oregon	69,800	658,500	982,300	567,400	718,100	20,000	100	0
California	65,200	142,200	55,000	416,000	447,100	32,200	14,100	12,100

Total:	**290,600**	**1,114,600**	**1,725,900**	**1,370,900**	**1,604,100**	**54,700**	**14,900**	**12,100**
Adaptive Management Areas								
Washington	44,600	113,000	167,700	61,100	63,200	800	0	0
Oregon	23,900	180,900	200,100	113,000	107,600	38,800	0	0
California	200	22,200	12,300	84,500	27,600	300	2,200	0
Total:	**68,700**	**316,100**	**380,100**	**258,600**	**198,400**	**39,900**	**2,200**	**0**
Administratively Withdrawn Areas								
Washington	15,800	65,400	137,100	59,400	53,700	200	0	0
Oregon	11,300	45,400	272,100	96,400	60,200	1,200	0	0
California	36,100	26,500	4,600	62,900	168,000	5,100	11,200	8,000
Total:	**63,200**	**137,300**	**413,800**	**218,700**	**281,900**	**6,500**	**11,200**	**8,000**

Diameter at breast height (dbh) for each size class:

Oregon, Western Washington		Eastern Washington		California
seedling	< 0.9 inches	seedling	< 0.9 inches	Definitions vary - see text.
sapling	1.0-4.9 inches	sapling	1.0-4.9 inches	
pole	5.0-8.9 inches	pole	5.0-8.9 inches	
small	9.0-20.9 inches	small	9.0-15.9 inches	
medium	21.0-31.9 inches	medium	16.0-23.9 inches	
large	> 31.9 inches	large	> 23.9 inches	

* Includes 147,000 acres of Managed Late-Successional Areas

** Table information the same for Option 6 and Option 10

Table IV-12. Projected future likelihoods for ecosystem outcomes under land management options

	Option 1	Option 3	Option 4	Option 5	Option 7	Option 8	Option 9
Ecosystem Outcomes	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4
Overall Ecosystem							
Dry Provinces	23 36 31 10	25 44 27 4	22 43 30 5	18 42 34 6	12 40 42 6	13 38 44 5	18 45 32 5
Moist Provinces	46 31 18 5	39 46 14 1	39 43 16 2	30 43 23 4	24 38 32 6	27 41 27 5	33 44 20 3

Abundance and Diversity						
Dry Provinces	28 38 18 16	35 40 19 6	32 43 19 6	24 45 25 6	20 44 26 10	26 38 30 6	24 45 25 6
Moist Provinces	53 33 12 2	44 48 6 2	49 44 5 2	36 44 18 2	30 36 24 10	31 38 23 8	42 34 22 2
Process and Function							
Dry Provinces	2 32 56 10	4 49 43 4	2 44 50 4	6 41 49 4	4 36 56 4	2 36 56 6	4 49 43 4
Moist Provinces	12 40 36 12	8 63 27 2	8 54 36 2	8 51 39 2	6 46 46 2	8 51 38 3	8 67 23 2
Connectivity							
Dry Provinces	38 38 18 6	36 42 20 2	33 43 22 2	25 41 27 7	12 39 43 6	12 41 45 2	25 41 27 7
Moist Provinces	72 20 6 2	64 26 8 2	59 31 8 2	47 33 13 7	37 31 26 6	41 33 20 6	48 32 16 4

Interpretation of outcomes under each option is explained in the text. Overall Ecosystem rating is an average of the likelihoods of three attributes

Likelihood values are expressed as percentages that total to 100 for a given attribute within an option. Numbers displayed may vary due to rounding errors.
See text for fuller explanation and discussion of the rating scale and outcomes.

Table IV-13. Likelihood of achieving outcomes 1 and 2 combined for different ecosystem attributes and average of attributes. Numbers in bold are at least 80 percent likelihood.
Attributes: A = Abundance and Diversity; P = Process and Function; C = Connectivity.

	Moist Provinces				Dry Provinces			
Option	A	P	C	Average	A	P	C	Average
1	186	52	92	77	66	34	76	59
3	92	71	90	85	75	53	78	69
4	93	62	90	82	75	46	76	65
5	80	59	80	73	69	47	66	60
7	66	50	68	62	64	41	51	52
8	69	59	74	68	64	38	53	51

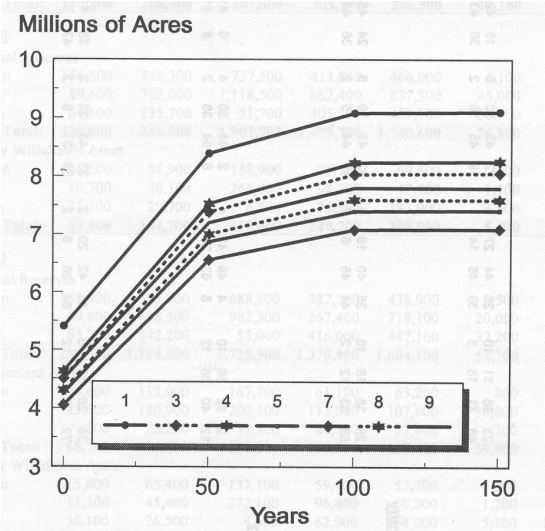

Figure IV-2. Projected acreage of late-successional forest (stands with dominant trees at least 21 inches in diameter) on Congressionally and Administratively Withdrawn Areas and in Late-successional Reserves in Oregon and Washington over the next 150 years.

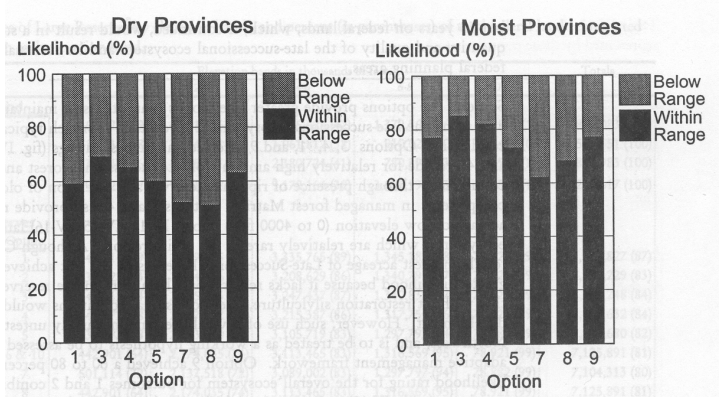

Figure IV-3. Likelihood of achieving outcomes in which most attributes of the late successional ecosystem fall within the typical range of variability (Outcomes 1 and 2) and in which most attributes of the late successional ecosystem fall below the typical range of variability (Outcomes 3 and 4) by dry and moist provinces.

The results indicate that none of the options had a 60 percent or greater likelihood of producing a late-successional/old-growth ecosystem with attributes that approximate at least long-term average conditions (outcome 1). This occurs primarily because 100 years is not long enough for the cutover landscapes to return to late-successional conditions that approximate prelogging conditions. Many late-successional attributes require 200 to 500 years to develop. In addition, many larger scale disturbance processes will probably not occur under any of the options, at least not to the extent that they would in an environment that was not influenced by humans.

Some options do have an 80 percent or greater likelihood of achieving an overall ecosystem condition at 100 years that is hypothesized to fall within the typical range of conditions that have occurred over previous centuries (outcomes 1 and 2 combined) This does not mean, however, that all attributes and stands would meet this condition. Many young forest plantations within Reserves are not developing along typical pathways, and fire suppression has and will alter the stand and landscape-level processes that have been typical of these ecosystems. In general, high rates of logging, forest plantations, fire suppression, ownership patterns, and human population and environmental influences have altered the regional ecosystem on federal lands to the extent that none of the options can provide for a return to conditions that closely match those of previous centuries. However, all of the options reverse the trend of the last 50 years on federal lands, which, if continued, would result in a steep decline in the quantity and quality of the late-successional ecosystem and its eventual loss in many federal planning areas.

Some of the options provide greater likelihoods than others of maintaining and enhancing the late-successional ecosystem at levels that approach typical long-term conditions. Options 3, 4, 1, and 9 received the highest ratings (fig. IV-3). Options 3 and 4 provide for relatively high

amounts of late-successional forest and strong connectivity through presence of riparian Reserves and retention of old-growth components in managed forest Matrix. Options 3 and 4 also provide relatively high acreage of low elevation (0 to 4000 feet) (tables IV-14, IV-15, IV-16) late successional ecosystems, which are relatively rare in the entire region. Although Option 1 provides for the highest acreage of Late-Successional Reserves, it did not achieve an 80 percent or greater likelihood because it lacks restoration silviculture in the reserves. We assumed that without restoration silviculture, late-successional conditions would be retarded in development. However, such use of silviculture remains largely untested in the Pacific Northwest, and is to be treated as a working hypothesis to be assessed by studies in an adaptive management framework. Option 9 achieved a 60 to 80 percent or greater likelihood rating for the overall ecosystem for outcomes 1 and 2 combined in moist provinces (table IV-13). Option 9 might have achieved a higher overall ranking if it provided for more acreage of late-successional ecosystems in the low elevations of Oregon (table IV-14). We felt that the opportunities to increase knowledge about ecosystem function and management in the adaptive management areas of Option 9, actually increased the likelihood that this option would provide late-successional characteristics in the future, given our poor understanding of ecosystem function and the likelihood of future environmental change.

Other reasons for not achieving 80 percent or greater likelihoods for outcome 1 alone or outcomes 1 and 2 combined include:

1. *Inherent dynamics of the ecosystems and environment.* The probabilities of large-scale disturbances and other environmental changes during the next 100 years are high. The region has historically been subjected to large fires and in coastal areas to wind disturbances that could substantially reduce the area and character of late-successional/old-growth forest ecosystems in reserves. Although fire suppression will be practiced, it may not be sufficient to prevent loss of large portions of late-successional/old-growth forests. The risk of large-scale change in Reserves is particularly high in the eastern Cascade provinces and drier portions of the Oregon and California Klamath provinces. The higher risk of large-scale change in these provinces is the primary reason that none of the options achieved an 80 percent or greater likelihood of outcome 1 and 2 combined in the eastern Cascades and Klamath area (table fV-13). In addition to disturbances such as fire and wind, climate change, projected to occur under increasing carbon dioxide levels in the atmosphere during the next century', could have widespread direct and indirect effects on ecosystem processes, functions, and stability (Franklin et al. 1991).

Potential mitigations:

Northern and Western provinces: None

Eastern Cascades and Klamath Provinces: Use active fire management, including thinning and prescribed fire to reduce risk of large-scale loss of late-successional/old-growth and restore fire-dependent types of old-growth. Manage entire public landbase to achieve late-successional/old growth objectives at a landscape scale rather than just designated reserves. Allow for more dynamic and less stable levels of late-successional/old growth habitat to reflect the dynamic character of the landscape. These mitigation measures could increase the ratings for outcomes 1 and 2 combined to at least 60-79 percent.

Table IV-14. Acres of Large Reserves[a] by elevation bands, and percent (in parentheses) of total federal land represented by those reserves in each elevation band.

		Elevation bands in thousands of feet.					Totals
		0-2	2-4	4-6	6-8	8-16	
Acres of Federal Land							
Washington		693,220 (8)	2,951,156 (33)	3,735,628 (42)	1,379,564 (16)	79,514 (1)	8,839,083 (100)
Oregon		1,719,436 (18)	3,844,861 (40)	3,061,812 (32)	910,027 (10)	28,415 (0)	9,564,551 (100)
California		379,471 (6)	2,275,601 (39)	2,380,724 (41)	780,599 (13)	40,587 (1)	5,856,983 (100)
Three State Total		2,792,128 (12)	9,071,618 (37)	9,178,164 (38)	3,070,190 (13)	148,516 (1)	24,260,617 (100)
Acres of Large Reserves							
	Option						
Washington	1	548,814 (79)	2,369,145 (80)	3,335,765 (89)	1,345,182 (98)	78,921 (99)	7,677,827 (87)
	2	439,028 (63)	2,234,856 (76)	3,208,629 (86)	1,340,795 (97)	78,921 (99)	7,302,229 (83)
	3	443,612 (64)	2,275,443 (77)	3,247,437 (87)	1,340,835 (97)	78,921 (99)	7,386,248 (84)
	4	543,677 (78)	2,287,892 (78)	3,215,387 (86)	1,317,755 (96)	78,921(99)	7,443,632 (84)
	5	539,883 (78)	2,193,400 (74)	3,105,719 (83)	1,297,797 (94)	78,882 (99)	7,215,680 (82)
	6 & 10	442,901 (64)	2,174,035 (74)	3,113,465 (83)	1,316,569 (95)	78,921 (99)	7,125,891 (81)
	7	501,114 (72)	2,137,518 (72)	3,089,002 (83)	1,297,797 (94)	78,882 (99)	7,104,313 (80)
	8	442,901 (64)	2,174,035 (74)	3,113,465 (83)	1,316,569 (95)	78,921(99)	7,125,891 (81)
	9	530,477 (77)	2,056,344 (70)	3,143,144 (84)	1,350,991 (98)	78;921(99)	7,159,878 (81)

Oregon	1	1,245,631 (72)	2,932,344 (76)	2,354,562 (77)	832,765 (92)	28,217 (99)	7,393,520 (77)
	2	1,087,195 (63)	2,428,702 (63)	2,065,552 (67)	810,279 (89)	28,217 (99)	6,419,945 (67)
	3	1,123,396 (65)	2,433,523 (63)	2,071,836 (68)	810,753 (89)	28,217 (99)	6,467,725 (68)
	4	1,146,633 (67)	2,160,242 (56)	1,898,383 (62)	788,543 (87)	28,217 (99)	6,022,018 (63)
	5	1,111,816 (65)	1,805,511 (47)	1,585,503 (52)	757,875 (83)	28,217 (99)	5,288,922 (55)
	6 & 10	1,094,783 (64)	2,010,106 (52)	1,789,149 (58)	781,824 (86)	28,217 (99)	5,704,080 (60)
	7	852,249 (50)	1,575,583 (41)	1,554,243 (51)	757,440 (83)	28,217 (99)	4,767,732 (50)
	8	1,094,783 (64)	2,010,106 (52)	1,789,149 (58)	781,824 (86)	28,217 (99)	5,704,080 (60)
	9	1,009,815 (59)	1,814,442 (47)	1,742,239 (57)	776,805 (85)	28,217 (99)	5,371,519 (56)
California	1	318,136 (84)	1,607,318 (71)	1,852,658 (78)	670,971 (86)	39,243 (97)	4,488,326 (77)
	2	287,429 (76)	1,314,791 (58)	1,507,451 (63)	547,273 (70)	38,018 (94)	3,694,962 (63)
	3	287,468 (76)	1,314,830 (58)	1,507,609 (63)	551,225 (71)	38,018 (94)	3,699,151 (63)
	4	226,924 (60)	1,282,384 (56)	1,491,485 (63)	545,020 (70)	37,979 (94)	3,583,792 (61)
	5	223,644 (59)	1,218,678 (54)	1,411,022 (59)	528,106 (68)	37,702 (93)	3,419,152 (58)
	6 & 10	222,379 (59)	1,244,406 (55)	1,467,299 (62)	532,809 (68)	37,386 (92)	3,504,278 (60)
	7	215,107 (57)	1,159,438 (51)	1,369,249 (58)	527,908 (68)	37,702 (93)	3,309,405 (57)
	8	222,379 (59)	1,244,406 (55)	1,467,299 (62)	532,809 (68)	37,386 (92)	3,504,278 (60)
	9	229,097 (60)	1,299,339 (57)	1,480,143 (62)	559,327 (72)	38,097 (94)	3,606,002 (62)
Three State Total	1	2,112,581 (76)	6,908;807 (76)	7,542,985 (82)	2,848,918 (93)	146,382 (99)	19,559,673 (81)
	2	1,813,652 (65)	5,978,348 (66)	6,781,632 (74)	2,698,347 (88)	145,157 (98)	17,417,136 (72)
	3	1,854,476 (66)	6,023,796 (66)	6,826,882 (74)	2,702,812 (88)	145,157 (98)	17,553,124 (72)
	4	1,917,234 (69)	5,730,519 (63)	6,605,254 (72)	2,651,318 (86)	145,117 (98)	17,049,442 (70)
	5	1,875,343 (67)	5,217,588 (58)	6,102,244 (66)	2,583,778 (84)	144,801 (97)	15,923,754 (66)
	6 & 10	1,760,063 (63)	5,428,546 (60)	6,369,913 (69)	2,631,202 (86)	144,525 (97)	16,334,248 (67)
	7	1,568,470 (56)	4,872,539 (54)	6,012,494 (66)	2,583,146 (84)	144,801 (97)	15,181,450 (63)
	8	1,760,063 (63)	5,428,546 (60)	6,369,913 (69)	2,631,202 (86)	144,525 (97)	16,334,248 (67)
	9	1,769,389 (63)	5,170,125 (57)	6,365,526 (69)	2,687,123 (88)	145,236 (98)	16,137,399 (67)

[a] Large Reserves are the combined Congressional Reserves, Administrative Reserves, Late Successional Reserves and Option 3 Managed Late Successional Areas. Option 9 Adaptive Management Areas are included in the Matrix.

Table IV-15. Acres of Riparian Reserves by elevation bands, and percent (in parentheses) of total federal land represented by those reserves in each elevation band.

		Elevation bands in thousands of feet.					Totals
		0-2	2-4	4-6	6-8	8-16	
Acres of Federal Land							
Washington		693,220 (8)	2,951,156 (33)	3,735,628 (42)	1,379,564 (16)	79,514 (1)	8,839,083 (100)
Oregon		1,719,436 (18)	3,844,861(40)	3,061,812 (32)	910,027 (10)	28,415 (0)	9,564,551 (100)
California		379,471 (6)	2,275,601 (39)	2,380,724 (41)	780,599 (13)	40,587 (1)	5,856,983 (100)
Three State Total		2,792,128 (12)	9,071,618 (37)	9,178,164 (38)	3,070,190 (13)	148,516 (1)	24,260,617 (100)
Acres of Large Reserves							
	Option						
Washington	1	44,728 (6)	224,832 (8)	146,070 (4)	11,215 (1)	213 (0)	427,059 (5)
	2	41,363 (6)	208,219 (7)	143,481 (4)	9,268 (1)	159 (0)	402,44 (5)
	3	43,870 (6)	221,752 (8)	149,644 (4)	10,751 (1)	162 (0)	426,179 (5)
	4	46,243 (7)	258,127 (9)	193,168 (5)	19,756 (1)	213 (0)	517,507 (6)
	5	41,765 (6)	254,203 (9)	196,656 (5)	21,519 (2)	171 (0)	514,314 (6)
	6 & 10	40,290 (6)	228,878 (8)	171,201 (5)	14,811 (1)	159 (0)	455,339 (5)
	7	11,195 (2)	59,948 (2)	46,247 (1)	5,027 (0)	41 (0)	122,458 (1)
	8	30,334 (4)	157,609 (5)	114,081 (3)	9,667 (1)	107 (0)	311,797 (4)
	9	16,159 (2)	231,006 (8)	170,306 (5)	8,299 (1)	162 (0)	425,932 (5)
Oregon	1	221,712 (13)	373,984 (10)	242,920 (8)	20,570 (2)	46 (0)	859,233 (9)
	2	231,355 (13)	423,700 (11)	250,490 (8)	19,942 (2)	33 (0)	925,520 (10)
	3	222,815 (13)	457,059 (12)	270,025 (9)	20,061 (2)	33 (0)	969,993 (10)
	4	263,249 (15)	671,076 (17)	407,315 (13)	33,245 (4)	46 (0)	1,374,931 (14)
	5	225,309 (13)	666,104 (17)	397,696 (13)	29,860 (3)	33 (0)	1,319,002 (14)
	6 & 10	224,260 (13)	541,515 (14)	320,493 (10)	24,861 (3)	33 (0)	1,111,161 (12)
	7	66,479 (4)	152,728 (4)	86,493 (3)	6,795 (1)	8 (0)	312,503 (3)
	8	151,428 (9)	338,785 (9)	198,833 (6)	15,311 (2)	20 (0)	704,376 (7)
	9	205,558 (12)	546,875 (14)	329,998 (11)	28,033 (3)	33 (0)	1,110,496 (12)
California	1	15,769 (4)	287,804 (13)	231,876 (10)	48,034 (6)	566 (1)	584,050 (10)
	2	20,195 (5)	293,019 (13)	275,150 (12)	75,536 (10)	809 (2)	664,709 (11)
	3	22,974 (6)	321,290 (14)	301,468 (13)	77,823 (10)	815 (2)	724,369 (12)

	4	54,488 (14)	430,372 (19)	395,519 (17)	106,929 (14)	1,155 (3)	988,463 (17)
	5	42,262 (11)	353,422 (16)	335,716 (14)	85,648 (11)	920 (2)	817,969 (14)
	6 & 10	39,283 (10)	313,838 (14)	287,750 (12)	80,040 (10)	996 (2)	721,907 (12)
	7	9,835 (3)	80,144 (4)	75,028 (3)	19,232 (2)	213 (1)	184,453 (3)
	8	25,977 (7)	207,367 (9)	190,036 (8)	54,974(7)	688 (2)	479,042 (8)
	9	38,862 (10)	299,863 (13)	278,812 (12)	76,496 (10)	791 (2)	694,824 (12)
Three State Total	1	282,209 (10)	886,620 (10)	620,867(7)	1 79,819 (3)	826 (1)	1,870,341 (8)
	2	292,912 (10)	924,937 (10)	669,121 (7)	104,746 (3)	1,002 (1)	1,992,719 (8)
	3	289,659 (10)	1,000,102 (11)	721,137 (8)	108,634 (4)	1,010 (1)	2,120,542 (9)
	4	363,980 (13)	1,359,574 (15)	996,002 (11)	159,931 (5)	1,414 (1)	2,880,902 (12)
	5	309,336 (11)	1,273,729 (14)	930,069 (10)	137,027 (4)	1,124 (1)	2,651,285 (11)
	6 & 10	303,833 (11)	1,084,231 (12)	779,443 (8)	119,712 (4)	1,188 (1)	2,288,407 (9)
	7	87,509 (3)	292,820 (3)	207,768 (2)	31,054 (1)	262 (0)	619,414 (3)
	8	207,739 (7)	703,761 (8)	502,949 (5)	79,951 (3)	815 (1)	1,495,215 (6)
	9	260,579 (9)	1,077,745 (12)	779,115 (8)	112,828 (4)	986 (1)	2,231,253 (9)

Table IV-16. Acres of Matrix' by elevation bands, and percent (in parentheses) of total federal land represented by Matrix in each elevation band.

		Elevation bands in thousands of feet.					Totals
		0-2	2-4	4-6	6-8	8-16	
Acres of Federal Land							
Washington		693,220 (8)	2,951,156 (33)	3,735,628 (42)	1,379,564 (16)	79,514 (1)	8,839,083 (100)
Oregon		1,719,436 (18)	3,844,861 (40)	3,061,812 (32)	910,027 (10)	28,415 (0)	9,564,551 (100)
California		379,471 (6)	2,275,601 (39)	2,380,724 (41)	780,599 (13)	40,587 (1)	5,856,983 (100)
Three State Total		2,792,128 (12)	9,071,618 (37)	9,178,164 (38)	3,070,190 (13)	148,516 (1)	24,260,617 (100)
Acres of Large Reserves							
	Option						
Washington	1	99,678 (14)	357,179 (12)	253,793 (7)	23,168 (2)	380 (0)	734,197 (8)
	2	212,830 (31)	508,081 (17)	383,518 (10)	29,501 (2)	434 (1)	1,134,364 (13)
	3	205,738 (30)	453,960 (15)	338,547 (9)	27,979 (2)	431 (1)	1,026,655 (12)

	4	103,300 (15)	405,138 (14)	327,073 (9)	42,053 (3)	380 (0)	877,944 (10)
	5	111,572 (16)	503,553 (17)	433,253 (12)	60,248 (4)	462 (1)	1,109,089 (13)
	6 & 10	210,030 (30)	548,243 (19)	450,962 (12)	48,184 (3)	434 (1)	1,257,853 (14)
	7	180,912 (26)	753,690 (26)	600,379 (16)	76,740 (6)	591 (1)	1,612,312 (18)
	8	219,986 (32)	619,513 (21)	508,083 (14)	53,328 (4)	485 (1)	1,401,395 (16)
	9	146,584 (21)	663,806 (22)	422,178 (11)	20,274 (1)	431 (1)	1,253,273 (14)
Oregon	1	252,094 (15)	538,533 (14)	464,329 (15)	56,691(6)	151 (1)	1,311,799 (14)
	2	400,886 (23)	992,460 (26)	745,769 (24)	79,806 (9)	165 (1)	2,219,086 (23)
	3	373,226 (22)	954,279 (25)	719,951 (24)	79,213 (9)	165 (1)	2,126,833 (22)
	4	309,554 (18)	1,013,543 (26)	756,114 (25)	88,239 (10)	151 (1)	2,167,602 (23)
	5	382,311 (22)	1,373,247 (36)	1,078,613 (35)	122,292 (13)	165 (1)	2,956,627 (31)
	6 & 10	400,393 (23)	1,293,241 (34)	952,170 (31)	103,342 (11)	165 (1)	2,749,310 (29)
	7	800,708 (47)	2,116,550 (55)	1,421,077 (46)	145,791 (16)	190 (1)	4,484,316 (47)
	8	473,225 (28)	1,495,971 (39)	1,073,830 (35)	112,892 (12)	178 (1)	3,156,096 (33)
	9	504,063 (29)	1,483,544 (39)	989,575 (32)	105,189 (12)	165 (1)	3,082,536 (32)
California	1	45,566 (12)	380,479 (17)	296,190 (12)	61,594 (8)	777 (2)	784,607 (13)
	2	71,847 (19)	667,791(29)	598,123 (25)	157,790 (20)	1,759 (4)	1,497,312 (26)
	3	69,029 (18)	639,480 (28)	571,648 (24)	151,551 (19)	1,754 (4)	1,433,462 (24)
	4	98,059 (26)	562,845 (25)	493,720 (21)	128,650 (16)	1,454 (4)	1,284,727 (22)
	5	113,565 (30)	703,501 (31)	633,986 (27)	166,845 (21)	1,965 (5)	1,619,862 (28)
	6 & 10	117,809 (31)	717,357 (32)	625,676 (26)	167,750 (21)	2,205 (5)	1,630,797 (28)
	7	154,528 (41)	1,036,019 (46)	936,447 (39)	233,459 (30)	2,672 (7)	2,363,125 (40)
	8	131,115 (35)	823,828 (36)	723,390 (30)	192,817 (25)	2,513 (6)	1,873,662 (32)
	9	111,512 (29)	676,399 (30)	621,770 (26)	144,776 (19)	1,699 (4)	1,556,156 (27)
Three State Total	1	397,338 (14)	1,276,191(14)	1,014,312 (11)	141,453 (5)	1,308 (1)	2,830,602 (12)
	2	685,563 (25)	2,168,332 (24)	1,727,411 (19)	267,098 (9)	2,357 (2)	4,850,762 (20)

3	647,993 (23)	2,047,720 (23)	1,630,145 (18)	258,744 (8)	2,349 (2)	4,586,951 (19)
4	510,913 (18)	1,981,525 (22)	1,576,908 (17)	258,942 (8)	1,985 (1)	4,330,273 (18)
5	607,449 (22)	2,580,301 (28)	2,145,852 (23)	349,385 (11)	2,591 (2)	5,685,578 (23)
6 & 10	728,232 (26)	2,558,841 (28)	2,028,808 (22)	319,277 (10)	2,803 (2)	5,637,961 (23)
7	1,136,149 (41)	3,906,259 (43)	2,957,902 (32)	455,990 (15)	3,452 (2)	8,459,752 (35)
8	824,326 (30)	2,939,312 (32)	2,305,303 (25)	359,037 (12)	3,176 (2)	6,431,153 (27)
9	762,159 (27)	2,823,749 (31)	2,033,523 (22)	270,240 (9)	2,294(2)	5,891,965 (24)

[a] Matrix is composed of Partial Cut, Long Rotation, General Forest and Option 9 Adaptive Management Areas. Option Managed Late-Successional Areas are included in Large Reserves.

2. *Effects of land use history and ownership patterns.* Past management practices and current ownership patterns and land use objectives contribute to the relatively low likelihood for outcome 1. Given the nature of the disturbance regime and the possibility of climate change, none of the options provides broad latitude for large-scale change and uncertainties of knowledge. Public lands alone may be adequate in area to maintain late successional ecosystems in the face of large-scale change. From a regional perspective the current area and diversity of late-successional/old-growth forest ecosystems has been reduced to less than 20 percent of the landscape (public and private land). Some late-successional/old-growth forest types, such as fire-dependent ponderosa pine, have been reduced to a small fraction of historical levels. Some community and ecosystem types of low elevations and valley margins have been totally lost. Stand level practices that have created dense young plantations within Reserves in all of the options have altered the typical pathways by which stands develop into old-growth. Artificially created overly dense young plantations may not develop late-successional conditions, such as multiple canopy layers, for long periods. In addition, plantations may be more susceptible to insect, disease, and fire disturbances that could threaten existing late-successional forests within reserves. It was our hypothesis that, without silvicultural practices to correct' or "restore' stand development conditions in plantations, the current and future late-successional ecosystem is at a relatively high risk of loss or inadequate development. This is the primary reason that Option 1, which Reserves the largest area for late-successional forest, did not achieve an 80 percent or greater likelihood rating in the overall ecosystem for outcomes 1 and 2 combined (table Iv-13). We felt that the absence of restoration silviculture in plantations in Reserves under this option reduced the likelihood of achieving outcome 1 and 2 combined to below 80 percent.

Potential mitigations:

Moist Provinces: Suggest potential management for late-successional/old-growth ecosystems or components of late-successional/old-growth ecosystems on state and private lands in provinces where federal lands occupy a small percentage of the land base, such as the California and Oregon Coast Range Provinces and areas where private and federal lands are interspersed in a checkerboard pattern of alternating sections. State lands in the western Washington Lowlands and northern Oregon Coast Range offer significant opportunities to fill gaps in the regional late-successional ecosystem. We hypothesize that careful application of restoration silviculture in young plantations to promote development of late-successional/old-growth forests would probably improve the rating of Option 1 to at least an 80 percent likelihood of reaching outcome 1 and 2 combined.

Eastern Cascades and Klamath provinces: Past history of fire exclusion has altered ecosystem structure and function and resulted in a loss of fire-dependent ecosystem conditions, such as Ponderosa Pine. Reintroducing fire or a suitable substitute, such as thinning and reducing fuels, could mitigate against this loss.

3. *Lack of scientific information.* The relatively low likelihood ratings for outcomes 1 and 2 combined for most options reflects either (1) some assurance that the outcomes are not likely, or (2) a lack of information about: processes and functions of late-successional and old-growth ecosystems; the nature, role, and importance of landscape-level ecological processes including disturbance; the role and relationship of species diversity and ecosystem functions such as productivity, nutrient cycling, and decomposition; and the effects of climate change. There was high uncertainty and differences of opinion among experts on the panel about particular outcomes. This reduced likelihood scores for all outcomes under all options.

Potential mitigation:

All provinces: continue to increase basic studies of ecosystem structure, function, and dynamics at multiple spatial and temporal scales. Conduct monitoring and long-term studies of processes associated with late-successional/old-growth and related ecosystems. Such studies might increase or decrease ecosystem ratings and suggest changes to standards and guidelines that increase the possibility of meeting ecological and resource objectives.

4. *Additional mitigation measures on federal lands.* Modifications to standards and guides. See item 1 above for the Eastern Cascades and Klamath provinces.

Note that the likelihoods of achieving functional, well-distributed late-successional/old-growth ecosystems, for some options were lower than the likelihoods of providing well-distributed habitat on federal lands for some individual species or species groups. Provision of individual species or species groups, in other words, does not ensure the provision of all aspects of late-successional/old-growth ecosystems. Also, the outcomes for the species evaluations, by their nature, described different conditions than did the outcomes for the ecosystems evaluations.

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Effects of Options on Terrestrial Ecosystems (continued)

Assessment of Viability of Each Species Under Each Option

Fungi

Fungi are neither plants nor animals but are recognized as a separate kingdom of organisms both in structure and function. The large number of fungi in late-successional and old-growth forests, especially those of uneven-aged structure, reflects the complexity of these ecosystems. Estimates indicate there are at least six species of fungi for every vascular plant species in a given temperate ecosystem (Hawksworth 1991).

The fungal flora of the Pacific Northwest is extremely diverse. Of the 527 species of fungi that were evaluated here as closely associated with late-successional and old-growth forests, 109 (21 percent) are considered to be endemic to the Pacific Northwest (appendix table IV-A-1) (J. Ammirati, J. Trappe, W. Denison, 1993, personal communication). Extirpation of these endemic species from this area would equate to extinction of the species.

Fungi may be saprobic (decomposers), parasitic, or symbiotic (mutualistic). The macrofungi (those that produce fruiting bodies visible to the naked eye) have either a short-lived, annual, or perennial vegetative stage (mycelium) from which the fruiting bodies (e.g., mushrooms) develop. The lifespan of these fruiting bodies is variable and depends on the species, lasting from several hours to decades. The fruiting bodies typically produce sexual spores. Spores are commonly dispersed by air currents, or by animals, including invertebrates, or water.

Many of the forest fungi that produce large fruiting bodies (mushrooms, boletes, corals, etc.) are involved in symbiotic relationships with vascular plants. The survival of most conifers and many flowering plants depends on their association with these mycorrhizal fungi for the uptake of nutrients and water (Harley and Smith 1983, Trappe and Luoma 1992). Thousands of ectomycorrhizal species occur in the Pacific Northwest. Nearly

2,000 species are associated with Douglas-fir (Trappe 1977). Many ectomycorrhizal fungi are host specific, while others have broad host ranges (Molina et al. 1992).

Equally prominent in the mycorrhizal flora of the Pacific Northwest forests are fungi that fruit below ground such as hypogeous fungi, including truffles, false truffles, and their allies. These organisms are not often seen by the casual observer. Hypogeous fungi and certain mushrooms are important food for small mammals, that in turn are important in spore dispersal of the fungi. The northern flying squirrel and red-backed vole, which use these fungi as their primary food source, are also the major prey of the northern spotted owl over much of its range (Maser et al. 1978, Ure and Maser 1982).

Saprobic fungi are a major component of all forest ecosystems, growing on a variety of substrates (e.g., recently fallen trees to well-decayed logs, litter, dung, and other fungi). They play an important role in decomposition and recycling of nutrients. Saprobes release nutrients bound in dead plant, fungus, and animal tissues that later become incorporated into the soil. Among the most notable are the white rot fungi which are responsible for the decay of lignin. In late-successional and old-growth conifer forests, saprobes are often abundant both in the number of species and the number of individual fruiting bodies. Conks or polypore are particularly prevalent in mature and old-growth forests because of the diversity of habitat structures and host species, and the abundance of coarse woody debris and standing dead trees.

Parasitic fungi (e.g., pathogens) have often been viewed as having negative impacts on forest health and productivity, hut they may also increase forest diversity ~Trappe and Luoma 1992). Disease-killed trees leave openings in the canopy, creating structural and habitat diversity for other organisms. Standing dead trees also provide habitat for cavity nesting birds and mammals.

The microfungi of late-successional forests have received little attention except for the few that cause disease in commercial timber species. There are several hundred known species. but undoubtedly many remain to be discovered (Carroll et al. 1980, Carroll 1981). Many species of these microscopic fungi are narrow specialists, recycling specific substrates, while others parasitize insects or foliage. Many have potential for future use as medicinals and biological control agents.

Preserving fungal diversity may have implications to human health. Fungi are major sources of antibiotics and show great potential as anticarcinogens (Stierle et al. 1993). Pharmaceutical companies are now actively screening many Pacific Northwest fungi.

Fungi are also important indicator species for monitoring forest stability and health.

Forest decline in Europe has been accompanied by a precipitous decline in diversity of forest fungi (Arnolds 1991). Over the past 20 years, an increasing number of reports from continental Europe have documented substantial declines in diversity of species and the fruiting bodies of fungi. There has been a 42 to 54 percent decline in the number of fungus species since the early 1900's (Arnolds 1991, Bas 1978, Schlumpf 1976, Winterhoff 1978, Winterhoff and Kriegleiteiner 1984). These decreases in fungal diversity occurred largely among ectomycorrhizal species; in some cases the number of saprobic species has increased (Arnolds 1991).

The reasons for these fungal declines are unclear, but they probably are associated with the deterioration in forest health occurring in many parts of Europe. Plochmann (1989) attributes many of these problems to results of intensive forestry practices, including the removal of coarse woody debris from the ecosystem (Esseen et al. 1992). Increases in amounts of available nitrogen (possibly in combination with acid rain), intensive collection of mushrooms for table use, air pollutants, acidification of forest soils, increased leaf litter accumulation, changes in the herb layer of forests, and decreased tree vitality are other possible factors contributing to declines of fungi (Arnolds 1991).

There is concern about a decrease in species richness of fungi in the Pacific Northwest from the removal of old-growth forests, particularly for many mycorrhizal species. Fungi are a major component of all stages of forest succession, with the greatest species richness in late-successional and old-growth forests (J. Ammirati and J. Trappe, 1993, personal communication). Each species has its own niche, its own season of active interaction with tree hosts, and its own combination of physiological functions (Molina et al. 1992, Trappe and Luoma 1992). This diversity lends seasonal and long-term resilience to the forest. A number of saprobic species also reach their peak in late-successional and old-growth forests.

Although fungi are seldom observed except when their fruiting bodies are present, extensive masses of fungal mycelium permeate the soil, litter, and logs on the forest floor, as well as being connected with the roots of most of the vascular plants. The vital role of fungi in forest ecosystems highlights the importance of maintaining viable populations of these species throughout the landscape.

Methods specific to fungi. A list of 527 species of fungi closely associated with late-successional and old-growth forests on federal lands, within the geographic range of the northern spotted owl, was developed following the criteria used by the Scientific Analysis Team (Thomas et al. 1993) (appendix table IV-A-1). While this list is not complete, it suggests the high degree of biological diversity of fungi that exist in late-successional and old-growth forests of the Pacific Northwest. There is little published information on the diversity of fungi in the old-growth forests of this region. Consequently, mycologists contributed to the development of this list based on their research and field experience throughout the region. The mycologists consulted included Joe Ammirati, Lorelei Norvell, Michelle Seidl, Glenn Walker, and Tom O'Dell of the University of Washington; Jim Trappe, Bill Denison, and Nancy Smith Weber of Oregon State University; Randy Molina of USDA Forestry Sciences Laboratory, Corvallis, Oregon; Dennis Desjardin and Harry Thiers of San Francisco State University; Dave Largent of Humboldt State University; Scott Redhead, Systematics Research Lab, Agriculture Canada; and Hal Burdsall, Tom Volk, Karen Nakasone, and G. Banik, USDA Forestry Sciences Laboratory, Madison, Wisconsin.

Table IV-17. Proiected future likelihoods of habitat outcomes for fungi under land management options.

	Option 1				Option 3				Option 4				Option 5				Option 7				Option 8				Option 9			
Fungi	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**
Mycorrhizal																												
Bolete-GARU, Rare	83	10	7	0	77	15	8	0	73	17	10	0	67	22	8	3	67	22	8	3	63	22	12	3	67	22	8	3
Bolete/False Truffles, Rare (3 species)	0	3	91	5	0	2	92	7	0	2	88	10	0	2	83	15	0	2	82	17	0	2	82	17	0	2	83	15
Boletes (13 species)	93	7	0	0	83	17	0	0	77	23	0	0	67	33	0	0	67	33	0	0	67	33	0	0	70	30	0	0
Boletes, Low Elevation (2 species)	20	53	27	0	20	43	37	0	20	43	37	0	17	47	37	0	17	47	37	0	17	43	40	0	17	43	40	0
Boletes, Rare (2 species)	13	67	17	3	8	65	22	5	8	57	30	5	3	52	33	12	2	52	28	18	3	48	28	20	2	52	28	18
Chanterelle-CAFO, Rare	33	33	28	5	27	35	33	5	22	37	35	7	13	37	32	18	10	30	38	22	0	30	38	22	10	33	38	18
Chanterelle-POMU, Rare	40	47	10	3	33	52	12	3	35	45	17	3	27	45	20	8	17	50	25	8	20	43	27	10	22	43	27	8
Chanterelles (3 species)	73	27	0	0	73	27	0	0	63	37	0	0	57	43	0	0	60	40	0	0	57	43	0	0	60	40	0	0
Chanterelles-Gomphus (4 species)	83	13	3	0	77	15	8	0	68	20	10	2	62	23	12	3	53	25	18	3	53	23	20	3	57	22	18	3
Coral Fungi (50+ species)	85	10	5	0	80	10	10	0	70	18	10	3	60	18	15	8	55	20	18	8	50	23	20	8	55	20	18	8
Ecto-Puffballs (2 species)	93	7	0	0	90	10	0	0	87	13	0	0	80	20	0	0	73	23	3	0	77	23	0	0	80	20	0	0
Ecto-Polypores, Rare (3 species)	10	50	37	3	7	52	35	7	8	43	38	10	3	42	37	18	2	42	35	22	3	38	38	20	2	42	38	18
Ecto-Polypores, Uncommon (2 species)	70	20	10	0	60	25	15	0	53	27	20	0	42	32	20	7	40	30	23	7	38	32	23	7	42	32	20	7
Ecto-Polypore-COPE	93	7	0	0	93	7	0	0	87	13	0	0	83	17	0	0	80	20	0	0	80	20	0	0	83	17	0	0
Ecto-Resupinate Fungi (3 species)	97	3	0	0	97	3	0	0	93	7	0	0	87	13	0	0	83	17	0	0	83	17	0	0	87	13	0	0
False Truffle-MALY, Rare	8	10	75	7	7	10	75	8	5	12	72	12	2	12	72	15	0	10	72	18	0	12	70	18	0	12	72	17
False Truffles (10 species)	95	5	0	0	85	15	0	0	80	15	5	0	70	20	10	0	50	30	20	0	55	25	20	0	55	25	20	0
False Truffles, Rare (22 species)	20	30	40	10	15	35	40	10	15	35	40	10	5	35	50	10	0	35	50	15	0	35	50	15	0	35	50	15
False Truffles,Uncommon(4species)	30	40	30	0	25	40	35	0	25	35	35	5	25	30	40	5	15	25	40	20	20	30	40	10	20	30	40	10
Gilled Mushroom-CHLO,Rare	0	3	91	5	0	2	92	7	0	2	88	10	0	2	83	15	0	2	82	17	0	2	82	17	0	2	83	15
Gilled Mushrooms (125 species)	93	7	0	0	83	17	0	0	73	23	3	0	63	33	3	0	60	33	7	0	63	30	7	0	67	27	7	0
Gilled Mushrooms, Rare (6 species)	20	60	15	5	15	65	15	5	10	58	25	8	5	50	28	18	5	45	28	23	5	45	30	20	5	50	28	18
Gilled Mushrooms, Uncommon (15 species)	65	25	10	0	60	30	10	0	50	33	18	0	40	35	15	10	40	30	15	15	35	30	20	15	40	30	15	15
Phaeocollybia (13 species)	70	23	7	0	63	30	7	0	53	37	10	0	47	38	10	5	40	35	15	10	42	38	15	5	45	38	12	5
Tooth Fungi (5 species)	93	7	0	0	83	17	0	0	73	23	3	0	73	33	3	0	60	33	7	0	63	30	7	0	67	27	7	0
Truffles (5 species)	90	10	0	0	90	10	0	0	85	15	0	0	80	20	0	0	75	25	0	0	75	25	0	0	75	25	0	0
Truffles, Rare (5 species)	10	20	60	10	8	23	60	10	8	20	58	15	3	20	60	18	0	18	55	28	0	15	60	25	0	18	60	23
Truffles-TURU	10	30	40	20	5	28	40	28	0	33	40	28	0	33	40	28	0	30	40	30	0	30	40	30	0	30	40	30
Undescribed Taxa, Rare (29 species)	0	10	80	10	0	10	70	20	0	10	60	30	0	0	60	40	0	0	50	50	0	0	60	40	0	0	60	40
Zvaomvcetes. Rare (3 species)	10	20	60	10	8	23	60	10	8	20	58	15	3	20	60	18	0	18	55	28	0	15	60	25	0	18	60	23
Parasitic																												
Cauliflower Mushroom	83	13	3	0	80	15	5	0	73	20	7	0	67	25	5	3	60	25	12	3	63	25	8	3	67	25	5	3
Parasitic Fungi (7 species)	65	25	10	0	60	30	10	0	50	28	23	0	40	30	25	5	35	30	25	10	35	30	30		5	40	30	25
Parasitic Fungi, Common (2 species)	90	10	0	0	90	10	0	0	80	20	0	0	75	25	0	0	70	30	0	0	70	30	0	0	75	25	0	0
Saprobic - (Decomposers)																												
Branched Coral Fungi (3 species)	90	10	0	0	85	15	0	0	75	25	0	0	65	35	0	0	60	40	0	0	60	40	0	0	65	35	0	0
Cup Fungi (15 species)	90	10	0	0	90	10	0	0	80	20	0	0	70	30	0	0	65	35	0	0	65	35	0	0	70	30	0	0
Cup Fungi, Rare (14 species)	15	40	28	18	10	40	33	18	0	45	35	20	0	35	38	28	0	35	38	28	0	30	38	33	0	35	38	28
Gilled Mushrooms (80 species)	90	10	0	0	85	15	0	0	75	25	0	0	65	35	0	0	60	40	0	0	60	40	0	0	65	35	0	0
Gilled Mushrooms, Rare (6 species)	10	55	25	10	10	50	25	15	3	50	30	18	0	40	38	23	0	35	43	23	0	35	40	25	0	40	38	23
Gilled Mushrooms, Uncommon (17 species)	65	30	5	0	60	30	10	0	50	33	18	0	40	35	15	10	35	35	15	15	35	35	20	10	40	35	15	10
Jelly Mushroom	60	35	5	0	55	35	10	0	55	33	13	0	35	30	25	10	35	25	25	15	30	30	30	10	35	30	25	10
Oxyporus nobilissimus	18	28	37	17	13	28	40	18	10	28	47	15	10	25	43	22	7	22	47	25	10	25	40	25	10	25	43	22
Polypores (10 species)	90	10	0	0	85	15	0	0	75	25	0	0	65	35	0	0	60	40	0	0	60	40	0	0	65	35	0	0
Resupinate Fungi (14 species)	90	10	0	0	85	15	0	0	75	25	0	0	65	35	0	0	60	40	0	0	60	40	0	0	65	35	0	0
Resupinates and Polypores, Rare (6 species)	10	70	10	10	10	70	10	10	5	60	20	15	0	50	25	25	0	50	25	25	0	40	30	30	0	50	25	25
Other																												

Bondarzewia mesenterica	40	30	30	0	40	30	30	0	35	28	33	5	30	25	30	15	30	20	30	20	25	25	35	15	30	25	30	15
Club Coral Fungi (unknown # of species)	85	10	5	0	80	15	5	0	65	23	13	0	55	30	10	5	50	30	15	5	50	25	20	5	55	25	15	5
Moss Dwelling Mushrooms (7 species)	55	35	10	0	50	35	15	0	45	35	20	0	40	35	25	0	35	40	25	0	35	40	25	0	40	35	25	0
Mushroom Lichen	95	5	0	0	95	5	0	0	90	10	0	0	80	20	0	0	75	25	0	0	75	25	0	0	80	20	0	0

A-Well Distributed B-Locally Restricted C-Restricted to Refugia D-Extirpation

Likelihood values are expressed as percentages that total to 100 for a given species within an option. Number displayed may vary due to rounding errors.
See text for fuller explanation and discussion of the rating scale.

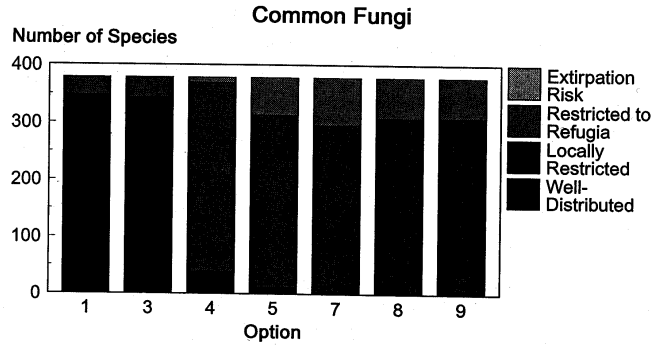


Figure IV-4. Outcomes for common fugi under each land management option. Values shown are the number of species that had an 80 percent or greater likeliood of achieving at least the specified outcome (based on distribution of habitat).

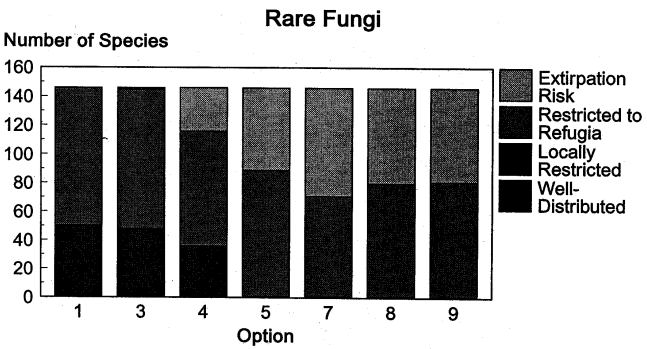


Figure IV-5. Outcomes for rare species of fungi under each land management option. Values shown are the number of species that had an 80 percent or greater likeliood of achieving at least the specified outcome (based on distribution of habitat).

Three mycologists were convened for the fungus panel. Two major functional divisions of fungi were identified, the ectomycorrhizal fungi, and the decomposers or saprobes. Several parasitic species were also included. The 527 species were divided into 36 groups, based on taxonomic and ecological relationships, and their degree of rarity.

Each species group was discussed and fungus species were added or deleted. Groups of species were finalized based on similarity in response to habitat provided by the various management options. Each group was then evaluated based on the projected future condition of habitat on federal lands (outcomes A-D, see Methods for assessing effects of options). Twelve species were treated individually because of differences in their biological or ecological attributes. Four species were not evaluated because of insufficient information and uncertainty about their biology and ecology. In addition, three orders of microfungi representing hundreds of species were discussed but not evaluated because of lack of information (appendix table IV-A-1).

A summary of outcome scores, based on the average scores of the three panelists, is presented for each group or species of fungi for each option (table IV-17).

Results. Ratings for the groups of fungi were based on habitat conditions on federal lands and varied considerably across the different options (table IV-17, figs. IV-4 and IV-5). For Option 1, 92 percent of the common fungi groups rated greater than 80 percent likelihood of having habitat of sufficient quality, distribution, and abundance to allow the species population to stabilize, well distributed across federal lands (outcome A), and 72 percent of the groups received this rating for Option 3. Options 4, 5, and 9 had lower ratings with 16-20 percent of the fungi groups rating 80 percent likelihood of outcome A, and only 8 percent received this rating for Options 7 and 8.

Mycorrhizal fungi: The 336 mycorrhizal fungi evaluated represent a diverse group of species, including boletes, chanterelles, corals, false truffles, gilled mushrooms, ecto-polypores, tooth fungi, and truffles (appendix table IV-A-1). These groups were subdivided into groups of common, uncommon, and rare species. Thirty-one percent of the mycorrhizal species evaluated were considered rare or uncommon (appendix table IV-A-1 and table IV-17).

Boletes (13 species), tooth fungi (5 species), and gilled mushrooms (125 species) represented 44 percent of the mycorrhizal species. As a group they were rated with an 80 percent likelihood of outcome A for Options 1 and 3. For Options 4, 5, 7,8, and 9, they received an 80 percent likelihood of having habitat of sufficient quality, distribution, and abundance to allow populations to stabilize, but with significant gaps in the historic species distribution (outcome B) (table IV-17).

Phaeocollybia (13 species) and chanterelles (3 species) were rated with 80 percent likelihood of outcome B or better for all options (table IV-17). Four chanterelle-like species rated with an 80 percent likelihood of outcome A for Option 1, and an 80 percent likelihood of outcome B or better for the other options (table IV-17).

Fifty species of coral fungi were rated with an 80 percent likelihood of achieving outcome A for Options 1 and 3. They were rated with 80 percent likelihood of achieving outcome B or better for Option 4, and with 80 percent likelihood of achieving outcome C (habitat only allows species existence in refugia) or better for Options 5, 7, 8 and 9 (table IV-17).

Ten species of false truffles had an 80 percent likelihood of achieving outcome A for Options 1, 3, 4, and an 80 percent likelihood of achieving outcome B or better for Options 5, 6, 7, 8, and 9 (table IV-17). Five species of truffles had an 80 percent likelihood of achieving outcome A for Options 1-5, and an 80 percent likelihood of achieving outcome B or better for Options 7-9 (table IV-17).

The three ecto-resupinate (flat, smooth fruiting bodies) species and *Coltrichia perennis* were the only fungi that rated with an 80 percent likelihood of outcome A for all options (table IV-17).

Saprobic fungi (Decomposers): This group of fungi was represented by 167 species, including gilled mushrooms, polypores, cup fungi, and resupinate fungi (appendix table IV-A-1). A total of 61 percent of the saprobic fungi, including common gilled mushrooms, polypores, resupinate fungi, and three species of coral fungi (*Clavulina*), rated 80 percent likelihood of achieving outcome A for Options 1 and 3, and 80 percent likelihood of achieving outcome B or better for the other options (table IV-17). The cup fungi had 80 percent likelihood of outcome A for Options 1, 3, 4, and 80 percent likelihood of achieving outcome B or better for the other options.

The outcome scores for parasitic fungi are shown in table IV-17. The ten species of parasitic fungi showed a similar pattern for the options as the saprobic fungi.

Rare and uncommon species: Rare or uncommon fungi totaled 146 species, or 28 percent of the fungi evaluated (appendix table IV-A-1). Rare mycorrhizal fungi included boletes, false truffles, truffles, chanterelles, gilled mushrooms, and polypores. Rare saprobic fungi included polypores, gilled mushrooms, cup fungi, and resupinates. Many of these species are restricted to refugia and are known from only one or a few locations, while others may be more widespread but sporadic in their distribution or abundance. Narrow distributions may be due to inherent life history characteristics, or species requiring specific habitats that are sporadic or rare in the landscape.

The rare and locally endemic species were generally rated with an 80 percent likelihood of outcome C, which reflects their current distribution, (table IV-17, figure IV-5). For many of these species, there was little difference in ratings across the options. This reflects the relatively random chance that a population will actually occur within a given reserve.

Gastroboletus ruber was the only rare species that had an 80 percent likelihood of achieving outcome B or better for all options. This mycorrhizal species is host specific with mountain hemlock. It occurs at high elevations, and most known locations are in Wilderness Areas or National Parks.

Discussion. The projected future outcomes for fungi corresponded with the acreage of Late-Successional Reserves and management in the Matrix. Most of the common, widespread fungi had potential outcomes for habitat being well distributed (outcome A), or well distributed but with significant gaps (outcome B). Those options that had fewer old-growth patches, less coarse woody debris and less green tree retention in the Matrix were rated lower for groups of fungi, as were options with less acres in reserves. The majority of species considered here occur on upland sites, so riparian buffers may not be as relevant for many of them. However, fungi associated with riparian areas were not well represented in this evaluation (appendix table IV-A-1).

Even small fragments of old-growth forests within the Matrix are important for fungi, because of their limited dispersal capabilities. These small patches of old-growth provide biological legacies (i.e., coarse woody debris, habitat structures, and hosts) that carryover in younger stands. These old-growth fragments function as refugia where fungi may persist until suitable habitat conditions become available in adjacent stands. Many species of fungi may be dispersal limited or rely on small mammals or invertebrates to disperse their spores (J. Ammirati, 1993, personal communication).

Large coarse woody debris is critical for maintaining populations of mycorrhizal and saprobic fungi (Harvey et al. 1979). Coarse woody debris is an important factor in the distribution and seasonality of hypogeous fungi, hence, is important to small mammals. Amaranthus and Trappe (in preparation) report that during the hot, dry time of year, coarse woody debris in old-growth fragments provide sites for truffle fruiting; this could be critical for maintenance of small mammal populations that eat and disperse these fungi.

The species at greatest risk of extirpation were the rare or locally distributed fungi. There are over 100,000 specimens of fungi from the Pacific Northwest in collections dating back to the turn of the century. However, the rare taxa are poorly represented in these collections. It is unknown if these species have always been rare or have been extirpated from large parts of their range. Because of difficulties inherent in surveying species with ephemeral fruiting bodies, it is possible that other undiscovered populations of these species may occur.

Many fungi associated with late-successional forests have specific host and substrate requirements, and fungal diversity increases as communities mature. Species that are present in young stands, may also occur in mature to old-growth forests, but a large number of species occur exclusively in older stands (J. Ammirati, 1993, personal communication). Maintenance of fungal diversity and viable populations of late-successional fungi will require habitat diversity, various successional stages, mixtures of tree species and ages, and significant amounts of coarse woody debris.

Natural disturbance is important for certain species of fungi (Esseen et al. 1981). Windthrows, gaps, and other small scale disturbances enhance the structure and diversity of mature and old-growth stands, creating microsites suitable for a variety of fungi. However, large-scale disturbances and intense site treatments may have detrimental effects. Intensive burning is detrimental to many species of late-successional fungi (J. Ammirati, 1993, personal communication) and reduces the quality and abundance of coarse woody debris and the humus layer. Results from northeastern California indicate that commercial thinning and broadcast burning alter the genera composition of hypogeous fungi (Waters and Zabel, in review).

The commercial harvest of edible forest fungi is a multimillion-dollar industry with several thousand tons harvested annually (Molina et al. 1993). Four species, king bolete (*Boletus edulis*), golden chanterelle (*Cantharellus cibarius*), edible morel (*Morchella esculenta*), and matsutake (*Tricholoma magnivelare*), account for most of the commercial harvest. Many other edible species are harvested in smaller quantities for personal use and gourmet food markets. Additional species have medicinal properties, and some are used in crafts. Both ecologists and mushroom harvesters have concerns regarding the sustainability of these fungi due to overharvesting and habitat depletion (Molina et al. 1993).

Although fungi are essential to the function of ecosystems, we know relatively little about their specific roles. Interactions among species such as competition or mutualism are not well understood. Little is known about how the species composition of fungi changes over time during forest succession, and the relationship among species that occur in young, mature, and old stands.

An important consideration for management of Pacific Northwest forests is not only preservation of fungal species but preservation of their function across the landscape. Many species of fungi associated with old-growth forests will likely persist within Late-Successional Reserves. Patches of old-growth distributed throughout the Matrix would help maintain those species and their functional role in ecosystems across the landscape. Until we have more complete knowledge, it is important to maintain all components of the ecosystem. This diversity across the landscape will help provide the resilience that ecosystems need to respond to environmental and biological stresses, such as climatic change, catastrophic fires, and insect or pathogen outbreaks.

Mitigation for Fungi

Retention of old-growth patches within the Matrix: Likelihood ratings for some options could be increased by retaining patches of late-successional or old-growth forest within the Matrix. These small patches of old-growth distributed throughout the Matrix (such as required in Options I and 3, and in some areas under Option 9) are important refugia for late-successional fungi, as well as a source of inoculum for dispersal into adjacent young stands. These old-growth patches are also important in that they are a source of large logs and snags which would otherwise be lacking in cutover areas. Species associated with mature and old-growth stands may also be important in younger stands. We currently don't know enough about the role of various fungi to select or favor particular species in managed forests.

Distribution and spacing of old-growth fragments is important. Because many fungi have limited dispersal capabilities, these patches need to be distributed throughout a watershed unit. The distribution of these stands should be addressed on different scales and within a landscape context. Patches should be large enough (5-10 acres at a minimum), not only to provide for habitat needs but also to lessen the risk of windthrow and to minimize alteration of the microclimate. A diverse mosaic of stand types with respect to host species, age-class distributions, successional stages, habitat structures, plant associations, and topographic positions (i.e., riparian, mid-slope, and ridgetop), should be maintained across the Matrix.

In the Coast Range of Oregon and the coastal Olympics, remaining old-growth stands are especially important because they are rare across the landscape, particularly in the Sitka Spruce Zone. Old-growth stands are also scarce at lower elevations. For areas where old-growth stands are limited, we need to identify additional stands to mature into old-growth that will provide for fungi that occur in late-successional forests.

Stand ages between 80 and 200 years are uncommon for some areas in this region. Some stands of this age class should be maintained in the Matrix to provide a link in fungal succession between young and old stands.

Green tree retention. Likelihood ratings for some options could be increased by retaining 15 percent of the green trees in patches or clumps within harvest units, as under Option 9. These patches should include not only the biggest and oldest trees, but a diversity of tree sizes, species, and ages within a patch. It is important to maintain the microclimate and associated habitat by leaving clumps of trees, because single leave trees may not support late-successional fungi within a harvested unit.

An accumulation of leave trees should be provided over successive rotations. Leaving large enough clumps to persist over time would accomplish this. With the next harvest, provide an additional buffer around the original patch to maintain a renewable supply of older legacies, such as trees, logs and snags.

Coarse woody debris. Under the short rotation scenario in the Matrix, large coarse woody debris is not a renewable resource. As an area progresses through several short rotations, the input of large coarse woody debris declines; trees do not have sufficient time to attain large diameters under the prescribed rotation lengths, except on highly productive sites. Allowing some stands and patches within younger stands to mature into older age classes within the Matrix, would help provide for continued input of large coarse woody debris, and would also provide a favorable microclimate for fungi.

Significant quantities of logs are important, as well as a distribution of decay classes. Attempt to replicate the quantity and quality of coarse woody debris that would occur in natural, unmanaged stands for particular plant associations and stand types. Provisions for leaving 12 logs per acre as required in Option 3 could serve as a guide until models could be developed that replicate natural stand conditions.

Coarse woody debris needs to occur in the microclimate provided by the canopy of a forest patch to provide for the fungal species that occupy this substrate. Logs scattered in the Matrix are exposed to a much different microclimate and will be occupied by a different suite of fungi.

Minimize site disturbance. Most options could be improved for fungi by minimizing site treatments such as burning, unless appropriate for certain habitats, communities, or conditions. Other mitigations could include minimizing soil disturbance from yarding and heavy equipment, and the intensity and frequency of stand treatments. Removal of humus layers, coarse woody debris, and soil compaction may impact populations of fungi, as well as significantly alter the role of decaying wood in the nutrient cycling process (Maser and Trappe 1984).

Rare and locally endemic species. All options could be improved by mitigation measures providing protection for areas where rare and locally endemic fungi occur. Inventory and monitoring should be conducted for rare or locally endemic taxa, and areas should be surveyed before management treatments occur; sites where rare and locally endemic species are located should be protected. Locations and distribution of these species of fungi should be documented and maintained in a Geographic Information System. All type localities should be preserved, especially those of rare taxa. A type locality is the site where the original material of a species was collected. The type collection forms the basis for defining that species.

Sites that are known to support rare taxa, high species diversity, unique areas, special habitats, communities, or features should be identified and these sites protected by establishing special interest areas or mycological preserves. Buffers should be provided to protect the sites from disturbance. It is not feasible to mention all rare taxa here, so several species are discussed as examples.

Oxyporus nobillisimus, the "Fuzzy Sandoze", is an endemic and extremely rare polypore, occurring in isolated populations from the central Oregon Cascades north to the Olympic Peninsula and Snoqualmie River drainage. Also known as the Noble Polypore, it attains large sizes and until recently held the Guinness Book of Records designation for the largest pore fungus (Guinness Book of Records, 1966-1990). This species is host specific to true firs and is restricted to old stumps, snags, and very large, old living trees. Discovered by the Sandoze brothers in the 1940's, it is only known from about 12 localities, including historic locations. This species is closely associated with old-growth forests, and it does not transfer onto younger trees or substrates. This species is on list 1 of the Oregon Natural Heritage Program (1991). *Oxyporus nobillisimus* is in need of active protective measures to ensure its survival (ONHP 1991). All known locations should be protected and populations monitored.

Gastroboletus imbellus and *Chroogomphus loculatus* are only known from the type collections at the Potholes Area of the Willamette National Forest at 5,000 feet elevation. To mitigate for these species, this area could be identified as an area of biological diversity and designated as a mycological special interest area. Other species of interest at this site include *Glomus radiatum* and many *Rhizopogon* species. This area should be protected from wildfire.

Tuber rufum is host specific to oak (*Quercus* spp.), and its viability is directly tied to maintaining oak well distributed throughout the landscape. Oak is slow growing and sporadic in its reproduction. Many oak sites are being converted for other uses, particularly in the Willamette Valley and southward. Most oak stands on federal lands occur outside of the reserves. Older stands of oak should be maintained and distributed across the landscape in appropriate habitats. Inventory and monitoring of *Tuber rufum* and host populations should be conducted.

Commercial and recreational harvest. To determine appropriate levels of sustained harvest for fungi, inventories should be conducted, baseline data collected, and effects of harvest monitored. The ephemeral nature of the fruiting bodies of most fungi poses challenges to these efforts, yet research is under way to study productivity and the effects of methods of harvest on chanterelles (L. Norvell, 1993, University of Washington). Monitoring programs suggested by Molina et al. (1993) form the basis for determining the effects of harvest, predicting yields, and developing management practices to maintain and enhance wild mushroom harvest.

Role of nonfederal lands. There are species of fungi whose survival is affected by land ownerships and associated management activities or land use of nonfederal land, particularly in the Coast Range of Oregon and coastal Olympic Peninsula, southwestern Washington, Willamette Valley, and low elevation Cascades. These are areas of special concern where little old-growth remains in the landscape because of past harvesting, and natural disturbance such as fire. Many species of fungi occur at lower elevations; they may have been more widely distributed historically, but land management activities have restricted their distribution. Federal agencies should work with state and private landowners to protect known locations of species of concern and associated old-growth fragments.

Research and information needs. A critical need exists for information on the diversity, biology, ecology, and distribution of the old-growth associated fungi in the forests of the Pacific Northwest. This information will help identify standards and guidelines that can be used to develop future management techniques that will help increase or maintain fungal species diversity, especially in the Matrix. A variety of studies are discussed below.

An inventory program should be developed for fungi, especially for the rare, common, and commercially harvested species. Surveys should be conducted for a minimum of 3-5 years (optimally 10 years) because of their ephemeral nature and seasonal as well as longer term fruiting patterns. Develop protocols for surveying for fungi in coordination with mycologists and ecologists. Species known from only a few locations should be inventoried to determine the extent of populations in those areas.

All study areas should be prioritized. Areas should be selected that are rich in fungal flora, as well as representative plant associations throughout the Pacific Northwest. Areas of rich fungal diversity should be established as mycological special interest areas.

Ecological studies are needed to determine how forest succession relates to fungal diversity and the process of fungus succession with stand development throughout the landscape. Studies should include (1) changes in species composition over time and in different successional stages, (2) relationships among species that occur in different successional stages, (3) the association between fungus species and canopy closure, coarse woody debris, and other biotic and abiotic habitat factors, and whether that varies with stand history and age, (4) relationships between coarse woody debris and fungal fruiting, especially as they relate to size and decay class of logs in different habitat types, (5) population sizes, (6) distance and effectiveness of dispersal, (7) specific habitat requirements, (8) functional attributes of different fungal groups, including nutrient dynamics and food chains, etc. and (9) genetic diversity within fungal species and populations.

Monitoring of specific sites should be conducted throughout the region to measure changes in diversity of fungal communities, species composition, and biomass production, and baseline data gathered to monitor long-term effects of pollution or climatic change, and forest management activities. Monitoring should include both epigeous and hypogeous fungi and should identify keystone or indicator species. A long-term study of the *Oxyporus nobilissimus* population on Snow Peak, and perhaps other sites, should be initiated to monitor population trends. It should be determined if this species can enter younger stands or become established on younger substrates. Microfungi that occur in soil, humus, and other substrates also need evaluation. This group of fungi are likely of importance to the health of mature arid old-growth forest ecosystems.

Long-term monitoring plans should be developed to evaluate effects of various stand management treatments, including survival and viability of fungus species in old-growth patches of different sizes within harvested areas and in various habitat types and geographic areas. Research should include the study of edge effects on interior forest fungi to assess (1) the importance of small isolated old-growth fragments as refugia and centers of biological diversity, (2) the effect at boundaries between stands of different ages, (3) how the diversity of fungal species is affected, (4) the distance from the edge where species richness stabilizes, (5) whether an abundant legacy of coarse woody debris in a young stand increases fungal diversity, and (6) the relationship between patch size and edge effect.

The relationship between patch size and survival and dispersal success of fungi also needs study. Effects of silvicultural manipulations on small mammal/fungal population interactions need research in order to develop suitable habitat for corridors between isolated populations.

Research should be conducted to identify the appropriate management to maintain an ecologically sustainable special forest products industry for fungi. Research should include the development of standards for harvest that take into account the production and abundance of fruiting to avoid damaging the resource and to ensure sustainability. Chanterelles and matsutake are important commercial species, and represent a substantial revenue for the special forest products industry. The possibility of managing stands for these species should be explored, and the techniques and benefits of co--managing chanterelles with forest trees, for example Douglas-fir/salal stands, as a cropping system to maximize economic output should be investigated.

A regional database and geographic information system layer should he developed that incorporates existing data for old-growth forest fungi from herbaria, historical and personal collections, and publications. This database should include host associates, habitats, patterns of occurrence, distribution and abundance, as well as other information, and should include a list of rare species. A regional geographic information system layer of locations for rare and locally endemic fungal species and type localities should be maintained. Information should be ground-truthed with a global positioning system. This source should be consulted when planning management activities to avoid extirpation of rare fungal species, or particularly rich habitats.

Education. Training for foresters and other professionals in resource management should be expanded to encompass a general tinderstanding of mycology and to emphasize the importance of the fungal component of ecosystems and its relation to forest health. A communication system should be established that links natural resource personnel with mycologists.

Lichens

The lichen flora in the Pacific Northwest is diverse and abundant. Lichens are a conspicuous component of old-growth forest ecosystems where they play a major ecological role. They make significant contributions to nutrient cycling and biomass production and are critical in the food chain of mammals and invertebrates. The lichen flora of the Pacific Northwest includes many endemic species, so extirpation of these species in the region would equate to the extinction of the species. Twenty-six of these lichens closely associated with old-growth forests are endemic to the Pacific Northwest (Appendix, table IV-A-2).

Lichens are a symbiotic association between a fungus and alga or cyanobacteria (blue--green algae), but form an organism with its own distinct characteristics. lichens absorb nutrients and moisture for growth from precipitation and atmospheric gases. The fungal component controls light intensity and absorbs moisture and nutrients that are transferred to the algae. The algae, in turn, conduct photosynthesis providing carbohydrates for the fungi. These fungal greenhouses provide for the growth of algae in sites where they could not exist without the protection and support of the fungi.

Lichen species occur in specific habitats and on specific substrates. Most forest lichens grow on trees but some grow on decaying wood, rock, soil, or in streams. Environmental factors limiting lichen distribution and growth include substrate, acidity, wetting and drying frequency, temperature regimes, humidity, light, and air pollution (Hawksworth and Hill 1984). Lichens occupy niches in the forest where they do not have to compete with other vegetation. Due to their ability to tolerate desiccation and their direct means of acquiring elements essential for growth lichens are able to survive in these variable microhabitats. Lichens contribute biological diversity and biomass, particularly within the canopy of a forest stand.

Lichens grow slowly compared to other organisms (Hawksworth and Hill 1984). Because of this slow growth, the persistence of substrate and amelioration of microclimate are important. Rapidly growing young trees are an unstable substrate that restricts lichen colonization and establishment. Microclimate also changes continuously as a young stand matures. Changes in substrate, humidity, and temperature within a forest canopy are reflected in a succession of lichen species present.

As a forest develops, an associated pattern of lichen succession also develops, portrayed by a change in species and an increase in lichen diversity and abundance. Some lichen species occur only after the stand has matured and provides stable and appropriate substrates with associated canopy microclimate. It may take over 200 years for these late successional lichens to become established in the forest (Lesica et al. 1991; McCune 1991; Henderson et al. 1988). Some lichens indicative of old-forest conditions occur only in forests that have not had major disturbances for centuries (500 or more years) (Goward 1992; Rose 1976). Old-growth forest lichen species require the ecological continuity of mature trees to persist, and they lack the ability to disperse widely, having only limited means of dispersal, making it difficult for them to invade new sites (Esseen et al. 1981). In England, a large number of lichen species are used as indicators of woodland age and ecological continuity (Broad 1989; Rose and Wolseley 1984).

The distribution of many lichens is dispersal limited (Esseen et al. 1981). Most forest lichens reproduce by asexual reproductive structures rather than by sexual spores. These vegetative propagules are small fragments composed of both fungal and algal cells and are more efficient than independent dispersal of the two symbionts (Hawksworth and Hill 1984). These fragments are larger than spores and therefore disperse only short distances. In the Oregon Cascades, half the biomass of lichen litterfall occurred within 6 meters of the edge of an old-growth forest patch, with a rapid decrease in litterfall with increasing distance from the old-growth forest edge (B. McCune 1993 personal communication).

Lichens are primary producers accumulating biomass and carbohydrates, and contribute to forest nutrient cycling. Arboreal lichens capture fog and retain moisture within the forest canopy. Many lichens fix atmospheric nitrogen (Denison 1973; Hawksworth and Hill 1984). Their litterfall provides organic material and increases the soil moisture holding capacity. The forage lichens are a major food source for animals such as flying squirrels, red-backed voles, and woodrats (Maser et al. 1985). They are also a food source for deer, elk and mountain goats during the winter (Hodgman and Bowyer 1985; Fox and Smith 1988). Native Americans used forage lichens for food (Turner 1990). Lichens provide habitat and food for canopy-dwelling invertebrates (Gerson and Seaward 1977), and are used by birds and small mammals for nest building material and camouflage (Broad 1989).

Air quality can be assessed by using lichens as biological indicators. Lichens are sensitive to sulfur dioxide and other gases and are efficient accumulators of heavy metals (McCune 1988). Some species of lichens show potential for antibiotic and medicinal qualities (Hawksworth and Hill 1984; Hale 1974).

Methods specific to lichens. The lichen panel assessed effects of the options on 157 lichen species that are closely associated with late-successional and old-growth forests. This is a fairly comprehensive list of the macrolichens that occur in old-growth forests in the Pacific Northwest. Nomenclature follows Egan (1987) and revisions. Lichen species were divided into 12 functional groups based on ecological relationships, and some of the groups were further subdivided by their degree of rarity. Some species were added, deleted, or moved among the various groups based on panel discussion. Seven species were not rated because of uncertainty about their biology or distribution (Appendix, table IV-A-2). The panel accepted the definitions of the outcomes A, B, C, and D as stated, rating the habitat conditions on federal lands. They felt that rare species that exist in refugia historically or 'naturally could not rate higher than outcome C because

these species will always be distributed in isolated pockets or refugia', regardless of the option. After refining the species groups and discussions about the ecology of each group, the panelists independently rated the expected outcome of each group for each option.

A summary of outcome scores for each group of lichens was based on the average scores of the five panelists (table IV-18).

Results. Viability assessments are presented here in table IV-18 for each of the ecological groups defined by the panelists.

Forage lichens: These species are long, pendant lichens on limbs and boles of trees or snags, and include the genera *Alectoria, Bryoria,* and *Usnea*. These lichens are an important food source for small forest mammals and ungulates, especially during the winter. Many of these species tend to be more common and abundant in montane forests. Eleven species were rated. One species is rare and verified from only three locations. This rare lichen, *Bryoria tortuosa,* rated an 80 percent or greater likelihood of outcome C or better under Options 1, 3, 4, and 9; and outcome D or better under Options 5, 7, and 8 (table IV-18). In contrast, the common forage lichens rated much higher with an 80 percent or greater likelihood of attaining outcome A under Option 1; outcome B or better under Options 3, 4, 5, and 9; and outcome C or better in Options 7 and 8 (table IV-18).

Arboreal leafy lichens: These lichens are short, tufted or flat, leaf-like species found on tree boles and twigs and include a variety of genera such as *Platismatia, Parmelia,* and *Cetraria*. Nineteen species were rated, including two rare species known only from only one or a few locations. The rare species rated with an 80 percent likelihood of attaining outcome C or better under all the options (table IV-18). The common arboreal leafy lichens were rated with an 80 percent or greater likelihood of attaining outcome A under Options 1 and 3; and outcome B or better for Options 4, 5, 7, 8, and 9 (table IV-18).

Table IV-18. Projected future likelihoods of habitat outcomes for lichens under land management options.

	Option 1				Option 3				Option 4				Option 5				Option 7				Option 8				Option 9			
Lichens	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**
Aquatic [3 species]	30	53	16	1	13	53	31	3	24	55	19	2	10	45	29	16	2	20	53	25	0	22	52	26	10	47	27	16
Decaying wood [8 species]	78	18	3	1	65	29	5	1	62	30	7	1	40	41	14	5	22	50	21	7	11	47	37	5	40	42	17	1
Forage Lichen (10 species)	80	18	1	1	70	27	2	1	58	39	2	1	47	41	9	3	28	49	19	4	34	47	17	2	61	32	5	2
Forage Lichen, Rare (1 species)	0	20	68	13	3	35	49	14	0	10	74	16	0	6	69	25	0	4	53	44	0	8	58	35	0	6	75	19
Leafy Arboreal (17 species)	89	9	1	1	81	17	1	1	76	19	4	1	59	33	7	1	37	45	17	1	36	45	18	1	52	40	7	1
Leafy Arboreal, Rare (2 species)	4	26	67	3	1	25	70	4	1	20	72	7	1	18	72	9	0	15	69	16	1	15	69	15	0	20	63	17
Nitrogen-fixing Lichens (20 species)	55	41	3	1	45	45	7	3	41	50	6	3	9	60	27	4	3	44	41	12	8	35	51	6	17	56	23	4
Nitrogen-fixing Lichens, Rare (6 species)	4	34	56	6	0	32	57	11	0	26	58	16	0	12	60	28	0	8	54	38	0	10	50	40	0	20	52	28
Oceanic Influence (4 species)	8	45	44	4	5	45	46	4	5	43	46	6	5	38	49	9	0	23	63	15	0	23	63	15	5	40	46	9
Oceanic Influence, Rare (12 species)	0	16	60	24	0	12	67	21	0	8	65	27	0	8	60	32	0	2	52	46	0	0	54	46	0	12	59	29
Pin Lichens (16 species)	37	47	15	1	30	48	21	1	30	48	21	1	23	47	27	3	11	38	42	9	10	30	51	9	22	46	29	3
Riparian (9 species)	18	61	18	3	11	53	33	3	16	62	19	3	6	52	36	6	2	36	48	14	4	26	50	20	9	54	32	5
Rock (4 species)	57	37	5	1	42	51	6	1	39	52	7	2	32	51	14	3	22	53	22	3	22	51	22	5	31	52	16	1
Rock, Rare (2 species)	3	15	65	18	0	15	60	25	0	13	64	24	0	13	59	29	0	10	45	45	0	8	49	44	3	13	56	29
Soil (8 species)	78	18	3	1	72	23	4	1	70	23	6	1	64	29	6	1	58	31	10	1	62	31	6	1	70	23	6	1
Tree boles (14 species)	76	21	2	1	69	26	4	1	60	33	4	3	55	36	6	3	26	57	13	4	26	60	11	3	46	44	7	3

A-Well Distributed B-Locally Restricted C-Restricted to Refugia D-Extirpation

Likelihood values are expressed as percentages that total to 100 for a given species within an option. Number displayed may vary due to rounding errors.
See text for fuller explanation and discussion of the rating scale.

Nitrogen-fixing lichens: This is a group of medium to large, lettuce-shaped lichens that include the genera *Lobaria, Nephroma, Pannaria, Pseudocyphellaria, Sticta* and *Peltigera*. These lichens contain cyanobacteria (blue-green algae), which fix atmospheric nitrogen. Their addition of nitrogen to the forest ecosystem is significant (Pike 1978; Denison 1973). They are also critical in the food chain of many invertebrates. Many of these lichens do not enter forest stands until late successional stages, and they become more frequent or abundant only in old-growth conifer forests after 200 years. Twenty-six species were rated including six rare species known from only a few sites. The rare species rated poorly with an 80 percent or greater likelihood of outcome C or better under Options 1, 3, and 4; and outcome D or better under Options 5-9 (table IV-18). For the more common nitrogen-fixing lichens, there is an 80 percent or greater likelihood of attaining outcome B or better under Options 1, 3, and 4; and outcome C or better under Options 5-9.

Pin lichens: These small to diminutive lichens resemble small pins arising from a bed of green algae. They are inconspicuous but are well documented as being closely associated with late-successional and old-growth forests (Rose 1992). Many different genera make up this group, which occur in sheltered microsites with high humidity, often on the underside of large leaning trees. Pin lichens are substrate specific. The sixteen species of pin lichens were rated with an 80 percent or greater likelihood of attaining outcome B or better under Option 1; and outcome C or better for Options 3, 4, 5, and 9, with Options 7 and 8 receiving somewhat lower ratings (table IV-18).

Decaying wood lichens: This group includes eight species that occur only on decaying wood in various decay classes. This group includes species in the genus *Cladonia* as well as *Xylographa*, and *Icmadophila*. These species rated with an 80 percent or greater likelihood of attaining outcome B or better under Options 1, 3, 4, 5, and 9; and outcome C under Options 7 and 8 (table IV-18).

Tree bole lichens: This diverse group of lichens includes 14 species that occur on the base and boles of trees or snags. Several genera are represented, including crustose lichens. This group received an 80 percent or greater likelihood of attaining outcome B or better under all the options (table IV-18).

Soil lichens: This group includes eight species that occur on soil, protecting the forest floor from surface erosion. This group rated with an 80 percent or greater likelihood of attaining outcome B or better under all the options (table IV-18).

Rock lichens: This group of six lichens occur on rocks in shaded, ameliorated climatic conditions maintained by old-growth forests canopies. Two of the species are rare and rated with an 80 percent or greater likelihood of outcome C or better only under Option 1; and outcome D or better under all the other options. The more common rock lichens rated higher with an 80 percent or greater likelihood of attaining outcome B or better under Options 1, 3, 4, 5, and 9; and outcome C or better under Options 7 and 8 (table IV-18).

Aquatic lichens: The three lichen species in this group are truly aquatic and unlike most other lichens will die if desiccated. They are found on rocks in streams and create conditions that enhance aquatic invertebrate populations. These species are good indicators of water quality and constancy of stream flow levels. These lichens rated with an 80 percent or greater likelihood of outcome B or better under Options 1 and 4; with outcome C or better under Option 3, 5 and 9; and outcome D or better under Options 7 and 8 (table IV-18).

Riparian lichens: This group includes nine species found on trees in riparian areas. The increased humidity and hardwood component within the riparian areas appear critical to the distribution of these species. They are generally medium to large, long, pendent lichens that become locally abundant and are usually conspicuous. These lichens rated with nearly an 80 percent or greater likelihood of attaining outcome B or better under Options 1 and 4; and outcome C or better in all the other options (table IV-18).

Oceanic influenced lichens: This diverse group includes 16 species that occur in mature trees within a short distance of the Pacific Ocean. Frequent fog along the coast, combined with moderate temperatures, create a unique environment for these lichens. All of these species are considered rare from a regional perspective with 12 considered very rare and known from only one or a few locations in the Pacific Northwest; three of these species are listed and three others are proposed for listing with the Oregon Natural Heritage Program (1991) as species of concern. These 12 rare Oceanic influenced species rated an 80 percent or greater likelihood of outcome D or better under all of the options. The more common species rated with an 80 percent or greater likelihood of attaining outcome C or better under all of the options (table TV-is).

Discussion. Outcomes for lichens were generally correlated with the acreage of Late-Successional Reserves, stand treatments within the Matrix, and protection for riparian corridors. Ratings were higher for lichens in the options with greater acreage within Late-Successional Reserves. Ratings were higher for aquatic and riparian lichens in the options with wider riparian buffer areas. Overall outcomes were highest for Options 1, 2, then 4, intermediate for 5 and 9 (equal) and lowest under 7 and 8 (table IV-18).

Some of the rare lichen species have narrow geographic ranges and only occur in specialized habitats. This group rated much lower than the others (fig. IV-6, IV-7). These species are typically distributed across the landscape only in isolated special habitats. Therefore, they need to be evaluated at a different scale than the common species that are more widely and evenly distributed. The management options considered here do not specifically address the concerns of species occurring in special habitats, which include geologic sites, refugia from fire, oceanic dune deflation plains, waterfalls, and river gorges. Many of these special habitats occur as rare combinations of abiotic and biotic conditions such as specific tree species in the fog zone of a waterfall at low elevations. These special habitats need to be addressed at the local level and were not mapped for the present review. Specific measures need to be implemented tinder all options that conserve such special habitats if the rare species are to be conserved.

Many of the lichen species addressed here occur worldwide, yet have experienced marked declines or extirpation in many parts of Europe and eastern North America (Olsen and Gauslaa 1991; Rose 1988; Rose and Wolseley 1984). The extirpation and drastic decline of these species has been attributed to both cutting of woodlands and air quality degradation (Alstrup and Sochting 1989; Broad 1989). In Denmark, 88 species of lichens have been extirpated due to air pollution and forestry practices (Alstrup and Sochting 1989). The decline of *Lobaria, Sticta, Pseudocyphellaria,* and *Nephroma* species in England is attributed to selective cutting of the mature large diameter trees (Rose 1988). The following 14 species are associated with old-growth forests in the Pacific Northwest and are documented to have been extirpated from parts of Europe:

Lobaria pulmonaria, Lobaria scrobiculata, Nephroma bellum, Nephroma laevigatum, Nephroma parile, Peltigera collina, Pannaria rubignosa, Pannaria mediterranea, Leptogium cyanescens, Leptogium saturninum, Collema nigrescens, Sticta fuliginosa, Sticta limbata, and *Usnea longissima* (Olsen and Gauslaa 1991; Rose 1988). Populations of these species should be closely monitored as indicators of biological diversity and forest ecosystem health.

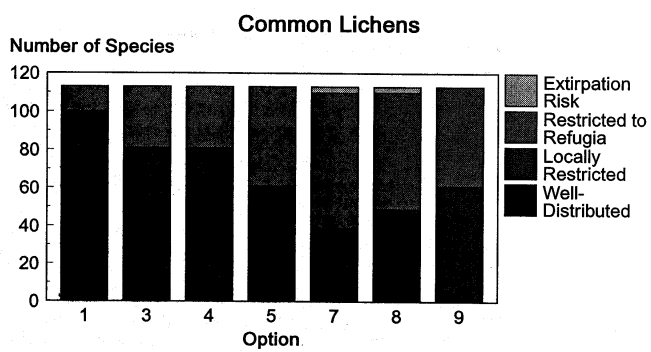


Figure IV-6. Outcomes for common lichens under each land management option. Values shown are the number of species that had as 80 percent or greater likelihood of achieving at least the specified outcome (based on distribution of habitat).

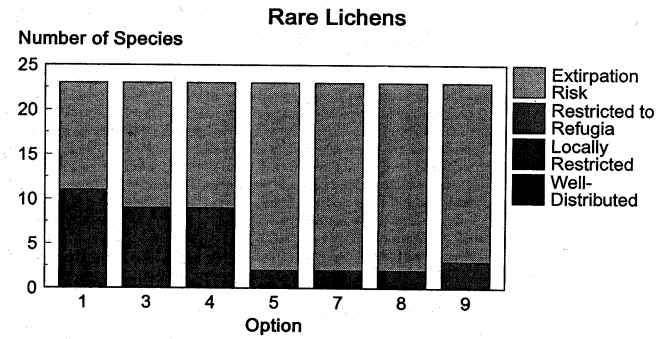


Figure IV-7. Outcomes for rare lichens under each land management option. Values shown are the number of species that had as 80 percent or greater likelihood of achieving at least the specified outcome (based on distribution of habitat).

Mitigation for Lichens

Several of these lichen species have limited dispersal capabilities and are not able to move far from the parent plant. Small patches (10-40 acres) of old-growth forests distributed across the landscape are important as refugia and centers of dispersal (Esseen et al. 1992). Some lichens, particularly the nitrogen-fixing species, do not become established until stands are several hundred years old (5~IcCune 1993). Older stands that are well distributed geographically are critical to the survival and persistence of these species in the ecosystem. Riparian buffers on all orders of streams are important for the riparian and aquatic lichens.

Many lichen species are rare, endemic, and not well studied; additional surveys are needed to identify populations of rare or endemic species, sites of species diversity, special habitats, or unique communities. Protection of key populations of rare lichen species from adverse management activities and designation of Botanical Special Interest Areas or Areas of Critical Environmental Concern are important mitigation for these groups. Conservation strategies have been developed by federal agencies for many rare animals and vascular plants; similar plans could be developed to address rare lichen species. Conservation strategies provide biological and habitat information, management direction, and recommendations for selecting and monitoring of key populations. Interagency coordination will improve the conservation and enhancement efforts for these rare species. The State Natural Heritage Programs coordinate, store, and track information on these rare species across all land ownerships and should be involved in this coordination process.

Leave trees should be clumped within managed stands to moderate climatic factors and provide a variety of microhabitats which contribute to the survival of many lichen species. These lichens are slow to recolonize and grow so old-growth clumps act as "seed trees." Therefore, it would be beneficial to maintain patches of large, old trees within the forest Matrix rather than leaving widely spaced individual retention trees. These patches may then become the source of genetic material and propagules to disperse lichens into the adjacent stands when conditions become suitable. Big, old trees with large lateral branches provide the best substrate for many species of lichens, and trees that have emergent crowns or are the largest, oldest trees in the stand should be retained. Maintaining the same leave trees over several harvest rotations is important due to the slow colonization and growth of most lichens. Additional mitigation in the Matrix under most options could include selecting for diverse tree species and structure in the leave tree patches; leaving large down logs within the shelter of the retention tree clumps to provide additional microhabitat and microclimatic conditions. Other mitigating measures include retention of trees on ridgelines for some lichen species because this location optimizes dispersal and interception of fog. This pattern mimics the retention patterns created by natural fire.

Buffering rock outcrops with a 'halo of trees at least one tree height in width maintains the appropriate shade and microclimate required by lichens that grow on rocks is another type of mitigation that will increase the likelihood of meeting outcome A for some lichen species.

Forage lichens: Bryoria tortuosa the only rare species in this group has only three documented locations. It is known from Eagle Point in Jackson County, Oregon, and in Washington from the Olympic Peninsula and in the Columbia River Gorge. Protection of these known locations is critical for its survival. Survey adjacent areas to determine its presence before management treatments occur.

Arboreal leafy lichens: Three rare species need site-specific habitat management. *Hypotrachyna revoluta* is known from one site in Washington. *Tholurna dissimilis* is a monotypic genus with seven known sites on windswept, stunted trees, in the fog zone, and in the upper canopy of old-growth low elevation Douglas-fir trees on the H.J. Andrews Experimental Forest (Pike 1972; Otto 1983). *Hypogymnia duplicata* is known from only three sites: Larch and Saddle Mountains in Oregon, and Sulfur Creek Lava Flow in Washington. Protection of the known sites for these three rare species is critical to their survival. Additional surveys should be conducted for new locations to prevent inadvertent destruction of site locations. Monitoring these known populations to assess their viability and trends should be conducted to determine management strategies. Other mitigation for the species could include protecting mature trees on ridgelines and windswept sites, especially within the Columbia River Gorge.

Nitrogen-fixing lichens: Most of these species, including the rare ones, are known to occur only in stands that are several hundred years old. Old-growth stand fragments including small scale 10-40 acres in size, distributed across the landscape are necessary to maintain viable populations of these species, due to their limited dispersal capabilities. This group of lichens includes several species that are restricted to lower elevation old-growth stands. Increasing the acreage of lower elevation old-growth stands would be beneficial for these species.

Nitrogen-fixing lichens are negatively affected by air pollution and are especially sensitive to sulfur dioxide (Hawksworth and Hill 1984). Air quality in forested areas is important to maintain healthy populations of these species. Air quality monitoring should be established to determine baseline conditions as well as to monitor changes in forest health.

Few known sites for rare nitrogen-fixing lichens occur within reserves. *Dendriscocaulon intricatulum* is known from only one site in Washington, at Sulfur Creek Lava Flow on the Mt. Baker-Snoqualmie National Forest; one site in Oregon, and more sites are known in British Columbia and Alaska. *Nephroma occultum* is known from only five sites in the United States and from several sites in British Columbia. It occurs in the upper canopy of old trees, generally over 400 years of age (Coward 1992). *Pseudocyphellaria rainierensis* is locally endemic and known from eight sites where it occurs in the canopy and lower tree boles in old stands. *Pannaria rubiginosa* is known from one site at Fisherman's Bend, a Bureau of Land Management recreational site near Salem. Protection of these sites is critical to the survival of the above lichens.

Pin lichens: All these species require stable, high atmospheric humidity provided by old--growth forest conditions (Tibell 1980). They occur on large tree boles, in microsite that are sheltered from the direct rain. Complex canopy structure and especially leaning boles of trees are optimal sites for these species. Retention of large coarse woody material will benefit these species. Standards and guidelines should be developed for all the options to retain clusters of trees, (rather than scattered individuals) including "leaning trees," selecting of leave trees that are the largest and oldest, along with some asymmetrical trees, and distributing the clumps of leave trees across a variety of landscape and topographic positions.

Aquatic and Riparian lichens: Reduced water quality and fluctuation of water flow can destroy aquatic lichens. Sediment in streams act as an abrasive, and sand-blast lichens off the rocks. Cumulative effects of logging in watersheds may have a detrimental impact on these organisms in the stream system. These lichens are limited by abilities to disperse and may recolonize slowly, especially upstream. Watershed protection guidelines that are part of Options 1, 3, 4, 5, and 9 are beneficial to both the aquatic and riparian lichen species. Surveys for these species should be conducted as part of the watershed analysis conducted before activities are allowed in these riparian buffers including hydroelectric projects.

Oceanic influenced lichens: Mitigation can be improved by surveying, monitoring, and developing conservation strategies to maintain viable populations of the rare oceanic species. Designating botanical special interest areas to protect known populations is critical to the survival of the species. Sutton Creek on the Siuslaw National Forest and located within the Matrix is an important location for many rare Oceanic lichens. Recreational activities and management guidelines to conserve these unique botanical resources should be developed.

Along the immediate coast, old-growth forests are rare, allowing more stands to develop into old-growth, to provide additional habitat for these rare and locally distributed species would enhance the survival of oceanic lichen species. Coordination between state and private sectors to inventory, evaluate and establish sites for conservation of these species is necessary. Portions of the Siuslaw National Forest near the ocean that are managed as Matrix should be surveyed, and suitable rare lichen habitat should be protected.

The role of nonfederal lands. The oceanic influenced lichens are locally distributed and many are rare. This group could benefit from management on nonfederal lands. Recreational developments should minimize degradation of botanical resources in state parks. Coastal areas should be surveyed for these species and suitable botanical areas acquired. Little old-growth forest remains in coastal areas of the Pacific Northwest as a result of fire history and past harvesting. Stands in coastal areas should be developed into old-growth conditions to provide habitat for coastal species.

Much of the low elevation forest land in the Pacific Northwest is under nonfederal ownership. This land includes thousands of acres and is generally managed on short harvest rotations. Given that lichens are slow to establish in rapidly growing stands and do not become abundant until later in the successional development, most of these stands are harvested before lichens have a chance to establish significant populations. Most lichen species are not able to disperse across extensive areas of young stands. Therefore, these lichen species may not be able to disperse across these non-federal lands.

Research and information needs. Lichen research needs include: basic inventory and monitoring, status reviews of rare species, successional studies, effectiveness of retention trees for dispersal, studies of lichen functions (e.g., climate control, nutrient cycling, forage for wildlife), and air quality monitoring.

Baseline inventories are needed to document presence of lichen species abundance, biomass, habitat requirements, and geographic distribution. Lichen inventory data should be incorporated into the general forest inventory, computerized, and mapped. Sampling methods for forest epiphytes need to be standardized. Identifications should be verified with voucher specimens deposited in recognized regional herbaria. Identification guides and annotated catalogs for lichens in each physiographic region should be developed. Land management agencies need knowledgeable and qualified staff to conduct lichen inventory and monitoring.

Status reviews and comprehensive surveys should be conducted for rare species. This information needs to be shared with the State Heritage Programs, that track species information across all land ownerships. Conservation strategy plans should be developed for rare species to enhance their viability through specific mitigation, standards and guidelines, and designation of reserves.

Successional studies should be conducted on lichen communities, including establishment, diversity, and abundance in stands of different ages and different plant associations, substrates, and vertical succession in the canopy. Basic research is needed to determine lichen dispersal patterns by species, groups of species (guilds), and forest types. This would be useful to quantify the importance of small, closely spaced forest fragments to the viability of these species.

Monitoring and research plans to evaluate the effects of forest management practices on lichens should be developed. The impacts from management activities including timber harvesting, silvicultural practices, grazing, and recreation should be monitored. For example, questions to be answered include: what species of lichens survive in retention trees and how is this survival affected by topographic position, tree symmetry, crown type, or clumping retention trees? What is the advantage of selecting leave trees that contain a diversity of lichen species and how effective are lichens on retention trees as centers of dispersal?

Nitrogen fixation rates of the nitrogen-fixing lichens in different forest types throughout the year should be determined. The quantity and nutrient content of lichen litter-fall should be determined for different forest types. Research projects should be conducted on the role of lichen litter-fall in the nutrient cycling and biomass production of the various types and ages of forests. Research should be conducted on both the west and east side forests on the trophic relationships of lichens, small mammals, and predators such as the spotted owl. Research into the species preferences of lichens for nest building by flying squirrels should be conducted to guide management actions. The role of lichens as habitat and food for forest mammals and invertebrates should also be investigated.

Research is also needed on the amount of fog moisture captured by epiphytic lichens and bryophytes, the role of these epiphytes in creating and maintaining the unique ameliorated climatic conditions under the canopy of old-growth forests, and the relationship between lichen abundance and structural diversity in the forest.

An integrated, regional air quality monitoring program should be developed using lichens as biological indicators of forest health, including impacts on lichen species and trends in lichen populations would further aid in their conservation. Forage and nitrogen-fixing lichens are especially sensitive to air pollution and should he monitored to detect reduction in their viability from a decline in air quality (Rose 1988).

Bryophytes

Hornworts, liverworts, and mosses, collectively known as bryophytes, are small, green, nonvascular, spore-bearing plants that have evolved a wide array of species well adapted to nearly every habitat on earth. About 170 species of liverworts and 450 species of mosses occur within the range of the northern spotted owl. About 20 percent of these species are endemic to western North America or to the Pacific Northwest (Lawton 1971).

Although bryophytes can reproduce by means of spores, dispersal is more often accomplished by vegetative means, either through fragmentation of leaves or stems, or by special asexual propagules. Given their proclivity for asexual reproduction, distribution of species is erratic and unpredictable, but populations will be viable as long as sufficient suitable habitat is available.

Epiphytic mosses and lichens can total up to 2.6 metric tons per hectare in old-growth Douglas-fir forests of western Oregon (McCune 1993). In the understory, mosses often comprise 20 percent of the biomass and 95 percent of the photosynthetic tissue biomass (Binkley and Graham 1981).

Old-growth forests may be essential to the continued existence of some bryophytes. Most species of bryophytes do not become established in stands until 100 years, and they are best developed in stands 400 years or older. Norris (1987) found nine of 128 bryophyte species of late-successional redwood forests to be absent from stands that had been clearcut 100 years earlier, and 22 other species were reduced in abundance in younger stands. McCune (1993) observed significant differences in species composition and biomass of epiphytic bryophytes in stands aged 95, 145, and 400 or more years. He noted a marked reduction of bryophyte biomass and species in the younger age classes. Lesica et al. (1991), found seven of eleven species of leafy liverworts to be restricted to old-growth stands, in a Montana forest, where their preferred substrate, decaying wood was more abundant. Additional studies in Europe (Söderström 1988, Laaka 1992) indicated that late-successional forests serve as refugia for bryophyte species that no longer occur in, or cannot colonize younger stands because of air pollution, acid rain effects, or short rotations in managed forests.

Bryophytes provide food and habitat for a host of invertebrates (Russell 1979, Gersun 1982, Varga 1992) and vertebrates. Marbled murrelets nest in moss mats in old-growth trees. Flying squirrels, birds, and mammals commonly use mosses as material in their nests.

The bryophytes are involved with nutrient cycles in old-growth stands. They act as sinks for nitrogen leachate from canopy lichens and free-living cyanobacteria that commonly cover tree leaves (McKee et al. 1987, Blinn et al. 1988, Greene and Blinn 1991). Bryophytes intercept, absorb, and buffer nutrients and water in the canopy and understory (Brown and Bates 1990). Bryophytes play an important role in the dynamics of understory vegetation, as well as soil structure, soil stability, and interception and retention of water. Many liverworts are mycorrhizal (Schuster 1966), and are generally limited to decaying wood in old-growth and late-successional stands.

Bryophytes are well developed in riparian areas on the maples and cottonwoods. Nadkarni (1984) showed that the mineral content of the epiphytes on bigleaf maple in the Olympic forests exceeded that of the leaves on the same tree. Bryophytes are also a major component of the forest stream ecosystem, providing year-round habitat for a wide array of algal species, aquatic invertebrates, and amphibians at all trophic levels. They are a perennial source of organic material. Bryophytes function as efficient filters for trapping sediments and small organic material.

Christy (1991) reviewed the findings of the International Association of Bryologists worldwide survey. More than 60 percent of the scientists surveyed cited forestry as causing the greatest decline of bryophytes, with epiphytes as the most threatened ecological group. Continued harvest of old-growth forest will cause a decline of bryophytes species that are restricted to or best developed in old-growth (Lesica et al. 1991). Old-growth stands provide sources of inoculum for adjacent stands when suitable habitat becomes available.

Air pollution is a potential threat to bryophytes within the range of the spotted owl. Hallingbäck (1992) described how air pollution has caused a widespread decline in bryophyte species, as well as a reduction in plant size and a decline in sexual reproduction. Small epiphytic species at the edge of stands and bryophytes on exposed summits and ridgelines may be seriously affected.

The unregulated harvest of "special forest products" is a potential threat to bryophytes of the old-growth forest. The harvest of bryophytes for the floral trade is depleting local populations and may have serious long-term implications for processes such as mineral cycling, moisture retention in logs, and seedbed availability for vascular plants. An estimated 40-60 tons of mosses arc harvested each year in Oregon and Washington (J. Freed, 1989, Washington State University, Cooperative Extension, personal communication). A large portion of the harvested moss is exported. A related threat could be the marketing of rotten logs and stumps as a soil amendment, much as peat moss is used. This would have a negative effect on many liverwort species dependent on coarse woody debris.

Methods. The panel evaluated 106 species of mosses and liverworts closely associated with old-growth forests, including 32 species endemic to western North America or the Pacific Northwest (appendix table IV-A-3). Nomenclature for mosses follows Anderson et al. (1990), and Stotler and Crandall-Stotler (1977) for liverworts.

Bryophytes were divided into 13 habitat groups to facilitate discussion (appendix table IV-A-3). Groups were based on ecological relationships or habitat associations, and some of the groups were further subdivided by their degree of rarity. Each group was rated based on the projected future condition of habitat on federal lands (outcomes A-D, see Methods for assessing effects of options). Three species were rated individually because they did not fit into species groups or were too poorly known, eight were rated individually because they were rare species, 16 were not rated because of lack of information.

Table IV-19. Projected future likelihoods of habitat outcomes for bryophytes under land management options.

	Option 1				Option 3				Option 4				Option 5				Option 7				Option 8				Option 9			
Bryophytes	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**
Individual Species																												
Blindia flexipoda	80	20	0	0	70	30	0	0	80	20	0	0	70	30	0	0	70	30	0	0	60	40	0	0	80	20	0	0
Diplophyllum pricatum	10	30	30	30	10	30	30	30	10	30	30	30	10	30	30	30	10	30	30	30	10	30	30	30	10	30	30	30
Fontinalis howellii	97	3	0	0	93	7	0	0	93	7	0	0	83	17	0	0	77	23	0	0	73	27	0	0	0	90	10	0
Kurzia makinoana	100	0	0	0	91	3	3	3	91	3	3	3	91	3	3	3	82	6	6	6	82	6	6	6	91	3	3	3
Marsupella emarginata var. aquatica	0	30	60	10	0	30	60	10	0	30	60	10	0	30	60	10	0	30	60	10	0	30	60	10	0	30	60	10
Pseudoleskeella serpentinense (CA)	100	0	0	0	90	10	0	0	90	10	0	0	90	10	0	0	90	10	0	0	80	20	0	0	90	10	0	0
Ptilidium californicum (CAonly)	100	0	0	0	90	10	0	0	80	20	0	0	80	20	0	0	70	30	0	0	70	30	0	0	100	0	0	0
Racomitrium pacificum	70	30	0	0	70	30	0	0	60	40	0	0	60	40	0	0	50	50	0	0	50	50	0	0	70	30	0	0
Schistostega pennata (WAonly)	100	0	0	0	100	0	0	0	100	0	0	0	80	20	0	0	80	20	0	0	80	20	0	0	100	0	0	0
Scouleria marginata	100	0	0	0	100	0	0	0	100	0	0	0	80	20	0	0	80	20	0	0	80	20	0	0	100	0	0	0
Thamnobryum neckeroides	70	13	17	0	67	13	20	0	67	13	20	0	60	20	20	0	53	23	20	3	53	17	20	10	60	20	20	0
Tritomaria exsectiformis	0	30	40	30	0	30	40	30	0	30	40	30	0	30	40	30	0	30	40	30	0	30	40	30	0	30	40	30
Bryophyte Groups																												
Abundant Decaying Wood	100	0	0	0	97	3	0	0	97	3	0	0	93	7	0	0	83	17	0	0	73	27	0	0	97	3	0	0
Aquatic	100	0	0	0	97	3	0	0	100	0	0	0	87	13	0	0	80	20	0	0	77	23	0	0	97	3	0	0
Canopy-Branch, Interior	77	23	0	0	73	27	0	0	70	30	0	0	70	30	0	0	70	30	0	0	63	37	0	0	73	27	0	0
Canopy-Twigs, Exterior	95	5	0	0	95	5	0	0	95	5	0	0	95	5	0	0	95	95	0	0	65	35	0	0	95	5	0	0
Decaying Wood	93	7	0	0	87	13	0	0	87	13	0	0	83	17	0	0	77	23	0	0	73	27	0	0	90	10	0	0
Flood Plain	100	0	0	0	97	3	0	0	97	3	0	0	90	10	0	0	77	23	0	0	77	23	0	0	97	3	0	0
Shaded Duff/Humic Soil	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	97	3	0	0	93	7	0	0	100	0	0	0
Shaded Mineral Soil	87	13	0	0	83	17	0	0	83	17	0	0	83	17	0	0	80	20	0	0	77	23	0	0	87	13	0	0
Shaded Rock Outcrops	93	7	0	0	80	20	0	0	77	23	0	0	73	27	0	0	67	30	3	0	60	37	3	0	83	17	0	0
Splash Zone	100	0	0	0	100	0	0	0	100	0	0	0	97	3	0	0	83	17	0	0	83	17	0	0	100	0	0	0
Tree Boles/Decaying Wood	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0
Tree Boles/Understory	90	10	0	0	90	10	0	0	90	10	0	0	90	10	0	0	83	17	0	0	80	17	3	0	90	10	0	0
Wet Shaded Humic Soil	100	0	0	0	97	3	0	0	97	3	0	0	93	7	0	0	83	17	0	0	80	20	0	0	93	7	0	0

A-Well Distributed B-Locally Restricted C-Restricted to Refugia D-Extirpation

Likelihood values are expressed as percentages that total to 100 for a given species within an option. Number displayed may vary due to rounding errors.
See text for fuller explanation and discussion of the rating scale.

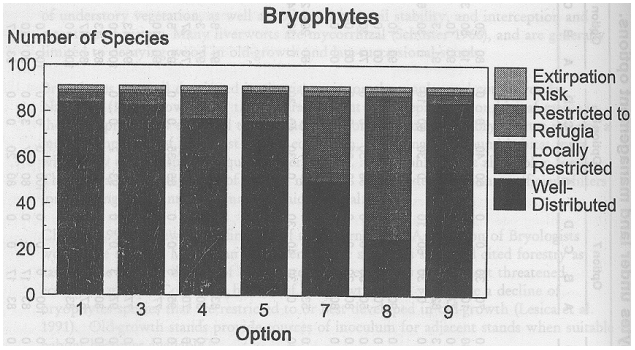


Figure IV-8. Outcomes for bryophytes under each land management option. Values shown are the number of species that had an 80 percent or greater likelihood of achieving at least the specified outcome (based on distribution of habitat).

Results. Ratings for bryophytes are presented by habitat association groups and for some individual species (table IV-19). A summary of outcome scores for each group or species was based on the average scores of three expert panelists (table IV-19, fig. IV-8).

Canopy exterior: The two species in this group are common and widespread on twigs and branches in the canopy of old-growth forests at low to middle elevations. *Ulota megalospora* is more common on slopes and ridgetops, and *Ulota obtusiuscula* is frequent on branches of hardwoods in stream valleys. They occur in drier, more exposed portions of the canopy where lichens replace bryophytes as the dominant epiphytes (Pike et al. 1975). Hallingbäck (1992) noted that *Ulota* was one of the genera in serious decline in Sweden due to air pollution. A likelihood rating of 80 percent or better in outcome A was achieved in all but Option 8.

Canopy interior: The two species in this group occur in the interior portion of tree canopies. *Antitrichia curtipendula* is a dominant moss, forming large mats in the inner canopy of old-growth conifers, and is best developed in wet coastal forests and stream terraces. It is common at low to middle elevations throughout the region. These extensive moss mats eventually form "perched soils" in the canopy, complete with rooted vascular plants, fungi, and an invertebrate fauna. They act as large sponges, absorbing and retaining both moisture and nutrients leached from lichens and foliage in the upper canopy (Pike 1978). The mats also form platforms used as nesting sites by the marbled murrelet and red tree vole. Although not well studied, *A. curtipendula* may be a "keystone" species in the canopy, helping to regulate microclimate and nutrient flow, as well as providing habitat for other organisms.

The liverwort *Douinia ovata* is frequently abundant on the underside of limbs beneath mats of *Antitrichia*, where it may be dependent on nutrients leached from the mats and intercepted in stem flow. It also occurs on trunks and branches of trees at the edge of stands, where fog interception occurs.

The two species rated at an 80 percent or greater likelihood of attaining outcome B or better for all options. This rating results from concerns about the "keystone" nature of this group in an already fragmented landscape.

Tree boles and decaying wood, common: Three species were treated in this group, which are common on the bark of conifers and to a lesser extent on decaying logs. A rating of 100 percent in outcome A was achieved for all options.

Tree boles/understory - less common: Five species were treated in this group, which are common on the bark of conifers. A rating of 100 percent in outcome A was achieved for all options.

Shaded mineral soil: The five species in this group are pioneers on exposed mineral soil within the shaded and humid microclimate of the old-growth forest at low to middle elevations. Except for *Pseudotaxiphyllum elegans*, none are common. Typical habitats are root balls of windthrown trees, banks of trails, and small soil slumps. An 80 percent or greater likelihood rating in outcome A was achieved for this group under all options except 8.

Shaded rock outcrops with thin soil: The base of rock outcrops, when shaded by an old-growth canopy, is habitat for a distinctive group of species found nowhere else in the landscape. Most are widespread throughout the region. *Heterocladium* species grow directly on cool, shaded rock faces; the other species grow on ledges that accumulate shallow soils. Removal of the canopy at these sites results in replacement of this group by xerophytic bryophytes and vascular plants typical of exposed outcrops. The seven bryophytes in this species group probably develop only after long periods of canopy stability. Options 1, 3, and 9 rated with an 80 percent likelihood of attaining outcome A, while Options 4, 5, 7, and 8 rated with an 80 percent or greater likelihood of attaining outcome B or better.

Wet shaded humic soil: This group of five species occurs on moist to wet soils with high organic content. The species are widespread in the region at lower to middle elevations. The liverwort genus *Plagiochila* is probably represented in this habitat by more than one species (Hong 1992). *Calypogeia azurea* and *C. muelleriana* may also occur on decaying wood. This group is sensitive to desiccation and requires the shaded, moist microclimate provided by old-growth canopies. *Calypogeia* is most common in riparian stands and on stream terraces. Riparian protection, including buffers on intermittent streams, is important for their viability. Outcome A was achieved with an 80 percent or greater likelihood for all options.

Shaded duff and humic soil: These three species occur on shaded duff and humic soil at middle to upper elevations. They typically occur midslope, on benches or in concave microtopography subject to snow accumulation. They rated with an 80 percent or greater likelihood of attaining outcome A under all options.

Decaying wood - common species: This group of 15 species contains the highest proportion of liverworts in old-growth forest and is composed of relatively common species that are widespread at low to middle elevations throughout the region. They occur exclusively on logs without bark (decorticated) to well-decayed logs and stumps, in cool to moist forest stands with deep shade. They are most abundant in riparian areas and stream terraces. This group is sensitive to changes in light level and microclimate caused by removal or thinning of the canopy. They also depend on continued input of coarse woody debris in various decay classes and diameters for their substrate. This group rated with an 80 percent or greater likelihood of attaining outcome A under all options except Option 8.

Decaying wood - less common species: These 11 species of liverworts and mosses are restricted to coarse woody debris in various stages of decay, in cool, moist, and deeply shaded stands. This group rated with an 80 percent or greater likelihood of attaining outcome A under all options except 8.

Aquatic submerged: These three species are inundated by perennially cold, clear water and occur throughout the region at low to middle elevations. *Chiloscyphus polyanthos* grows on rocks, submerged wood, or organic matter in springs or seeps, with low flows. The other two species occur on submerged rocks in swift flowing streams or rivers. This group rated with an 80 percent or greater likelihood of attaining outcome A under all options except 8.

Splash zone: Five species of bryophytes in this group occur on rocks just above the level of mean (low) summer flows, in small to large fast-flowing streams, or in the spray zone of rapids and waterfalls. They are adapted to fluctuating water levels, and are sensitive to abrasion by sediment carried by the force of the current (Rosentreter 1984). *Jungermannia atrovirens* is most common in coastal streams in Oregon and northern California. Outcome A was achieved with an 80 percent or greater likelihood under all options.

Floodplain: The 13 floodplain species occur on a variety of substrates at low to high elevations throughout the region in both the Cascades and Coast Range. Most are common and widely distributed, but *Rhizomnium nudum* is uncommon to rare. *Conocephalum conicum*, *Dicranella palustris*, *Hookeria lucens*, *Pellia epiphylla*, *Pellia neesiana*, and *Rhytidiadelphus subpinnatus* occur in dense shade, on moist to wet, organic substrate, decaying logs, gravel and rocks, along streambanks, or on steam terraces. *Rhizomnium nudum* occurs on wet, rotten wood within these habitats. *Porotrichum bigelovii*, *Racomitrium obesum* and *Schistidium agassizii* occur on wet rocks, gravel, or mineral soil in streambeds and on banks. *Plagiomnium insigne* is common on moist, shaded soil and duff on stream terraces. *Apometzgeria pubescens* and *Metzgeria conjugata* occur on cool, shaded boles of hardwoods and on moist rock faces on streambanks and stream terraces. *Plagiomnium insigne* appears to be mycorrhizal.

These species were grouped together because they are almost exclusively associated with riparian zones and would be influenced by riparian prescriptions identified in the management options. All are dependent on shade, wet soils, organic litter and humid microclimate. This group rated with an 80 percent or greater likelihood for attaining outcome A under all options except 7 and 8.

Species rated individually: These species were rated individually because they did not fit readily into other habitat groups, or because there was a lack of information about them.

Fontinalis howellii (= *F. antipyretica* var. *oregonensis*) grows on sediment and submerged wood in cold, clear water of spring-fed ponds and pools, on both stream terraces and midslope in sag ponds (ponds formed by land slumps on slopes). While not containing significant populations of fish, these ponds and pools are extremely important as breeding areas for amphibians. This group rated with an 80 percent or greater likelihood of attaining outcome A under all options except 7 and 8.

Kurzia makinoana grows on well-shaded rotten wood and humic soil (Hong et al. 1989) at low elevation. It occurs throughout the region but apparently is uncommon. California populations are more common in mires (small bogs), while those in Oregon and Washington are more closely associated with old-growth forests. This species rated with an 80 percent or greater likelihood of attaining outcome A for all options.

Thamnobryum neckeroides, endemic to the Pacific Northwest, occurs in dense shade, on moist organic soil and rocks in thickets of willow, vine maple, and Sitka alder at middle to higher elevations. These thickets usually occur at the margins of avalanche tracks, seepage areas, and the bases of talus slopes, adjacent to stands of old-growth forest. Sites often have snowpacks that persist until early summer. This species rated with nearly an 80 percent or greater likelihood of attaining outcome B or better for all options except Option 8, reflecting its present somewhat spotty distribution.

Rare species: Blindia flexipoda is only known from a limited area of serpentine along the Smith River in northern California, where it occurs in the splash zone of streams. It is an effective sediment trap, and gold miners remove large quantities of this species to extract gold. This species rated with an 80 percent or greater likelihood of attaining outcome A under Options 1, 4, and 9, and rated to outcome B or better in the other options.

Diplophyllum plicatum occurs sparsely in two sites in old-growth Sitka spruce forest on the Oregon Coast (Schofield and Godfrey 1979; Oregon Natural Heritage Program 1991). It has also been collected in the North Cascades and Olympic National Park (Hong et al. 1989). It grows on bark, decaying wood, and thin soil over rock. It rated with an 80 percent or greater likelihood of outcome D or better under all options.

Marsupella emarginata var. *aquatica* is known in our region from one site at Waldo Lake in the Oregon Cascades, where it is abundant on submerged rocks of a high elevation stream. This is the only known location in western North America. It rated with an 80 percent or greater likelihood of attaining outcome C or better for all options.

Pseudoleskeella serpentinense is restricted to the Smith River watershed in northern California and southwestern Oregon; it grows on serpentine outcrops near streams (Wilson and Norris 1989). It rated with an 80 percent or greater likelihood of attaining outcome A for all options, indicating that riparian prescriptions are adequate for continued viability.

Ptilidium calfornicum, common on boles of conifers, particularly old-growth silver fir, throughout montane forests in Oregon and Washington, becomes rare in northern California, where it is only known from old-growth white fir at high elevations. It rated with an 80 percent or greater likelihood of attaining outcome A for all hut Options 7 and 8, which rated at an 80 or greater likelihood of attaining outcome B or better.

Racomitrium pacificum occurs sporadically on perennially moist, partially-shaded rocks in humid old-growth forests at low elevations (Frisvoll 1988), usually near streams. It occurs primarily in coastal forest, but is found more commonly under Douglas fir than Sitka spruce. It rated with an g~ percent or greater likelihood of attaining outcome B or better for all options.

Schistostega pennata is known in the region only from Washington, where it occurs on soil in dark, moist crevices under root wads of fallen trees. It can also occur on rock in dark, moist crevices, and caves. It rated with an 80 percent or greater likelihood of attaining outcome A for all options.

Tritomaria exsectiformis and *Tritomaria quinquedentata* occur on shaded moist soil or rocks (Hong et al. 1989), from low to high elevation. In Oregon, *Tritomaria exsectiformis* occurs primarily in riparian areas. It rated with an 80 percent or greater likelihood of outcome D or better for all options. A similar species *Tritomaria quinquedentata* is known in Oregon only from Saddle Mountain State Park in the northern Coast Range and it was not rated.

Species not Rated: Sixteen species were not rated due to a lack of either sufficient ecological or distributional knowledge to properly evaluate and rate them at this time.

Discussion. In general, the ratings for the species groups indicate that bryophyte diversity in old-growth forests within the region is greatest in three general habitats: (1) streams and riparian zones, (2) bases of shaded rock outcrops, and (3) trees on summits and along ridgelines subject to fog interception. Most species of bryophytes closely associated with old-growth forests require the shaded and moist microclimates provided in these sites. Nearly all the liverworts are more sensitive to desiccation than mosses. There is significant overlap in optimal habitat requirements for bryophytes and amphibians.

The common, widely distributed species rated with nearly an 80 percent or greater likelihood of attaining outcome A under all options. Options 1, 3, 4, 5, and 9 consistently rated higher than Options 7 and 8 for most bryophytes (table IV-19). Four extremely rare species have outcomes of less than 80 percent likelihood of attaining outcome B or better. These ratings do not vary by option and are not primarily reflective of option design.

The riparian prescriptions in all options except 7 and 8 caused the ratings for the majority of the bryophyte groups to be near an 80 percent or greater likelihood of attaining outcome A. However, riparian buffer widths were often inadequate to protect the flood plain bryophytes" that occur in stream terraces. In addition, intermittent streams are extremely important habitat for bryophytes, and adequate buffers should be extended to these areas in all watersheds.

Bryophyte groups associated with rock outcrops and soil had somewhat lower ratings for those options that afforded less protection to shaded rock outcrops and fog-prone summits. These sites are habitat for some of the rarest bryophytes in the region, particularly the coastal fog-drenched peaks. They may be impacted by ridgeline roads, landings, trails, and telecommunication towers. However, the ratings of these rare species should be accorded less significance because by definition the species already have significant gaps in their distributions, and populations are isolated from one another. In most cases, this scattered distribution seems to have been the historical distribution.

Mitigation for Bryophytes

Bryophytes should receive considerable protection under riparian prescriptions, especially those with full SAT riparian buffers. However, protection for some bryophytes should be extended to encompass the entire floodplain because considerable species diversity exists on stream terraces that may extend beyond one or two tree lengths. Large areas in the floodplains have been lost to roads. Some of these roads should be removed from the stream terraces. Riparian stands older than 80 years should not he thinned or harvested.

Commercial collecting of the special forest product "moss" or "decaying wood" should not be permitted in any Reserve area or in the riparian buffers under any of the options. These mosses buffer water and nutrient loading. Harvesting of special forest products in the Matrix should be regulated for sustained yields.

The following specific mitigation measures for bryophytes should raise the probability of the group or species attaining outcome A to greater than 80 percent rating. For bryophytes that occur on shaded rock outcrops with thin soil, the base of rock outcrops could be buffered by retaining protective clumps of green trees (two to three tree lengths) around each rock outcrop. These buffers will protect the shaded microclimate needed for these species.

Longer rotations in the Matrix would provide a variety of age and diameter classes. Additional green tree retention in some options will help maintain recruitment of large woody debris essential for bryophytes that thrive on decaying wood. Clumped retention of green trees in the Matrix would provide appropriate microclimate for bryophytes to survive. Large riparian buffers, as proposed in Thomas et al. (1993), that includes small and intermittent streams, are essential to maintain suitable substrate. Retention of coarse woody debris in harvest units will provide suitable habitat for species requiring this substrate.

Rare species: Four extremely rare species have outcomes of less than 80 percent likelihood of attaining outcome B or better. These ratings do not vary by option and are not primarily reflective of option design. Important mitigation for these species for all options is conducting surveys and protecting locations where these rare species occur.

Intensive inventories should be conducted to locate additional populations of these species and to provide data for species management guidelines, as is done for vascular plants. Populations of rare bryophytes should be protected and monitored to determine successional status and population trends. More acreage of old-growth Sitka spruce forests should be managed in the coastal areas. Cold springs need to be recognized as important resources for biological diversity. Water pollution from sewage and motorboats at Waldo Lake could negatively impact the population of *Marsupella emarginata* var. *aquatica*. For *Schistostega pennata*, windfalls need to be left in place to provide structurally diverse habitat. Windfirm buffers of trees along fog-drenched ridges would maintain biological diversity.

Role of nonfederal lands. There is little habitat for late-successional/old-growth bryophyte species on private lands in the region. Most of the old-growth coniferous forest on private lands within the range of the northern spotted owl has been logged, and the landscape currently is being managed on relatively short (30-70 year) rotations. There will be little chance for survival or effective dispersal of most bryophytes in such a landscape. Survival of other species at lower elevations in nonconiferous habitats (e.g., *Antitrichia curtipendula* in oak stands in the Willamette Valley) is equally in doubt. Many of these oak stands are being converted to agricultural or residential developments. Potential declines in air quality may further affect this species.

The bryophytes of the aquatic habitat group are affected by sedimentation, temperature change, hydroelectric projects, mining, and nonpoint source pollution that can occur on state and private lands. These species are sensitive to such changes.

State lands, and state parks especially, provide a brighter picture for viability, particularly in the coastal Sitka spruce region. Many of these parks contain the last remnant of old-growth forests. Saddle Mountain State Park in Oregon, a high peak with a fog-drenched summit, hosts some of the rarest bryophytes in the Pacific Northwest. Unfortunately, these sites also may be impacted by declining air quality, although not so severely as parks in the interior valleys or Cascade foothills.

Research and information needs. Bryophyte research needs include basic inventory, status reviews of rare species, monitoring, ecosystem function, nutrient cycling, and sustainable moss harvest studies.

Baseline inventories to document species presence, abundance, biomass, habitat requirements, and geographic distribution are needed. Methods for sampling forest epiphytes need to be standardized. Identifications should be verified with voucher collections deposited in herbaria. The taxonomic status of many rare bryophyte species needs to be clarified. Land management agencies should conduct status surveys on rare bryophyte species and special habitats. This information needs to be shared with the state Natural Heritage Programs, which track species information and occurrences across all land ownerships. Conservation strategy plans should be developed for rare species to enhance their viability through specific mitigation, standards and guidelines, and designation of reserves. Establishment of small, site-specific special interest areas for rare bryophytes is needed to conserve the diversity of these species. The land-management agencies should provide training opportunities for field personnel in bryophyte taxonomy, and coordinate with bryologists to develop monitoring and inventory protocols.

Monitoring of rare bryophytes and their habitats is needed on a regional basis. Permanent, long term study plots of bryophyte population trends should be established on a regional basis. Key bryophyte indicator species should be identified for monitoring water quality. Use of mosses and liverwort species as indicators of microclimatic changes caused by forest management actions should be developed. Succession patterns of liverwort species on large decaying wood should he investigated. Interspecific relationships among bryophytes and their symbiont species need to be studied.

Ongoing forest management studies should include the effects of various silvicultural practices on the epiphytic and coarse woody debris species of bryophytes. Research on moss species used for nesting sites of marbled murrelets and those selected by flying squirrels should be conducted.

The special forest products market for bryophytes needs to be studied and regulated. Management should determine which species, locations, forest types and quantities of bryophytes that are being harvested. The effects of the harvest on forest functions such as nutrient cycling, water regulation, soil moisture retention, invertebrate habitat, and seedbed formation for vascular plants should be investigated.

Vascular Plants

The largest and most dominant organisms of the late-successional and old-growth forest ecosystem are the vascular plants, which may tower over 300 feet, with lifespans over 1,000 years. They create the structure of the forest and function as the primary producers, capturing sunlight through photosynthesis and converting its energy to foods consumed by animals and fungi. Ranging from the dominant conifers to the delicate ferns, vascular plants are defined as those that contain conducting or vascular tissue. They include seed-bearing plants (flowering plants and conifers) and spore-bearing forms, such as ferns, horsetails, and clubmosses. In general, vascular plants provide substrate and habitat for other organisms, influence microclimate (e.g., sunlight, humidity, temperature, and interception of snow and rainfall), and provide forage, hiding, and thermal cover for vertebrate and invertebrate species. They produce litterfall that contributes to organic matter and soil development. Many species are symbiotic with mycorrhizal fungi and other vascular plants (e.g., mycotrophic ericads and orchids), while others fix nitrogen (e.g., alder, ceanothus, members of the pea family).

Trees provide nesting and denning habitat for a wide range of birds and mammals. For example, trees colonized by dwarf mistletoe develop dense broom-like structures that are utilized by northern spotted owls and flying squirrels. When trees fall, they provide habitat for invertebrates, lichens, mosses, fungi, amphibians, and small mammals. Many vascular plants have close relationships with specific animal pollinators and seed dispersers, which facilitate plant gene flow through pollen and seed dispersal, and provide a food source for animal vectors.

In addition to their vital role in maintaining a functioning forest ecosystem, vascular plants provide important commercial resources, including both timber and other special forest products. Harvest of medicinal, horticultural, and edible plants from Pacific Northwest forests has increased dramatically in recent years. The total annual wholesale value of floral and holiday greens, Christmas trees, edible, medicinal, and landscaping plants in the Pacific Northwest is estimated at $174 million (I. Freed and J. Myer, Washington State University, 1993, personal communication). In addition to the timber species, commercially important vascular plants include beargrass, salal, huckleberry, sword-fern, Pacific yew, and cascara. Many additional species are harvested on a smaller scale.

The vascular flora of the Western United States is highly diverse. In Washington, Oregon, and California, the number of recorded taxa (including species, varieties, and subspecies) is 4,302, 5,343, and 7,700, respectively (K. Urban, U.S. Forest Service, 1993, personal communication; Smith 1987). Within the range of the northern spotted owl, several important areas of high diversity are recognized that feature plants restricted to narrow geographical areas. The Klamath Province, the Columbia River Gorge, and the Olympic and Wenatchee Mountains are among the areas with high endemism. Several rare species are restricted to the coastal redwood forests. Rare and local plants are often restricted to peculiar soils, such as those developed from ultramafic rocks in southwestern Oregon, northern California, and the Wenatchee Mountains of Washington, and to special habitats, such as rock outcrops, bogs, and wetlands.

While hundreds of vascular plant species occur in late-successional forests in the Pacific Northwest, less than 130 species are considered closely associated with this seral stage. In addition to the obvious dominance of the conifers, many other families are well represented (appendix table IV-A-4). Numerous species of heaths and orchids are closely associated with late-successional forest, and both groups have photosynthetic and nongreen representatives. The nonphotosynthetic species, such as fringed pinesap and coralroot orchid, are characterized by complex, symbiotic relationships involving both fungi and photosynthetic vascular plants (Wells 1981, Furman and Trappe 1971). Of the species considered closely associated with late-successional and old-growth forest, 29 have federal, state, or agency status.

At least 200 additional species occur within special habitats such as serpentine barrens, bogs, and wetlands within the range of the northern spotted owl. These species and their habitats may be affected by forest management, but are not specifically addressed in this report. At least 54 of these special habitat species have status as federally listed or candidate species.

Whereas many vascular plants colonize habitat quickly and have short reproductive cycles, most species closely associated with late-successional and old-growth forests are long-lived perennials. Many woody and herbaceous vascular plants are extremely long-lived, and decades may be required before plants reach reproductive size (Hanzawa and Kalisz 1993). Recolonization of disturbed areas and establishment may be slow, particularly for species with limited dispersal and special requirements. Many rare plants are characterized by low seedling production (Crowder 1978; Fredricks 1992). Recruitment of young plants into populations is often limited by low seed production, high seed predation, limited numbers of 'safe sites", and competition from other species.

Methods specific to vascular plants. The "short list" of vascular plant species in the Scientific Analysis Team Report (Thomas et al. 1993, appendix 5-B) formed the basis of the list developed for this analysis. Species that met the criteria of close association with old growth as defined by the Scientific Analysis Team (Thomas et al. 1993) in any significant portion of their range were included.

The present list was developed with input from botanists with the Bureau of Land Management, Oregon Department of Agriculture Plant Conservation Biology Program, U.S. Fish and Wildlife Service, National Park Service, Oregon State University, Humboldt State University, Berry Botanic Garden, Pacific Northwest Experimental Station, Pacific Southwest Experiment Station, Southern Oregon College, University of Washington, The Nature Conservancy, University of Oregon, the Pacific Northwest and Pacific Southwest Regions of the U.S. Forest Service, and the Heritage Programs of Washington, Oregon, and California. Twenty-five species not evaluated in the Scientific Analysis Team Report (Thomas et al. 1993) were added. Nine species considered in the Scientific Analysis Team Report were found not to meet the criteria of close association with late-successional and old-growth forests and were omitted from this analysis. While the list is fairly comprehensive, it is possible that further study and new information may justify inclusion of additional species.

The vascular plant panel included six professional botanists whose knowledge of the vascular plant flora spanned the geographic range of the northern spotted owl. A total of 124 vascular plant species were evaluated based on the projected future condition of habitat on federal lands (outcomes A-D, see Methods for assessing effects of options). Four other species were not rated. Seven species that exhibited different ecological characteristics in different portions of their range were rated separately based on geographical areas.

Maps illustrating the locations of populations of 19 threatened, endangered, and sensitive plants tracked by the state Natural Heritage Programs were overlayed on the 1:500,000 scale maps of the withdrawn and Reserve areas being considered in the analysis. The species maps included both historic localities and current occurrences. The number and percentage of known populations that occur within various Reserve areas and the Matrix were also calculated by option and used in this analysis.

Rare and geographically restricted (endemic) species were identified and treated separately in some analyses. In this report, rare species include those with state, federal, or agency status as threatened, endangered, or sensitive, as well as those that are infrequently encountered (e.g., *Allotropa virgata*).

Results. Average ratings for vascular plant habitat varied considerably among options (table IV-20; fig. IV-9). A total of 110 vascular plant species or species ranges (84 percent) received greater than 80 percent likelihood of having habitat of sufficient quality, distribution, and abundance to allow populations to stabilize well-distributed across federal lands within their natural geographic range (outcome A) in Option 1, while only 78 species or species ranges (59 percent) received the same rating under Option 7, Ratings among Options 3, 4, and 5 were similar (fig. IV-9). Option 9 tended to have likelihoods of achieving outcome A that were lower than Options 3, 4, and 5 and higher for most species than for Options 7 and 8. Options 7 and 8 consistently received the lowest ratings.

In general, ratings tended to be lowest for rare species that were geographically restricted (e.g., *Aster vialis*) or sparsely distributed throughout a larger range (e.g., *Allotropa virgata*, *Cypripedium fasciculatum*) (table IV-20). Because rare species are often restricted to localized areas, the Reserve areas in this analysis afforded different degrees of protection to individual species. The Late-Successional Reserve areas in Option 1 provide greatest protection to the 19 rare species tracked by state Natural Heritage Programs; 83 percent of the populations tabulated occurred in these areas (table IV-21). In Options 7 and 9, 55 and 53 percent, respectively, of the populations are within Late-Successional Reserves.

Many of the populations of *Poa laxiflora* (86 percent) and *Cimicifuga elata* (23 percent) occur within 50 miles of salt water. Of the populations of *Collomia mazama*, 43 percent occur within Administratively and Congressionally Withdrawn Areas. Key Watersheds are important for both riparian and upland species including *Botrychium montanum*, *Coptis trifolia*, *Corydalis aquae-gelidae*, *Frasera umpquaensis*, and *Pleuricospora fimbriolata*.

Table IV-20. Projected future likelihoods of habitat outcomes for vascular plants under land management options.

	Option 1				Option 3				Option 4				Option 5				Option 7				Option 8				Option 9			
Vascular Plants	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	A	**B**	**C**	**D**
Abies lasiocarpa (California)	50	13	38	0	50	13	38	0	50	13	38	0	50	13	38	0	50	13	38	0	50	13	38	0	50	13	38	0
Achlys triphylla	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	85	15	0	0	82	19	0	0	97	4	0	0
Adenocaulon bicolor	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	95	5	0	0	95	5	0	0	100	0	0	0
Adiantum pedatum	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	92	8	0	0	92	8	0	0	98	2	0	0
Adiantum jordanii	100	0	0	0	78	23	0	0	78	23	0	0	75	25	0	0	68	33	0	0	68	33	0	0	78	23	0	0
Allotropa virgata	62	34	4	0	34	53	13	0	34	53	13	0	33	51	17	0	19	52	25	4	28	52	17	4	28	53	16	4
Anemone deltoidea	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	92	9	0	0	92	9	0	0	98	2	0	0
Apocynum pumilum	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	75	25	0	0	90	10	0	0	90	10	0	0
Aralia californica	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	87	13	0	0	87	13	0	0	94	6	0	0
Arceuthobium tsugense	0	80	20	0	0	80	20	0	0	80	20	0	0	60	40	0	0	50	50	0	0	50	50	0	0	50	50	0
Amica latifolia	100	0	0	0	100	0	0	0	100	0	0	0	98	2	0	0	93	7	0	0	98	2	0	0	100	0	0	0
Asarum caudatum	97	4	0	0	87	14	0	0	88	12	0	0	87	14	0	0	81	19	0	0	82	18	0	0	87	14	0	0
Asarum hartwegii	100	0	0	0	93	7	0	0	87	13	0	0	83	17	0	0	72	28	0	0	75	25	0	0	83	17	0	0
Asarum marmoratum	80	20	0	0	60	40	0	0	60	40	0	0	60	40	0	0	60	40	0	0	60	40	0	0	60	40	0	0
Asarum wagneri	100	0	0	0	100	0	0	0	90	10	0	0	90	10	0	0	80	20	0	0	80	20	0	0	90	10	0	0
Aster vialis	0	61	39	0	0	61	39	0	0	59	41	0	0	56	44	0	0	26	74	0	0	26	74	0	0	48	53	0
Bensoniella oregana (California)	90	10	0	0	0	0	50	50	0	0	50	50	0	0	50	50	0	0	50	50	0	0	50	50	0	0	50	50
Bensoniella oregana (Oregon)	78	23	0	0	68	33	0	0	73	28	0	0	63	38	0	0	31	43	26	0	31	43	26	0	58	33	10	0
Berberis pumila	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	95	5	0	0	98	3	0	0	100	0	0	0
Boschniakia strobilacea	88	12	0	0	80	20	0	0	80	20	0	0	80	20	0	0	58	33	8	0	62	30	8	0	80	20	0	0
Botrychium minganense	30	58	12	0	30	50	20	0	30	50	20	0	30	50	20	0	30	43	27	0	30	43	27	0	30	50	20	0
Botrychium montanum	30	58	12	0	30	50	20	0	30	50	20	0	30	50	20	0	30	43	27	0	30	43	27	0	30	50	20	0
Botrychium virginanum	63	32	5	0	58	35	7	0	58	37	5	0	54	39	7	0	48	32	20	0	48	32	20	0	52	41	7	0
Calypso bulbosa	90	10	0	0	86	14	0	0	86	14	0	0	86	14	0	0	80	16	4	0	82	14	4	0	84	16	0	0
Chamaecyparis lawsoniana (north)	87	7	7	0	80	13	7	0	80	13	7	0	77	17	7	0	60	27	13	0	60	27	13	0	77	17	7	0
Chamaecyparis lawsoniana (south)	80	10	10	0	60	30	10	0	60	30	10	0	60	30	10	0	30	50	20	0	30	50	20	0	60	30	10	0
Chamaecyparis nootkatensis	100	0	0	0	98	2	0	0	98	2	0	0	98	2	0	0	93	7	0	0	93	7	0	0	98	2	0	0
Chimaphila menziesii	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	92	8	0	0	94	6	0	0	98	2	0	0
Chimaphila umbellata	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	92	8	0	0	94	6	0	0	98	2	0	0
Cimicifuga elata	69	21	10	0	53	36	11	0	50	39	11	0	48	41	11	0	29	40	31	0	34	38	29	0	48	40	13	0
Cimicifuga laciniata	100	0	0	0	90	10	0	0	90	10	0	0	90	10	0	0	80	20	0	0	80	20	0	0	90	10	0	0
Clintonia andrewsiana	80	20	0	0	70	27	3	0	70	27	3	0	70	27	3	0	57	33	10	0	60	30	10	0	70	27	3	0
Clintonia uniflora	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	93	8	0	0	93	8	0	0	98	2	0	0
Collomia mazama	100	0	0	0	85	15	0	0	85	15	0	0	85	15	0	0	70	30	0	0	70	30	0	0	85	15	0	0
Coptis asplenifolia	0	10	90	0	0	10	90	0	0	10	90	0	0	10	90	0	0	0	90	10	0	0	90	10	0	10	90	0
Coptis laciniata	98	3	0	0	93	8	0	0	93	8	0	0	90	10	0	0	71	29	0	0	71	29	0	0	83	18	0	0
Coptis trifolia	50	30	20	0	30	30	40	0	30	30	40	0	30	30	40	0	0	30	40	30	0	30	40	30	20	30	50	0
Corallorhiza maculata	98	2	0	0	97	3	0	0	97	3	0	0	97	3	0	0	86	14	0	0	88	13	0	0	95	5	0	0
Corallorhiza mertensiana	98	2	0	0	97	3	0	0	97	3	0	0	97	3	0	0	88	13	0	0	89	11	0	0	95	5	0	0
Corallorhiza striata	98	2	0	0	98	2	0	0	97	3	0	0	97	3	0	0	88	13	0	0	89	11	0	0	95	5	0	0
Corydalis aquae-gelidae	20	49	31	0	17	47	37	0	20	49	31	0	10	48	40	2	2	32	57	10	2	30	58	10	10	48	40	2
Cypripedium fasciculatum (Cascades)	0	28	38	33	0	17	43	40	0	17	43	40	0	17	40	43	0	8	40	52	0	8	37	55	0	8	37	55
Cypripedium fasciculatum (Klamath)	50	40	10	0	15	50	20	15	15	50	20	15	5	55	30	10	0	40	35	25	0	43	38	20	0	43	38	20
Cypripedium montanum (east Cascades)	0	75	25	0	0	50	50	0	0	50	50	0	0	50	50	0	0	25	50	25	0	25	50	25	0	25	75	0
Cypripedium montanum (west Cascades)	12	33	41	14	0	25	50	25	0	25	48	27	0	23	50	27	0	14	42	44	0	17	41	42	0	21	52	27
Dentaria californica	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	95	5	0	0	95	5	0	0	100	0	0	0
Disporum hooken	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	92	8	0	0	92	8	0	0	98	2	0	0
Disporum smithii	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	91	9	0	0	91	9	0	0	98	2	0	0
Dryopteris austriaca	100	1	0	0	100	1	0	0	100	1	0	0	100	1	0	0	87	13	0	0	87	13	0	0	95	6	0	0
Eburophyton austiniae	83	8	8	0	83	8	8	0	83	8	8	0	83	8	8	0	76	11	13	0	78	9	13	0	82	5	13	0
Erythronium montanum	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	97	3	0	0	97	3	0	0	100	0	0	0
Frasera umpquaensis	78	20	3	0	65	33	3	0	65	33	3	0	63	35	3	0	33	51	16	0	33	51	16	0	60	35	5	0
Galium kamtschaticum	0	90	10	0	0	90	10	0	0	90	10	0	0	70	30	0	0	70	30	0	0	70	30	0	0	70	30	0
Gallium oreganum (Klamath)	98	3	0	0	98	3	0	0	98	3	0	0	93	8	0	0	85	15	0	0	88	13	0	0	93	8	0	0
Gaultheria humifusa	95	5	0	0	95	5	0	0	95	5	0	0	90	10	0	0	85	15	0	0	85	15	0	0	85	15	0	0
Gaultheria ovatifolia	98	2	0	0	98	2	0	0	98	2	0	0	98	2	0	0	94	6	0	0	96	4	0	0	98	2	0	0
Goodyera oblong ifolia	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	95	5	0	0	97	4	0	0	98	2	0	0
Gym nocarpium dryopteris	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	96	4	0	0	96	4	0	0	100	0	0	0
Habenaria orbiculata	100	0		0	0	80	20	0	0	80	20	0	0	80	20	0	0	50	50	0	0	50	50	0	0	50	50	0
Habenaria saccata	100	0	0	0	98	2	0	0	98	2	0	0	98	2	0	0	91	9	0	0	91	9	0	0	96	4	0	0
Habenarja unalascensis	100	0	0	0	98	3	0	0	98	3	0	0	98	3	0	0	94	6	0	0	94	6	0	0	98	3	0	0
Hemitomes congestum	82	18	0	0	69	23	8	0	69	23	8	0	63	29	8	0	52	29	19	0	57	24	19	0	58	26	16	0
Hierochloe occidentalis	100	0	0	0	92	8	0	0	92	8	0	0	88	12	0	0	72	28	0	0	72	28	0	0	87	13	0	0
Hypopitys monotropa	90	10	0	0	69	23	8	0	69	23	8	0	66	26	8	0	55	29	16	0	58	26	16	0	62	28	10	0
Isopyrum haliii	80	20	0	0	70	30	0	0	70	30	0	0	70	30	0	0	60	40	0	0	60	40	0	0	70	30	0	0
Lathyws polyphyllus	100	0	0	0	95	5	0	0	95	5	0	0	95	5	0	0	89	11	0	0	91	9	0	0	95	5	0	0
Listera borealis	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	90	10	0	0	90	10	0	0	100	0	0	0
Listera caurina	98	3	0	0	96	4	0	0	96	4	0	0	91	9	0	0	84	16	0	0	89	11	0	0	88	13	0	0
Listera convallarioides	97	3	0	0	95	5	0	0	95	5	0	0	88	12	0	0	83	17	0	0	90	10	0	0	83	17	0	0
Listera cordata	100	0	0	0	99	1	0	0	99	1	0	0	96	4	0	0	87	13	0	0	91	9	0	0	92	9	0	0
Luzula hitchcockii	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	96	4	0	0	96	4	0	0	100	0	0	0
Lycopodium selago	93	7	0	0	83	17	0	0	83	17	0	0	80	20	0	0	73	27	0	0	73	27	0	0	83	17	0	0
Lysichiton amencanum	100	0	0	0	98	2	0	0	98	2	0	0	97	4	0	0	93	7	0	0	93	7	0	0	96	4	0	0
Melica subulata	98	2	0	0	98	2	0	0	98	2	0	0	98	2	0	0	96	4	0	0	97	3	0	0	98	2	0	0
Menziesia ferruginea	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	91	9	0	0	91	9	0	0	100	0	0	0
Mitella breweri	97	3	0	0	97	3	0	0	97	3	0	0	97	3	0	0	90	10	0	0	90	10	0	0	97	3	0	0
Mitella caulescens	98	3	0	0	95	5	0	0	98	3	0	0	95	5	0	0	86	14	0	0	86	14	0	0	95	5	0	0
Mitetla ovalis	98	2	0	0	97	3	0	0	98	2	0	0	97	3	0	0	89	11	0	0	89	11	0	0	95	5	0	0
Mitefla pentandra	97	3	0	0	93	7	0	0	93	7	0	0	93	7	0	0	87	13	0	0	87	13	0	0	90	10	0	0
Mitella triflda	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	85	15	0	0	85	15	0	0	90	10	0	0
Monotropa unifiora	89	11	0	0	70	25	5	0	70	25	5	0	62	28	10	0	58	30	12	0	60	28	12	0	63	27	10	0
Oxalis oregana	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	98	2	0	0	98	2	0	0	100	0	0	0
Oxalis trillifolia	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	88	13	0	0	88	13	0	0	100	0	0	0
Pedicularis howellii	85	15	0	0	40	45	15	0	40	45	15	0	40	45	15	0	20	30	40	10	25	25	35	15	30	40	25	5

Phlox adsurgens	100	0	0	0	96	4	0	0	96	4	0	0	96	4	0	0	88	13	0	0	88	13	0	0	95	5	0	0
Picea breweriana	83	17	0	0	82	18	0	0	82	18	0	0	82	18	0	0	67	23	10	0	68	22	10	0	82	18	0	0
Pityopis californica	92	8	0	0	78	22	0	0	78	22	0	0	78	22	0	0	60	33	7	0	70	23	7	0	73	23	3	0
Pleuricospora fimbriolata	88	12	0	0	78	22	0	0	78	22	0	0	76	24	0	0	60	33	7	0	63	30	7	0	72	27	2	0
Poa laxiflora (Cascade)	85	15	0	0	70	30	0	0	80	20	0	0	70	30	0	0	55	35	10	0	55	35	10	0	70	30	0	0
Poa laxiflora (Coast)	90	10	0	0	83	17	0	0	83	17	0	0	83	17	0	0	60	40	0	0	60	40	0	0	83	17	0	0
Polystichum californicum (Cascades)	100	0	0	0	78	23	0	0	73	28	0	0	73	28	0	0	50	50	0	0	63	38	0	0	73	28	0	0
Pterospora andromedea	82	18	0	0	78	23	0	0	78	23	0	0	73	28	0	0	62	33	6	0	64	30	6	0	73	28	0	0
Pyrola asarifolia	100	0	0	0	99	1	0	0	99	1	0	0	97	3	0	0	89	11	0	0	91	9	0	0	95	5	0	0
Pyrola chlorantha	97	3	0	0	97	3	0	0	97	3	0	0	93	7	0	0	90	10	0	0	93	7	0	0	93	7	0	0
Pyrola dentata	100	0	0	0	95	5	0	0	95	5	0	0	93	8	0	0	81	19	0	0	84	16	0	0	93	8	0	0
Pyrola picta	98	2	0	0	98	2	0	0	98	2	0	0	97	3	0	0	90	10	0	0	92	8	0	0	95	5	0	0
Pyrola secunda	100	0	0	0	99	1	0	0	99	1	0	0	97	3	0	0	91	9	0	0	92	8	0	0	95	5	0	0
Pyrola uniflora	93	7	0	0	87	13	0	0	87	13	0	0	83	17	0	0	75	25	0	0	78	22	0	0	87	13	0	0
Rubus lasiococcus	100	0	0	0	99	2	0	0	99	2	0	0	99	2	0	0	95	5	0	0	95	5	0	0	97	3	0	0
Rubus nivalis	98	2	0	0	94	6	0	0	94	6	0	0	92	8	0	0	86	14	0	0	89	11	0	0	90	10	0	0
Rubus pedatus	100	1	0	0	100	1	0	0	100	1	0	0	95	6	0	0	95	6	0	0	95	6	0	0	100	1	0	0
Sarcodes sanguinea	73	21	6	0	64	24	13	0	64	24	13	0	61	26	13	0	53	33	15	0	58	28	15	0	60	28	13	0
Satureja douglasii	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	93	8	0	0	93	8	0	0	100	0	0	0
Scoliopus biglovei	100	0	0	0	73	28	0	0	73	28	0	0	73	28	0	0	55	45	0	0	55	45	0	0	65	35	0	0
Scoliopus haliii	100	0	0	0	90	10	0	0	98	3	0	0	90	10	0	0	78	23	0	0	78	23	0	0	90	10	0	0
Selaginella oregana	60	33	7	0	53	40	7	0	53	40	7	0	53	40	7	0	47	47	7	0	47	47	7	0	53	40	7	0
Smilaciha racemosa	100	0	0	0	99	1	0	0	99	1	0	0	99	1	0	0	95	5	0	0	95	5	0	0	97	4	0	0
Smilacina stellata	100	0	0	0	99	1	0	0	99	1	0	0	99	1	0	0	95	5	0	0	95	5	0	0	97	4	0	0
Streptopus amp lexifolius	100	0	0	0	99	1	0	0	99	1	0	0	99	1	0	0	93	7	0	0	93	7	0	0	97	4	0	0
Streptopus roseus	100	0	0	0	97	3	0	0	97	3	0	0	97	3	0	0	86	14	0	0	86	14	0	0	95	5	0	0
Streptopus streptopoides (Oregon)	95	5	0	0	80	20	0	0	80	20	0	0	80	20	0	0	60	40	0	0	60	40	0	0	80	20	0	0
Streptopus streptopoides (Washington)	90	10	0	0	90	10	0	0	90	10	0	0	90	10	0	0	90	10	0	0	90	10	0	0	90	10	0	0
Synthyris schizantha	97	3	0	0	97	3	0	0	97	3	0	0	97	3	0	0	93	7	0	0	93	7	0	0	97	3	0	0
Taxus brevifolia (entire range)	97	4	0	0	93	7	0	0	93	7	0	0	92	9	0	0	78	22	0	0	80	20	0	0	87	14	0	0
Taxus brevifolia (NW California)	80	20	0	0	60	40	0	0	60	40	0	0	60	40	0	0	40	60	0	0	40	60	0	0	40	60	0	0
Thuja plicata	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	98	2	0	0	98	2	0	0	98	2	0	0
Tiarella trifoliata	100	0	0	0	97	3	0	0	99	1	0	0	97	3	0	0	95	5	0	0	95	5	0	0	97	3	0	0
Tiarella unifoliata	100	0	0	0	97	3	0	0	99	1	0	0	97	3	0	0	95	5	0	0	95	5	0	0	97	3	0	0
Trillium ovatum	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	98	2	0	0	98	2	0	0	100	0	0	0
Vaccinium alaskaense	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	98	3	0	0	98	3	0	0	100	0	0	0
Vaccinium membranaceum	100	0	0	0	99	1	0	0	99	1	0	0	99	1	0	0	98	2	0	0	99	1	0	0	99	1	0	0
Vaccinium ovalifolium	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0
Vaccinium parvifolium	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0
Vancouveria hexandra	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	97	4	0	0	97	4	0	0	100	0	0	0
Vancouvena planipetaia	97	3	0	0	88	12	0	0	87	13	0	0	85	15	0	0	75	25	0	0	75	25	0	0	88	12	0	0
Vicia americana var. villosa	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	98	2	0	0	98	2	0	0	100	0	0	0
Viola glabella	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	96	4	0	0	96	4	0	0	97	3	0	0
Viola orbiculata	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	97	3	0	0	97	3	0	0	100	0	0	0
Viola renifolia	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	95	5	0	0	95	5	0	0	100	0	0	0
Whipplea modesta	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	98	2	0	0	98	2	0	0	100	0	0	0
Xerophyllum tenax (Olympic Penisula)	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0

A-Well Distributed B-Locally Restricted C-Restricted to Refugia D-Extirpation

Likelihood values are expressed as percentages that total to 100 for a given species within an option. Number displayed may vary due to rounding errors.
See text for fuller explanation and discussion of the rating scale.

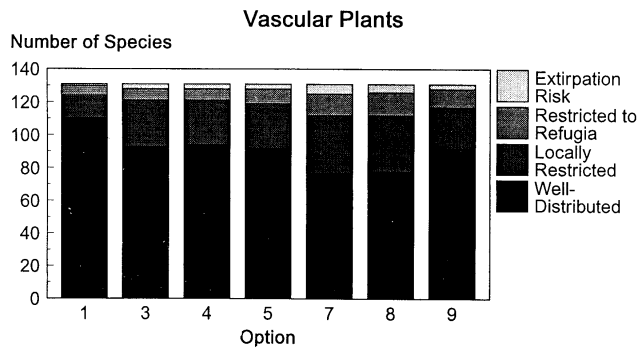


Figure IV-9. Outcomes for vascular plants under each land management option. Values shown are the number of species/species ranges that had an 80 percent or greater likelihood of achieving at least the specified outcome (based on distribution of habitat).

Only two species were considered to have risk of extirpation under Option 1, and for those only within portions of their range (*Cypripedium fasciculatum* in the Cascades Province and *C. montanum* in the Western Cascades). Three species were considered to have greater than 40 percent likelihood of extirpation under Option 7 (*Bensoniella oregana* in California, *Cypripedium fasciculatum* in the Cascades Province, *Cypripedium montanum* in the Western Cascades).

In Option 1, 22 species or species ranges had less than 80 percent likelihood of achieving outcome A. Five of these species are local endemics, three are on the periphery of their range, and thirteen are rare or uncommon. One species, *Arceuthobium tsugense*, is a parasitic epiphyte found principally on older hemlocks (*Tsuga heterophylla*) and is most abundant in stands generally older than 600 years, particularly in the wetter climatic areas (J. Henderson, 1993, U.S. Forest Service, personal communication). Significant gaps in its historic range currently exist, and panel members predicted that the gaps would persist even under Option 1. Seven species were considered to have no likelihood of achieving outcome A; three of these species (*Coptis asplenifolia*, *Galium kamtschaticum*, and *Habenaria orbiculata*) are more common to the north. Historic data suggest that two species, *Cypripedium montanum* and *C. fasciculatum*, were previously more common; past forest management activities may have contributed to declines in their populations. It is unlikely that most populations of these two species have retained the potential to interact. Because of their extremely slow growth rate, complex symbiotic relationships with other organisms, and possible fire requirements it was concluded that recolonization of these species throughout their former range was unlikely. However, both species fared considerably better in Option 1 than in the other options, in part due to the protection of all the smaller late-successional and old-growth fragments within the Matrix.

Table IV-21. Percent of vascular plant populations within Reserve Areas (R), Managed Late-Successional Areas (MA), Adaptive Management Areas (AA) and Matrix (M) by Option for 19 rare species tracked by Oregon, Washington, and California Natural Heritage Programs. Riparian buffers included in Matrix for this analysis.
N = number of federal populations analyzed.

		Option 1		Option 3			Option 4		Option 5		Option 7		Option 8		Option 9		
Species	N	R	M	R	M	MA	R	M	R	M	R	M	R	M	R	M	AA
Asarum wagneri	31	77	23	65	35	0	65	35	45	55	42	58	65	35	52	45	3

Aster vialis	10	60	40	10	70	20	30	70	20	80	20	80	10	90	10	90	0
Bensoniella oregana	64	83	17	66	34	0	66	34	66	34	27	73	66	34	45	55	0
Botrychium minganense	9	89	11	89	11	0	89	11	78	22	78	22	89	11	89	11	0
Botrychium montanum	8	88	12	88	12	0	88	13	75	25	75	25	88	0	100	0	0
Cimicfuga elata	38	82	18	53	39	8	55	45	39	61	34	66	53	47	42	42	16
Collomia mazama	42	90	10	83	12	5	83	17	74	26	74	26	83	17	79	21	0
Coptis asplenifolia	1	100	0	100	0	0	100	0	100	0	100	0	100	0	100	0	0
Coptis trifolia	3	67	33	33	33	33	33	67	33	67	33	67	33	67	33	67	0
Corallorhiza trifida	2	100	0	100	0	0	100	0	100	0	100	0	100	0	100	0	0
Corydalis aquae-gelidae	73	79	21	62	27	11	63	37	48	52	48	52	62	38	37	67	1
Cypripedium fasciculatum	78	79	21	47	35	18	49	51	37	63	35	65	46	54	33	31	36
Frasera umpquaensis	44	91	9	66	27	11	84	16	75	25	73	27	66	34	75	25	0
Galium kamtschaticum	3	100	0	100	0	0	100	0	100	0	100	0	100	0	100	0	0
Lycopodium selago	78	83	17	40	36	24	41	59	33	67	32	68	40	60	42	58	0
Pleuricospora fimbriolata	187	86	14	80	15	5	88	12	80	20	80	20	79	21	63	34	3
Poa laxiflora	85	74	26	69	31	0	73	27	71	29	53	47	69	31	49	18	33
Polystichum californicum	7	71	29	57	29	14	57	43	43	57	43	57	57	43	42	29	29
Streptopus streptopoides	54	85	15	74	17	9	74	26	69	31	67	33	74	26	74	24	2
Total	817	83	17	65	26	9	69	31	61	39	55	45	64	36	53	38	9

In Option 7, 53 species had less than 80 percent likelihood of achieving outcome A. in addition to the 22 species that received a similar outcome in Option 1, two commercially important conifers were included in this category for Option 7. Pacific yew (*Taxus brevifolia*) and Port Orford Cedar (*Chamaecyparis lawsoniana*) would have less than 80 percent likelihood of being well distributed throughout their range under this option.

Under Option 9, 39 species had less than 80 percent likelihood of achieving outcome A. Pacific yew in the Klamath Province and Port Orford Cedar throughout its range are included in this category. Others included seven mycotrophic species, three orchids, one root parasite, and five species of ferns.

Although all the nonphotosynthetic, mycotrophic species fared well under Option 1, as a group they received lower ratings, on average, under the other options compared to other species. This reflects their complex life histories involving fungal symbionts, other vascular plants, and in some cases, unidentified seed disseminators.

Discussion. While relatively few vascular plant species occur only in old-growth, many species reach their highest frequency in late-successional and old-growth stands, and others require habitat components characteristic of old-growth stands. Some species establish only on large rotting logs, while others require specific fungi for germination and growth (e.g., most orchids, some heaths). At least 12 species of nongreen flowering plants are closely associated with late-successional and old-growth forests; most are symbiotic species that require the close relationship between a truffle-forming fungus and a photosynthetic conifer or flowering plant. Ten of these are nonphotosynthetic orchids and ericads and are rarely found in stands less than 80 years old.

Rare species may occur only in rare habitats, they may be very localized, or they may have few individuals; in fact, seven types of rarity are generally recognized (Kruckeberg and Rabinowitz 1985, Rabinowitz et al. 1986). Fifteen species closely associated with late-successional and old-growth forests were considered locally endemic, while 18 species were identified as more widespread, but restricted in habitat or population size throughout their range. In addition, many species may be rare within portions of their ranges. Other rare and endemic species that have narrow habitat specificity were not considered closely associated with late-successional and old-growth forests, but occur within special habitats which may be affected by timber harvest.

The importance of down logs for the establishment of western hemlock seedlings in lat& successional and old-growth forest communities has been well documented (Harmon 1986). In addition, some herbaceous species establish primarily on coarse woody debris (e.g., *Pyrola uniflora*, *Allotropa virgata*, *Listera borealis*). *Streptopus streptopoides* appears to be completely restricted to rotting wood substrates, leading to the suggestion that fungal interactions may be involved (Kagan and Vrilakas 1993). Quality and quantity m coarse woody debris are therefore necessary for these species; Matrix prescriptions with larger numbers of logs, snags, and green trees per acre may provide future habitat for these and other species.

Some vascular plants require canopy gaps that may have been maintained historically by natural fires caused by lightning (e.g., *Aster vialis*, *Cimicifuga elata*, *Frasera umpquaensis*). Fire reduces understory competition, increases light, provides a pulse of available nitrogen, and stimulates germination of some fire-adapted species. The role of fire in the life history of *Cypripedium montanum* and *C. fasciculatum* warrants further investigation. The mechanism remains unclear, but it appears fire is necessary for the maintenance of viable populations of these species. Underburning treatments prescribed in the standards and guidelines were considered in the evaluations. Although these prescriptions may improve habitat for fire-adapted species, site-specific treatments were considered more important than broad scale treatments for these species.

Small fragments of late-successional and old-growth forests may be vital to certain vascular plants with limited dispersal capabilities. Species with ephemeral seeds may be particularly vulnerable to isolation, while those with seed banks are at lower risk. Even small fragments of late-successional forest may serve as genetic Reserves for recolonization of adjacent habitat. Distribution and spacing of fragments are also important for pollen vectors and animal seed dispersers. Presence and distribution of small fragments of late-successional forest stands were considered important in the discussion and rating of species including *Arceuthobium tsugense*, *Adiantum jordanii*, *Allotropa virgata*, *Bensoniella oregana*, *Clintonia andrewsiana*, *Coptis trifolia*, *Corallorhiza striata*, *Cypripedium fasciculatum*, *C. montanum*, *Habenaria orbiculata*, *Hemitomes congestom*, *Hypopitys monotropa*, *Isopyrum hallii*, *Monotropa uniflora*, *Pedicularis howellii*, *Pityopus california*, *Pterospora andromedea*, and *Scoliopus bigelovii*. Protection of small remnant stands of late-successional and old-growth forest resulted in higher ratings (greater than 15 likelihood points) in Option 1 over other options for most of these species.

At least 12 species closely associated with old-growth typically occur below 3000 feet in elevation, yet low elevation old growth is particularly limited. Remaining small fragments of old-growth forest are especially critical to locally endemic low elevation species, such as *Aster vialis* and *Scoliopus bigelovii*.

Many vascular plants associated with late-successional and old-growth forests occupy upper headwaters, intermittent streams, and seeps within late-successional and old-growth forests. Twenty-nine species that were evaluated occupy riparian and wetland habitats. Many additional species that occur in special habitats, such as bogs, wet meadows and other wetlands, were not considered for this analysis. Opening of the canopy and disrupting the hydrology of these sites may adversely affect shade-tolerant species. There was some concern that riparian standards and guidelines may be insufficient to protect some riparian-inhabiting species. Those species with highly restricted ranges (e.g., *Bensoniella oregana*, *Corydalis aquae-gelidae*, *Scoliopus bigelovii*) received the lowest ratings of the riparian inhabitants, particularly in Options 7 and 8, which had the most limited riparian reserves.

Four species were more widespread north of the range considered here (*Coptis asplenifolia*, *Coptis trifolia*, *Galium kamtschaticum*, and *Listera borealis*). Because disjunct populations and populations on the fringe of a species' range may be genetically distinct, populations of these species warrant special protection.

Effects of air pollution and climate change on vascular plants are poorly known. However, concerns were raised regarding other environmental conditions off federal lands for several species. Due to the close restriction of *Bensoniella oregana* to the coastal fog belt, fluctuations and changes in climate could affect its distribution over the next century. The less populations are reduced by management, the more resilient they will be to climatic change and other environmental stresses.

Mitigation for Vascular Plants

General mitigations: General guidelines address maintaining quality habitat necessary to ensure viable populations. The following features need to be defined and maintained: (1) corridors for seed dispersal to facilitate gene exchange, (2) adequate distribution and spacing of old-growth fragments, and (3) viable populations of pollinators and seed dispersers.

Special area designations: The Late-Successional Reserve areas are insufficient to ensure viability of some rare and locally endemic species, such as *Aster vialis*, *Bensoniella oregana*, *Cimicifuga elata*, *Corydalis aquae-gelidae*, *Frasera umpquaensis*, *Poa laxiflora*, and *Streptopus streptopoides*. Establishment of special Reserves (e.g., Botanical Special Interest Areas and Areas of Critical Environmental Concern) on federal lands to protect habitat and key populations of species at risk will be necessary. Key habitat and populations of many of these species have been already identified in existing conservation strategies (Cripps 1993; Gamon 1991; Goldenberg 1990; Grenier 1992; Kagan and Vrilakas 1993; Kaye and Kirkland 1993; Lang 1988, USDA Forest Service 1983a, USDA Forest Service 1983 b).

Species specific mitigation and habitat treatments: Many rare vascular plants have conservation strategies in preparation, draft, or final form prepared by the Bureau of Land Management and Forest Service, often in conjunction with other cooperators. These documents provide biological and habitat information, management direction, and recommendations for protection and monitoring of key populations. Developing, updating, and implementing conservation strategies for species, species groups, and habitats not provided for by the options, can reduce risk for many sensitive species.

While establishment of special botanical areas or protecting known locations may provide sufficient mitigation for many rare and endemic species, others will require specific management practices to enhance their viability. Some may benefit from prescribed fire (e.g., *Aster vialis*, *Cypripedium fasciculatum*, *C. montanum*) while others may be fire-intolerant (e.g., *Taxus brevifolia*, Pacific Yew, USDA Forest Service 1992b). Specific protocols need to be developed to apply fire effectively.

A pathogenic root rot (*Phytophthora lateralis*) has spread through much of the range of Port Orford cedar (*Chamaecyparis lawsoniana*), resulting in the elimination of stands from some habitats and threatening the commercial status of the species throughout its range (Zobel et al. 1985). The root rot has spread from the northern portions of the species range into remote areas, killing trees of all ages. No known genetic resistance or chemical control has been identified. The spores are spread via water or are transported by people, machinery, and animals, and through root grafts (Zobel et al. 1985). Therefore, it is critical for the conservation of this species to close roads and restrict further road construction in watersheds that contain uninfected stands (e.g. inland California populations).

Retention of habitat components: Specific habitat element standards and guidelines in most options include Matrix prescriptions that retain coarse woody debris, green trees, and snags. Coarse woody debris provides a habitat component necessary for vascular plant species that require rotting logs for establishment (e.g., *Allotropa virgata*, *Pyrola uniflora*, *Listera borealis*, *Streptopus streptopoides*). Coarse woody debris in the Matrix without canopy cover, however, may be inferior to that within the closed canopy.

While it may provide future substrate for establishment of these species, removal of the canopy alters the effective microclimate, log decay processes, and fungal associations. It is uncertain how these alterations in large woody debris ecology influence the future utilization of these logs by late-successional and old-growth associated vascular plants.

Mycotrophic species, such as *Pleuricospora fimbriolata*, are characterized by complex interactions involving symbiotic relationships with fungi and photosynthetic vascular plants and may require seed dissemination by fungivores such as the red-backed vole and northern flying squirrel. Maintenance of viable populations of these co-dependent organisms is essential to their survival.

Role of nonfederal lands. While the panels only evaluated habitat on federal lands, land ownership patterns may affect future viability of at least 10 species, including a number of coast range inhabitants that occur in areas where there is little federal land. Uncertainty regarding the management of nonfederal habitat is a concern for species that have significant portions of their range or key populations occurring off federal lands. Species most strongly influenced by nonfederal land ownership patterns include *Adiantum jordanii*, *Aralia californica*, *Aster vialis*, *Bensoniella oregana* (particularly in California), *Cimicifuga elata*, *Clintonia andrewsiana*, *Cypripedium fasciculatum* (Cascades Province), *Isopyrum hallii*, *Poa laxiflora* (coast range), and *Scoliopus bigelovii*. One of these species, Scoliopus bigelovii, occurs in the redwood forests of California and would benefit by both reducing redwood harvest and increasing the time between harvests. All could benefit from land exchanges, coordination among nonfederal landowners and federal agencies, protection of old-growth fragments with documented populations and suitable habitat, and maintenance of old-growth fragments and corridors to facilitate gene exchange among populations.

Special habitats. Most species that occur in special habitats including meadows, rock outcrops, bluffs, serpentine barrens and savannahs, marshes, and hogs were not included on the list to be analyzed, but in many situations they would be affected by adjacent activities in late-successional and old-growth forests. Many rare plants restricted to special habitats require highly specific site characteristics, although the factors limiting these species are often unknown. Modification of the hydrology, shading, and microclimate of these sites could result in extirpation of locally adapted species with highly specific habitat requirements. To maintain viable populations, development and implementation of standards and guidelines for special habitats will be essential (Dimling and McCain 1992). Mapping of these habitats using geographical information systems, in conjunction with species-specific surveys, will aid in managing these species and their habitats. Interagency coordination involving State Natural Heritage Programs, will be essential in this effort.

Research and information needs. Life histories and distributions of many vascular plant species are well documented, however, we lack basic information for others. In addition to inventories, biological and ecological studies of plant species should be conducted, particularly for the rare taxa. Ecological requirements need to be identified to be able to predict potential habitats. A regional database and associated geographic information system layer should be developed for rare and sensitive taxa, with continued and increasing coordination with state Natural Heritage Programs. Global positioning systems can be used to facilitate accurate mapping of rare plant localities.

Well-designed monitoring studies should be implemented to track population trends of rare species, as well as continuing those that are currently- in progress. This should he identified as a priority for rare species, particularly those that have been identified as being at risk. Demographic monitoring and modeling studies to predict the future of rare plant populations such as those conducted by Menges (1986), and Guerrant (1992), and Fredricks (1992) are necessary to evaluate trends and provide management recommendations.

Biological studies of obligate old-growth species are needed to determine specific habitat characteristics necessary to maintain populations, as well as to ensure that essential habitat features are retained or developed in forest corridors and Matrix. Corridors are most important for species with limited dispersal potential in order to maintain gene exchange.

Studies of limiting factors and management prescriptions may provide valuable insights into rare plant management. Demographic studies of the *Cyripedium* species should be conducted to investigate their extremely low reproductive rates, and controlled burns monitored to determine if seedling establishment is fire limited.

Monitoring studies that investigate the effects of disturbance on species of concern are warranted prior to further alteration of their habitat. For example, investigating the effectiveness of buffers for maintaining *Pleuricospora fimbriolata* populations, the value of logging while the ground is covered by snow (to lessen impacts on species intolerant of ground disturbance), and the effect of canopy removal on *Asarum wagneri* are studies that are either under way or have been proposed.

Baseline monitoring is recommended for selected species to determine if climatic change is altering their distribution. Studies to evaluate effects of climate on species thought to be at risk (e.g., *Abies lasiocarpa*, "fog-belt species" such as *Clintonia andrewsiana*, *Scoliopus bigelovii*) could be incorporated into the environmental monitoring and assessment program. Species with highly specific habitat requirements would likely be most sensitive to climatic influence.

Approximately 23 percent of the species evaluated here occur in wetland and riparian habitats, including five species of special concern with federal, state, or agency status. Protocols for wetland and riparian vegetation inventory and classification by the Forest Service, Bureau of Land Management, U.S. Fish and Wildlife Service, and National Park Service need to be developed and implemented and riparian vegetation mapped.

Markets for special forest products have increased dramatically in recent years (e.g., Pacific yew, beargrass). Basic inventories and studies to determine sustainable yields should be conducted to avoid overexploitation of these resources.

Species should be prioritized for future study, including all listed and sensitive taxa, as well as selected common species. At least four general categories of field research should be identified, including (1) demography (i.e., long-term monitoring of populations on a yearly basis to provide data for modeling population growth or decline; (2) reproduction (i.e., focusing on short term detriments or benefits to fecundity and population recruitment, such as pollination and pollinator requirements, levels of seed-set and germinability, effects of disturbance and isolation on population genetics, and rates of vegetative propagation); (3) environment (i.e., examining autecological factors and various biotic interactions that influence the viability of populations); and (4) biogeography (i.e., documenting range-wide distributions of species and the importance of remaining old-growth and late-successional forests and their survival). These studies should be designed to compare undisturbed sites with sites subjected to varying levels of forest disturbance, and investigate aspects of succession, species reactions to natural disturbance, and the importance of habitat fragmentation to distribution and abundance.

Mollusks

The mollusks represent a major source of biological diversity in late-successional forests of the Pacific Northwest. Mollusk species of Northwest coniferous forests comprise the land snails, slugs, and aquatic snails and clams. They are diverse in number and function and many species have highly restricted geographic ranges and narrow ecological requirements. Scientists are still discovering and describing new species in coniferous forests of the Northwest, and estimate that the known number of species may eventually double (Frest and Johannes 1993; Roth 1993). Currently, approximately 350 species of mollusks are known to occur in forests within the range of the northern spotted owl.

Land snails and slugs account for over 150 of the 350 species of mollusks. Most are found in moist forest environments and in areas around springs, bogs, and marshes. Basalt and limestone talus slopes are also important habitats for many species. Several areas within the range of the northern spotted ow1 are characterized by large numbers of endemic species. Their distribution is influenced by geological history, soil type, moisture requirements, and vegetative cover. Over 100 species have been identified as being associated with late-successional forests.

The land snails and slugs are mostly herbivores. A few consume animal matter, and several, (for example, *Ancotrema*) are carnivorous on other snail species. Primary food items for the herbivorous species include deciduous tree leaves (both green and fallen), understory vegetation, large fungi, and inner bark layers. Many mammals, snakes and some birds are consumers of land snails and slugs. Local populations of slugs or snails are often termed colonies. Densities of colonies vary from species to species, and potentially stable colonies can occupy areas ranging in size from tens to hundreds of square feet. Most of the land mollusks are poor dispersers and do not move far from their natal sites. Because of their restricted ranges and dispersal capabilities, land snails and slugs are vulnerable to disturbances from fire, timber harvesting, grazing, and other forest activities.

The freshwater mollusks are found in permanent water bodies of all sizes. In the Pacific Northwest, spring-fed streams and pools often support the greatest abundance and diversity of both clams and snails. Many freshwater snails are restricted geographically, with the highest concentration of endemism in northern California and southern Oregon. In this area, some species inhabit only a few seeps or springs, resulting in total ranges that cover only a few square miles.

The freshwater mollusks are primary herbivores. They serve as food for a variety of other species including fish, aquatic insects, and birds. Some clams and snails are also eaten by raccoons, otters, and beavers. Generally, freshwater mollusks are negatively affected by any increase in siltation, decrease in water flow, nutrient enrichment, or increase in temperature. These sensitivities make them vulnerable to grazing, removal of canopy cover, and damming of water flow. Narrowly endemic mollusks are often found closely associated with other endemic groups or species including arthropods and some salamanders.

Methods specific to mollusks. The list of species considered in this assessment was developed by Drs. Terrence Frest, Edward Johannes, and Barry Roth. It was partially based on lists developed for two previous efforts (Thomas et al. 1993; USD1 1992c). The current list represents updated information that was not available for the previous efforts.

The assessment of likely future habitat condition for mollusks was based on an expert panel. The three scientists who developed the list also participated on the panel. As with other taxa, members of the Forest Ecosystem Management Assessment Team made the final assessment of species' viability based on the panel results, but because no Team member is a recognized expert in mollusks, the panel's assessments were accepted without modification.

Results. The list of mollusks considered in the Final Draft Recovery Plan for the Northern Spotted Owl (USD1 1992c) and Thomas et al. (1993) included 58 species. The list for this effort included 108 species. However, six of those species were not assessed because they are not known to occur on public land, or they are likely extinct. The final list of 102 species that were assessed included 38 land snails, 7 slugs, 54 freshwater snails, and 3 freshwater clams (table IV-22). Most of these species are associated with both late-successional forests and riparian areas. However, the strength of these associations is not well understood in many cases, and some species are probably more closely associated with riparian vegetation than they are with late-successional forests. The 102 species that were assessed included eight that had been identified as candidates for federal listing. Seven are classified as category 2 candidates for federal listing (*Anodonta californiensis, Monadenia fidelis minor, Monadenia setosa, Monadenia troglodytes troglodytes, Vespericola karokorum, Fluminicola columbiana,* and *Pisidium (C.) ultramontanum*) and one category 3 candidate species (*Fisherola nuttalli nuttalli*).

Habitat assessments for Land Snails: The results of the assessments, in table IV-22, indicate the likelihood of achieving specified habitat conditions for each species under each option. One possible display of these results is presented in figures IV-10 through IV-13. These figures show the least favorable outcome that would be expected with a cumulative total of 80 percent likelihood.

For land snails, the likelihood of achieving outcome A only reached 80 percent for four species under option 1 (table IV-22). No land snail species was judged to have 80 percent likelihood of reaching outcome A under any of the other options. Looking at species judged to have 50 percent likelihood of reaching outcome A helps display the relative pattern among options. Under option 1, 35 species were judged to have a 50 percent likelihood or better of reaching outcome A; 15 species under Option 3; 7 species under Option 4; 6 species under Option 6; 4 species under Option 7; and 5 species under Options 8 and 9. This trend is also seen clearly in figure iv-i0. In addition, the figure shows that there were a significant number of species for which the 80 percent cumulative likelihood included outcome D (extirpation).

Table IV- 22. Projected future likelihoods of habitat outcomes for vascular plants under land management options.

	Option 1				Option 3				Option 4				Option 5				Option 7				Option 8				Option 9			
Mollusks	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**
Land Snails																												
Ancotrema voyanum	57	33	7	3	3	20	50	27	0	27	47	27	0	17	47	37	3	13	27	57	0	13	33	53	7	13	30	50
Cryptomastix devia	33	33	20	13	17	30	33	20	10	25	48	17	13	20	50	17	0	10	47	43	0	10	47	43	0	7	50	43
Cryptomastix hendersoni	53	30	10	7	47	28	18	7	32	23	30	15	32	23	30	15	13	20	33	33	27	22	25	27	27	22	25	27
Helminthoglypta arrosa monticola	70	23	7	0	63	28	8	0	57	33	7	3	57	33	7	3	53	33	3	10	60	27	13	0	53	30	17	0
Heiminthoglypta hertleini	50	33	10	7	40	28	25	7	40	28	25	7	40	28	25	7	23	35	30	12	33	23	32	12	32	27	30	12
Helminthoglypta talmadgei	57	33	10	0	40	38	22	0	33	40	20	7	33	40	23	3	22	37	32	10	27	37	30	7	27	40	27	7
Megomphix californicus	57	25	18	0	47	32	20	2	33	30	27	10	27	33	27	13	13	23	37	27	17	27	30	27	17	30	30	23
Megomphix hemphilli	43	40	17	0	30	37	27	7	23	37	30	10	17	37	33	13	7	23	47	23	10	30	43	17	13	33	37	17
Monadenia callipeplus	60	27	10	3	20	28	22	30	20	28	25	27	20	28	22	30	7	23	27	43	17	22	28	33	20	22	25	33
Monadenia chaceana	53	33	10	3	35	35	25	5	35	35	25	5	30	25	30	15	25	30	30	15	25	25	20	30	23	37	27	13
Monadenia churchi	70	23	7	0	53	33	10	3	47	30	13	10	43	33	13	10	33	33	17	17	33	33	17	17	40	33	13	13
Monadenia fidelis celeuthia	60	30	10	0	40	30	27	3	33	27	30	10	33	27	30	10	12	30	45	13	33	37	23	7	33	33	23	10
Monadenia fidelis flava	70	20	10	0	50	30	20	0	47	33	20	0	40	37	23	0	17	37	30	17	23	37	37	3	27	37	30	7
Monadenia fidelis klamathica	67	23	10	0	43	33	20	3	37	30	27	7	33	37	23	7	17	25	25	33	27	30	23	20	23	27	33	17
Monadenia fidelis leonina	43	33	17	7	40	30	20	10	33	30	27	10	30	30	30	10	17	22	28	33	23	30	30	17	27	33	30	10
Monadenia fidelis minor	70	20	10	0	50	32	18	0	47	32	22	0	43	35	22	0	28	32	22	18	43	32	15	10	43	35	22	0
Monadenia fidelis ochromphalus	60	33	7	0	47	33	13	7	43	37	17	3	40	33	20	7	23	37	27	13	33	33	20	13	40	30	20	10
Monadenia fidelis salmonensis	70	20	10	0	50	28	22	0	50	33	17	0	50	30	20	0	37	30	30	3	43	30	27	0	47	30	23	0
Monadenia rotifer	80	20	0	0	50	50	0	0	50	50	0	0	50	50	0	0	50	25	25	0	50	50	0	0	50	50	0	0
Monadenia scottiana	57	27	10	7	43	3	23	10	42	23	25	10	42	23	25	10	23	23	23	30	30	25	32	13	42	23	25	10
Monadenia setosa	63	23	10	3	33	30	30	7	33	30	33	3	37	28	28	7	23	23	30	23	27	27	30	17	30	28	28	13
Monadenia troglodytes troglodytes	67	27	7	0	60	30	10	0	33	37	17	13	33	37	17	13	27	33	23	17	30	30	27	13	33	37	17	13
Monadenia troglodytes wintu	67	27	7	0	60	30	10	0	33	37	17	13	33	37	17	13	27	33	23	17	30	30	27	13	33	37	17	13
Oreohelix n. sp.	55	30	15	0	50	30	15	5	40	35	15	10	40	35	15	10	35	35	20	10	40	35	15	10	40	35	15	10
Pristiloma articum crateris	63	30	7	0	47	37	13	3	47	33	17	3	40	37	17	7	40	37	17	7	40	37	17	7	40	37	17	7
Punctum (Toltecia) hannai	80	20	0	0	60	40	0	0	60	40	0	0	60	40	0	0	50	25	25	0	60	40	0	0	60	40	0	0
Trilobopsis roperi	63	27	7	3	47	23	20	10	40	30	23	7	37	30	27	7	27	27	30	17	37	27	23	13	37	30	23	10
Trilobopsis tehamana	67	23	7	3	50	27	17	7	43	33	20	3	40	33	23	3	30	30	27	13	40	30	20	10	40	33	20	7
Vertigo n. sp.	60	20	15	5	35	25	25	15	40	35	20	5	35	30	25	10	30	25	35	10	35	25	30	10	35	25	25	15
Vespericola depressa	63	30	7	0	50	32	18	0	47	32	22	0	43	35	22	0	25	28	25	22	43	35	22	0	43	35	22	0
Vespericola euthales	50	50	0	0	40	50	10	0	40	40	20	0	40	40	20	0	25	25	40	10	30	40	30	0	40	40	20	0
Vespericola karokorum	80	20	0	0	70	30	0	0	70	30	0	0	70	30	0	0	50	40	10	0	60	40	0	0	70	30	0	0
Vespericola pressleyi	50	50	0	0	20	40	30	10	20	40	30	10	20	40	30	10	0	20	50	30	10	20	50	20	20	40	30	10
Vespericala shasta	50	30	20	0	33	30	27	10	37	33	27	3	30	33	27	10	23	28	33	15	27	33	30	10	30	33	27	10
Vespencola sierrana	53	30	17	0	47	30	17	7	53	30	17	0	43	33	17	7	37	33	20	10	37	37	20	7	43	33	17	7
Vespericola undescribed # 1	70	20	10	0	50	30	10	10	40	30	20	10	40	30	20	10	0	20	50	30	30	30	30	10	40	30	20	10
Vespericola undescribed # 2	50	40	10	0	30	30	30	10	30	30	30	10	30	30	30	10	20	30	25	25	30	30	30	10	30	30	30	10
Vespericola undescribed # 3	80	20	0	0	70	30	0	0	70	30	0	0	70	30	0	0	50	40	10	0	60	40	0	0	70	30	0	0
Slugs																												
Deroceras hesperium	70	15	10	5	30	40	15	15	40	25	25	10	30	35	20	15	30	25	25	20	30	25	25	20	30	30	20	20
Hemphillia barringtoni	63	23	10	3	33	40	17	10	40	30	23	7	33	37	20	10	33	23	23	20	33	27	23	17	33	27	20	20
Hemphillia glandulosa	50	23	20	7	20	40	27	13	27	30	33	10	20	37	30	13	20	27	33	20	20	30	33	17	20	33	30	17
Hemphillia malonei	70	20	10	0	37	35	22	7	40	28	25	7	37	25	25	13	28	25	25	22	28	32	22	18	28	28	25	18
Hemphillia pantherina	70	20	7	3	50	28	18	3	47	28	18	7	40	25	22	13	32	25	22	22	43	28	18	10	32	25	22	22
Prophysaon coeruleum	65	30	5	0	50	25	15	10	50	30	15	5	50	25	15	10	50	25	15	10	50	25	15	10	50	25	15	10
Prophysaon dubium	63	23	3	0	57	23	17	3	57	27	13	3	57	23	17	3	53	25	18	3	57	23	17	3	57	23	17	3
Riparian																												
Anodonta californiensis	45	25	15	15	30	30	20	20	30	30	20	20	30	30	20	20	10	25	35	30	25	30	25	20	30	25	25	20
Anodonta wahlametensis	40	25	20	15	30	30	20	20	30	30	20	20	30	30	20	20	20	30	25	25	25	30	25	20	30	25	25	20
Fisherola nuttalli nuttalli	60	20	15	5	45	25	25	5	40	30	25	5	35	30	25	10	25	30	25	20	30	30	25	15	35	30	25	10
Fluminicola columbiana	60	20	15	5	45	25	25	5	40	30	25	5	35	30	25	10	25	30	25	20	30	30	25	15	35	30	25	10
Fluminicola n. sp. 1	60	20	15	5	50	20	20	10	50	25	25	0	40	20	30	10	30	20	30	20	30	20	30	20	40	20	30	10
Fluminicola n. sp. 2	40	25	20	15	30	15	30	25	40	20	20	20	40	20	20	20	20	25	25	30	30	20	30	20	30	20	25	25
Fluminicola n. sp. 3	50	15	20	15	40	20	25	15	50	15	20	15	35	30	15	20	25	30	20	25	25	35	20	20	35	30	15	20
Fluminicola n. sp. 4	70	20	10	0	50	25	20	5	70	15	15	0	40	25	15	20	25	30	20	25	25	35	25	15	40	25	15	20
Fluminicola n. sp 5	70	20	10	0	50	25	20	5	70	15	15	0	40	25	15	20	25	30	20	25	25	35	25	15	40	25	15	20
Fluminicola n. sp. 6	70	20	10	0	50	25	20	5	70	15	15	0	40	25	15	20	25	30	20	25	25	35	25	15	40	25	15	20
Fluminicola n. sp. 7	70	20	10	0	50	25	20	5	70	15	15	0	40	25	15	20	25	30	20	25	25	35	25	15	40	25	15	20
Fluminicola n. sp. 8	70	20	10	0	50	25	20	5	70	15	15	0	40	25	20	15	25	30	20	25	25	35	25	15	40	25	15	20
Fluminicola n. sp. 9	70	20	10	0	50	25	20	5	70	15	15	0	40	25	20	15	25	30	20	25	25	35	25	15	40	25	15	20
Fluminicola n. sp. 10	70	20	10	0	50	25	20	5	70	15	15	0	40	25	20	15	25	30	20	25	25	35	25	15	40	25	20	15
Fluminicola n. sp. 11	50	15	20	15	40	20	25	15	50	15	20	15	35	30	15	20	25	30	20	25	25	35	20	20	35	30	15	20
Fluminicola n. sp. 12	40	30	25	5	25	30	30	15	35	30	25	10	25	33	33	10	20	20	30	30	25	30	25	20	25	30	30	15
Fluminicola n. sp. 13	60	15	20	5	40	20	20	20	35	25	30	10	35	25	20	20	35	20	20	25	35	25	20	20	35	30	20	15

Fluminicola n. sp. 14	70	20	10	0	40	15	25	20	50	15	20	15	40	20	20	20	25	20	30	25	25	25	30	20	40	20	20	20
Fluminicola n. sp. 15	70	20	10	0	40	15	25	20	50	15	20	15	40	20	20	20	25	20	30	25	25	25	30	20	40	20	20	20
Fluminicola n. sp. 16	60	20	20	0	40	30	20	10	40	30	30	0	40	30	20	10	30	30	20	20	30	30	20	20	25	30	25	20
Fluminicola n. sp. 17	60	20	20	0	40	30	20	10	40	30	30	0	40	30	20	10	30	25	25	20	30	30	20	20	25	30	25	20
Fluminicola n. sp. 18	70	20	10	0	40	15	25	20	50	15	25	10	40	20	20	20	25	20	30	25	25	25	30	20	40	20	20	20
Fluminicola n. sp. 19	55	20	15	10	30	25	25	20	50	15	20	15	30	20	30	20	30	20	25	25	30	20	30	20	30	20	30	20
Fluminicola n. sp. 20	55	20	15	10	30	25	25	20	50	15	20	15	30	20	30	20	30	20	25	25	30	20	30	20	30	20	30	20
Fluminicola seminalis	70	20	10	0	35	30	20	15	50	20	25	5	35	25	25	15	25	25	30	20	30	25	25	20	30	25	25	20
Helisoma newberryi newberryi	70	20	10	0	45	25	25	5	60	30	10	0	50	25	20	5	35	20	10	35	40	15	20	25	40	20	20	20
Juga (C.) acutifilosa	70	20	10	0	45	20	15	20	70	20	10	0	50	20	15	15	35	20	10	35	40	15	20	25	40	15	15	30
Juga (C.) occata	70	20	10	0	45	20	15	20	70	20	10	0	40	25	15	20	35	15	15	35	40	20	15	25	40	20	15	25
Juga (J.) n. sp. 1	70	10	10	10	50	30	20	0	70	10	10	10	40	10	30	20	30	20	30	20	30	20	30	20	40	10	30	20
Juga (J.) n. sp. 3	70	10	10	10	50	30	20	0	70	15	10	5	45	10	25	20	30	20	25	25	30	20	30	20	40	10	30	20
Juga (O.) n.sp. 1	70	10	10	10	50	20	20	10	40	20	30	10	30	20	30	20	20	20	20	40	40	20	10	30	40	20	20	20
Juga (O.) n. sp. 2	70	15	10	5	50	20	20	10	40	20	30	10	30	20	30	20	25	20	20	35	40	20	15	25	40	20	20	20
Juga (O.) n.sp. 3	60	20	20	0	40	30	20	10	40	30	30	0	40	30	20	10	30	30	20	20	30	30	20	20	25	30	25	20
Juga (Oreobasis) chacei	70	20	10	0	50	20	20	10	60	20	20	0	40	30	20	10	30	25	25	20	40	25	25	10	40	25	25	10
Juga (Oreobasis) orickensis	70	20	10	0	50	30	10	10	60	30	10	0	40	40	10	10	30	20	30	20	40	20	20	20	40	40	10	10
Juga hemphilli dallesensis	50	20	10	20	50	30	20	0	50	20	10	20	40	10	30	20	30	20	20	30	30	20	30	20	40	10	30	20
Juga hemphilli hemphilli	70	10	10	10	50	30	20	0	70	10	10	10	40	10	30	20	30	20	20	30	30	20	30	20	40	10	30	20
Juga hemphilli n. subsp. 1	70	10	10	10	50	30	20	0	70	10	10	10	40	10	30	20	30	20	20	30	30	20	30	20	40	10	30	20
Lanx alta	70	20	10	0	50	30	20	0	70	20	10	0	40	15	30	15	30	20	20	30	35	20	30	15	40	15	30	15
Lanx klamathensis	50	20	20	10	40	20	20	20	50	20	20	10	40	20	20	20	30	20	20	30	30	20	30	20	40	20	20	20
Lanx patelloides	70	20	10	0	50	20	20	10	60	20	20	0	50	20	20	10	40	20	20	20	50	20	20	10	50	20	20	10
Lanx subrotundata	70	20	10	0	50	20	20	10	60	20	20	0	50	20	20	10	40	20	20	20	50	20	20	10	50	20	20	10
Lyogyrus n. sp. 1	70	10	10	10	50	30	20	0	70	10	10	10	40	10	30	20	30	20	20	30	30	20	30	20	40	10	30	20
Lyogyrus n. sp. 2	60	20	0	20	50	20	10	20	60	20	0	20	50	10	20	20	30	20	20	30	30	20	30	20	50	10	20	20
Lyogyrus n. sp. 3	40	30	20	10	30	20	20	30	30	25	20	25	35	20	20	25	25	20	25	30	30	20	20	30	30	20	20	30
Lyogyrus n. sp. 4	50	20	15	15	30	15	30	25	50	20	15	15	40	20	20	20	30	15	25	30	30	15	25	30	30	15	25	30
Lyogyrus n. sp. 5	50	20	15	15	30	15	30	25	50	20	15	15	40	20	20	20	30	15	25	30	30	15	25	30	30	15	25	30
Lyogyrus n. sp. 6	40	25	20	15	30	15	30	25	40	20	20	20	40	20	20	20	20	25	25	30	30	20	30	20	30	20	25	25
Physella columbiana	30	25	30	15	20	25	25	30	30	25	25	20	20	20	30	30	15	15	30	40	20	20	30	30	20	20	30	30
Pisidium (C.) ultramontanum	70	20	10	0	40	20	30	10	60	20	20	0	40	20	30	10	30	20	10	40	40	10	30	20	40	20	30	10
Pyrgulopsis archimedis	40	25	20	15	30	15	30	25	40	20	20	20	40	20	20	20	20	25	25	30	30	20	30	20	30	20	25	25
Pyrgulopsis intermedia	70	20	10	0	40	20	30	10	70	20	10	0	40	20	30	10	30	20	30	20	40	25	25	10	40	20	30	10
Pyrgulopsis n. sp. 1	40	25	20	15	30	15	30	25	40	20	20	20	40	20	20	20	20	25	25	30	30	20	30	20	30	20	25	25
Vorticifex klamathensis klamathensis	50	20	15	15	30	15	30	25	50	20	15	15	40	20	20	20	30	15	25	30	30	15	25	30	30	15	25	30
Vorticifex klamathensis sinitsini	40	25	20	15	30	15	30	25	40	20	20	20	40	20	20	20	20	25	25	30	30	20	30	20	30	20	25	25
Vorticifex n. sp. 1	40	30	20	10	30	20	20	30	30	25	20	25	35	20	20	25	25	20	25	30	30	20	20	30	30	20	20	30
Vorticifex neritoides	30	25	30	15	20	25	30	25	30	25	25	20	20	20	30	30	15	15	30	40	20	20	30	30	20	20	30	30

A-Well Distributed B-Locally Restricted C-Restricted to Refugia D-Extirpation

Likelihood values are expressed as percentages that total to 100 for a given species within an option. Number displayed may vary due to rounding errors.
See text for fuller explanation and discussion of the rating scale.

Habitat assessments for slugs: None of the seven slug species associated with late-successional forests was judged to have 80 percent likelihood of achieving outcome A under any of the options (table IV-22 and fig. IV-11). All seven species were judged to have 50 percent or greater likelihood of achieving outcome A under Option 1. Three species were judged to have 50 percent or greater likelihood of outcome A under Option 3, and two species were rated at that level under all other options. Under Option 1, there is an 80 percent likelihood of achieving outcome B or better for all species except *Hemphilli glandulosa*. For Options 3, 4, 5, and 8, the 80 percent cumulative likelihood included outcome C. For Options 7 and 9, outcome D was also included in the 80 percent cumulative level.

Habitat assessments for freshwater snails and clams: Results for the 54 freshwater snails and three freshwater clams indicated that no species was judged at 80 percent likelihood of achieving outcome A under any of the options (table IV-22 and figure IV-12). Of the 57 species, 45 were judged to have 50 percent likelihood or better of achieving outcome A under Option 1; 22 species were judged to have 50 percent likelihood or better of achieving outcome A under Option 3; 36 species under Option 4; 5 species under Option 5; none under Option 7; 2 under Option 8; and 3 under Option 9. Under Option 1 all species have an 80 percent likelihood of achieving either outcome C or better or B or better (figure IV-12). Under all other options, there were species for which the 80 percent cumulative likelihood includes outcome D (extirpation). This included 12 species under Option 3; 2 species under Option 4; 4 species under Option 5; 44 species under Option 7; 12 species under Option 8; and 14 species under Option 9.

Discussion. The mollusk assessment suggests that the options considered here are less effective in providing for mollusks than for any of the other species groups (figure IV-13). According to the assessment, only Option 1 provides habitat to maintain any of the mollusk species well-distributed across federal lands with a likelihood of 80 percent or better. Assessments for Options 3 through 9 all indicate that a large number of species will have significant probabilities of being confined to refugia or extirpated. Differences among the options for land snails and slugs were based primarily on the total acres proposed for reserves, the locations of specific reserves, and the management proposed within reserves. The judgments for freshwater snails and clams responded primarily to the proposed forms of watershed protection. Options 1 and 4 contain the full riparian protections proposed by Thomas et al. (1993) and analysis shows that the freshwater species would fare better under these options.

High degrees of endemism, rareness and habitat specialization account, in part, for the low ratings assigned the mollusks. Many of the mollusk species are endemic to only one region or river drainage, and dispersal capabilities of this group of invertebrates is low. Several of the land and freshwater mollusks in the Pacific Northwest have highly limited geographic ranges, and most of these species are confined to a coastal belt that extends only from the crest of the Cascade Mountains to the Pacific Ocean. There are sizeable groups of endemic species in the land snail genera *Monadenia*, *Trilobopsis*, *Megomphix*, and *Vespericola*, and the slug genus *Hemphillia*. Geologic history, substrate, moisture requirements, and vegetative cover are the physical factors that limit their distribution. Because most land snails do not disperse far from their natal areas, areas are rarely repopulated following extirpation. For freshwater mollusks, endemic species are most notable for the genera *Juga*, *Lanx*, and *Fluminicola*. Species are often confined to single streams, particularly intermittent streams, springs, and seeps. For the species that have localized geographic ranges, potential exists for serious impacts from even small ground-disturbing activities or changes in stream conditions. This potential was reflected in the judgments for those species.

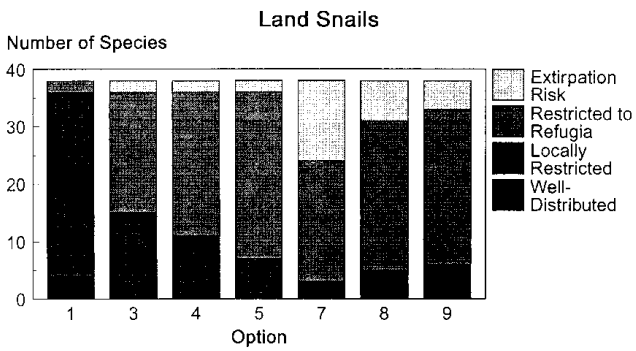


Figure IV-13. Outcomes for land snails under each land management option. Values shown are the number of species that had an 80 percent or greater likelihood of achieving at least the specified outcome (based on distribution of habitat).

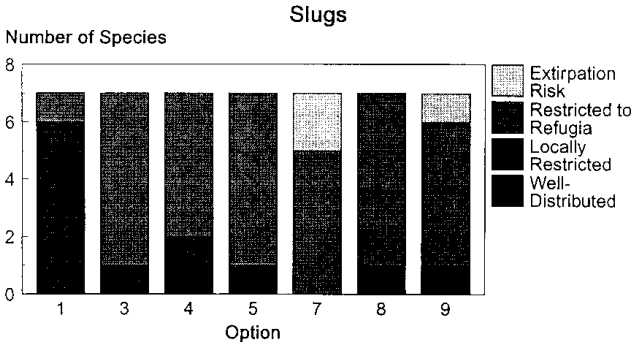


Figure IV-11. Outcomes for slugs under each land management option. Values shown are the number of species that had an 80 percent or greater likelihood of achieving at least the specified outcome (based on distribution of habitat).

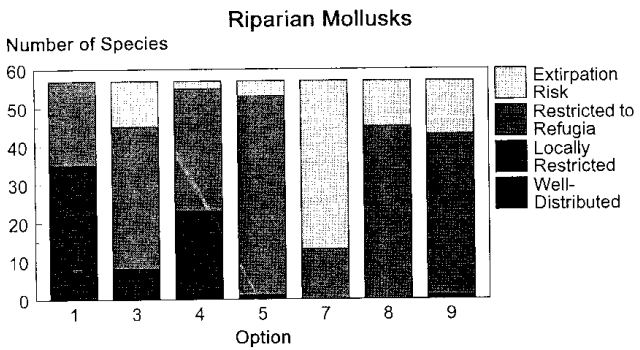


Figure IV-12. Outcomes for riparian mollusks under each land management option. Values shown are the number of species that had an 80 percent or greater likelihood of achieving at least the specified outcome (based on distribution of habitat).

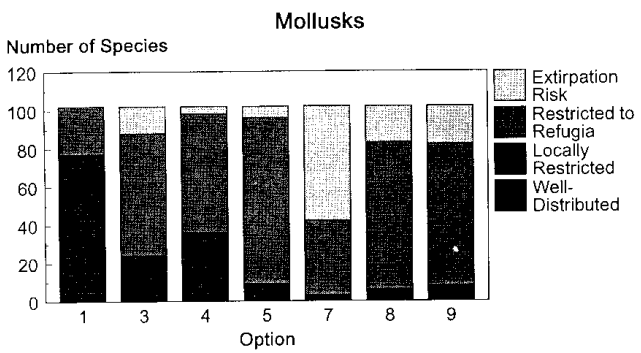


Figure IV-13. Outcomes for all mollusks under each land management option. Values shown are the number of species that had an 80 percent or greater likelihood of achieving at least the specified outcome (based on distribution of habitat).

In addition to rarity, endemism, and habitat specialization, several other reasons can be cited for the low ratings given to habitat outcomes for mollusks:

1. The mollusk experts acknowledged that past agency performance was a consideration in their judgments. While this is not an inappropriate consideration, it is inconsistent with the effort to compare management options.

2. The experts also had difficulty separating the influence of state and private habitat management from federal management in their judgments. Again, this is not inappropriate but is inconsistent with a comparison of federal management options.

3. Those species currently confined to refugia because of habitat history and species life history were judged unlikely to expand their range and were rated accordingly. Therefore, in even the most favorable situations such species were judged unlikely to be well distributed.

4. All ground-disturbing activities, even those proposed for management inside reserves, were considered potential threats to the mollusks and caused ratings to be low. Thus, even species whose entire ranges were located inside Reserves received ratings with significant potential for isolation or extirpation.

In the team's judgment, the assessments for mollusks are quite conservative because of the above factors. The team believes that the options, implemented properly, would result in more favorable outcomes than indicated by these results. In addition, specific mitigation for many of the mollusk species could be relatively straightforward as discussed below.

Mitigation for Mollusks

Mitigation for the mollusk species is relatively straightforward: sites need to be identified through surveys and then protected from disturbances that would cause high levels of mortality. The following specific recommendations are made for mitigation:

1. Mollusks should be included in the watershed analysis for Riparian Reserves (see the section on Watershed Analysis). Protocols for surveying mollusks should be developed and standardized. For best efficiency, surveys should be focused on riparian features (i.e., springs and seeps) that are most likely to support mollusk populations. Because some mollusks and amphibians have similar habitat requirements and are associated with intermittent streams, springs, and seeps, there may be some sampling protocols that would sample both groups. When populations of mollusk species that may be at risk are found, they should be protected with buffers that are at least one site potential tree height in diameter.

2. In addition to surveys as part of the watershed analysis process, upland sites with high potential as mollusk habitat should be surveyed prior to ground disturbance. Talus and limestone areas are two priority habitat types for survey. Again, surveys may be designed to address mollusks along with other species such as salamanders. In addition, some of the amphibians may serve as indicator species of areas of high endemism for mollusks (Roth 1993) because endemic forms of both taxa occur in the same area (e.g., limestone areas in the Shasta National Forest). When located, populations of mollusk species at risk should be protected with buffers that are at least one site potential tree height in width.

3. Surveys and protection for mollusks must be conducted inside Reserves when management activities are contemplated in the reserves.

4. Surveys should be prioritized to (1) known mollusk locations and (2) areas of high diversity or endemism as described below.

Areas of high diversity or endemism: Several areas of high diversity and endemism of mollusks occur within the range of the northern spotted owl. For land snails, species in the genera *Helminthoglypta*, *Monadenia*, *Tilobopsis*, *Megomphix*, *Vespericola*, and the slug genera *Prophysaon* and *Hemphilli* exhibit high endemism. The most significant endemic clusters of land snails and slugs occur in the following areas (Frest and Johannes 1993):

1. The southern half of the western Washington Cascades, the Olympic Mountains, and the extreme northwestern corner of the Oregon Coast Range.

2. The Columbia Gorge of Washington and Oregon.

3. Shasta River Canyon in northern California.

4. Salmon and Marble Mountains in Siskiyou County, California.

5. Trinity Mountains of northern California.

6. Mt. Shasta and vicinity, Shasta County, California.

For the freshwater species, endemic clusters are most common in the family *Hydrobiidae* (*Fluminicola*, *Lyogyrus*, *Pyrgulopsis*) and in the genus *Juga*. The family *Lancidae* is restricted solely to Western North America and is generally limited to coastal areas in southwestern Oregon and northwestern California. The following areas are likely to have endemic groups of species of freshwater mollusks (Frest and Johannes 1993):

1. The lower Columbia River from The Dalles, Oregon to its mouth.

2. Columbia River tributaries and springs in the Columbia Gorge.

3. The Rogue and Umpqua River systems of Oregon.

4. The Upper Klamath Lake region of Oregon and the west side of the lake.

5. The lower and middle stretches of the Klamath River and its tributaries and springs, including the Trinity and Smith Rivers, California and Oregon.

6. The upper Sacramento River system, Shasta County, California including the Pit and McCloud Rivers, Hat Creek, and their tributaries and springs.

The above areas of endemism and high diversity of mollusks were identified by Roth (1993) and Frest and Johannes (1993). They should be one focus of surveys and mitigation measures for mollusks.

Role of nonfederal lands. Nonfederal lands are an important consideration for the viability of some mollusks, particularly in southwestern Washington and northern California. Management of slug species needs to be addressed on nonfederal lands in southwestern Washington. Many endemic freshwater mollusks are also associated with a mixture of federal and nonfederal lands in northern California in the headwaters of the Shasta, Pit, and Sacramento Rivers. As more areas are surveyed for mollusks conservation needs on federal and nonfederal lands will become more evident.

Research Needs. Inventory and research data for mollusks are not extensive. The most critical need is for improved surveys, particularly in areas where ground-disturbing activities are proposed. Survey techniques must be appropriate to mollusk species, and are somewhat different from methods for arthropod surveys (Frest and Johannes 1993). To improve conservation strategies, additional information is also needed on species life histories and ecological requirements.

Arthropods and Their Allies

Arthropods are a major source of biological diversity in late-successional forests in the Pacific Northwest. Olson (1992) estimated that about 7,000 species of arthropods inhabit these forests and assume numerous ecological roles that are important to ecosystem function.

Arthropods inhabit virtually every part of the coniferous forest system including coarse woody debris, litter and soil layer, understory vegetation, canopy foliage, tree trunks, snags, and the aquatic system. The litter and soil of the forest floor are the sites of some of the greatest biological diversity found anywhere. The soil under a square yard of forest may hold as many as 200,000 mites from a single taxonomic group, plus tens of thousands of other mites, beetles, centipedes, pseudoscorpions, springtails, and spiders. Many of these species are undescribed and poorly understood, but the structure and function of temperate forest soils may be determined by the dietary habits of the soil arthropods (Lattin and Moldenke 1992). They are the basic consumers of the forest floor where they ingest and process massive quantities of organic litter and debris, from large logs to bits of moss (Lattin and Moldenke 1992). The richness of arthropod species in late-successional forests suggests a great number of different processes and functions, but little is known about how arthropods interact, survive, and contribute to ecosystem function.

Methods specific to arthropods. Assessment of the capability of habitat to support arthropod populations is complex for several reasons. First, scientists estimate that 20-30 percent of the species have not been described, resulting in a lack of information on specific habitat associations. Second, there have not been adequate surveys of the arthropods in the Pacific Northwest. Third, the diversity of arthropods is greater than any other class of organisms (Lattin and Moldenke 1992).

Given this complexity, the panelists aggregated the arthropods into 11 functional groups based on their ecological roles: (1) coarse wood chewers, (2) litter and soil dwellers, (3) understory and forest gap herbivores, (4) canopy herbivores, (5) epizootic forest species, (6) aquatic herbivores, (7) aquatic detritivores, (8) aquatic predators, (9) pollinators, (10) riparian herbivores, and (11) riparian predators.

Because there is a gradient of increasing species richness and endemicity of arthropods with decreasing latitude, groups 1-4 were rated separately in the southern and northern portions of the range of the northern spotted owl. Thus, a total of 15 arthropod groups or ranges were assessed (11 functional groups, four of which received ratings for both north and south portions of their range). The southern portion consisted of the Klamath Province of southern Oregon and northern California, the California Cascades, and the California Coast Range. The northern portion consisted of the eastern and western Oregon and Washington Cascades; the Oregon Coast Range; the Western Washington Lowlands; and the Olympic Peninsula.

Ratings were an expression of the likelihood that habitat to support functional groups would be maintained rather than on the viability of individual species. This approach emphasizes ecosystem function rather than a species by species analysis and was necessary because many of the species have not yet been identified and described. We do not know enough about the distribution or habitat associations of most species to make the assessment on a species by species basis.

Habitat and population assessments for arthropods should be viewed with caution because of the paucity of information on this group. Ratings should be considered preliminary and subject to modification as new understanding and scientific information become available.

Results. The panel reviewed lists of arthropods that are associated with or indicative of late-successional forests in the Pacific Northwest. (USD1 1992c; Thomas et al. 1993) A revised list of species was assembled but was not used because species were combined into functional groups. The revised list of arthropods associated with late successional forests is on file with the Forest Ecosystem Management Assessment Team's other unpublished documents and reports. The list includes 155 insects, 25 spiders, 25 millipedes, and 1 crustacean for a total of 206 species.

Habitat sufficiency for arthropods and allies: We assessed the sufficiency of habitat on federal lands to provide for well-distributed populations of the various functional groups. The ratings of these groups varied among the seven options (table IV-23). For Option 1, there was an 80 percent likelihood of achieving outcome A for all groups except aquatic herbivores and understory/gap herbivores (fig. IV-14). These latter two groups were judged to have at least an 80 percent likelihood for achieving at least outcome B. Populations of aquatic and understory/gap herbivores respond to sunlight, and panelists felt that Option 1 would result in a more closed canopy with less penetration of sunlight to the forest floor than other options. Thus, they rated Option 1 as less likely than others to provide habitat conditions of outcome A for these groups.

Table IV-23. Projected future likelihoods of habitat outcomes for arthropods under land management options.

	Option 1				Option 3				Option 4				Option 5				Option 7				Option 8				Option 9			
Arthropods	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**
Aquatic detritivores	88	11	1	0	86	14	0	0	81	19	0	0	80	20	0	0	74	26	0	0	70	29	1	0	75	25	0	0
Aquatic herbivores	76	21	3	0	84	14	3	0	81	18	1	0	80	19	1	0	81	18	1	0	81	18	1	0	84	16	0	0
Aquatic predators	81	16	3	0	85	15	0	0	81	19	0	0	80	20	0	0	79	21	0	0	78	21	1	0	83	18	0	0
Canopy herbivores (North range)	83	18	0	0	79	21	0	0	79	21	0	0	79	21	0	0	64	34	3	0	68	32	0	0	69	29	3	0
Canopy herbivores (South range)	84	16	1	0	74	26	1	0	76	21	2	1	74	24	2	1	71	24	5	1	58	28	11	4	66	29	4	2
Coarse wood chewers (North range)	90	10	0	0	86	13	1	0	76	21	1	1	76	21	1	1	75	21	3	4	65	23	9	4	76	20	3	1
Coarse wood chewers (South range)	80	16	4	0	80	16	4	0	70	20	8	3	70	20	8	3	68	19	10	9	54	23	15	9	65	21	10	4
Epizootic forest species	94	6	0	0	86	14	0	0	80	20	0	0	80	20	0	0	80	20	0	0	70	28	3	0	69	31	0	0
Litter & soil dwelling species (North range)	94	6	0	0	86	13	1	0	80	18	1	1	76	20	3	1	71	20	8	1	65	24	9	3	71	19	9	1
Litter & soil dwelling species (South range)	83	14	4	0	78	18	5	0	76	15	6	3	74	16	6	4	65	20	9	6	50	23	19	9	60	20	15	6
Pollinators	84	15	1	0	85	15	0	0	80	20	0	0	80	20	0	0	83	18	0	0	83	17	0	0	85	14	1	0
Riparian herbivores	81	19	0	0	80	20	0	0	78	23	0	0	76	24	0	0	70	28	1	0	71	21	6	1	85	15	0	0
Riparian predators	81	19	0	0	79	21	0	0	79	21	0	0	78	23	0	0	68	28	5	0	71	19	8	3	86	14	0	0
Understory & forest gap herbivores (North range)	75	25	0	0	74	26	0	0	69	31	0	0	69	31	0	0	70	29	1	0	58	38	5	0	63	36	1	0
Understory & forest gap herbivores (South range)	71	23	6	0	66	29	6	0	58	32	7	4	56	33	8	4	54	34	9	4	35	42	17	6	47	45	5	4

A-Well Distributed B-Locally Restricted C-Restricted to Refugia D-Extirpation

Likelihood values are expressed as percentages that total to 100 for a given species within an option. Number displayed may vary due to rounding errors.
See text for fuller explanation and discussion of the rating scale.

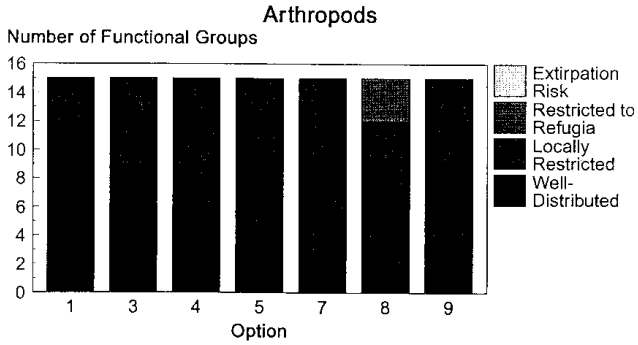


Figure IV-14. Outcomes for arthropod functional groups under each land management option. Values shown are the number of species that had an 80 percent or greater likelihood of achieving at least the specified outcome (based on distribution of habitat).

At the other extreme, Option 8 was judged to have less than an 80 percent likelihood of achieving at least outcome B for any functional group (fig. IV-14). Coarse wood chewers, litter and soil species, and understory/gap herbivores were considered to have an 80 percent likelihood of at least outcome C within the southern portions of their ranges. The decreased likelihoods of outcomes A or B for these groups generally resulted from concerns that greater management intensities would reduce levels of coarse woody debris, increase soil disturbance, and reduce the diversity of understory plants associated with late successional forests. As discussed below, there was a concern that southern groups were more sensitive to management because of high levels of endemism and specialized adaptation to specific plant communities and fire regimes.

For most functional groups, other options fell between the extremes of Options 1 and 8 (fig. IV-13). Most groups for most options were judged as having an 80 percent likelihood of achieving at least outcome B, with only Option 3 consistently rated at an 80 percent likelihood for outcome A.

Areas of high endemism and special concern: Several areas within the range of the northern spotted owl are high in endemism or are of special concern for arthropods. The California Coast Range and the Klamath Province are the areas of greatest endemism. In addition, Point Reyes, the Siskiyou Mountains, the Oregon Coast Range, and the Olympic Peninsula are areas with considerable numbers of endemic species. Richness and endemicity of arthropods increases with decrease in latitude and toward coastal regions. Of particular importance is the Siskiyou Mountain region of northern California and southern Oregon where there is high species richness and endemism. The entire area has a rich and complex geologic history coupled with great edaphic and climatic zonation that has contributed to the diversity of vegetation and arthropods.

Discussion. Arthropods in late-successional forests are of concern for several reasons. First, many species are flightless, which means that their dispersal capabilities are limited. In fact, little is known about the dispersal capabilities of many of the invertebrates. Second, the flightless condition is believed to reflect habitat stability and permanence over a long period. Third, many of the old-forest associates have disjunct distributions and are found only in undisturbed forests. Fourth, arthropods are key to ecosystem function and may serve as indicators of ecosystem conditions. They are key to nutrient cycling of downed logs, are major components of the litter and soil, are herbivores of the forest canopy, play important roles in aquatic systems, and are pollinators of flowering plants. Lastly, many of the species native to this region have not been described or named (Lattin and Moldenke 1992). For these reasons conservation of the biodiversity of arthropods must be given consideration along with other taxonomic groups.

For the purposes of this discussion the viability of the groups of arthropods refers to the maintenance of the ecological functions of these groups across all federal lands. This does not imply that all species must be maintained across all of these areas because not all species have been identified. However, an appropriate goal should be to conserve biological diversity of arthropods, and all of the functional groups should be maintained across the landscape.

Outcome A should maintain the ecological functions of groups across the landscape, with outcome B resulting in gaps in the distribution of these groups and therefore loss of their function in some areas. Under outcome C, arthropod function would be lost in many portions of ecosystems across the range of the northern spotted owl.

For most functional groups, Options 1 and 3 provide the greatest likelihood that arthropod function will be maintained across federal lands. Twelve and nine of the 15 groups or ranges, respectively, were given an 80 percent likelihood of outcome A under these options. Options 4, 5, and 9 provide for a lower likelihood with 6, 5, and 5 groups, respectively, reaching an 80 percent likelihood of Outcome A. Options 7 and 8 provide for only minimal likelihood that arthropod function would be maintained on federal lands, with 3 and 2 groups, respectively, receiving an 80 percent rating for outcome A.

Although for many of the options, the likelihood of maintaining well-distributed functional groups across federal lands was less than 80 percent, most of the groups failing to achieve this level of likelihood received ratings of more than 70 percent (table IV-23) Understory/forest gap herbivores were an exception, especially in the southern portions of the range where only Option 1 received a 70 percent or greater likelihood of outcome A, with other options rated as low as 35 percent (Option 8). These low ratings reflect the significant levels of endemism in northern California and vulnerability to disturbance.

So little is known about a large portion of the forest-dwelling invertebrates that it is tempting to recommend that as much of the late-successional forest be preserved as possible. However, D. Murphy, P. Brussard and P. Erlich (1993, Personal communication) do not concur with such a position. They believe that sufficient information exists on the population biology of invertebrates that inhabit forest communities to allow several observations and recommendations that can be used as a basis for regional conservation planning. First, they consider it unrealistic and probably not helpful to demand that conservation planning be based on an extensive understanding of the autecology of individual invertebrate species. Adherence to a regional goal of protecting a substantial portion of all habitat types will be the most effective strategy for invertebrate conservation. Second, while the report of the Interagency Scientific Committee (Thomas et al. 1990) correctly indicates that narrow habitat corridors may not benefit species such as the spotted owl, this is not necessarily true for invertebrates. Reserves that support late-successional forests and are substantially interconnected by similar forests should provide for invertebrate dispersal necessary to allow gene flow and recolonization of habitat after local extirpation of species. Not only will greater watershed protection provide for greater protection of both terrestrial and aquatic invertebrates, it will provide for greater interconnectedness and dispersal between such conservation areas.

In summary, Murphy, Brussard and Ehrlich believe that a strategy such as that of the Interagency Scientific Committee (Thomas et a1. 1990) will serve the conservation requirements of many but certainly not all invertebrates. At the landscape scale of regional planning, invertebrates are usually not useful tools in the context of the design of reserves. Instead conservation planning should endeavor to protect an adequate representation of all physiographic and vegetational features that are associated with late-succession forests. Where possible Reserves should be interconnected by landscape linkages, and riparian areas will likely serve this purpose quite well.

Mitigation for Arthropods

Panelists did not suggest specific mitigation measures that would increase the likelihood of achieving Outcome A for each option. Instead, they made general recommendations for improvement of habitat under most options.

Mitigation is not likely to greatly improve Option 8; rather, significant modification of this option would be required. For example, salvage would need to be limited, additional watershed protection would be required, and silvicultural manipulations within late-successional forests reduced. Most other options could be improved for arthropods by implementing a number of mitigating measures.

Coarse woody debris is especially important for arthropods. Guidelines in Options 1 and 3, if incorporated into other options, would likely improve habitats for coarse wood chewers and litter and soil dwelling species. In addition, the panel identified other measures for the forest Matrix that may be beneficial to arthropods including (1) providing a full spectrum of species and sizes of trees for retention of green trees and coarse woody debris and (2) cessation of burning as a means of site preparation after timber harvest. Burning often negatively impacts the arthropods that are associated with coarse woody debris and the litter and soil layers.

Existing small fragments of late-successional forests within the Matrix provide valuable habitat for arthropods, especially canopy herbivores in lowland areas. Relatively little remains of lowland late- successional forests, and these fragments provide refugia for arthropods. Therefore, protection of LS/OG3s (Johnson et al. 1991) or other such late-successional remnants in the Matrix, as under Option 1 and to some extent under Options 3 and 9, would greatly benefit arthropods.

The panelists were concerned that objectives for adaptive management areas in Option 9 were quite general, and therefore management should be conservative until knowledge and understanding is improved. Ratings for this option may have reflected the panelists' uncertainty. Although not actually a form of mitigation, the ratings for Option 9 may be improved with further development of objectives and guidelines.

Role of nonfederal lands. Most late-successional arthropod groups are likely to be maintained on federal lands without contributions from nonfederal lands. However, the potential exists for movement of epizootic species between federal and nonfederal ownerships. This is most likely to occur in the eastern and southern portions of the range of the northern spotted owl. Management responses will vary on a case by case basis, but epizootic species should be recognized as a natural part of the forest ecosystem.

Research needs. We have little information concerning arthropods and late successional forests, and a great need for surveys and research. This is exemplified by the number of new species of arthropods that are likely to be discovered in the future (Lattin and Moldenke 1992). Any assessment of their status and distribution will require considerable effort and should be approached through broad-scale inventories aimed at describing species composition and distribution. In addition, there is a lack of information about the taxonomy, distribution, and abundance of arthropods in different forest types throughout the Pacific Northwest. Many arthropods are sensitive to land-use practices that alter the microclimates upon which they depend. Given the lack of information about many species and the restricted geographic ranges, there are likely to be arthropod species whose ranges are not included in or adequately protected by some of the reserves. Surveys and research are needed to provide this information to determine if further conservation measures will be required. Additionally, arthropods should be monitored as indicators of forest ecosystem condition (i.e., as "canaries in the mine".)

Amphibians and Reptiles

The number of species of amphibians and reptiles in coniferous forests of the Pacific Northwest is not large compared to the number of birds and mammals. However, amphibians and reptiles compose a distinct and important component of the vertebrate fauna (Bury 1988). The amphibian fauna of the Pacific Northwest includes 13 species that are endemic to the range of the northern spotted owl (they occur nowhere else in the world). The Pacific Northwest supports the second highest number of amphibian species in the United States, second only to the Southeast (Nussbaum et al. 1983). Approximately 62 species of amphibians are found in the Pacific Northwest, but fewer are found in coniferous forests. Most forested areas support as many as 19 to 23 species of amphibians and reptiles (Nussbaum et al. 1983; Stebbins 1985). These vertebrate communities are ecologically important because of the high numbers and biomass they attain (Bury 1988). A total of 10 species of reptiles were evaluated by Thomas et al. (1993) for their association with late-successional forests, and none was found to be closely associated with this forest type. However, some reptiles, such as the sharp-tailed snake and northern alligator lizard, are associated with components of late-successional forests, including down logs and forest litter cover.

Amphibians are functionally significant components of coniferous forests in the Pacific Northwest. Any loss of amphibian diversity would have ecological consequences. Amphibians, particularly salamanders, compose significant biomass in forest ecosystems as they can reach densities as high as 5,000 individuals per acre in suitable habitat. Aquatic larvae, terrestrial juveniles, and adults may function as predators or as the major food sources for other vertebrate species and aquatic invertebrates (Walls et al. 1992).

Amphibians are particularly sensitive to environmental change because their complex life cycle exposes them to hazards in both the aquatic and terrestrial environments. Most amphibians require cool, moist conditions to maintain respiratory function. Stream-dwelling species generally require cool water and are sensitive to sedimentation that can inhibit reproduction and foraging. Within locales in the Pacific Northwest, populations of several species of amphibians have been extirpated, and the ranges of numerous species have become drastically reduced (Blaustein and Wake 1990). Most declines have occurred in forest-dwelling species. Several species including Del Norte, Larch Mountain, Siskiyou Mountains, and Shasta salamanders, and western spotted, red-legged, and Cascades frogs, are candidates for listing (USD1 1992b). Therefore, we must understand their ecological requirements if we are to provide for their continued existence.

Many amphibians are highly specialized, including the predatory giant salamanders (*Dicamptodon* spp.) and the very primitive tailed frog. Most amphibians have specific habitat requirements such as association with headwater streams or with coarse woody debris. The clouded salamander, for example, is found most frequently in the space between the bark and sapwood of large-diameter downed logs. Twelve species of salamanders are associated with riparian areas, particularly headwater streams, springs, and seeps. Two species (Oregon slender and clouded salamanders) are closely associated with coarse woody debris. Some species have highly restricted geographic ranges, particularly the Larch Mountain, Siskiyou Mountains, and Shasta salamanders. The special natural history traits of salamanders include low mobility and dependency on moist environments for all phases of their life cycle; the loss of moist environments following timber harvest undoubtedly influences both their local abundance and distribution.

There is considerable genetic variability among and within species of amphibians, as exemplified by the recent subdivision of Pacific giant salamanders into three species and the Olympic salamanders into four species within the range of the northern spotted owl (Good 1989; Good and Wake 1992). Continuing research may result in other wide-ranging species being subdivided into separate species. This high degree of variability is probably a result of their specific habitat associations and limited mobility.

There is evidence of population declines and range reductions in a number of amphibian populations (Blaustein and Wake 1990; Welsh 1990). Their conservation should be promptly addressed because future activities will likely modify amphibian habitats, further limiting future conservation options.

Methods specific to amphibians. Thomas et al. (1993) listed 28 amphibian and 10 reptilian species for initial consideration as associates with late-successional forest. Following application of a set of screening criteria to identify species *closely* associated with such forests, this list was reduced to 19 species of salamanders and frogs (no reptiles were retained). During panel deliberations, we dropped one of these species (California slender salamander) from further consideration because it occurs on very few federal lands within the range of the northern spotted owl. Therefore, we evaluated 18 species (17 salamanders, 1 frog). In addition, we subdivided one species (Van Dyke's salamander) into two portions of its total range (Washington Cascades; Washington coast, including the Olympic peninsula) and evaluated habitat conditions separately within each portion.

Table IV-24. Projected future likelihoods of habitat outcomes for amphibians under land management options.

Amphibians	Option 1				Option 3				Option 4				Option 5				Option 7				Option 8				Option 9			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
Riparian																												
Black salamander	80	15	5	0	75	15	10	0	80	15	5	0	75	15	10	0	65	20	15	0	60	20	20	0	75	15	10	0
Cascade torrent salamander	85	15	0		70	24	5	1	85	15	0	0	70	24	5	1	23	41	34	3	34	39	25	3	70	24	5	1
Columbia torrent salamander	5	20	54	21	3	15	55	28	5	20	54	21	3	15	55	28	0	10	44	46	1	14	46	39	3	21	54	23
Cope's giant salamander	86	14	0	0	79	20	1	0	86	14	0	0	79	20	1	0	63	30	8	0	66	31	3	0	79	20	1	0
Dunn's salamander	91	9	0	0	81	18	1	0	91	9	0	0	81	18	1	0	71	26	3	0	66	30	4	0	81	18	1	0
Northwestern salamander	90	10	0	0	83	15	3	0	88	13	0	0	83	15	3	0	64	28	8	1	66	25	8	1	80	16	4	0
Olympictorrent salamander	86	13	1	0	81	16	3	0	86	13	1	0	81	16	3	0	74	21	5	0	71	24	5	0	81	16	3	0
Pacificgiant salamander	93	8	0	0	86	13	1	0	93	8	0	0	86	13	1	0	68	30	3	0	70	28	3	0	84	14	3	0
Rough-skinned newt	94	6	0	0	89	10	1	0	94	6	0	0	89	10	1	0	73	25	3	0	81	16	3	0	88	11	1	0
Southern torrent salamander	81	19	0	0	74	23	3	1	79	21	0	0	74	23	3	1	41	36	20	3	48	31	19	3	74	23	3	1
Tailed frog	93	8	0	0	80	19	1	0	90	10	0	0	83	16	1	0	63	30	8	0	64	31	5	0	78	20	3	0
Van Dyke's salamander																												
(Cascades)	0	25	58	18	0	23	56	21	3	25	58	15	0	23	56	21	0	16	46	38	0	14	49	38	0	20	58	23
(Coastal, Oly. Penin.)	45	40	13	3	36	44	18	3	45	40	13	3	36	44	18	3	28	43	23	8	25	46	23	6	36	48	14	3
Terrestrial																												
Clouded salamander	93	6	1	0	91	8	1	0	81	18	1	0	81	18	1	0	71	26	3	0	74	24	3	0	81	18	1	0
Del Norte salamander	93	8	0	0	90	10	0	0	90	10	0	0	90	10	0	0	65	28	8	0	65	33	3	0	90	10	0	0
Larch Mountain salamander	80	20	0	0	70	25	5	0	70	25	5	0	65	25	10	0	45	30	20	5	45	30	20	5	75	20	5	0
Oregon Slender salamander	91	9	0	0	88	13	0	0	75	21	4	0	68	24	9	0	54	26	18	3	58	25	15	3	70	24	6	0
Shasta salamander	10	40	40	10	10	40	40	10	10	40	40	10	10	40	40	10	0	10	40	50	0	10	40	50	0	40	40	20
Siskiyou Mountains salamander	60	30	10	0	45	35	20	0	50	30	20	0	50	30	20	0	10	40	40	10	10	40	40	10	50	30	15	5

A-Well Distributed B-Locally Restricted C-Restricted to Refugia D-Extirpation

Likelihood values are expressed as percentages that total to 100 for a given species within an option. Number displayed may vary due to rounding errors.
See text for fuller explanation and discussion of the rating scale.

We recognized two general groups, those species associated with riparian habitats and those associated with terrestrial or upland habitats (table IV-24). Within the riparian group, some species are found primarily in intermittent, headwater streams, (e.g., Van Dyke's and Dunn's salamanders, two species of giant salamanders, four species of torrent salamanders, and the tailed frog). Other riparian associates breed in ponds or streams but forage in terrestrial habitats (rough-skinned newt, northwestern salamander).

Results. Ratings for individual species were highly variable among options (table VI-24). Because of the preponderance of riparian-associated species, overall results of the viability assessment were strongly influenced by the level of riparian buffer protection along headwater and intermittent streams in each option. Options I and 4, which included the widest interim buffer widths on all intermittent streams and seeps, had the greatest number of species for which the likelihood was judged to be 80 percent or greater that habitat on federal lands would be sufficient to support well-distributed, stable populations over the next 100 years (fig. IV-15). Overall ratings for Options 3, 5, and 9 were similar, again reflecting their similar riparian standards. Options 7 and 8 had much lower overall ratings. No species had a likelihood greater than 80 percent of a stable, well-distributed population under Option 7, and only 1 species had such a likelihood under Option 8.

No option provides complete assurance of providing sufficient habitat on federal lands to ensure well-distributed, viable populations of all amphibian species. Table IV-25 shows that 11 of the 19 species or subpopulations occur as local endemics, restricted through habitat specialization and geographic subtleties to small, isolated populations. These small populations are at risk of local extirpation through either land management activity or large-scale habitat modification due to natural events. Three species, the Columbia torrent salamander, Shasta salamander, and Cascades population of Van Dyke's salamander were not rated with an 80 percent likelihood or greater for any outcome better than C (restricted to refugia) for any of the options (table IV-24, fig. IV-16).

Total number of species that were rated into the four viability-outcome classes varied among options. For Option 1, there is an 80 percent or greater likelihood that outcomes for 16 species would be B or better. Of these, 14 attained outcome A. In contrast, Options 3, 4, 5 and 9 also provide habitat conditions for 16 species resulting in likelihood levels of 80 percent or more for outcome B or better, but only half of these species were most likely to achieve outcome A. For Options 7 and 8, five species were rated as achieving 80 percent likelihood of habitat conditions of only outcome C or better. For three species, the 80 percent cumulative likelihood level includes some likelihood of extirpation.

Mitigation for Amphibians

Results of the assessment were based on the assumption that mitigation listed in the Scientific Analysis Team report (Thomas et al. 1993) would be implemented for all options we assessed except 7 and 8. These mitigations prescribe the designation and protection of occupied sites for Del Norte salamander, Larch Mountain salamander, Siskiyou Mountains salamander, and Shasta salamander.

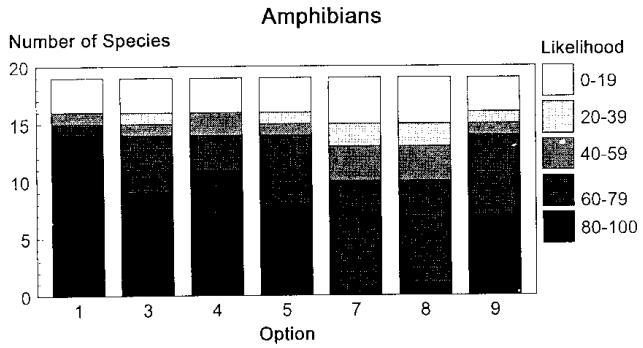
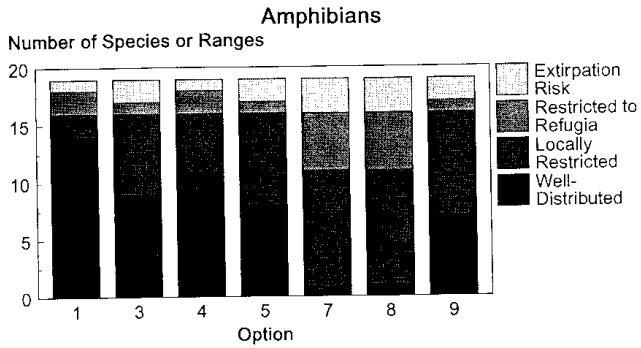


Figure IV-15. Summary of the numbers of amphibian species that are expected to achieve varying likelihoods of attaining stable, well-distributed populations in response to habitat conditions provided under land management options over the next 100 years.



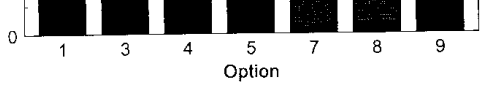


Figure IV-16. Outcomes for amphibians under each land management option. Values shown are the number of species/species ranges that had an 80 percent or greater likelihood of achieving at least the specified outcome (based on distribution of habitat).

Additional mitigation will be required to bring ratings for most species up to an 80 percent likelihood level for outcome A (stable, well-distributed populations) for many of the options (table IV-25). For the riparian-associated species, mitigation generally involves prescribing buffer widths of at least two site-potential tree heights along portions of streams occupied by the species; mitigations are more variable for the terrestrial species (table IV-25). Although some mitigation may be possible for the Columbia torrent salamander, Van Dyke's salamander, Siskiyou Mountains, and Shasta salamander, none could be specified to achieve an 80 percent likelihood of outcome A.

Role of nonfederal lands. Most species of amphibians have less than 50 percent of their range on federal lands. This is especially true for riparian-associated species where only one species overlaps federal lands by more than 50 percent (tailed frog, table IV-25). Overlap of species ranges with federal lands vary from 44 percent to 78 percent for terrestrial species. Only 6 percent of the range of the Columbia torrent salamander (a riparian species), occurs on federal land, and thus land management practices on state and private lands are of particular concern for this species. Streamside protection measures on nonfederal lands will likely continue to have a strong influence on overall population viability of riparian associated amphibian species.

Research and information needs. Habitat requirements of amphibians in late-successional forests of the Pacific northwest have received some attention over the past 10 years (Raphael 1988; Ruggiero et al. 1991) but further work is needed to better understand how habitat variation affects population viability. Because so many of the species of amphibians are associated with riparian systems, understanding the relationships between riparian management and population dynamics is a high priority. A. second high priority should be research on the dispersal ability of terrestrial species in relation to characteristics of forest stands, especially in the Matrix. Third, further work is needed to better understand the population dynamics of the rare and locally endemic species such as Shasta salamander, Van Dyke's salamander, and Columbia torrent salamander. Research on these species is a particularly high priority.

Mitigation measures proposed for any of the options that fail to meet high likelihoods of providing sufficient habitat to assure stable, well-distributed populations require surveys to determine occupied sites. Further research is needed to develop cost-effective survey protocols for these species that can be implemented over large areas. These protocols should be designed to be conducted within the watershed analysis procedure.

Northern Spotted Owl

Introduction. The life history and management of the northern spotted owl has been described in the section on Terrestrial Species of Special Political, Legal, and Biological Interest. Because this species is federally listed as a threatened species, and does not have a final recovery plan, it was paneled separately.

Methods specific to northern spotted owls. Methods used to assess the adequacy of different options were as described in the section on I\4ethods for Assessing Effects of Options. The assessment panel consisted of three experts with many years of research experience on the spotted owl.

Table IV-25. Summary of mitigation measures required for an 80 percent or better likelihood of achieving habitat conditions to support stable, well distributed populations of amphibians on federal lands.

Species	Local endemic	Percent of range on federal lands	Option[a]	Mitigation
Riparian Associates				
Northwestern salamander		38	7,8	Riparian Reserve 1 around occupied sites.
Cope's giant salamander	X	44	3,5,7,8,9	Riparian Reserve 1 around occupied sites.
Pacific giant salamander		47	7,8	Riparian Reserve 1 around occupied sites.
Olympic torrent salamander	X	42	7,8	Riparian Reserve 1 around occupied sites.
Columbia torrent salamander	X	6	All[b]	None[c]
Southern torrent salamander		37	7,8	Riparian Reserve 1 around occupied sites.
Cascade torrent salamander	X	48	3,5,7,8,9	Riparian Reserve 1 around occupied sites.
Rough.skinned newt		37	7	Riparian Reserve 1 around occupied sites.
Dunn's salamander		38	7,8	Riparian Reserve 1 around occupied sites.
Van Dyke's salamander				
(Cascades)	X	48	All[b]	None[c]
(Coast, Olympic Peninsula)	X	40	All[b]	Riparian Reserve 1 around occupied sites.
Black salamander		25	3,5,7,8,9	Riparian Reserve 1 around occupied sites.
Tailed frog		56	7,8	Riparian Reserve 1 around occupied sites.
Terrestrial Associates				
Larch mountain salamander	X	63	3,4,5,7,8,9	Extend buffers to 2 tree-heights on south-facing slopes.
Del Norte salamander	X	67	7,8	Add mitigation measures from Thomas et al. (1993).
Siskivou Mountains salamander	X	78	All	Extend buffers to 2 tree-heights on south-facing slopes.[c]
Clouded salamander		44	7,8	Retain logs > 16 inches diameter at levels comparable to unmanaged stands.
Oregon slender salamander	X	62	4,5,7,8,9	Retain logs > 16 inches diameter at levels comparable to unmanaged stands.
Shasta salamander	X	66	All	Extend buffers to 2 tree-heights on south-facing slopes.[c]

[a] Options are listed whenever a species' rating fell below an 80 percent h likelihood of achieving outcome A (habitat conditions to support a stable, well-distributed population over the next 100 years); see table IV-26 for source of ratings.

[b] No Option achieved an 80 percent likelihood of providing outcome A.

[c] No mitigation measures could assure an 80 percent or better likelihood of outcome A; where mitigations are listed, they will raise the likelihood at least to outcome B (viable population, but significant gaps in distribution).

Results. Options 1-6 and 9 all had a greater than 80 percent likelihood of achieving outcome A (table IV-26). Options 7,8, and 10 received scores of 71, 65, and 73, respectively, for outcome A. No likelihood points were assigned to outcome D (extirpation on federal lands) for any of the seven options.

Total acres of currently available northern spotted owl habitat by allocation under each option is displayed in tables IV-27 to IV-35. A summary of the total acreage of spotted owl habitat on federal lands by option and allocation is shown in table IV-36. The number of confirmed spotted owls that are protected within Reserves under each option are also shown in table IV-36. Total acres within reserves, regardless of current suitability for spotted owls, is displayed for each option in table 11-5. Number of sites occupied by spotted owls within Reserves areas and Matrix areas by option are shown in figure IV-17.

Discussion. There was some concern that the hands-off policy in the Reserve system under Option 1 (and several other options) could result in an elevated risk of catastrophic fire in reserves. This was why Option 1 received a 1 percent likelihood for outcome C. Option 8 was rated particularly low for outcome A for two reasons: (1) it did not ensure the adequacy of dispersal habitat in the Matrix, and (2) it allowed harvest in suitable owl habitat within reserves. Option 7 rated less than 80 percent likelihood for outcome A primarily because of the fact that Bureau of Land Management protection of the Matrix was less protective in the short term than the 50-11-40 prescription.

Mitigation for Northern Spotted Owls

Option 1 could be improved by increasing the emphasis on fire management within reserves. Prescribed fire, fuel breaks, and silviculture could be used to reduce risk of catastrophic fire. Prescribed fire or a silvicultural equivalent could be used to retain some types of late-successional/old-growth forest that would not persist without periodic episodes of low intensity fire.

Options 3 and 4 (and most other Options) could be improved by emphasizing retention of hardwoods in harvested areas in the Klamath Province. Option 4 could be improved by increasing green tree retention to include at least six of the largest trees per acre.

Land exchanges to consolidate federal ownership could reduce the amount of fragmentation in areas currently characterized by mixed federal and nonfederal ownership. All options require the development of a unified research design that will allow managers to learn from harvest treatments, regardless of whether those treatments occur in the Reserves, Matrix, or Adaptive Management Areas.

Role of nonfederal lands. We did not assess northern spotted owls on nonfederal lands. However, nonfederal lands are critical to the continued existence of the owl in some areas, especially in areas where federal lands are uncommon. Southwestern Washington, northwestern Oregon, and northern California are areas of particular concern (Thomas et al. 1990; USD1 1992c). The Final Draft Recovery Plan for the Northern Spotted Owl (USD1 1992c) identified other areas where the contribution of nonfederal lands was considered essential to recovery of the owl. These areas included the Oregon Coast Range, the northern portion of the Klamath Province in Oregon, the California Cascades, and the corridor surrounding Highway 1-90 in the Washington Cascades.

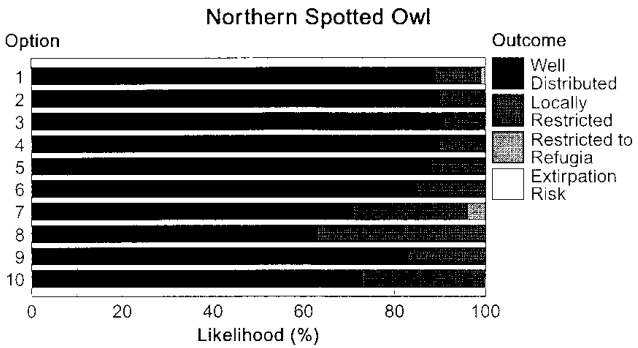


Figure IV-17. Number of currently confirmed sites occupied by northern spotted owls within Reserve Areas and Matrix areas by management option. For this comparison occupied sites in Managed Late-Successional Areas (Option 3) and Adaptive Management Areas (Option 9) were included in the count of sites in Reserves.

Research needs. Research needs for the spotted owl have been summarized by several sources (e.g., Thomas et al. 1990; USD1 1992c). The Final Draft Recovery Plan for the Northern Spotted Owl (USD1 1992c:233-252) provided a particularly detailed listing of the types of research and monitoring needed by geographic province. Priorities included better information on population size and trends, habitat requirements, factors affecting prey populations, dynamics of dispersal, and landscape level factors that influence numbers or distribution of owls. Other items identified as research priorities included the development and testing of silvicultural methods for creating spotted owl habitat and the development of more realistic population viability models that can be used to investigate population response to different management approaches.

Marbled Murrelet

Introduction. The life history and management of the marbled murrelet have been described in the section entitled "Terrestrial Species of Special Political, Legal, and Biological Interest." Because this species is federally listed as a threatened species, and has not been addressed in a recovery plan, it was paneled separately.

Although the Forest Ecosystem Management Assessment was designed to address only federal lands within the range of the northern spotted owl, the marbled murrelet is an example of a species whose life history requirements cannot be accommodated only on federal lands. The marbled murrelet is a seabird that nests inland and therefore is influenced by both marine and terrestrial environments. Its nesting range in the three-state area also includes land that is south of the range of the northern spotted owl. In addition, several areas that are considered key to the recovery of the marbled murrelet involve private and state lands. These limitations must be considered when analyzing the viability of the species on federal lands. However, this does not negate the substantial and important contribution of federal forest management to the continued existence of marbled murrelet nesting habitat. Habitat on federal lands is a key component of any marbled murrelet management strategy because the loss of nesting habitat was the principal reason the species was listed as threatened under the Endangered Species Act.

Methods specific to marbled murrelets. Two separate assessments were made for marbled murrelets. One assessment was based on how well the options provided for well-distributed nesting habitat on federal lands, as per the guidelines established by the marbled murrelet working team (see Development and Description of Terrestrial Options). The other assessment examined the probability of having a viable population of marbled murrelets on federal lands in 100 years, taking into account all the factors that influence murrelets in addition to the availability of suitable nesting habitat on federal lands. Because of the various biological factors that may affect the marbled murrelet in each of the three states, adequacy of habitat was analyzed separately for each state, then averaged to get an overall estimate. Possible outcomes for each option were as described in the section entitled Methods For Assessing Effects of Options.

Results. Total acres of currently available marbled murrelet nesting habitat within Reserves managed for marbled murrelets is displayed in tables IV-27 to IV-35 for all options developed by the Interagency Team. Total acres within reserves, regardless of current suitability for marbled murrelets, is displayed for each option in table 11-5. Table IV-36 summarizes current information on the number of sites on federal lands known to be occupied by marbled murrelets during the 1986-1992 survey period. The number of occupied sites within Reserves will undoubtedly increase as further surveys are conducted.

Based on the assessment of habitat conditions, Options 1-6, 9, and 10 had an 80 percent or greater likelihood of achieving outcome A. Likelihoods of achieving outcome A under Options 7 and 8, were 26 and 29 percent, respectively (table IV-26, fig. P1-18).

The assessment of population viability indicated much greater risk to murrelets than the assessment based only on habitat. When all factors affecting the species are taken into account, including at-sea conditions and land ownership patterns, we believe there is only about a 60 percent likelihood (with a range of 50 to 75 percent) that the marbled murrelet population on federal lands will be stable and well distributed after 100 years, regardless of which option is selected.

Discussion. The greatest concern with marbled murrelets is maintaining the species over the next 50-100 years (see section on Short Term Effects). This concern relates to both inland nesting habitat and possible adverse impacts in the marine environment. An ecosystem plan constrained to federal lands contributes to only one aspect of the marbled murrelet's life history requirements. With the marbled murrelet, both the marine environment and the contribution of state and private lands for nesting habitat must be considered in any viability assessment on federal lands, even though those factors are mostly beyond the control of federal land managers.

Table IV-26. Projected future likelihoods of habitat outcomes under land management options.

	Option 1				Option 3				Option 4				Option 5				Option 7				Option 8				Option 9			
Marbled Murrelet	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	D
Marbled Murrelet California (long-term)	90	10	0	0	82	18	0	0	82	18	0	0	82	18	0	0	5	28	67	0	33	35	30	2	80	20	0	0
Marbled Murrelet Oregon (long-term)	90	10	0	0	83	17	0	0	83	17	0	0	83	17	0	0	3	25	70	2	25	39	33	3	80	20	0	0
Marbled Murrelet Washington (long-term)	97	3	0	0	87	13	0	0	87	13	0	0	87	13	0	0	63	37	0	0	30	47	23	0	80	20	0	0
Three State Average	92	8	0	0	84	16	0	0	84	16	0	0	84	16	0	0	26	30	44	0	29	40	29	2	80	20	0	0

	Option 2				Option 6				Option 10			
	A	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**
Three State Average	84	16	0	0	84	16	0	0	80	20	0	0

Note - Likelihoods for Option 2,6, and 10 are internal assessments; these Options were not rated by expert panels.

	Option 1				Option 3				Option 4				Option 5				Option 7				Option 8				Option 9			
Northern Spotted Owl	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**
Strix occidentalis caurina	89	10	1	0	90	10	0	0	91	9	0	0	88	13	0	0	71	25	4	0	65	35	0	0	83	18	0	0

	Option 2				Option 6				Option 10			
	A	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**
Strix occidentalis caurina	90	10	0	0	85	15	0	0	73	27	0	0

Note - Likelihoods for Option 2,6, and 10 are internal assessments; these Options were not rated by expert panels.

A-Well Distributed B-Locally Restricted C-Restricted to Refugia D-Extirpation

Likelihood values are expressed as percentages that total to 100 for a given species within an option. Number displayed may vary due to rounding errors.
See text for fuller explanation and discussion of the rating scale.

Table IV-27. Allocation of acres of habitat for northern spotted owls and marbled murrelets on federal lands in Option 1

			Congressionally Withdrawn Areas		Administratively Withdrawn Areas		Acres of spotted owl NRF* habitat in:			Acres of marbled murrelet nesting habitat in:		
Physiographic province	Total acres spotted owl NRF* habitat	Total acres marbled murrelet nesting habitat	Spotted owl NRF* habitat	Marbled murrelet nesting habitat	Spotted owl NRF* habitat	Marbled murrelet nesting habitat	Late-Successional Reserves	Riparian Reserves	Matrix	Late-Successional Reserves	Riparian Reserves	Matrix
Washington												
Eastern Cascades	713,100	6,600	213,500	3,300	15,000	0	400,700	32,600	51,400	2,500	0	0
Western Cascades	1,112,600	363,600	345,400	122,100	32,200	10,100	653,700	32,100	49,100	137,200	8,100	18,900
Western Lowlands	0	0	0	0	0	0	0	0	0	68,100	0	0
Olympic Peninsula	562,700	605,600	340,700	393,900	300	600	212,300	4,800	4,700	158,600	12,500	12,200

Total:	2,388,400	975,800	899,600	519,300	47,500	10,700	1,266,700	69,500	105,200	366,400	20,600	31,100
Oregon												
Klamath	802,500	530,800	76,700	72,400	10,300	8,600	655,200	26,200	34,100	348,200	18,900	22,100
Eastern Cascades	439,600	0	101,800	0	15,600	0	244,200	27,900	50,100	88,500	0	0
Western Cascades	2,066,100	900	243,700	0	24,400	0	1,502,700	127,100	168,100	900	0	0
Coast Range	529,200	434,300	13,000	13,000	500	400	468,900	26,000	20,800	371,300	17,200	11,000
Willamette Valley	5,700	600	0	0	0	0	2,900	1,300	1,500	21,900	0	0
Total:	3,843,100	966,600	435,200	85,400	50,800	9,000	2,873,900	208,500	274,600	830,800	36,100	33,100
California												
Coast range	7,700	31,600	1,300	13,500	200	100	5,900	100	200	10,200	700	1,400
Klamath	1,074,900	587,500	303,800	129,100	4,400	2,400	742,300	10,400	13,900	227,800	3,700	5,200
Cascades	75,400	0	800	0	1,800	0	66,700	2,500	3,500	225,000	0	0
Total:	1,158,000	619,100	305,900	142,600	6,400	2,500	814,900	13,000	17,600	463,000	4,400	6,600
Three-State Total:	7,389,500	2,561,500	1,640,700	747,300	104,700	22,200	4,955,500	291,000	397,400	1,660,200	61,100	70,800

* NRF Nesting, roosting, and foraging

Table IV-28. Allocation of acres of habitat for northern spotted owls and marbled murrelets on federal lands in Option 2.

			Congressionally Withdrawn Areas		**Administratively Withdrawn Areas**		**Acres of spotted owl NRF* habitat in:**			**Acres of marbled murrelet nesting habitat in:**		
Physiographic province	Total acres spotted owl NRF* habitat	Total acres marbled murrelet nesting habitat	Spotted owl NRF* habitat	Marbled murrelet nesting habitat	Spotted owl NRF* habitat	Marbled murrelet nesting habitat	Late-Successional Reserves	Riparian Reserves	Matrix	Late-Successional Reserves	Riparian Reserves	Matrix
Washington												
Eastern Cascades	713,100	6,600	213,500	3,300	24,500	0	350,600	34,700	89,900	2,500	0	0
Western Cascades	1,112,600	363,600	345,400	122,100	55,000	17,700	583,700	38,900	89,600	116,900	10,600	36,600
Western Lowlands	0	0	0	0	0	0	0	0	0	60,400	0	0
Olympic Peninsula	562,700	605,600	340,700	393,900	500	700	209,800	4,900	6,900	155,400	11,600	16,300
Total:	**2,388,400**	**975,800**	**899,600**	**519,300**	**80,000**	**18,400**	**1,144,100**	**78,500**	**186,400**	**335,200**	**22,200**	**52,900**
Oregon												
Klamath	802,500	530,800	76,700	72,400	17,000	14,000	469,500	70,700	168,700	272,800	41,900	74,300
Eastern Cascades	439,600	0	101,800	0	22,200	0	220,600	23,000	71,900	83,200	0	0
Western Cascades	2,066,100	900	243,700	0	43,500	0	1,213,100	169,400	396,300	800	0	100
Coast Range	529,200	434,300	13,000	13,000	1,200	1,000	391,500	47,200	76,300	306,800	35,900	56,900
Willamette Valley	5,700	600	0	0	0	0	1,600	1,500	2,600	21,100	100	100
Total:	**3,843,100**	**966,600**	**435,200**	**85,400**	**83,900**	**15,000**	**2,296,300**	**311,800**	**715,800**	**684,700**	**77,900**	**131,400**
California												
Coast range	7,700	31,600	1,300	13,500	300	300	2,900	1,000	2,200	7,900	1,000	3,300
Klamath	1,074,900	588	303,800	129,100	91,400	60,600	478,000	64,600	137,200	123,600	35,200	77,700
Cascades	75,400	0	800	0	4,900	0	51	5,700	13,100	166,800	0	0
Total:	**1,158,000**	**619,100**	**305,900**	**142,600**	**96,600**	**60,900**	**531,700**	**71,300**	**152,500**	**298,300**	**36,200**	**81,000**
Three-State Total:	**7,389,500**	**2,561,500**	**1,640,700**	**747,300**	**260,500**	**94,300**	**3,972,100**	**461,600**	**1,054,700**	**1,318,200**	**136,300**	**265,300**

* NRF Nesting, roosting, and foraging

Table IV-29. Allocation of acres of habitat for northern spotted owls and marbled murrelets on federal lands in Option 3.

			Congressionally Withdrawn Areas		**Administratively Withdrawn Areas**		**Acres of spotted owl NRF* habitat in:**				**Acres of marbled murrelet nesting habitat in:**			
Physiographic province	Total acres spotted owl NRF* habitat	Total acres marbled murrelet nesting habitat	Spotted owl NRF* habitat	Marbled murrelet nesting habitat	Spotted owl NRF* habitat	Marbled murrelet nesting habitat	Late-Successional Reserves	Managed Late-Successional Areas	Riparian Reserves	Matrix	Late-Successional Reserves	Managed Late-Successional Areas	Riparian Reserves	Matrix
Washington														
Eastern Cascades	713,100	6,600	213,500	3,300	22,200	0	375,400	0	31,500	70,500	2,500	0	0	0
Western Cascades	1,112,600	363,600	345,400	122,100	74,500	20,600	529,300	37,200	43,000	83,200	115,100	3,800	11,900	33,300
Western Lowlands	0	0	0	0	0	0	0	0	0	0	57,600	0	0	0
Olympic Peninsula	562,700	605,600	340,700	393,900	500	700	210,200	0	5,100	6,400	156,300	0	12,100	14,900
Total:	**2,388,400**	**975,800**	**899,600**	**519,300**	**97,200**	**21,300**	**1,114,900**	**37,200**	**79,600**	**160,100**	**331,500**	**3,800**	**24,000**	**48,200**
Oregon														
Klamath	802,500	530,800	76,700	72,400	25,800	18,500	398,600	63,000	72,300	166,200	248,800	25,000	42,000	73,200
Eastern Cascades	439,600	0	101,800	0	21,100	0	225,500	0	24,500	66,700	78,600	0	0	0
Western Cascades	2,066,100	900	243,700	0	71,100	0	895,400	290,200	190,900	374,800	800	0	0	100
Coast Range	529,200	434,300	13,000	13,000	1,500	1,100	400,400	1,300	44,600	68,400	315,600	700	33,400	49,900
Willamette Valley	5,700	600	0	0	0	0	1,500	100	1,500	2,600	21,000	0	100	100
Total:	**3,843,100**	**966,600**	**435,200**	**85,400**	**119,500**	**19,600**	**1,921,400**	**354,600**	**333,800**	**678,700**	**664,800**	**25,700**	**75,500**	**123,300**
California														
Coast range	7,700	31,600	1,300	13,500	300	300	2,900	0	1,200	2,000	7,900	0	1,300	3,100
Klamath	1,074,900	587,500	303,800	129,100	112,300	76,000	423,600	33,600	75,400	126,200	101,800	21,900	41,000	71,800
Cascades	75,400	0	800	0	4,900	0	50,800	0	5,700	13,100	151,400	0	0	0
Total:	**1,158,000**	**619,100**	**305,900**	**142,600**	**117,500**	**76,300**	**477,300**	**33,600**	**82,300**	**141,300**	**261,100**	**21,900**	**42,300**	**74,900**
Three-State Total:	**7,389,500**	**2,561,500**	**1,640,700**	**747,300**	**334,200**	**117,200**	**3,513,600**	**425,400**	**495,700**	**980,100**	**1,257,400**	**51,400**	**141,800**	**246,400**

* NRF Nesting, roosting, and foraging

Table IV-30. Allocation of acres of habitat for northern spoiled owls and marbled murrelets on federal lands in Option 4.

			Congressionally Withdrawn Areas		**Administratively Withdrawn Areas**		**Acres of spotted owl NRF* habitat in:**			**Acres of marbled murrelet nesting habitat in:**		
Physiographic province	Total acres spotted owl NRF* habitat	Total acres marbled murrelet nesting habitat	Spotted owl NRF* habitat	Marbled murrelet nesting habitat	Spotted owl NRF* habitat	Marbled murrelet nesting habitat	Late-Successional Reserves	Riparian Reserves	Matrix	Late-Successional Reserves	Riparian Reserves	Matrix
Washington												
Eastern Cascades	713,100	6,600	213,500	3,300	20,000	0	384,500	33,800	61,400	2,500	0	0
Western Cascades	1,112,600	363,600	345,400	122,100	50,200	13,800	592,400	53,400	71,300	129,600	10,800	23,700
Western Lowlands	0	0	0	0	0	0	0	0	0	64,400	0	0
Olympic Peninsula	562,700	605,600	340,700	394	200	300	212,800	4,600	4,500	159,600	12,000	11,700
Total:	**2,388,400**	**975,800**	**899,600**	**519,300**	**70,400**	**14,100**	**1,189,700**	**91,800**	**137,200**	**356,100**	**22,800**	**35,400**
Oregon												
Klamath	802,500	530,800	76,700	72,400	21,900	17,200	444,301	95,900	163,700	266,000	49	74,000
Eastern Cascades	439,600	0	101,800	0	28,700	0	192,900	40,600	75,700	79,900	0	0
Western Cascades	2,066,100	900	243,700	0	58,800	0	987,400	322,200	453,900	900	0	0

Coast Range	529,200	434,300	13,000	13,000	1,300	1,000	422,600	45,300	47,000	333,100	33,300	33,200
Willamette Valley	5,700	60	0	0	0	0	1,500	1,900	2,300	21,100	100	100
Total:	**3,843,100**	**966,600**	**435,200**	**85,400**	**110,700**	**18,200**	**2,048,700**	**505,900**	**742,600**	**701,000**	**82,800**	**107,300**
California												
Coast range	7,700	31,600	1,300	13,500	300	300	3,000	1,300	1,700	9,200	1,200	2,000
Klamath	1,074,900	587,500	303,800	129,100	92,000	62,100	451,800	100,900	126,400	103,300	57,110	76,100
Cascades	75,400	0	800	0	2,600	0	57,800	6,100	8,000	165,400	0	0
Total:	**1,158,000**	**619,100**	**305,900**	**142,600**	**94,900**	**62,400**	**512,600**	**108,300**	**136,100**	**277,900**	**58,300**	**78,100**
Three-State Total:	**7,389,500**	**2,561,500**	**1,640,700**	**747,300**	**276,000**	**94,700**	**3,751,000**	**706,000**	**1,015,900**	**1,335,000**	**163,900**	**220,800**

* NRF Nesting, roosting, and foraging

Table IV-31. Allocation of acres of habitat for northern spoiled owls and marbled murrelets on federal lands in Option 5.

			Congressionally Withdrawn Areas		Administratively Withdrawn Areas		Acres of spotted owl NRF* habitat in:			Acres of marbled murrelet nesting habitat in:		
Physiographic province	Total acres spotted owl NRF* habitat	Total acres marbled murrelet nesting habitat	Spotted owl NRF* habitat	Marbled murrelet nesting habitat	Spotted owl NRF* habitat	Marbled murrelet nesting habitat	Late-Successional Reserves**	Riparian Reserves	Matrix	Late-Successional Reserves**	Riparian Reserves	Matrix
Washington												
Eastern Cascades	713,100	6,600	213,500	3,300	51,900	0	338,500	32,800	76,400	2,500	0	0
Western Cascades	1	363,600	345,400	122,100	62,600	15,200	533,200	64,300	107,200	126,500	10,200	27,300
Western Lowlands	0	0	0	0	0	0	0	0	0	63,000	0	0
Olympic Peninsula	562,700	605,600	340,700	393,900	200	300	212,800	4,000	5,000	160	11,700	13,000
Total:	**2,388,400**	**975,800**	**899,600**	**519,300**	**114,700**	**15,500**	**1,084,500**	**101,100**	**188,600**	**351,600**	**20,900**	**40,300**
Oregon												
Klamath	802,500	530,800	76,700	72,400	31,600	23,000	396,800	91,900	205,600	250,400	51,100	88,000
Eastern Cascades	439,600	0	101,800	0	48,100	0	115,600	45,100	129,000	74,100	0	0
Western Cascades	2,066,100	900	243,700	0	114,500	0	629,200	362,400	716,300	700	100	200
Coast Range	529	434,300	13,000	13	1,300	1,000	421,300	36,900	56,700	332,800	26,800	40,000
Willamette Valley	5,700	600	0	0	200	0	700	1,800	3,000	21,100	100	100
Total:	**3,843,100**	**966,600**	**435,200**	**85,400**	**195,700**	**24,000**	**1,563,600**	**538,100**	**1,110,600**	**679,100**	**78,100**	**128,300**
California												
Coast range	7,700	31,600	1,300	13,500	300	300	3,000	1,100	1,900	9,200	1,000	2,100
Klamath	1,074,900	587,500	303,800	129,100	107,200	68,300	387,600	101,700	174,600	81,700	55,200	99,500
Cascades	75,400	0	800	0	3,000	0	54,600	5,300	11,700	159,200	0	0
Total:	**1,158,000**	**619,100**	**305,900**	**142,600**	**110,500**	**68,600**	**445,200**	**108,100**	**188,200**	**250,100**	**56,200**	**101,600**
Three-State Total:	**7,389,500**	**2,561,500**	**1,640,700**	**747,300**	**420,900**	**108,100**	**3,093,300**	**747,300**	**1,487,400**	**1,280,800**	**155,200**	**270,200**

* NRF Nesting, roosting, and foraging
** Includes 147,000 acres of Managed Late-Successional Areas.

Table IV-32. Allocation of acres of habitat for northern spoiled owls and marbled murrelets on federal lands in Option 6 and 10.

			Congressionally Withdrawn Areas		Administratively Withdrawn Areas		Acres of spotted owl NRF* habitat in:			Acres of marbled murrelet nesting habitat in:		
Physiographic province	Total acres spotted owl NRF* habitat	Total acres marbled murrelet nesting habitat	Spotted owl NRF* habitat	Marbled murrelet nesting habitat	Spotted owl NRF* habitat	Marbled murrelet nesting habitat	Late-Successional Reserves	Riparian Reserves	Matrix	Late-Successional Reserves	Riparian Reserves	Matrix
Washington												
Eastern Cascades	713,100	6,600	213,500	3,300	32,200	0	326,000	38,900	102,600	2,500	0	0
Western Cascades	1,112,600	363,600	345,400	122,100	74,500	20,600	529,300	52,800	110,500	115,100	11,300	37,700
Western Lowlands	0	0	0	0	0	0	0	0	0	57,600	0	0
Olympic Peninsula	562,700	605,600	340,700	393,900	500	700	210,200	4,700	6,700	156,300	11,200	15,800
Total:	**2,388,400**	**975,800**	**899,600**	**519,300**	**107,200**	**21,300**	**1,065,500**	**96,400**	**219,800**	**331,500**	**22,500**	**53,500**
Oregon												
Klamath	802,500	530,800	76,700	72,400	25,800	18,500	398,600	86,700	214,800	248,800	50,100	90,200
Eastern Cascades	439,600	0	101,800	0	36,600	0	171,300	31,700	98,200	78,600	0	0
Western Cascades	2,066,100	900	243,700	0	71,100	0	895,400	251,800	604,000	800	0	100
Coast Range	529,200	434,300	13,000	13,000	1,500	1,100	400,400	43,100	71,200	315,600	32,000	52,000
Willamette Valley	5,700	600	0	0	0	0	1,500	1,500	2,700	21,000	100	100
Total:	**3,843,100**	**966,600**	**435,200**	**85,400**	**135,000**	**19,600**	**1,867,200**	**414,800**	**990,900**	**664,800**	**82,200**	**142,400**
California												
Coast range	7,700	31,600	1,300	13,500	300	300	2,900	1,000	2,200	7,900	1,000	3,300
Klamath	1,074,900	587,500	303,800	129,100	112,300	76,000	423,600	74,700	160,500	101,800	41,500	93,200
Cascades	75,400	0	800	0	5,200	0	49,500	6,000	13,800	151,400	0	0
Total:	**1,158,000**	**619,100**	**305,900**	**142,600**	**117,800**	**76,300**	**476,000**	**81,700**	**176,500**	**261,100**	**42,500**	**96,500**
Three-State Total:	**7,389,500**	**2,561,500**	**1,640,700**	**747,300**	**360,000**	**117,200**	**3,408,700**	**592,900**	**1,387,200**	**1,257,400**	**147,200**	**292,400**

* NRF Nesting, roosting, and foraging

Table IV-33. Allocation of acres of habitat for northern spoiled owls and marbled murrelets on federal lands in Option 7.

			Congressionally Withdrawn Areas		Administratively Withdrawn Areas		Acres of spotted owl NRF* habitat in:			Acres of marbled murrelet nesting habitat in:		
Physiographic province	Total acres spotted owl NRF* habitat	Total acres marbled murrelet nesting habitat	Spotted owl NRF* habitat	Marbled murrelet nesting habitat	Spotted owl NRF* habitat	Marbled murrelet nesting habitat	Late-Successional Reserves**	Riparian Reserves	Matrix	Late-Successional Reserves**	Riparian Reserves	Matrix
Washington												
Eastern Cascades	713,100	6,600	213,500	3,300	51,900	0	338,500	7,500	101,700	2,500	0	0
Western Cascades	1,112,600	363,600	345,400	122,100	78,700	23,100	499,100	15,300	174,200	116,400	2,600	45,100
Western Lowlands	0	0	0	0	0	0	0	0	0	55,000	0	0
Olympic Peninsula	562,700	605,600	340,700	393,900	2,700	2,300	184,500	2,900	31,900	137,800	3,800	41,600
Total:	**2,388,400**	**975,800**	**899,600**	**519,300**	**133,300**	**25,400**	**1,022,100**	**25,700**	**307,800**	**311,700**	**6,400**	**86,700**
Oregon												
Klamath	802,500	530,800	76,700	72,400	69,700	60,900	234,700	27,500	394,000	136,100	17,400	233,900
Eastern Cascades	439,600	0	101,800	0	48,100	0	114,300	9,900	165,500	36,200	0	0
Western Cascades	2,066,100	900	243,700	0	114,600	0	618,400	74,700	1,014,600	600	0	300
Coast Range	529,200	434,300	13,000	13,000	2,900	2,600	328,000	14,900	170,500	250,900	12,100	136,600
Willamette Valley	5,700	600	0	0	200	0	200	400	4,900	19,200	0	400
Total:	**3,843,100**	**966,600**	**435,200**	**85,400**	**235,500**	**63,500**	**1,295,600**	**127,400**	**1,749,500**	**443,000**	**29,500**	**371,200**
California												
Coast range	7,700	31,600	1,300	13,500	300	300	3,000	200	2,900	9,100	200	3,000
Klamath	1,074,900	587,500	303,800	129,100	133,100	94,100	308,500	23,400	306,100	28,500	14,100	193,900
Cascades	75,400	0	800	0	3,000	0	54,600	1,200	15,700	133,300	0	0
Total:	**1,158,000**	**619,100**	**305,900**	**142,600**	**136,400**	**94,400**	**366,100**	**24,800**	**324,700**	**170,900**	**14,300**	**196,900**
Three-State Total:	**7,389,500**	**2,561,500**	**1,640,700**	**747,300**	**505,200**	**183,300**	**2,683,800**	**177,900**	**2,382,000**	**925,600**	**50,200**	**654,800**

* NRF Nesting, roosting, and foraging
** Includes 147,000 acres of Managed Late-Successional Areas.

Table IV-34. Allocation of acres of habitat for northern spoiled owls and marbled murrelets on federal lands in Option 8.

			Congressionally Withdrawn Areas		Administratively Withdrawn Areas		Acres of spotted owl NRF* habitat in:			Acres of marbled murrelet nesting habitat in:		
Physiographic province	Total acres spotted owl NRF* habitat	Total acres marbled murrelet nesting habitat	Spotted owl NRF* habitat	Marbled murrelet nesting habitat	Spotted owl NRF* habitat	Marbled murrelet nesting habitat	Late-Successional Reserves	Riparian Reserves	Matrix	Late-Successional Reserves	Riparian Reserves	Matrix
Washington												
Eastern Cascades	713,100	6,600	213,500	3,300	32,200	0	326,000	25,600	115,900	2,500	0	0
Western Cascades	1,112,600	363,600	345,400	122,100	74,500	20,600	529,300	36,500	126,800	115,100	7,600	41,400
Western Lowlands	0	0	0	0	0	0	0	0	0	57,600	0	0
Olympic Peninsula	562,700	605,600	340,700	393,900	500	700	210,200	3,800	7,700	156,300	8,900	18,100
Total:	**2,388,400**	**975,800**	**899,600**	**519,300**	**107,200**	**21,300**	**1,065,500**	**65,900**	**250,400**	**331,500**	**16,500**	**59,500**
Oregon												
Klamath	802,500	530,800	76,700	72,400	25,800	18,500	398,600	54,000	247,500	248,800	28,900	111,400
Eastern Cascades	439,600	0	101,800	0	36,600	0	171,300	19,400	110,500	78,600	0	0
Western Cascades	2,066,100	900	243,700	0	71,100	0	895,400	158,200	697,700	800	0	100
Coast Range	529,200	434,300	13,000	13,000	1,500	1,100	400,400	29,300	85,000	315,600	22,200	61,800
Willamette Valley	5,700	600	0	0	0	0	1,500	1,000	3,200	21,000	0	100
Total:	**3,843,100**	**966,600**	**435,200**	**85,400**	**135,000**	**19,600**	**1,867,200**	**261,900**	**1,143,900**	**664,800**	**51,100**	**173,400**
California												
Coast range	7,700	31,600	1,300	13,500	300	300	2,900	600	2,600	7,900	700	3,700
Klamath	1,074,900	587,500	303,800	129,100	112,300	76,000	423,600	51,100	184,100	101,800	28,600	106,100
Cascades	75,400	0	800	0	5,200	0	49,500	4,100	15,800	151,400	0	0
Total:	**1,158,000**	**619,100**	**305,900**	**142,600**	**117,800**	**76,300**	**476,000**	**55,800**	**202,500**	**261,100**	**29,300**	**109,800**
Three-State Total:	**7,389,500**	**2,561,500**	**1,640,700**	**747,300**	**360,000**	**117,200**	**3,408,700**	**383,600**	**1,596,000**	**1,257,400**	**96,900**	**342,700**

* NRF Nesting, roosting, and foraging

Table IV-35. Allocation of acres of habitat for northern spoiled owls and marbled murrelets on federal lands in Option 9.

			Congressionally Withdrawn Areas		Administratively Withdrawn Areas		Acres of spotted owl NRF* habitat in:				Acres of marbled murrelet nesting habitat in:			
Physiographic province	Total acres spotted owl NRF* habitat	Total acres marbled murrelet nesting habitat	Spotted owl NRF* habitat	Marbled murrelet nesting habitat	Spotted owl NRF* habitat	Marbled murrelet nesting habitat	Late-Successional Reserves	Adaptive Management Areas	Riparian Reserves	Matrix	Late-Successional Reserves	Adaptive Management Areas	Riparian Reserves	Matrix
Washington														
Eastern Cascades	713,100	6,600	213,500	3,300	50,900	0	270,000	38,800	46,200	93,700	2,500	0	0	0
Western Cascades	1,112,600	363,600	345,400	122,100	61,100	18,100	453,100	78,700	62,400	112,000	98,500	22,100	13,200	34,800
Western Lowlands	0	0	0	0	0	0	0	0	0	0	55,600	0	0	0
Olympic Peninsula	562,700	605,600	340,700	393,900	0	0	205,500	16,500	0	0	150,700	34,500	0	0
Total:	**2,388,400**	**975,800**	**899,600**	**519,300**	**112,000**	**18,100**	**928,600**	**134,000**	**108,600**	**205,700**	**307,300**	**56,600**	**13,200**	**34,800**
Oregon														
Klamath	802,500	530,800	76,700	72,400	26,200	24,700	338,700	72,000	95,600	193,500	215,500	11,300	63,400	101,200
Eastern Cascades	439,600	0	101,800	0	40,700	0	142,400	0	41,400	113,300	68,700	0	0	0
Western Cascades	2,066,100	900	243,700	0	89,200	0	774,300	134,100	256,600	568,200	0	0	300	600
Coast Range	529,200	434,300	13,000	13,000	1,400	1,100	345,100	63,400	39,500	66,900	288,300	34,300	31,500	52,600
Willamette Valley	5,700	600	0	0	100	0	300	100	1,900	3,300	13,800	0	100	200
Total:	**3,843,100**	**966,600**	**435,200**	**85,400**	**157,600**	**25,800**	**1,600,800**	**269,600**	**435,000**	**945,200**	**586,300**	**45,600**	**95,300**	**154,600**
California														
Coast range	7,700	31,600	1,300	13,500	200	300	3,200	0	1,100	1,900	9,200	0	1,000	2,100
Klamath	1,074,900	587,500	303,800	129,100	101,000	70,100	413,700	44,300	79,500	132,600	86,000	22,900	46,900	85,400
Cascades	75,400	0	800	0	4,800	0	54,100	0	4,800	10,900	152,500	0	0	0
Total:	**1,158,000**	**619,100**	**305,900**	**142,600**	**106,000**	**70,400**	**471,000**	**44,300**	**85,400**	**145,400**	**247,700**	**22,900**	**47,900**	**87,500**
Three-State Total:	**7,389,500**	**2,561,500**	**1,640,700**	**747,300**	**375,600**	**114,300**	**3,000,400**	**447,900**	**629,000**	**1,296,300**	**1,141,300**	**125,100**	**156,400**	**276,900**

* NRF Nesting, roosting, and foraging

Table IV-36. Summary of acreage for northern spotted owl and marbled murrelet habitat on various federal lands in the range of the northern spotted owl for each option. Number of sites occupied by spotted owls and marbled murrelets are indicated by land allocation for each option.

		Option 1				Option 2			Option 3			
Habitat/species	Total on federal land	Congressional Withdrawn Areas	Late-Successional Reserves	Administrative Withdrawn	Riparian Reserves	Late-Successional Reserves	Administrative Withdrawn	Riparian Reserves	Late-Successional Reserves	Managed Late-Successional Reserves	Administrative Withdrawn	Riparian Reserves
Spotted Owl nesting, roostrng, and foraging habitat acres	7,389,400	1,640,700	4,955,700	104,610	291,100	3,972,000	260,500	461,500	3,513,400	425,400	334,300	495,700
Marbled Murrelet nesting habitat acres	2,561,500	747,300	1,660,200	22200	61,000	1,318,300	94,300	136,400	1,257,400	51,400	117,200	141,800
Late-successional conifer acres small conifer:	5,768,900	1,619,400	2,377,700	333,200	580,600	225,300	335,000	475,700	2,096,500	181,800	368,300	489,410
Medium/large conifer acres Single story:	4,032,200	1,150,500	2,880,700	0	400	1,747,600	189,700	278,110	1,556,400	178,900	227,400	300,500
acres Multi-story:	4,498,400	1,300,300	3,180,000	0	6,600	2,030,100	241,700	283,200	1,779,500	217,200	290,400	308,700
Spotted Owl pairs:	2,772	273	2,211	26	-	1,856	88	-	1,581	247	128	-
Spotted Owl singles:	761	94	563	7	-	439	21	-	373	59	33	-
Occupied Murrelet sites:	577	44	533	0	-	533	0	-	533	0	0	-

		Option 4				Option 5			Option 6 & 10**		
Habitat/species	Total on federal land	Congressional Withdrawn Areas	Late-Successional Reserves*	Administrative Withdrawn	Riparian Reserves	Late-Successional Reserves*	Administrative Withdrawn	Riparian Reserves	Late-Successional Reserves	Administrative Withdrawn	Riparian Reserves
Spotted Owl nesting, roostrng, and foraging habitat acres	7,389,400	1,640,700	3,751,000	276,000	706,100	3,093,200	420,900	747,200	3,408,500	360,000	593,000
Marbled Murrelet nesting habitat acres	2,561,500	747,300	1,334,900	94,700	163,800	1,280,700	108,200	155,100	1,257,400	117,200	147,200
Late-successional conifer acres small conifer:	5,768,900	1,619,400	2,102,100	399,200	656,700	1,651,500	538,600	623,100	1,907,700	432,600	539,800
Medium/large conifer acres Single story:	4,032,200	1,151,500	1,657,500	202,700	414,700	1,330,700	286,000	414,200	1,479,700	249,710	337,500
acres Multi-story:	4,498,400	1,300,300	1,896,200	251,100	436,900	1,599,400	324,900	424,200	1,740,600	311,000	345,200

Spotted Owl pairs:	2,772	273	1,802	86	-	1,522	136	-	1,549	132	-
Spotted Owl singles:	761	94	401	27	-	324	44	-	366	34	-
Occupied Murrelet sites:	577	44	533	0	-	533	0	-	533	0	-

			Option 7			Option 8			Option 9			
Habitat/species	Total on federal land	Congressional Withdrawn Areas	Late-Successional Reserves*	Administrative Withdrawn	Riparian Reserves	Late-Successional Reserves*	Administrative Withdrawn	Riparian Reserves	Late-Successional Reserves	Adaptive Management Areas	Administrative Withdrawn	Riparian Reserves
Spotted Owl nesting, roostrng, and foraging habitat acres	7,389,400	16,407	2,683,700	505,100	177,900	3,408,500	360,000	383,600	3,000,500	447,800	375,400	628,900
Marbled Murrelet nesting habitat acres	2,561,500	747,300	925,700	183,300	50,200	1,257,400	117,200	97,000	1,141,100	125,200	114,500	156,400
Late-successional conifer acres small conifer:	5,768,900	1,619,400	1,384,200	587,600	146,800	1,907,700	432,600	349,600	1,725,900	380,000	413,800	519,000
Medium/large conifer acres Single story:	4,032,200	1,150,500	1,220,500	305,100	94,900	1,479,700	249,700	215,400	1,370,900	258,600	218,700	334,600
acres Multi-story:	4,498,400	1,300,300	1,358,500	386,500	99,200	1,740,600	301,000	235,800	1,604,100	198,400	281,900	361,900
Spotted Owl pairs:	2,772	273	1,325	152	-	1,549	132	-	1,366	230	102	-
Spotted Owl singles:	761	94	268	52	-	366	34	-	326	50	31	-
Occupied Murrelet sites:	577	44	258	99	-	383	10	-	533	0	0	-

*Includes 147,000 acres of Managed Late-Successional Areas
* * Table information is the same for Option 6 and Option 10

Mitigation for Marbled Murrelets

In developing a strategy for marbled murrelet nesting habitat on federal lands, the key components were: (1) stabilization or improvement of nesting habitat through protection of all occupied sites (both current and future); (2) development of future habitat in large blocks (creating more interior habitat and possibly decreasing avian predation); and (3) improvement of distribution of habitat, thereby improving distribution of marbled murrelet populations.

Role of nonfederal lands. In some parts of the range of the marbled murrelet, private lands arc key to maintaining the existing distribution of marbled murrelets and providing for potential recovery of the species. Areas where there are large gaps in federal ownership, and where contributions from private and state lands may be especially important include northern California, the area between the Siskiyou and Siuslaw National Forests in Oregon, and the area between the central Coast Ranges of Oregon and the Olympic Peninsula in Washington. In these areas, which are largely in private or state ownership, past harvest activities have produced a landscape dominated by young forests with isolated small tracts of late-successional/old-growth forest. Where gaps in federal ownership exist, management and development of murrelet habitat on private and state lands could provide for a higher viability rating and an increased likelihood that the ecosystem plan adopted on federal lands will maintain marbled murrelets for the long term. Federal agencies should actively encourage state and private landowners to join in cooperative management efforts for marbled murrelets.

Research needs. Virtually all aspects of the biology and ecology of the marbled murrelet need further research. Key areas that need more study include: (1) population ecology, including determination of age-specific birth and death rates, population trends, and population size; (2) determination of relative influence of factors affecting demographic rates, including nest site characteristics, forest fragmentation, prey populations, net fisheries, predation, and contaminants; (3) distribution and abundance by land ownership and geographic area; and (4) influence of habitat pattern on nest site selection. In addition, information is needed on the extent to which marbled murrelets are capable of moving to alternate nest sites when historical nest locations are lost to harvest or natural events such as fire or wind.

Other Birds

Introduction. We assessed 36 species of birds closely associated with late-successional and old-growth forests as identified in the “short list’ of The Scientific Analysis Team Report (Thomas et al. 1993). The marbled murrelet and northern spotted owl were addressed in separate assessments because both were listed as threatened under the Endangered Species Act, because neither species had a final recovery plan, and because both species have been a major focus in the scientific, political, legal, and social controversy surrounding late-successional/old-growth forest management issues.

The bald eagle, which is federally listed as “threatened’ under the Endangered Species Act in Oregon and Washington and “endangered” in California, is included in this assessment. All options incorporated the guidelines suggested in the U.S. Fish and Wildlife Service recovery plan for the bald eagle (USD1 Fish and Wildlife Service 1986).

Table IV-37. Projected future likelihoods of habitat outcomes for birds under land management options.

	Option 1				Option 3				Option 4				Option 5				Option 7				Option 8				Option 9			
Birds	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**
Bald eagle	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0
Barred owl	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0
Barrow’s goldeneye	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	80	20	0	0	100	0	0	0	100	0	0	0
Black-backed woodpecker	100	0	0	0	93	7	0	0	93	7	0	0	93	7	0	0	93	7	0	0	53	47	0	0	73	27	0	0
Brown creeper	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0
Bufflehead	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	87	13	0	0	100	0	0	0	100	0	0	0
Chestnut-backed chickadee	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0
Common merganser	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	93	7	0	0	87	13	0	0	100	0	0	0
Flammulated owl	100	0	0	0	93	7	0	0	93	7	0	0	93	7	0	0	93	7	0	0	70	30	0	0	93	7	0	0
Golden-crowned kinglet	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0
Great gray owl	93	7	0	0	90	10	0	0	90	10	0	0	83	17	0	0	80	20	0	0	73	27	0	0	83	17	0	0
Hairy woodpecker	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0
Hammond’s flycatcher	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0
Harlequin duck	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	80	20	0	0	100	0	0	0	100	0	0	0
Hermit thrush	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0
Hermit warbler	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0
Hooded merganser	100	0	0	0	93	7	0	0	93	7	0	0	93	7	0	0	90	10	0	0	77	23	0	0	93	7	0	0
Northern flicker	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0
Northern goshawk	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	93	7	0	0	83	17	0	0	100	0	0	0
Northern pygmy-owl	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	80	20	0	0	100	0	0	0
Pileated woodpecker	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	93	7	0	0	100	0	0	0
Pygmy nuthatch	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	80	20	0	0	70	30	0	0	100	0	0	0
Red crossbill	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0
Red-breasted nuthatch	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0
Red-breasted sapsucker	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0
Three-toed woodpecker	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	80	20	0	0	100	0	0	0
Varied thrush	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0
Vaux's swift	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	93	7	0	0	83	17	0	0	100	0	0	0
Warbling vireo	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0
Western flycatcher (Pacific slope flycatcher)	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0
White breasted nuthatch	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	93	7	0	0	93	7	0	0	100	0	0	0
White-headed woodpecker	100	0	0	0	97	3	0	0	97	3	0	0	97	3	0	0	77	23	0	0	67	33	0	0	100	0	0	0
Williamson’s sapsucker	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	80	20	0	0	67	33	0	0	100	0	0	0
Wilson’s warbler	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0
Winter wren	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0
Wood duck	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	8713	0	0	100	0	0	0		100	0	0	0

A-Well Distributed B-Locally Restricted C-Restricted to Refugia D-Extirpation

Likelihood values are expressed as percentages that total to 100 for a given species within an option. Number displayed may vary due to rounding errors.
See text for fuller explanation and discussion of the rating scale.

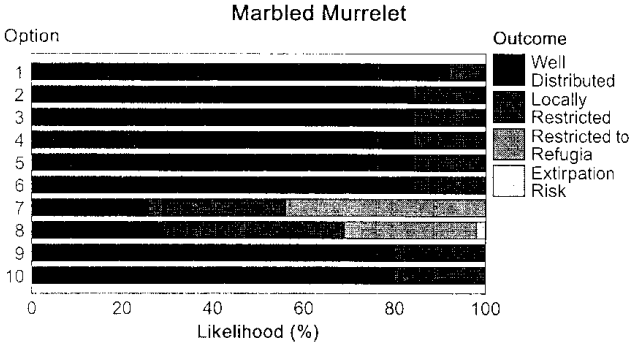


Figure IV-18. Outcomes for marbled murrelets under each management option. Values shown are the number of the species that had an 80 percent or greater likelihood of achieving at least the specified outcome.

Methods specific to other birds. Methods used to assess the effects of options on birds were the same as those described in the section on Methods of Assessing Effects of Options. Options 2,6, and 10 were not assessed for birds other than the northern spotted owl and marbled murrelet.

Results. For Options 1,3, 4, and 5, we concluded that all 36 bird species had an 80 percent or greater likelihood of achieving outcome A (table IV-37, fig. IV-19). For Options 7 and 9, 35 species had an 80 percent or greater likelihood of achieving outcome A. For option 8, seven species were rated less than 80 percent likelihood of achieving outcome A, and one species (black-backed woodpecker) was rated less than 60 percent likelihood of achieving outcome A (table IV-37).

Discussion. Essential considerations for bird viability ratings were (1) provision of a system of large reserves, (2) provision of standards and guidelines for riparian protection and analysis as identified for watershed guidelines in the report of the Scientific Analysis learn (Thomas et al. 1993) report, and (3) provisions for retention of green trees, snags, and down woody material within the matrix. When one or more of these factors was judged inadequate in an option, some subset of the total species usually rated lower. For example, Option 7, which included rather narrow riparian buffers, rated lower for a number of waterfowl that nest adjacent to streams or lakes. Option 8, which allowed considerable salvage and harvest within reserves, rated lower than most other options for a number of woodpeckers and other cavity festers that depend upon large snags. Options 7 and 8 also rated lower for a number of species because neither option included the mitigation measures that were proposed by Thomas et al. (1993) for selected species that were thought to be at risk under the existing Forest Plans.

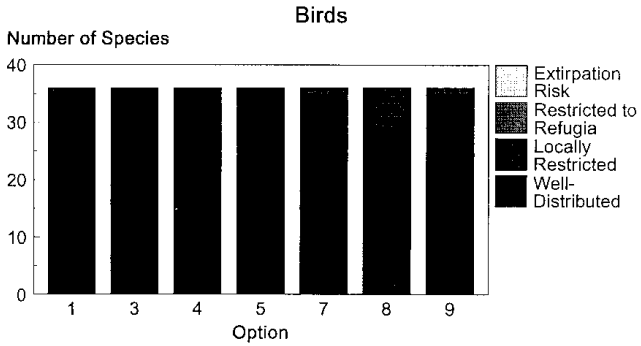


Figure IV-19. Outcomes for species of birds under each land management option. Values shown are the number of species that had an 80 percent or greater likelihood of achieving at least the specified outcome (based on distribution of habitat).

For 19 of the 36 bird species considered in this assessment, all seven options were rated as providing a 100 percent likelihood of achieving outcome A. Of the species that did not rate 100 percent likelihood of outcome A in all options, most need further study to better understand and address their habitat needs. In addition, the ranges of a number of species (e.g., Barrow's goldeneye, bufflehead, harlequin duck, great gray owl and flammulated owl) only slightly overlap the range of the northern spotted owl. Addressing these species on federal lands outside the range of the spotted owl is recommended as well. These species may also be affected by activities on nonfederal lands and within Canada (see below).

Because the common merganser occupies low elevation waterways often outside the influence of federal management, its viability cannot be adequately insured by any of the options considered here. The other waterfowl addressed in this assessment winter in lowland areas where they are subject to hunting and other forms of disturbance. The viability of these species is only partially a function of the quality of habitat on federal lands.

Mitigation for Other Birds

Those options that have reduced riparian protection (e.g., 7 and 8) could be improved for waterfowl by implementing wider riparian buffers. Three woodpeckers (black-backed, white-headed and Williamson's woodpeckers) rated less than 80 percent likelihood of achieving outcome A under one or more options. All three species are primarily located in the eastern Cascades Province. Mitigation for these three species could include adoption of more restrictive guidelines for salvage in the eastern Cascades Provinces.

There were two species of concern for which mitigation could increase their rating in Options 7 and 8. The northern goshawk could be mitigated by protecting occupied and key nesting and foraging habitat within the Matrix as per Thomas et al. (1993) or the U.S. Forest Service Regional guidelines (whichever are more protective). Mitigation for the flammulated owl could include surveys followed by protection of nesting locations. Flammulated owls often nest in loose aggregations or 'clusters" of territorial pairs. Surveys and studies of this species may provide information to better understand their distribution patterns.

The pygmy nuthatch was rated a 70 percent likelihood of achieving outcome A under Option 8. Mitigation for this option would include adoption of the Thomas et al. (1993) mitigation measures for the pygmy nuthatch.

The great gray owl rated only 73 percent likelihood of achieving outcome A under Option 8. Mitigation for this species would include adoption of the Thomas et al. (1993) mitigation measures for the great gray owl. These measures included protection of forest buffers around meadows and other forest openings within the range of the species.

Role of nonfederal lands. All of the 36 birds in this assessment occur on both federal and nonfederal lands. Some (flammulated owl, Hammond's flycatcher, hermit warbler, warbling vireo, western flycatcher, Wilson's warbler, Vaux's swift) are neotropical migrants that spend the winter in Mexico or central America. All six of the waterfowl on the list winter on lowland ponds, bays, rivers, estuaries, or surf zones, where they are subject to hunting and other forms of disturbance. For all of these species, habitat on the winter range is critical for their well-being. In addition, for those waterfowl that are subject to hunting, state and federal regulatory mechanisms play a critical role in their population trends.

Research needs. Studies are needed to better understand habitat needs and population status for most of the 36 bird species that were assessed. Studies that result in a better understanding of population response relative to different levels of snag and coarse woody debris retention, riparian protection, and disturbance levels are recommended. Research is also needed to determine the effects of livestock grazing on prey utilized by great gray owls. Inventory and monitoring efforts for most of the 36 species will provide baseline data and a means for tracking changes in populations or habitat.

Mammals Other Than Bats

Temperate coniferous forests of the Pacific Northwest provide habitat for a diverse array of mammal species. Foliage- and fungi-eating mammals such as flying squirrels and red-hacked voles have important functional roles in these coniferous forests (Trappe and Maser 1976; Ure and Maser 1982; Maser and Trappe 1985). Mycophagists such as northern flying squirrels and red-hacked voles eat mostly fungi, including lichens, but they prefer truffles (Ure and Maser 1982).

Spores of hypogeous fungi are primarily dispersed by small mammals in their fecal pellets. At least one study has shown that passage through the digestive tract of small mammals enhances spore germination (Cork and Kenagy 1989). Fecal pellets contain not only fungal spores, but also nitrogen-fixing bacteria and yeast that are deposited onto the forest floor. These mammals also serve an important role in physically distributing lichens throughout the forest ~Rosentreter 1991).

Many small mammals are prey for larger animals within the forest community. Northern flying squirrels, woodrats, red tree voles, and red-backed voles are the primary prey of northern spotted owls throughout their range (Thomas et al. 1990). Microtine votes (*Microtus* spp.) and red-backed voles (*Clethrionomys* spp.) are prey for American martens (Strickland and Douglas 1987a). These small mammals depend on fir needles, fungi, and lichens in coniferous forests and in turn serve as food sources to predators that eat them.

Large, decayed logs and snags are important to many mammals. They are used by larger mammals, such as fishers and American martens, for resting and denning sites. The California red-hacked vole uses logs for cover and forages on truffles which fruit mostly in rotten wood (Maser and Trappe 1984). Some species of shrews are abundant around fallen, decayed trees where their arthropod prey live. These species are all prey of larger animals, such as northern spotted owls, illustrating the interdependence of components within forests in the Pacific Northwest.

Methods specific to mammals other than bats. Fifteen mammals other than bats were identified as closely associated with late-successional forests (sec appendix table IV-A-6). These included forest carnivores (fishers, American martens, lynx), rodents (several species of squirrels, mice, voles, and a woodrat), and insectivores (shrews and the shrew-mole).

There are some updates from the list of species of Thomas et al. (1993) and the Final Draft Recovery Plan for the Northern Spotted Owl (USD1 1992c). The vagrant shrew (*Sorex vagrans*) species complex (Jackson 1928) has been revised to include Baird's shrew (*S. bairdii*) and the fog shrew (*S. somonae*) as defined by Carraway (1990). Baird's shrew is closely related to *Sorex monticolus*, which is not associated with late-successional forests (Ruggiero et al. 1991); therefore, Baird's shrew was not included on the list of species. The Pacific shrew (*S. pacificus*) has been reclassified to exclude the fog shrew; therefore, the fog shrew, a new species, has been added to the list. Because field studies have not distinguished the habitat associations of fog and Pacific shrews, the two were rated as the Pacific/fog shrew complex. Two species of chipmunks were added to the list of species associated with late-successional forests: Allen's chipmunk (*Tamias senex*) and the Siskiyou chipmunk (*T. siskiyou*). But because there is currently no reliable information to separate habitat associations of *T. senex* and *T. siskiyou* from *T. townsendii*, the three species were rated as the Townsend's chipmunk complex.

The lynx was included on the list of species associated with late-successional forests in Thomas et al. (1993), but was dropped from our list. Therefore, we did not rate the species. While there is some indication that lynx use late-successional forests for denning, there are also indications that such habitat is not required.

Results. All seven options achieved an 80 percent or better likelihood of outcome A for all mammals except the red tree voles (*Phenacomys longicaudus* and *P. pomo*), American martens, and fishers (table IV-38; fig. IV-20). Nine species (deer mouse, dusky-footed woodrat, elk, forest deer mouse, northern flying squirrel, Senex chipmunk, Townsend's chipmunk, southern red-backed vole, Pacific shrew) were rated as having 90 percent or greater likelihood of achieving outcome A under all options. An additional three species (Douglas squirrel, shrew-mole, western red-backed vole) were rated as having 80 percent or greater likelihood for outcome A under all of the options.

Table IV-38. Projected future likelihoods of habitat outcomes for mammals under land management options.

	Option 1				Option 3				Option 4				Option 5				Option 7				Option 8				Option 9			
Mammals	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**
Deer mouse	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0
Douglas squirrel	98	2	0	0	97	3	0	0	97	3	0	0	93	7	0	0	83	15	2	0	88	12	0	0	88	12	0	0
Dusky-footed woodrat (Klamath Province)	98	2	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0
Elk	97	3	0	0	98	2	0	0	98	2	0	0	100	0	0	0	96	4	0	0	96	4	0	0	96	4	0	0
Fisher	85	15	0	0	82	18	0	0	73	27	0	0	70	30	0	0	67	33	0	0	63	37	0	0	63	37	0	0
Forest deer mouse	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0	100	0	0	0
Marten	83	17	0	0	73	23	3	0	77	23	0	0	67	27	7	0	57	33	7	3	67	30	3	0	67	27	3	3
Northern flying squirrel	100	0	0	0	100	0	0	0	100	0	0	0	98	2	0	0	90	10	0	0	90	10	0	0	93	7	0	0
Red tree vole (P.longicaudus)	98	2	0	0	95	5	0	0	95	5	0	0	82	18	0	0	58	33	8	0	60	35	5	0	73	25	2	0
Red tree vole (P.pomo)	100	0	0	0	95	5	0	0	93	8	0	0	88	13	0	0	68	30	3	0	75	25	0	0	78	23	0	0
Shrew-mole	100	0	0	0	100	0	0	0	100	0	0	0	96	4	0	0	84	16	0	0	96	4	0	0	98	2	0	0
Southern red-backed vole	100	0	0	0	98	2	0	0	100	0	0	0	98	2	0	0	96	4	0	0	98	2	0	0	98	2	0	0
Townsend's Chipmunk complex	100	0	0	0	100	0	0	0	100	0	0	0	98	2	0	0	97	3	0	0	97	3	0	0	98	2	0	0
Pacific/Fog shrew complex	100	0	0	0	100	0	0	0	100	0	0	0	98	2	0	0	92	8	0	0	96	4	0	0	96	4	0	0
Western red-backed vole	100	0	0	0	98	2	0	0	100	0	0	0	93	7	0	0	73	22	5	0	85	15	0	0	90	10	0	0

A-Well Distributed B-Locally Restricted C-Restricted to Refugia D-Extirpation

Likelihood values are expressed as percentages that total to 100 for a given species within an option. Number displayed may vary due to rounding errors.
See text for fuller explanation and discussion of the rating scale.

Both species of red tree voles were rated as having greater than 80 percent likelihood of achieving outcome A under Options 1, 3, 4, and 5 (table IV-38). Ratings were progressively lower for Options 9, 8, and 7 where the likelihood of outcome A was rated at 58-78.

American martens were rated for the entirety of their range within the range of the northern spotted owl. They were rated as having greater than 80 percent likelihood of achieving outcome A under Option 1; Options 3 and 4 were rated 73-77 percent for outcome A. Ratings for Options 5, 8, and 9 were lower with approximately 67 percent likelihood assigned to outcome A. Option 7 rated lowest, with less than 60 percent likelihood of achieving outcome A.

Ratings for the fisher were similar to those for martens. Fishers were rated as having greater than 80 percent likelihood of achieving outcome A for Options 1 and 3 (table IV-38). Ratings for Options 4 and 5 were greater than 70 percent for outcome A. For Options 7, 8, and 9 fishers rated less than 70 percent for achieving outcome A. Ratings for fisher reflected a general uncertainty about the future welfare of this species regardless of the option.

Discussion. The amount and distribution of habitat for all mammals except red tree voles, martens, and fishers was generally rated above 80 percent likelihood under all of the options. Options 1, 3, 4, and 5 were rated as providing sufficient and well distributed habitat for red tree voles with greater than 80 percent likelihood. Options 1 and 2 for the fisher and only Option 1 for the marten rated 80 percent or better likelihood of providing sufficient habitat, well distributed to provide for viable populations. All other options had greater than 20 percent likelihood of outcome B, distributed with gaps.

Red tree voles have limited dispersal capabilities, and connectivity of older forests may be important to metapopulation function, at least for *P. longicaudus*. Therefore, red tree voles were rated as having medium to high risk of extirpation by the Scientific Analysis Team (Thomas et al. 1993) under options comparable to those in this document. In contrast, Options 1, 3, 4, and 5 were rated at least 80 percent likelihood of providing habitat for adequate, stable, well-distributed populations of red tree voles. Watershed guidelines of the Scientific Analysis Team (Thomas et al. 1993) as applied in this effort will likely provide for connectivity of forest stands under most options except 7 and 8. In addition, all of the options will provide adequate Late-Successional Reserves for abundant and well-distributed populations of these species. New information on the habitat relationships of *P. pomo* indicates that it is equally common in young and late--seral stages in northwestern California (Meiselman 1992); therefore, it may not be as closely associated with late-successional forests as *P. Longicaudus*. However, *P. pomo* will be influenced by forest management on nonfederal lands because only a small proportion of its range occurs on federal lands. Recent information from radio-tagged *P. longicaudus* in Oregon indicates that individuals will travel across the forest floor at least as far as 1/4 mile (C. Meslow, 1993, personal communication, B. Biswell unpublished data). These new studies provide supporting evidence that habitat for red tree voles will be sufficient and well distributed under Options 1, 3, 4, and 5 but lower under Options 7, 8 and 9.

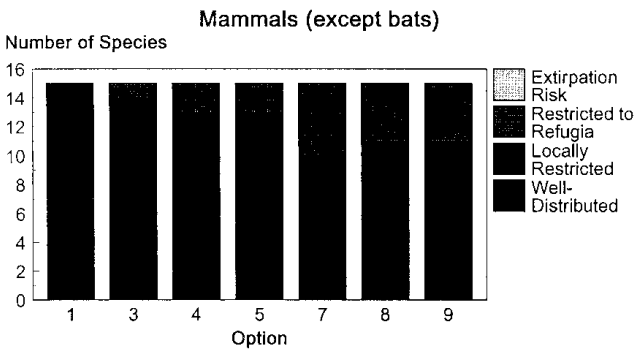


Figure IV-20. Outcomes for mammals, except bats, under each land management option. Values shown are the number of species that had an 80 percent or greater likelihood of achieving at least the specified outcome (based on distribution of habitat).

American martens occur at higher elevations than fishers, and their densities appear to be greatest in subalpine areas, which are higher in elevation than suitable spotted owl habitat. Populations of American marten are very low on the Olympic Peninsula and in the Oregon Coast Range; therefore, there is doubt that populations of martens will ever be well distributed throughout their range. Habitat of martens in this effort was rated as being sufficient and well distributed only under Option 1.

Riparian buffers provide potential habitat (including large snags and cover) for both fishers and American martens. Riparian areas are used for foraging and resting; martens select resting sites in large trees or in piles of woody debris in riparian areas (Jones and Raphael 1992). Large coarse woody debris and canopy cover are important for martens during winter because they have limited energy Reserves in winter and are not morphologically adapted to minimize heat loss (Buskirk et al. 1989). Winter habitat requirements include more than 30 percent overstory cover and subnivean (below snow) access to resting sites (Steventon and Major 1982; Buskirk 1984; Hargis and McCullough 1984; Corn and Raphael 1992). Martens have been found to rest more frequently and for longer periods where coarse woody debris formed all or part of the subnivean resting sites (Zielinski 1981; Spencer 1987). Structural features, including coarse woody debris (slash, stumps, or downfall), may also make subnivean prey more accessible to marten. Other resting sites for martens include cavities in large snags, hollow stumps, and under logs (Campbell 1979; Spencer 1987; Strickland and Douglas 1987a). Large old trees, snags, and large logs are important as den sites (Hauptman 1979; Simon 1980; Hargis and McCullough 1984; Wynne and Sherburne 1984) and provide young with protection from thermal stress and predators.

Fisher populations are small and localized throughout most of the Pacific Northwest. Fishers tend to be associated with riparian areas and continuous forest canopy but not necessarily old-growth forests. We do not know the extent to which forest management practices influence fisher populations, but some evidence indicates forest fragmentation may have negative effects (Rosenberg and Raphael 1986). The greatest concern for fishers is the past population declines and the apparent inability of populations to rebound from low levels. There is also speculation that poisoning programs for predators and porcupines plus indiscriminate trapping may have influenced their populations. Concern has also been expressed for their elusive and secretive nature and that human disturbance, including roads and logging, may impact populations.

Options 1 and 3 rated highest for fishers. The ratings reflect some uncertainty about the future of this species, due to the paucity of information on habitat relationships of the species in the Pacific Northwest and their low populations. Studies from the Rocky Mountains and Eastern North America indicate that fishers use a wider range of habitats than martens. Fishers appear to select ecotones and edges, transition areas between different types of habitat, and dense riparian forests with a conifer understory in Eastern North America (Kelly 1977; Leonard 1980; Raine 1983; Johnson 1984). Forested riparian areas are used as travel corridors during both summer and winter (Buck 1982; Mullis 1985; Jones 1991). Fishers may select mature conifer forest with high canopy cover in areas with deep snow where their movements may be restricted (Clem 1977; Leonard 1980; Raine 1983; Rosenberg and Raphael 1986; Raphael 1988). Resting sites in California were associated with snags and downed logs 200-250 inches diameter at breast height (Buck et al. 1983). Requirements for natal den sites appear to be more restrictive than for resting sites (Banci 1989). Natal den sites are found in cavities of live or dead hardwood trees in other areas (Grinnell et al. 1937; Hamilton and Cook 1955; Kelly 1977; Leonard 1980; Powell 1982; Mullis 1985; Arthur 1987; Banci 1989). Therefore, there seems to be an association with

components of late-successional forests (large snags for natal dens, coarse woody debris for foraging and resting) in the Pacific Northwest.

Mitigation for Mammals Other Than Bats

Following suggestions for mitigation in the Scientific Analysis Team (Thomas et al. 1993), we recommend closure of all federal lands to kill-trapping of martens (under all options) until incidental take of fishers is determined to be insignificant. The rate of incidental capture of fishers in the course of trapping other carnivores and effects of porcupine poisoning need to be evaluated. In addition, National Forests in California should finalize and implement their draft habitat capability model for fishers and American martens. National Forests in Oregon, 'Washington, and California should conduct more thorough surveys for both species. Retention of large snags and coarse woody debris in the forest matrix outside of Reserves could be important for both species. None of these measures however, are likely to significantly alter the ratings achieved for either martens or fishers.

Role of nonfederal lands. State and private lands should also be closed to kill-trapping of martens to avoid incidental take of fishers as stated above. Forest management on nonfederal lands in northwestern California and western Oregon could be important for both species of red tree voles.

Research and information needs. Most studies of fisher habitat associations and diet have been conducted in Eastern North America where fisher densities are higher than in the West (Powell 1982; Strickland and Douglas 1987b; Banci 1989). Few marten studies have been completed in the range of the northern spotted owl, Studies of habitat selection, home range size, and diet of both species need to be conducted in the Pacific Northwest. Habitat selection for denning sites, foraging areas, and prey need to be addressed. Studies are needed to determine effects of timber management practices on habitat use, home range sizes, and movement patterns of fishers and martens.

Monitoring efforts using track plates and remote cameras (to determine presence of forest carnivores) need to be standardized and expanded across forests in the Pacific Northwest. Regional monitoring needs to be developed and designed to detect changes in abundance over time, as recommended by the Interagency Lynx-Wolverine-Fisher Working Group (Weaver 1993). Surveys need to be conducted using an appropriate number of randomly selected sample units within biologically relevant strata, independent of timber sale or other management activity areas. These should be stratified by physiographic province, habitat, and elevation.

Little is known about the red tree vole. Studies are needed to better understand its basic ecology, including its habitat associations and dispersal capabilities. Further genetic research is needed to determine whether *P. pomo* and *P. longicaudus* are distinct species.

Bats

Bats are a diverse order of mammals. There may be more species of bats in some North American temperate forests than any other order of mammals (Cross 1976). All forest-dwelling bats in the Pacific Northwest are insectivores. Bats that concentrate their foraging in riparian areas and fly to upland forests to roost may serve as dispersers of nutrients (Perkins and Cross 1988). Because of their large population numbers, bats may play an important role in nutrient cycling within forests (Christy and West 1993). Bats also serve an important role as predators of forest pest species because of the vast quantities of insects they consume (Whitaker et al. 1977).

Results. Eleven species of bats were identified as being associated with late-successional forests, including seven species of *Myotis*, the big brown, pallid, silver-haired, and hoary bats (see appendix table IV-A-6).

Although consideration was given to Townsend's big-eared bat it was not included on the final list of 11 species. This species is not closely associated with late-successional forests for roosting, but the available data suggest they use forests and mature oak woodlands for foraging (Clark 1991; Brown et al. 1992; V. Dalton, 1993, personal communication; E. Pierson, unpublished data). Townsend's big-eared bat populations are probably declining primarily due to disturbance of roost sites in caves and mines. Most of the range of the coastal subspecies of Townsend's big-eared bat (*Plecotus townsendii townsendii*), a category 2 federal candidate, lies within the range of the northern spotted owl. The species was not added to the list for habitat assessment, but comments on appropriate management are included below.

The different options varied in their likelihoods of providing sufficient and well--distributed habitat on federal lands to ensure viability for bats. Options I and 3 were rated highest, and Options 7 and 8 rated lowest. All species rated more than 80 percent likelihood for outcome A under Options 1 and 3 (table IV-39, fig. IV-20). For Option 4, eight species rated more than 80 percent likelihood for outcome A (all except Keen's myotis, fringed myotis, and silver-haired bats, which rated 75, 77, and 78 percent, respectively). Under Option 5, four species rated more than 80 percent likelihood for outcome A, and seven species rated 65-73 percent (fringed myotis, Keen's myotis, long-eared myotis, long-legged myotis, pallid bat, silver-haired bat, and hoary bat). For Option 9, four species rated more than 80 percent for outcome A, two species rated 60-70 percent (long-eared myotis, and pallid bat), and five species rated 45-55 percent (fringed myotis, Keen's myotis, long-legged myotis, silver-haired bat, and hoary bat). No species rated more than 80 percent for outcome A under Options 7 or 8, and seven species rated less than 60 percent under each of these options.

Table IV-39. Projected future likelihoods of habitat outcomes for bats under land management options.

	Option 1				Option 3				Option 4				Option 5				Option 7				Option 8				Option 9			
Bats	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**
Big brown bat	100	0	0	0	95	5	0	0	93	8	0	0	93	8	0	0	72	25	3	0	68	30	3	0	83	18	0	0
California myotis	100	0	0	0	100	0	0	0	95	5	0	0	95	5	0	0	75	25	0	0	74	26	0	0	85	15	0	0
Fringed myotis	97	3	0	0	87	13	0	0	77	23	0	0	70	30	0	0	33	57	10	0	33	53	10	3	47	47	5	2
Hoary bat	98	3	0	0	91	9	0	0	83	18	0	0	68	33	0	0	45	50	5	0	40	53	8	0	53	48	0	0
Keen's myotis	100	0	0	0	95	5	0	0	75	25	0	0	65	35	0	0	45	45	5	5	35	50	10	5	50	40	5	5
Little brown myotis	100	0	0	0	96	4	0	0	91	9	0	0	90	10	0	0	73	28	0	0	70	28	3	0	84	16	0	0
Long-eared myotis	98	3	0	0	93	8	0	0	80	20	0	0	68	33	0	0	50	45	5	0	48	48	5	0	64	35	1	0
Long-legged myotis	100	0	0	0	90	10	0	0	83	18	0	0	69	31	0	0	45	48	8	0	41	51	8	0	55	45	0	0
Pallid bat	100	0	0	0	96	4	0	0	85	15	0	0	73	25	3	0	48	41	9	2	45	44	10	2	63	35	3	0
Silver-haired bat	98	3	0	0	91	9	0	0	78	23	0	0	68	33	0	0	45	50	5	0	40	53	8	0	53	48	0	0
Yuma myotis	100	0	0	0	95	5	0	0	90	10	0	0	89	11	0	0	70	29	1	0	73	28	0	0	83	18	0	0

A-Well Distributed B-Locally Restricted C-Restricted to Refugia D-Extirpation

Likelihood values are expressed as percentages that total to 100 for a given species within an option. Number displayed may vary due to rounding errors.
See text for fuller explanation and discussion of the rating scale.

Large acreages of Late-Successional Reserves well distributed across the landscape were considered critical for bats because of the importance of large green trees and snags for roosting sites. Option 8 was consistently rated lower because it allowed salvage without special guidelines and harvest of stands up to 180 years old inside Late-Successional Reserves. There was concern that Options 7 and 8 would possibly result in disjunct bat populations due to smaller amounts of acreage in Reserves at low elevations.

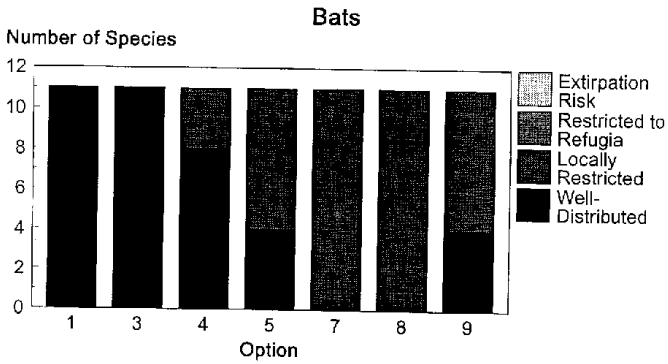


Figure IV-21. Outcomes for bats under each land management option. Values shown are the number of species that had an 80 percent or greater likelihood of achieving at least the specified outcome (based on distribution of habitat).

Proposed management for the forest Matrix was also a critical factor in the ratings, primarily due to density of snags. Option 3, which contained standards and guidelines developed by the Forest Ecosystem Management Assessment Team, was rated higher than options containing only the 50-11-40 rule with lower snag, log, and green tree retention standards. Leaving 10 percent of harvest areas in green tree islands, enough snags for 40 percent of the potential primary excavators, and all decay class 3-5 logs, as under Option 3, will provide better habitat conditions for bats in the forest Matrix. Options 7, 8, and 9 that did not contain the 50-11-40 rule were rated lower than the other options.

Options containing the Scientific Analysis Team (Thomas et al. 1993) watershed guidelines, protecting intermittent streams, Key Watersheds, and small lakes and ponds (less than 1 acre) with a full tree height were consistently rated higher than options containing watershed guidelines that protect permanent streams equally but protect intermittent streams with one-half (or less) a site potential tree height.

Keen's myotis was rated lower than other species because it has a geographic range largely restricted to low elevation, nonfederal lands on the Olympic Peninsula of Washington. It may rely entirely on forest roost sites (Thomas and West 1991), and forested habitat within its range has declined substantially due to urbanization around Puget Sound.

Fringed myotis was also rated lower than other species (except for Keen's myotis). Panelists thought this species was more vulnerable than other species because it is rare, occurs in a restricted elevation zone, and has strong site fidelity. For these reasons, fringed myotis populations may be more likely to become isolated when forests are fragmented. The silver-haired bat generally rated lower than most species due to its dependence on snags and trees for roost sites, most importantly maternity sites. Silver-haired and hoary bats are considered to be obligate tree roosters; all other species are facultative tree roosters that will also roost in other structures (e.g., rock crevices, buildings, caves, abandoned mines, under bridges).

Discussion. Large snags and large green trees are important because bats use them for maternity roosts, day roosts, temporary night roosts, and hibernacula (Barbour and Davis 1969; Kunz 1982; Rainey et al. 1992). Bats in the Pacific Northwest seem to prefer old forests, presumably due to more potential roost sites under bark, in crevices, or in hollows of large, old trees (Perkins and Cross 1988; Thomas and West 1991). Suitable roost sites require access to water (for drinking and foraging), protection from predators, and favorable temperature and moisture regimes (Christy and West 1993). Temperature regimes are important to bats (van Zyll de Jong 1985; Fenton and Barclay 1980), and thermal stability may be influenced by structural characteristics within large snags or trees. According to Christy and West (1993:12), "Structural characteristics of old, live trees, such as cracks and crevices in thick bark, bark pulling away from the trunk which forms crevices, and holes in the bole where limbs have been shed, offer potential roosting sites. Snags with cracks, peeling bark, bird holes, and hollow interiors provide ideal sites for maternity colonies that Myotis bats commonly form."

The hoary bat is the only foliage-roosting bat (Constantine 1966; Barclay 1985) on the list of species associated with late-successional forests. Hoary bats are not very maneuverable during flight and need tall trees with foliage high from the ground so they can drop to gain momentum for flight (Perkins and Cross 1988).

Large snags and large green trees should be well distributed throughout the Matrix to maximize benefits to bats. Density of snags outside of Late-Successional Reserves is critical for bats for several reasons: (1) an individual bat colony may use several roosts during a season as temperature and other weather conditions change; (2) migrating bats may roost under bark in small groups (Barclay 1984); (3) bats are competing for snags with other species that use cavities; and (4) in addition to day roost sites, bats use short-term night roosts. Bats commonly forage for a short time and then rest in a night roost while eating or digesting prey. Night roasts are generally at sites different from day roasts and are often used by several species.

Numbers of snags or green trees per acre that would be optimal for bats is unclear, but in southern Oregon captures of both the big brown and silver-haired bats were most frequent in areas of high snag density and forest cover (Cross 1976). Acoustic detections of bats were significantly higher in old-growth stands than in younger stands (Thomas and West 1991). Roost site availability may play a major role in determining population sizes and distributions (Kunz 1982).

Large logs with loose bark may also be used by Yuma myotis and little brown bats for roasting. However, bats generally seek height for roasting, where predation risks may be lower and ambient temperatures higher. Therefore, snags are likely to be more important than logs.

Bats use riparian areas for foraging and less frequently for roasting. Thomas and West (1991) found that feeding rates (as measured by acoustic detectors) are significantly higher over water than within forest stands in the Pacific Northwest. Many species of bats forage over streams and in adjacent riparian habitat (Barbour and Davis 1969; Fenton and Barclay 1980; Kunz 1982; Barclay 1986; Manning and Jones 1989; Brigham 1991; Brigham et al. 1992). They use drainages as travel corridors to reach foraging sites, and some species feed in drainages of small, intermittent streams (e.g., long-legged myotis). Wide and diverse riparian zones accommodate the differing foraging habits of different species that feed over water, in marginal thickets, on flood plains, and in adjacent timber stands. The pallid bat has been radio-tracked foraging along stream drainages and in a broad riparian zone up to 1550 feet from water (Brown 1982; Pierson and Rainey 1992, unpublished data). Long-eared myotis has been netted over streams and in mature oak woodlands 1550 feet upslope from rivers in northern California (E. Pierson, 1993, personal communication). The distribution of breeding populations of many bat species is limited by elevation and proximity to water. Greater diversity and abundances are found at low to mid-elevations in association with larger river drainages. Many species also forage in forests, often over clearings and along edges, and when gleaning insects, some species may feed within or above the canopy (Black 1974; Whitaker et al. 1977; Kunz and Martin 1982; Barclay 1985; Christy and West 1993). Bat species such as long-eared myotis that feed by gleaning arthropods from foliage may be especially susceptible to pesticide spraying.

Distances bats travel between roasting and foraging sites vary among species, from less than 0.6 mile up to 25 miles (Barclay 1984). Ambient temperature and other microhabitat parameters (e.g., size of crevice or cavity) undoubtedly influence roost selection, and insect availability presumably governs choice of foraging areas. Roasting and foraging areas may be geographically separate. Little brown myotis have been observed foraging 1.3-3.1 miles from day roasts (Thomas and West 1991), and big brown bats are known to travel up to 2.5 miles to forage (Brigham and Fenton 1986). Distances bats travel and foraging microhabitat may vary with bat age, reproductive condition, and local species diversity (Barclay 1984; Adams 1990; Brigham et al. 1992; Kalcounis 1992). Tree corridors may be important for bats traveling between roosting and foraging areas (Tuttle 1979).

Biologists suspect that bat populations have been declining, but few data exist to document such a trend. Population declines that have been documented worldwide are attributed to loss of habitat and disturbance of maternity colonies and hibernacula (Mohr 1948; Edgerton et al.1966; Cockrum 1969; Tuttle 1979; McCracken 1988).

Mitigation for Bats

Species that use caves and mines for breeding, maternity sites, or hibernacula are vulnerable to human disturbance. Under all options, bat colonies in caves and abandoned mines need to be identified and protected. Logging should be regulated near caves and abandoned mines that are used by bats. The Federal Cave Resources Protection Act of 1988 requires that cave systems be inventoried and considered in forest planning on federal lands. Sediment and debris from logging and road construction can clog portions of cave systems; decomposition of organic material can cause large accumulations of carbon dioxide; and logging residues may cause siltation and deplete oxygen concentrations in water flowing through these systems (Stringer et al. 1991). Clearing vegetation near cave entrances may reduce concealment and increase vulnerability to both human disturbance and predation en route to foraging areas. At least one species, the gray bat (*Myotis grisescens*) on the East Coast, appears to limit its foraging activities to forested areas near caves during cold weather (Tuttle 1979). Road construction near cave and mine roosts can introduce recreational activities and lead to permanent abandonment of roosts. For instance, recreational caving in the Mother Lode area of California has led to the disappearance of most historically known roosts and an 82 percent decline in mean colony size for the few known remaining colonies of Townsend's big-eared bat (Pierson and Rainey 1992). When bats are disturbed while hibernating in caves, they may come out of torpor, causing them to loose weight and decreasing their chances of survival (Davis and Hitchcock 1965).

Examples of buffer widths around caves are 450 feet on the Deschutes National Forest and 0.25 mile on the Daniel Boone National Forest. No timber management should occur within these buffer zones, and road access should be closed. Site-specific analyses should be done to determine species using the structure, approximate size of the colony, and whether it is a hibernaculum, maternity, or bachelor colony. An example of process and priorities for site protection is described by Tuttle (1979) and Tuttle and Stevenson (1978). Cave entrances should be gated in such a way that air flow patterns are maintained (Tuttle 1977), people are excluded, and bats can freely enter and exit. If these mitigation measures were implemented and enforced, assessments for the group of bats that roost in both trees and other structures could be improved.

Bat boxes (artificial roost sites) may be of some value in mitigating for loss of tree roosting sites. However, use of such structures by the species of greatest concern has not been clearly demonstrated. Employment of bat boxes should only be considered as a short-term measure to be used during the rejuvenation of natural sites associated with old living trees and snags.

Role of nonfederal lands. Keen's myotis is found exclusively in the Pacific Northwest and occupies a restricted range within western Washington, western British Columbia, and southeastern Alaska. In Washington, it is found primarily on nonfederal lands. This species most likely has a strong association with late-successional forests; it was included in the group of Myotis species that were judged to he associated with old-growth forests by Thomas and West (1991). Forested habitat within the range of this species has declined substantially due to urbanization in lowland areas around Puget Sound.

The northern California coast has few federal lands and state parks. Bat diversity and numbers are higher on the California coast than the Oregon coast (Maser et al. 1981), and bat populations here are of concern.

Mature oak woodlands are important for hats in California near the southern end of the northern spotted owl's range, especially for pallid bats. The pallid bat is often found in agricultural areas (e.g., on the margins of the Central Valley) and in open oak woodlands (e.g., in Mann County), but has shown marked declines in areas where there has been a loss of oak woodlands. Presence of mature oak woodlands seems to he important to maintaining pallid hat viability, and private lands play a key role.

Research and information needs. Mitigating for effects of timber management activities on bats is difficult due to a lack of knowledge about the basic ecology of bats. Recent advances in miniaturization of radiotelemetry equipment create the potential to examine roosting and foraging habitat associations. Automated ultrasonic detectors may be useful to assess bat activity in relation to the varied forest stand and age characteristics created by logging.

Surveys to document distribution and estimate population sizes need to be continued and expanded (Cross 1976; Maser and Cross 1981; Perkins 1983). Studies to estimate species composition and relative abundances of bats in different habitats need to be done. General surveys to locate caves, mines, and buildings that are used as roosts or hibernacula are sorely needed. Keen's myotis should be given high priority because it is so poorly known and occupies a restricted range (Thomas and West 1991).

Characteristics of roosts and patterns of use by bats need to be determined. Studies are needed to assess the importance of roost microclimate and structure of snags/trees in relation to seasonal use of roost sites and roost fidelity. Habitat preferences for maternity roosts should be given highest priority.

Research is needed on patterns of habitat use, diet, intraspecific and interspecific variation in foraging patterns, and effects of age, sex, and season on foraging behavior. The role of bats as predators on forest pests such as bark beetles and other insects needs study.

Short Term Habitat Trends -- The Transition Period

Because some spotted owls occur outside Late-Successional Reserves and use forests younger than 80 years old, at least some of their habitat inevitably will be harvested no matter which option is chosen. Thus, habitat for spotted owls will likely continue to decline in the near future. Over the long term, most of the options will eventually produce substantially more suitable habitat for northern spotted owls and marbled murrelets than currently exists, and that habitat will be in larger blocks than at present. The current landscape is characterized by highly fragmented blocks of late-successional forest interspersed with young, managed stands that are mostly less than 50 years of age. These young, managed stands will require considerable time to develop into suitable nesting habitat for marbled murrelets.

The period of recovery to a new stable equilibrium has been termed the "transition period." For all options assessed by the Forest Ecosystem Management Assessment Team, the discrepancy between the existing conditions and the projected equilibrium conditions in Reserves is most pronounced during the first 50 years after implementation (see previous section in this chapter, Amounts of Late Successional and Old-growth Forest; fig. IV-2).

One concern that has been expressed regarding the spotted owl and marbled murrelet is that existing levels of fragmentation within Late-Successional/Old-Growth Reserves, together with high rates of habitat loss in the Matrix, could result in such rapid population declines during the transition period that populations will not be able to stabilize at a new equilibrium level once habitat within the Reserves is regenerated. For the northern spotted owl and marbled murrelet the critical transition period will likely occur during the first 50-150 years after a management plan is implemented (Thomas et al. 1990; McKelvey 1992; McKelvey et al. 1993). After that time, most cutover areas within Reserves will have assumed old-forest characteristics, and levels of fragmentation will have been greatly reduced.

Of the seven options for which we did full assessments, Options 1, 3, 4, 5, and 9 included more protection of Riparian Reserves and Late-Successional/Old-Growth Reserves than in previous plans proposed for the northern spotted owl (Thomas et al. 1990). These additional levels of protection should provide additional habitat for spotted owls, reducing the magnitude of any demographic or habitat "bottleneck" that might occur during the transition period.

Spotted Owl Population Status and Trends

Although most biologists seem to agree that spotted owl populations are declining, exact rates of decline are unclear. An analysis by Anderson and Burnham (1992) indicated that populations of adult female northern spotted owls on five study areas in Washington, Oregon, and California were declining at an average rate of 7.5 percent per year. The analysis also suggested that female survival rates were declining over time. The declining female survival rate was considered alarming because it could indicate a population that had passed some demographic threshold and was on an accelerating trajectory toward extinction (Harrison 1992; Karieva 1992; Orions 1992). This interpretation was challenged by Thomas et al. (1993), who argued that such a conclusion should not be drawn from data collected during a period of transition from one habitat level to another. Thomas et al. (1993) suggested that it was highly unlikely that the owl population had declined below any demographic threshold, except possibly in some isolated and heavily cutover areas such as southwestern Washington. Dr. David Anderson (personal communication, 1993) challenged this conclusion, and the issue appears unresolved.

Options 1, 2, 3, 4, 5, 6, and 9 were all rated as having an 80 percent or greater likelihood of providing sufficient habitat for a well-distributed population of northern spotted owls on federal lands over the next 100 years. An obvious question is how any option could have been rated this optimistically when the existing demographic information was taken into consideration. Our rationale was two-fold. First, we question whether rates of population decline are as steep as is indicated by Anderson and Burnham (1992). The banding data that were analyzed by Anderson and Burnham are potentially subject to a number of biases. Our main concern is that emigration of adult and juvenile females may be causing female survival rates to be underestimated, which would result in an underestimate of the population growth rate. Second, it is questionable whether demographic rates estimated during a period of declining habitat can or should be used to evaluate whether a population will eventually stabilize at some new equilibrium (Thomas et al. 1990, 1993).

Because of the above concerns regarding the interpretation of current demographic data, we believe that evaluation of efficacy of a particular option must be based largely on theoretical grounds relative to (1) the known size and distribution of existing populations (Thomas et al. 1990, USD1 1992c, Thomas et al. 1993), (2) the expected size and distribution of the future population under the proposed management scheme, and (3) the amount and distribution of habitat expected to be present during the transition period, including habitats other than old growth (e.g., table IV-11; figure IV-2). These factors were the basis for our evaluation of habitat sufficiency.

While there is concern about the transition period, that concern is partially alleviated by the fact that the current owl population is still relatively large, despite 100 years of timber harvest within the range of the owl. We conclude that, as long as an extensive network of late-successional forests is protected, there will be little risk that the spotted owl population will drop below a viable level during the transition period. We readily admit that this conclusion cannot be proven. It is professional opinion, based upon our review of the evidence.

Several other recent efforts to develop management guidelines for northern spotted owls have been criticized because they lacked formal, quantitative risk assessments. These included the report of Thomas et al. (1990) and the adoption of that report by the Forest Service (USDA 1992). These challenges assert that, without a formal risk analysis, there is no demonstration that the management plans will provide for conservation or recovery of the species. These challenges deserve attention. A formal, quantitative risk assessment would help to determine whether the options presented here would ultimately be successful.

Despite the potential value of a risk assessment, it is unlikely that a truly compelling assessment could be produced any time in the near future, if ever. A valid, quantitative assessment would require complete knowledge about owl responses to a full spectrum of habitat and landscape conditions. Some of these conditions are not currently observable within the owl's range, so their study is not possible. A risk assessment would also require full knowledge of owl population responses to dynamic landscapes. Complete knowledge in this area is years or decades away. Full understanding of habitat trends, including responses to management and projections of catastrophic events, would also be required.

Even with all this information, there would still be substantial challenges in the development of a reliable risk assessment. All of this information would have to be synthesized, most likely by bringing it together in a modeling framework. Assumptions in the model, and the overall model structure, would require validation. These requirements make the development of a robust model, and a truly quantitative risk analysis, problematic. However, models can still be useful. They can contribute to the understanding of implications of a variety of assumptions, and they can help generate new research hypotheses. They also can help us simulate the possible responses of owls to the dynamics of future landscapes. The results of modeling efforts could make a substantial contribution to risk assessments, even if the final assessment is ultimately dependent on professional judgment.

We recommend that a variety of modeling efforts continue, and that their results, in conjunction with other research and monitoring efforts, be considered in ongoing assessments of risk. Modeling and risk assessment must play a key role in adaptive management. Modeling efforts that should continue include further assessments of the demographic data and its analysis; further work on models that simulate owl population dynamics in response to landscape dynamics; and efforts to improve the ability to project future habitat conditions in managed and unmanaged situations.

While risk assessments will continue to rely on professional judgments into the foreseeable future, results of modeling efforts will help to improve those professional judgments.

Marbled Murrelet Population Status

Based on current estimates of population sizes for Washington, Oregon, and California, the three-state area has considerably lower numbers of murrelets than other areas within the species' range (e.g., British Columbia and Alaska). During the last century, there has been a substantial reduction of old-growth forests within the range of the marbled murrelet, especially at lower elevations in the coastal lowlands of Washington, Oregon, and California. Anecdotal evidence of concurrent declines in the murrelet population in some areas includes relatively low numbers of marbled murrelet counted in recent years, compared to historical reports which referred to marbled murrelets as common, or even abundant. Because historical information was extremely qualitative, however, exact rates of decline in the murrelet population are unknown. At-sea surveys of marbled murrelets are continuing in Washington, Oregon, and California to obtain better estimates of population size, distribution, and productivity.

The low estimates of population numbers and juvenile recruitment, and the likely time before current habitat conditions for the marbled murrelet improve, emphasize the concern for the species over the next 50-150 years. A number of factors (e.g., nesting habitat, marine environments, mortality associated with net fisheries and contaminants, prey population conditions) must be factored into any assessment of population status. In 1992, the Forest Service initiated a conservation assessment of the marbled murrelet throughout its range; the process is ongoing. The Marbled Murrelet Recovery Team is also working with the conservation assessment group to help determine the population status and recovery objectives for marbled murrelets in Washington, Oregon, and California.

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Summary and Conclusions

The options assessed in this report were all designed to respond to immediate biological problems exemplified by declining late-successional habitats and species, while rebuilding resilient late-successional ecosystems over the long term. The need for these actions has developed over many decades as a result of forest harvesting and road building. These activities have reduced the amount of late-successional forest historically present on federal lands by about one-half. Late-successional forests have been nearly eliminated on many nonfederal lands.

Our assessments underscore the complexity of Pacific Northwest forest ecosystems and the difficulty of developing a comprehensive management strategy for them. The changes in management proposed in all of the options are dramatic. These changes appear necessary if we are to maintain species and processes associated with late-
successional forests.

The options developed for this report share common components of an ecosystem strategy. Assessments in this chapter have aided our understanding of how those components may function, both from a species perspective and an ecosystem perspective.

Essential Components of an Ecosystem Strategy

The 10 management options are based on principles of conservation that have become broadly accepted. The primary components of these options are large Late-

Successional Reserves, management guidelines for forests within the intervening Matrix, and riparian protection provided by buffers or Reserves along both permanent and intermittent bodies of water.

The Late-Successional Reserve systems in the different options vary in the size of individual reserves, distribution of the Reserves across the landscape, total acreage included in reserves, and the management proposed for forests inside reserves. Management of forests in the Matrix also varies among options, including different prescriptions for retention of green trees, logs, and snags in individual harvest units; and various landscape level controls such as the 50-11-40 rule. Riparian protection varies among options with the size of Reserves proposed (i.e., buffer widths), and the stream classes or wetlands that will be protected.

None of these components, taken individually, constitutes an adequate conservation strategy. Each of them has important influences on species and ecosystem responses. Through the expert panel process we attempted to evaluate responses by a broad range of organisms to components of different conservation strategies for late-successional forest ecosystems.

Response of Species to Components

Reserves

A system of Late-Successional Reserves was the central feature of all options considered. The extent of the reserve system, i.e., its total acreage, was the single most distinguishing feature across the array of options. Species across all taxa responded positively to increasing total area within Reserves (fig. 11-7).

The appropriate size for individual Reserves is a function of several considerations. First, the reserve size must reach a threshold that maintains the integrity of the reserve itself; blocks as small as 50-80 acres begin to offer some significant area with interior forest conditions. Second, the reserve must be adequate to support the requisite numbers of individuals of the desired species or community of organisms. All options included Reserves designed to accommodate about 20 pairs of northern spotted owls (30,000 to 100,000 acres). Because of the large home range of spotted owls these Reserves are believed to be adequate to accommodate self-sustaining populations of many other organisms; exceptions are the large, mobile predators, migratory species, and rare, local endemic species which may not occur in the large reserves.

Reserve distribution must reflect the dispersal abilities of the orgax~iism the system is designed to accommodate. Organisms with limited dispersal capabilities require relatively close spacing of patches of suitable habitat. The spacing of 6-12 miles between Reserves in the options considered was designed to accommodate dispersal capabilities of juvenile northern spotted owls. Scattered smaller Reserves of late-successional forest within the Matrix facilitate dispersal and enhance distribution of organisms with more restricted dispersal capabilities and smaller home ranges.

The placement of Reserves was often dictated by the occurrence of late-successional forests. In the future, Reserve locations may migrate across the landscape as conditions evolve, to provide a more effective distribution. In all options, Reserves were designed to include representative late-successional ecosystems from a broad range of elevational and geographical

distributions. However, because a large proportion of lands at low elevation is privately owned, late-successional forests at low elevation are not as well represented within any of the options as those at higher elevations.

An important lesson learned through the expert panels was to attempt to incorporate locations of locally endemic species within Reserves planned for other species or objectives. This effort will require special attention to surveys for a wide variety of organisms which are often cryptic, poorly understood, and otherwise difficult to locate. It seems appropriate to begin such surveys during watershed analysis.

Connectivity among components of the late-successional forest ecosystem may be provided by a system of corridors or by a Matrix which is permeable, if not entirely hospitable, to late-successional forest organisms. The Riparian Reserves included in all options link the Late-Successional Reserves via riparian corridors to various degrees. Corridors are especially important for late-successional forest habitat specialists that have limited mobility Or dispersal capabilities (e.g., fungi, plants, flightless insects, amphibians, mollusks). The demand for continuous connectivity provided by an actual corridor declines as the mobility of the organisms increase. For example, many birds can easily fly over short distances of inhospitable habitat that might pose a challenge to many amphibians or small mammals, and be.a virtual barrier to mollusks or flightless insects.

Management intervention within Reserves may hasten restoration of late-successional conditions where disturbance has set back succession. Active management seems most appropriate where past human activity has created conditions that jeopardize old forest conditions within reserves. For instance, fire

suppression for the last several decades has led to conditions in the Eastern Washington and Oregon Cascades Provinces where the threat of landscape scale alterations caused by insects and fire is imminent. Management intervention to reduce such risk seems warranted. Likewise, it may be appropriate to treat plantations that are now within reserves, to enhance their development toward late-successional forest conditions. All management activities that involve the removal of wood from Late-Successional Reserves should truly advance the objectives of the reserve, and provide for the retention of components of the previous stand as a legacy for the future stand. Road construction and soil compaction should be minimized during any management activity.

Matrix

The Matrix should not be treated solely as a wood fiber production area. While timber is an important product of the Matrix, many other values must ~e accommodated to maintain forest function and health.

Dispersal of organisms among Reserves and patches within the Matrix is essential to the maintenance of a functional ecosystem. In addition to, or in place of actual connecting links of late-successional forest, dispersal can be facilitated by a Matrix that provides conditions at least adequate for organisms to survive while moving between reserves. The 50-1 1-40 rule, which was designed specifically to accommodate dispersal of the spotted ow[1], is an example of how the Matrix can be managed to facilitate dispersal by providing a juxtaposition of stands of various ages.

Retention of small patches of late-successional forest in the Matrix, as well as green trees, snags, and logs, provides a diverse mosaic of stand conditions and

habitat for dispersing organisms. The least mobile organisms should dictate the spatial scale of these elements. For sedentary species, greater numbers of patches, spaced closely together, will provide better dispersal habitat. Retention.of about 15 percent of late-successional cover within cutting units, as small patches and green trees, seems to be a reasonable objective.

Although an important function of the Matrix is to provide for dispersal of organisms, perhaps of greater importance is the maintenance of organisms with key functional roles in the forest ecosystem. Taxa such as fungi, nitrogen-fixing organisms, and arthropods influence natural succession, nutrient cycling, and other ecosystem processes. Maintenance of populations of these organisms in the Matrix is essential to long-term forest productivity, as well as biodiversity.

Old forest patches as small as only a few acres can also provide important refugia for sedentary organisms which can tolerate less than interior forest conditions. Lichens, fungi, bryophytes, mollusks, arthropods, vascular plants, and the less mobile vertebrates were consistently identified during the expert panel process as benefitting from even small fragments of old forest. Panelists consistently reiterated the important functional roles played by these organisms. Panelists highlighted the necessity of maintaining these organisms well-distributed throughout the ecosystem, not just confined to reserves. Patches of green trees of varioussi zes, ages, and species will promote species diversity of fungi, lichens, plants, and arthropods. Single trees provide a less protected microclimate than trees in small patches. Many of these organisms require moist, cool microclimates and do not tolerate exposed conditions. Maintaining well-distributed, functional groups of non-vertebrate taxa is an

especially important challenge faced by ecosystem managers. The options that maintained patches of old forest distributed throughout the landscape (Options 1, 3, and 9) consistently received positive evaluation or comment by the expert panelists.

Landscape controls, such as the 50-11-40 rule, serve to regulate human disturbance of the landscape to establish desired patterns. Many landscape controls are initiated to preserve scenic values. Others are regulatory in nature and directed at establishing specific spatial configurations of stands of various ages. Landscape guidelines could be effectively employed to mimic the pattern of natural succession within a watershed. The edge-to- area ratios within a watershed, for instance, can be manipulated to achieve desired interior forest area, thus favoring late-successional and interior forest species. Longer rotations for some stands within the Matrix would contribute to habitat diversity and provide for organisms which enter stands later in succession. These stands would also provide for a renewable source of structural components and biological legacies.

Riparian Reserves

Riparian Reserves, especially those that provide buffers equal to a site potential tree height on intermittent streams, provide ribbons of connectivity across landscapes. Just as importantly, for the many non-riparian organisms, they serve as additional acreage of Late-Successional Reserves. In fact, where stream density is high, as in the Oregon Coast Range, Riparian Reserves can probably effectively replace the 50-11-40 rule as a landscape control prescription for the northern spotted owl. Most vertebrates regularly use riparian zones for at least part of their activities;

thus Riparian Reserves will also provide habitat for vertebrates associated with late-successional forests. Riparian Reserves will also protect wet micro-sites, seeps, and springs, that are important for maintaining aquatic associated arthropods, mollusks, bryophytes, vascular plants, and amphibians. Options 1 and 4, which have the largest riparian buffers, were consistently rated as most favorable for many of the species in these groups.

Role of Nonfederal Lands

The assessment presented in this chapter has focused on the management of federal forests. However, virtually all species inhabiting late-successional federal forests have significant portions of their range on non-federal lands. This can be illustrated by data on mammal, bird, and amphibian species ranges within the range of the owl (see Appendix IV-C). For many of these species, more than half of their range is on nonfederal land. Nonfederal land also assumes significance because it generally occurs at lower elevations and in different ecological zones than much of the federal land.

For nearly all the species groups discussed in this report, nonfederal lands can have potentially important roles. In some cases, these lands may be crucial to species conservation. The role of nonfederal lands in riparian conservation and in the recovery of threatened and endangered species should be priorities.

Summary of Mitigation Measures Having Broad Benefits

During the assessments of viability for the various taxa, a number of general mitigation measures were identified that would provide for a broad range of late-

successional species, processes and functions. These general mitigating measures were:

(1) Retain adequate levels of large down logs for arthropods, fungi, bryophytes, amphibians, and small mammals within the Matrix. A full spectrum of tree species and sizes should be retained to promote a diversity of these species, including those that are host or substrate specific.

(2) Retain enough large snags to support up to 100 percent of potential populations of species that use cavities within the Matrix (birds and mammals). These snags should be well distributed across the landscape.

(3) Provide for sustained recruitment of large down logs and snags within the Matrix. fhis can best be accomplished by retaining some green trees through multiple rotations to allow them to grow to large size. These trees should be retained singly and in patches.

(4) Retain small patches of late-successional or old-growth forest within the Matrix. These small patches can provide important habitat for arthropods, fungi, lichens, bryophytes, vascular plants, mollusks, small mammals, amphibians, and bats. Species that are poor dispersers, narrow in their habitat requirements, have restricted geographic ranges and are sensitive to variation in microclimates will benefit most from retention of these patches of late-successional forest.

(5) Provide riparian buffers with widths equal to at least a site potential tree for streams occupied by amphibians and cavity-nesting waterfowl, and those used by bat populations of concern.

(6) Survey upland sites for rare, endemic or sensitive organisms prior to any disturbance caused by

management. Protect sites where these organisms occur (e.g., special habitats such as serpentine barrens, wetlands, rock outcrops).

(7) Include terrestrial species in the watershed analysis for Riparian Reserves. Provide full riparian buffers where rare, endemic or sensitive species are found.

Ecosystem management

In our view, the objective of an ecosystem management plan for late-successional forests should be to maintain the full range of biological diversity, process and function that is typical of these forests. We acknowledge that our concept of ecosystem management is only partially developed, and that we have much to learn about managing ecosystems. For example, it is not clear how well the strategy of Reserves will provide for late- successional ecosystem attributes in the long-term, under a changing climate, altered disturbance regime, and increasing human populations. The role of active management in producing and maintaining late-successional ecosystems is controversial and we need to proceed cautiously. Adaptive Management Areas may provide valuable information, allowing us to modify the selected eéosystem strategy in the future to maintain late- successional values as well as provide higher levels of ecosystem production for humans. Although we are only beginning to conduct ecosystem management, we believe that options 1, 3, 4, 5, and 9 better provide for important late-successional ecosystem functions and processes than do options 7 and 8.

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Appendix A

Appendix Table IV-A-1. Fungi closely associated with late-successional or old-growth forests within the range of the northern spotted owl. An asterisk (*) denotes species that are endemic to the Pacific Northwest.

MYCORRHIZAL

Boletes (13 species)

Boletus chrysenteron
* *Boletus coniferarum*
Boletus edulis
* *Boletus mirabilis*
Boletus rubripes
* *Boletus smithii*
Boletus subtomentosus
Boletus truncatus
* *Boletus zelleri*
* *Gastroboletus subalpinus*
Gastroboletus turbinatus
Phylloporus rhodoxanthus
* *Suillus punctatipes*

Boletes, low elevation (2 species)

Boletus piperatus
* *Tylopilus pseudoscaber*

False Truffles (continued)

Thaxterogaster pingue

Uncommon False Truffles (4 species)

* *Macowanites chlorinosmus*
* *Martellia maculata*
* *Martellia variabilispora*
* *Rhizopogon exiguus*

Rare False Truffles (23 species)

* *Alpova alexsmithii*
Alpova olivaceotinctus
Arcangeliella crassa
* *Arcangeliella lactarioides*
Chamonixia caespitosa
* *Destuntizia fusca*
* *Destuntzia rubra*
Gautieria magnicellaris

* *Suillus punctatipes*

Boletes, low elevation (2 species)

Boletus piperatus
* *Tylopilus pseudoscaber*

Rare Boletes (3 species)

* *Boletus haematinus*
* *Boletus pulcherrimus*
* *Gastroboletus ruber*

Rare Bolete/False Truffles (3 species)

* *Gastroboletus imbellus*
* *Octavianina macrospora*
* *Octavianina papyracea*

False Truffles (10 species)

* *Alpova trappei*
Choiromyces alveolatus
* *Endoptychum depressum*
* *Gautieria pterosperma*
* *Leucogaster citrinus*
Mycolevis siccigleba
* *Nivatogastrium nubigenum*
Rhizopogon atroviolaceus
Rhizopogon truncatus
Alpova olivaceotinctus
Arcangeliella crassa
* *Arcangeliella lactarioides*
Chamonixia caespitosa
* *Destuntizia fusca*
* *Destuntzia rubra*
Gautieria magnicellaris
Gautieria otthii
* *Leucogaster microsporus*
* *Macowanites lymanensis*
Macowanites mollis
Martellia fragrans
Martellia idahoensis
* *Martellia monticola*
Rhizopogon abietis
Rizopogon atroviolaceus
Rhizopogon brunneicolor
Rhizopogon evadens var. subalpinus
Rhizopogon flavofibrillosus
Rhizopogon inquinatus
* *Sedecula pulvinata*
* *Zelleromyces oregonensis*

Undescribed Taxa, Rare (29 species)

* *Alpova* sp. nov., Trappe # 9730[a]
* *Alpova* sp. nov., Trappe #1966
* *Arcangeliella* sp. nov., Trappe # 12383

[a] #9730 designates collection number of specimen.

Appendix Table IV-A-1. (continued)

[9] #9730 designates collection number of specimen.

Appendix Table IV-A-1. (continued)

MYCORRHIZAL (continued)

Undescribed Taxa, Rare (continued)

* *Arcangeliella* sp. nov., Trappe #12359
* *Chamonixia* sp. nov., Trappe #12768
* *Elaphomyces* sp. nov., Trappe #1038
* *Gastroboletus* sp. nov., Trappe #2897
* *Gastroboletus* sp. nov., Trappe #7515
* *Gastrosuillus* sp. nov., Trappe #7516
* *Gastrosuillus* sp. nov., Trappe #9608
* *Gymnomyces* sp. nov., Trappe # 4703, 5576
* *Gymnomyces* sp. nov., Trappe # 5052
* *Gymnomyces* sp. nov., Trappe #1690, 1706, 1710
* *Gymnomyces* sp. nov., Trappe #7545
* *Hydnotrya* sp. nov., Trappe #787, 792
* *Hydnotrya* sp. nov., Trappe 1861
* *Martellia* sp. nov., Trappe # 649
* *Martellia* sp. nov., Trappe #1700
* *Martellia* sp. nov., Trappe #311
* *Martellia* sp. nov., Trappe #5903
* *Octavianina* sp. nov., Trappe #7502, 11172
* *Picoa* sp. nov., Trappe # 12658
* *Picoa* sp. nov., Trappe # 13027
* *Rhizopogon* sp. nov., Trappe #9432
* *Thaxterogaster* Trappe #4867, 6242,7427,7962,8520
* *Tuber* sp. nov., Trappe #11643
* *Tuber* sp. nov., Trappe #2302
* *Tuber* sp. nov., Trappe 12493
* Unnamed new genus & species, Trappe # 7654

Chanterelles (3 species)

Cantharellus cibarius
Cantharellus subalbidus ‡
Cantharellus tubaeformis

Chanterelles - Gomphus (4 species)

Gomphus bonarii
Gomphus clavatus
Gomphus floccosus
Gomphus kauffmanii

Rare Chanterelle (2 species)

* *Cantharellus formosus*
Polyozellus multiplex

Coral Fungi (50+ species)

Ramaria spp.

Phaeocollybia (13 species)

* *Phaeocollybia attenuata*
* *Phaeocollybia californica*
* *Phaeocollybia carmanahensis*

* *Rhizopogon* sp. nov., Trappe #9432
* *Thaxterogaster* Trappe #4867, 6242,7427,7962,8520
* *Tuber* sp. nov., Trappe #11643
* *Tuber* sp. nov., Trappe #2302
* *Tuber* sp. nov., Trappe 12493
* Unnamed new genus & species, Trappe # 7654

Truffles (5 species)

Elaphomyces granulatus
Elaphomyces muricatus
Geopora cooperi f. *cooperi*
Hydnotrya cerebriformis
* *Hydnotrya variformis* var. *pallida* Trappe var. nov.

Rare Truffles (6 species)

Balsamia nigra
Choiromyces venosus
Elaphomyces anthracinus
Elaphomyces subviscidus
Genea verrucosa
Tuber rufum

Ramaria spp.

Phaeocollybia (13 species)

* *Phaeocollybia attenuata*
* *Phaeocollybia californica*
* *Phaeocollybia carmanahensis*
* *Phaeocollybia fallax*
* *Phaeocollybia gregaria*
* *Phaeocollybia kauffmanii*
* *Phaeocollybia olivacea*
* *Phaeocollybia oregonensis*
* *Phaeocollybia piceae*
* *Phaeocollybia pseudofestiva*
* *Phaeocollybia scatesiae*
* *Phaeocollybia sipei*
* *Phaeocollybia spadicea*

Gilled Mushrooms (125 species)

* *Amanita constricta*
Amanita farinosa
Amanita francheti Tuber rufum
Amanita gemmata
Amanita inaurata
Amanita muscaria var. *formosa*

Appendix Table IV-A-1. (continued)

MYCORRHIZAI. (continued)

Gilled Mushrooms (continued)

Gilled Mushrooms (continued)

MYCORRHIZAI. (continued)

Gilled Mushrooms (continued)

* *Amanita pachycolea*
Amanita pantherina
Amanita porphyria
* *Amanita smithiana*
Chroogomphus tomentosus
Cortinarius acutus
Cortinarius adalberti
Cortinarius allutus
Cortinarius anomalus
Cortinarius arquatus
Cortinarius badiovinaceus
Cortinarius callisteus
Cortinarius calochrous
Cortinarius camphoratus
Cortinarius caninus
Cortinarius clandestinus
Cortinarius collinitus var. *collinitus*
Cortinarius collinitus var. *olympianus*
Cortinarius crassus/subaustralis
Cortinarius delibutus
Cortinarius evernius
Cortinarius flexipes
Cortinarius gentilis
Cortinarius glaucopus
Cortinarius griseoviolaceus
Cortinarius guttatus
Cortinarius herpeticus/montanus
Cortinarius infractus

Gilled Mushrooms (continued)

Cortinarius violaceus
Cortinarius zinziberatus
Dermocybe crocea
* *Dermocybe idahoensis*
Dermocybe malicoria
* *Dermocybe phoenicea* var. *occidentalis*
Dermocybe sanguinea
Dermocybe semisanguinea
Dermocybe zakii
Hebeloma crustuliniforme
Hygrophorus amarus
* *Hygrophorus bakerensis*
Hygrophorus camarophyllus
Hygrophorus chrysodon
Hygrophorus discoideus
Hygrophorus eburneus
Hygrophorus erubescens
Hygrophorus inocybiformis
Hygrophorus megasporus
Hygrophorus olivaceoalbus
Hygrophorus tephroleucus
Inocybe agglutinata
Inocybe calamistrata
Inocybe fuscodisca
Inocybe hirsuts var. *maxima*
Inocybe lanuginosa
Inocybe obscura
Inocybe praetervisa

Cortinarius flexipes
Cortinarius gentilis
Cortinarius glaucopus
Cortinarius griseoviolaceus
Cortinarius guttatus
Cortinarius herpeticus/montanus
Cortinarius infractus
Cortinarius junghuhnii
Cortinarius laniger
Cortinarius limonius
Cortinarius miniatopus
* *Cortinarius mutabilis*
Cortinarius obtusus
Cortinarius paleaceous
Cortinarius paragaudis
Cortinarius pinetorum sensu kauffman
Cortinarius pseudoarquatus
Cortinarius renidens
Cortinarius rubicundulus
Cortinarius salor
Cortinarius scutulatus
Cortinarius traganus
Cortinarius vanduzerensis
Cortinarius venetus var. *montanus*
Cortinarius vibratilis

Inocybe calamistrata
Inocybe fuscodisca
Inocybe hirsuts var. *maxima*
Inocybe lanuginosa
Inocybe obscura
Inocybe praetervisa
Inocybe sororia
Inocybe whitei
Laccaria amethysteo-occidentalis
Laccaria bicolor
Laccaria laccata
Lactarius alnicola
Lactarius deliciosus var. *deliciosus*
* *Lactarius deliciosus* var. *olivaceosordidus*
Lactarius fallax var. *concolor*
Lactarius fallax var. *fallax*
Lactarius kauffmanii
Lactarius olivaceoumbrinus
Lactarius olympianus
Lactarius pallescens
Lactarius pseudomucidus
Lactarius scrobiculatus
Lactarius subviscidus

Appendix Table IV-A-1. (continued)

MYCORRHIZAL (continued)

Gilled Mushrooms (continued)

Limacella glioderma
Rozites caperata
Russula aeruginea
Russula albonigra

Uncommon Gilled Mushrooms (continue

* Hygrophorus vernalis
Russula mustelina

Gilled Mushrooms (continued)

Limacella glioderma
Rozites caperata
Russula aeruginea
Russula albonigra
Russula bicolor
Russula brevipes var. *acrior*
Russula crassotunicata
Russula decolorans
Russula nigricans
Russula occidentalis
Russula olivascens
Russula pelargonia
Russula rosacea
Russula variata
Russula xerampelina
Tricholoma davisiae
Tricholoma flavovirens
Tricholoma foxale
Tricholoma imbricatum
Tricholoma inamoenum
Tricholoma magnivelare
Tricholoma pessundatum
Tricholoma portentosum
Tricholoma saponaceum
Tricholoma sejunctum
Tricholoma squarrulosum
Tricholoma vaccinum
Tricholoma virgatum

Uncommon Gilled Mushrooms (15 species)

Catathelasma ventricosa
Cortinarius azureus

Uncommon Gilled Mushrooms (continue

* Hygrophorus vernalis
Russula mustelina

Rare Gilled Mushrooms (7 species)

* *Chroogomphus loculatus*
Cortinarius canabarba
* *Cortinarius rainierensis*
Cortinarius varipes
* *Cortinarius verrucisporus*
* *Cortinarius wiebeae*
Tricholoma venenatum

Ecto-Polypore

Colpichia perennis

Uncommon Ecto-Polypores, (2 species)

Albatrellus ellisii
Albatrellus fletcii

Rare Ecto-Polypores (3 species)

Albatrellus avellaneus
Albatrellus caeruleoporus
Polyporoletus sublividus

Tooth Fungi (5 species)

Hydnum repandum
Hydnum umbilicatum

Tricholoma vaccinum
Tricholoma virgatum

Uncommon Gilled Mushrooms (15 species)

Catathelasma ventricosa
Cortinarius azureus
* *Cortinarius boulderensis*
Cortinarius cyanites
* *Cortinarius magnivelatus*
* *Cortinarius olympianus*
Cortinarius spilomius
Cortinarius tabularis
Cortinarius valgus
* *Dermocybe humboldtiensis*
* *Hebeloma olympiana*
* *Hygrophorus caeridens*
Hygrophorus karstenii

Albatrellus caeruleoporus
Polyporoletus sublividus

Tooth Fungi (5 species)

Hydnum repandum
Hydnum umbilicatum
Phellodon atratum
Sarcodon fuscoindicum
Sarcodon imbricatus

Ecto-Resupinate Fungi (3+ species)

Amphinema byssoides
Piloderma bicolor
Tomentella spp.

Appendix Table IV-A-1. (continued)

MYCORRHIZAL (continued)

Ecto-Puffballs (2 species)

Lycoperdon nigrescens
Lycoperdon pyriforme

Rare Zygomycetes (3 species)

Endogone acrogena
* *Endogone oregonensis*
Glomus radiatum

SAPROBES (DECOMPOSERS)

Gilled Mushrooms (continued)

Mycena amabilissima
Mycena amicta
Mycena aurantiidisca
Mycena aurantiomarginata
Mycena capillaripes
Mycena elegantula/purpureofusca
Mycena epipterygia
Mycena filopes
Mycena galopus
Mycena longiseta
Mycena robromarginata

Endogone acrogena
* *Endogone oregonensis*
Glomus radiatum

SAPROBES (DECOMPOSERS)

Gilled Mushrooms (80 species)

* *Caulorhiza umbonata*
Chrysomphalina aurantiaca
Clitocybe avellaneialba
Clitocybe clavipes
Clitopilus prunulus
Collybia acervata
Collybia butyracea
Collybia maculata var. *maculata*
Collybia maculata var. *occidentalis*
Collybia maculata var. *scorzonerea*
Galerina mammillata
Galerina sideroides
Galerina stylifera
Gymnopilus bellulus
Gymnopilus hybridus
Gymnopilus spectabilis
Hemimycena delectabilis
Hygrocybe conica
Hygrocybe laeta
Hygrophoropsis aurantiaca
Hypholoma capnoides
Hypholoma dispersum
Kuhneromyces lignicola
Kuhneromyces mutabilis
Lyophyllum semitale
Marasmiellus papilatus
Marasmiellus pluvius
Marasmius pallidocephalus
Marasmius quercophilus
Mycena capillaripes
Mycena elegantula/purpureofusca
Mycena epipterygia
Mycena filopes
Mycena galopus
Mycena longiseta
Mycena robromarginata
Mycena strobilinoides
Mycena epipterygia
Mycena galericulata (syn. *M. rugulosiceps*)
Mycena leptocephala
Mycena maculata
Mycena rosella
Mycena sanguinolenta
Mycena viscosa
Nolanea staurospora
Nolanea cathionis
Nolanea cetrata
Nolanea cuneata
Nolanea stricta
Omphalina epichysium
Panellus longiquus
Paxillus atrotomentosus
Paxillus panuoides
Pholiota flavida
Pholiota lubrica
Pholiota astragalina
Pholiota decorata
Pholiota flammans
Pholiota scamba
Pleurocybella porrigens
Rhodocybe trachyospora var. *purpureoviolaceum*
Resinomycena moniana
Resupinatus applicatus
Stropharia hornemannii
Tricholomopsis decora
Tricholomopsis flavissima
Xerompbalina campanellcides

Hypholoma dispersum
Kuhneromyces lignicola
Kuhneromyces mutabilis
Lyophyllum semitale
Marasmiellus papilatus
Marasmiellus pluvius
Marasmius pallidocephalus
Marasmius quercophilus
Marasmius salalis
* *Melanotus textilis*
Micromphale perforans
Micromphale sequiaea

Pleurocybella porrigens
Rhodocybe trachyospora var. *purpureovioiaceum*
Resinomycena montana
Resupinatus applicatus
Stropharia hornemannii
Tricholomopsis decora
Tricholomopsis flavissima
Xeromphalina campanelloides

Appendix Table IV-A-1. (continued)

SAPROBES (DECOMPOSERS) (continued)

Uncommon Gilled Mushrooms (17 species)

Xeromphalina cauticinalis
Xeromphalina cirrus
Xeromphalina cornui
Xeromphalina fulvipes
* *Xeromphalina orickiana*
Baeospora myriadophylla
Chrysomphalina grossula
* *Collybia bakerensis*
Fayodia gracilipes (rainierensis)
* *Gymnopilus puntifolius*
Marasmius applanatipes
* *Mycena quinaultensis*
Mycena tenax
* *Mycena hudsoniana*
Mycena lilacifolia
Mycena marginella
Mycena monticola
Mycena overholtsii

Noble Polypore (rare and endangered)

* *Oxyporus nobilissimus*

Other Polypore

Bondarzewia mesenterica

Resupinate Fungi (14 species)

Aleurodiscus grantii
Aleurodiscus peniciallatus
Coniophora arida
Grandinia alutaria
Grandinia aspera
Grandinia breviseta
Hericium abietis
Leucogyrophana mollusca
Phlebia tremellosa

* *Mycena quinaultensis*
Mycena tenax
* *Mycena hudsoniana*
Mycena lilacifolia
Mycena marginella
Mycena monticola
Mycena overholtsii
Mycobiconyces corneipes
* *Neolentinus kauffmanii*
Pholiota albivelata
Stagnicola perplexa

Rare Gilled Mushrooms (6 species)

Clitocybe subditopoda
Clitocybe senilis
Neolentinus adherens
Rhodocybe (Entoloma) nitida
* *Rhodocybe speciosa*
* *Tricholoniopsis fulvescens*

Polypores (10 species)

Ganoderma oregonense
Ganoderma tsugae
Ischnoderma resinosum
Jahnoporus hirtus
Laetiporus sulfureus
Oligoporus guttulatus
Osteina obducta
Polyporus melanopus
Pycnoporellus alboluteus
Pycnoporellus fulgens

Coniophora arida
Grandinia alutaria
Grandinia aspera
Grandinia breviseta
Hericium abietis
Leucogyrophana mollusca
Phlebia tremellosa
Phlebiella vaga
Resinicium furfuraceum
Stromatoscypha fimbriata
Trechispora farinacea
Trechispora mollusca

Rare Resupinates and Polypores (6 species)

Aleurodiscus farlowii
Dichostereum granulosum
Grandinia microsporella
Phlebia diffusa
Postia rennyii
Scytinostroma cf. *galatinum*

Cup Fungi (15 species)

Cudonia circinans
Cudonia monticola
Gyromitra californica
Gyromitra esculenta
Gyromitra infula
Gyromitra melaleucoides
Gyromitra montana (syn. *G. gigas*)
Otidea leporina
Otidea onotica
Otidea smithii
Plectania melastoma

Polyporus melanopus
Pycnoporellus alboluteus
Pycnoporellus fulgens

Gyromitra montana (syn. *G. gigas*)
Otidea leporina
Otidea onotica
Otidea smithii
Plectania melastoma

Appendix Table IV-A-1. (continued)

SAPROBES (DECOMPOSERS) (continued)

Cup Fungi (continued)

Podostroma alutaceum
Sarcosoma mexicana
Sarcosphaera eximia
Spathularia flavida

Rare Cup Fungi (14 species)

Aleuria rhenana
Bryoglossum gracile
Gelatinodiscus flavidus
Helvella compressa
Helvella crassitunicata
Helvella elastica
Helvella maculata
Neournula pouchetii
Pithya vulgaris
* *Plectania latahensis*
* *Plectania milleri*
* *Psedaleuria quinaultiana*
Sarcoleotia globosa
Trichophaeopsis tetraspora

Parasitic Fungi (continued)

Hypomyces luteovirens
Scytinostroma cf. *galatinum*

Cauliflower Mushroom

Sparassis crispa

OTHER FUNGI

Moss Dwelling Mushrooms (7 species)

Cyphellostereum laeve
Galerina atkinsoniana
Galerina cerina
Galerina heterocystis
Galerina sphagnicola
Galerina vittaeformis
Rickenella setipes

Club Coral Fungi

Clavariadelphus spp.

Jelly Mushroom

Pilboja calgaris
* *Plectania latahensis*
* *Plectania milleri*
* *Psedaleuria quinaultiana*
Sarcoleotia globosa
Trichophaeopsis tetraspora

Branched Coral Fungi (3 species)

Clavulina cinerea
Clavulina cristata
Clavulina ornatipes

PARASITES

Common Parasitic Fungi (2 species)

Hypomyces aurantium
Hypomyces lactifluorum

Parasitic Fungi (7 species)

Asterophora lycoperdoides
Asterophora parasitica
Collybia racemosa
Cordyceps capitata
Cordyceps ophioglossoides

Club Coral Fungi

Clavariadelphus spp.

Jelly Mushroom

Phlogoitis helvelloides

Mushroom Lichen

Phytoconis ericetorum

NOT RATED

Clavaria americana
Clavulinopsis (Ramariopsis) laeticolor and relatives
Calocera furcata
Clavicorona avellanea
Hypocreales
Laboulbeniales
Pleosporales

Appendix Table IV-A-2. Lichens closely associated with late-successional or old-grc forests within the range of the northern spotted owl, arranged by ecological groups. asterisk (*) denotes species that are endemic to the Pacific Northwest or Western Nc America.

Rare Forage Lichen (arboreal)

Rare Nitrogen-fixing Lichens (6 species)

Appendix Table IV-A-2. Lichens closely associated with late-successional or old-grc forests within the range of the northern spotted owl, arranged by ecological groups. asterisk (*) denotes species that are endemic to the Pacific Northwest or Western Nc America.

Rare Forage Lichen (arboreal)

Bryoria tortuosa

Forage Lichens (arboreal) (10 species)

Alectoria lata
Alectoria sarmentosa
* *Alectoria vancouverensis*
Bryoria capillaris
Bryoria friabilis
Bryoria glabra
* *Bryoria pikei*
* *Bryoria pseudofuscescens*
Usnea filipendula
Usnea scabrata

Rare Leafy (arboreal) Lichens (2 species)

Hypogymnia duplicata
Tholurna dissimilis

Arboreal Leafy Lichens (17 species)

* *Ahtiana sphaerosporella*
Cavernularia hultenii
Cavernularia lophyrea
Cetraria subalpina
* *Hypogymnia metaphysodes*
* *Hypogymnia rugosa*

Rare Nitrogen-fixing Lichens (6 species)

Dendriscocaulon intricatulum
Lobaria hallii
Lobaria linita
* *Nephroma occultum*
Pannaria rubiginosa
* *Pseudocyphellaria rainierensis*

Nitrogen-fixing Lichens (20 species)

* *Lobaria oregana*
Lobaria pulmonaria
Lobaria scrobiculata
Nephroma bellum
Nephroma helveticum
Nephroma laevigatum
Nephroma parile
Nephroma resupinatum
Pannaria leucostictoides
Pannaria mediterranea
Pannaria saubinetii
Peltigera collina
Peltigera neckeri
* *Peltigera pacifica*
* *Pseudocyphellaria anomala*
* *Pseudocyphellaria anthraspis*
Pseudocyphellaria crocata
* *Sticta beauvoisii*

* *Ahtiana sphaerosporella*
Cavernularia hultenii
Cavernularia lophyrea
Cetraria subalpina
* *Hypogymnia metaphysodes*
* *Hypogymnia rugosa*
Melanelia subelegantula
Parmelia kerguelensis
Parmelia squarrosa
Parmotrema arnoldii
Parmotrema chinense
Parmotrema crinitum
* *Platismatia herrei*
Platismatia norvegica
* *Platismatia stenophylla*
Sphaerophorus globosus
* *Tuckermannopsis pallidula*

Peltigera neckeri
* *Peltigera pacifica*
* *Pseudocyphellaria anomala*
* *Pseudocyphellaria anthraspis*
Pseudocyphellaria crocata
* *Sticta beauvoisii*
Sticta fuliginosa
Sticta limbata

Pin Lichens (16 species)

Calicium abietinum
Calicium adaequatum

Appendix Table IV-A-2. (continued)

Pin Lichens (continued)

Calicium adspersum
Calicium glaucellum
Calicium viride
Chaenotheca brunneola
Chaenotheca chrysocephala
Chaenotheca ferruginea
Chaenotheca furfuracea
Chaenotheca subroscida
Chaenothecopsis pusilla
Cyphelium inquinans
Microcalicium arenarium

Soil occurring Lichens (continued)

* *Pannaria cyanolepra*
Pannaria pezizoides
Peltigera horizontalis
Peltigera leucophlebia
Peltigera neopolydactyla
Peltigera venosa

Rare Rock Lichens (2 species)

* *Pilophorus nigricaulis*
Sticta arctica

Chaenotheca chrysocephala
Chaenotheca ferruginea
Chaenotheca furfuracea
Chaenotheca subroscida
Chaenothecopsis pusilla
Cyphelium inquinans
Microcalicium arenarium
Mycocalicium subtile
* *Stenocybe clavata*
Stenocybe major

Decaying Wood (8 species)

Cladonia bacillaris
Cladonia bellidiflora
Cladonia cenotea
Cladonia macilenta
Cladonia umbricola
Icmadophila ericetorum
Xylographa abietina
Xylographa vitiligo

Tree Boles (14 species)

Buellia penichra
Dimerella lutea
Dimerella pineti
Hypocenomyce friesii
Lecanactis megaspora
Lopadium pezizoideum
Mycoblastus alpinus
Mycoblastus sanguinarius
Ochrolechia androgyna
Ochrolechia oregonensis
Parmeliopsis hyperopta
Pertusaria amara
Pertusaria multipuncta
Peltigera leucophlebia
Peltigera neopolydactyla
Peltigera venosa

Rare Rock Lichens (2 species)

* *Pilophorus nigricaulis*
Sticta arctica

Rock Lichens (4 species)

Leptogium gelatinosum
Pilophorus acicularis
Pilophorus clavatus
Psoroma hypnorum

Riparian Lichens (9 species)

Cetrelia cetrarioides
Collema nigrescens
Leptogium burnetiae var. *hirsutum*
Leptogium cyanescens
Leptogium saturninum
Leptogium teretiusculum
Platismatia lacunosa
Ramalina thrausta
Usnea longissima

Aquatic Lichens (3 species)

Dermatocarpon luridum
* *Hydrothyria venosa*
Leptogium rivale

Rare Oceanic Influenced Lichens (12 species)

Bryoria pseudocapillaris
Bryoria spinulifera

Lepadium pezizoideum
Mycoblastus alpinus
Mycoblastus sanguinarius
Ochrolechia androgyna
Ochrolechia oregonensis
Parmeliopsis hyperopta
Pertusaria amara
Protoparmelia ochrococca
Thelotrema lepadinum

Soil occurring Lichens (8 species)

Baeomyces rufus
Epilichen scabrosus

Appendix Table IV-A-2. (continued)

Rare Oceanic Influenced Lichens (continued)

* *Niebla cephalota*
Pseudocyphellaria mougeotiana
Teloschistes flavicans
Usnea hesperina

Oceanic Influenced Lichens (4 species)

* *Cetraria californica*
Heterodermia leucomelos
* *Loxospora sp nov. "corallifera"* (*Brodo* in edit)
Pyrrhospora quernea

Species Not Rated (7 species)

Cladonia norvegica
* *Heterodermia sitchensis*
Hyptogymnia vittata
Dermatocarpon miniatum
* *Hydrothyria venosa*
Leptogium rivale

Rare Oceanic Influenced Lichens (12 species)

Bryoria pseudocapillaris
Bryoria spiralifera
Bryoria subcana
* *Buellia oidalea*
Erioderma sorediatum
Hypogymnia oceanica
Leioderma sorediatum
Leptogium cephalota

Pyrenospora quernea

Species Not Rated (7 species)

Cladonia norvegica
* *Heterodermia sitchensis*
Hyptogymnia vittata
Hypotrachyra revoluta
* *Nephroma isidiosum*
Ramalina pollinaria
Sulcaria badia

Appendix Table IV-A-3. Bryophytes closely associated with late-successional or old-growth forests within the range of the northern spotted owl, arranged by ecological groups. An asterisk (*) denotes species that are endemic to the Pacific Northwest.

Canopy Exterior (2 species)

* *Ulota megalospora*
* *Ulota obtusiuscula*

Canopy Interior (2 species)

Antitrichia curtipendula
Douinia ovata

Tree Boles/Decaying Wood (3 species)

Dicranum fuscescens
* *Hypnum circinale*
* *Scabania bolanderi*

Tree Boles/Understory - (5 species)

* *Pseudoleskea baileyi*
* *Pseudoleskea stenophylla*
Pterigynandrum filiforme

Humic Soil (continued)

Plagiochila asplenioides complex

Shaded Duff/Humic Soil (3 species)

* *Brachythecium hylotapetum*
* *Rhytidiopsis robusta*
* *Roellia roellii*

Decaying wood - Abundant (15 species)

Blepharostoma trichophyllum
Calypogeia neesiana
Cephalozia bicuspidata sp. *lammersiana*
Cephalozia connivens
Cephalozia lunulifolia
Lepidozia reptans
Lophocolea bidentata
Lophocolea cuspidata
Lophocolea heterophylla

* *Scabania bolanderi*

Tree Boles/Understory - (5 species)

* *Pseudoleskea baileyi*
* *Pseudoleskea stenophylla*
Pterigynandrum filiforme
* *Ptilidium californicum* (OR & WA)
* *Radula bolanderi*

Shaded Mineral Soil (5 species)

* *Ditrichum schimperi*
* *Fissidens pauperculus*
* *Pohlia pacifica*
Pseudotaxiphyllum elegans
Trichodon cylindricus

Shaded rock outcrops with thin soil (7 species)

* *Bryum gemmascens*
Heterocladium dimorphum
Heterocladium macounii
* *Heterocladium procurrens*
Plagiothecium piliferum
Timmia austriaca
Timmia megapolitana

Wet Shaded Humic Soil (5 species)

Calypogeia azurea
Calypogeia fissa
Calypogeia muelleriana
Isopterygiopsis pulchella

Table IV-A-3. (continud)

Cephalozia bicuspidata sp. *lammersiana*
Cephalozia connivens
Cephalozia lunulifolia
Lepidozia reptans
Lophocolea bidentata
Lophocolea cuspidata
Lophocolea heterophylla
Lophozia incisa
Lophozia ventricosa
Plagiothecium undulatum
* *Rhizomnium glabrescens*
Riccardia latifrons
Tetraphis pellucida

Decaying Wood - less common (11 species)

Bazzania ambigua
Bazzania denudata
Bazzania tricrenata
* *Buxbaumia piperi*
Buxbaumia viridis
Calypogeia suecica
Geocalyx graveolens
Herzogiella seligeri
Lophozia longiflora
Riccardia palmata
Scapania umbrosa

Calypogeia azurea
Calypogeia fissa
Calypogeia muelleriana
Isopterygiopsis pulchella

Table IV-A-3. (continued)

Aquatic (submerged) (3 species)

Chiloscyphus polyanthos
* *Fissidens ventricosus*
Scapania undulata

Splash Zone (5 species)

Dichodontium pellucidum
Jungermannia atrovirens
Racomitrium aciculare
Schistidium rivulare
Scouleria aquatica

Flood Plain (13 species)

Apomerzgeria pubescens
Conocephalum conicum
Ducranella palustris
Hookeria lucens
Metzgeria coniugata
Pellia epiphylla
Pellia neesiana
* *Plagiomnium insigne*
* *Porotrichum bigelovii*
* *Racomitrium obesum*
* *Rhizomnium nudum*
Rhytidiadelphus subpinnatus
Schistidium agassizii

Species Not Rated (16 species)

Bartramiopsis lescurii
* *Brotherella roelli*
Diplophyllum albicans
* *Encalypta brevicolla* var. *cruciana*
Herbertus aduncus
Herbertus sakuraii
Iwatsukiella leucotricha
Orthodontium gracile
Plagiochila satoi
Plagiochila semidecurrens
* *Pleuroziopsis ruthenica*
Racomitrium aquaticum
Radula brunnea
* *Scouleria marginata*
Tetraphis geniculata
Tritomaria quinquedentata

Pellia neesiana
* *Plagiomnium insigne*
* *Porotrichum bigelovii*
* *Racomitrium obesum*
* *Rhizomnium nudum*
Rhytidiadelphus subpinnatus
Schistidium agassizii

Species Rated Individually (3 species)

Fontinalis howellii
Kurzia makinoana
* *Thamnobryum neckeroides*

Rare Species (8 species)

* *Blindia flexipoda*
Diplophyllum plicatum
Marsupella emarginata var. aquatica
* *Pseudoleskeella serpentinense*
* *Ptilidium californicum* (CA only)
Racomitrium pacificum
Schistostega pennata
Tritomaria exsectiformis

Appendix table IV-A-4. Vascular plants closely associated with late-successional or old-growth forests within the range of the northern spotted owl. Federal status based on USDI (1990b). An asterisk (*) denotes species added since Scientific Analysis Team report (Thomas et al. 1993).

Species name	Common name	Family	Rare Endemic	Federal Status
* *Abies lasiocarpa* (California only)	subalpine fir	Pinaceae	R	
Achlys triphylla	vanilla leaf	Berberidaceae		
Adenocaulon bicolor	trail plant	Asteraceae		

report (Thomas et al. 1993).

	Species name	Common name	Family	Rare Endemic	Federal Status
*	*Abies lasiocarpa* (California only)	subalpine fir	Pinaceae	R	
	Achlys triphylla	vanilla leaf	Berberidaceae		
	Adenocaulon bicolor	trail plant	Asteraceae		
*	*Adiantum jordanii*	Jordan's maidenhair fern	Polypodiaceae		
	Adiantum pedatum	northern maidenhair fern	Polypodiaceae		
	Allotropa virgata	candy stick	Ericaceae	R	
	Anemone deltoidea	threeleaf anemone	Ranunculaceae		
	Angelica tomentosa	California angelica	Apiaceae		
	Apocynum pumilum	mountain dogbane	Apocynaceae		
*	*Aralia californica*	California aralia	Araliaceae		
	Arceuthobium tsugense	dwarf mistletoe	Loranthaceae		
	Arnica latifolia	mountain arnica	Asteraceae		
	Asarum caudatum	wild ginger	Aristolochiaceae		
	Asarum hartwegii	Hartweg's wild ginger	Aristolochiaceae		
*	*Asarum marmoratum*	marbled wild-ginger	Aristolochiaceae	E	
	Asarum wagneri	green-flowered wild ginger	Aristolochiaceae	E	
*	*Aster vialis*	wayside aster	Asteraceae	E	C2
	Bensoniella oregana	bensoniella	Saxifragaceae	E	C2
	Berberis pumila	dwarf mahonia	Berberidaceae		
	Boschniakia strobilacea	ground cone	Orobanchaceae		
	Botrychium minganense	mingan moonwort	Ophioglossaceae	R	
	Botrychium montanum	mountain moonwort	Ophioglossaceae	R	
*	*Botrychium virginianum*	Virginia grape fern	Ophioglossaceae	R	
	Calypso bulbosa	fairy slipper	Orchidaceae		
	Chamaecyparis lawsoniana	Port Orford cedar	Cupressaceae		
	Chamaecyparis nootkatensis	Alaska yellow cedar	Cupressaceae		
	Chimaphila menziesii	pipsissewa	Ericaceae		
	Chimaphila umbellata	common pipsissewa	Ericaceae		
	Cimicifuga elata	tall bugbane	Ranunculaceae	E	

*	*Botrychium virginianum*	Virginia grape fern	Ophioglossaceae	R	
	Calypso bulbosa	fairy slipper	Orchidaceae		
	Chamaecyparis lawsoniana	Port Orford cedar	Cupressaceae		
	Chamaecyparis nootkatensis	Alaska yellow cedar	Cupressaceae		
	Chimaphila menziesii	pipsissewa	Ericaceae		
	Chimaphila umbellata	common pipsissewa	Ericaceae		
	Cimicifuga elata	tall bugbane	Ranunculaceae	E	
*	*Cimicifuga laciniata*	cut-leaved bugbane	Ranunculaceae	E	
*	*Clintonia andrewsiana*	Redwood beadlily	Liliaceae	E	
	Clintonia uniflora	queen cup beadlily	Liliaceae		
*	*Collomia mazama*	one-sided-flowered collomia	Polemoniaceae	E	C2
	Coptis asplenifolia	spleenwort-leaved goldthread	Ranunculaceae	R	
	Coptis laciniata	goldthread	Ranunculaceae		
*	*Coptis trifolia*	threeleaflet goldthread	Ranunculaceae		
	Corallorhiza maculata	Pacific coralroot	Orchidaceae		
	Corallorhiza mertensiana	western coralroot	Orchidaceae		
*	*Corallorhiza striata*	striped coralroot	Orchidaceae		

Table IV-A-4. (continued).

	Cypripedium fasciculatum	clustered ladyslipper	Orchidaceae	R	
	Cypripedium montanum	mountain ladyslipper	Orchidaceae	R	
	Dentaria californica	toothwort	Brassicaceae		
	Disporum hookeri	fairy-bell	Liliaceae		
*	*Disporum smithii*	fairy lantern	Liliaceae	E	
	Dryopteris austriaca	mountain woodfern	Polypodiaceae		
	Eburophyton austiniae	phantom orchid	Orchidaceae		
	Erythronium montanum	avalanche lily	Liliaceae		
*	*Frasera umpquaensis*	Umpqua swertia	Gentianiaceae	E	C2
	Galium kamtschaticum	boreal bedstraw	Rubiaceae	R	
*	*Galium oreganum* (Klamath)	Oregon bedstraw	Rubiaceae		

	Dryopteris austriaca	mountain woodfern	Polypodiaceae		
	Eburophyton austiniae	phantom orchid	Orchidaceae		
	Erythronium montanum	avalanche lily	Liliaceae		
*	*Frasera umpquaensis*	Umpqua swertia	Gentianiaceae	E	C2
	Galium kamtschaticum	boreal bedstraw	Rubiaceae	R	
*	*Galium oreganum* (Klamath)	Oregon bedstraw	Rubiaceae		
	Gaultheria humifusa	western wintergreen	Ericaceae		
	Gaultheria ovatifolia	Oregon wintergreen	Ericaceae		
	Goodyera oblongifolia	rattlesnake plantain	Orchidaceae		
	Gymnocarpium dryopteris	oak fern	Polypodiaceae		
	Habenaria obtusata	small northern bog-orchid	Orchidaceae	R	
	Habenaria orbiculata	large round-leaved rein-orchid	Orchidaceae	R	
	Habenaria saccata	slender bog-orchid	Orchidaceae		
	Habenaria unalascensis	Alaska rein-orchid	Orchidaceae		
	Hemitomes congestum	gnome plant	Ericaceae	R	
	Hieracium scouleri	woolly-weed	Asteraceae		
*	*Hierochloe occidentalis*	California vanilla grass	Poaceae		
	Hypopitys monotropa	pinesap	Ericaceae		
*	*Isopyrum hallii*	Hall's rue-anemone	Ranunculaceae		
	Lathyrus polyphyllus	leafy peavine	Fabaceae		
	Listera borealis	twinflower	Orchidaceae	R	
	Listera caurina	western twayblade	Orchidaceae		
	Listera convallarioides	broad-lipped twayblade	Orchidaceae		
	Listera cordata	twayblade	Orchidaceae		
	Luzula hitchcocki	smooth woodrush	Juncaceae		
*	*Lycopodium selago*	fir clubmoss	Lycopodiaceae	R	
	Lysichiton americanum	skunk cabbage	Araceae		
	Melica subulata	Alaska oniongrass	Poaceae		
	Menziesia ferruginea	fool's huckleberry	Ericaceae		
	Mitella breweri	Brewer's mitrewort	Saxifragaceae		
*	*Mitella caulescens*	star-shaped mitrewort	Saxifragaceae		
*	*Mitella ovalis*	oval-leaved mitrewort	Saxifragaceae		

	Lysichiton americanum	skunk cabbage	Araceae		
	Melica subulata	Alaska oniongrass	Poaceae		
	Menziesia ferruginea	fool's huckleberry	Ericaceae		
	Mitella breweri	Brewer's mitrewort	Saxifragaceae		
*	*Mitella caulescens*	star-shaped mitrewort	Saxifragaceae		
*	*Mitella ovalis*	oval-leaved mitrewort	Saxifragaceae		
*	*Mitella pentandra*	five-stamened mitrewort	Saxifragaceae		
*	*Mitella trifida*	Pacific mitrewort	Saxifragaceae		
	Monotropa uniflora	Indian pipe	Ericaceae		
	Oxalis oregana	Oregon wood-sorrel	Oxalidaceae		
*	*Oxalis trillifolia*	trillium-leaved woodsorrel	Oxalidaceae		
*	*Pedicularis howellii*	Howell's lousewort	Scrophulariaceae	E	C2

Table IV-A-4. (continued).

	Phlox adsurgens	woodland phlox	Polemoniaceae		
	Picea breweriana	Brewer's spruce	Pinaceae		E
	Pityopis californica	pinefoot	Ericaceae		R
	Pleuricospora fimbriolata	fringed pinesap	Ericaceae		
	Poa laxiflora	loose-flowered bluegrass	Poaceae		E
*	*Polystichum californicum* (Cascades)	California swordfern	Polypodiaceae		R
	Pterospora andromedea	woodland pinedrops	Ericaceae		R
	Pyrola asarifolia	alpine pyrola	Ericaceae		
	Pyrola chlorantha	greenish pyrola	Ericaceae		
	Pyrola dentata	toothleaf pyrola	Ericaceae		
	Pyrola picta	white vein pyrola	Ericaceae		
	Pyrola secunda	side-bells pyrola	Ericaceae		
	Pyrola uniflora	single flowered pyrola	Ericaceae		
	Rubus lasiococcus	dwarf bramble	Rosaceae		
	Rubus nivalis	snow bramble	Rosaceae		
	Rubus pedatus	five-leaved bramble	Rosaceae		

Pyrola picta	white vein pyrola	Ericaceae	
Pyrola secunda	side-bells pyrola	Ericaceae	
Pyrola uniflora	single flowered pyrola	Ericaceae	
Rubus lasiococcus	dwarf bramble	Rosaceae	
Rubus nivalis	snow bramble	Rosaceae	
Rubus pedatus	five-leaved bramble	Rosaceae	
Sarcodes sanguinea	snow plant	Ericaceae	
Satureja douglasii	yerba buena	Lamiaceae	
Scoliopus bigelovii	Bigelove's slink lily	Liliaceae	E
Scoliopus hallii	slink lily	Liliaceae	
Selaginella oregana	Oregon selaginella	Selaginellaceae	R
Smilacina racemosa	solomon's seal	Liliaceae	
Smilacina stellata	star-flowered solomon's plume	Liliaceae	
Streptopus amplexifolius	clasping-leaved twisted stalk	Liliaceae	
Streptopus roseus	rosy twisted stalk	Liliaceae	
Streptopus streptopoides	twisted stalk	Liliaceae	
Synthyris schizantha	fringed synthyris	Scrophulariaceae	R
Taxus brevifolia	Pacific yew	Taxaceae	
Thuja plicata	western redcedar	Cupressaceae	
Tiarella trifoliata	trefoil foamflower	Saxifragaceae	
Tiarella unifoliata	coolwort foamflower	Saxifragaceae	
Trillium ovatum	wake-robin	Liliaceae	
Trillium ovatum ssp. *oettingeri*	Salmon Mountain wakerobin	Liliaceae	
Vaccinium alaskaense	Alaska huckleberry	Ericaceae	
Vaccinium membranaceum	thin-leaved huckleberry	Ericaceae	
Vaccinium ovalifolium	oval-leaf huckleberry	Ericaceae	
Vaccinium parvifolium	red huckleberry	Ericaceae	
Vancouveria hexandra	inside-out flower	Berberidaceae	
Vancouveria planipetala	small-flowered vancouveria	Berberidaceae	E

Vaccinium alaskaense	Alaska huckleberry	Ericaceae	
Vaccinium membranaceum	thin-leaved huckleberry	Ericaceae	
Vaccinium ovalifolium	oval-leaf huckleberry	Ericaceae	
Vaccinium parvifolium	red huckleberry	Ericaceae	
Vancouveria hexandra	inside-out flower	Berberidaceae	
Vancouveria planipetala	small-flowered vancouveria	Berberidaceae	E
Vicia americana var. *villosa*	American vetch	Fabaceae	
Viola glabella	pioneer violet	Violaceae	
Viola orbiculata	round-leaved violet	Violaceae	
Viola renifolia	kidney-leaved violet	Violaceae	
Whipplea modesta	yerba de selva	Hydrangeaceae	
Xerophyllum tenax (Olympic)	beargrass	Liliaceae	

Appendix Table IV-A-5. Mollusks closely associated with late-successional forests within the range of the northern spotted owl.

Land Snails

Ancotrema voyanum	hooded lancetooth
Cryptomastix devia	Puget oregonian
Cryptomastix hendersoni	Columbia oregonian
Helminthoglypta arrosa monticola	mountain shoulderband
Helminthoglypta hertleini	Oregon shoulderband
Helminthoglypta talmadgei	Klamath shoulderband
Megomphix californicus	California megomphyx
Megomphix hemphilli	Oregon megomphyx
Monadenia callipeplus	no common name
Monadenia chaceana	Chace sideband
Monadenia churchi	Klamath sideband
Monadenia fidelis celeuthia	traveling sideband

Megomphix californicus	California megomphyx
Megomphix hemphilli	Oregon megomphyx
Monadenia callipeplus	no common name
Monadenia chaceana	Chace sideband
Monadenia churchi	Klamath sideband
Monadenia fidelis celeuthia	traveling sideband
Monadenia fidelis flava	green sideband
Monadenia fidelis klamathica	no common name
Monadenia fidelis leonina	tawny sideband
Monadenia fidelis minor	Dalles sideband
Monadenia fidelis ochromphalus	yellow-base sideband
Monadenia fidelis salmonensis	Salmon River sideband
Monadenia rotifer	wheel sideband
Monadenia scottiana	Scott River sideband
Monadenia setosa	Trinity bristlesnail
Monadenia troglodytes troglodytes	Shasta sideband
Monadenia troglodytes wintu	Wintu sideband
Oreohelix n. sp.	Chelan mountainsnail
Pristiloma articum crateris	Crater lake tightcoil
Punctum (Toltecia) hannai	Hanna spot
Trilobopsis roperi	Shasta chaparral
Trilobopsis tehamana	Tehama chaparral
Vertigo n. sp.	Hoko vertigo
Vespericola depressa	Dalles hesperian
Vespericola euthales	large hesperian
Vespericola karokorum	Karok hesperian
Vespericola pressleyi	Pressley hesperian
Vespericola shasta	Shasta hesperian
Vespericola sierrana	Siskiyou hesperian
Vespericola undescribed #1	Sasquatch hesperian
Vespericola undescribed #2	Reeves Bar hesperian

Vespericola karokorum	Karok hesperian
Vespericola pressleyi	Pressley hesperian
Vespericola shasta	Shasta hesperian
Vespericola sierrana	Siskiyou hesperian
Vespericola undescribed #1	Sasquatch hesperian
Vespericola undescribed #2	Reeves Bar hesperian
Vespericola undescribed #3	Klamath hesperian

Appendix Table IV-A-5. (continued)

Slugs

Deroceras hesperium	evening fieldslug
Hemphillia burringtoni	Burrington jumping-slug
Hemphillia glandulosa	warty jumping-slug
Hemphillia malonei	Malone jumping-slug
Hemphillia pantherina	panther jumping-slug
Prophysaon coeruleum	blue-gray tail-dropper
Prophysaon dubium	Papillose tail-dropper

Riparian

Anodonta californiensis	California floater
Anodonta wahlametensis	Willamette floater
Fisherola nuttalli nuttalli	shortface lanx
Fluminicola columbiana	Columbia pebblesnail
Fluminicola n. sp. 1	Klamath pebblesnail
Fluminicola n. sp. 2	tall pebblesnail
Fluminicola n. sp. 3	Klamath Rim pebblesnail
Fluminicola n. sp. 4	nerite pebblesnail
Fluminicola n. sp. 5	toothed pebblesnail
Fluminicola n. sp. 6	diminutive pebblesnail

Fluminicola n. sp. 1	Klamath pebblesnail
Fluminicola n. sp. 2	tall pebblesnail
Fluminicola n. sp. 3	Klamath Rim pebblesnail
Fluminicola n. sp. 4	nerite pebblesnail
Fluminicola n. sp. 5	toothed pebblesnail
Fluminicola n. sp. 6	diminutive pebblesnail
Fluminicola n. sp. 7	topaz pebblesnail
Fluminicola n. sp. 8	Fall Creek pebblesnail
Fluminicola n. sp. 9	lunate pebblesnail
Fluminicola n. sp. 10	Keene Creek pebblesnail
Fluminicola n. sp. 11	Fredenburg pebblesnail
Fluminicola n. sp. 12	Umpqua pebblesnail
Fluminicola n. sp. 13	Sacramento pebblesnail
Fluminicola n. sp. 14	Potem pebblesnail
Fluminicola n. sp. 15	flat-top pebblesnail
Fluminicola n. sp. 16	Shasta pebblesnail
Fluminicola n. sp. 17	disjunct pebblesnail
Fluminicola n. sp. 18	globular pebblesnail
Fluminicola n. sp. 19	umbilicate pebblesnail
Fluminicola n. sp. 20	Lost Creek pebblesnail
Fluminicola seminalis	nugget pebblesnail
Helisoma newberryi newberryi	Great Basin rams-horn
Juga (C.) *acutifilosa*	scalloped juga
Juga (C.) *occata*	topaz juga
Juga (J.) n. sp. 1	brown juga
Juga (J.) n. sp. 3	tall juga
Juga (O.) n. sp. 1	no common name
Juga (O.) n. sp. 2	no common name
Juga (O.) n. sp. 3	no common name
Juga (Oreobasis) chacei	Chace juga
Juga (Oreobasis) orickensis	redwood juga
Juga berryhilli dallesensis	Dalles juga

Juga (O.) n. sp. 3	[illegible] juga
Juga (O.) n. sp. 1	no common name
Juga (O.) n. sp. 2	no common name
Juga (O.) n. sp. 3	no common name
Juga (Oreobasis) chacei	Chace juga
Juga (Oreobasis) orickensis	redwood juga
Juga hemphilli dallesensis	Dalles juga
Juga hemphilli hemphilli	barren juga
Juga hemphilli n. subsp. 1	no common name
Lanx alta	highcap lanx

Appendix IV-A-5. (continued)

Lanx klamathensis	scale lanx
Lanx patelloides	kneecap lanx
Lanx subrotundata	rotund lanx
Lyogyrus n. sp. 1	Columbia duskysnail
Lyogyrus n. sp. 2	Washington duskysnail
Lyogyrus n. sp. 3	canary duskysnail
Lyogyrus n. sp. 4	Klamath duskysnail
Lyogyrus n. sp. 5	nodose duskysnail
Lyogyrus n. sp. 6	mare's egg duskysnail
Physella columbiana	rotund physa
Pisidium (C.) *ultramontanum*	montane peaclam
Pyrgulopsis archimedis	Archimedes pyrg
Pyrgulopsis intermedia	Crooked Creek springsnail
Pyrgulopsis n. sp. 1	lake pyrg
Vorticifex klamathensis klamathensis	Klamath rams-horn
Vorticifex klamathensis sinitsini	Sinitsin rams-horn
Vorticifex n. sp. 1	knobby rams-horn
Vorticifex neritoides	nerite rams-horn

Pyrgulopsis arcifinalis	Arcifinal pyrg
Pyrgulopsis intermedia	Crooked Creek springsnail
Pyrgulopsis n. sp. 1	lake pyrg
Vorticifex klamathensis klamathensis	Klamath rams-horn
Vorticifex klamathensis sinitsini	Sinitsin rams-horn
Vorticifex n. sp. 1	knobby rams-horn
Vorticifex neritoides	nerite rams-horn

Appendix table IV-A-6. Common and scientific names of vertebrates mentioned in this report.

Amphibians and Reptiles	
Ambystoma gracile	Northwestern salamander
Aneides ferreus	Clouded salamander
Aneides flavipunctatus	Black salamander
Ascaphus truei	Tailed frog
Batrachoseps attenuatus	California slender salamander
Batrachoseps wrighti	Oregon slender slamander
Contia tenuis	Sharp-tailed snake
Dicamptodon copei	Cope's giant salamander
Dicamptodon tenebrosus	Pacific giant salamander
Elgaria coerula	Northern alligator lizard
Hydromantes shastae	Shasta salamander
Plethodon dunni	Dunn's salamander
Plethodon elongatus	Del Norte salamander
Plethodon larselli	Larch Mountain salamander
Plethodon stormi	Siskiyou Mtn. salamander
Plethodon vandykei	Van Dykes salamander
Rana pretiosa	Western spotted frog
Rana cascadae	Cascades frog

Plethodon elongatus	Del Norte salamander
Plethodon larselli	Larch Mountain salamander
Plethodon stormi	Siskiyou Mtn. salamander
Plethodon vandykei	Van Dykes salamander
Rana pretiosa	Western spotted frog
Rana cascadae	Cascades frog
Rhyacotriton cascadae	Cascade torrent salamander
Rhyacotriton kezeri	Columbia torrent salamander
Rhyacotriton olympicus	Olympic torrent salamander
Rhyacotriton variegatus	Southern torrent salamander
Taricha granulosa	Rough-skinned newt

Mammals

Antrozous pallidus	Pallid bat
Canis lupus	Gray wolf
Cervus elephus	Elk
Clethrionomys californicus	Western red-backed vole
Clethrionomys gapperi	Southern red-backed vole
Eptesicus fuscus	Big brown bat
Glaucomys sabrinus	Northern flying squirrel
Lasiurus cinereus	Hoary bat
Lasionycterus noctivagans	Silver-haired bat
Lynx canadensis	Lynx
Martes americana	American marten
Martes pennanti	Fisher
Myotis californicus	California myotis
Myotis ciliolabrum	Small-footed myotis
Myotis evotis	Long-eared myotis
Myotis grisescens	Gray bat

Martes pennanti	Fisher
Myotis californicus	California myotis
Myotis ciliolabrum	Small-footed myotis
Myotis evotis	Long-eared myotis
Myotis grisecens	Gray bat
Myotis keenii	Keen's myotis
Myotis lucifugus	Little brown myotis
Myotis thysanodes	Fringed myotis
Myotis volans	Long-legged myotis
Myotis yumanensis	Yuma myotis
Neotoma fuscipes	Dusky-footed woodrat
Neurotrichus gibbsii	Shrew-mole
Peromyscus maniculatus	Deer mouse
Peromyscus oreas	Forest deer mouse
Phenacomys longicaudus	Red tree vole
Phenacomys pomo	Red tree vole (CA)
Sorex bairdii	Baird's shrew
Sorex monticolus	Montane shrew
Sorex pacificus	Pacific shrew
Sorex sonomae	Fog shrew
Sorex vagrans	Vagrant shrew
Tamiasciurus douglasii	Douglas' squirrel
Tamias townsendii	Townsend's chipmunk
Tamias senex	Allen's chipmunk
Tamias siskiyou	Siskiyou chipmunk
Ursus arctos	Grizzly bear

<u>Birds</u>

Tamias senex	Allen's chipmunk
Tamias siskiyou	Siskiyou chipmunk
Ursus arctos	Grizzly bear

Birds

Accipiter gentilis	Northern goshawk
Aix sponsa	Wood duck
Brachyramphus marmoratus	Marbled murrelet
Bucephala albeola	Bufflehead
Bucephala islandica	Barrow's goldeneye
Catharus guttatus	Hermit thrush
Certhia americana	Brown creeper
Chaetura vauxi	Vaux's swift
Colaptes auratus	Northern flicker
Corvus corax	Common raven
Corvus	Common crow
Dendroica occidentalis	Hermit warbler
Dryocopus pileatus	Pileated woodpecker
Empidonax difficilis	"Western" flycatcher
Empidonax hammondii	Hammond's flycatcher
Falco peregrinus annatum	American peregrine falcon

Appendix table IV-A-6. (continued.)

Glaucidium gnoma	Northern pygmy-owl
Haliaeetus leucocephalus	Bald eagle
Histrionicus histrionicus	Harlequin duck
Ixoreus naevius	Varied thrush

Glaucidium gnoma	Northern pygmy-owl
Haliaeetus leucocephalus	Bald eagle
Histrionicus histrionicus	Harlequin duck
Ixoreus naevius	Varied thrush
Lophodytes cucullatus	Hooded merganser
Loxia curvirostra	Red crossbill
Mergus merganser	Common merganser
Otus flammeolus	Flammulated owl
Parus rufuscens	Chestnut-backed chickadee
Picoides albolarvatus	White-headed woodpecker
Picoides arcticus	Black-headed woodpecker
Picoides tridactylus	Three-toed woodpecker
Picoides villosus	Hairy woodpecker
Regulus satrapa	Golden-crowned kinglet
Sitta canadensis	Red-breasted nuthatch
Sitta carolinensis	White-breasted nuthatch
Sitta pygmaea	Pygmy nuthatch
Sphyrapicus ruber	Red-breasted sapsucker
Sphyrapicus thyroideus	Williamson's sapsucker
Strix nebulosa	Great gray owl
Strix occidentalis caurina	Northern spotted owl
Strix varia	Barred owl
Troglodytes troglodytes	Winter wren
Vireo gilvus	Warbling vireo
Wilsonia pusilla	Wilson's warbler

Strix occidentalis caurina	Northern spotted owl
Strix varia	Barred owl
Troglodytes troglodytes	Winter wren
Vireo gilvus	Warbling vireo
Wilsonia pusilla	Wilson's warbler

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Appendix B

Appendix IV-B. Species expert viability panels.

Amphibians
- Robert Anthony, panel leader, USDI Fish & Wildlife Service
- Martin Raphael, panel leader, USDA Forest Service
- Keith Aubrey, USDA Forest Service
- Steve Corn, USDI Fish & Wildlife Service
- Deanna Olson, USDA Forest Service
- Hartwell Welsh, USDA Forest Service

Arthropods
- Bruce Marcot, panel leader, USDA Forest Service
- Ed Starkey, panel leader, USDI National Park Service
- Robert Gara, University of Washington
- Jack Lattin, Oregon State University
- Andy Moldenke, Oregon State University
- David Olson, World Wildlife Fund, Washington, D.C.

Bats
- Cynthia Zabel, panel leader, USDA Forest Service
- Steve Cross, So. Oregon State College
- Elizabeth Pierson, private consultant, Berkeley, CA
- Mark Perkins, private consultant, Portland, OR
- Steve West, University of Washington

Birds
- Bruce Marcot, panel leader, USDA Forest Service
- Charles Meslow, panel leader, USDI Fish & Wildlife Service
- Charles Bruce, Corvallis, OR
- Eric Forsman, USDA Forest Service
- David Marshall, Portland, OR
- Bill McComb, Oregon State University

Bryophytes
- Robin Lesher, panel leader, USDA Forest Service
- Roger Rosentreter, USDI Bureau of Land Management
- John Christy, The Nature Conservancy
- Dan Norris, Oregon State University
- David Wagner, University of Oregon

Fungi
- Robin Lesher, panel leader, USDA Forest Service
- Joe Antonirati, University of Washington
- Bill Denison, Oregon State University
- Jim Trappe, Oregon State University

Appendix IV-B. (continued)

Lichens
- Roger Rosentreter, panel leader, USDI Bureau of Land Managem
- Bill Denison, Oregon State University
- Sherry Pittam, Oregon State University
- Bruce McCune, Oregon State University
- Fred Rhoades, Western Washington University

Mammals, other than bats
- Cynthia Zabel, panel leader, USDA Forest Service
- Robert Anthony, panel leader, USDI Fish & Wildlife Service
- Keith Aubrey, USDA Forest Service
- Steve Cross, So. Oregon State College
- Tom Kucera, private consultant, Berkeley, CA
- Bruce Marcot, USDA Forest Service
- Charles Meslow, USDI Fish & Wildlife Service
- Dan Rosenberg, Oregon State University
- Steve West, University of Washington

Marbled Murrelets
- Gary Miller, panel leader, USDI Fish & Wildlife Service
- Charles Meslow, panel leader, USDI Fish & Wildlife Service
- Eric Forsman, USDA Forest Service
- Tom Hamer, private consultant, Sedro Wooley, WA
- Ian Jones, University of British Columbia
- Kathy Kuletz, USDI Fish & Wildlife Service
- David Manuwal, University of Washington
- S. Kim Nelson, Oregon State University

Mollusks
- Bob Anthony, panel leader, USDI Fish & Wildlife Service
- Richard Holthausen, panel leader, USDA Forest Service
- Terrence Frest, Deixis Consultants, Seattle, WA
- Edward Johanness, Deixis Consultants, Seattle, WA
- Barry Roth, private consultant, San Francisco, CA

Northern Spotted Owl
- Charles Meslow, panel leader, USDI Fish & Wildlife Service
- Eric Forsman, USDA Forest Service
- Alan Franklin, Colorado State University
- Grant Gunderson, USDA Forest Service
- Larry Irwin, NCASI, Corvallis, OR
- Joe Lint, USDI Bureau of Land Management
- Gary Miller, USDI Fish & Wildlife Service
- Barry Mulder, USDI Fish & Wildlife Service

Appendix IV-B. (continued)

Old-Growth
- Tom Spies, panel leader, USDA Forest Service
- Jim Agee, University of Washington
- Tom Atzet, USDA Forest Service
- Nancy Diaz, USDA Forest Service
- Jerry Franklin, University of Washington
- Everett Hansen, Oregon State University
- Mark Harmon, Oregon State University
- Bruce Marcot, USDA Forest Service
- Reed Noss, consultant, Corvallis, OR
- David Perry, Oregon State University
- Dale Thornburgh, Humboldt State University
- Phil Weatherspoon, USDA Forest Service

Vascular Plants
- Nancy Fredricks, panel leader, USDA Forest Service
- Kenton L. Chambers, Oregon State University
- Jan Henderson, USDA Forest Service
- Russ Holmes, USDI Bureau of Land Management
- David Imper, consultant, Sacramento, CA
- Jimmy Kagan, Oregon Natural Heritage Program
- Robert Meinke, Oregon Department of Agriculture
- Julie Nelson, USDA Forest Service
- Nancy Wogen, USDI Bureau of Land Management

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Appendix C

Appendix Table IV-C-1. Species ranges, percentage of range on federal land, and percentage of range by allocation on federal land for Option 1.

Species	Season	Total range (acres)	% of range on federal land	Percent of range in: Congressionally reserved	Late-Successional Reserves	Adminstrative Withdrawn Areas	Matrix
Amphibians							
Northwestern salamander		37,175,600	38	32	49	3	16
Clouded salamander		20,723,400	45	16	61	3	20
Black salamander		8,179,700	27	8	59	7	26
Tailed frog		33,462,800	56	33	47	5	16
Oregon slender salamander		3,392,200	62	18	59	3	20
Cope's giant salamander		5,618,400	43	32	48	4	16
Pacific giant salamander		36,745,300	47	26	51	4	19
Shasta salamander		248,500	66	0	70	7	23
Dunn's salamander		12,763,000	38	11	65	2	22
Del Norte salamander		4,064,300	69	29	56	4	12
Larch Mountain salamander		1,209,500	64	22	58	6	14
Siskiyou Mountains salamander		353,000	78	2	71	8	18
Van Dyke's salamander		2,776,700	48	40	44	2	14
Cascade torrent salamander		4,863,900	49	15	61	3	21
Columbia torrent salamander		2,641,500	3	0	55	2	44
Olympic torrent salamander		3,611,400	42	64	28	0	8
Southern torrent salamander		10,448,000	37	17	62	3	17
Rough-skinned newt		49,530,400	37	23	53	4	20
Birds							
Northern goshawk		35,636,600	61	31	46	5	18
Wood duck	summer	50,733,600	39	28	49	4	19
Wood duck	winter	32,889,400	31	22	54	[illegible]	[illegible]

Columbia torrent salamander		2,641,500	3	0	55	2	44
Olympic torrent salamander		3,611,400	42	64	28	0	8
Southern torrent salamander		10,448,000	37	17	62	3	17
Rough-skinned newt		49,530,400	37	23	53	4	20
Birds							
Northern goshawk		35,636,600	61	31	46	5	18
Wood duck	summer	50,733,600	39	28	49	4	19
Wood duck	winter	32,889,400	31	22	54	3	21
Bufflehead	summer	1,055,700	98	40	32	13	15
Bufflehead	winter	57,104,800	42	29	47	4	19
Barrow's goldeneye	summer	9,108,200	79	44	35	7	14
Barrow's goldeneye	winter	6,538,800	10	12	54	6	28
Hermit thrush		33,937,300	27	14	59	3	24
Brown creeper		56,443,500	43	29	47	4	19
Vaux's swift	summer	56,431,900	43	29	48	4	19
Northern flicker		57,104,800	42	29	47	4	19
Hermit warbler	summer	34,483,300	48	22	53	4	21
Pileated woodpecker		56,120,900	43	29	48	4	19
Western flycatcher	summer	54,810,800	42	30	47	4	18
Hammond's flycatcher	summer	38,867,200	55	30	47	5	18
Northern pgymy-owl		56,854,800	42	29	47	4	19
Bald eagle	summer	41,765,400	42	21	54	4	21
Bald eagle	winter	57,106,100	42	29	47	4	19
Harlequin duck	summer	10,805,400	78	51	32	5	11
Varied thrush		55,825,300	42	29	47	4	19
Hooded merganser	summer	37,300,400	40	34	46	4	17
Red crossbill		54,743,000	44	29	48	4	19
Common merganser		56,581,200	42	29	47	4	19
Flammulated owl	summer	15,405,800	57	20	50	6	23
Chestnut-backed chickadee		51,370,500	42	31	47	4	17
White-headed woodpecker		13,298,500	61	20	50	5	24
Black-backed woodpecker		11,927,900	65	24	50	6	20
Three-toed woodpecker		7,827,600	87	53	30	6	11
Hairy woodpecker		56,662,800	43	29	47	4	19
Golden-crowned kinglet		57,104,800	42	29	47	4	19
Red-breasted nuthatch		57,058,300	43	29	47	4	19

Appendix Table IV-C-1. Option 1 continued

% of range Percent of range in:

Hairy woodpecker		56,662,800	43	29	47	4	19
Golden-crowned kinglet		57,104,800	42	29	47	4	19
Red-breasted nuthatch		57,058,300	43	29	47	4	19

Appendix Table IV-C-1. Option 1 continued

Species	season	Total range (acres)	% of range on federal land	Percent of range in: Congressionally reserved	Late-Sucessional Reserves	Adminstrative Withdrawn Areas	Matrix
Birds (continued)							
White-breasted nuthatch		28,432,300	47	17	53	5	25
Pygmy nuthatch		9,674,900	43	13	46	6	34
Red-breasted sapsucker		50,882,900	42	29	49	4	18
Williamson's sapsucker		6,259,100	58	32	40	5	23
Great gray owl		1,589,300	88	37	39	7	17
Barred owl		45,896,500	43	31	47	4	17
Winter wren		54,152,700	43	30	47	4	18
Warbling vireo	summer	56,808,200	43	29	47	4	19
Wilson's warbler	summer	55,407,800	43	30	48	4	18
Mammals							
Elk		26,353,100	48	22	53	4	21
Western red-backed vole		27,305,200	45	19	56	4	20
Southern red-backed vole		20,903,800	42	48	35	5	12
Townsend's chipmunk		36,320,000	38	32	47	4	17
Northern flying squirrel		53,855,100	44	29	47	4	19
American marten		21,361,600	65	39	39	6	17
Fisher		20,957,700	66	35	45	4	16
Dusky-footed woodrat		17,918,200	34	16	55	4	26
Shrew-mole		52,585,300	44	30	47	4	18
Deer mouse		49,286,100	37	21	52	4	22
Forest deer mouse		15,405,600	52	52	33	5	10
Red tree vole		13,071,500	35	10	64	2	24
Red tree vole (CA)		5,752,100	22	28	52	3	17
Pacific shrew		4,786,400	62	27	48	6	19
Fog shrew		16,810,900	46	15	61	3	20

Forest deer mouse		12,463,600	32	32	52		
Red tree vole		13,071,500	35	10	64	2	24
Red tree vole (CA)		5,752,100	22	28	52	3	17
Pacific shrew		4,786,400	62	27	48	6	19
Fog shrew		16,810,900	46	15	61	3	20

Appendix Table IV-C-2. Species ranges, percentage of range on federal land, and percentage of range by allocation on federal land for Option 2.

Species	season	Total range (acres)	% of range on federal land	Percent of range in: Congressionally reserved	Late-Successional Reserves	Adminstrative Withdrawn Areas	Matrix
Amphibians							
Northwestern salamander		37,175,600	38	32	40	5	23
Clouded salamander		20,723,400	45	16	48	5	31
Black salamander		8,179,700	27	8	40	12	40
Tailed frog		33,462,800	56	33	37	7	23
Oregon slender salamander		3,392,200	62	18	48	4	29
Cope's giant salamander		5,618,400	43	32	44	5	19
Pacific giant salamander		36,745,300	47	26	40	6	28
Shasta salamander		248,500	66	0	67	8	25
Dunn's salamander		12,763,000	38	11	54	3	32
Del Norte salamander		4,064,300	69	29	41	9	22
Larch Mountain salamander		1,209,500	64	22	53	7	18
Siskiyou Mountains salamander		353,000	78	2	55	11	32
Van Dyke's salamander		2,776,700	48	40	41	3	16
Cascade torrent salamander		4,863,900	49	15	52	4	28
Columbia torrent salamander		2,641,500	3	0	49	2	49
Olympic torrent salamander		3,611,400	42	64	27	0	9
Southern torrent salamander		10,448,000	37	17	51	5	27
Rough-skinned newt		49,530,400	37	23	40	5	31
Birds							
Northern goshawk		35,636,600	61	31	36	7	26
Wood duck	summer	50,733,600	39	28	38	6	28
Wood duck	winter	32,889,400	31	22	41	5	32
Bufflehead	summer	1,055,700	98	40	25	16	19
Bufflehead	winter	57,104,800	42	29	37	6	28
Barrow's goldeneye	summer	9,108,200	79	44	29	9	19
Barrow's goldeneye	winter	6,538,800	10	12	40	6	42
Hermit thrush		33,937,400	27	[illegible]			

Northern goshawk		35,636,600	61	31	36	7	26
Wood duck	summer	50,733,600	39	28	38	6	28
Wood duck	winter	32,889,400	31	22	41	5	32
Bufflehead	summer	1,055,700	98	40	25	16	19
Bufflehead	winter	57,104,800	42	29	37	6	28
Barrow's goldeneye	summer	9,108,200	79	44	29	9	19
Barrow's goldeneye	winter	6,538,800	10	12	40	6	42
Hermit thrush		33,937,300	27	14	46	5	35
Brown creeper		56,443,500	43	29	37	6	28
Vaux's swift	summer	56,431,900	43	29	37	6	28
Northern flicker		57,104,800	42	29	37	6	28
Hermit warbler	summer	34,483,300	48	22	41	6	31
Pileated woodpecker		56,120,900	43	29	37	6	28
Western flycatcher	summer	54,810,800	42	30	37	6	27
Hammond's flycatcher	summer	38,867,200	55	30	36	6	27
Northern pgymy-owl		56,854,800	42	29	37	6	28
Bald eagle	summer	41,765,400	42	21	41	6	32
Bald eagle	winter	57,106,100	42	29	37	6	28
Harlequin duck	summer	10,805,400	78	51	27	7	15
Varied thrush		55,825,300	42	29	37	6	27
Hooded merganser	summer	37,300,400	40	34	38	5	24
Red crossbill		54,743,000	44	29	37	6	27
Common merganser		56,581,200	42	29	37	6	28
Flammulated owl	summer	15,405,800	57	20	36	9	34
Chestnut-backed chickadee		51,370,500	42	31	37	6	26
White-headed woodpecker		13,298,500	61	20	34	8	37
Black-backed woodpecker		11,927,900	65	24	39	8	29
Three-toed woodpecker		7,827,600	87	53	24	8	14
Hairy woodpecker		56,662,800	43	29	37	6	28
Golden-crowned kinglet		57,104,800	42	29	37	6	28
Red-breasted nuthatch		57,058,300	43	29	37	6	28

Appendix Table IV-C-2. Option 2 continued

Species	season	Total range (acres)	% of range on federal land	Congressionally reserved	Percent of range in: Late-Successional Reserves	Adminstrative Withdrawn Areas	Matrix
Birds (continued)							
White-breasted nuthatch		28,432,300	47	17	39	7	37
[illegible]		9,674,900	43	13	33	7	46

Species	season	Total range (acres)	% of range on federal land	Percent of range in: Congressionally reserved	Late-Successional Reserves	Administrative Withdrawn Areas	Matrix
Birds (continued)							
White-breasted nuthatch		28,432,300	47	17	39	7	37
Pygmy nuthatch		9,674,900	43	13	33	7	46
Red-breasted sapsucker		50,882,900	42	29	37	6	27
Williamson's sapsucker		6,259,100	58	32	29	7	33
Great gray owl		1,589,300	88	37	32	9	22
Barred owl		45,896,500	43	31	38	6	25
Winter wren		54,152,700	43	30	37	6	27
Warbling vireo	summer	56,808,200	43	29	37	6	28
Wilson's warbler	summer	55,407,800	43	30	37	6	27
Mammals							
Elk		26,353,100	48	22	42	5	31
Western red-backed vole		27,305,200	45	19	42	7	32
Southern red-backed vole		20,903,800	42	48	29	6	16
Townsend's chipmunk		36,320,000	38	32	39	5	24
Northern flying squirrel		53,855,100	44	29	37	6	28
American marten		21,361,600	65	39	30	8	23
Fisher		20,957,700	66	35	33	7	25
Dusky-footed woodrat		17,918,200	34	16	40	5	39
Shrew-mole		52,585,300	44	30	37	6	26
Deer mouse		49,286,100	37	21	40	6	33
Forest deer mouse		15,405,600	52	52	29	6	13
Red tree vole		13,071,500	35	10	54	3	33
Red tree vole (CA)		5,752,100	22	28	42	5	25
Pacific shrew		4,786,400	62	27	40	8	25
Fog shrew		16,810,900	46	15	47	6	32

Appendix Table IV-C-3. Species ranges, percentage of range on federal land, and percentage of range by allocation on federal land for Option 3.

Species	season	Total range (acres)	% of range on federal land	Percent of federal land in: Congressionally reserved	Late-Succession Reserves	Managed Late-sucession Reserves	Administrative Withdrawn Areas	Matrix
Amphibians								

Appendix Table IV-C-3. Species ranges, percentage of range on federal land, and percentage of range by allocation on federal land for Option 3.

Species	season	Total range (acres)	% of range on federal land	Congress-tionally reserved	Percent of federal land in: Late-Sucession Reserves	Managed Late-sucession Reserves	Adminstrative Withdrawn Areas	Matrix
Amphibians								
Northwestern salamander		37,175,600	38	32	36	4	5	23
Clouded salamander		20,723,400	45	16	41	7	5	31
Black salamander		8,179,700	27	8	36	5	12	40
Tailed frog		33,462,800	56	33	34	3	7	23
Oregon slender salamander		3,392,200	62	18	39	9	4	29
Cope's giant salamander		5,618,400	43	32	41	3	5	19
Pacific giant salamander		36,745,300	47	26	36	4	6	27
Shasta salamander		248,500	66	0	67	0	8	25
Dunn's salamander		12,763,000	38	11	49	6	3	31
Del Norte salamander		4,064,300	69	29	38	3	9	22
Larch Mountain salamander		1,209,500	64	22	48	5	7	18
Siskiyou Mountains salamand		353,000	78	2	36	19	11	32
Van Dyke's salamander		2,776,700	48	40	40	1	3	16
Cascade torrent salamander		4,863,900	19	15	45	8	4	28
Columbia torrent salamander		2,641,500	3	0	53	0	2	45
Olympic torrent salamander		3,611,400	42	64	27	0	0	9
Southern torrent salamander		10,448,000	37	17	49	2	5	26
Rough-skinned newt		49,530,400	37	23	36	5	5	30
Birds								
Northern goshawk		35,636,600	61	31	32	4	7	26
Wood duck	summer	50,733,600	39	28	36	3	6	27
Wood duck	winter	32,889,400	31	22	39	3	5	31
Bufflehead	summer	1,055,700	98	40	25	1	16	18
Bufflehead	winter	57,104,800	42	29	34	3	6	28
Barrow's goldeneye	summer	9,108,200	79	44	27	3	8	17
Barrow's goldeneye	winter	6,538,800	10	12	41	0	6	41
Hermit thrush		33,937,300	27	14	41	5	5	35
Brown creeper		56,413,500	43	29	34	3	6	28
Vaux's swift	summer	56,431,900	43	29	34	4	6	27
Northern flicker		57,104,800	42	29	34	3	6	28
Hermit warbler	summer	34,483,300	48	22	37	5	6	30
Pileated woodpecker		56,120,900	43	29	34	4	6	27
Western flycatcher	summer	54,810,800	42	30	34	4	6	26
Hammond's flycatcher	summer	38,867,200	55	30	33	4	6	26
Northern pgymy-owl		56,854,800	42	29	34	4	6	27

Brown creeper		56,413,500	43	29	34	3	6	28
Vaux's swift	summer	56,431,900	43	29	34	4	6	27
Northern flicker		57,104,800	42	29	34	3	6	28
Hermit warbler	summer	34,483,300	48	22	37	5	6	30
Pileated woodpecker		56,120,900	43	29	34	4	6	27
Western flycatcher	summer	54,810,800	42	30	34	4	6	26
Hammond's flycatcher	summer	38,867,200	55	30	33	4	6	26
Northern pgymy-owl		56,854,800	42	29	34	4	6	27
Bald eagle	summer	41,765,400	42	21	37	5	6	31
Bald eagle	winter	57,106,100	42	29	34	3	6	28
Harlequin duck	summer	10,805,400	78	51	25	2	7	14
Varied thrush		55,825,300	42	29	34	4	6	27
Hooded merganser	summer	37,300,400	40	34	36	4	5	23
Red crossbill		54,743,000	14	29	34	4	6	27
Common merganser		56,581,200	42	29	34	4	6	28
Flammulated owl	summer	15,405,800	57	20	33	3	9	34
Chesnut-backed chickadee		51,370,500	42	31	34	4	6	25
White-headed woodpecker		13,298,500	61	20	32	3	8	37
Black-backed woodpecker		11,927,900	65	24	36	4	8	28
Three-toed woodpecker		7,827,600	87	53	24	2	8	14
Hairy woodpecker		56,662,800	43	29	34	3	6	28
Golden-crowned kinglet		57,104,800	42	29	34	3	6	28
Red-breasted nuthatch		57,058,300	43	29	34	3	6	28

Appendix Table IV-C-3. Option 3 continued

Species	season	Total range (acres)	% of range on federal land	Percent of federal land in: Congressionally reserved	Late-Succession Reserves	Managed Late-succession Reserves	Adminstrative Withdrawn Areas	Matrix
Birds (continued)								
White-breasted nuthatch		28,432,300	47	17	33	5	7	37
Pygmy nuthatch		9,674,900	43	13	34	1	7	45
Red-breasted sapsucker		50,882,900	42	29	34	4	6	27
Williamson's sapsucker		6,259,100	58	32	31	0	6	31
Great gray owl		1,589,300	88	37	30	3	9	22
Barred owl		45,896,500	43	31	35	4	6	24
Winter wren		54,152,700	43	30	34	4	6	26
Warbling vireo	summer	56,808,200	43	29	34	3	6	28
Wilson's warbler	summer	55,407,800	43	30	34	4	6	27
Mammals								
Elk		26,353,300	48	22	39	5	5	30
Western red-backed vole		27,305,200	45	19	37	6	7	32
				48	30	1	6	15

Great gray owl		1,589,300	88	37	30	3	6	24
Barred owl		45,896,500	43	31	35	4	6	26
Winter wren		54,152,700	43	30	34	4	6	28
Warbling vireo	summer	56,808,200	43	29	34	3	6	27
Wilson's warbler	summer	55,407,800	43	30	34	4	6	
Mammals								
Elk		26,353,300	48	22	39	5	5	30
Western red-backed vole		27,305,200	45	19	37	6	7	32
Southern red-backed vole		20,903,800	42	48	30	1	6	15
Townsend's chipmunk		36,320,000	38	32	36	3	5	23
Northern flying squirrel		53,855,100	44	29	34	4	6	27
American marten		21,361,600	65	39	29	1	7	23
Fisher		20,957,700	66	35	29	4	7	25
Dusky-footed woodrat		17,918,200	34	16	36	4	5	39
Shrew-mole		52,585,300	44	30	34	4	6	26
Deer mouse		49,286,100	37	21	36	4	6	33
Forest deer mouse		15,405,600	52	52	28	1	6	12
Red tree vole		13,071,500	35	10	50	5	3	32
Red tree vole (CA)		5,752,100	22	28	39	3	5	25
Pacific shrew		4,786,400	62	27	37	4	8	24
Fog shrew		16,810,900	46	15	40	8	5	32

Appendix Table IV-C-4. Species ranges, percentage of range on federal land, and percentage of range by allocation on federal land for Option 4.

Species	season	Total range (acres)	% of range on federal land	Percent of range in: Congressionally reserved	Late-Sucessional Reserves*	Adminstrative Withdrawn Areas	Matrix
Amphibians							
Northwestern salamander		37,175,600	38	32	39	5	24
Clouded salamander		20,723,400	45	16	43	6	35
Black salamander		8,179,700	27	8	32	14	46
Tailed frog		33,462,800	56	33	35	7	25
Oregon slender salamander		3,392,200	62	18	41	4	36
Cope's giant salamander		5,618,400	43	32	41	6	21
Pacific giant salamander		36,745,300	47	26	37	7	30
Shasta salamander		248,500	66	0	6	24	70
Dunn's salamander		12,763,000	38	11	52	3	34
Del Norte salamander		4,064,300	69	29	39	9	24
Larch Mountain salamander		1,209,500	64	22	48	8	22
Siskiyou Mountains salamander		353,000	78	[illegible]	[illegible]	[illegible]	[illegible]

Oregon slender salamander		3,392,200	62	18	41	4	36
Cope's giant salamander		5,618,400	43	32	41	6	21
Pacific giant salamander		36,745,300	47	26	37	7	30
Shasta salamander		248,500	66	0	6	24	70
Dunn's salamander		12,763,000	38	11	52	3	34
Del Norte salamander		4,064,300	69	29	39	9	24
Larch Mountain salamander		1,209,500	64	22	48	8	22
Siskiyou Mountains salamander		353,000	78	2	38	15	44
Van Dyke's salamander		2,776,700	48	40	41	3	17
Cascade torrent salamander		4,863,900	49	15	48	4	32
Columbia torrent salamander		2,641,500	3	0	56	2	43
Olympic torrent salamander		3,611,400	42	64	28	0	8
Southern torrent salamander		10,448,000	37	17	51	6	26
Rough-skinned newt		49,530,400	37	23	38	6	33
Birds							
Northern goshawk		35,636,600	61	31	32	7	29
Wood duck	summer	50,733,600	39	28	37	6	29
Wood duck	winter	32,889,400	31	22	40	6	32
Bufflehead	summer	1,055,700	98	40	16	21	23
Bufflehead	winter	57,104,800	42	29	35	7	30
Barrow's goldeneye	summer	9,108,200	79	44	27	9	20
Barrow's goldeneye	winter	6,538,800	10	12	43	10	35
Hermit thrush		33,937,300	27	34	44	5	37
Brown creeper		56,443,500	43	29	35	7	30
Vaux's swift	summer	56,431,900	43	29	35	7	30
Northern flicker		57,104,800	42	29	35	7	30
Hermit warbler	summer	34,483,300	48	22	38	7	33
Pileated woodpecker		56,120,900	43	29	35	7	29
Western flycatcher	summer	54,810,800	42	30	35	7	28
Hammond's flycatcher	summer	38,867,200	55	30	34	7	28
Northern pygmy-owl		56,854,800	42	29	35	7	29
Bald eagle	summer	41,765,400	42	21	38	7	34
Bald eagle	winter	57,106,100	42	29	35	7	30
Harlequin duck	summer	10,805,400	78	51	26	8	16
Varied thrush		55,825,300	42	29	35	7	29
Hooded merganser	summer	37,300,400	40	34	38	5	24
Red crossbill		54,743,000	44	29	35	7	29
Common merganser		56,581,200	42	29	35	7	29
Flammulated owl	summer	15,405,800	57	20	31	11	38
Chestnut-backed chickadee		51,370,500	42	31	35	7	27

Bald eagle	winter	57,106,100	42	29	35	7	30
Harlequin duck	summer	10,805,400	78	51	26	8	16
Varied thrush		55,825,300	42	29	35	7	29
Hooded merganser	summer	37,300,400	40	34	38	5	24
Red crossbill		54,743,000	44	29	35	7	29
Common merganser		56,581,200	42	29	35	7	29
Flammulated owl	summer	15,405,800	57	20	31	11	38
Chestnut-backed chickadee		51,370,500	42	31	35	7	27
White-headed woodpecker		13,298,500	61	20	30	9	40
Black-backed woodpecker		11,927,900	65	21	34	10	32
Three-toed woodpecker		7,827,600	87	53	22	9	16
Hairy woodpecker		56,662,800	43	29	35	7	30
Golden-crowned kinglet		57,104,800	42	29	35	7	30
Red-breasted nuthatch		57,058,300	43	29	35	7	30

Appendix Table IV-C-4. Option 4 continued

Species	season	Total range (acres)	% of range on federal land	Percent of range in: Congressionally reserved	Late-Sucessional Reserves*	Adminstrative Withdrawn Areas	Matrix
Birds (continued)							
White-breasted nuthatch		28,432,300	47	17	33	8	41
Pygmy nuthatch		9,674,900	43	13	30	8	48
Red-breasted sapsucker		50,882,900	42	29	35	7	29
Williamson's sapsucker		6,259,100	58	32	29	7	33
Great gray owl		1,589,300	88	37	23	13	27
Barred owl		45,896,500	43	31	36	6	26
Winter wren		54,152,700	43	30	35	7	28
Warbling vireo	summer	56,808,200	43	29	35	7	30
Wilson's warbler	summer	55,407,800	43	30	35	7	29
Mammals							
Elk		26,353,100	48	22	40	5	32
Western red-backed vole		27,305,200	45	19	38	7	35
Southern red-backed vole		20,903,800	42	48	31	6	15
Townsend's chipmunk		36,320,000	38	32	39	5	24
Northern flying squirrel		53,855,100	44	29	35	7	29
American marten		21,361,600	65	39	29	8	24
Fisher		20,957,700	66	35	30	7	28
Dusky-footed woodrat		17,918,200	34	16	37	6	42

Elk	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Western red-backed vole	27,305,200	45	19	38	7	35
Southern red-backed vole	20,903,800	42	48	31	6	15
Townsend's chipmunk	36,320,000	38	32	39	5	24
Northern flying squirrel	53,855,100	44	29	35	7	29
American marten	21,361,600	65	39	29	8	24
Fisher	20,957,700	66	35	30	7	28
Dusky-footed woodrat	17,918,200	34	16	37	6	42
Shrew-mole	52,585,300	44	30	35	7	28
Deer mouse	49,286,100	37	21	37	7	35
Forest deer mouse	15,405,600	52	52	29	6	12
Red tree vole	13,071,500	35	10	54	3	34
Red tree vole (CA)	5,752,100	22	28	40	6	26
Pacific shrew	4,786,400	62	27	36	10	27
Fog shrew	16,810,900	46	15	42	7	36

* Includes 147,000 acres of Managed Late-Successional Areas

Appendix Table IV-C-5. Species ranges, percentage of range on federal land, and percentage of range by allocation on federal land for Option 5.

Species	season	Total range (acres)	% of range on federal land	Percent of range in: Congress-ionally reserved	Late-Sucessional Reserves*	Adminstrative Withdrawn Areas	Matrix
Amphibians							
Northwestern salamander		37,175,600	38	32	32	6	30
Clouded salamander		20,723,400	45	16	36	7	41
Black salamander		8,179,700	27	8	27	16	49
Tailed frog		33,462,800	56	33	29	9	29
Oregon slender salamander		3,392,200	62	18	27	6	48
Cope's giant salamander		5,618,400	43	32	35	7	26
Pacific giant salamander		36,745,300	47	26	31	8	35
Shasta salamander		248,500	66	0	6	24	70
Dunn's salamander		12,763,000	38	11	44	4	41
Del Norte salamander		4,064,300	69	29	37	9	25
Larch Mountain salamander		1,209,500	64	22	41	9	28
Siskiyou Mountains salamander		353,000	78	2	23	21	53
Van Dyke's salamander		2,776,700	48	40	35	4	21

Cope's giant salamander		5,018,400	43	32	35	7	26
Pacific giant salamander		36,745,300	47	26	31	8	35
Shasta salamander		248,500	66	0	6	24	70
Dunn's salamander		12,763,000	38	11	44	4	41
Del Norte salamander		4,064,300	69	29	37	9	25
Larch Mountain salamander		1,209,500	64	22	41	9	28
Siskiyou Mountains salamander		353,000	78	2	23	21	53
Van Dyke's salamander		2,776,700	48	40	35	4	21
Cascade torrent salamander		4,863,900	49	15	34	6	44
Columbia torrent salamander		2,641,500	3	0	56	2	43
Olympic torrent salamander		3,611,400	42	64	28	0	8
Southern torrent salamander		10,448,000	37	17	49	6	28
Rough-skinned newt		49,530,100	37	23	32	7	38
Birds							
Northern goshawk		35,636,600	61	31	25	9	34
Wood duck	summer	50,733,600	39	28	31	8	33
Wood duck	winter	32,889,400	31	22	36	7	35
Bufflehead	summer	1,055,700	98	40	8	24	28
Bufflehead	winter	57,104,800	42	29	28	9	34
Barrow's goldeneye	summer	9,108,200	79	44	20	12	24
Barrow's goldeneye	winter	6,538,800	10	12	42	10	35
Hermit thrush		33,937,300	27	14	38	6	42
Brown creeper		56,443,500	43	29	28	9	34
Vaux's swift	summer	56,431,900	43	29	28	9	34
Northern flicker		57,104,800	42	29	28	9	34
Hermit warbler	summer	33,483,300	48	22	30	9	39
Pileated woodpecker		56,120,900	43	29	28	9	34
Western flycatcher	summer	54,810,800	42	30	29	8	33
Hammond's flycatcher	summer	38,867,200	55	30	27	9	33
Northern pgymy-owl		56,851,800	42	29	28	9	34
Bald eagle	summer	41,765,400	42	21	31	8	40
Bald eagle	winter	57,106,100	42	29	28	9	34
Harlequin duck	summer	10,805,400	78	51	20	10	19
Varied thrush		55,825,300	42	29	28	9	34
Hooded merganser	summer	37,300,400	40	34	32	6	29
Red crossbill		54,743,000	41	29	29	9	34
Common merganser		56,581,200	42	29	28	9	34
Flammulated owl	summer	15,405,800	57	20	23	14	44
Chestnut-backed chickadee		51,370,500	42	31	29	8	31
White-headed woodpecker		13,298,500	61	20	23	12	45
[illegible]		[illegible]	65	31	25	13	38

Varied thrush		55,825,300	42	29	28	9	34
Hooded merganser	summer	37,300,400	40	34	32	6	29
Red crossbill		54,743,000	41	29	29	9	34
Common merganser		56,581,200	42	29	28	9	34
Flammulated owl	summer	15,405,800	57	20	23	14	44
Chestnut-backed chickadee		51,370,500	42	31	29	8	31
White-headed woodpecker		13,298,500	61	20	23	12	45
Black-backed woodpecker		11,927,900	65	24	25	13	38
Three-toed woodpecker		7,827,600	87	53	15	12	19
Hairy woodpecker		56,662,800	43	29	28	9	34
Golden-crowned kinglet		57,104,800	42	29	28	9	34
Red-breasted nuthatch		57,058,300	43	29	28	9	34

Appendix Table IV-C-5. Option 5 continued

Species	season	Total range (acres)	% of range on federal land	Congressionally reserved	Percent of range in: Late-Sucessional Reserves*	Administrative Withdrawn Areas	Matrix
Birds (continued)							
White-breasted nuthatch		28,432,300	17	17	24	10	48
Pygmy nuthatch		9,674,900	43	13	23	11	53
Red-breasted sapsucker		50,882,900	42	29	29	8	33
Williamson's sapsucker		6,259,100	58	32	20	11	37
Great gray owl		1,589,300	88	37	10	18	34
Barred owl		45,896,500	43	31	29	8	31
Winter wren		54,152,700	43	30	29	9	33
Warbling vireo	summer	56,808,200	43	29	28	9	34
Wilson's warbler	summer	55,407,800	43	30	29	8	33
Mammals							
Elk		26,353,100	48	22	32	7	38
Western red-backed vole		27,305,200	45	19	32	9	41
Southern red-backed vole		20,903,800	42	48	27	8	17
Townsend's chipmunk		36,320,000	38	32	32	7	29
Northern flying squirrel		53,855,100	44	29	29	8	34
American marten		21,361,600	65	39	24	10	27
Fisher		20,957,700	66	35	24	9	33
Dusky-footed woodrat		17,918,200	34	16	31	7	47
Shrew-mole		52,585,300	44	30	29	9	33
Deer mouse		49,286,100	37	21	30	8	40
[illegible]		15,405,600	52	52	25	8	15

Townsend's chipmunk	36,320,000	38	32	32	7	29
Northern flying squirrel	53,855,100	44	29	29	8	34
American marten	21,361,600	65	39	24	10	27
Fisher	20,957,700	66	35	24	9	33
Dusky-footed woodrat	17,918,200	34	16	31	7	47
Shrew-mole	52,585,300	44	30	29	9	33
Deer mouse	49,286,100	37	21	30	8	40
Forest deer mouse	15,405,600	52	52	25	8	15
Red tree vole	13,071,500	35	10	47	3	39
Red tree vole (CA)	5,752,100	22	28	36	6	29
Pacific shrew	4,786,400	62	27	29	12	32
Fog shrew	16,810,900	46	15	35	8	42

* Includes 147,000 acres of Managed Late-Successional Areas

Appendix Table IV-C-7. Species ranges, percentage of range on federal land, and percentage of range by allocation on federal land for Option 7.

Species	season	Total range (acres)	% of range on federal land	Percent of range in: Congressionally reserved	Late-Sucessional Reserves*	Adminstrative Withdrawn Areas	Matrix
Amphibians							
Northwestern salamander		37,175,600	38	32	27	7	34
Clouded salamander		20,723,400	45	16	27	9	48
Black salamander		8,179,700	27	8	26	16	50
Tailed frog		33,462,800	56	33	25	10	33
Oregon slender salamander		3,392,200	62	18	27	6	48
Cope's giant salamander		5,618,400	43	32	32	7	29
Pacific giant salamander		36,745,300	47	26	26	9	39
Shasta salamander		248,500	66	0	6	24	70
Dunn's salamander		12,763,000	38	11	33	6	50
Del Norte salamander		4,064,300	69	29	18	15	38
Larch Mountain salamander		1,209,500	64	22	41	9	28
Siskiyou Mountains salamander		353,000	78	2	23	21	53
Van Dyke's salamander		2,776,700	48	40	31	5	24
Cascade torrent salamander		4,863,900	49	15	34	6	44

Pacific giant salamander		30,745,300	47	26	26	9	39
Shasta salamander		248,500	66	0	6	24	70
Dunn's salamander		12,763,000	38	11	33	6	50
Del Norte salamander		4,064,300	69	29	18	15	38
Larch Mountain salamander		1,209,500	64	22	41	9	28
Siskiyou Mountains salamander		353,000	78	2	23	21	53
Van Dyke's salamander		2,776,700	48	40	31	5	24
Cascade torrent salamander		4,863,900	49	15	34	6	44
Columbia torrent salamander		2,641,500	3	0	42	2	55
Olympic torrent salamander		3,611,400	42	64	24	0	12
Southern torrent salamander		10,448,000	37	17	32	9	41
Rough-skinned newt		49,530,400	37	23	27	8	42
Birds							
Northern goshawk		35,636,600	61	31	22	10	36
Wood duck	summer	50,733,600	39	28	27	9	37
Wood duck	winter	32,889,400	31	22	28	8	42
Bufflehead	summer	1,055,700	98	40	8	24	28
Bufflehead	winter	57,104,800	42	29	24	9	37
Barrow's goldeneye	summer	9,108,200	79	44	19	12	24
Barrow's goldeneye	winter	6,538,800	10	12	36	11	41
Hermit thrush		33,937,300	27	14	29	8	49
Brown creeper		56,443,500	43	29	24	9	37
Vaux's swift	summer	56,431,900	43	29	24	9	37
Northern flicker		57,104,800	42	29	24	9	37
Hermit warbler	summer	34,483,300	48	22	25	10	43
Pileated woodpecker		56,120,900	43	29	24	9	37
Western flycatcher	summer	54,810,800	42	30	25	9	36
Hammond's flycatcher	summer	38,867,200	55	30	25	9	36
Northern pgymy-owl		56,854,800	42	29	24	9	37
Bald eagle	summer	41,765,400	42	21	27	9	43
Bald eagle	winter	57,166,100	42	29	24	9	37
Harlequin duck	summer	10,805,400	78	51	19	10	19
Varied thrush		55,825,300	42	29	24	9	37
Hooded merganser	summer	37,300,400	40	34	27	7	32
Red crossbill		54,743,000	44	29	25	9	37
Common merganser		56,581,200	42	29	24	9	37
Flammulated owl	summer	15,405,800	57	20	21	14	44
Chestnut-backed chickadee		51,370,500	42	31	25	9	35
White-headed woodpecker		13,298,500	61	20	22	12	46
Black-backed woodpecker		11,927,900	65	24	24	13	39
Three-toed woodpecker		7,827,600	87	53	15	13	19

Hooded merganser	summer	37,300,400	40	34	27	7	32
Red crossbill		54,743,000	44	29	25	9	37
Common merganser		56,581,200	42	29	24	9	37
Flammulated owl	summer	15,405,800	57	20	21	14	44
Chestnut-backed chickadee		51,370,500	42	31	25	9	35
White-headed woodpecker		13,298,500	61	20	22	12	46
Black-backed woodpecker		11,927,900	65	24	24	13	39
Three-toed woodpecker		7,827,600	87	53	15	13	19
Hairy woodpecker		56,662,800	43	29	24	9	37
Golden-crowned kinglet		57,104,800	42	29	24	9	37
Red-breasted nuthatch		57,058,300	43	29	24	9	37

Appendix Table IV-C-7. Option 7 continued

Species	season	Total range (acres)	% of range on federal land	Percent of range in: Congressionally reserved	Late-Sucessional Reserves*	Adminstrative Withdrawn Areas	Matrix
Birds (continued)							
White-breasted nuthatch		28,432,300	47	17	23	10	49
Pygmy nuthatch		9,674,900	43	13	23	11	53
Red-breasted sapsucker		50,882,900	42	29	25	9	37
Williamson's sapsucker		6,259,100	58	32	20	11	37
Great gray owl		1,589,300	88	37	10	18	34
Barred owl		45,896,500	43	31	25	9	35
Winter wren		54,152,700	43	30	25	9	36
Warbling vireo	summer	56,808,200	43	29	24	9	37
Wilson's warbler	summer	55,407,800	43	30	25	9	36
Mammals							
Elk		26,353,100	48	22	28	8	43
Western red-backed vole		27,305,200	45	19	25	10	46
Southern red-backed vole		20,903,800	42	48	25	9	18
Townsend's chipmunk		36,320,000	38	32	28	7	32
Northern flying squirrel		53,855,100	44	29	25	9	37
American marten		21,361,600	65	39	21	11	30
Fisher		20,957,700	66	35	21	10	34
Dusky-footed woodrat		17,918,200	34	16	24	8	52
Shrew-mole		52,585,300	44	30	25	9	36
Deer mouse		49,286,100	37	21	25	9	44
Forest deer mouse		15,405,600	52	52	23	9	16
Red tree vole		13,071,500	35	10	34	5	50

Northern flying squirrel	53,855,100	44	29	25	9	37
American marten	21,361,600	65	39	21	11	30
Fisher	20,957,700	66	35	21	10	34
Dusky-footed woodrat	17,918,200	34	16	24	8	52
Shrew-mole	52,585,300	44	30	25	9	36
Deer mouse	49,286,100	37	21	25	9	44
Forest deer mouse	15,405,600	52	52	23	9	16
Red tree vole	13,071,500	35	10	34	5	50
Red tree vole (CA)	5,752,100	22	28	28	9	35
Pacific shrew	4,786,400	62	27	25	12	37
Fog shrew	16,810,900	46	15	26	10	49

* Includes 147,000 acres of Managed Late-Successional Areas

Appendix Table IV-C-8. Species ranges, percentage of range on federal land, and percentage of range by allocation on federal land for Option 8.

Species	Season	Total range (acres)	% of range on federal land	Congressionally reserved	Percent of range in: Late-Successional Reserves	Adminstrative Withdrawn Areas	Matrix
Amphibians							
Northwestern salamander		37,175,600	38	32	35	6	28
Clouded salamander		20,723,400	45	16	40	6	38
Black salamander		8,179,700	27	8	29	15	48
Tailed frog		33,462,800	56	33	32	8	27
Oregon slender salamander		3,392,200	62	18	37	5	39
Cope's giant salamander		5,618,400	43	32	39	6	23
Pacific giant salamander		36,745,300	47	26	34	8	32
Shasta salamander		248,500	66	9	6	24	70
Dunn's salamander		12,763,000	38	11	48	3	37
Del Norte salamander		4,064,300	69	29	37	10	25
Larch Mountain salamander		1,209,500	64	22	47	8	23
Siskiyou Mountains salamander		353,000	78	2	30	17	51
Van Dyke's salamander		2,776,700	48	40	40	3	18
Cascade torrent salamander		4,863,900	49	15	44	5	36
Columbia torrent salamander		2,641,500	3	0	53	2	45
Olympic torrent salamander		3,611,400	42	64	27	0	9
Southern torrent salamander		10,448,000	37	17	49	6	28
Rough-skinned newt		49,530,400	37	23	34	6	36

Siskiyou Mountains salamander		353,000	78	2	30	17	51
Van Dyke's salamander		2,776,700	48	40	40	3	18
Cascade torrent salamander		3,863,900	49	15	44	5	36
Columbia torrent salamander		2,641,500	3	0	53	2	45
Olympic torrent salamander		3,611,400	42	64	27	0	9
Southern torrent salamander		10,448,000	37	17	49	6	28
Rough-skinned newt		49,530,400	37	23	34	6	36
Birds							
Northern goshawk		35,636,600	61	31	29	8	32
Wood duck	summer	50,733,600	39	28	33	7	32
Wood duck	winter	32,889,400	31	22	37	6	35
Bufflehead	summer	1,055,700	98	40	15	21	23
Bufflehead	winter	57,104,800	42	29	31	8	33
Barrow's goldeneye	summer	9,168,200	79	44	22	10	23
Barrow's goldeneye	winter	6,538,800	10	12	32	10	46
Hermit thrush		33,937,300	27	14	39	6	41
Brown creeper		56,443,500	43	29	31	8	33
Vaux's swift	summer	56,431,900	43	29	31	8	32
Northern flicker		57,104,800	42	29	31	8	33
Hermit warbler	summer	34,483,300	48	22	34	8	36
Pileated woodpecker		56,120,900	43	29	31	8	32
Western flycatcher	summer	54,810,800	42	30	33	7	31
Hammond's flycatcher	summer	38,867,200	55	30	30	8	32
Northern pygmy-owl		56,854,800	42	29	31	8	32
Bald eagle	summer	41,765,400	42	23	34	8	37
Bald eagle	winter	57,106,100	42	29	31	8	33
Harlequin duck	summer	10,805,400	78	51	22	9	18
Varied thrush		55,825,300	42	29	31	8	32
Hooded merganser	summer	37,300,400	40	34	34	5	28
Red crossbill		54,743,000	44	29	31	8	32
Common merganser		56,581,200	42	29	31	8	32
Flammulated owl	summer	15,405,800	57	20	28	12	40
Chestnut-backed chickadee		51,370,500	42	31	31	7	30
White-headed woodpecker		13,298,500	61	20	27	10	43
Black-backed woodpecker		11,927,900	65	24	30	11	36
Three-toed woodpecker		7,827,600	87	53	19	10	18
Hairy woodpecker		56,662,800	43	29	31	8	33
Golden-crowned kinglet		57,101,800	42	29	31	8	33
Red-breasted nuthatch		57,058,300	43	29	31	8	33

Appendix Table IV-C-8. Option 8 continued

White-headed woodpecker		13,298,500	61	20	27	10	43
Black-backed woodpecker		11,927,900	65	24	30	11	36
Three-toed woodpecker		7,827,600	87	53	19	10	18
Hairy woodpecker		56,662,800	43	29	31	8	33
Golden-crowned kinglet		57,101,800	42	29	31	8	33
Red-breasted nuthatch		57,058,300	43	29	31	8	33

Appendix Table IV-C-8. Option 8 continued

Species	season	Total range (acres)	% of range on federal land	Percent of range in: Congressionally reserved	Late-Successional Reserves	Administrative Withdrawn Areas	Matrix
Birds (continued)							
White-breasted nuthatch		28,432,300	47	17	29	9	44
Pygmy nuthatch		9,674,900	43	13	27	9	51
Red-breasted sapsucker		50,882,900	42	29	32	8	32
Williamson's sapsucker		6,259,100	58	32	24	8	36
Great gray owl		1,589,300	88	37	22	13	28
Barred owl		45,896,500	43	31	32	7	29
Winter wren		54,152,700	43	30	31	8	31
Warbling vireo	summer	56,808,200	43	29	31	8	33
Wilson's warbler	summer	55,407,800	13	30	31	7	32
Mammals							
Elk		26,353,100	48	22	36	6	36
Western red-backed vole		27,305,200	45	19	35	8	38
Southern red-backed vole		20,903,800	42	48	27	7	18
Townsend's chipmunk		36,320,000	38	32	34	5	28
Northern flying squirrel		53,855,100	44	29	31	7	32
American marten		21,361,600	65	39	26	9	26
Fisher		20,957,700	66	35	27	8	31
Dusky-footed woodrat		17,918,200	34	16	34	6	45
Shrew-mole		52,585,300	44	30	32	7	31
Deer mouse		49,286,100	37	21	33	7	38
Forest deer mouse		15,405,600	52	52	26	7	15
Red tree vole		12,071,500	35	10	49	3	37
Red tree vole (CA)		5,752,100	22	28	38	6	28
Pacific shrew		4,786,400	62	27	33	11	29
Fog shrew		16,810,900	46	15	39	7	39

Deer mouse		49,286,100	37	21	33	7	38
Forest deer mouse		15,305,600	52	52	26	7	15
Red tree vole		12,071,500	35	10	49	3	37
Red tree vole (CA)		5,752,100	22	28	38	6	28
Pacific shrew		4,786,400	62	27	33	11	29
Fog shrew		16,810,900	46	15	39	7	39

Appendix Table IV-C-9. Species ranges, percentage of range on federal land, and percentage of range by allocation on federal land for Option 9.

Species	season	Total range (acres)	% of range on federal land	Percent of federal land in: Congressionally reserved	Late-Successional Reserves	Adaptive Management Areas	Adminstrative Withdrawn Areas	Matrix
Amphibians								
Northwestern salamander		37,175,600	38	32	31	7	5	25
Clouded salamander		20,723,400	45	16	35	7	6	36
Black salamander		8,179,700	27	8	29	10	14	39
Tailed frog		33,462,800	56	33	29	7	7	24
Oregon slender salamander		3,392,200	62	18	28	7	6	41
Cope's giant salamander		5,618,400	43	32	34	11	5	18
Pacific giant salamander		36,745,300	47	26	30	7	7	30
Shasta salamander		248,500	66	0	7	0	24	69
Dunn's salamander		12,763,000	38	11	41	9	3	36
Del Norte salamander		4,064,300	69	29	35	2	10	25
Larch Mountain salamander		1,209,500	64	22	34	15	6	23
Siskiyou Mountains salamand		353,000	78	2	22	66	4	6
Van Dyke's salamander		2,776,700	48	40	36	9	3	13
Cascade torrent salamander		4,863,900	49	15	34	6	6	39
Columbia torrent salamander		2,641,500	3	0	7	87	0	6
Olympic torrent salamander		3,611,400	42	64	27	9	0	0
Southern torrent salamander		10,448,000	37	17	45	6	6	25
Rough-skinned newt		49,530,400	37	23	31	8	6	32
Birds								
Northern goshawk		35,636,600	61	31	27	5	7	29
Wood duck	summer	50,733,600	39	28	31	7	6	28
Wood duck	winter	32,889,400	31	22	34	10	6	29
Bufflehead	summer	1,055,700	98	40	15	0	21	24
Bufflehead	winter	57,104,800	42	29	29	6	7	29
Barrow's goldeneye	summer	9,108,200	79	44	22	4	9	21
Barrow's goldeneye	winter	6,538,800	10	12	38	10	10	31
Hermit thrush		33,937,300	27	14	37	10	5	34

Northern goshawk		35,636,600	61	31	27	5	7	29
Wood duck	summer	50,733,600	39	28	31	7	6	28
Wood duck	winter	32,889,400	31	22	34	10	6	29
Bufflehead	summer	1,055,700	98	40	15	0	21	24
Bufflehead	winter	57,104,800	42	29	29	6	7	29
Barrow's goldeneye	summer	9,108,200	79	44	22	4	9	21
Barrow's goldeneye	winter	6,538,800	10	12	38	10	10	31
Hermit thrush		33,937,300	27	14	37	10	5	34
Brown creeper		56,443,500	43	29	29	6	7	29
Vaux's swift	summer	56,431,900	43	29	29	6	7	29
Northern flicker		57,104,800	42	29	29	6	7	29
Hermit warbler	summer	34,483,300	48	22	31	7	7	33
Pileated woodpecker		56,120,900	43	29	29	6	7	29
Western flycatcher	summer	54,810,800	42	30	29	6	7	28
Hammond's flycatcher	summer	38,867,200	55	30	29	6	7	28
Northern pgymy-owl		56,854,800	42	29	29	6	7	29
Bald eagle	summer	41,765,400	42	21	32	7	7	33
Bald eagle	winter	57,106,100	42	29	29	6	7	29
Harlequin duck	summer	10,805,400	78	53	21	4	8	17
Varied thrush		55,825,300	42	29	29	6	7	29
Hooded merganser	summer	37,300,400	40	34	31	6	5	25
Red crossbill		54,743,000	44	29	29	6	7	28
Common merganser		56,581,200	42	29	29	6	7	29
Flammulated owl	summer	15,405,800	57	20	28	5	11	36
Chestnut-backed chickadee		51,370,500	42	31	29	7	7	26
White-headed woodpecker		13,298,500	61	20	27	7	9	38
Black-backed woodpecker		11,927,900	65	24	28	4	10	34
Three-toed woodpecker		7,827,600	87	53	20	4	8	15
Hairy woodpecker		56,662,800	43	29	29	6	7	29
Golden-crowned kinglet		57,104,800	42	29	29	6	7	29
Red-breasted nuthatch		57,058,300	43	29	29	6	7	29

Appendix Table IV-C-9. Option 9 continued

Species	season	Total range (acres)	% of range on federal land	Percent of federal land in: Congressionally reserved	Late-Sucessional Reserves	Adaptive Management Areas	Adminstrative Withdrawn Areas	Matrix
Birds (continued)								
White-breasted nuthatch		28,432,300	47	17	28	6	8	40
Pygmy nuthatch		9,674,900	43	13	29	3	8	47
Red-breasted sapsucker		50,882,900	42	29	29	7	7	28
Williamson's sapsucker		6,259,100	58	32	27	2	6	33

Species	season	Total range (acres)	on federal land	Congressionally reserved	Late-Sucessional Reserves	Adaptive Management Areas	Administrative Withdrawn Areas	Matrix
Birds (continued)								
White-breasted nuthatch		28,432,300	47	17	28	6	8	40
Pygmy nuthatch		9,674,900	43	13	29	3	8	47
Red-breasted sapsucker		50,882,900	42	29	29	7	7	28
Williamson's sapsucker		6,259,100	58	32	27	2	6	33
Great gray owl		1,589,300	88	37	20	3	13	27
Barred owl		45,896,500	43	31	30	6	6	26
Winter wren		54,152,700	43	30	29	6	7	28
Warbling vireo	summer	56,808,200	43	29	29	6	7	29
Wilson's warbler	summer	55,407,800	43	30	29	6	7	28
Mammals								
Elk		26,353,100	48	22	33	5	6	35
Western red-backed vole		27,305,200	45	19	32	8	8	33
Southern red-backed vole		20,903,800	42	48	27	5	5	14
Townsend's chipmunk		36,320,000	38	32	32	7	4	25
Northern flying squirrel		53,855,100	44	29	29	6	7	29
American marten		21,361,600	65	39	27	3	8	23
Fisher		20,957,700	66	35	26	6	7	26
Dusky-footed woodrat		17,918,200	34	16	30	8	6	41
Shrew-mole		52,585,300	44	30	30	6	7	27
Deer mouse		49,286,100	37	21	31	7	7	34
Forest deer mouse		15,405,600	52	52	25	6	5	11
Red tree vole		13,071,500	35	10	40	9	3	37
Red tree vole (CA)		5,752,100	22	28	37	7	7	21
Pacific shrew		4,786,400	62	27	31	0	11	31
Fog shrew		16,810,900	46	15	35	7	7	36

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