UPLAND FOREST VEGETATION ANALYSIS: UMATILLA AND MEACHAM WATERSHEDS

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INTRODUCTION

Ecosystem analysis at the watershed scale is used to characterize the human, aquatic, riparian, and terrestrial conditions and processes within a watershed. It provides a systematic way to understand and organize ecosystem information. In so doing, watershed analysis enhances our ability to estimate the effects of management activities and disturbance[1] agents in a drainage. The understanding gained from ecosystem analysis is critical for helping to sustain the health and productivity of natural resources administered on behalf of the American people (Regional Ecosystem Office 1995).

Federal agencies view ecosystem analysis as a way to shift their focus from individual species and sites to the larger ecosystems that support them. It is believed that this change in perspective will improve understanding about the ecological consequences of management actions before they are implemented. A watershed is used as the analysis unit because it represents a mid-scale land area with relatively homogenous features and processes, at least from a hydrologic standpoint (Regional Ecosystem Office 1995).

Watershed analysis is driven by issues. Rather than attempting to address everything in the ecosystem, analysis teams focus on watershed-specific issues and concerns. The issues and concerns may be known or suspected before embarking on the process, or may be discovered during the analysis itself. The analysis identifies ecological processes of greatest concern, establishes how well those processes are functioning, and then determines the conditions or circumstances under which restoration and other management activities could occur in the watershed (Regional Ecosystem Office 1995). An important function of watershed analysis is to set the stage for subsequent decision-making processes by providing context for fine-scale project planning (figure 1).

Watershed analysis is an incremental endeavor, with new information derived from surveys or monitoring incorporated whenever it becomes available. The Umatilla and Meacham watersheds provide an example of that concept in action because an ecosystem analysis was first completed in 1996, but subsequent project-level planning found that the vegetation data used for the first analysis was flawed. As a result of that finding, it was decided to revise the ecosystem analysis by using a different data source to characterize upland-forest conditions (EVG was used rather than satellite-based data).

Previous ecosystem analyses have analyzed forests within the context of one primary issue – vegetation sustainability. This analysis does the same. Forest sustainability is defined as being an ecosystem-oriented approach that allows the utilization of forests for multiple purposes (e.g., biodiversity, timber harvesting, non-wood products, soil and water conservation, tourism and recreation) without undermining their availability and quality for present and future generations (Gardner-Outlaw and Engelman 1999).

The vegetation analysis was designed to respond to these key questions:

1. What is the area's potential vegetation?
2. What is the current and historical situation with respect to forest cover types, size classes, density classes, and structural stages?
3. How does the current representation of forest structural stages compare with what would have been expected historically?
4. What influence have disturbance processes had on forest conditions?
5. Are existing forest conditions believed to be sustainable and, if not, what modifications could occur to create a sustainable condition?

[1] Scientific or technical terms are defined in the glossary.

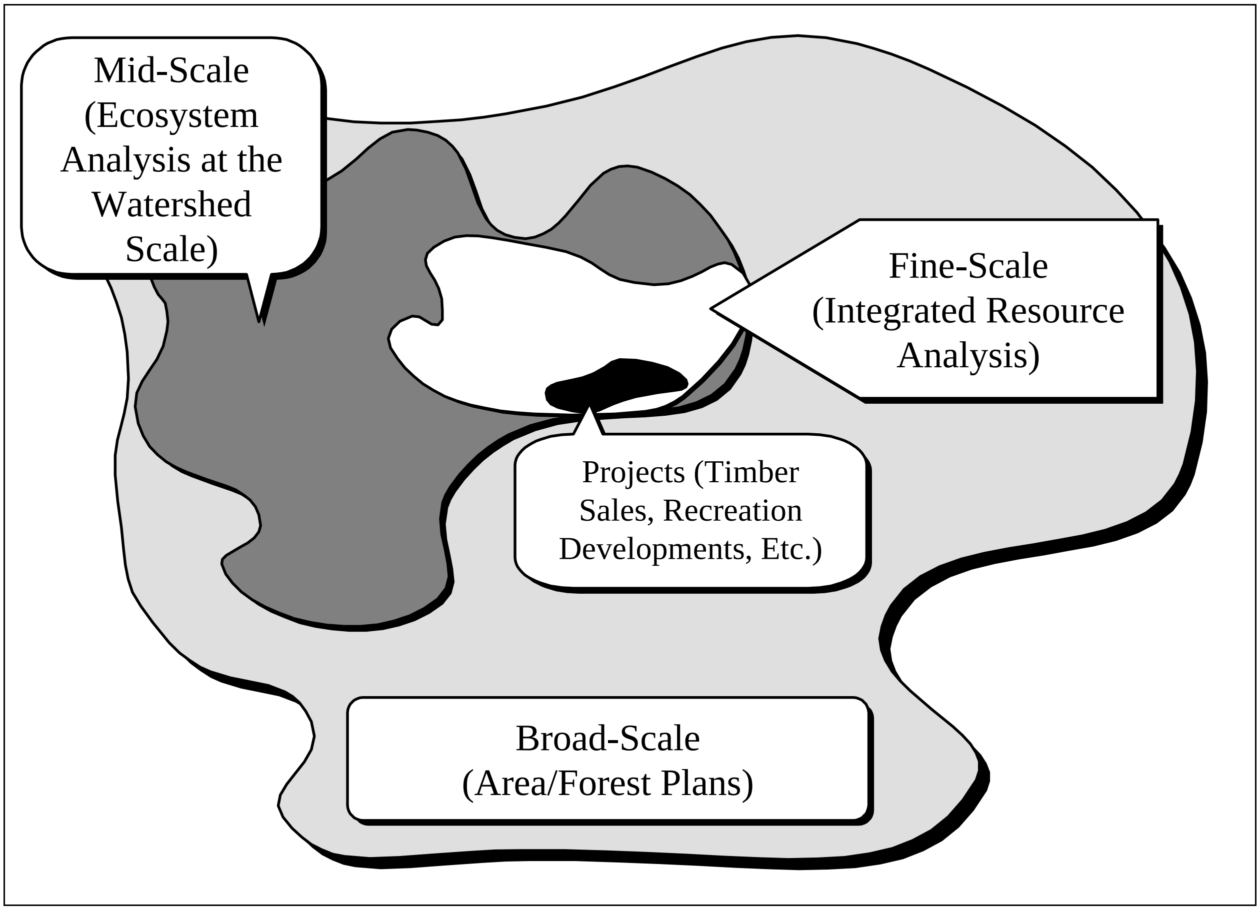


Figure 1 – Analysis scales, showing that "ecosystem analysis at the watershed scale" is considered to be a mid-scale process.

This report describes the potential vegetation, cover types, size classes, structural stages, density (canopy cover), and disturbance processes for upland forests of the Umatilla/Meacham analysis area. In addition, several other upland-forest analyses were completed, including the historical range of variability for forest structural stages, an assessment of stocking levels, and consideration of limited vegetation components. At the end of this report, an appendix describes the vegetation databases that were used during the analyses; another one provides suggested stocking levels for tree species that occur in the analysis area. A variety of information sources were used for the analyses; the most important ones are described in table 1.

POTENTIAL VEGETATION

A distant summer view of the Blue Mountains shows a dark band of coniferous forest occurring above a lighter-colored zone of grassland, shrubland, or woodland. Each of the two contrasting zones seems to be homogeneous, and the border between them appears sharp. A closer view, however, reveals great diversity within each zone and borders that are poorly defined. Herbaceous communities and stands of deciduous trees are scattered throughout the coniferous forest, and the species of dominant conifer changes from one site to another. Fingers of forest and ribbon-like shrub stands invade the adjoining grassland for varying distances but become progressively less common before disappearing entirely.

Table 1: Data sources used for analysis of upland-forest vegetation.

DATA SOURCE	DESCRIPTION
CVS (Current Vegetation Survey).	CVS is an equal-interval grid system that sampled both forest and nonforest ecosystems. Each installation was a 5-point plot cluster occupying about 1 hectare (2.5 acres). Plots were installed every 1.7 miles (3.4 miles in Wilderness). Each 1.7-mile plot represents an area of 1,853 acres. CVS plots were used to assess insect and disease risk for the analysis area.
EVG (Existing Vegetation).	EVG stores information about existing vegetation at the stand level. The original data was based on interpretation of aerial photography acquired in June and July of 1987. Photo-interpreted data is replaced with field survey results when they become available; for the Umatilla/Meacham area, 42% of the polygons were characterized using field surveys.
Government Land Office (GLO) Survey Notes.	The GLO was formed in 1812 to survey the public domain. Their survey notes described vegetation and other features. Survey notes from the late 1850s to the early 1900s were used to assemble a database, and it was then used as a source of historical information for vegetation analyses.
Historical Forest-Type Maps.	Two historical forest-type maps were used for the analysis: one published in 1936 and another in 1958 (both were produced at a scale of 1 inch = 1 mile). The maps were published by the Pacific Northwest Forest and Range Experiment Station during a county-level forest survey program.
Insect Detection and Damage Surveys.	The Pacific Northwest Region of the Forest Service has been monitoring the impacts of important forest insects since 1947, when the first aerial sketch map was completed to provide information about a spruce budworm outbreak (Dolph 1980). Sketch maps have been completed annually since then; maps from 1980-1998 were used to characterize insect-caused damage for the Umatilla/Meacham analysis area.
MSS (Managed Stand Survey).	MSS is a plot-based system that sampled young, managed stands with an average diameter of 3 inches or more – primarily plantations that had been thinned at least once. Each installation was a 5-point plot cluster covering about 1 acre. Designed to be remeasured periodically. Thirty-six MSS plots were installed in the Umatilla/Meacham analysis area in 1990.
DD (Datacell Database).	During Forest planning, a resource cell database and associated map was prepared. Fifteen factors were used to generate polygons (the factors were called line generators). Each resulting polygon was then assigned a code identifying the plant community type (Hall 1973) and slope class.
R6-TSE (Stand Exam).	Stand exams are designed to collect information at the stand level. Site, stand, tree and fuels (optional) data are collected on temporary plots. Summary information from the stand exam, including a plant association code, was then used to update the EVG database.
ADB (Activities Database).	ADB is a normalized, relational database system assembled and maintained by the Walla Walla Ranger District. Detailed information is stored about current and historical timber harvest, reforestation, site preparation, thinning, pruning, and other management activities.

Sources/Notes: See appendix 1 for more information about EVG, historical forest type maps, and stand exams.

The Blue Mountains biome, then, is actually broken up into a myriad of small units, most of which are repeated in an intricate pattern. Making sense of this landscape pattern is possible using a concept called potential vegetation (PV). Potential vegetation implies that, in the course of time and in the absence of future disturbance events, similar plant communities will develop on similar sites.

The genetic structure of a plant species allows it to be adapted to a specific range of environmental conditions, which is called its ecological amplitude (Daubenmire 1968). An ecological amplitude can be related to a variety of site factors such as elevation, aspect, geology and soil type. Together these factors create the underlying foundation, or a “geomorphic template,” upon which the biological landscape is constructed. The biophysical components of a plant’s environment interact to form a temperature and moisture regime.

Because of their diverse landforms and topography, mountainous areas support a variety of temperature and moisture regimes. Since plant distributions are influenced primarily by temperature and moisture (as controlled by their ecological amplitude), any significant change in an area’s temperature or moisture status will cause a change in plant composition. In the Umatilla/Meacham analysis area, temperature and moisture varies somewhat predictably with changes in elevation, aspect, and slope exposure (figure 2).

The climax plant composition associated with a particular set of temperature and moisture conditions is called a plant association. A plant association is named for the dominant plant species in its vegetation layers – the grand fir/twinflower plant association is dominated by grand fir in the overstory (tree) layer, and twinflower in the undergrowth layer. In the analysis area, 41 forested plant associations have been identified (Johnson and Clausnitzer 1992, Johnson and Simon 1987; see table 2).

Sites that can support similar plant associations are grouped together as a plant association group (PAG). In a similar way, closely related plant association groups can be aggregated into potential vegetation groups (PVG). The ultimate result is a hierarchy of potential vegetation, ranging from plant associations at the lowest level to potential vegetation groups at the highest level (table 2). Table 3 summarizes selected characteristics of the PVGs; table 4 summarizes PAG areas (acres) by subwatershed. Figures 3 and 4 show the location and distribution of upland-forest PAGs and PVGs, respectively.

Some vegetation types that occur frequently on the landscape have been referred to as plant community types. Plant community types often refer to vegetation that may be climax, but about which there is uncertainty. Forested plant community types have one or more dominant tree species in the overstory, and a well-developed undergrowth. The undergrowth may reflect the climax composition, but the overstory dominants are often long-lived seral trees that exist because a previous disturbance event favored their establishment instead of the climax species. In the analysis area, 7 forested plant community types have been identified (Johnson and Clausnitzer 1992, Johnson and Simon 1987; see table 2).

Why do we care about the potential vegetation (PV) of the Umatilla/Meacham area? The main reason is that PV has an important influence on ecosystem processes. It is the “engine” that powers vegetation change – it controls the speed at which shade-tolerant species get established beneath shade-intolerant trees, the rate at which forests produce and accumulate biomass, and the impact that fire, insects, pathogens, and other disturbance agents have on forest composition and structure. The implications of those processes are predictable, at least to some extent, for a reason – they can be related to PV, and research has shown that sites with the same PV behave in a similar way (Cook 1996, Daubenmire 1961).

During the Umatilla/Meacham vegetation analysis, potential vegetation (PV) was used when evaluating the effect of disturbance processes on vegetation conditions, particularly during application of a concept called the historical range of variability (HRV). PV was also used when assessing forest stocking levels, and when formulating management recommendations for situations that may be unsustainable.

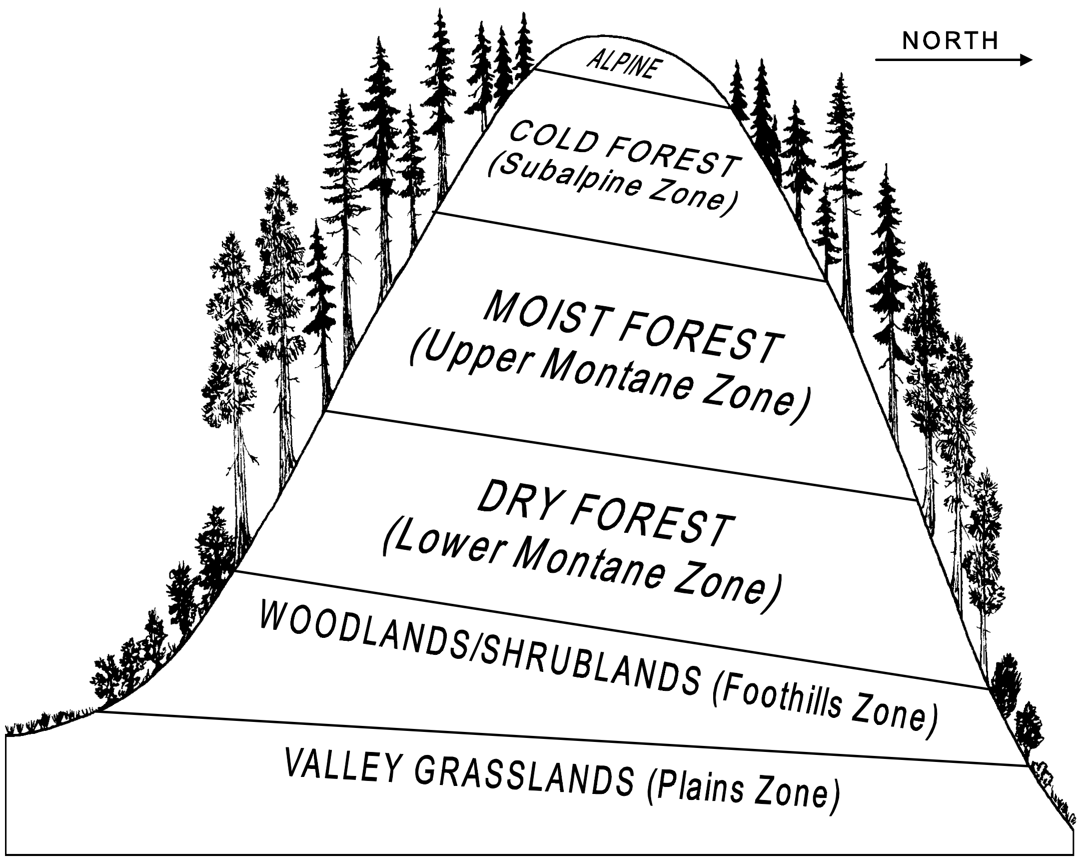


Figure 2 – Vegetation zones of the Blue Mountains. Vegetation types tend to occur in zones as one moves up or down in elevation. In the Northern Hemisphere, a south-facing slope receives more solar radiation than a flat surface, and a north-facing slope receives less. Thus the same temperature conditions found on a plateau or bench may occur higher on an adjacent south-facing slope, and lower on a north aspect. Because of this, a particular vegetation type will be found above its ordinary elevational range on south slopes and below it on north slopes (Bailey 1996). The end result is shown above – vegetation zones arranged vertically in response to elevation (moisture), and sloping downward from south to north in response to slope exposure (temperature). Each of the three forest zones typically occupies about 2,000 feet of elevation, with the upper edge of a zone controlled by tolerance to low temperatures and the lower edge by tolerance to a lack of moisture. Note that these effects can be modified by the direction of moisture-bearing winds, by variations in fog or cloud cover, and by latitude since the maritime climatic influence gradually deteriorates from north to south in the Blue Mountains. Also, fire suppression has blurred the historical zonation of forest vegetation; Douglas-fir *(Pseudotsuga menziesii)*, grand fir *(Abies grandis)* and Engelmann spruce *(Picea engelmannii)* have all expanded their ranges to lower elevations over the last 90 years. Valley grasslands occur at low elevations where moisture is too limiting to support trees except along waterways. The foothills zone tends to be dominated by western juniper *(Juniperus occidentalis)* in the central and southern Blue Mountains, although shrublands (serviceberry, hawthorne, chokecherry, etc.) occupy this zone in the northern Blues where a maritime climate prevails. Dry forests occur on hot and warm dry sites where ponderosa pine *(Pinus ponderosa)*, Douglas-fir or grand fir are the climax species. These sites were historically dominated by ponderosa pine because it is well adapted to survive a natural disturbance regime featuring low-intensity wildfires occurring every 8 to 20 years. The moist forest zone is relatively common, especially in the northern Blue Mountains. It includes moist, mixed-conifer sites where Douglas-fir, grand fir or subalpine fir are the climax species. Lodgepole pine *(Pinus contorta)* and western larch *(Larix occidentalis)* are common seral species. Western white pine *(Pinus monticola)* occurs in this forest zone. This mixed-conifer zone often has maximal species diversity because the Blue Mountains function as a transverse bridge between the Cascade Range to the west and the Rocky Mountains to the east, allowing tree species and other floristic elements from both areas to intermingle. Cold forests occur at high elevations in the subalpine zone and are dominated by forests of subalpine fir and Engelmann spruce. Lodgepole pine or whitebark pine *(Pinus albicaulis)* often forms persistent plant communities there. Above the cold-forest zone is a treeless alpine zone, although alpine environments are uncommon in the relatively low-elevation Blue Mountains.

Table 2: Potential vegetation hierarchy for the Umatilla/Meacham ecosystem analysis area.

PVG	PAG	ABBREVIATION	COMMON NAME OF VEGETATION TYPE	AREA
Cold Upland Forest	Cold Dry	ABGR/VASC	Grand Fir/Grouse Huckleberry	646
		ABLA2/CAGE	Subalpine Fir/Elk Sedge	20
		ABLA2/POPU	Subalpine Fir/Polemonium pct	25
		ABLA2/STOC	Subalpine Fir/Western Needlegrass pct	83
		ABLA2/VASC	Subalpine Fir/Grouse Huckleberry	902
		ABLA2/VASC/POPU	Subalpine Fir/Grouse Huckleberry/Polemonium	204
Moist Upland Forest	Cool Wet	ABGR/TABR/CLUN	Grand Fir/Pacific Yew/Queen's Cup Beadlily	4,649
		ABGR/TABR/LIBO2	Grand Fir/Pacific Yew-Twinflower	556
		ABLA2/STAM	Subalpine Fir/Twisted Stalk pct	73
	Cool Very Moist	ABGR/GYDR	Grand Fir/Oakfern	1,018
		ABGR/POMU-ASCA3	Grand Fir/Sword Fern-Ginger	2,595
		ABGR/TRCA3	Grand Fir/False Bugbane	1,081
		PICO(ABGR)/ALSI	Lodgepole Pine (Grand Fir)/Twisted Stalk pct	67
	Cool Moist	ABGR/CLUN	Grand Fir/Queen's Cup Beadlily	10,688
		ABGR/LIBO2	Grand Fir/Twinflower	10,345
		ABGR/VAME	Grand Fir/Big Huckleberry	15,217
		ABGR/VASC-LIBO2	Grand Fir/Grouse Huckleberry-Twinflower	539
		ABLA2/CLUN	Subalpine Fir/Queen's Cup Beadlily	3,156
		ABLA2/LIBO2	Subalpine Fir/Twinflower	48
		ABLA2/TRCA3	Subalpine Fir/False Bugbane	575
		ABLA2/VAME	Subalpine Fir/Big Huckleberry	2,290
		PICO(ABGR)/VAME	Lodgepole Pine (Grand Fir)/Big Huckleberry pct	69
	Warm Very Moist	ABGR/ACGL	Grand Fir/Rocky Mountain Maple	7,371
	Warm Moist	ABGR/ACGL-PHMA	Grand Fir/Rocky Mountain Maple-Ninebark pct	1,372
		ABGR/BRVU	Grand Fir/Columbia Brome	1,158
		PSME/ACGL-PHMA	Douglas-fir/Rocky Mountain Maple-Ninebark	1,127
Dry Upland Forest	Warm Dry	ABGR/CAGE	Grand Fir/Elk Sedge	1,252
		ABGR/CARU	Grand Fir/Pinegrass	552
		ABGR/SPBE	Grand Fir/Birchleaf Spirea	606
		GRASS/TREE MOSAIC	Grass/Tree Mosaic	8,505
		PIPO/CAGE	Ponderosa Pine/Elk Sedge	468
		PIPO/CARU	Ponderosa Pine/Pinegrass	618
		PIPO/SPBE	Ponderosa Pine/Birchleaf Spirea pct	13
		PIPO/SYAL	Ponderosa Pine/Common Snowberry	217
		PSME/CAGE	Douglas-fir/Elk Sedge	737
		PSME/CARU	Douglas-fir/Pinegrass	1,080
		PSME/HODI	Douglas-fir/Oceanspray	5,463
		PSME/PHMA	Douglas-fir/Ninebark	10,694
		PSME/SPBE	Douglas-fir/Birchleaf Spirea	40
		PSME/SYAL	Douglas-fir/Common Snowberry	1,453
		PSME/SYOR	Douglas-fir/Mountain Snowberry	202
		PSME/VAME	Douglas-fir/Big Huckleberry	238
	Hot Dry	PIPO/AGSP	Ponderosa Pine/Bluebunch Wheatgrass	470
		PIPO/FEID	Ponderosa Pine/Idaho Fescue	354

Table 2: Potential vegetation hierarchy for Umatilla/Meacham analysis area (CONTINUED).

PVG	PAG	ABBREVIATION	COMMON NAME OF VEGETATION TYPE	AREA
Moist Upland Woodland	Hot Moist	JUOC/FEID-AGSP	Western Juniper/Idaho Fescue-Bluebunch Wheatgrass	16
Wet Riparian Forest	Cold Wet HSM	ABLA2/ATFI	Subalpine Fir/Lady Fern	10
		PIEN/SETR	Engelmann Spruce/Arrowleaf Groundsel	11
	Warm Wet MSM	PSME/ACGL-PHMA (Floodplain)	Douglas-fir/Rocky Mountain Maple-Ninebark (Floodplain)	4
		NF	Nonforest (unclassified herbland & shrubland)	48,822

Sources/Notes: Adapted from Powell (1998). "Pct" after a common name refers to a plant community type (a seral or successional plant community); all other vegetation types are plant associations. The "Area" column shows the National Forest System acreage that supports the vegetation type (summarized from the 1999veg database). See appendix 2 for a list of scientific plant names corresponding to the species codes (abbreviations) that were used to name the plant associations and community types.

Table 3: Selected characteristics of potential vegetation groups (PVGs) for upland forests.

PVG	AREA (ACRES)	DISTURBANCES	FIRE REGIME	PATCH SIZE	ELEVATION (FEET)	SLOPE (PERCENT)	DOMINANT ASPECTS
Dry Upland Forest	32,961	Fire Insects Harvest	Low	1-2,000	3,872 (2,020-5,769)	41 (2-80)	North West Northeast
Moist Upland Forest	63,995	Diseases Harvest Fire Insects	Moderate	1-10,000	4,406 (2,180-5,775)	31 (1-75)	Northeast North Northwest West
Cold Upland Forest	1,880	Wind Insects Fire Diseases	High	1-1,000	5,015 (3,581-5,730)	25 (2-67)	West North Northeast Northwest

Sources/Notes: Areas, elevations, slope percents, and aspects were summarized from the 1999veg database (see appendix 1). Patch size (acres) was taken from Johnson (1993). Disturbances, which show the primary agents affecting upland-forest ecosystems, were based on the author's judgment. For elevations and slope gradients, values are portrayed in the following format: average (minimum-maximum). Fire regime ratings have the following interpretation (Agee 1993):

Low: 1-25 year fire return interval; 0-20 percent mortality of large trees; a non-lethal fire regime.
Moderate: 26-100 year fire return interval; 20-70 percent large-tree mortality; a mixed fire regime.
High: greater than 100 year fire return interval; greater than 70% large-tree mortality; a lethal fire regime.

Table 4: Area (acres) of upland-forest plant association groups by subwatershed (SWS).

SWS	Cold Dry (CD)	Cool Wet (CW)	Cool Very Moist (CVM)	Cool Moist (CM)	Warm Very Moist (WVM)	Warm Moist (WM)	Warm Dry (WD)	Hot Dry (HD)
13A		112	20	1,398	961	86	1,526	18
13B			36			103	1,039	
13C		53	413	1,833	180	170	1,102	
13D	6	15	358	2,100	152	169	768	
13E	654	138	320	6,834	178	40	737	
13F		799	161	46		38	728	
13G	56	81	1,248	2,652	407	160	1,597	
13H	4	40		2,419	256	423	1,204	
13I		540	42	2,751	541	44	932	
13J		1,402	45	1,550	182	319	1,294	
13K		1,487	325	3,121	584	281	1,545	
UMA	720	4,667	2,968	24,704	3,441	1,833	12,472	18
89A					37	60	1,120	
89B				718	100	349	1,595	
89C			260	2,137	194	426	678	
89D	14	76		635	152	99	2,195	
89E				209	19	260	418	
89F			189	1,297		15	815	
89G	215		1,221	1,869	1,422	113	2,027	
89H	564	33		2,200	1,230	125	1,655	84
89I	279	158	69	3,382	163	112	1,818	71
89J		28		143			481	
89K		73		1,601	75	14	1,638	
89L		139	54	2,151	175	6	2,641	82
89M				254	31		721	
89N				761		15	619	
89O	87	102		794	332	228	1,244	530
89Q				72				40
MEA	1,159	609	1,793	18,223	3,930	1,822	19,665	807
Total	1,879	5,276	4,761	42,927	7,371	3,655	32,137	825

Sources/Notes: Areas (acres) were summarized from the 1999veg database. This summary includes National Forest System lands only. Refer to table 2 and Powell (1998) for information about how plant associations and community types were assigned to plant association groups.

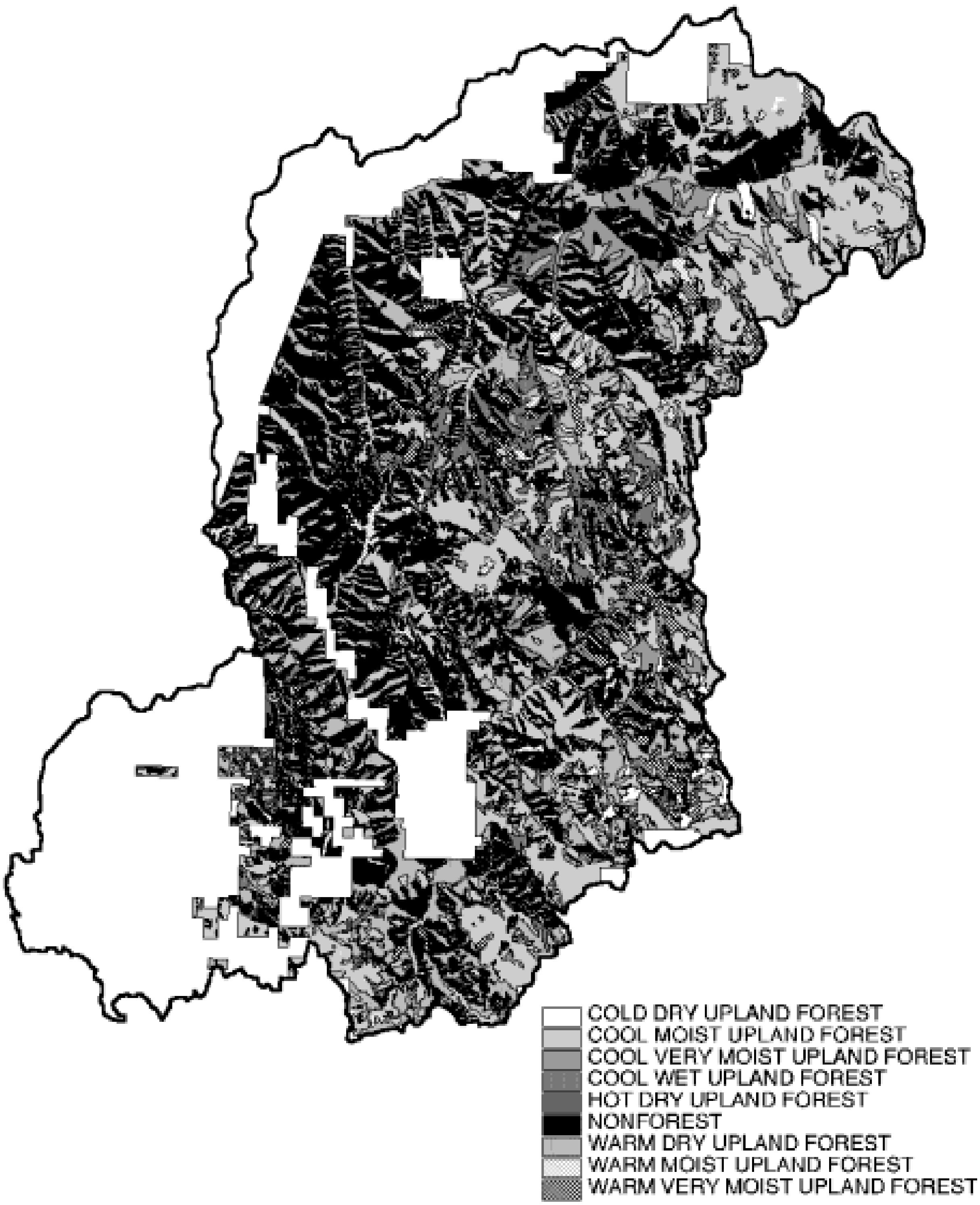


Figure 3 – Plant association groups (PAGs) for the Umatilla/Meacham analysis area. See table 2 for additional information about the upland-forest plant associations (Ecoclasses) that were aggregated to form these plant association groups.

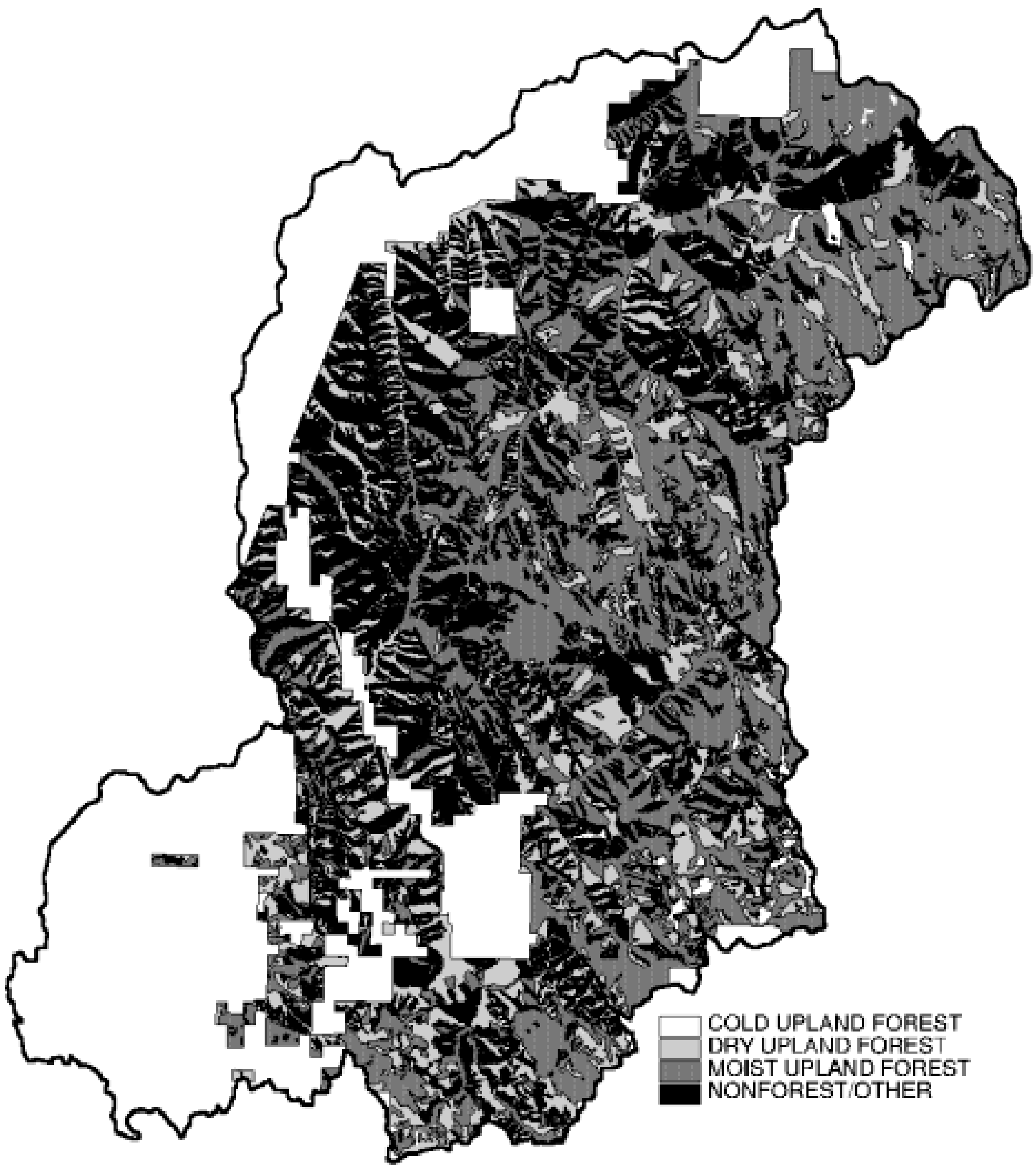


Figure 4 – Potential vegetation groups (PVGs) for the Umatilla/Meacham analysis area. See table 2 for additional information about the upland-forest plant association groups (PAGs) that were aggregated to form these potential vegetation groups.

FOREST COVER TYPES

The preceding section of this report described the potential vegetation of the Umatilla/Meacham analysis area, e.g., the plant composition that would be expected to occur if disturbances were prevented from interrupting plant succession. This section describes forest composition as it exists right now, regardless of whether it represents the potential vegetation or a transitory (successional) stage.

Tree species occur in either pure or mixed stands called cover types. Some cover types are ecologically stable, whereas others are seral (successional) plant communities. Cover types are classified using existing tree composition, so they reflect what a land manager finds on the ground and must deal with on a daily basis. Cover type classifications have a long history and are commonly used for management purposes; forest cover types of the United States and Canada are described in Eyre (1980).

Forest cover types are based on a plurality of stocking and are seldom pure – for example, the grand fir type has a predominance (50% or more) of grand fir trees, but it also contains Douglas-fir, western larch, ponderosa pine, and other species. Forested polygons containing a diverse mixture of species, no one of which comprised 50% or more of the stocking, were assigned to a mixed cover type (see table 5).

Current Conditions. Table 5 summarizes the area of existing forest cover types. It shows that the predominant forest type in the analysis area is mixed-species forest (63% of the vegetated area), followed by the grand fir (2%) and Douglas-fir (2%) forest cover types. Forest stands with a predominance of Engelmann spruce, lodgepole pine, ponderosa pine, subalpine fir, or western larch are uncommon in the Umatilla/Meacham area. Table 6 shows the area of forest cover types by subwatershed.

About 33% of the analysis area supports nonforest vegetation, most of which is grassland. Dry meadows and bunchgrass communities (dominated by fescues and bluebunch wheatgrass) are common grassland types. Shrublands comprise a relatively small proportion of the nonforest vegetation, although a diverse mix of shrub types are present. Areas of sparse vegetation also occur; those areas of shallow soil are typically referred to as scablands. Table 7 shows the area of nonforest lands by subwatershed.

Historical Conditions. Table 5 summarizes the area of historical cover types. It shows that the predominant forest type in 1958 was Douglas-fir (25% of the vegetated area), followed by the grand fir (18%) and ponderosa pine (13%) cover types. Since the 1958 vegetation map did not include a “mixed” category, it is difficult to make a direct comparison between the 1958 and 1999 forest cover types. Nevertheless, it is apparent that much of what was classified as Douglas-fir, ponderosa pine, or western larch in 1958 would eventually become “mixed” forest in 1999. Forest stands with a predominance of Engelmann spruce or lodgepole pine were relatively uncommon in the analysis area in 1958. Thirty-four percent of the analysis area supported nonforest vegetation in 1958.

In 1936, the predominant forest cover type was mixed forest (36% of the vegetated area), followed by the grand fir (14%) and ponderosa pine (10%) cover types. Forest stands with a predominance of Engelmann spruce, lodgepole pine, subalpine fir, or western larch were relatively uncommon in the analysis area in 1936. Thirty-three percent of the analysis area supported nonforest vegetation in 1936.

It is interesting that a small amount of hardwood forest (the black cottonwood forest cover type in this instance) was identified in the Umatilla/Meacham area in both 1936 and 1958, but not in 1999. An apparent loss of cottonwood reflects landscape homogenization and its associated impact on forest composition, particularly with respect to limited vegetation components such as aspen and cottonwood.

Current and historical vegetation types are compared on a percentage basis in figure 5. Figure 6 shows the location and distribution of upland-forest cover types in the analysis area.

Table 5: Area (acres) of forest cover types for the Umatilla/Meacham analysis area.

CODE	COVER TYPE DESCRIPTION	1999	1958	1936
BU	Burns at time of survey (no forest type provided)			24
CA	Forests with a predominance of subalpine fir trees	95	2,907	1,061
CC	Clearcut at time of survey (no forest type provided)		2	
CD	Forests with a predominance of Douglas-fir trees	2,365	37,737	6,065
CE	Forests with a predominance of Engelmann spruce trees	52	1,297	
CL	Forests with a predominance of lodgepole pine trees	7	1,732	1,072
CP	Forests with a predominance of ponderosa pine trees	195	19,257	14,468
CT	Forests with a predominance of western larch trees		7,790	2,664
CW	Forests with a predominance of grand fir trees	3,441	27,265	20,767
HC	Forests dominated by hardwoods (black cottonwood)		97	101
Mix	Forests with a mixed conifer composition (many species)	92,721		53,190
	Subtotal for Forests:	**98,876**	**98,084**	**99,412**
NF	Nonforested lands (not delineated further by type)	48,822	50,154	48,626
Unknown	Unclassified: cover type information was unavailable		156	356

Sources/Notes: Area (acres) were summarized from the 1999veg, 1958veg, and 1936veg databases (see appendix 1). This summary includes National Forest System lands only.

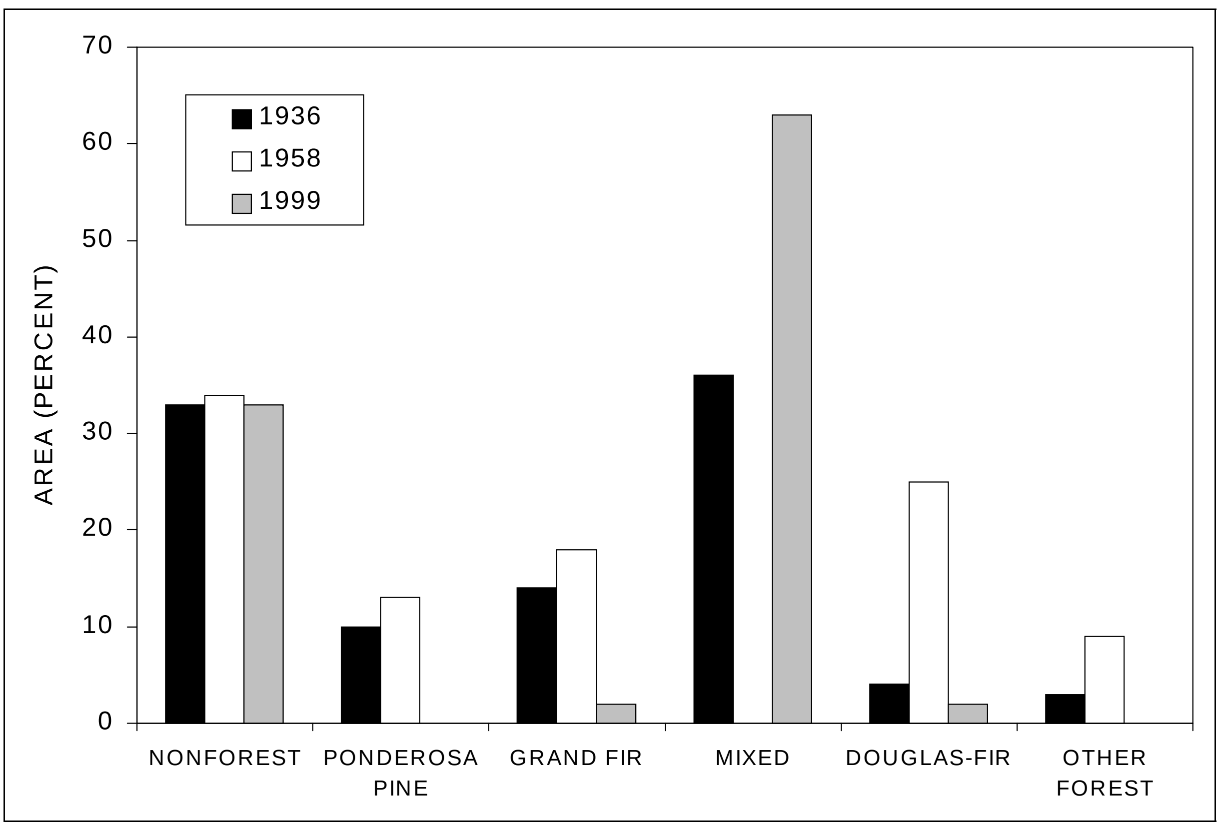


Figure 5 – Forest cover type percentages through time (“other forest” includes any type not shown separately).

Table 6: Area (acres) of upland-forest cover types by subwatershed (SWS).

SWS	Sub-alpine Fir	Douglas-fir	Engel-mann Spruce	Lodge-pole Pine	Pon-derosa Pine	Grand Fir	Mixed
13A		133				92	3,897
13B		89					1,088
13C		119				391	3,242
13D		24	26			168	3,351
13E	62	82		7		407	8,366
13F		128					1,644
13G		54			49	206	5,892
13H		34				107	4,206
13I					10	18	4,823
13J		12	14		9	377	4,381
13K					9	384	6,951
UMA	62	675	40	7	77	2,150	47,841
89A		89					1,128
89B		569			42		2,152
89C		129				125	3,441
89D		386				42	2,743
89E		25				48	833
89F						31	2,285
89G	33	59				377	6,398
89H		85	11			233	5,562
89I		108				136	5,808
89J		13					643
89K		14			77		3,311
89L		93				203	4,968
89M		66					939
89N		25				20	1,351
89O		31				79	3,208
89Q							112
MEA	33	1,692	11	0	119	1,294	44,882
Total	95	2,367	51	7	196	3,444	92,723

Sources/Notes: Areas (acres) were summarized from the 1999veg database. Refer to table 5 for a description of the forest cover types that were used as the column headings in this table. This summary includes National Forest System lands only.

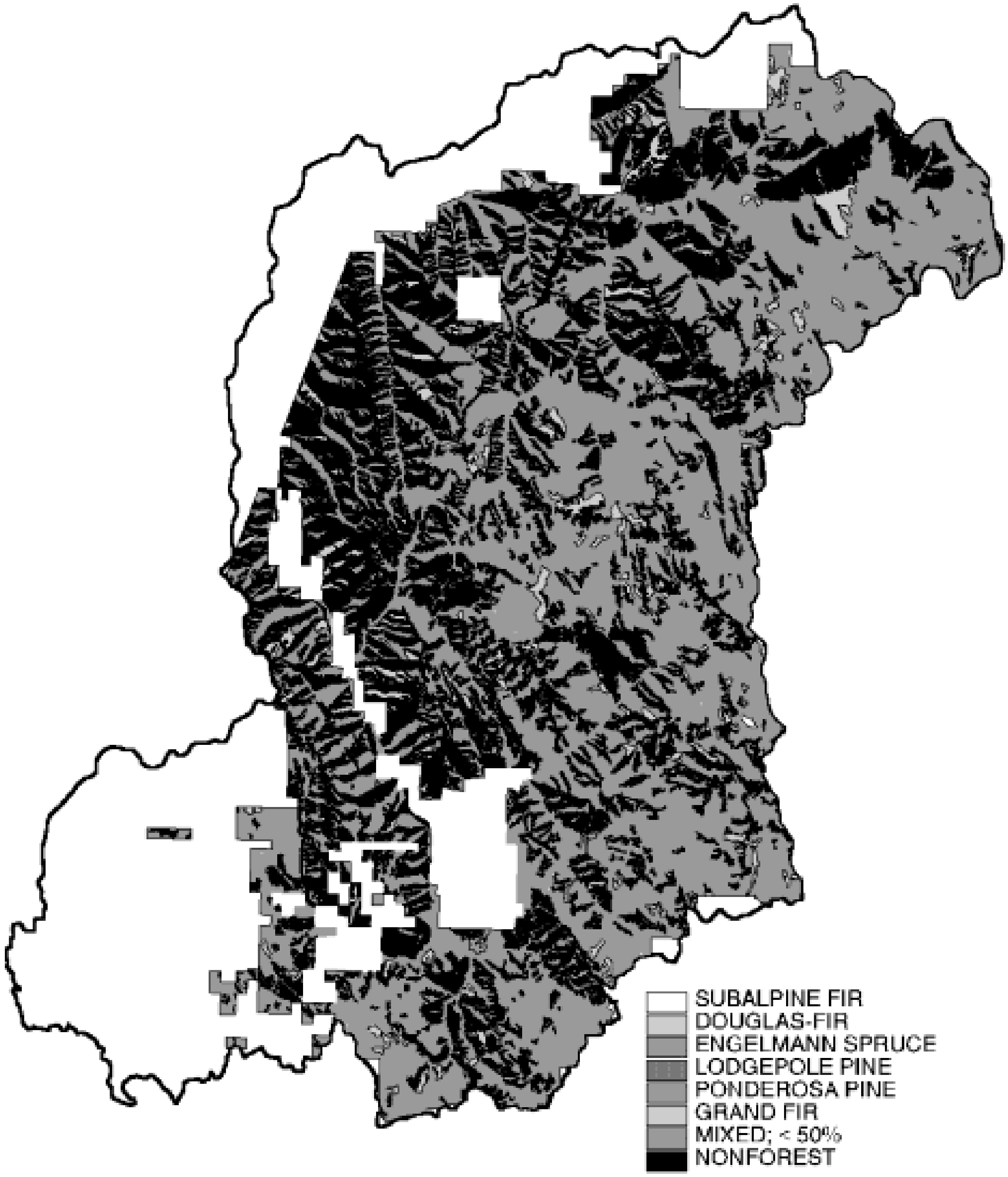


Figure 6 – Upland forest cover types of the Umatilla/Meacham analysis area (see table 5 for more information about the cover-type codes and their derivation).

IMPLICATIONS AND TRENDS

- **There has been a dramatic decline in the acreage occupied by early-seral forest types**.

Table 5 shows that the lodgepole pine and ponderosa pine cover types declined dramatically between 1958 and 1999. It also shows that the western larch cover type disappeared entirely during that period. Although declines similar to these have been reported for other areas in the Blue Mountains and elsewhere in the Interior Northwest (Lehmkuhl and others 1994, Oliver and others 1994), they were generally not of the magnitude seen here.

- **There is less nonforest vegetation now than in 1958.**

Table 7 indicates that more than 1,300 acres of nonforest vegetation was replaced with forest between 1958 and 1999 (note that a loss of 1,300 acres is the net effect because some watersheds had increases in nonforest while others had decreases). Because these changes are considered significant, table 7 summarizes forest and nonforest areas for both 1999 and 1958, and the percentage change in each, by subwatershed. Table 7 indicates that nonforest vegetation actually had a net increase in the Umatilla watershed between 1958 and 1999, whereas the Meacham drainage experienced a substantial net decrease in nonforest types during that same period.

- **There is less diversity of forest cover types now than in 1958.**

Limited forest types such as hardwoods (black cottonwood and aspen) have apparently disappeared between 1958 and 1999 (see table 5). This vegetation trend reflects the diminished role of fire, flooding (an important ecosystem process for obtaining cottonwood reproduction) and other disturbance processes that create the ecological niches required by early-seral species.

GRASS–TREE MOSAIC

An abundance of nonforest vegetation is an interesting feature of the Umatilla/Meacham area. Often, the nonforest vegetation occurs as a juxtaposition of forest and grassland referred to as a grass-tree mosaic (GTM). In general, GTM consists of stringers or "fingers" of forest alternating with nonforest communities (grasslands and shrublands). The forest sometimes occurs as "islands" rather than as linear stringers. Often, the forest stringers occupy swales, drainages, or other physiographic positions that tend to be moister than adjacent areas. Shrublands (ninebark, snowberry, chokecherry, hawthorne) occasionally occur as a transitional zone between the moister forest and the dryer grassland (the grasslands are typically dominated by Idaho fescue or bluebunch wheatgrass).

At a landscape scale, GTM patterns vary with temperature and moisture gradients, which in turn are controlled by elevation, aspect (slope exposure), and soil depth and texture (rock content, etc.). The origin of grass-tree mosaic can be traced to several factors – in some situations, it occurs under specific edaphic or physiographic conditions such as shallow soils on steep, southerly exposures; in other instances, it represents a disturbance-maintained ecosystem where historical fire patterns allowed the grassland to "hold its ground" against tree invasion.

Table 7: Area (acres) of forest and nonforest lands by subwatershed (SWS).

SWS	UPLAND FORESTS 1999	UPLAND FORESTS 1958	UPLAND FORESTS CHANGE	NONFOREST LANDS 1999	NONFOREST LANDS 1958	NONFOREST LANDS CHANGE
13A	4,122	4,106	16	2,893	2,743	150
13B	1,178	2,119	-941	907	620	287
13C	3,751	3,167	584	3,182	2,918	264
13D	3,568	3,949	-381	2,150	2,019	131
13E	8,923	9,164	-241	2,557	2,485	72
13F	1,772	1,705	67	654	456	198
13G	6,201	5,591	610	1,381	1,546	-165
13H	4,347	4,967	-620	2,458	1,820	638
13I	4,851	5,033	-182	783	326	457
13J	4,792	4,942	-150	1,104	1,326	-222
13K	7,343	7,977	-634	2,540	2,423	117
13L	0	6	-6	0	0	0
UMA	50,848	52,726	-1,878	20,609	18,682	1,927
89A	1,217	1,355	-138	2,358	2,288	70
89B	2,763	2,556	207	5,299	6,577	-1,278
89C	3,695	3,132	563	2,761	2,749	12
89D	3,171	2,419	752	3,912	3,453	459
89E	906	665	241	924	1,201	-277
89F	2,316	1,975	341	792	941	-149
89G	6,867	6,155	712	2,387	3,152	-765
89H	5,891	5,770	121	1,441	1,907	-466
89I	6,052	6,302	-250	1,825	1,762	63
89J	655	655	0	480	971	-491
89K	3,401	3,222	179	1,272	1,024	248
89L	5,264	5,863	-599	1,923	1,781	142
89M	1,005	985	20	664	150	514
89N	1,395	1,471	-76	554	377	177
89O	3,318	2,712	606	1,573	3,086	-1,513
89Q	112	123	-11	48	52	-4
MEA	48,028	45,360	2,668	28,213	31,471	-3,258
Total	98,876	98,086	790	48,822	50,153	-1,331

Sources/Notes: Areas (NFS acreage) were summarized from the 1999veg and 1958veg databases. "Upland forests" includes all of the forest cover types shown in table 5, combined. Note that the "Change" columns use 1958 as a base year; negative change values indicate a decrease between 1958 and 1999, whereas positive values indicate an increase during that time period.

FOREST SIZE CLASSES

Historically, forest size classes were defined using economically important criteria that emphasized product or utilization standards (small sawtimber, large sawtimber, etc.). Recently, size class definitions have been evolving to incorporate a biological approach based on tree size or physiological maturity. This analysis of upland-forest conditions for the Umatilla and Meacham watersheds used size class definitions that reflect tree size (size was based on tree diameter rather than height).

Current Conditions. Table 8 summarizes the area of existing forest size classes. It shows that the predominant size class is a mixture of small and medium trees, which occupies 46% of the forested area. The area occupied by other size classes is relatively well distributed, with the upper-half of the small-tree size class (15-20.9" DBH) occurring on 34% of the forested acreage, poles and the lower-half of the small-tree class (5-14.9" DBH) on 15%, medium and large trees (21-47.9" DBH) on 3%, and seedlings and saplings (0-4.9" DBH) on the remaining 2%. Table 9 provides the area of forest size classes by subwatershed.

Historical Conditions. Table 8 summarizes the area of historical forest size classes. It shows that the predominant forest size class in 1958 was medium and large trees mixed (60% of the forested area), followed by small trees (34%), poles and small trees mixed (6%), and seedlings and saplings (less than 1%). In 1936, the predominant size class was small and medium trees mixed (58% of the forested area), followed by saplings and poles mixed (20%), medium trees (15%), small trees (3%), and poles and small trees mixed (3%). Seedlings and saplings were rare in 1936, occupying less than one percent of the analysis area.

Current and historical forest size classes are compared on a percentage basis in figure 7. The location and distribution of upland-forest size classes are portrayed in figure 8.

IMPLICATIONS AND TRENDS

- **The mix of forest size classes is more diverse now than in 1958 or 1936.**

The primary reasons for size-class changes were that a commercial timber management program removed large-diameter trees and replaced them with regenerated stands of seedling-sized trees; that certain bark beetle species preferentially sought out and attacked large-diameter trees because the phloem of smaller trees is unsuitable habitat for their broods (Gast and others 1991); and that wide-area outbreaks of defoliating insects (budworm and tussock moth) initiated new stands now dominated by seedling and saplings. Some of the changes probably reflect differences in data resolution between both historical sources and the current source (the historical mapping was "coarser" and may have been biased toward large trees).

- **There is less area dominated by large trees now than there was historically.**

In 1958, stands dominated by medium or large trees comprised 60% of the forested area; in 1936, medium or large trees occupied about 73% of the area. By 1999, the forested area supporting medium or large trees had apparently declined to 49%. This change is probably due to a variety of factors, including differences in data resolution (the historical mapping was "coarser" and had been prepared using techniques that may have been biased toward large trees); plant succession (there is more within-stand diversity and heterogeneity now than previously, which means that small, understory trees counterbalance the effect of large, overstory trees); and disturbance processes (insects, windstorms, diseases, and timber harvest have all affected the abundance of large trees).

Table 8: Area (acres) of forest size classes for the Umatilla/Meacham analysis area.

CODE	SIZE CLASS DESCRIPTION	1999	1958	1936
1	Seedlings (trees less than 1 inch DBH*)	336		
2	Seedlings and saplings mixed	734	98	800
3	Saplings (trees 1-4.9” DBH)	381		
4	Saplings and poles mixed	511		20,055
5	Pole trees (5-8.9” DBH)	290		
6	Poles and small trees mixed	11,532	6,090	2,702
77	Small trees (9-14.9” DBH)	3,400		
88	Small trees (15-20.9” DBH)	33,164	33,150	3,425
8	Small trees and medium trees mixed	45,628		57,043
9	Medium trees (21-31.9” DBH)	1,460		14,301
10	Medium and large trees mixed	1,358	58,726	
11	Large trees (32-47.9” DBH)	33		
12	Large and giant trees mixed	49		
	Subtotal for Forests:	**98,876**	**98,064**	**98,326**
N/A	Not applicable (nonforest)	48,822	50,154	48,626
None	Unclassified: data unavailable or missing		175	1,085

* DBH is diameter at breast height, a measurement point standardized at 4.5 feet.

Sources/Notes: Area (acres) were summarized from the 1999veg, 1958veg, and 1936veg databases (see appendix 1). This summary includes National Forest System lands only.

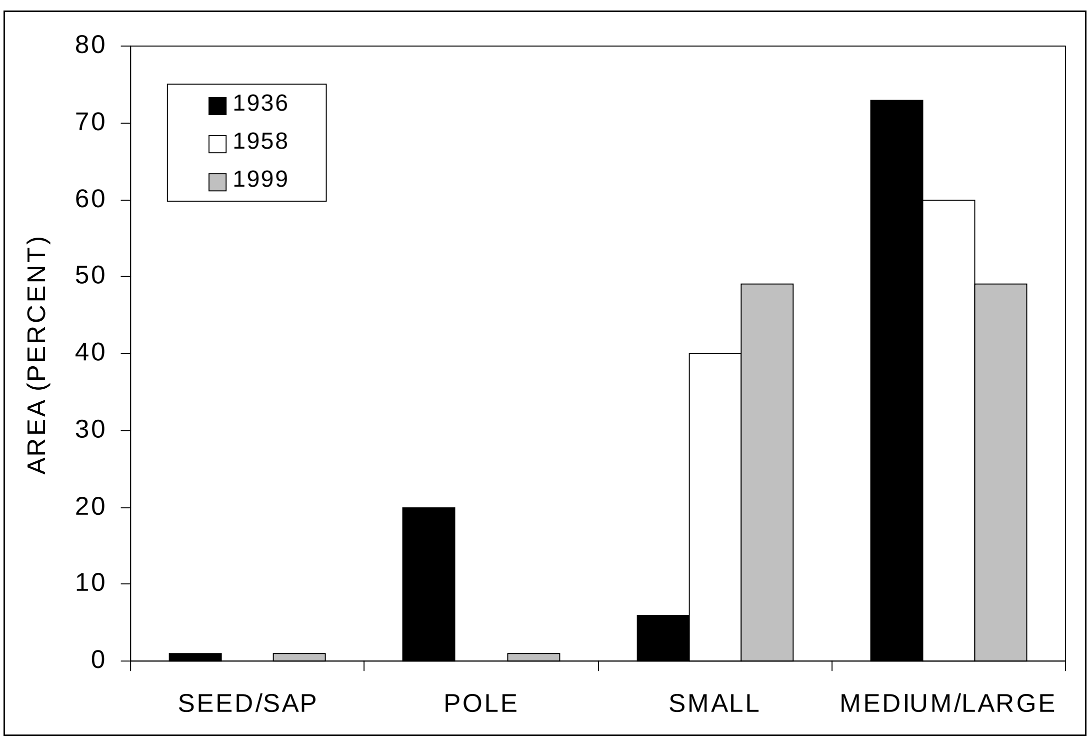


Figure 7 – Forest size class percentages through time. “Seed/sap” includes size classes 1 through 3, “pole” includes 4 and 5, “small” includes 6, 77, and 88, and “medium/large” includes classes 8-12.

Table 9: Area (acres) of upland-forest size classes (overstory only) by subwatershed (SWS).

	FOREST SIZE CLASS CODE FOR OVERSTORY TREE LAYER												
SWS	**1**	**2**	**3**	**4**	**5**	**6**	**77**	**88**	**8**	**9**	**10**	**11**	**12**
13A						539		1,447	2,119	17			
13B						77		357	623	34	87		
13C		57	46	113		219	30	338	2,502	56	390		
13D	27	11		64		323		1,529	1,496	86	32		
13E	48	138	89		51	1,533	554	3,035	3,333	51	59	33	
13F						138		38	1,595				
13G	18	278	21	44	12	1,096	20	1,447	3,091	41	133		
13H	44	23	39	21	12	805	37	1,402	1,848	113	3		
13I	1		54	31	30	607	213	1,496	2,311	49	59		
13J			5	78	39	406	323	1,381	2,354	147	59		
13K	96	132	15	85	11	926	33	2,193	3,309	177	366		
UMA	234	639	269	436	155	6,669	1,210	14,663	24,581	771	1,188	33	
89A								266	951				
89B						475		532	1,756				
89C		6	19		2	199	25	1,506	1,846	20	22		49
89D						619		725	1,763	64			
89E						111		171	623				
89F						273	723	297	1,023				
89G		4			9	440	802	2,249	3,072	291			
89H						291	229	2,959	2,093	207	111		
89I		54		18	30	414	334	2,748	2,399	52	3		
89J				14	15	36		197	395				
89K	61		50		18	341		1,976	944		11		
89L	41	22	42	43	35	854	51	2,503	1,595	55	23		
89M						195		758	52				
89N					28	229	27	844	267				
89O		8				384		769	2,157				
89Q									112				
MEA	102	94	111	75	137	4,861	2,191	18,500	21,048	689	170		49
Total	336	733	380	511	292	11,530	3,401	33,163	45,629	1,460	1,358	33	49

Sources/Notes: Areas (acres) were summarized from the 1999veg database. This summary includes National Forest System lands only. See table 8 for a description of the forest size class codes that are used as the column headings in this table.

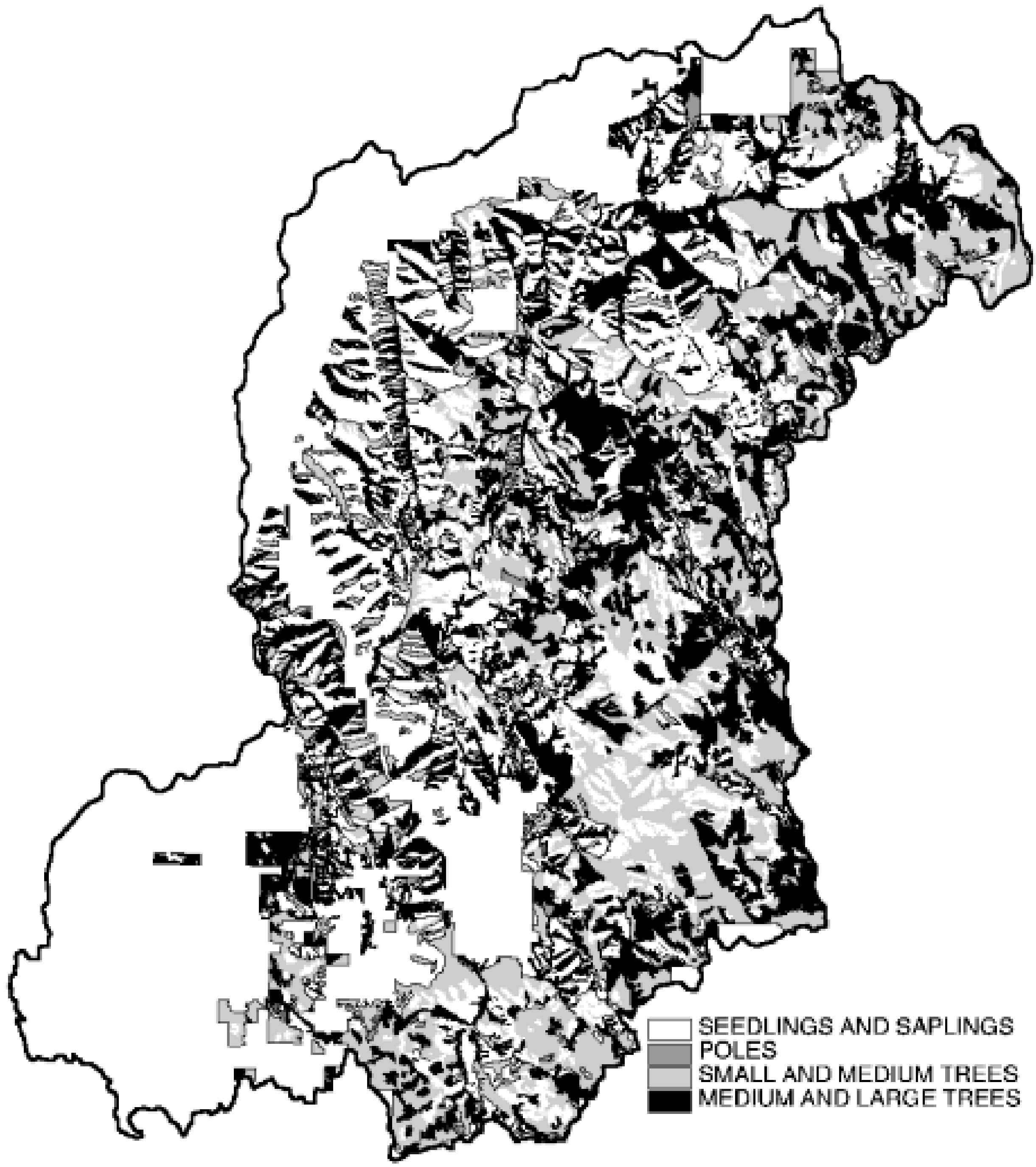


Figure 8 – Upland forest size classes (overstory layer only) for the Umatilla/Meacham analysis area. Note that "seedlings and saplings" includes size classes 1 through 3, poles includes classes 4 and 5, "small and medium trees" is classes 6, 77, and 88, and medium and large trees includes classes 8 through 12 (see table 8 for more information about the size-class codes and their derivation).

FOREST DENSITY CLASSES

Defensible, accurate inventory information is critical when completing ecosystem assessments at the fine, mid, or broad scale (see figure 1). Since the early 1990s, inventory budgets have declined substantially, resulting in reduced availability of high-resolution, fine-scale data sources (stand exams, etc.). Only 42 percent of the Umatilla and Meacham watersheds has been recently examined using field surveys such as stand examinations. For that reason, quantified data suitable for characterizing forest density (such as trees per acre or basal area per acre) was not available for the entire analysis area. Consequently, canopy cover percentages derived from a low-resolution data source (aerial photographs) were used as a proxy for a stand-based measure of forest density.

Using canopy cover percentages instead of a stand-based measure of forest density does offer certain advantages. For example, many wildlife objectives have been articulated as canopy cover percentages, particularly standards relating to elk or deer habitat (Thomas 1979). Recent recommendations for landscape-level connectivity corridors for an old-growth network in the Blue Mountains were also expressed as canopy cover percentages (Noss and Cooperrider 1994). Stocking-level recommendations, which are typically expressed as trees per acre and basal area per acre, were recently translated into their equivalent canopy cover percentages to increase their compatibility with wildlife standards (Powell 1999).

Current Conditions. Table 10 summarizes the area of existing forest density classes, as expressed using canopy cover percentages. It shows that the predominant forest situation is moderate-density stands (those with 41-70% canopy cover), a condition which occurs on 54% of the forested lands. Low-density forests (10-40% canopy cover) occupy 31% of the forested area, with the remaining 15% supporting high-density stands (71-100% canopy cover).

Historical Conditions. Table 10 also summarizes the area of historical forest densities. It shows that the predominant upland-forest situation in 1958 was high-density stands (82% of the forested area for which density information was available), followed by stands in the moderate (14%) and low (4%) density categories. In 1936, the predominant situation was moderate-density forests (52% of the forested area for which density information was available), followed by stands in the high (45%) and low (3%) density categories.

Current and historical forest density classes are compared on a percentage basis in figure 9. Figure 10 shows the location and distribution of upland-forest density classes in the analysis area.

IMPLICATIONS AND TRENDS

- **The mix of forest density classes is better balanced now than in 1958 or 1936.**

A reduction in high-density forests between 1958 and 1999 can probably be attributed to several factors, including the 1972-1974 Douglas-fir tussock moth outbreak, the 1980-1992 spruce budworm outbreak, the 1990 windstorm, late 1980s outbreaks of several bark beetles, the 1985-1992 drought, timber harvests, and other disturbance processes (see tables 15 and 20).

From a sustainability perspective, reductions in forest density have probably been beneficial. Insects and diseases provide an important mechanism for reducing forest density, thereby restoring conditions that are more sustainable and better able to survive the next perturbation (Powell 1999).

Table 10: Area (acres) of forest density classes for the Umatilla/Meacham analysis area.

CODE	FOREST DENSITY CLASS DESCRIPTION	1999	1958	1936
Low	Low-density forests (10-40% canopy cover)	30,965	2,261	837
Moderate	Moderate-density forests (41-70% canopy cover)	53,127	8,609	13,431
High	High-density forests (71-100% canopy cover)	14,784	50,645	11,793
	Subtotal for Forests:	**98,876**	**61,515**	**26,061**
N/A	Not applicable (nonforest)	48,822	50,154	48,626
None	Unclassified: data unavailable or missing		36,725	73,350

Sources/Notes: Area (acres) were summarized from the 1999veg, 1958veg, and 1936veg databases (see appendix 1). This summary includes National Forest System lands only. Note that for unknown reasons, a density class was not assigned to a substantial portion of the forested area in the 1936 and 1958 historical mapping.

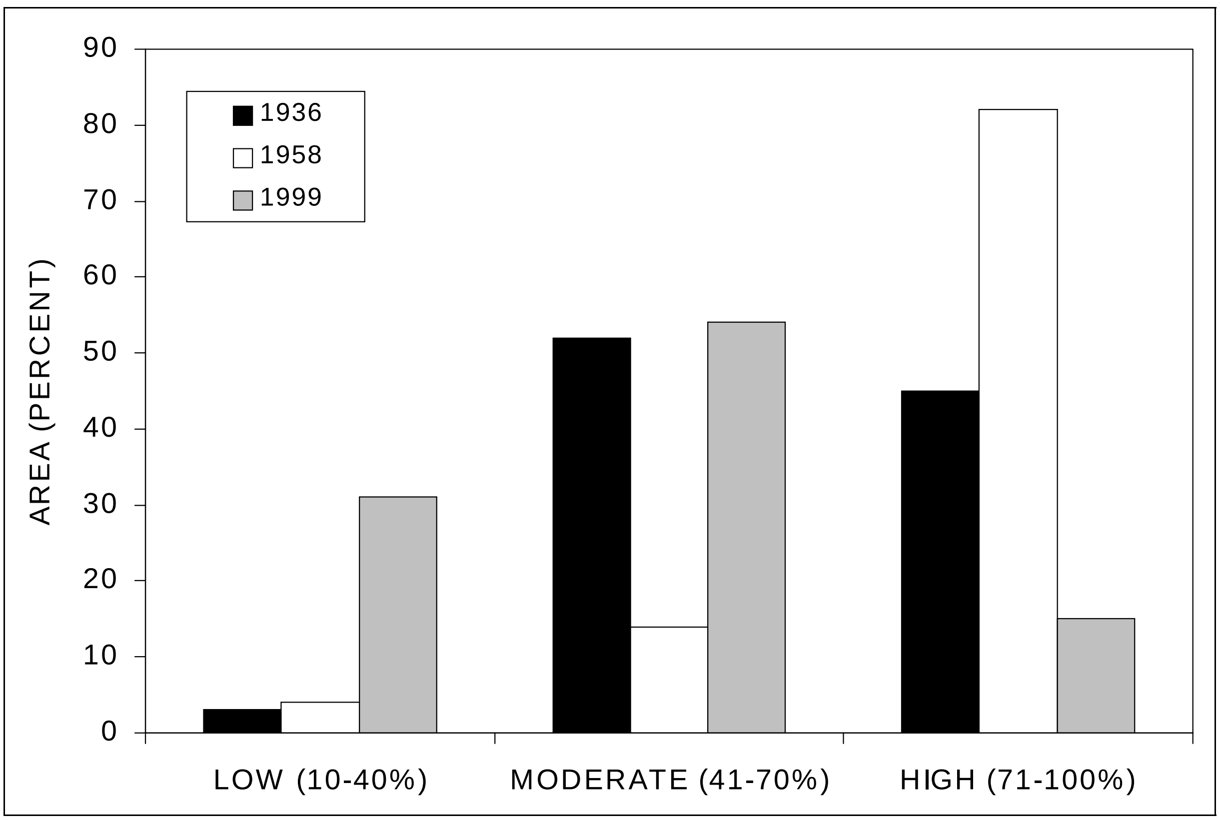


Figure 9 – Forest density class percentages through time.

Table 11: Area (acres) of upland-forest density classes by subwatershed (SWS).

SWS	LOW (10-40%)	MODERATE (41-70%)	HIGH (71-100%)
13A	781	2,739	602
13B	293	820	64
13C	427	2,711	614
13D	715	1,212	1,641
13E	2,550	5,103	1,271
13F	285	1,471	16
13G	1,918	2,985	1,297
13H	1,419	2,540	388
13I	1,963	2,565	323
13J	2,107	1,845	841
13K	2,546	3,669	1,128
UMA	15,004	27,660	8,185
89A	112	743	363
89B	450	1,893	420
89C	1,226	2,277	192
89D	647	1,987	537
89E	363	484	59
89F	828	1,286	202
89G	2,717	2,814	1,336
89H	2,235	2,536	1,120
89I	2,386	3,308	357
89J	108	520	27
89K	1,479	1,626	296
89L	1,587	2,691	986
89M	351	654	
89N	93	789	513
89O	1,339	1,860	118
89Q	40		72
MEA	15,961	25,468	6,598
Total	30,965	53,128	14,783

Sources/Notes: Areas (acres) were summarized from the 1999-veg database. This summary includes National Forest System lands only. See table 10 for a description of the forest density class codes that are used as the column headings in this table.

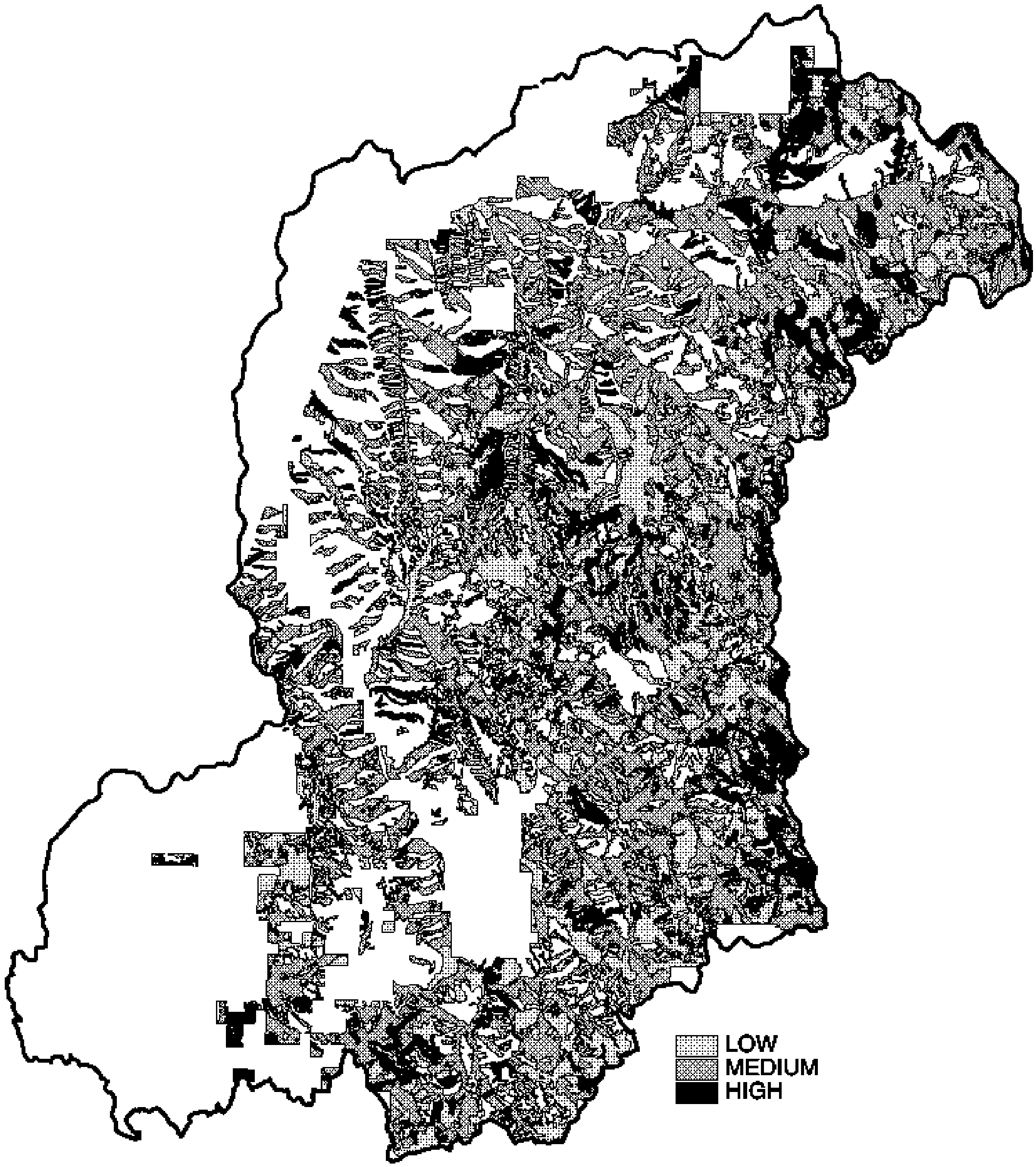


Figure 10 – Upland forest density classes for the Umatilla/Meacham analysis area (see table 10 for more information about the density-class codes and their derivation). Note that the low-density class includes forests with 10 to 40 percent canopy cover, medium includes 41 to 70 percent canopy cover, and high includes 71 percent and greater.

FOREST STRUCTURAL STAGES

As a forest matures, it passes through successive and predictable stages with regard to its structural development. It usually begins as a young, single-layer stand, but does not stay in that stage forever and eventually occupies other stages as part of a normal maturation (successional) process (see table 14). In some classification systems, structural entities have been referred to as "classes" rather than "stages" because it is not always appropriate to assume a sequential progression from one stage to another (O'Hara and others 1996).

One of the first efforts to characterize vertical forest structure in the Interior Northwest was Thomas's (1979) description of structural development for forest stands in the Blue Mountains of northeastern Oregon and southeastern Washington. Those stages described the sequential development of stands following clearcutting and, barring additional disturbance, involved a six-step progression: seedlings and saplings, saplings and poles, poles, small sawtimber, large sawtimber, and old growth. Although Thomas's stages were designed to represent vertical stand structure, their quantification was actually based on tree diameter classes rather than canopy stratification (layering).

Since publication of Thomas's classification, other structural approaches have been developed. Recently, a series of four process-based stand development stages were published by Oliver and Larson (1996). Their stages were defined primarily by the availability of, and competition for, growing space, especially by single-cohort (even-aged) stands originating after a stand-replacement disturbance event. Oliver and Larson's (1996) stages are stand initiation, closed canopy stem exclusion, understory reinitiation, and old growth.

Stand initiation begins with a stand-replacing disturbance and ends when growing space is fully occupied. Closed canopy stem exclusion is the period when intense inter-tree competition precludes new regeneration. During understory reinitiation, the single-cohort nature of a stem-exclusion stand begins to break down, and a new cohort of seedlings and saplings becomes established. The final stage, old growth, is characterized by a relative uniformity of ecological processes and an absence of trees established from allogenic (abiotic) disturbances (Oliver 1981, Oliver and Larson 1996).

Although Oliver and Larson's (1996) classification works well for the geographical area in which it was developed (coniferous forests located west of the Cascade crest in Oregon and Washington), several forest structures of the Interior Northwest do not fit their four-stage approach. Consequently, it was recently expanded to seven stages to include a greater variety of structural conditions (O'Hara and others 1996).

The three additional classes were: open canopy stem exclusion where crown cover is constrained by below-ground competition for site resources; young forest multi-strata resulting from a series of minor disturbances to the overstory (including timber harvest) that maintains a multi-layer, multi-cohort structure and precludes dominance by large trees; and old forest single stratum that consists of multi-aged trees in a single layer with large trees being a dominant feature – this stage was maintained by frequent, low-intensity surface fires or similar disturbance processes (O'Hara and others 1996).

Current Conditions. Table 12 summarizes the area of existing forest structural stages. It shows that the predominant upland-forest situation is understory reinitiation, a stage occupying 41% of forested lands within the analysis area. Other forest structural stages, and their corresponding percentages, are: stand initiation (18%); young forest multi strata (16%), old forest multi strata (14%), stem exclusion open canopy (4%), stem exclusion closed canopy (2%); and old forest single stratum (4%). Table 13 summarizes forest structural stages by subwatershed.

Historical Conditions. Table 12 also summarizes the historical area of forest structural stages. It shows that the predominant structural stage in 1958 was old forest multi strata (43% of the forested area), followed by understory reinitiation (27%), old forest single stratum (20%), stem exclusion closed canopy (6%), and young forest multi strata (3%). Stem exclusion open canopy and stand initiation were rare in 1958, occupying less than one percent of the analysis area.

In 1936, the predominant forest structural stage was old forest multi strata (58%), followed by stem exclusion closed canopy (14%), old forest single stratum (13%), stand initiation (9%), young forest multi strata (3%) and understory reinitiation (2%). Stem exclusion open canopy was rare in 1936, occupying less than one percent of the analysis area.

Current and historical forest structural stages are compared on a percentage basis in figure 11. The location and distribution of upland-forest structural stages are portrayed in figure 12.

IMPLICATIONS AND TRENDS

- **Old forest structures are less common now than in 1958.**

In 1958, old forest structures comprised 63% of the forested area; by 1999, old forest had apparently declined to only 18% of the area. This change is probably due to the factors described below.

1. *Differences in mapping standards and data resolution*. Since the 1958 mapping was based on photo interpretation, a technique that tends to overestimate the abundance of large trees because they are most easily discerned, it is possible that the amount of old forest was over-represented in 1958.
2. *Plant succession*. Ninety years of fire suppression has resulted in heterogeneous conditions featuring multi-layered, multi-cohort stands with a diverse mix of tree species. As stand structures have become increasingly more complex through time, the relative importance of large trees has diminished in response to increasing numbers of small trees in subordinate canopy layers.
3. *Disturbance processes*. Insect and disease outbreaks, windstorms, droughts, timber harvests and other disturbance events have occurred during the last 40 years (see table 15). Many of those processes have affected the distribution and abundance of old forest structural stages.

- **The mix of forest structural stages is apparently more diverse now than in 1958 or 1936.**

As was discussed in the forest size classes section, the primary reasons for structural-stage changes were that a commercial timber management program removed large-diameter trees and replaced them with regenerated stands of seedling-sized trees; that certain bark beetle species preferentially sought out and attacked large-diameter trees because the phloem of small trees provides unsuitable habitat for their broods (Gast and others 1991); and that landscape-level outbreaks of defoliating insects (budworm and tussock moth) initiated new stands now dominated by seedling and saplings. Some of the changes probably reflect differences in data resolution between both of the historical sources and the current source (e.g., the historical mapping was “coarser” and may have been biased toward large trees and their associated structural stages).

- **Timber harvest alone cannot be used to explain a reduction in old forest structure.**

Since 1956, regeneration harvests have affected a small proportion of the analysis area (see table 19 on page 45). This means that plant succession and other agents of change (such as defoliator and bark beetle outbreaks) have been responsible for much of an apparent reduction in old forest structure.

Table 12: Area (acres) of forest structural stages for the Umatilla/Meacham analysis area.

CODE	FOREST STRUCTURAL STAGE	1999	1958	1936

Table 12: Area (acres) of forest structural stages for the Umatilla/Meacham analysis area.

CODE	FOREST STRUCTURAL STAGE	1999	1958	1936
SI	Stand Initiation	18,068	100	9,314
SEOC	Stem Exclusion, Open Canopy	4,361	420	315
SECC	Stem Exclusion, Closed Canopy	2,262	5,743	13,818
UR	Understory Reinitiation	40,921	26,591	1,864
YFMS	Young Forest, Multi Strata	15,625	3,253	3,425
OFMS	Old Forest, Multi Strata	13,870	42,652	57,389
OFSS	Old Forest, Single Stratum	3,769	19,308	13,287
	Subtotal for Forests:	**98,876**	**98,067**	**99,412**
NF	Nonforest (grassland, rock, etc.)	48,822	50,154	48,626
None	Unclassified: no data was available		173	

Sources/Notes: Area (acres) were summarized from the 1999veg, 1958veg, and 1936veg databases (see appendix 1). This summary includes National Forest System lands only. See table 8 for a detailed description of the forest structural stages.

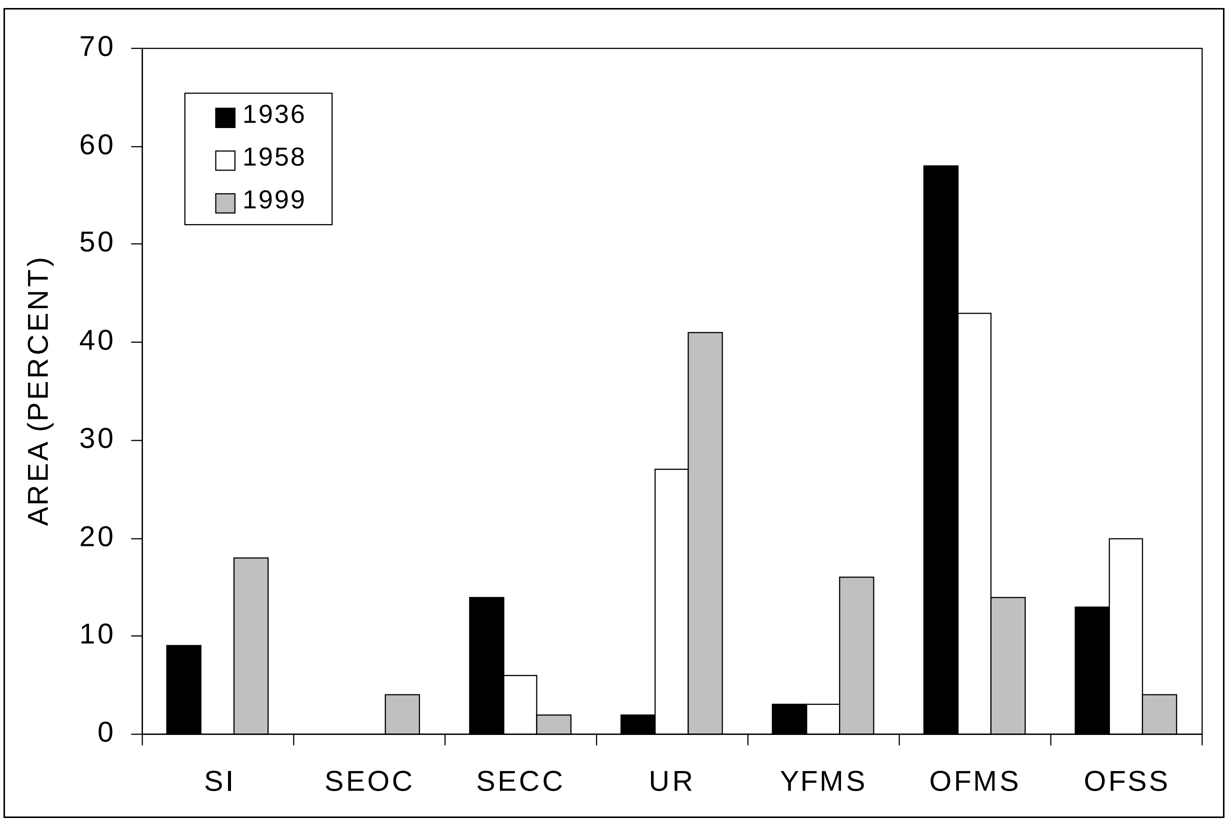


Figure 11 – Forest structural stage percentages through time.

Table 13: Area (acres) of upland-forest structural stages by subwatershed (SWS).

	FOREST STRUCTURAL STAGE CODE						
SWS	**SI**	**SEOC**	**SECC**	**UR**	**YFMS**	**OFMS**	**OFSS**
13A	424	97	87	2,348	917	103	146
13B			77	280	103	684	34
13C	376	111	57	1,016		1,382	811
13D	469	92	102	1,680	359	799	68
13E	1,525	362	440	2,447	2,085	1,857	209
13F	186	11	16	949		512	98
13G	1,376	502	93	1,382	638	1,827	383
13H	985	156	122	1,839	870	285	90
13I	950	260	43	2,221	944	326	108
13J	963	242	6	2,055	1,032	485	10
13K	1,568	324	42	2,322	1,093	1,648	346
UMA	8,822	2,157	1,085	18,539	8,041	9,908	2,303
89A	30	173		96	37	822	60
89B	126	382	294	1,550	13	251	146
89C	453	193	65	1,930	761	171	122
89D	246	302	373	1,843	28	348	31
89E	28	84	20	195	86	306	188
89F	657	77	197	570	744	5	67
89G	1,918	314	135	2,324	1,530	389	257
89H	1,263	124	60	2,795	996	333	320
89I	1,149	162		3,378	888	282	194
89J	68	25		402	15	103	42
89K	1,046	50	10	1,552	395	320	29
89L	1,195	105	23	2,732	1,049	152	8
89M	388			548	70		
89N	132			591	593	80	
89O	550	214		1,861	382	307	3
89Q				17		95	
MEA	9,249	2,205	1,177	22,384	7,587	3,964	1,467
Total	18,071	4,362	2,262	40,923	15,628	13,872	3,770

Sources/Notes: Areas (acres) were summarized from the 1999veg database. Refer to tables 12 and 14 for a description of the forest structural stage codes that were used as the column headings in this table. This summary includes National Forest System lands only.

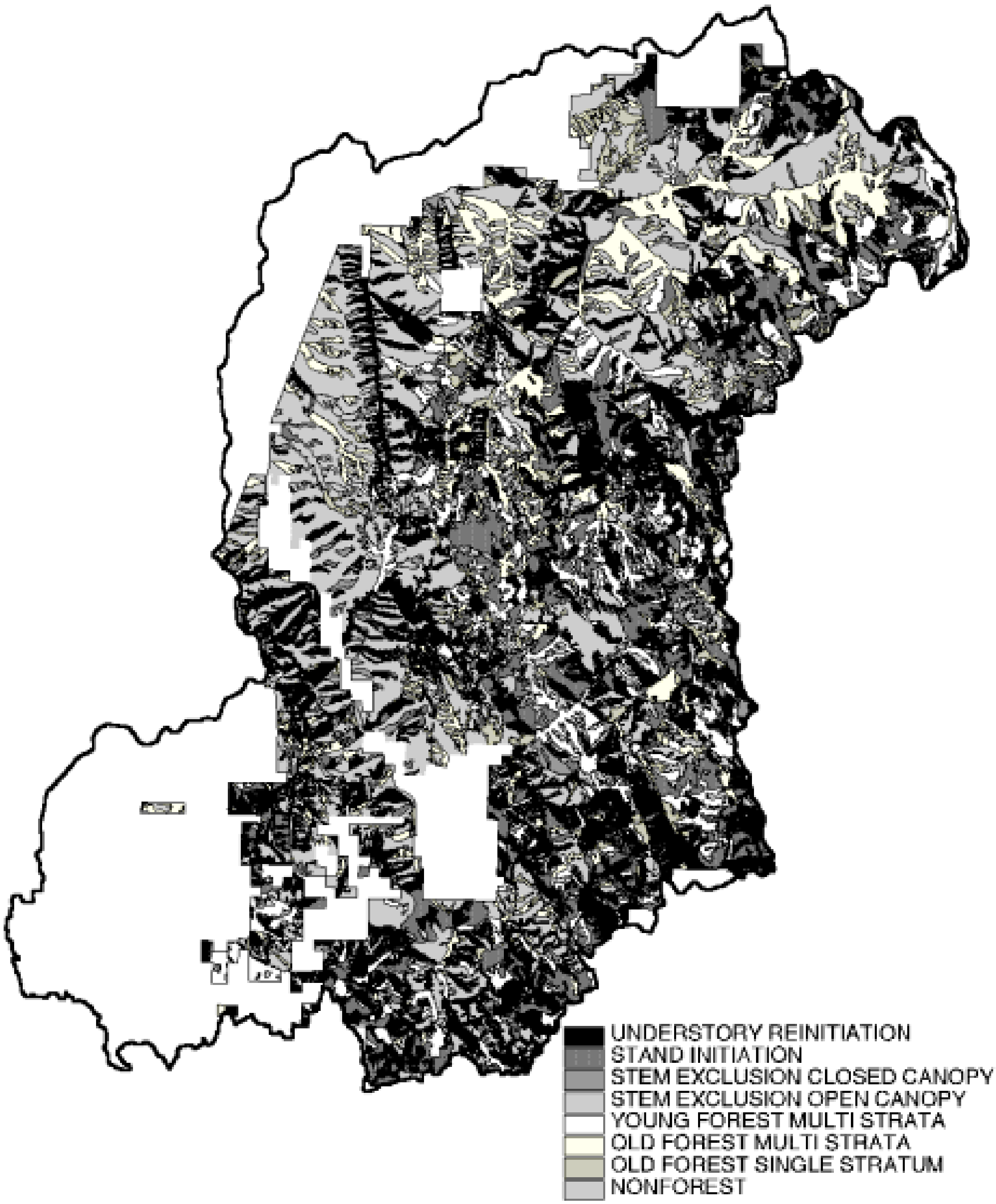
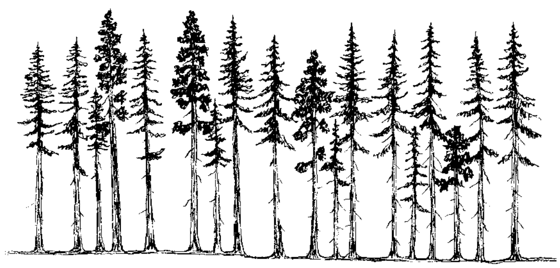
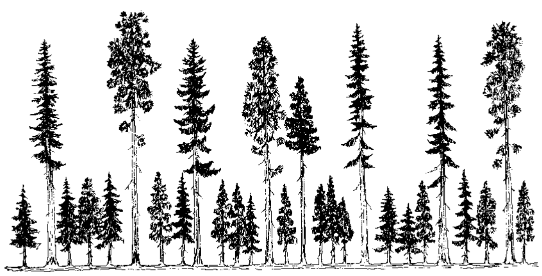


Figure 12 – Upland forest structural stages for the Umatilla/Meacham analysis area (see tables 12 and 14 for more information about the structural-stage codes and their derivation).

Table 14: Description of forest structural stages.

	**Stand Initiation (SI)**. Following a stand replacing disturbance such as wildfire or timber harvest, growing space is occupied rapidly by vegetation that either survives the disturbance or colonizes the area. Survivors literally survive the disturbance above ground, or initiate new growth from their underground roots or from seeds on the site. Colonizers disperse seed into disturbed areas, the seed germinates, and the new seedlings establish and develop. A single canopy stratum of tree seedlings and saplings is present in this stage.
	**Stem Exclusion (SECC** or **SEOC)**. In this stage of development, growing space is occupied by vigorous, fast-growing trees that compete strongly for available light and moisture. Because trees are tall and reduce light, understory plants (including smaller trees) are shaded and grow more slowly. Species that need sunlight usually die; shrubs and herbs may become dormant. In this stage, establishment of new trees is precluded by a lack of sunlight (**stem exclusion closed canopy**) or by a lack of moisture (**stem exclusion open canopy**).
	**Understory Reinitiation (UR)**. As the forest develops, a new age class of trees (cohort) eventually gets established after overstory trees begin to die or because they can no longer occupy their growing space completely. This period of overstory crown "shyness" results when tall, slender trees abrade each other in the wind. Regrowth of understory seedlings and other vegetation then occurs, and trees begin to develop in vertical layers (canopy stratification). This stage consists of a sparse to moderately dense overstory with small trees beneath.
	**Young Forest Multi Strata (YFMS)**. In this stage of forest development, three or more tree layers have become established as a result of minor disturbances (including timber harvest) that affect the overstory layer, thereby perpetuating a multi-layer, multi-cohort structure. This stage consists of a broken overstory layer with a mix of sizes present (large trees are scarce); it provides high vertical and horizontal diversity.
	**Old Forest (OFSS** or **OFMS)**. This developmental stage is marked by many age classes and vegetation layers and usually contains large old trees. Decaying fallen trees may also be present that leave a discontinuous overstory canopy. The illustration shows a single-layer stand of ponderosa pine that evolved from high-frequency, low-intensity wildfire (**old forest single stratum**). On cool moist sites without recurring underburns, multi-layer stands with large trees in the uppermost stratum may be present (**old forest multi strata**).

Sources/Notes: Based on O'Hara and others (1996) and Oliver and Larson (1996).

DISTURBANCE PROCESSES

"Natural disturbance maintains structural complexity, promoting plant and animal diversity"
(Hansen and others 1991)

Disturbance, the primary initiator of plant succession, is an important and integral process in many forest ecosystems. A disturbance is defined as a relatively discrete event that disrupts the structure of an ecosystem, plant community, or population, and changes resource availability or the physical environment. Disturbances happen over relatively short time intervals: windstorms occur over hours to days, fires occur over hours to weeks, and volcanoes erupt over periods of days or weeks (Turner 1998).

Insects, diseases, and other disturbances come in all shapes and sizes, ranging from relatively minor to relatively major events. They can be caused by biotic (insects, diseases, animal damage, etc.) or abiotic (wind, fire, flood, etc.) factors. The spatial and temporal impact of any particular disturbance event depends upon the hierarchical scale being considered. An example is the burrowing activity of pocket gophers *(Thomomys* spp.) and other small mammals, which may be viewed as a disturbance at one scale but not at another (White 1979).

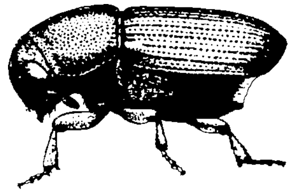
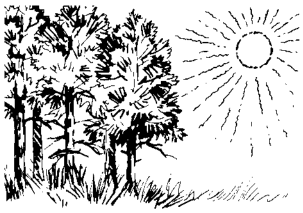
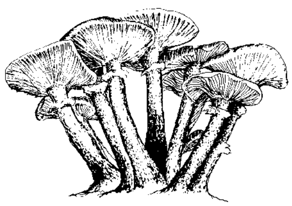
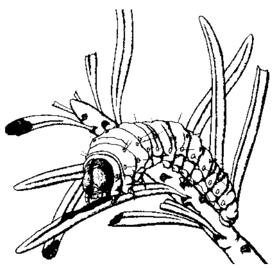
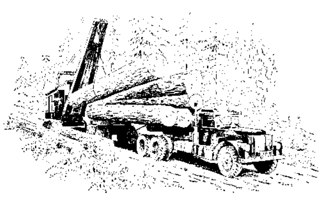
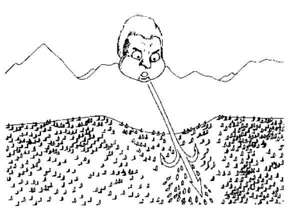
Disturbances frequently have a renewal effect by helping to recycle nutrients. Fire used to be the predominant recycling force in forests of the Interior Northwest because it consumed fallen needles and branches, rejuvenated many herb and shrub species while selecting against others, thinned young tree stands, and raised the height of live tree crowns (Agee 1993, Hall 1976, Harvey 1994, Johnson and others 1994). In many Interior Northwest forest ecosystems, the average interval between fire events was historically less than the life span of an individual member of the dominant species.

When humans alter a disturbance regime, it can eventually lead to simplification (homogenization) of a landscape (Lehmkuhl and others 1994, Turner 1998). When a landscape undergoes simplification, the first elements to be affected are often limited vegetation components such as quaking aspen; riparian forests of cottonwood, alder, birch, or willows; western white pine; and certain types of shrubland. In some situations, humans altered the disturbance regime by introducing an anthropogenic activity such as livestock grazing; in others, it resulted from suppression of a native disturbance process such as frequent surface fires.

If historical disturbance regimes had been allowed to maintain an appropriate range of ecological conditions (composition and structure) in Blue Mountain landscapes, then they could have played an important role in perpetuating both species and genetic diversity (Haufler 1994). This approach has been referred to as a "coarse filter" for conservation of biological diversity (AKA biodiversity); it is based on the premise that native species are adapted to indigenous disturbance regimes and their resulting range of habitat patterns (Hunter 1990). A coarse filter reflects the fact that we cannot even name all of the species in a landscape, much less rationally plan for their habitat needs and ecosystem functions (Cissel and others 1994).

Ecologists often distinguish between a discrete disturbance event – like an individual windstorm or wildfire – and the disturbance regime that shapes an ecosystem or landscape. A disturbance regime refers to the spatial and temporal dynamics of disturbance events over a long time period (Turner 1998). This section discusses defoliating insects, fire, and timber harvest – three particularly important disturbance agents that have influenced forest vegetation in the Umatilla/Meacham analysis area (table 15).

Table 15: Important disturbance agents of the Umatilla/Meacham analysis area.

DISTURBANCE AGENT	DESCRIPTION
	**Bark Beetles**. Douglas-fir beetle and fir engraver are the main bark beetles affecting mid-elevation mixed-conifer forests in the analysis area. Their populations were highest in the late 1980s and early 1990s. Mountain pine beetle has affected both ponderosa and lodgepole pines, with large outbreaks first appearing in the mid 1940s (Buckhorn 1948) and then again in the 1970s.
	**Drought**. Droughts are cyclic events of varying magnitude. The last drought was assumed to be 1985–1992, although reduced precipitation was not universal throughout the Blue Mountains. Subalpine firs died at high rates during the drought, and are continuing to die at an accelerated pace throughout the central and northern Blue Mountains (although more causes than just drought may be responsible for this mortality).
	**Parasites and Pathogens**. Root diseases tend to be localized, but can cause significant tree mortality in affected areas. Armillaria root disease is found in the Shimmiehorn area (13I). Annosus root disease is associated with areas that have been selectively cut in the past, especially if fir stumps were created by the harvest. Dwarf mistletoes, a tree parasite, affect ponderosa pine, lodgepole pine, western larch, and Douglas-fir in the Umatilla/Meacham watershed.
	**Defoliating Insects**. The analysis area has experienced 2 spruce budworm outbreaks over the last 50 years: one in 1944–1958, and another from 1980–1992. In the first outbreak, the entire analysis area was defoliated to some degree by 1949; portions of it were sprayed with DDT in 1950 and 1951 (Dolph 1980). In the second outbreak, defoliation peaked by the late 1980s and B.t. was sprayed in 1988 and 1992 (Sheehan 1996). Douglas-fir tussock moth defoliated mixed-conifer stands between 1972 and 1974; DDT was sprayed in the area in 1974.
	**Wildfires**. A large fire occurred in the analysis area about 1850; it came "from the present Umatilla Indian Reservation, burned up the river Umatilla, then turned north along the heads of the Walla Wallas, and reached as far as the head of the Wenaha" (Kent 1904). When a forest-type map of Oregon was published in 1900, it showed 24 burnt areas in the Umatilla/Meacham area; the average size of the burned patches was 516 acres (Thompson and Johnson 1900).
	**Timber Harvest**. Timber harvesting and other management activities have been used to provide the various goods and services required by a human society. Timber removals in the Blue Mountains began over a century ago, when small mills cut a few thousand board feet a day to meet the lumber and fuel demands of local farmers and settlers (Weidman 1936).
	**Windstorms**. A major windstorm occurred on January 8, 1990. It affected 421 acres in the analysis area, particularly in subalpine fir/Engelmann spruce stands along Highway 204 and in the Tollgate/Spout Springs area. The infamous 1962 Columbus Day windstorm, which caused damage throughout the Pacific Northwest, had little impact in the analysis area. Windstorms were often mentioned in historical accounts of the Blue Mountains (Smith and Weitknecht 1915).

Sources/Notes: Based on annual, aerial insect detection surveys; and unpublished records available at the Walla Walla Ranger District and at the Umatilla National Forest Supervisor's Office.

DEFOLIATING INSECTS

Western spruce budworm is a natural, unobtrusive inhabitant of mixed-conifer ecosystems throughout western North America. It feeds on Douglas-fir, grand fir, subalpine fir, Engelmann spruce and, to a limited extent, western larch. Occasionally, after weather and other environmental conditions become ideal for its growth and survival, budworm populations explode in what is called an outbreak (epidemic). Budworm outbreaks tend to be cyclic, with eruptive episodes covering large landscapes every 15 to 30 years. Forests comprised mostly of pines or western larch have little defoliation risk because those species are seldom fed upon by western spruce budworm.

The Umatilla/Meacham ecosystem analysis area has experienced two budworm outbreaks during the last 50 years. Early in the first outbreak (1944-1958), most of the budworm-host type in the analysis area was defoliated to some degree. In response to the defoliation, almost all of the Umatilla/Meacham area was sprayed with an environmentally-persistent, chemical insecticide called DDT during 1950 or 1951.

DDT became a popular insecticide after two early successes; it was used to control Douglas-fir tussock moth outbreaks in northern Idaho (Carlson and others 1983) and in the northern Blue Mountains west of Troy, Oregon in 1947 (Wickman and others 1973), and it was used for experimental suppression of spruce budworm populations on the Heppner Ranger District and adjacent Kinzua lands in 1948 (Eaton and others 1949). Although DDT was commonly used against budworm, land managers eventually realized that it failed to provide long-term control because the underlying problem had not been addressed – a proliferation of budworm-host type throughout the western United States (Carolin and Coulter 1971, Fellin 1983).

Table 16: Shade tolerance, successional status, and budworm susceptibility ratings for common tree species of the Umatilla/Meacham analysis area.

SHADE TOLERANCE	SUCCESSIONAL STATUS	BUDWORM SUSCEPTIBILITY
Subalpine Fir (most)	Subalpine Fir (latest)	Grand Fir (most)
Grand Fir	Grand Fir	Douglas-fir
Engelmann Spruce	Engelmann Spruce	Subalpine Fir
Douglas-fir	Douglas-fir	Engelmann Spruce
Western White Pine	Western White Pine	Western Larch (least)
Ponderosa Pine	Ponderosa Pine	Pines (nonhosts)
Lodgepole Pine	Western Larch	
Western Larch (least)	Lodgepole Pine (earliest)	

Sources/Notes: From Daniel, Helms and Baker (1979) for shade tolerance, and Powell (1994) for successional status and budworm susceptibility. Species ratings are based on the predominant situation for each trait. A trait can vary during the lifespan of an individual tree, and from one individual to another in a population, e.g., ponderosa pine can tolerate some shade when young, but requires almost full sunlight when mature.

After the earlier outbreak collapsed in 1958, western spruce budworm remained at endemic levels until 1980, when another outbreak began in mixed-conifer stands near Cove, Oregon. The 1980-1992 outbreak moved from south to north in the Blue Mountains; the Umatilla/Meacham watersheds were not seriously defoliated until the latter half of the 1980s and the early 1990s (see table 21). Portions of that outbreak were also treated with insecticides; some of the Umatilla/Meacham analysis area was sprayed with a bacterium called B.t. *(Bacillus thuringiensis)* in 1988 and 1992 (figure 13). As was the case for the 1950s DDT treatments, research found that application of insecticides during the 1980s outbreak had little long-term impact on budworm populations or host-tree damage (Torgersen and others 1995).

Douglas-fir tussock moth defoliates true firs and Douglas-firs from the top down, killing trees outright or setting them up for future attack by bark beetles such as Douglas-fir beetle or fir engraver. Like budworm, Douglas-fir tussock moth is a natural component of coniferous ecosystems and has been active in the Umatilla/Meacham area for as long as a food supply has been available there. Historically, budworm and tussock moth outbreaks were smaller in extent than the most recent outbreaks because the insect food base (primarily grand fir and Douglas-fir) was less continuous then (Hessburg and others 1994).

The last major outbreak occurred between 1972 and 1974, when mixed-conifer stands in the southern and central portions of the analysis area were defoliated by tussock moth. This 1970s outbreak in the Interior Northwest was the largest and most severe one ever recorded (Brookes and Campbell 1978). In 1974, stands near Meacham (west of Meacham Creek and north of Kamela) and west of Mount Emily (near the southeast corner of the analysis area) were treated with DDT to minimize defoliation-related damage (Graham and others 1975), although tussock moth outbreaks have a short lifespan and tend to collapse on their own after about 3 years. (The use of DDT required special approval because it had been banned in 1972; however, that approval was granted because the outbreak was considered an emergency situation.)

Although application of an insecticide (DDT) was the primary Forest Service response to tussock moth defoliation in the early 1970s, salvage sales to harvest damaged and dead timber were also completed. The first Umatilla National Forest salvage sale was sold on November 28, 1972. The last of forty tussock moth salvage sales was sold on September 3, 1974. Old harvest units in places such as Ruckel Ridge, Phillips Creek, upper Tiger Canyon, and many other locations on both the Pomeroy and Walla Walla Ranger Districts date from the tussock moth salvage program of the mid-1970s.

One result of the 1970s outbreak was that the Forest Service instituted an early-warning system for Douglas-fir tussock moth. It utilizes pheromone traps to monitor tussock moth population levels (pheromones are biochemicals whose odor is used to attract insects – in this case, male tussock moths). The early-warning system was developed and tested in the late 1970s, and then implemented throughout the western United States in 1980. Since tussock moth develops very rapidly, the early-warning system was designed to predict population increases with enough lead time to implement a treatment program (such as an insecticide applications) before serious damage to high-value areas could occur. It is interesting that the early-warning system now indicates that the Blue Mountains will be facing another tussock-moth outbreak in 2000 or 2001.

FIRE

Forests dominated by ponderosa pine or western larch evolved with fire as a regular and ecologically important influence, primarily because their bark thickness and crown length characteristics contribute to high fire resistance (table 17). Historically, many low-elevation sites in the Umatilla and Meacham watersheds supported open, park-like forests of ponderosa pine, often with a luxuriant undergrowth of tall grasses. Those conditions had been created and maintained by low-intensity surface fires occurring at frequent intervals, usually every 8 to 20 years (Hall 1976).

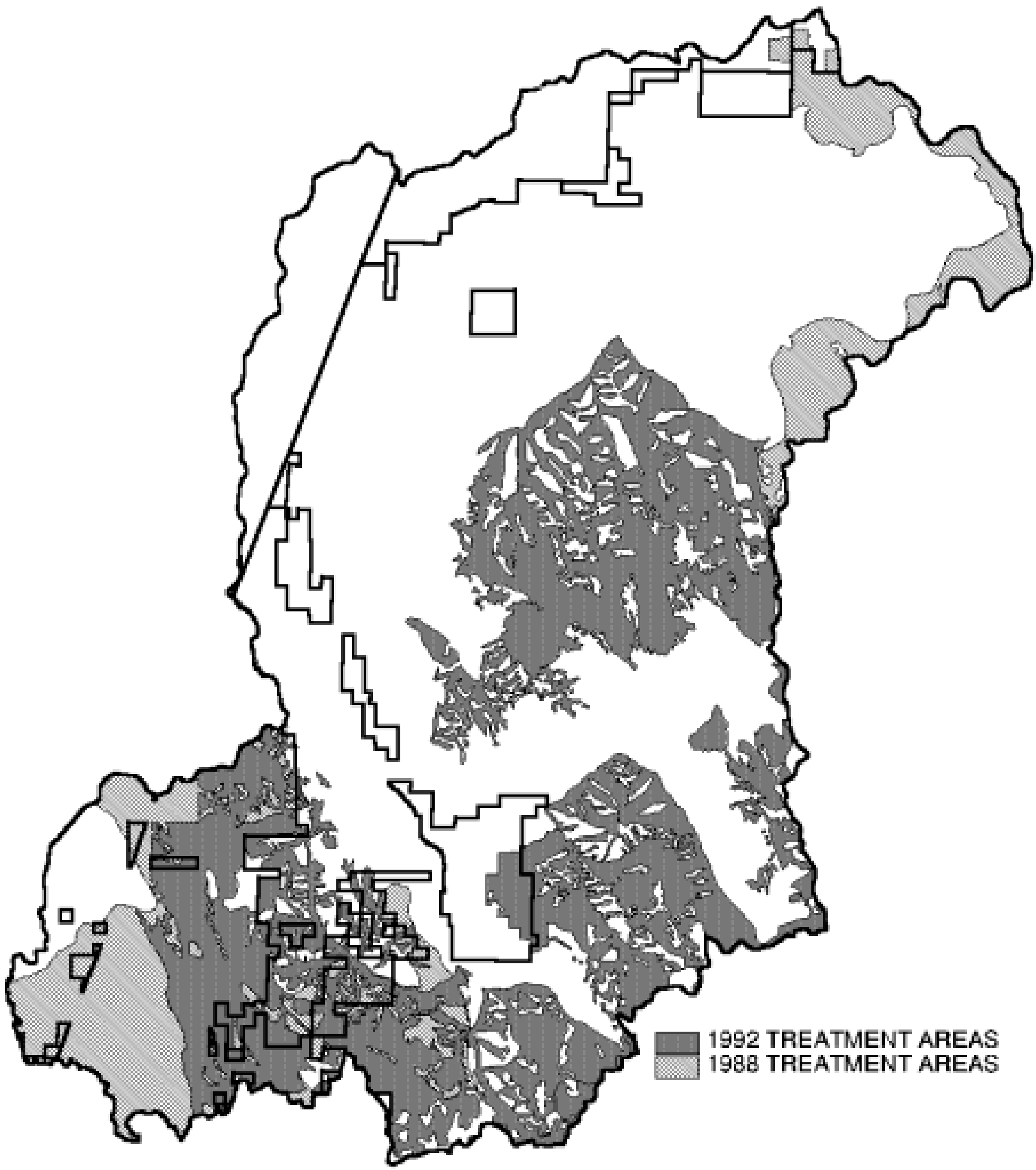


Figure 13 – Areas treated with *Bacillus thuringiensis* (B.t.) in 1988 or 1992 to control western spruce budworm. By the mid 1980s, B.t. was the insecticide of choice because of its low risk to the environment and human health. It directly affects a narrow range of organisms – only butterflies and moths in the Lepidoptera insect order are killed. Use of B.t. allowed land managers to maintain more of the pretreatment arthropod diversity than had been possible with carbaryl, acephate, mexacarbate or the other chemical insecticides in common usage at that time. Note that research found that application of insecticides during the 1980-1992 spruce budworm outbreak had little long-term impact on either budworm populations or host-tree damage (Powell 1994, Torgersen and others 1995). Also, note that both spray projects included some of the non-National Forest System lands in the analysis area.

Table 17: Bark thickness, crown length, and fire resistance ratings for common tree species of the Umatilla/Meacham analysis area.

BARK THICKNESS	CROWN LENGTH	FIRE RESISTANCE
Ponderosa Pine (thickest)	Western Larch (shortest)	Western Larch (highest)
Western Larch	Western White Pine	Ponderosa Pine
Douglas-fir	Lodgepole Pine	Douglas-fir
Grand Fir	Ponderosa Pine	Western White Pine
Western White Pine	Douglas-fir	Grand Fir
Engelmann Spruce	Grand Fir	Lodgepole Pine
Subalpine Fir	Engelmann Spruce	Engelmann Spruce
Lodgepole Pine (thinnest)	Subalpine Fir (longest)	Subalpine Fir (lowest)

Sources/Notes: From Keane and others (1989), Haig and others (1941), and Minore (1979). Species rankings are based on the predominant situation for each trait. A species trait is not absolute – it can vary during the lifespan of an individual tree, and from one individual to another in a population. For example, grand fir's bark is thin when young, but relatively thick when mature.

Although many wildfires were ignited by lightning storms in mid or late summer (Plummer 1912), a large number were apparently started by American Indians (Cooper 1961, Johnston 1970, Robbins 1997). When analyzing early journals from the western United States, Gruell (1985) found that over 40 percent of the fires were described as being started by American Indians.

Many studies concluded that American Indians were far from the passive hunters and gatherers depicted in western novels and movies (Kay 1994). Their activities had a profound influence on the structure and composition of western ecosystems – a not unexpected result when considering that they used hundreds of plants and animals for food, fiber, shelter, forage, and medicine. Fire was often their main tool for creating and maintaining the habitats required by those plants and animals.

Fire was also used by American Indians to clear brush for improved hunting access, for entertainment, and for a variety of cultural activities. For example, Oregon Indians used smoke to harvest pandora moths – after fire was run through an infested pine stand, the caterpillars would drop from the trees to the ground and were then gathered for food (Pyne 1982). [It is interesting that most of the life stages of this insect were used for food – the Klamath and Modoc tribes dug up and used the pupae in a concoction called "bull quanch," whereas the Piutes gathered and dried the mature caterpillars and combined them with vegetable-type plant materials in a dish called "peage" (Patterson 1929).]

Large fires were also common during Euro-American settlement of the Interior Northwest. Many fires were set by emigrants, either accidentally or intentionally. Miners often set fires to clear away brush and forest debris, thereby exposing rock outcrops for inspection by prospectors (Veblen and Lorenz 1991). Likewise, some early fires were started by livestock permittees to remove brush and promote grass growth (Harley 1918). Whether of human or natural origin, large fires certainly occurred in the Umatilla/Meacham area during the presettlement era:

> Practically every portion of the reserve has suffered more or less from fire. The largest and most important of these was one which came from the present Umatilla Indian Reservation about fifty years ago, burned up the river Umatilla, into the reserve, then turned north along the west slope across the heads of the Walla Wallas, and reached as far as the head of the Wenaha. This burn has generally restocked finely, principally to tamarack and lodgepole pine.
>
> **The Proposed Wenaha Forest Reserve (Kent 1904).**

Even though emigrants caused some fires, they also contributed to conditions that limited fire intensity and spread. For instance, immense bands of sheep grazed in the Blue Mountains during the latter part of the nineteenth century, which caused enduring changes in the vegetative composition (Coville 1898, Irwin and others 1994, Tucker 1940). Figure 14 summarizes historical grazing trends for three classes of livestock (cattle and calves, sheep and lambs, horses and ponies). It pertains to Umatilla County, Oregon, which comprises the majority of the analysis area (well over 90%).

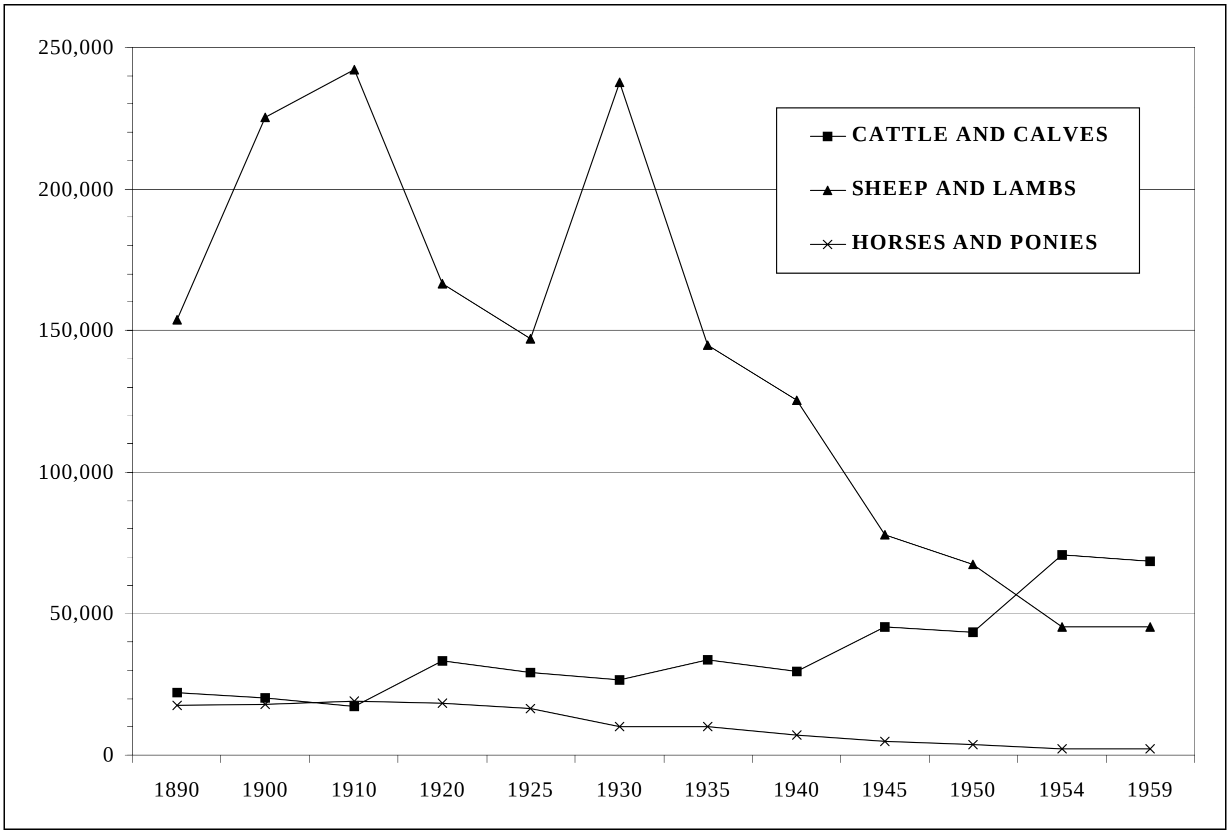


Figure 14 – Number of grazing animals for Umatilla County, Oregon (taken from Bureau of Census records).

After sheep removed most of the herbaceous vegetation from beneath forest stands, it was very difficult for fires to spread through them. That was particularly true for open stands of ponderosa pine because herbaceous vegetation was an important fuel component. When heavy livestock grazing coincided with effective suppression of low-intensity surface fires, the result was an increase in forest regeneration:

> And in open, overmature stands this [yellow pine] reproduction is even now so dense and large in many places as to practically prevent grazing. This advance reproduction has mostly come in during the last 25 or 30 years, and is due to the protection from fire which the forest has received partly by the Forest Service and partly by the unconscious efforts of the settlers and stockmen.
>
> **Yellow Pine Management Study in Oregon in 1916 (Weitknecht 1917).**

On dry-forest sites that historically supported park-like pine, suppression of the indigenous disturbance regime – frequent surface fires (underburning) – had the unintended consequence of allowing grand firs and Douglas-firs to replace the pines. By the late 1970s, it was believed that at least 25 percent of the historical ponderosa pine type had been replaced with mixed-conifer forest (Barrett 1979); the reduction was apparently much greater than that for the southern Blue Mountains (Malheur National Forest), where ponderosa pine declined by more than half between 1936 and 1980 (Powell 1994).

Park-like ponderosa pine was replaced with mixed-conifer forest after humans began altering the prevailing fire regime. This allowed multi-storied stands of late-seral or climax species (grand fir and Douglas-fir) to get established on pine sites, often at high densities (Powell 1994). Thick layers of organic matter accumulated beneath the invading fir trees, tying up nitrogen and other nutrients that are cycled slowly without fire (Harvey 1994). Little natural thinning occurred, and the trees that died were usually the pines and larches that succumb to suppression before the firs. Fuels accumulated at an alarming rate (Hall 1976). Herbage production declined substantially, eventually affecting both native and introduced ungulates (Hall 1976, Hedrick and others 1968, Irwin and others 1994).

If fire suppression caused major shifts in species composition, then why weren't those changes recognized earlier? Actually, it turns out that many of them were recognized, but weren't acted upon because of the prevailing attitudes of the time. As an example, the following questions and observations were made by a prominent fire researcher over fifty years ago.

> It is obvious that the present policy of attempting complete protection of ponderosa pine stands from fire raises several very important problems. How, for instance, will the composition of the reproduction be controlled? If ponderosa pine is desired on vast areas how, unless fire is employed, can other species such as white fir be prevented from monopolizing the ground? On the other hand, if it is decided to permit such species as white fir to come in under mature ponderosa pine, how much of the public's money are foresters justified in spending in trying to keep fire out? Even with unlimited funds, personnel, and equipment, can they give reasonable assurance that they can continue to keep such extremely hazardous stands from burning up? If they feel reasonably sure of this, can they then give assurance that the timber products of such stands will be more valuable than those that might otherwise be derived from ponderosa pine and will in addition justify the high protection costs?
>
> **Fire as an Ecological and Silvicultural Factor in the Ponderosa Pine Region (Weaver 1943).**

TIMBER HARVEST

Some level of selective harvesting has been occurring ever since the Blue Mountains were settled by Euro-American emigrants. The first commercial logging in the Northwestern pine region of eastern Oregon and Washington began around 1890 (Weidman 1936), although limited harvesting occurred during the preceding 25 years to meet the needs of miners and early settlers. Some of the first roads reaching into the Blue Mountains were wagon roads for hauling wood and rails out to farms and ranches.

A local demand for construction timbers – trusses for mine tunnels and wooden viaducts to carry water – resulted in the first timber harvests in the Blue Mountains. Within a year after gold was discovered in the John Day River valley (in June of 1862 near Canyon City, Oregon), an enterprising person opened a sawmill to cut lumber for miners who were building flumes and sluices (Robbins 1997).

During the Euro-American settlement era, timber met a variety of the homesteaders' needs including logs for homes, posts and poles for corrals, and rails for fencing. The resinous, durable woods of ponderosa pine and western larch were ideal for providing many of those necessities (Robbins 1997, Tucker 1940). In the early days, lodgepole pine was harvested to provide an important heat source; table 18 shows that the Meacham area produced over 9,000 cords of wood a year (mostly fuelwood) during a 41-year period (converted to board feet at 2 cords per thousand, that harvest level was equivalent to about 5 million board feet annually).

After World War II, ponderosa pine and other species were intensively harvested to feed a rapidly growing market for clear lumber for home construction, railroad ties, and to fabricate shipping boxes for apples and other agricultural products (Gedney 1963, Robbins 1997).

Table 18: Historical cordwood production from the Meacham area, 1884-1924.

TIME PERIOD	CORDS PER YEAR	TOTAL CORDS HARVESTED	TOTAL MMBF HARVESTED
1884-1899	10,000	150,000	75
1900-1909	15,000	150,000	75
1910-1915	8,000	48,000	24
1916-1920	3,500	17,500	9
1920-1924	2,500	10,000	5
Average/Total	9,159 (Avg)	375,500 (Total)	188 (Total)

Sources/Notes: Data derived from Tucker (no date). Tucker mentions that these figures could be conservative because it was a "well known fact that cordwood production in that area was as high as 50,000 cords for a few years during the time when electric power was generated in Pendleton by wood fired boilers." Most wood cutters worked alone at their job and averaged between 200 and 250 cords per year per man.

Due to market conditions, early partial cuttings were typically a "diameter-limit" harvest with the largest trees being removed. Diameter-limit cutting gradually altered the forest composition by removing the marketable trees (large-diameter ponderosa pines, larches, and Douglas-firs), leaving behind a high proportion of unmerchantable firs and Douglas-firs. The following passage describes how partial cutting was applied in the early ponderosa pine forests of Oregon.

> The system of cutting which seems to be ideal for this type of forest is a form of selection cutting. Periodic cuttings are made, in each of which all the overmature and thoroughly ripe trees in the stand and all the defective ones are removed; and the saplings, poles, and young, thrifty trees are left standing to form the basis for the next crop. No tree is removed until it has reached its majority, so to speak, and no old, slow-growing tree is allowed to stand and occupy space which should be devoted to young and rapid-growing trees. It is customary to set an appropriate diameter limit of from 16 to 22 inches, the majority of the trees above which limit are cut, and those below left.
>
> **Western Yellow Pine in Oregon (Munger 1917).**

Why was diameter-limit cutting used if it favored firs to the detriment of pine and larch? Under the market conditions of that era, selective cutting was viewed as a wise use of forest resources. It removed mature trees that had some value, thereby initiating a rudimentary level of forest management. Low-value trees were harvested to the extent that markets would allow. Many low-value species were left in the hope that some of them would become merchantable by the next entry in 40-60 years. The following passage describes this situation for western white pine, but it was also true for ponderosa pine forests.

> The low values are due to high susceptibility to heart rot of western hemlock, grand fir, and some other species, and to the fact that the selling price of lumber manufactured from these species is often insufficient to meet production costs even if nothing were paid for the standing timber. Where trees of such species are not defective, the Forest Service policy has been to leave them uncut in the hope that at some future time they can be sold at a profit. But leaving these low-value species on areas that are cut over encourages their reproduction and tends to decrease the proportion of western white pine in the reproduction – an undesirable result both silviculturally and economically.
>
> **Natural Regeneration in the Western White Pine Type (Haig and others 1941).**

In many respects, partial cutting had the opposite effect of natural processes in mixed-conifer stands. Underburns discriminated against the long-crowned, thin-barked invaders (grand fir and Douglas-fir), while favoring the thick-barked trees with short, open crowns (ponderosa pine and western larch). In contrast, partial cutting removed fire-resistant pines and larches while retaining the late-successional species that are susceptible to a variety of insects and pathogens.

Timber harvest, and the associated activities that follow harvest (site preparation, tree planting, thinning, etc.) have had a widespread but somewhat limited impact on vegetation conditions in the analysis area. Table 19 summarizes the silvicultural treatments that occurred in the Umatilla/Meacham analysis area between 1956 and 1995. It shows that regeneration harvests affected very little of the National Forest ownership in the analysis area since 1956, which means that plant succession and disturbance processes have been responsible for many of the recent changes in forest conditions.

For national forest lands located in eastern Oregon and eastern Washington, timber harvest levels declined by 72 percent between 1990 and 1995 (O'Laughlin and others 1998). That trend is clearly reflected in the timber harvest history for the Umatilla National Forest (figure 15); recent harvest levels are the lowest since the mid- to late-1950s.

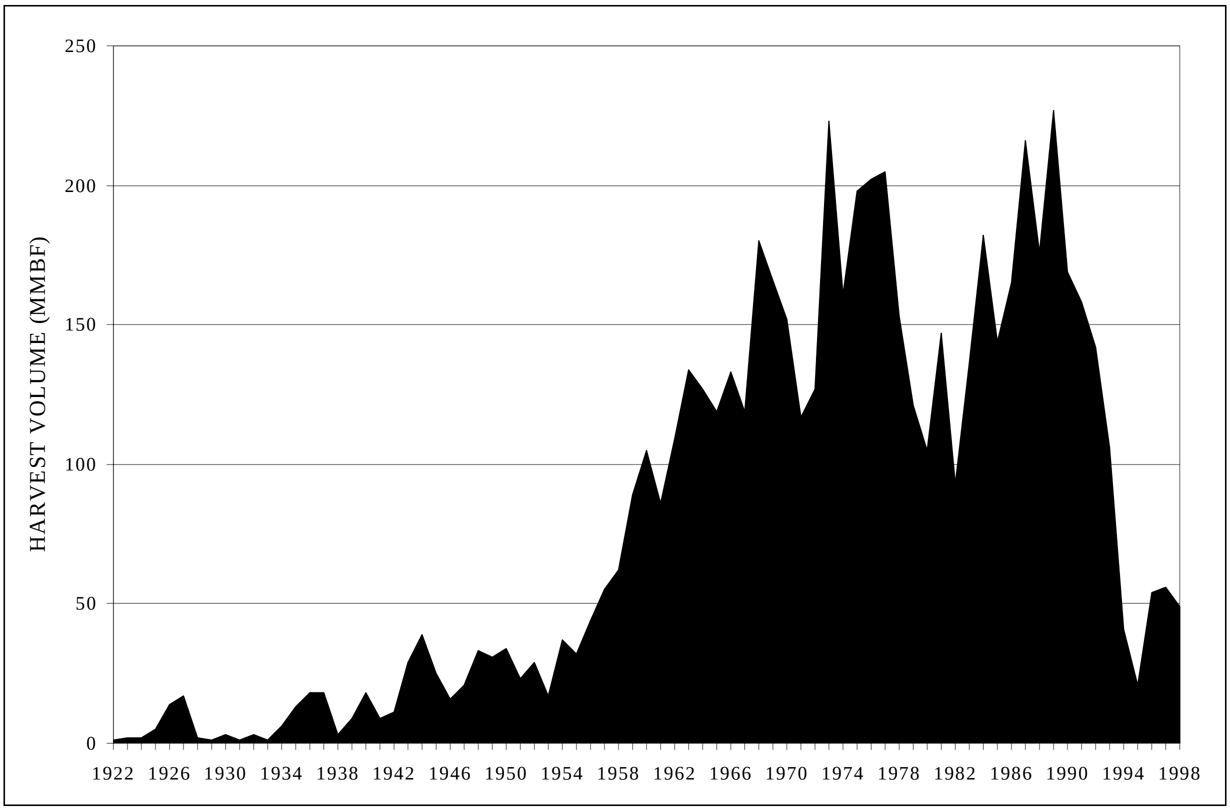


Figure 15 – Timber harvest history for the Umatilla National Forest, 1922-1998. Since 1993, timber harvest has declined dramatically on the Umatilla NF, and that trend is also true for the analysis area.

Table 20 summarizes tree density for 36 managed stand survey plots located in the Umatilla/Meacham analysis area. It shows that reforestation following timber harvest has been very successful, at least when tree density is used as a criterion of success. On average, the sampled plantations support 1,335 trees per acre, but only 14½ percent of those trees are early seral species. Plantations with high tree densities will eventually need to be thinned to maintain tree vigor and to avoid future forest health problems. Delaying the thinnings until the stands are pole-sized would help address a deficiency of the stem exclusion closed canopy structural stage in the analysis area (see table 25). For forest health and a variety of other reasons, early-seral species should be retained in the thinnings.

Table 19: Area (acres) of upland-forest vegetation treatments by subwatershed (SWS).

SWS	TIMBER HARVEST Reg. Cuts	Int. Cuts	BURNING Area	Jackpot	Machine Piling	YUM	REGENERATION Planting	Natural	Noncom. Thinning
13A	47	166	0	0	0	0	47	0	0
13C	235	35	0	0	48	0	48	178	133
13D	650	108	360	0	89	0	569	0	385
13E	1,346	545	292	4	146	45	984	241	350
13G	807	49	405	0	164	55	693	69	45
13H	700	74	363	0	25	0	634	23	317
13I	738	150	424	0	0	0	714	29	485
13J	201	117	168	0	0	0	256	0	111
13K	512	692	106	102	20	0	680	28	0
UMA	5,236	1,936	2,118	106	492	100	4,625	568	1,826
89C	100	25	20	0	0	0	76	6	0
89G	74	11	10	0	0	0	74	4	10
89I	643	191	19	0	0	0	166	249	12
89J	305	40	8	0	0	0	23	77	8
89K	464	69	22	0	89	0	84	195	79
89L	1,067	45	275	46	310	143	543	468	282
89M	31	0	0	0	0	31	0	31	0
89N	12	0	12	0	0	0	0	0	0
MEA	2,696	381	366	46	399	174	966	1,030	391
Total	7,932	2,317	2,484	152	891	274	5,591	1,598	2,217

Sources/Notes: Areas (NFS acres) were derived from the Walla Walla Ranger District Activities Database (see table 1). Regeneration (Reg.) cuts included stand clearcutting (HCSD), patch clearcutting (HCPH), seed-tree seed cuts (HSST), shelterwood preparatory cuts (HPSW), shelterwood seed cuts (HSSW), shelterwood removal cuts (HRSW), overstory removals (HROS), group selection (HSEG), and individual-tree selection (HSEI). Intermediate (Int.) cuts included improvement cuts (HIIM), partial removal cuts (HPRC), commercial thinnings (HITH), and sanitation (HISS). Area burning included prescribed burning (RPPB) and underburning (RPUB). Jackpot burning included burn and plant (RPJB) and burn with natural regeneration (RPJP). Machine piling included machine piling and burning (RPPP), machine scarification (RPMS), and machine piling (RPPL). YUM (Yard Unutilized Material) included whole-tree yarding (RPWT), YUM (RPYU), and yarding of tops (RPYT). Planting included planting with site preparation (RSPS) and planting without site preparation (RSPL). Natural regeneration included natural regeneration without site preparation (RSNP) and natural regeneration with site preparation (RSNS). Noncommercial thinning included records with activity code SPTP. Note that this information includes all silvicultural treatments completed between 1956 and 1995.

Table 20: Tree density (trees per acre) for 36 managed stand survey plots located in the analysis area.

		EARLY SERAL TREES					LATE SERAL TREES					Other	Grand
PLOT	PAG	WL	LP	PP	Total	Pct.	GF	DF	ES	SF	Total	Trees	Total
2755	CM	53	81	152	287	11	2,051	191	64	0	2,305	0	**2,592**
2758	CM	20	0	64	84	5	1,299	60	277	0	1,636	0	**1,720**
2759	CM	20	0	0	20	11	83	0	85	0	168	0	188
2764	CM	0	0	0	0	0	71	20	47	0	137	28	165
2765	CM	4	0	43	47	3	221	52	180	0	453	884	**1,384**
2767	CM	107	0	24	131	4	1,535	225	541	0	2,301	1,000	**3,432**
2768	CM	91	0	79	169	50	157	8	0	0	165	4	**339**
2769	CM	0	0	52	52	4	739	16	40	0	795	456	**1,303**
2770	CM	60	0	227	287	24	848	0	0	0	848	80	**1,215**
2771	CM	4	0	247	251	19	680	33	88	0	801	240	**1,292**
2773	CM	0	75	0	75	5	204	0	563	591	1,357	0	**1,432**
2774	CM	24	0	160	184	8	1,639	64	332	0	2,035	40	**2,259**
2776	CM	0	28	8	36	6	4	0	349	169	523	0	**559**
2778	CM	47	0	52	99	31	185	40	0	0	225	0	**324**
2785	CM	4	0	0	4	1	536	0	120	0	656	0	**660**
2786	CM	108	0	20	128	7	1,117	104	567	0	1,788	0	**1,916**
2788	CM	184	20	40	244	24	627	72	68	0	767	0	**1,011**
2789	CM	0	0	0	0	0	257	0	100	0	357	16	**373**
2790	CM	108	643	4	755	18	0	0	1,348	2,091	3,439	0	**4,193**
2791	CM	28	247	4	279	11	420	0	1,376	404	2,200	0	**2,479**
2792	CM	4	863	8	875	44	120	40	708	248	1,116	0	**1,991**
2795	CM	7	0	204	211	15	1,024	55	112	0	1,191	0	**1,401**
2796	CM	36	92	4	132	10	744	0	236	235	1,215	0	**1,347**
2801	CM	4	152	8	164	9	468	0	183	1,084	1,735	0	**1,899**
2802	CM	8	24	0	32	3	227	24	264	656	1,171	0	**1,203**
2818	CM	4	4	195	203	10	1,145	328	400	0	1,873	0	**2,076**
2821	CM	120	320	153	593	15	360	20	2,537	509	3,427	0	**4,020**
2823	WD	4	0	519	523	47	160	439	0	0	599	0	**1,121**
2824	CM	44	8	0	52	4	1,224	84	36	0	1,344	0	**1,396**
2826	CM	73	0	140	213	39	209	120	0	0	329	0	**543**
2829	CM	25	33	16	75	13	428	76	4	0	508	4	**587**
2831	WD	0	0	0	0	0	92	69	0	0	161	0	161
2832	CM	64	0	24	88	21	309	31	0	0	340	0	**428**
UMA	Avg	38	78	74	191	13	581	66	322	181	1,150	83	1,424
2750	CM	157	32	57	247	70	88	20	0	0	108	0	**355**
2779	HD	0	0	159	159	93	0	12	0	0	12	0	171
2815	WD	8	0	291	299	55	80	163	0	0	243	0	**541**
MEA	Avg	55	11	169	235	66	56	65	0	0	121	0	356
Total	Avg	39	73	82	194	15	538	66	295	166	1,065	76	1,335
Pct. of Total		3.0	5.5	6.1	14.5		40.3	4.9	22.1	12.5	79.7	5.7	

Sources/Notes: Summarized from 36 managed stand survey plots (see table 1) installed in 1990. PAG refers to plant association group. Species codes used as column headings are: WL, western larch; LP, lodgepole pine; PP, ponderosa pine; GF, grand fir; DF, Douglas-fir, ES, Engelmann spruce; SF, subalpine fir. “Other Trees” includes Pacific yew, paper birch, and willow. Black cells in the “Grand Total” column indicate future thinning opportunities.

RECOMMENDATIONS AND OPPORTUNITIES

"Hands off management shows good taste but poor insight. The hope of the future lies not in curbing the influence of human occupancy – it is already too late for that – but in creating a better understanding of the extent of that influence and a new ethic for its governance."
Aldo Leopold, Game Management (1933)

This section provides management recommendations that could facilitate either short-term recovery, or long-term restoration, of upland-forest vegetation in the Umatilla/Meacham analysis area. Recommendations and opportunities were developed after analyzing the following issues, all of which relate to one larger issue – vegetation sustainability:

- **FOREST DAMAGE**
- **FOREST DENSITY**
- **HISTORICAL RANGE OF VARIABILITY FOR FOREST STRUCTURAL STAGES**
- **SPECIES COMPOSITION AND VEGETATION DIVERSITY**

Each issue will be presented and described individually, although three summary tables (tables 26, 27 and 28) are also provided. Tables 26 and 27 compare not only the issues but also some opportunities to respond to them because both the issues and the treatment opportunities are summarized there; table 28 categorizes subwatersheds as having high, medium, or low priority for action with respect to these issues.

Note that any recommendations did not explicitly consider project feasibility (logging operability, etc.), so they are basically management opportunities. Whether those opportunities can be realized or not will depend on project planning efforts following this ecosystem analysis. *It must be emphasized that these recommendations pertain to upland-forest sites only* (not to riparian habitat conservation areas).

FOREST DAMAGE

The last twenty to forty years saw a period of rapid change for literally millions of acres in the Blue Mountains. Some of that change was related to normal forest growth and maturation, but much of it resulted from abnormally high levels of insects and diseases, including substantial outbreaks of mountain pine beetle *(Dendroctonus ponderosae)*, western spruce budworm *(Choristoneura occidentalis)*, Douglas-fir tussock moth *(Orgyia pseudotsugata)*, Douglas-fir beetle *(Dendroctonus pseudotsugae)*, and fir engraver *(Scolytus ventralis)* (Gast and others 1991). Residents of the Blue Mountains often assumed that the high damage levels were an indicator of impaired forest health (Shindler and Reed 1996).

Do wide-ranging insect and disease outbreaks indicate that ecosystems are unhealthy? And what do large, landscape-scale wildfires indicate in an ecological sense? Since ecosystems are constantly changing, we need to evaluate their health in a similar context. Healthy forests can not only tolerate periodic disturbance, but may even depend on it for rejuvenation and renewal (Johnson and others 1994). However, significant changes in the magnitude (extent), intensity, or pattern of disturbance can often be an indicator of impaired forest health.

Forest damage was evaluated using information from the Pacific Northwest Region's annual insect detection and damage surveys (see table 1). Those surveys resulted in what is called a "sketch map." The sketch maps for a 19-year period (1980 to 1998) were used to assess insect-caused forest damage for the relatively recent past. An acreage summary for the 19-year period is provided in table 21.

Table 21: Area (acres) of insect-caused forest damage in the Umatilla/Meacham analysis area, 1980-1998.

Year	Pine Beetles	Mixed-Conifer Beetles	Western Spruce Budworm	Other	Total
1980	7,836	584			8,420
1981	3,629	578			4,207
1982	840	1,413			2,253
1983	400	696			1,096
1984	371	372			743
1985	41	1,920	31,929		33,890
1986	51	1,029	145,918		146,998
1987	174	1,148	158,766		160,088
1988	52	16,337	105,424		121,813
1989	585	5,495	69,884		75,964
1990	321	5,158	89,831	421	95,731
1991	167	287	146,565		147,019
1992	192	1,386	97,197		98,775
1993	153	1,018		54	1,225
1994		2,725		1,010	3,735
1995	551	3,755			4,306
1996	22	466			488
1997	166	1,430			1,596
1998	33	276			309

Sources/Notes: Areas (acres) were derived from annual insect detection and damage surveys (sketch maps) completed by the Pacific Northwest Region of the Forest Service (see table 1). Note that the areas in this table also include ownerships other than National Forest System lands. "Pine beetles" includes mountain pine beetle in either lodgepole pine or ponderosa pine, *Ips* beetle in pine, and western pine beetle. "Mixed-conifer beetles" includes Douglas-fir beetle, fir engraver, spruce beetle, Douglas-fir engraver, and western balsam bark beetle. "Other" includes windthrow (trees blown over in a windstorm) and needle cast in western larch. Note that totals were not calculated for the damage categories because the same acres are counted from one year to the next when insect activity is on-going in an area. Calculating totals would be inappropriate in this situation because damage values are not mutually exclusive from year to year.

Current ecological conditions in forests of the Interior Northwest suggest that immediate management action may be warranted, particularly for dry-forest sites. This management intervention needs to be intensive and to cover wide areas of the landscape, but to be effective it must be substantially different in both impact and appearance from what was done historically (Sampson and others 1994). Using a variety of cutting patterns is important to avoid uniform landscapes; grouping harvest areas reduces the total amount of edge, minimizes fragmentation, and maintains larger patches of older forest.

Management intervention should use an adaptive approach that considers the forest as a fully-functioning ecosystem. Ecological principles form the basis of this approach, which assumes that if the effects of forest management activities closely resemble those of indigenous disturbances, the risk of losing native species and altering ecosystem processes is greatly reduced (Delong and Tanner 1996, Rowe 1992).

However, it is important that management action focuses on the effects of disturbance processes and the function of biological legacies, rather than attempting to directly replicate a particular disturbance agent.

Deciding to take immediate action can result in a philosophical shift toward proactive management to curtail excessive fire and insect impacts, and a shift away from reactive management in response to landscape-scale disturbances. The solution could start with thinnings and understory removals to reduce stand density in overcrowded forests (Oliver and others 1994). No single silvicultural system, however, can hope to precisely reproduce the inherent variability of a landscape because forests and other ecosystems are shaped by a variety of disturbance processes (Voller and Harrison 1998).

A computerized model (UPEST) was used to derive risk ratings (existing susceptibility) for eight insects and diseases present in the analysis area, along with a composite rating (Ager 1998). Risk ratings were based on Current Vegetation Survey plots located in either the Umatilla River or Meacham Creek watersheds (see table 1). The risk-rating results are provided in table 22; it shows that susceptibility to Douglas-fir tussock moth and western spruce budworm are particularly high for the analysis area.

Table 22: Insect and disease risk ratings for the Umatilla and Meacham watersheds.

INSECT OR DISEASE	RISK RATING	MEACHAM CREEK	UMATILLA RIVER
Douglas-fir Beetle	Low	40%	53%
	Moderate	38%	24%
	High	22%	23%
Douglas-fir Dwarf Mistletoe	Low	2%	3%
	Moderate	98%	93%
	High	< 1%	3%
Mountain Pine Beetle (Lodgepole Pine)	Low	100%	100%
	Moderate	0%	0%
	High	0%	0%
Mountain Pine Beetle (Ponderosa Pine)	Low	85%	97%
	Moderate	3%	0%
	High	12%	3%
Mixed Conifer Root Diseases	Low	80%	81%
	Moderate	0%	0%
	High	20%	19%
Spruce Beetle	Low	90%	79%
	Moderate	7%	11%
	High	3%	9%
Western Spruce Budworm	Low	15%	8%
	Moderate	10%	5%
	High	75%	87%
Douglas-fir Tussock Moth	Low	4%	7%
	Moderate	35%	32%
	High	61%	61%
Composite (Average)	Low	42%	60%
	Moderate	50%	38%
	High	7%	2%

Sources/Notes: Based on Current Vegetation Survey plots located in the analysis area.

Treatment Opportunities

1. Salvage of Dead Trees. Trees die when they cannot acquire or mobilize sufficient resources to heal injuries or otherwise sustain life (Waring 1987). In areas with a substantial number of dead trees, some of them may be salvaged. As is often the case with forest management activities, salvage logging can have both positive and negative effects. Some important benefits of salvage are to harvest and utilize wood fiber while it is still merchantable, to remove enough dead trees to promote regeneration of shade-intolerant seral species, and to reduce fuel accumulations to the point where wildfire risk is acceptable and a prescribed burning program could be initiated (Powell 1994).

Any salvage removals should be done carefully. Enough dead trees should be left to provide adequate habitat for cavity-dependent birds. Retaining dead trees also provides habitat for ants and other invertebrates that prey on the larvae of defoliating insects. And standing dead trees eventually fall to the ground, where they contribute to nutrient cycling, long-term site productivity, and mycorrhizal habitat. In particular, more of the brown-rot species (pines, Douglas-fir, western larch) should be retained on-site than the white-rot species (true firs and Engelmann spruce) because their downed logs are most effective at providing long-term mycorrhizal habitat and soil moisture storage.

I recommend that salvage cutting be considered for subwatersheds with substantial amounts of forest damage. Table 26 summarizes forest damage areas (acres) by subwatershed. A salvage program should emphasize dry-forest areas because they have experienced the most pronounced changes in both species composition and forest structure over the last 90 years. Salvage logging could also help generate revenue (K-V funds) to finance tree planting, noncommercial thinning, and other restoration treatments. Table 23 shows the management areas in which the Umatilla National Forest Plan allows salvage cutting and associated tree planting to occur.

2. Planting. Planting is a powerful tool for influencing the future composition of a forest. In areas with substantial stand damage, planting can help reestablish a high proportion (60-70%) of early-seral, pest-resistant species. At lower elevations on warm dry sites, Douglas-fir or grand fir are the climax species and the choice of resistant species is limited, with ponderosa pine being the most obvious one. At higher elevations on cool moist sites, grand fir or subalpine fir are climax and the selection of nonhost species is wider – lodgepole pine, western larch, ponderosa pine, western white pine, or quaking aspen could be used depending on the ecological conditions of the planting site.

If salvage treatments are completed in response to the stand damages described above, then the treated areas should be evaluated to determine their suitability for planting. Any planting evaluations should consider establishing western larch and ponderosa pine where they are early-seral species; western white pine should also be considered for sites in the moist-forest potential vegetation group. If forest health is an objective, then planting should attempt to establish a future stand with at least 60 percent of the composition being early-seral species. This recommendation is particularly appropriate for areas with high future risk for budworm or tussock moth defoliation.

NOTE: a map was not prepared for the “forest damage” issue because most of the analysis area had been affected by forest insects to some degree during the previous 19 years (1980-1998), and because the various damaging agents (pine beetles, western spruce budworm, etc.) tend to overlap each other from one year to the next. For those reasons, a map did not provide further insights for the “forest damage” issue.

Table 23: Management direction summary for the Umatilla/Meacham analysis area.

MANAGEMENT AREA ALLOCATION	SALVAGE PERMITTED?	SUITABLE LANDS?	PLANT USING NFFV FUNDS?	PERCENT OF AREA
A3: Viewshed 1	Yes	Yes	Yes	1
A4: Viewshed 2	Yes	Yes	Yes	4
A5: Roaded Natural	Yes	Yes	Yes	<1
A6: Developed Recreation	Yes	No	No♦	<1
A9: Special Interest Area	Yes	No	No♦	<1
B1: Wilderness	No	No	No♦	14
C1: Dedicated Old Growth	Yes*	No	No♦	3
C4: Wildlife Habitat	Yes	Yes	Yes	28
C5: Riparian (Fish and Wildlife)	Yes	Yes	Yes	1
C8: Grass–Tree Mosaic	Yes	No	No♦	42
E2: Timber and Big Game	Yes	Yes	Yes	6
F3: High Ridge Evaluation Area	Yes	No	No♦	<1
P: Private (non NFS) Lands	N.A.	N.A.	N.A.	N.A.
PACFISH (Riparian Mgmt. Areas)	Yes	No	No♦	N.A.

Sources/Notes: Management area allocations are from the Umatilla NF Forest Plan (USDA Forest Service 1990). The "salvage permitted?" item shows whether salvage timber harvests are allowed by the management direction (standards and guidelines) for each land allocation; the "suitable lands?" item shows whether capable forested lands in the management area are designated as suitable by the Forest Plan; the "plant using NFFV funds" shows whether tree planting on denuded or understocked lands could be financed using appropriated forest vegetation funds (NFFV); the "percent of area" item shows the percentage of National Forest System lands in the analysis area allocated to the management emphasis. N.A. is not applicable.

* Salvage harvest allowed only if an old-growth tree stand is killed by a catastrophic disturbance.

♦ Although appropriated NFFV funds cannot be used for planting because these lands are unsuitable, planting could occur if appropriated funds were provided by the benefiting resource (wildlife, fish, etc.) OR if a salvage harvest occurred and K–V funds were collected to finance the planting.

FOREST DENSITY

Forest density was evaluated using the canopy cover percentages available from the 1999veg database, in conjunction with suggested stocking guidelines for Blue Mountain forests (Cochran and others 1994, Powell 1999). Since moist sites are capable of supporting higher stand densities than dry sites, potential vegetation (as represented by the plant association groups) was used as a tool to identify sites with differing capacity to support tree stocking.

The results of the stocking analysis are provided in table 24. It summarizes the National Forest System acreage in each of five canopy-cover classes, by plant association group, for the two watersheds comprising the analysis area. The black cells in table 24 shows the acreage that is overstocked if the objective is to maintain a stand composition favoring the early-seral tree species. It is important to emphasize that an evaluation of forest stocking levels is species dependent; the results in table 24 would be much different if the objective was to favor stands dominated by mid- or late-seral species such as grand fir, Douglas-fir, and subalpine fir.

Recent concerns about forest health in the Blue Mountains (McLean 1992) have recognized the value of maintaining stand density levels that promote high tree vigor and minimize damage from insects and pathogens. By regulating stand density and thereby increasing tree vigor, thinning can reduce susceptibility to certain insects and diseases (Hessburg and others 1994, Oliver and others 1994, Pitman and others 1982).

TREATMENT OPPORTUNITIES

1. Thinning. An important silvicultural treatment is thinning, where some trees are removed so that those which remain receive additional moisture, nutrients, and sunlight. Trees respond to a thinning by producing more foliage and by developing a higher level of root reserves, both of which improve their ability to resist and recover from insect and disease problems. For example, the residual trees remaining after a thinning eventually develop increased vigor, which allows them to produce more resin and better repel bark beetle attacks (Safranyik and others 1998).

To grow well, a tree needs a place in the sun and some soil to call its own. After a tree stand occupies all of its growing space, competition begins to cause the death of some trees and the survivors then compete for the growing space relinquished by the demise of their neighbors (Long and Dean 1986). Thinnings mimic this natural tendency for a few large trees to ultimately occupy the space that once supported many small trees.

Thinnings that anticipate density-related (competition-induced) mortality by removing trees from beneath the main canopy are called a low thinning or “thinning from below.” Thinning from below can be advantageous because it creates an open, single-storied stand structure that is amenable to reintroduction of low-intensity surface fires. Low thinning also offers an opportunity to remove some of the pest-susceptible trees and thereby favor early-seral species (Powell 1994).

By reducing the number of trees and opening up a stand, thinning provides more sunlight, water and nutrients for the residual trees. Research from the Blue Mountains consistently found substantial increases in tree growth following a low thinning. This result was obtained for thinned stands of western larch (Seidel 1987), ponderosa pine (Cochran and Barrett 1993, 1995) or lodgepole pine (Cochran and Dahms 1998). Research from central Oregon showed a similar response for thinned stands of Douglas-fir, grand fir, western white pine, or Engelmann spruce (Seidel and Cochran 1981).

Over the long run, thinning and certain other silvicultural practices may be the most effective way to deal with defoliating insects such as western spruce budworm. Research from Montana found that thinning improved budworm resistance by increasing stand vigor, increasing budworm larval mortality during their dispersal period, and by reducing the budworm-host species in mixed-conifer forests. Thinning provided short-term protection for treated stands, and would presumably contribute to long-term resistance once landscape-sized areas were treated (Carlson and Wulf 1989).

The watershed/PAG combinations with apparent overstocking in table 24 (the black cells) should be field examined to determine if the high densities actually exist. If high stand densities are present, then the affected areas should be evaluated to determine their suitability for a thinning treatment. The tables in appendix 3 provide tree density recommendations by species and by plant association (plus an average for each plant association group). They establish a “management zone” in which stand densities are presumed to be ecologically sustainable and relatively resistant to insect and disease problems.

Figures 16 and 17 show the location and distribution of upland-forest sites that apparently represent a noncommercial thinning or commercial thinning treatment opportunity. Both of those opportunities were designed to respond to this “forest density” issue.

Table 24: Forest stocking analysis by watershed.

	PAG	AREA (NFS Acres) BY CANOPY COVER 11-25%	26-45%	46-65%	66-75%	>75%	TOTAL AREA	OVER-STOCKED
MEACHAM WATERSHED	CW	137	116	155	103	**99**	610	99
	CVM	56	297	928	318	**196**	1,795	196
	CD	338	329	244	**53**	**196**	1,160	249
	CM	1,994	4,488	7,936	**2,643**	**1,162**	18,223	3,805
	WVM	33	751	1,913	**809**	**424**	3,930	1,233
	WM	107	664	737	**239**	**76**	1,823	315
	WD	6,323	3,489	**6,165**	**2,569**	**1,120**	19,666	9,854
	HD	491	**227**	**68**	**12**	**9**	807	316
	Total	9,479	10,361	18,146	6,746	3,282	48,014	16,067
UMATILLA WATERSHED	CW	374	727	1,871	1,366	**330**	4,668	330
	CVM	121	64	615	2,108	**59**	2,967	59
	CD	98	185	396	**29**	**13**	721	42
	CM	3,692	4,533	9,379	**4,592**	**2,510**	24,706	7,102
	WVM	211	976	925	**934**	**395**	3,441	1,329
	WM	66	517	842	**297**	**114**	1,836	411
	WD	3,499	2,729	**4,147**	**1,548**	**548**	12,471	6,243
	HD	4	**13**	**0**	**0**	**0**	17	13
	Total	8,065	9,744	18,175	10,874	3,969	50,827	15,529

Sources/Notes: A stand density analysis was based on five categories of forest canopy cover and the up-land-forest plant association groups (see table 2 for information about the PAGs). PAG abbreviations are as follows: CW – Cool Wet; CVM – Cool Very Moist; CD – Cold Dry; CM – Cool Moist; WVM – Warm Very Moist; WM – Warm Moist; WD – Warm Dry; HD – Hot Dry. The black cells indicate the National Forest System acreage that is presently overstocked if the objective is to maintain healthy stands of early- or mid-seral species. For the CD PAG, overstocking was based on the recommendations for lodgepole pine (table 34). For the CW and CVM PAGs, overstocking was based on recommendations for Engelmann spruce (table 33). For the CM, WVM, and WM PAGs, overstocking was based on recommendations for western larch (table 35). For the WD and HD PAGs, overstocking was based on recommendations for ponderosa pine (table 37). The numerical values that were used as thresholds for overstocking were the canopy cover means associated with the lower limit of the management zone for the tree species specified above, by plant association group (appendix 3).

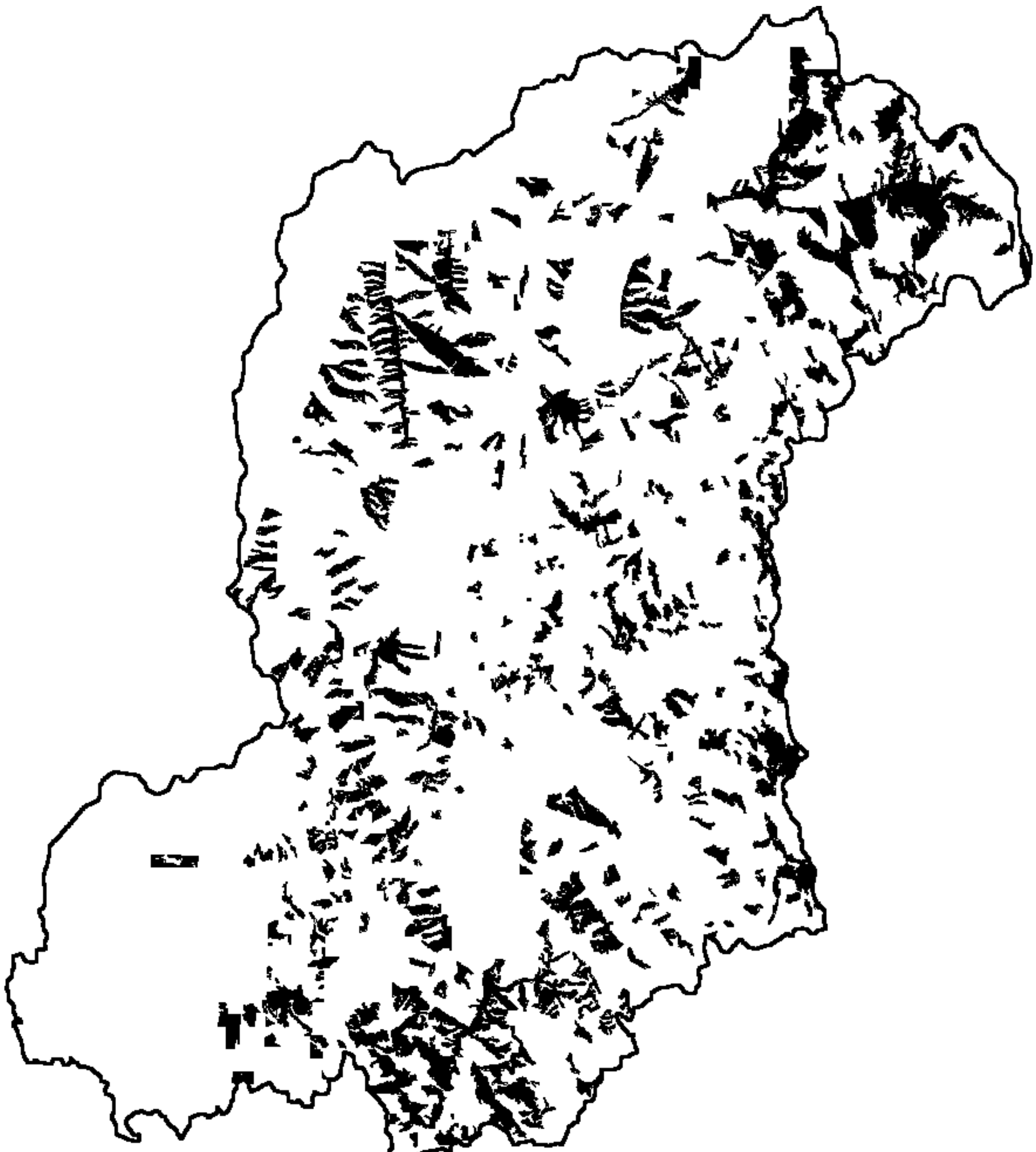


Figure 16 – Overstocked areas that apparently represent a noncommercial thinning treatment opportunity (see table 27). This map relates primarily to the "forest density" issue, but secondarily to the "inconsistent structure on dry-forest sites," and "restoration of ponderosa pine and western larch" issues. Note that this map was based exclusively on the stocking analysis; it does not include any explicit consideration of project feasibility (operability, accessibility, availability, etc.).

Figure 17 – Overstocked areas that apparently represent a commercial thinning treatment opportunity (see table 27). This map relates primarily to the "forest density" issue, but secondarily to the "inconsistent structure on dry-forest sites," and "restoration of ponderosa pine and western larch" issues. Note that this map was based exclusively on the stocking analysis; it does not include any explicit consideration of project feasibility (operability, accessibility, availability, etc.).

HISTORICAL RANGE OF VARIABILITY FOR FOREST STRUCTURAL STAGES

The historical range of variability (HRV) is a technique to characterize inherent variation in ecosystem composition, structure and processes, reflecting recent evolutionary history and the dynamic interplay of biotic and abiotic factors. It represents ecosystem properties that are free of major influence by Euro-American humans, providing an insight into the characteristics of sustainable ecosystems (Kaufmann and others 1994). HRV helps us to understand what an ecosystem is capable of, how historical disturbance regimes operated, and the underlying variation in ecosystem processes and functions – the patterns, connectivity, seral stages, and cover types produced by ecological processes operating at a landscape scale (USDA Forest Service 1997).

The past can teach us what worked and what lasted – how resilient ecosystems sustained themselves through time. The type and frequency of presettlement disturbances can serve as a management template for maintaining sites within their historical range of plant communities and vegetation structures. This approach ensures that management treatments are consistent with the conditions under which native species, gene pools, communities, landscapes, and ecosystem processes have evolved (Delong and Tanner 1996).

HRV is intended to serve as a benchmark from which change can be measured; it is not a specific condition that ecosystem management strives to attain (USDA Forest Service 1997). A common misconception is that it might be appropriate to use HRV as a management objective by linking desired future conditions directly to HRV, but a better approach is to let historical data inform an analyst about ecosystem behavior and potential management consequences (Millar 1997). Helping to identify opportunities to restore an ecosystem's resilience – its capacity for regeneration and renewal – is perhaps the most important contribution that HRV information can offer to an assessment or planning effort.

Even if land managers wished to "turn back the clock" to some golden presettlement era, the current reality of dams, roads, human settlements, fire suppression, and mounting demands on wildland resources to meet societal needs would make that goal problematic. Clearly, we cannot turn all our wheat fields back into bluebunch wheatgrass prairies, no matter how inadequate they may seem from an ecological perspective. We simply cannot go back in time and undo all that has happened and, in that sense at least, we are prisoners of time and our own history (Worster 1996). A recent scientific assessment for the Interior Columbia River Basin suggests that presettlement conditions could not be restored even if that was an explicit objective (Quigley and Arbelbide 1997).

HRV was used as an analytical technique to evaluate forest structural stages. As part of the analysis, potential vegetation was used to explicitly recognize that not all forest stands will pass through every structural stage, and that different forest types will not spend the same amount of time in any particular stage.

The results of the HRV analysis are provided in table 25. It summarizes the current percentage of each structural stage, by plant association group, for the Umatilla and Meacham watersheds individually. The historical ranges for each of the structural stages are also shown in table 25; it clearly shows that the historical percentages vary by plant association group.

Perusing the HRV results summarized by watershed (Umatilla and Meacham) shows that the stand initiation (SI) structural stage has a surplus for many of the watershed/PAG combinations. Both of the old forest stages (multi strata and single stratum; OFMS and OFSS) are deficient for one or more of the watershed/PAG combinations. Stem exlusion closed canopy (SECC) and young forest multi strata (YFMS) are also deficient for certain plant association groups. In particular, understory reinitiation (UR) is consistently above HRV because it has a "surplus" for almost every watershed/PAG combination.

Table 25: Historical range of variability (HRV) analysis for forest structural stages.

	PAG		UPLAND FOREST STRUCTURAL STAGES							NFS
			SI	SEOC	SECC	UR	YFMS	OFMS	OFSS	Acres
MEACHAM WATERSHED	CD	H%	1-20	0-5	5-20	5-25	10-40	10-40	0-5	
		C%	**26**	1	**2**	**63**	8	**0**	1	1,160
	CW	H%	1-10	0-5	1-10	5-25	20-50	30-60	0-5	
		C%	**16**	3	0	**53**	29	**0**	0	609
	CVM	H%	1-10	0-5	5-20	5-25	20-60	20-40	0-5	
		C%	4	6	**0**	**42**	31	**14**	3	1,793
	CM	H%	1-10	0-5	5-25	5-25	40-60	10-30	0-5	
		C%	**14**	2	**2**	**52**	**24**	**3**	1	18,223
	WVM	H%	1-15	0-5	5-20	5-20	20-50	20-40	0-5	
		C%	4	0	**0**	**38**	44	**8**	6	3,928
	WM	H%	1-15	0-5	5-20	5-20	20-50	10-30	0-5	
		C%	6	0	**0**	**44**	30	15	5	1,822
	WD	H%	5-15	5-20	1-10	1-10	5-25	5-20	15-55	
		C%	**28**	8	4	**43**	0	13	**4**	19,666
	HD	H%	5-15	5-20	0-5	0-5	5-10	5-15	20-70	
		C%	**47**	17	0	**29**	**0**	6	**1**	807
UMATILLA WATERSHED	CD	H%	1-20	0-5	5-20	5-25	10-40	10-40	0-5	
		C%	17	5	**1**	**35**	**4**	36	2	721
	CW	H%	1-10	0-5	1-10	5-25	20-50	30-60	0-5	
		C%	**15**	2	0	**38**	25	**16**	3	4,668
	CVM	H%	1-10	0-5	5-20	5-25	20-60	20-40	0-5	
		C%	4	1	**1**	17	**7**	**57**	**13**	2,968
	CM	H%	1-10	0-5	5-25	5-25	40-60	10-30	0-5	
		C%	**19**	1	**2**	**39**	**21**	14	4	24,705
	WVM	H%	1-15	0-5	5-20	5-20	20-50	20-40	0-5	
		C%	**19**	0	**0**	**37**	25	**13**	6	3,442
	WM	H%	1-15	0-5	5-20	5-20	20-50	10-30	0-5	
		C%	10	0	**0**	**41**	36	9	4	1,836
	WD	H%	5-15	5-20	1-10	1-10	5-25	5-20	15-55	
		C%	**18**	15	4	**35**	**0**	**25**	**4**	12,471
	HD	H%	5-15	5-20	0-5	0-5	5-10	5-15	20-70	
		C%	**0**	**24**	0	0	**0**	**0**	**76**	17

Sources/Notes: Summarized from the 1999veg database (see appendix 1). Current percentages (C%) were based on National Forest System lands only. Historical percentages (H%) were derived from Hall (1993), Johnson (1993), and USDA Forest Service (1995), as summarized in Blackwood (1998). Plant association groups (PAG) are described in Powell (1998) and in tables 2 and 4; structural stage codes are described in appendix 1 and in table 14. Cells with bold numbers indicate those instances where the current percentage (C%) exceeds the historical percentage (H%) for a structural stage. Black cells with white numbers show those instances where the current percentage is less than the historical percentage. Since an HRV analysis is somewhat imprecise, deviations (whether above or below the H% range) were only noted where the current percentage differed by 2 percent or more. The HRV analysis was conducted on each watershed individually; the table's top half shows results for the Meacham watershed, the bottom half for the Umatilla watershed.

TREATMENT OPPORTUNITIES

1. Understory Removals. This silvicultural practice is used in multi-storied stands, typically those with an overstory of early-seral trees and an understory of shade-tolerant species. The objective is to remove a high proportion of the understory trees, which improves overstory vigor by reducing competition and, when the overstory trees are mature ponderosa pines or western larches, this treatment can be effective at ensuring their continued survival (Arno and others 1995).

Understory removals are implemented in at least two ways: on an area basis, or around individual trees. In the first method, understory trees are removed on areas having a relatively uniform stand composition and structure. Area-wide understory removals can be especially useful before initiating a prescribed fire program. In areas lacking uniform conditions, the understory is removed from around individual overstory trees with the objective of prolonging their survival by decreasing inter-tree competition and thereby increasing overstory vigor.

a. *The subwatersheds with warm dry PAGs and a deficient amount of old forest single stratum (OFSS) in table 25 should be evaluated for understory removals (area basis) to convert understory reinitiation (UR) to OFSS*. Shade-tolerant, late-seral species in the understory should be removed; some proportion of fire-resistant trees in the understory could be retained if it is believed they would survive a prescribed fire. In some instances, the overstory may need to be lightly thinned to hasten production of large-diameter trees for wildlife objectives; if so, fire-resistant species should be preferentially retained.

b. *The subwatersheds with deficiencies in old forest multi strata (OFMS) in table 25 should be evaluated for understory removals (individual-tree basis) or thinnings to enhance the survivability and representation of large-diameter trees*. If inadequate densities of large trees are an issue, then the objective of either understory removals or thinnings should be to produce large-diameter trees as soon as possible. As was the case above, stands within the understory reinitiation structural stage should be considered first for these treatments because UR has a large surplus in the Umatilla/Meacham area.

2. Restoration of Old Forest Structure. An HRV analysis for forest structural stages indicates that the existing amount of old forest structure is substantially reduced from historical levels (table 25). Information on historical amounts and distribution of old forests is scarce, but a recent assessment effort identified that old forest abundance has been significantly reduced in most of eastern Oregon and Washington since the pre-settlement era (Lehmkuhl and others 1994).

In the Umatilla/Meacham analysis area, old forest structure occurs in two forms, and each form was developed and maintained by a different disturbance regime. In dry forest areas, plant succession toward a climatic climax was historically interrupted by low- and moderate-intensity fires that maintained forest stands in an early-seral condition. These seral communities were very stable because ecosystems with frequent disturbances exhibit only a narrow range of plant communities (Steele and Geier-Hayes 1995).

An example of a stable, early-seral community from the Blue Mountains is “park-like” ponderosa pine, a forest condition with large, widely-spaced trees growing above a dense undergrowth of tall grasses. In some situations, that same vegetative condition existed with western larch as the dominant species instead of ponderosa pine. Those attractive landscapes had been created and maintained by low-intensity, high-frequency wildfires occurring on a cycle of 8 to 20 years. In this report, the old forest structure associated with early-seral conditions is referred to as *old forest single stratum* (see tables 14 and 25).

Some moist or cold forest areas, by virtue of their topographic position, soil type, or a combination of environmental conditions and vegetation attributes, are less frequently affected by stand-replacing disturbances than the surrounding landscape. These areas may be thought of as semi-stable elements in a dynamic landscape because their environmental settings allow them to function as old-forest fire refugia.

Disturbance refugia are often associated with specific physiographic settings such as upper headwalls, the confluence of two stream channels, areas with perched water tables, and valley bottoms immediately adjacent to perennial streams (Camp and others 1997, Taylor and Skinner 1998).

Disturbance refugia typically differ from the surrounding landscape matrix in species composition, or in structural attributes such as tree height, density, or diameter distribution. Refugia may harbor plant and animal species that would otherwise be absent if an entire landscape was subjected to the same disturbance regime. Whereas fire was the predominant disturbance agent for matrix areas in the landscape, disturbance refugia were more often affected by insects and diseases that created soft snags and other biotic components missing from the surrounding forest (Camp and others 1997).

Old forest structure associated with disturbance refugia typically consists of late-successional species occurring in multi-cohort, high density stands (e.g., stands of grand fir, Engelmann spruce, or subalpine fir with multiple canopy layers and a high canopy cover percentage). In this report, the old forest associated with disturbance refugia is referred to as *old forest multi strata* (see tables 14 and 25).

Old forests can contribute significantly to local and regional biodiversity. For that and other reasons, there is strong interest in restoring old forest structure to a level that approximates its historical abundance. Any restoration approach should incorporate the following concepts relating to the landscape ecology of eastern Oregon (Camp and others 1997, Everett and others 1994):

- Current anomalous landscapes and disturbance regimes need to be restored to a more sustainable state if old-forest remnants are to be conserved and old-forest networks created and maintained;
- Today, many old-forest remnants are surrounded by a mosaic of young forest types with heightened fire and insect hazard;
- Given the limited contribution from any individual old-forest patch, additional old-forest stands need to be continually created to maintain a dynamic balance through time;
- Efforts to conserve old forest should not sacrifice contributions from other structures or components in the landscape;
- Conserving the disturbance processes that influence ecosystems is every bit as important as conserving individual plant and animal species or old forest structure – a lack of disturbance can be as threatening to biological diversity as excessive disturbance;
- Management of old forest patches must be integrated with the disturbance regimes characteristic of their associated landscape;
- Any plan to sustain old forests must first sustain the landscape of which they are a part;
- In managing old forests, a landscape perspective is needed that coordinates species requirements with the functional attributes of ecosystems;
- Forest ecosystems of the Interior Pacific Northwest are in a constant state of change, and it must be recognized that the successional pathway of a high proportion of the forest stands will be interrupted by fire, windthrow, insect attack, or disease before they can reach an old-forest condition.

A restoration strategy for old forests could include the following components (Camp and others 1997, Everett and others 1994):

- Conservation of the remaining old-forest patches is the cornerstone of any management scheme, if for no other reason than it best maintains future options;
- Sites that do not have a full complement of old forest characteristics can partially function as old forest for those attributes that are present;
- The potential for increasing the amounts and distribution of *old forest multi strata* stands is present on the landscape in the form of mid- to late-seral structural stages (specifically, the *understory reinitiation* and *young forest multi strata* stages);

- Although mid- to late-seral stands are “in the pipeline” to replace old forests lost to natural disturbances, we still do not know the appropriate ratio of late-seral to old forest to ensure that current or desired levels of old forests are maintained in perpetuity;
- In some parts of the landscape it may be necessary to designate areas of younger forest as old-growth management areas in order to meet desired future objectives with respect to a seral stage distribution;
- Evaluating historical amounts of old forest (as is often done when analyzing the historical range of variability for forest structural stages) can provide a first approximation of old forest abundance that was sustainable and in which plant and animal species evolved;
- Ideally, historical evaluations should incorporate several reference points in time and at a sufficient spatial scale to ensure that major disturbance regimes have been accounted for;
- A successful old forest strategy would allow flexibility in specific on-the-ground locations over time. The “shifting mosaic” landscape concept suggests a dynamic framework in which old forest patches are lost and created in an equilibrium at appropriate spatial and temporal scales;
- Restoration of old forests carries with it long-term management costs with little expectation of substantial commodity production. Creation of an old-forest network explicitly assumes that biological diversity and other old-forest values are specifically desired by human society;
- A dynamic ecosystems philosophy should be the foundation of any old-forest strategy – an ecologically sustainable representation of old forest structure in the landscape is more important than preservation of individual old forest patches.

How could these concepts be applied in the Umatilla and Meacham watersheds? I believe that the following process would contribute to development of an old forest network:

1. Identify any existing old-forest patches and conserve them from anthropogenic disturbances such as timber harvest so they could serve as a cornerstone of a future network.
2. Identify mid- to late-seral patches (*understory reinitiation* and *young forest multi strata* stands) in close proximity to existing old forest patches as potential replacements for them.
3. Examine the mid- to late-seral patches on the ground to determine which old forest attributes they currently have, and to determine if cultural activities (thinnings, etc.) could promote missing attributes more quickly than would occur by doing nothing.
4. Identify a desired future patch distribution and determine if young-seral stands (*stand initiation* and *stem exclusion*) located on a desirable spacing could be cultured (thinned, etc.) to produce old-forest attributes more quickly than would occur by doing nothing.
5. When identifying candidates for future *old forest multi strata*, stands should be selected that have the highest potential to survive to the old forest stage – namely areas on north-facing aspects and at high elevations, particularly if they occur within valley bottoms and drainage headwalls. The predicted location of semi-stable environmental settings could be modeled using criteria described by Camp and others (1997).

Figure 18 shows the location and distribution of upland-forest sites that represent a “conserve” approach with respect to an old forest network. “Conserve” sites are those that currently qualify as old forest, e.g., the “old forest multi strata” and “old forest single stratum” patches. Figure 18 also shows the upland-forest sites that apparently represent an opportunity to enhance existing structural conditions in order to promote old forest more quickly than would occur by doing nothing. “Enhance” sites in figure 18 are those that currently qualify as mid- to late-seral patches, e.g., the “young forest multi strata” and “understory reinitiation” structural stages.

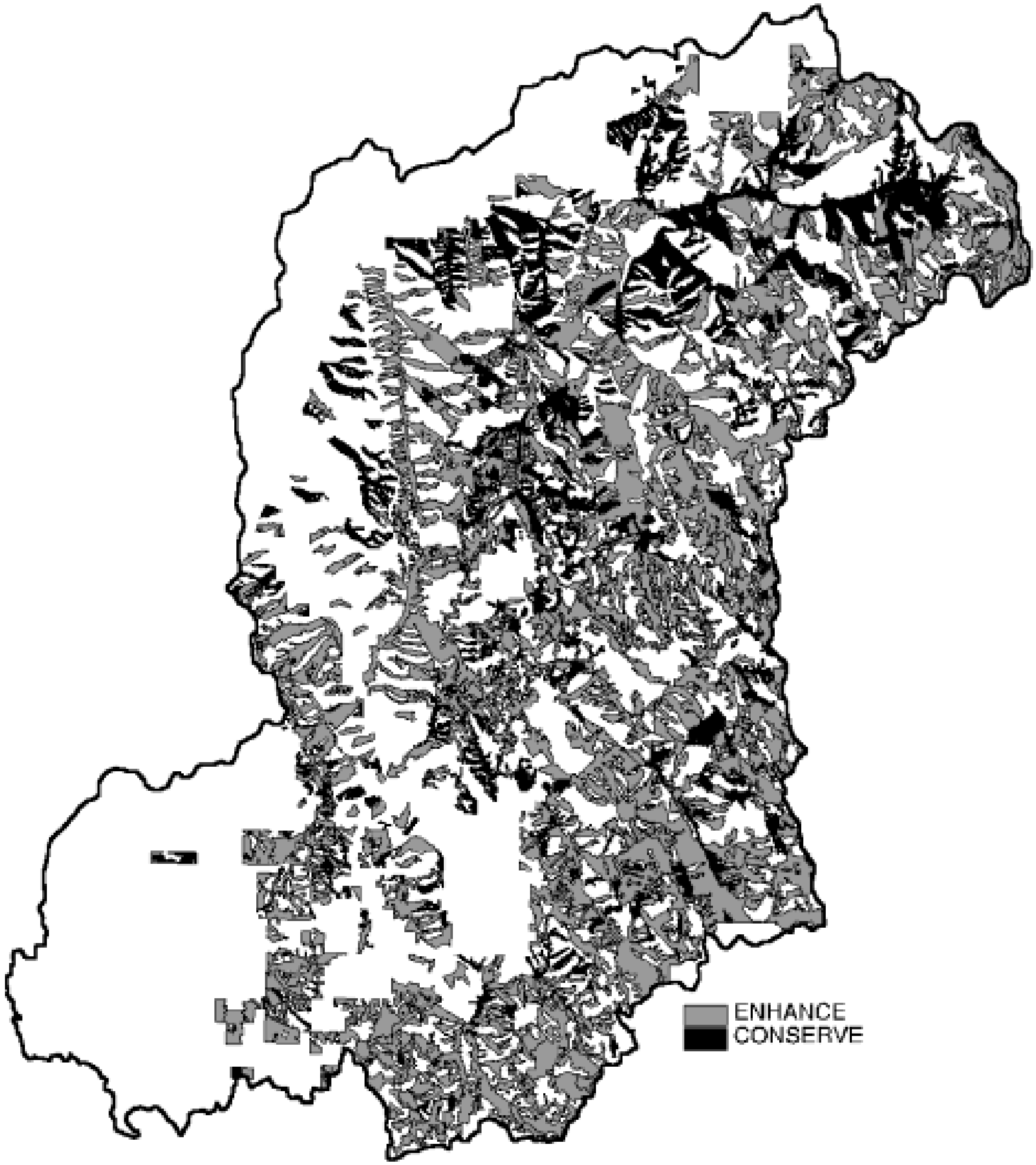


Figure 18 – Upland-forest patches that could contribute to an old forest network. The "enhance" patches are mid- to late-seral structures (the "young forest multi strata" and "understory reinitiation" stages) that could receive cultural treatments (thinnings, etc.) as a way to produce large-diameter trees and other old-forest attributes more quickly than would occur by doing nothing. The "conserve" patches include upland-forest stands that currently qualify as old forest (the "old forest multi strata" and "old forest single stratum" stages). These areas would need to be conserved from anthropogenic disturbances such as timber harvest to ensure their continued availability as a potential cornerstone of a future old-forest network.

SPECIES COMPOSITION AND VEGETATION DIVERSITY

An evaluation of species composition and vegetation diversity was centered on three issues: grassland replaced with forest; inconsistent structure on dry-forest sites; and restoration of ponderosa pine and western larch. The analysis results for these three issues are provided in table 26.

All three of these issues are related to vegetation diversity and the fact that landscapes are less diverse now than they were historically (Lehmkuhl and others 1994). Certain aspects of this diminished diversity can be characterized as "landscape homogenization and ecological simplification" because it resulted from livestock grazing, fire suppression, and other anthropogenic changes that caused certain ecosystem components to be reduced or lost altogether (see page 28 for more discussion about this issue).

The "grassland replaced with forest" factor in table 26 relates to an implication derived from analysis of forest cover types (see page 12). The grassland loss figures in table 26 are substantial, especially considering the relatively short time period involved in the comparison (approximately 40 years).

A sizable loss of grassland in a short time period indicates that some of the change may not be real – it could be due to differences in data resolution and mapping procedures, or it could reflect possible registration problems with the 1958 map. Further analysis indicates that the "net loss" of grassland between 1958 and 1999 was only 1,331 acres on National Forest System lands. This means that much of the gross acreage of grassland loss in table 26 may have been offset by situations where forest was lost to grassland.

The "inconsistent structure on dry-forest sites" and "restoration of ponderosa pine and western larch" issues in table 26 are related to forest health concerns, particularly regarding changes in species composition and their impact on susceptibility to spruce budworm and other defoliating insects (Powell 1994). "Inconsistent structure on dry-forest sites" shows the acreage of warm dry and hot dry PAGs that supports fir types (e.g., Douglas-fir, grand fir, or "mixed"). "Restoration of ponderosa pine and western larch" portrays the NFS acreage that was mapped as pine or larch in 1958, but now supports other forest cover types such as grand fir, Douglas-fir, or "mixed."

The "inconsistent structure on dry-forest sites" issue addresses situations where Douglas-fir and grand fir would be viewed as ecologically "offsite" species. Although those species can obviously get established on many ponderosa pine sites, they would not have been able to persist there without human intervention in the form of fire suppression. A recent assessment showed that three watersheds in the northern part of the Umatilla National Forest experienced a 90% decline in ponderosa pine cover, and corresponding 35% to 230% increases in Douglas-fir/grand fir cover, between 1938 and 1987. Western larch cover also declined by 80% to 100% in those same watersheds (Lehmkuhl and others 1994).

Two of the three watersheds used by Lehmkuhl and others (1994) occur in the Wenaha-Tucannon Wilderness Area. Even in those relatively "undisturbed" watersheds, it was found that substantial declines in ponderosa pine, grass/forb and other early-seral patch types had occurred. This finding reflects one result of long-term fire suppression – the landscape had become more homogeneous, with fewer vegetation types (particularly early-seral stages), larger patches at lower patch densities, and less total edge than would have been expected for the native disturbance regime (Lehmkuhl and others 1994).

Many land managers would agree that wildfire suppression was a policy with good intentions, but it failed to consider the ecological consequences of a major shift in species composition. Grand firs and Douglas-firs can get established under ponderosa pines in the absence of underburning, but they may not have enough resiliency to persist over the long run, let alone survive the next drought. Perhaps the recent deterioration of forest health in the Blue Mountains is not surprising when considering the changes in species composition occurring after fire was prevented from fulfilling its ecological role (Powell 1994).

Table 26: Summary of upland forest issues by subwatershed (SWS).

SWS	FOREST DAMAGE	GRASSLAND REPLACED WITH FOREST	INCONSISTENT STRUCTURE ON DRY-FOREST SITES	RESTORATION OF PONDEROSA PINE & WESTERN LARCH
13A	24,194	990	1,351	355
13B	3,011	278	657	668
13C	15,010	710	860	767
13D	24,449	354	450	386
13E	47,282	658	185	897
13F	12,714	315	529	92
13G	35,397	664	289	491
13H	36,697	476	401	1,051
13I	38,234	162	246	1,063
13J	43,223	769	230	201
13K	64,717	1,204	661	790
UMA		6,580	5,859	6,761
89A	6,280	406	836	92
89B	11,349	1,054	824	208
89C	28,251	862	400	1,072
89D	18,598	1,097	1,157	425
89E	5,828	386	57	261
89F	16,445	570	23	496
89G	60,435	1,234	340	1,733
89H	51,014	856	173	1,971
89I	48,742	760	735	1,789
89J	4,994	176	324	74
89K	32,666	352	752	1,522
89L	45,475	395	1,707	2,676
89M	8,294	234	357	542
89N	11,121	131	543	703
89O	23,378	845	714	1,343
89Q	879	18	40	41
MEA		9,376	8,982	14,948
Total		15,956	14,841	21,709

Sources/Notes: The “forest damage” issue is described in table 21. The “grassland replaced with forest” column shows the NFS acreage that was mapped as grassland in 1958 but classified as a forest type in 1999. The “inconsistent structure on dry-forest sites” column shows the NFS acreage of warm dry and hot dry plant association groups with multi-layered stands whose density would be considered overstocked using the stocking level recommendations in appendix 3. The “restoration of ponderosa pine and western larch” column shows the NFS acreage that was mapped as ponderosa pine or western larch in 1958 but classified as another forest type (grand fir, Douglas-fir, or mixed) in 1999.

Reestablishing ponderosa pine and western larch on sites that are suitable for their survival and growth, and a thinning or prescribed fire program to keep those stands open and vigorous, would undoubtedly contribute much toward ensuring future forest sustainability (Powell 1994).

TREATMENT OPPORTUNITIES

1. Tree Removal. Table 26 shows an apparent loss of grassland to forest encroachment between 1958 and 1999. The subwatersheds where significant amounts of grassland loss have occurred should be field examined to verify the accuracy of information in table 26. If significant losses have occurred, and *if those losses are considered to be undesirable based on Forest Plan standards and guidelines or desired future conditions*, then the affected areas should be evaluated to determine their suitability for a “tree removal” treatment.

If the trees to be removed are merchantable and accessible, then timber harvest may be an acceptable removal tool. If the trees are too small or too widely scattered to support a harvest operation, then stand-replacement fire may be the best way to kill them. From an ecological standpoint, fire would probably be the preferable method, especially if it could occur in late summer or fall to mimic the natural fire regime. Timber harvest may be an economically efficient removal tool if it was coordinated with harvest operations in adjacent areas.

2. Understory Removals and Thinnings. See the understory removals discussion in the “HRV for forest structural stages” section (page 46), and the thinning discussion in the forest density section (page 39), for more information about these silvicultural treatments. Table 26 shows an apparent development of unsustainable forest structures (overstocked, multi-cohort stands) on dry-forest sites that historically supported single-layer ponderosa pine stands. Table 26 also summarizes the acreage of mixed-species stands that historically supported a predominance of ponderosa pine or western larch in their composition.

The subwatersheds with significant acreage of inconsistent structure on dry-forest sites, or restoration of ponderosa pine and western larch, should be field examined to verify the accuracy of information in table 26. If the data in table 26 is correct, then the affected areas should be evaluated to determine their suitability for understory removal and/or thinning treatments. *An understory removal would be particularly appropriate as a treatment to remove Douglas-firs and grand firs that have invaded on warm dry sites*.

Understory removals may also be effective on sites with a remnant ponderosa pine or western larch component, especially if the pine or larch occurs as an overstory and the other species as an understory. On some sites with remnant pine and larch, thinning would be effective at reducing densities to more sustainable levels, thereby improving the vigor and survivability of the pine and larch.

3. Prescribed Fire. After completing the tree removals, understory removals, and thinnings described in this section, managers should strongly consider implementing a prescribed fire program for the dry-forest areas. Once ponderosa pines or western larches are 10 to 12 feet tall, a prescribed burn could be completed, although a low-intensity fire would leave most of the 6- to 8-foot trees undamaged as well (Wright 1978). From that point on, surface fires could be used on a regular cycle, usually at intervals of 15 to 25 years. Fall burns, which are desirable from an ecological perspective because they replicate the natural fire regime, result in fewer losses of overmature pines to fire damage or to western pine beetle attack (Swezy and Agee 1991).

Periodic burning can also be used to increase the nutrient capital of a site by maintaining a representation of snowbrush ceanothus, lupines, peavines, vetch, buffaloberry, and other nitrogen-fixing plants. Numerous studies have documented the slow decomposition rates associated with large, woody material in the interior West (Gruell 1980, Gruell 1983, Gruell and others 1982). This means that forests of the Interior Northwest may have depended more on nitrogen-fixing plants and low-intensity fires to recycle soil nutrients than on microbial decomposition of woody debris.

Providing adequate levels of site nutrition is important for maintaining tree resistance to insects and diseases (Mandzak and Moore 1994). In central Oregon, for example, Reaves and others (1984, 1990) found that ash leachates (chemical substances produced when water percolates through the ash remaining after a fire) from prescribed burns in ponderosa pine forests had a direct negative effect on the growth of *Armillaria ostoyae*, cause of Armillaria root disease. Much of the Armillaria suppression was due to a fungus called *Trichoderma*, which was strongly antagonistic to *Armillaria ostoyae* in burned soils.

Fire may not be beneficial on all upland-forest sites; on moist areas, burns could favor dominance by bracken fern, western coneflower, and other allelopathic plants that inhibit conifer regeneration (Ferguson 1991, Ferguson and Boyd 1988). Table 27 shows subwatersheds where bracken fern could pose an allelopathic risk for forest regeneration.

Prescribed fire has recently been proposed as a possible replacement for mechanical thinning. On droughty sites in eastern Washington, residual trees increased growth following surface fires which killed intermediate and suppressed trees, but growth increases were greater when the forest was thinned by manual cutting. Unlike fire, manual thinning did not damage roots, so residual trees reoccupied the growing space quickly. After overstory trees appropriated the additional growing space provided by a thinning, grasses did not readily invade (Oliver and Larson 1996).

On poor to moderate forest sites (generally dry areas with coarse or shallow soils and thin forest floors), broadcast burning can be detrimental from a nutritional standpoint. The short-term benefits of prescribed fire, such as improved access for tree planters, fuel reduction, site preparation, and increased soil temperature regimes, may be achieved at a cost of high soil pH, nitrogen and sulfur deficiencies, and other nutritional problems later in a forest's life (Brockley and others 1992). In central Oregon, prescribed fire was observed to cause a net decrease in nitrogen mineralization rates and a decline in long-term site productivity (Cochran and Hopkins 1991, Monleon and others 1997).

I recommend that prescribed fire be used on dry-forest PAGs (warm dry and hot dry) after multi-layer stands have received an understory removal or thinning treatment, and that it be considered as a future treatment for any plantations established on those same PAGs. Prescribed fire will probably not be feasible for at least 30 years after plantations have been established, but it could then be coordinated with thinning and pruning treatments that were designed to create stand structures with low risk of crown fire or other undesirable fire behavior (Agee 1996, Scott 1998).

4. Consideration of Limited Vegetation Components. By its very nature, ecosystem analysis at the watershed scale (EAWS) encourages analysts to adopt a broad perspective that emphasizes looking beyond site-level conditions to focus on ecological processes at the landscape scale. One potential pitfall of a broad perspective, however, is the risk of overlooking limited vegetation components such as quaking aspen, western white pine, or black cottonwood – many of which have a restricted distribution and are indistinguishable at a landscape scale.

For the Umatilla and Meacham watersheds, quaking aspen, black cottonwood, and western white pine are three limited components of particular concern.

Quaking aspen is a good example of an ecosystem element that is valued for a wide variety of benefits. Its leaves and buds are a choice food for ruffed grouse, beaver, snowshoe hares, Rocky Mountain elk and many other species. And in winter, when foliage is no longer present, elk like to feed on its smooth white bark. After dying, aspen may be used by almost as many species as when alive, since dead trees are prized by woodpeckers, flickers and many other species that use cavities (DeByle 1985). When present in areas dominated by conifer forests, the golden yellows or tawny russets of fall aspen foliage provide a welcome splash of color. Although it may be difficult to prove (or quantify), it is very likely that aspen was historically more abundant in the Blue Mountains than it is now – fire suppression over the last 90 years has undoubtedly reduced its distribution.

Aspen is a clonal species that primarily regenerates by producing suckers from its root system (Schier and others 1985). Unfortunately, the suckers are highly palatable to elk, deer, and domestic livestock. In order to allow the suckers to persist and eventually grow above the browse height of large ungulates, it is a common practice to fence aspen clones to prevent grazing damage. Relict aspen clones exist sporadically in the Umatilla/Meacham analysis area; table 27 shows the subwatersheds where remnant aspen is known to occur. Some of those clones have been fenced but others have not, so I recommend that clones without enclosures be fenced as soon as possible.

Black cottonwood has a wide geographical distribution but it is mainly a tree of the Pacific Northwest. Like other cottonwoods, its habitat consists of wet areas – along live streams, around seeps, and on floodplains. It can tolerate yearly spring flooding and in some respects almost requires it for survival (Lanner 1984). Its growth is enhanced by frequent depositions of nutrient-rich sediments, and the fine gravels or sand supplied by periodic flooding provide an ideal substrate for cottonwood regeneration. After humans intervened by curtailing spring flooding or by grazing domestic ungulates, black cottonwood has declined or disappeared altogether (Case and Kauffman 1997, Peterson and others 1996).

Unlike aspen, black cottonwood does not reproduce from root suckers, but it does sprout from the root collar and occasionally from rhizomes located close to the parent tree. It can also be propagated by sticking a branch cutting into moist soil and letting it form roots (Rose and others 1998). Although long-term trend data is unavailable for the Umatilla National Forest, black cottonwood is another species whose distribution is thought to be reduced from historical levels. Grazing by wildlife and livestock, and curtailment of frequent spring flooding, have combined with other factors to limit cottonwood regeneration.

I recommend that black cottonwood be planted on appropriate sites in both the upper portion of the dry forest PVG and in the moist forest PVG. Ecologically, black cottonwood is not considered an appropriate revegetation species for the cold forest PVG.

Western white pine, a mid-seral tree species, is sometimes found on cool moist, cool wet, and warm moist sites in the upper montane and lower subalpine vegetation zones (Powell 1998). It was characterized as having a restricted geographical distribution in the Blue Mountains (Haig and others 1941). In actuality, western white pine has a relatively wide distribution as a minor species in mixed-conifer forests, although it seldom comprises a plurality of the basal area in any individual stand. Due to changes caused by fire suppression, bark-beetle outbreaks, white pine blister rust *(Cronartium ribicola)* and other factors, it is believed that white pine in the Blue Mountains was more abundant historically than at present.

Over the last 15 years, western white pine has increasingly been used in reforestation plantings because it survives well and has rapid juvenile growth. I recommend that rust-resistant sources of white pine continue to be planted on moist-forest sites where it is ecologically well adapted. In the near future, some of the historical plantations containing white pine will need to be thinned. Although stocking levels have not been developed specifically for white pine (Powell 1999), I suggest that the Douglas-fir stocking levels also be used for white pine, as was recommended by Seidel and Cochran (1981).

Table 27 summarizes the area (acres), by subwatershed, for three of the primary treatment opportunities discussed in this section (noncommercial thinning, commercial thinning, and understory removal). It was prepared to summarize the upland-forest treatment opportunities for each subwatershed, while also facilitating a comparison between subwatersheds. Table 27 also describes aspen and cottonwood restoration opportunities, and an allelopathic silvicultural concern related to bracken fern, by subwatershed.

Table 27: Area (acres) of treatment opportunities by subwatershed (SWS).

SWS	Noncommercial Thinning	Commercial Thinning	Understory Removal	Other Considerations

13A	1,720	210	1,338	BF, QA
13B	622	138	657	BC
13C	1,071	344	860	BF, QA
13D	1,663	63	450	BF
13E	2,992	107	185	BF, QA
13F	545		529	BF
13G	968	554	289	BF
13H	906	128	401	BF
13I	506	71	246	QA
13J	870	215	230	
13K	1,105	731	661	BF
UMA	12,968	2,561	5,846	
89A	873	173	836	BF
89B	1,062	493	824	QA
89C	486	175	400	
89D	1,545	229	1,157	
89E	105		57	
89F	308		23	
89G	1,569	277	340	BF, QA
89H	996	387	173	BF
89I	1,037	166	692	BF, QA
89J	351		324	
89K	896	50	752	BF
89L	2,434	123	1,633	
89M	427		357	
89N	831	151	543	BF
89O	773	39	556	
89Q	112			
MEA	13,805	2,263	8,667	
Total	26,773	4,824	14,513	

Sources/Notes: The first three columns of this table summarize the area (NFS acres) of treatment opportunities as related to the “inconsistent structure on dry-forest sites” and “restoration of ponderosa pine and western larch” forest issues. The “other considerations” column relates to forest restoration opportunities and one silvicultural concern, as follows: BC = opportunity to restore black cottonwood that was mapped in 1958 but not in 1999; BF = bracken fern, a perennial herb that presents a high potential for conifer regeneration problems due to allelopathy; QA = opportunity to restore or expand quaking aspen (location information provided primarily by Karl Urban).

Table 28 summarizes the subwatersheds with high, moderate, or low priority for action for each of the issues discussed in this section. It was designed to show how one subwatershed compares with others in the same watershed (Umatilla and Meacham are summarized separately).

Table 28: Subwatershed priorities by upland-forest issue.

Watershed	Subwatersheds With High Action Priority	Subwatersheds With Medium Action Priority	Subwatersheds With Low Action Priority
FOREST DAMAGE ISSUE			
Umatilla	13E, J, K	13G, H, I	13A, B, C, D, F
Meacham	89G, H, I, L	89C, D, F, K, O	89A, B, E, J, M, N, Q
FOREST DENSITY ISSUE			
Umatilla	13A, D, E	13C, G, H, K	13B, F, I, J
Meacham	89B, D, G, I, L	89A, H, K, N, O	89C, E, F, J, M, Q
GRASSLAND REPLACED WITH FOREST ISSUE			
Umatilla	13A, C, J, K	13E, G, H	13B, D, F, I
Meacham	89B, D, G	89C, F, H, I, O	89A, E, J, K, L, M, N, Q
LIMITED VEGETATION COMPONENTS ISSUE			
Umatilla	13A, B, C, E, I	Not Rated	Not Rated
Meacham	89B, G, I	Not Rated	Not Rated
INCONSISTENT STRUCTURE ON DRY-FOREST SITES ISSUE			
Umatilla	13A, B, C, K	13D, F, H	13E, G, I, J
Meacham	89A, B, D, L	89C, I, K, N, O	89E, F, G, H, J, M, Q
RESTORATION OF PONDEROSA PINE AND WESTERN LARCH ISSUE			
Umatilla	13C, E, H, I, K	13B, G	13A, D, F, J
Meacham	89G, H, I, K, L, O	89C, D, F, M, N	89A, B, E, J, Q

Sources/Notes: Summarized from the relative subwatershed rankings in tables 26 and 27 (table 27 was used for the forest density issue and was ranked by summing the thinning opportunities).

Figure 19 shows the location and distribution of areas that were mapped as grassland in 1958, but are now classified as a forest type. This figure relates to the “grassland replaced with forest” issue. Figure 20 shows the location and distribution of overstocked, multi-layer stands that apparently represent an understory removal treatment opportunity. This figure relates to the “inconsistent structure on dry-forest sites” and “restoration of ponderosa pine and western larch” forest issues. Figure 21 shows the location and distribution of areas that were mapped as ponderosa pine, western larch, or black cottonwood in 1958, but are now classified as another vegetation type. This figure relates to the “restoration of ponderosa pine and western larch” and “limited vegetation components” forest issues.

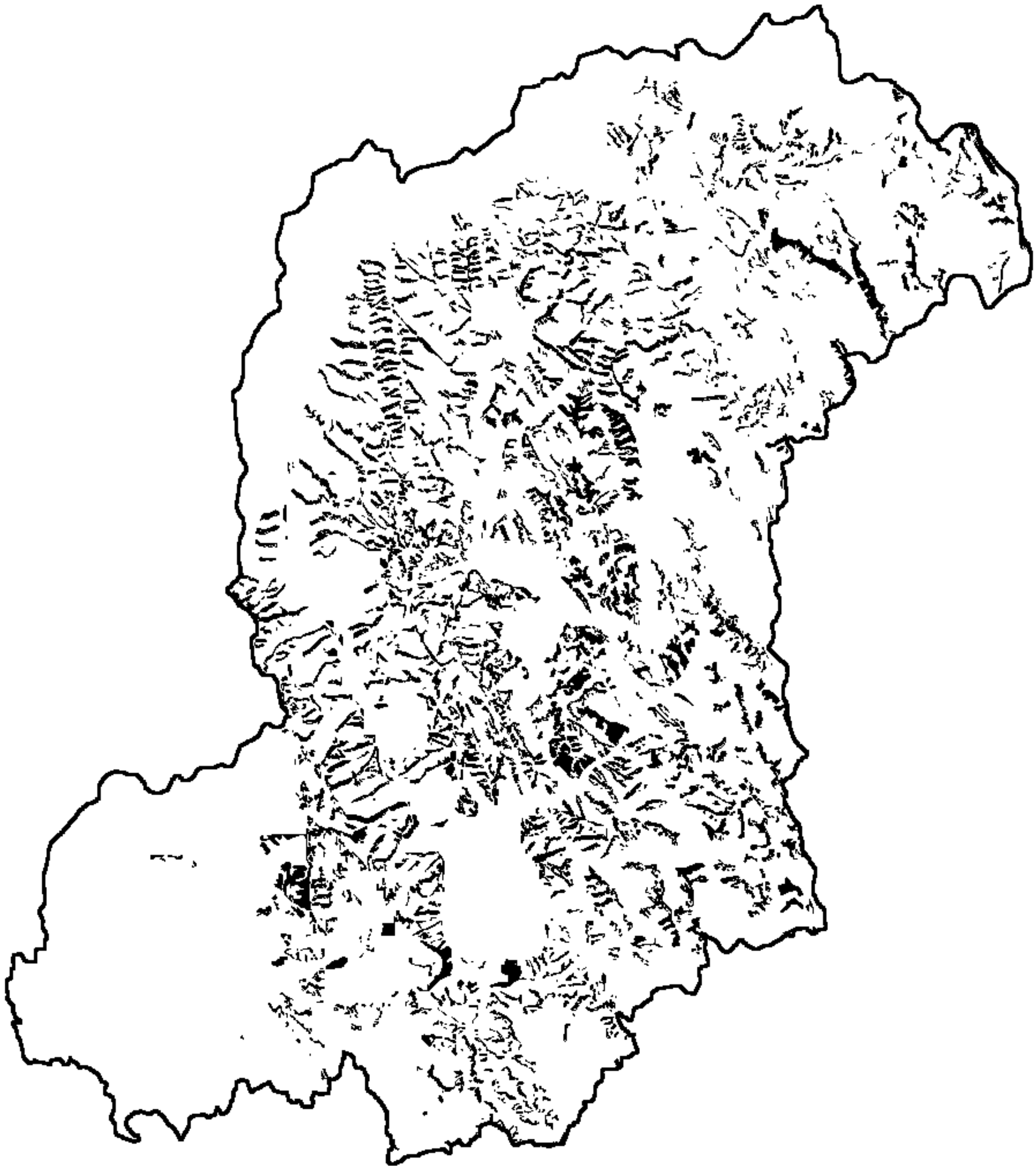


Figure 19 – Areas mapped as grassland in 1958 that were classified as a forest type in 1999. This map relates to the "grassland replaced with forest" issue. These areas apparently represent a "tree removal" treatment opportunity if the grassland loss is considered to be undesirable based on Forest Plan standards and guidelines or desired future conditions. Note that this map was derived exclusively from the grassland analysis; it does not include any explicit consideration of project feasibility (operability, accessibility, availability, etc.). Also, note that not all of the grassland loss portrayed here is real because of differences in data resolution and mapping procedures, and definite problems with map registration, between the 1958 and 1999 data sources.

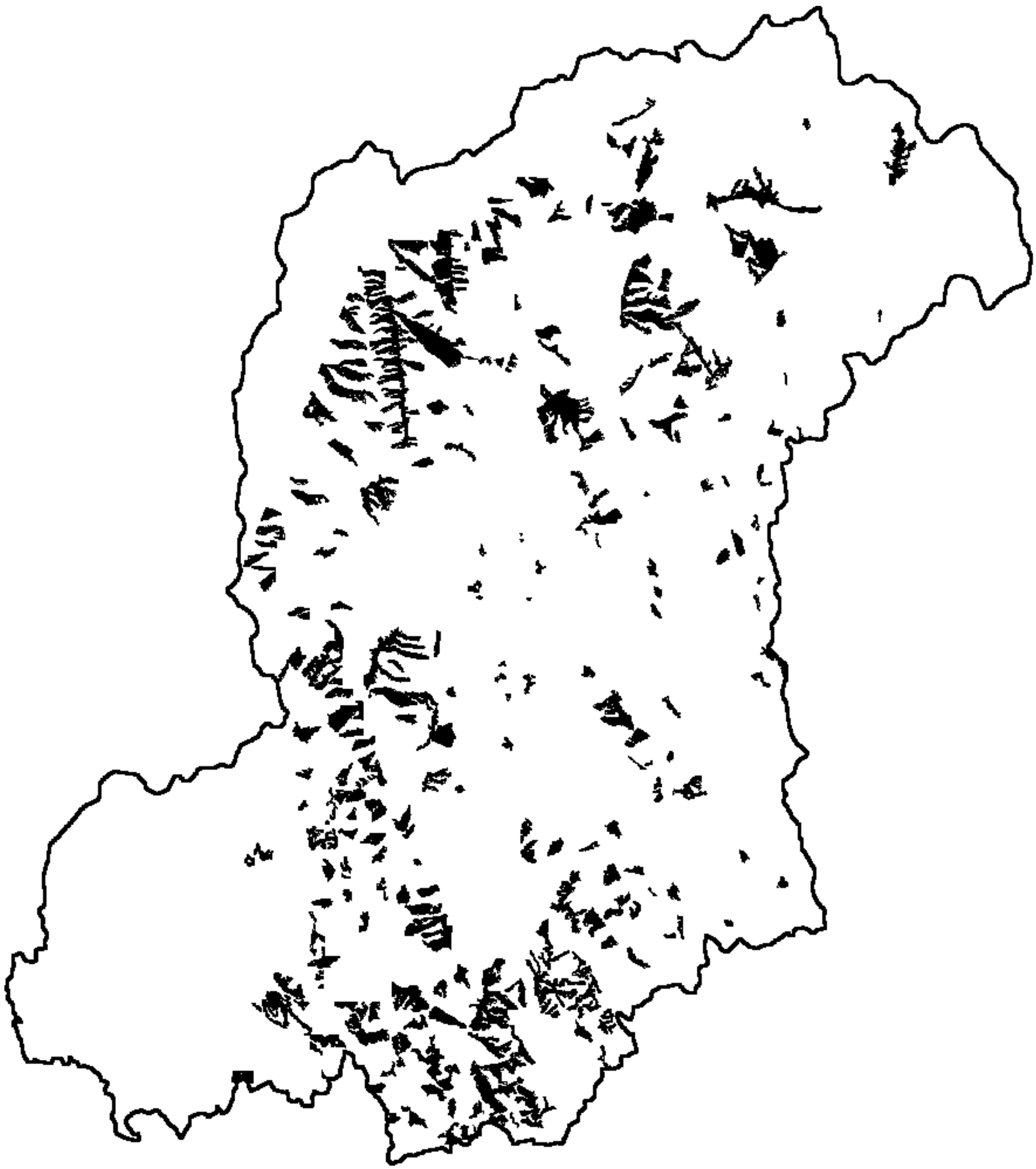


Figure 20 – Overstocked, multi-layered stands that apparently represent an understory removal treatment opportunity (see table 27). This map relates primarily to the "inconsistent structure on dry-forest sites" issue, but secondarily to the "restoration of ponderosa pine and western larch" issue. Note that this map was based exclusively on a structural analysis; it does not include any explicit consideration of project feasibility (operability, accessibility, availability, etc.).

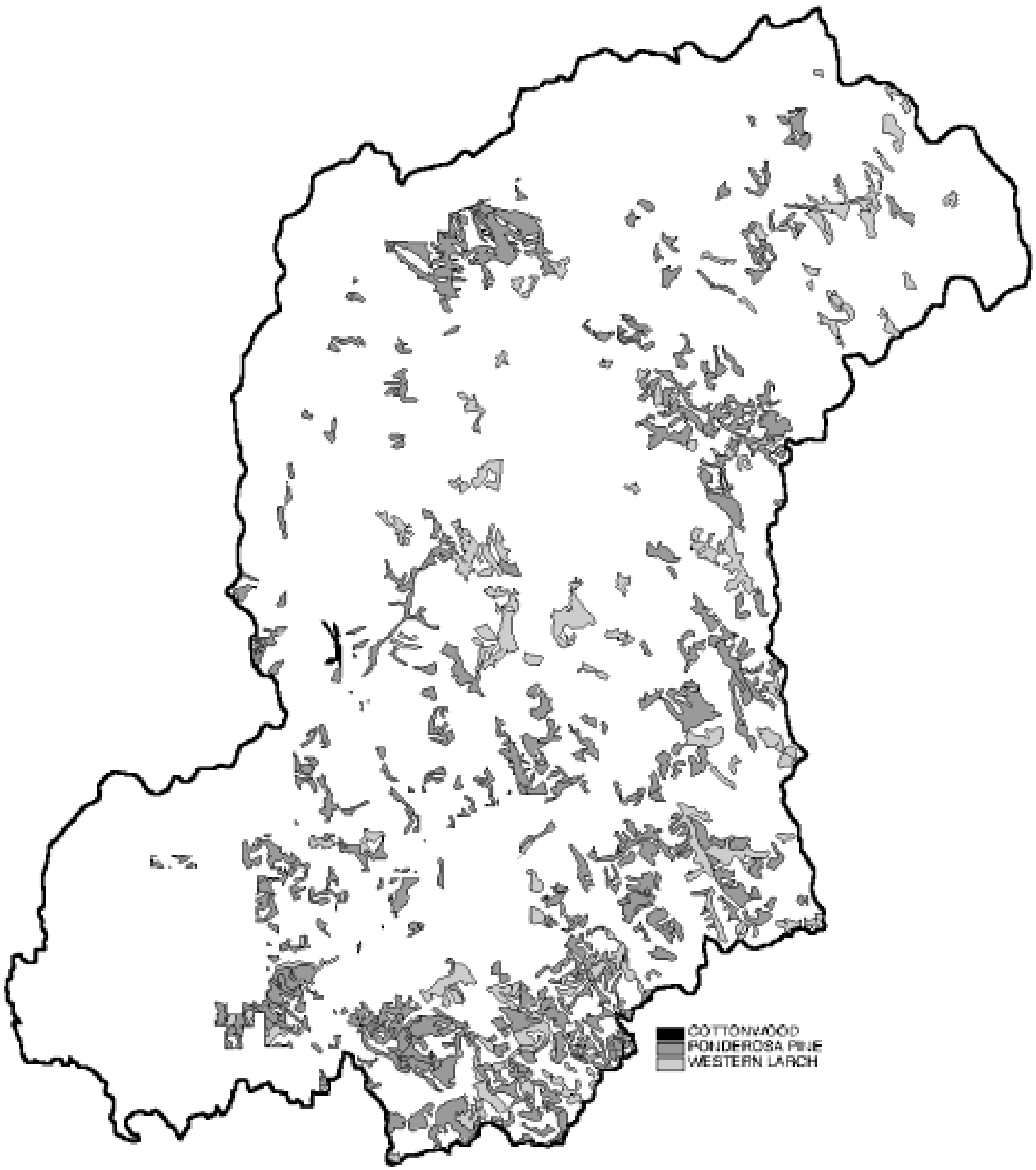


Figure 21 – Areas mapped as ponderosa pine, western larch, or black cottonwood forest cover types in 1958. This map relates primarily to the "restoration of ponderosa pine and western larch" issue, but also illustrates one aspect of the "limited vegetation components" issue (loss of cottonwood). Do these issues mean that larch and cottonwood became extinct between 1958 and 1999, or that ponderosa pine is now an endangered species (see table 5)? No, it actually indicates that larch or cottonwood no longer comprised the plurality of stocking (over 50% of the composition) in any of the upland-forest stands, and that pine constituted the plurality on only 195 acres. Remnant pine, larch, and cottonwood still exist in the analysis area, but at stocking levels that are less than plurality (50%) of the forest composition.

HISTORICAL ACCOUNTS OF VEGETATION CONDITIONS

"Those who cannot remember the past are condemned to repeat it."
George Santayana, American philosopher and poet

Vegetation conditions and disturbance processes were occasionally described in the journals of early Euro-American explorers, missionaries, and emigrants. This section provides accounts of historical conditions, which can help put the current situation in its proper context. A caveat is in order here – just because a document is old and faded or was published in 1884 does not mean that everything it says is true. There is a tendency on the part of non-historians to accept old documents at face value, forgetting that early writers were as fallible and biased as the modern writers we critique so carefully today. When reviewing old reports and journals, it is important to evaluate them carefully before accepting their contents wholeheartedly (Forman and Russell 1983).

Many journals were written during a period that was particularly conducive to fires. For example, eastern Oregon underwent a severe drought from 1839 to 1854 (Keen 1937), when early Oregon Trail emigration occurred and many journals were written. It is likely that fires were more prevalent during that dry period. By 1861, however, weather conditions had moderated and eastern Oregon experienced a particularly wet year, resulting in extensive flooding.

Portions of many early journals are contained in a recent book entitled *Powerful Rockey: The Blue Mountains and the Oregon Trail, 1811–1883* (Evans 1990). Some passages from Powerful Rockey that describe fire and vegetation are provided below; any misspellings or punctuation errors from the original journals are retained in the excerpts.

> ...the grass has been lately consumed, and many of the trees blasted by the ravaging fire of the Indians. These fires are yet smouldering, and the smoke from them effectually prevents our viewing the surrounding country, and completely obscures the beams of the sun.
> **Journal of John Kirk Townsend, August 31, 1834**.

Townsend's journal was one of several that described fires started by American Indians.

> They [mountains] are mostly covered with high bunch grass, which at this season is quite dry. This often gets on fire, burning for miles and days together. One of these burnings is in sight of us today. It is on the opposite side of the river from us, or I should feel alarmed. The fire in the mountains last night was truly grand. It went to the tops of them spreading far down their sides. We were obliged to go over after our cattle at dark and bring them across the stream. The fire extended for several miles, burning all night, throwing out great streamers of red against the night sky. This morning there is none visible. **Journal of Esther Hanna, August 15-16, 1852.**

Hanna's comments illustrate how far-reaching the fires were, and how fast they moved when burning through bunchgrass and other fine fuels.

> After dinner, when we had ascended the first hill, we looked back upon the country we had passed through. I can almost say I never saw anything more beautiful, the river winding about through the ravines, the forests so different from anything I have seen before. The country all through is burnt over, so often there is not the least underbrush, but the grass grows thick and beautiful. It is now ripe and yellow and in the spaces between the groves (which are large and many) looks like fields of grain ripened, ready for the harvest. **Journal of Rebecca Ketcham, September 6, 1853.**

Ketcham's journal eloquently describes the open, grassy, pine stands that were apparently quite common during presettlement times.

> Came to trees, at first quite thin & without underbrush having fine grass. But as we arose we came to a densly timbered country, mostly pine & fir. The most beautiful tall straight trees. Our traviling through the timber was quite difficult as the path wound back and forth and many logs lay across it.
>
> **Journal of Medorem Crawford, September 12, 1842.**

Crawford's journal shows that the Blue Mountains supported more than just open pine stands.

Captain John C. Fremont surveyed the Oregon Trail in the fall of 1843; his route passed through the Meacham watershed. Fremont's journals provide detailed information about Blue Mountains vegetation, although his tree names are unconventional. (His European larch was actually western larch; his balsam pine was probably grand fir; and his white spruce was undoubtedly Engelmann spruce.) It is interesting that he found larch to be abundant; the same statement would not be true today for the Umatilla/Meacham analysis area.

Fremont's journals are also valuable because they provide quantified information about tree dimensions – his journal entry for October 20th mentioned that tree diameters averaged 38 to 46 inches, with pines occasionally reaching 80 inches in diameter. Excerpts from his journal for 3 days in October of 1843 are provided below (Fremont 1988).

> ...the mountains here are densely covered with tall and handsome trees; and, mingled with the green of a variety of pines, is the yellow of the European larch *(pinus larix)*, which loses its leaves in the fall. From its present color, we were enabled to see that it forms a large proportion of the forests on the mountains, and is here a magnificent tree, attaining sometimes the height of 200 feet, which I believe is elsewhere unknown. [October 17, 1843.]
>
> ...we made an early start, continuing our route among the pines, which were more dense than yesterday, and still retained their magnificent size. The larches cluster together in masses on the sides of the mountains, and their yellow foliage contrasts handsomely with the green of the balsam and other pines. After a few miles we ceased to see any pines, and the timber consisted of several varieties of spruce, larch, and balsam pine, which have a regular conical figure. These trees appeared from 60 to nearly 200 feet in height; the usual circumference being 10 to 12 feet, and in the pines sometimes 21 feet. In open places near the summit, these trees become less high and more branching, the conical form having a greater base. [October 20, 1843.]
>
> We continued to travel through the forest, in which the road was rendered difficult by fallen trunks, and obstructed by many small trees, which it was necessary to cut down. Some of the white spruces which I measured today were twelve feet in circumference, and one of the larches ten; but eight feet was the average circumference of those measured along the road. I held in my hand a tape line as I walked along, in order to form some correct idea of the size of the timber. Their height appeared to be from 100 to 180, and perhaps 200 feet, and the trunks of the larches were sometimes 100 feet without a limb; but the white spruces were generally covered with branches nearly to the root. All these trees have their branches, particularly the lower ones, declining. [October 21, 1843.]
>
> **Journal of Captain John Charles Fremont (Fremont 1988).**

The Geological Survey examined Oregon's forests almost a hundred years ago. Fire's effect on vegetation was clearly recognized during their survey, as described in the following passage.

> ...the burns are greatest and most frequent in the most moist and most heavily timbered parts of the State, and are smaller and fewer where the rainfall is less and where the timber is lighter. This is owing to the density and abundance of the undergrowth in the heavily forested regions, which feeds the fire and vastly increases its heat. In the comparatively sparsely timbered southern portions of the Coast Range and the Cascades and in the Blue Mountains, where the forests are largely or mainly of yellow pine in open growth, with very little litter or underbrush, destructive fires have been few and small, although throughout these regions there are few trees which are not marked by fire, without, however, doing them any serious damage. **The Forests of Oregon (Gannett 1902).**

The first comprehensive study of Oregon's ponderosa pine forests was completed between 1910 and 1915 by the U.S. Forest Service (Munger 1917). Oregon's largest concentration of ponderosa pine was found in the Blue Mountains; they had 42.7% of the commercial acreage and 43.9% of the volume. The following excerpts from Munger's report describe stand conditions and fire effects in ponderosa pine forests of the Blue Mountains.

> In the Blue Mountains the herbage is rather more luxuriant and varied than on the eastern slopes of the Cascades and their outstanding ranges. In the early summer the open yellow-pine forests are as green with fresh herbage as a lawn, except here and there where the green is tinged with patches of yellow or purple flowers. Some of this luxuriant herbage is pine grass *(Calamagrostis* sp.), a plant which is not eaten by stock except very early in the season; but much of the ground cover makes excellent range for cattle and sheep.
>
> In the Blue Mountains western larch *(Larix occidentalis)* is its [western yellow pine] usual companion and grows with it in an intimate and harmonious mixture. In the moister situations white fir *(Abies concolor)* is a common associate, as is also Douglas fir *(Pseudotsuga taxifolia)* in most parts of the State. In the Blue Mountains it is common for the south slopes to be covered with a fine stand of yellow pine, while the north slopes are covered almost entirely with larch, white fir, and Douglas fir.
>
> In the Blue Mountains the reproduction of yellow pine is very abundant, both in the virgin forest and after cuttings. Perhaps it is more prolific here than anywhere else. In this region where an area has not been burned over by a surface fire for a number of years, there is quite commonly a veritable thicket of little trees from a few inches to several feet high. Actual counts have shown that there are sometimes 14,000 seedlings on a single acre, the ages ranging from 13 to 21 years.
>
> In pure, fully stocked stands in the Blue Mountains region there are commonly from 20 to 30 yellow pines per acre over 12 inches in diameter, of which but few are over 30 inches. Over large areas the average number per acre is ordinarily less than 20. In mixed stands the number of yellow pines of merchantable size is naturally less, though the total number of trees of all species is as a rule larger, the moist soil on which the mixed forest grows being able to carry a denser stand.
>
> Light, slowly spreading fires that form a blaze not more than 2 or 3 feet high and that burn chiefly the dry grass, needles, and underbrush start freely in yellow-pine forests, because for several months each summer the surface litter is dry enough to burn readily. Practically every acre of virgin yellow-pine timberland in central and eastern Oregon has been run over by fire during the lifetime of the present forest, and much of it has been repeatedly scourged. It is sometimes supposed that these light surface fires, which have in the past run through the yellow-pine forests periodically, do no damage to the timber, but that they "protect" it from possible severe conflagrations by burning up the surface debris before it accumulates. This is a mistake. These repeated fires, no matter how light, do in the aggregate an enormous amount of damage to yellow-pine forests, not alone to the young trees, but to the present mature merchantable timber.
>
> A careful cruise of every tree on 154.5 sample acres in typical yellow-pine stands in several localities in the Blue Mountains showed that 42 out of every 100 trees were fire-scarred.
>
> Ordinarily, a fire in yellow-pine woods is comparatively easy to check. Its advance under usual conditions may be stopped by patrolmen on a fire line a foot or so wide, either with or without backfiring. The open character of the woods makes the construction of fire lines relatively easy, and in many places horses may be used to plow them. **Western Yellow Pine in Oregon (Munger 1917).**

Since the late 1800s, timber harvesting and fire suppression have replaced indigenous disturbance processes as the primary forces shaping forest landscapes. Many of the vegetation changes caused by fire suppression have been recognized for quite some time. The following passages describe suppression-related changes occurring shortly after establishment of the Blue Mountains National Forests.

> There are patches of "scabland," characterized by very shallow soil, many rock fragments and a total absence of vegetation except in the spring months. It is interesting to note that some of these areas are being occupied by sagebrush where a few years ago, there was none. A possible explanation is that the annual fires of the Indians kept it killed out and now it has a chance to develop. Yellow pine is slowly encroaching upon the sagebrush, the chief factor in its rate of advance being moisture, provided fire is kept out. The same statement will hold true in regard to the other open areas as well. As fast as the reproduction has pushed out from under the protection of the parent trees, the periodical fires have killed it back, thus keeping the timber line practically stationary. In recent years, conditions have improved, and it is noticeable that the pine is reaching out, although slowly. The north slopes [are] being occupied by a thick stand of fir reproduction. Even pine is gaining a foothold here, and is gradually creeping across the ridge to the south slopes.
> **General Silvical Report; Wallowa and Minam Forests (Evans 1912).**

> Stockmen of long experience in these mountains tell me that the reproduction is rapidly changing the looks of the country and that where twenty-five years ago there were open spots or prairies there are now dense thickets, lodgepole, of course, playing a prominent part in this natural reproduction.
> **Annual Planting Report, Umatilla National Forest (Cryder 1915).**

Vegetation changes were also caused by timber harvesting. The late-successional species favored by partial cutting, especially grand fir and Douglas-fir, had less value for timber products than western larch and ponderosa pine. Early Blue Mountains foresters recognized that partial cutting could have an undesirable impact on species composition, as described below.

> White fir, though of slower height growth, is far more tolerant than bull pine, reproduces fairly freely, and under normal conditions would naturally supplant the pine in time. This condition has been greatly aggravated in the portions that have been lumbered by cutting the pine and leaving the white fir. The fir, often already on the ground under the pine, springs up, and pine reproduction is thus impossible. **The Proposed Wenaha Forest Reserve (Kent 1904).**

> In all sales on this Forest, care should be exercised in marking the timber not to leave the cutting area in such condition that a valuable stand be supplanted by inferior species. White fir, though occasionally used for fuel when no better species are available, makes poor fuel wood, while for saw timber it is all but valueless owing to the fact that nearly all mature trees are badly rotted by a prevalent polyporus, and the wood season-checks badly. Unless care is taken this species is prone to supplant such species as yellow pine and tamarack since it is much more tolerant of shade in early life.
> **Report on Silvics of Blue Mountains (E) National Forest (Foster 1907).**

> Under the present system of conducting our timber sales we are cutting all the yellow pine and most of the Douglas fir and larch on the north slopes. This leaves a majority of lodgepole pine and white fir, which soon becomes so dense that no other species can get a foothold and the resulting stand will be a very inferior jungle. **Recommendations for Cutting Inferior Species (Starker 1915).**

> White fir in this region is very poor and should be considered a weed. If merchantable, heavy marking should be the rule, especially on the yellow pine areas. Trees of this species over 16 inches D.B.H. are seldom sound because of the heavy attacks of indian paint fungus which gain access to the tree through frost cracks and fire scars.
> **Instructions for Marking Timber in the Western Yellow Pine Region (Starker 1916).**

Vegetation conditions were often described in the establishment reports and silvics narratives for the Wenaha Forest Reserve and the Wenaha National Forest, which were established in the early 1900s. Several of those reports have specific comments about the Umatilla/Meacham area (in particular, see excerpts from Schmitz below). (Note that the Umatilla/Meacham area, and all of the north half of the Umatilla National Forest (the Pomeroy and Walla Walla Ranger Districts), was originally included in the Wenaha National Forest. The Wenaha and Umatilla forests were combined in November of 1920.) Some passages from those reports follow:

The timbered area is gaining, rather than decreasing, and apparently only the simplest precautions are needed to provide for restocking cut over tracts, such as proper disposal of refuse, protection of small yellow pine, and, when possible, taking the latter species chiefly from north and east slopes or flats. Generally it will not be necessary to watch cutting methods very closely to insure perpetuation of the forest, for it will be attained with ordinary care.

Yellow pine is more or less infested by Dendroctonus, but not alarmingly so. Lodgepole shows much more injury from this beetle or a *Tomicus* – I am not sure which – and several areas of a few acres each were seen which will be dead next year. As usual in the Pacific northwest, spruce tips are badly stung by an insect which deposits eggs and produces cone-like galls. *Arceuthobium* is abundant, especially on red fir and yellow pine. **Inspection Report for Wenaha Forest Reserve (Allen 1906).**

Reproduction of all species is remarkably abundant, and the forest is extending its limits naturally. There is some danger in mixed stands that the yellow pine will not be able to compete with the other species owing to its less frequent seed years. But as a rule the species in reproduction bear about the same proportion as the mature stands.

Forest types conform to the general topography of the country, each topographic type having a different class of forest which varies in the nature of the species found on each, and in the condition of the timber and the forest floor. The forest types may be divided into the summit type, the flat, and the canyon.

Occasionally along the ridges in open spaces groups of aspen are found, and around springs alder grows. Along streams cottonwood and balm of Gilead is found with mountain maple, wild cherry, and other broadleaf species.

The canopy is usually very broken, though in pure stands of lodgepole pine the canopy is dense.

Reproduction after burns is usually very prolific, the principal species which come in as second growth being lodgepole pine and tamarack, with a lesser proportion of white fir, lowland fir, and the spruces. On unburned areas, reproduction is rather backward, especially in thick stands of timber, but in blanks reproduction often is rather abundant and of the same proportion as the surrounding forest.

The yellow pine, lodgepole pine, and tamarack often occur in pure forest; lowland fir and spruce characteristically occur in groups of from 5 to 10 individuals, while red fir occurs more often singly in mixture with any or all of the other species.

In the yellow pine forests reproduction is by groups in blanks or openings in the forest. On burned areas the new growth is very apt to be either of tamarack or lodgepole pine and on such areas is abundant.

The slopes are thin-soiled and usually not well watered. If it were not for the forest growth upon them, the soil should soon wash off, exposing the bare rock. This has happened where the bunch grass has been overgrazed by sheep, and there are no trees to hold the soil.

The species of the canyons are yellow pine, red fir, lowland fir, tamarack, and lodgepole pine, the commonest species being yellow pine, and after it, red fir. Along streams cottonwood and balm of Gilead is found with mountain maple, wild cherry, and other broadleaf species.

Report on Silvics of Wenaha Forest Reserve (Foster 1906).

In these hills the conditions have undergone decided changes. Thirty-five years ago the foothills presented a practically unbroken body of heavy coniferous forests. Today, along the entire eastern and northern sides of the reserve, this belt has nearly disappeared and what is left is going rapidly. Thirty-five years ago the summits and upper slopes of the high interior hills probably had but little more forest cover than at present, but these high hills were then covered with a profuse growth of bunch grass, weeds, and shrubs, which have since been destroyed by small fires and sheep grazing. This growth of weeds and shrubs has been replaced largely by hard, baked earth, and often bare rock from which the scanty soil has been completely eroded.

There has been practically no lumbering on the area included in the proposed reserve. Considerable timber has been cut, however, from the foothills of the west and southwest sides. As a rule, these foothill lands are cleared after lumbering and make excellent farms. When not cleared for farms, and if not periodically burned, these cuttings reproduce rapidly and thickly to white and red fir, and bull pine. This lumbering is done on a very small scale, the mills cutting but a few thousand feet a day. The logs are sawed on the ground and the lumber marketed in the nearby towns at the following scale of prices:

Tamarack for finishing .... $35.00 per M
Bull pine, fir, and balsam; Rough lumber, etc. .... $15.00 to $20.00 per M
Cordwood, usually bull pine .... $4.00 to $5.00 per cord

The Proposed Wenaha Forest Reserve (Kent 1904).

There is but a small part covered with merchantable forest. The greater part of the tract is covered with scattering bunches of timber, brush land, chaparral and open bunchgrass ridges and slopes which had never been covered with timber. The merchantable forest in the Black and Wilber Mountain regions are chiefly white fir, red fir, and yellow pine. In the southwestern part there is considerable lodgepole pine which is being extensively used for fuel and I will consider it merchantable forest. The timber of the woodland part is too scattering to be of any merchantable value at the present time, although it probably will be used in the future.

Very little damage has been done by fire. There are a few small burnt tracts but they are so scattering and of small area that they are hardly worth considering. There is very little cultivated land. The country is too rough for cultivation. A few small patches are being cultivated in the canyons.

Very little lumbering has been done on the proposed addition. About 500,000 feet B.M. has been cut on the east fork of Meacham Creek. It was only culled over and no harm was done to the forest cover. There will be little or no lumbering for several years. The timber is too scattering to make it profitable. Some cordwood may be cut in the southwestern part.

Report on Examination of Proposed Addition to Wenaha Forest Reserve (Schmitz 1906).

The Transition type is determined by altitude. Here on the cooler and moister slopes are found certain species possessing a comparatively shallow root system and thin bark, which cannot withstand the long summer droughts of the lower altitudes. As regards species this type is distinguished from the other two types already described by the large per cent of alpine fir, spruce, and lodgepole, which comprise the dominant species. There is a total absence of yellow pine in this type and larch is apt to be scarce. Although the trees are generally of small size in the Transition type, they are unusually well formed and, being fairly tolerant, are capable of standing very close together, thereby yielding a large quantity of wood useful for many purposes. However, over a large part of the area covered by this type, the trees, since the last great fires, have not had sufficient time to grow to sizes which make them of commercial value for lumber. Although trees on this type frequently grow to sawlog size, the most valuable stands are composed of lodgepole and larch in proportions suitable for posts and poles.

It was noticeable that the individual members of certain species attain to larger size on the Wenaha Forest than on the Umatilla, especially among the less important species. Alder occurs often over two feet in diameter and yew occurs in tree form a foot or so in diameter and is often cut in free use for posts for which it proves to be excellent. Black cottonwood attains a D.B.H. of 6 feet and quaking aspen of 15 or 16 inches. These dimensions are larger than those found on the Umatilla. Engelmann spruce and alpine fir occur much more abundantly on this Forest than on the Umatilla, especially in the northern half where it frequently attains a size of 5 feet D.B.H. Mountain birch does not occur at all on the Umatilla, but here it is found in nearly all the river canyons where sometimes it attains a D.B.H. of 18 inches.

Patches of beetle-infested lodgepole are widely and thinly scattered over the entire Forest wherever a mature stand of this species occurs. Judging by the few brown and dying trees which one sees, the

> pest is not increasing very fast, as it is on the Whitman and Umatilla Forests. Mistletoe, it is thought, is on the increase. It is killing many Douglas fir. Nearly every large or medium-sized Douglas fir will often be found to be infested with this disease, on certain north slopes. There is very little bark-beetle infestation among the yellow pine, probably accounted for in part by the fact that the stands of this species are all small and isolated.
>
> White pine was at one time distributed over the entire Forest but it was killed out by fires, to which it is so particularly susceptible, years ago. It is thought that white pine would be an excellent tree to plant on all the burns found on the higher altitudes of the Wenaha. It attains good size and form in such places, and its wood is superior to any of the other species with which it occurs in such places.
>
> **Extensive Reconnaissance of Wenaha National Forest (Bright 1914).**

The potential implications of selective harvesting and fire suppression were clearly recognized during inventories completed by the Forest Service's forest survey unit. The following comments are from a report summarizing the results of the 1950s forest inventories for eastern Oregon counties.

> If present trends continue, the proportion of ponderosa pine will be less in the future than at present. In 29 percent of all the pine sawtimber types, there is no understory of pine, only other species – Douglas-fir, white fir, and lodgepole pine. In another 27 percent of the pine sawtimber stands, the understory is a mixture of young ponderosa pine and other species. On more than half of this area, species other than pine predominate. Unless something happens to change this relationship, or unless more intensive forest management is undertaken, about 40 percent of the pine sawtimber type is likely to shift to some other type.
>
> **Toward Complete Use of Eastern Oregon's Forest Resources (Gedney 1963).**

DATA CONSIDERATIONS AND INFORMATION GAPS

"Data resides in a swamp, and the swamp beckons."
Dave Caraher, Hydrologist, Pacific Northwest Region

Future Conditions Were Not Considered. Most of this vegetation analysis focused on historical and current conditions. There was no explicit description of future (desired) conditions, although they were considered indirectly when formulating management recommendations and opportunities. Future conditions were not considered due to time constraints imposed by the size, breadth, and scope of the 150,000-acre analysis area, and because explicit consideration of future conditions is not a requirement of the "ecosystem analysis at the watershed scale" process (Regional Ecosystem Office 1995).

Future ecosystem assessments would benefit from having the "third leg of the triangle" (e.g., future conditions) take its place alongside historical and current conditions. Allowing additional analysis time, or analyzing smaller areas in the same time as was available for this effort, might allow future conditions to be assessed using a successional model such as the Vegetation Dynamics Development Tool (Beukema and Kurz 1996).

Quality of the Historical Maps. This upland-forest analysis made extensive use of historical maps. Those maps were generally unregistered, available on a variety of media, and produced at a scale of 1 inch equals 1 mile (1:63,360). The digitizing process required that the maps be registered as well as they could be, using section corners as control points and USGS 7½ minute quad maps (1:24,000) as references. All polygon boundaries on those maps must be assumed to be approximate, due to distortions in the media over time and the inexact nature of the registration process.

Accuracy of Structural Stage Determinations. The structural stage determinations were based on generalized characteristics for each forest polygon (see tables 26-27 in appendix 1). Had stand exam information been available for all forested area, it could have significantly improved the determination of structural stages, particularly for old forest. Since stand exams were available for only 42% of the National Forest System lands in the analysis area, it was necessary to use some low-resolution data sources (photo interpretation) to derive forest structural stages. Without a structural stage assignment for every polygon, it would have been impossible to complete an HRV (historical range of variability) analysis.

Missing Portion of the 1936 Map. The 1936 historical cover-type map was used for several analyses. However, its use was constrained slightly because coverage was unavailable for a small portion of the analysis area (primarily Union County in the east and south ends of the analysis area).

Reliability of Canopy Cover Equations. Several analyses relied upon canopy cover information, which was often used as a surrogate for vegetation or stand density. Since stand density guidelines do not include canopy cover directly, it was necessary to calculate that information using equations developed from an elk cover study (Dealy 1985). Although Dealy's equations were derived from a large sample, their predictive accuracy (r^2 values) were not particularly high (ranging from .21 to .49) and it must be assumed that canopy cover calculations are estimates. In this analysis it was necessary to apply canopy cover equations developed at the series level (CP, CW, etc., from Hall 1973) to individual tree species. Since some unknown portion of Dealy's sample consisted of multiple-species stands, it must be assumed that use of his equations could be compromised to some degree when used for a single-species scenario.

GLOSSARY

Abiotic. The nonliving components of the environment, not currently part of living organisms, such as soils, rocks, water, air, light, and nutrients (Dunster and Dunster 1996). Compare with *biotic*.

Biome. A biological subdivision that reflects the ecological and physiognomic character of the vegetation. Biomes are the largest geographical biotic communities that it is convenient to recognize; they correspond broadly with climatic regions (Allaby 1998).

Biotic. Any living component of an ecosystem, including plants and animals (Dunster and Dunster 1996). Distinct from abiotic physical and chemical components (Allaby 1998). Compare with *abiotic*.

Climax. The culminating seral stage in plant succession for any given site where, in the absence of catastrophic disturbance, the vegetation has reached a highly stable condition and undergoes change very slowly (Dunster and Dunster 1996). A self-replacing community that is relatively stable over several generations of the dominant plant species, or very persistent in comparison to other stages (Kimmins 1997).

Cohort. A group of trees developing after a single disturbance, commonly consisting of trees of similar age, although one cohort can include a considerable span of ages ranging from seedlings or sprouts to trees that predated the disturbance (Helms 1998). Stands are often characterized as "single-cohort" or "multicohort" depending on whether they contain one or several cohorts (Oliver and Larson 1996).

Competition. The extent to which each organism maximizes fitness by both appropriating contested resources from a pool that is not sufficient for all, and adapting to an environment altered by all participants in the community or population. For trees, competition results in a density-related scarcity of certain environmental factors that are related to tree growth (Helms 1998).

Cover type. The plant species forming a plurality of the composition across a given land area, e.g., the Engelmann spruce-subalpine fir, ponderosa pine, or lodgepole pine forest cover types (Helms 1998).

Disturbance. A relatively discrete event that disrupts the structure of an ecosystem, community or population, and changes resource availability or the physical environment. Disturbances include processes such as fires, floods, insect outbreaks, disease epidemics and windstorms (Dodson and others 1998).

Disturbance regime. The spatial and temporal dynamics of disturbance events over a long time period. Description of a disturbance regime would include characteristics such as the spatial distribution of disturbance events; disturbance frequency (number of disturbance events in a specified time interval, or the probability of a disturbance event occurring within a particular time interval); return interval (average time between successive disturbance events); rotation period (length of time until an area equivalent to the size of an analysis area would be affected in one disturbance event); disturbance size; and the magnitude, or intensity, of a disturbance event (Dodson and others 1998).

Ecological environments. The composite temperature and moisture condition resulting from a combination of edaphic and physiographic factors (soil, aspect, elevation, topographic position, etc.). A south-facing slope at 5,000 feet elevation and a north-facing slope at 4,000 feet could represent equivalent ecological environments.

Ecological niche. An organism's actual place within a community, including its tolerances for the physical environment, its interactions with other organisms, and the manner in which it uses the component parts of its habitat. Ecological niche is analogous to ecological range, which describes the range of environmental conditions within which an organism can live and survive (Dunster and Dunster 1996).

Ecology. The branch of biology that deals with interrelationships. The name was coined in 1866 by Ernst Haeckel. The major theme throughout the history of ecology and the ideas that underlie it has been the interdependence of living things. An awareness, more philosophical than purely scientific, of this quality is what has generally been meant by an "ecological point of view." Thus, the question of whether ecology is primarily a science, rather than a philosophy or "world view," has been a persistent identity problem (Worster 1996).

Ecosystem. A spatially explicit, relatively homogeneous unit of the earth that includes all interacting organisms and components of the abiotic environment within its boundaries (Helms 1998). A term first used by A. G. Tansley in 1935 to describe a discrete unit consisting of living and non-living components, interacting to form a stable system (Allaby 1998).

Forest health. The perceived condition of a forest based on concerns about such factors as its age, structure, composition, function, vigor, presence of unusual levels of insects or disease, and resilience to disturbance. Note that perception and interpretation of forest health is influenced by individual and cultural viewpoints, land management objectives, spatial and temporal scales, the relative health of stands that comprise the forest, and the appearance of a forest at any particular point in time.

Habitat type. An ecological classification unit based on potential vegetation which represents, collectively, all parts of the landscape that support, or have the capability to support, the same plant association (Alexander 1985). In effect, habitat types are mapping or land classification units; plant associations are their descriptors or taxonomic labels. See also *plant association* and *potential natural community*.

Historical range of variability. A characterization of the fluctuations in ecosystem conditions or processes over time. The historical range of variability defines the bounds of ecosystem behavior that remain relatively consistent through time (Morgan and others 1994).

Indicator plant. Plant species that convey information about the ecological nature of a site, such as the nitrogen content of a soil, its alkalinity or acidity, etc. A plant species having a sufficiently consistent association with a particular environmental condition or another species so that its presence can be used to indicate or predict the environmental condition or the potential for the other species (Kimmins 1997).

Management implication. An index or attribute that can be quantified to determine the success of implementing land management planning guidelines. An example is the use of wildlife indicator species (Dunster and Dunster 1996).

Overstory. That portion of the trees in a forest of more than one story (layer), forming the uppermost canopy layer; in a two-storied forest, the tallest trees form the overstory, the shortest trees the *understory*.

Physiognomy. The form and structure of vegetation in natural communities (Allaby 1998, Dunster and Dunster 1996).

Physiography. Refers to factors that influence the development of landforms or a landscape, such as relief and topography, bedrock geology and structure, and geomorphological history (Dunster and Dunster 1996).

Plant association. A plant community with similar physiognomy (form and structure) and floristics; commonly it is a *climax* community (Allaby 1998). It is believed that 1) the individual species in the association are, to some extent, adapted to each other; 2) the association is made up of species that have similar environmental requirements; and 3) the association has some degree of ecological integration (Kimmins 1997). See also *habitat type* and *potential natural community*.

Plant association group. Groupings of plant associations that represent similar ecological environments (temperature and moisture settings); somewhat synonymous with biophysical environments.

Plant community type. An aggregation of all plant communities with similar structure and floristic composition. A vegetation classification unit with no particular successional status implied (Dunster and Dunster 1996).

Plant succession. The process by which a series of different plant communities and associated animals and microbes successively occupy and replace each other over time in a particular landscape location following a disturbance to that ecosystem (Kimmins 1997).

Potential natural community. The community of plants that would become established if all successional sequences were completed, without interference by people, under existing environmental conditions. "Existing environmental conditions" includes the current climate and eroded or damaged soils (Hall and others 1995). See also *habitat type* and *plant association*.

Potential vegetation. The vegetation that would develop if all successional sequences were completed under the present site conditions (Dunster and Dunster 1996). See also *potential natural community*.

Potential vegetation group. An hierarchical level that includes plant association groups with similar environmental conditions and are dominated by similar types of plants.

Seral stage. The identifiable stages in the development of a sere, from an early pioneer stage, through various early and mid-seral stages, to late-seral climax stages. The stages are identified by different plant communities, different ages of the dominant vegetation, and by different microclimatic, soil and forest conditions (Kimmins 1997).

Sere. The characteristic sequence of developmental (seral) stages occurring in plant succession (Allaby 1998).

Series. A level in the potential vegetation hierarchy that represents major environmental differences reflected by distributions of tree species at climax. A series is named for the projected climax tree species – the subalpine fir series includes all plant associations where subalpine fir is presumed to be the dominant tree species at climax (Pfister and Arno 1980).

Silviculture. The techniques used to manipulate vegetation and to direct stand and tree development to create or maintain desired conditions. Silvicultural practices influence rates of tree growth and stand development, stand composition, stand structure, and biodiversity. Silviculture is based on an ecosystem concept that emphasizes the need to evaluate the many abiotic and biotic factors influencing the choice and outcome of silvicultural treatments and their sequence over time, and the long-term consequences and sustainability of management regimes (derived from multiple sources).

Stand density. A quantitative measure of stocking expressed absolutely in terms of number of trees, basal area, or volume per unit area (Helms 1998).

Stocking. The amount of anything on a given area, particularly in relation to what is considered optimum; in silviculture, an indication of growing-space occupancy relative to a pre-established standard.

Stocking levels. *Stand density* objectives expressed as constant or uniform amounts of *stocking* (Cochran and others 1994).

Tolerance. A forestry term expressing the relative ability of a plant (tree) to complete its life history, from seedling to adult, under the cover of a forest canopy and while experiencing competition with other plants (Harlow and others 1996).

Understory. All of the vegetation growing under a forest overstory. In some applications, understory is only considered to be small trees (e.g., in a forest comprised of multiple canopy layers, the taller trees form the overstory, the shorter trees the understory); in other instances, understory is assumed to include herbaceous and shrubby plants in addition to trees. When understory is assumed to refer to trees only, other plants (herbs and shrubs) are often called an undergrowth to differentiate between the two (Helms 1998).

APPENDIX 1: DESCRIPTION OF FOREST DATABASES

Vegetation data pertaining to the Umatilla/Meacham analysis area was stored in four separate databases. This document serves as a data dictionary for both the existing and the historical vegetation databases, as described below:

- A published map contained in the back pocket of a 1902 report (Gannett 1902) was used for a coarse characterization of vegetation conditions as they existed in 1900 (Thompson and Johnson 1900). The database name is: **1900veg**.
- Colored, thematic, cover-type maps published by the Pacific Northwest Forest and Range Experiment Station (Sankela and Lynch 1936) were used to characterize upland-forest conditions as they existed in the early 1930s. These maps were produced by county, although coverage for the Umatilla/Meacham analysis area was incomplete. The database name is: **1936veg**.
- Thematic, county-level forest type maps published by the Pacific Northwest Forest and Range Experiment Station (authors unknown) were used to characterize upland-forest conditions as they existed in the early to mid 1950s. These maps were digitized by the Regional Office in Portland, Oregon, although adjoining counties were not edge-matched and that short-coming limited their usability during this analysis. The database name is: **1958veg**.
- Intensive stand examinations, walk-through examinations, and interpretation of aerial photography were used as data sources to characterize existing (current) conditions for upland forests. Much of this information was acquired between 1985 and 1997, although minor updates to account for vegetation changes since its acquisition may have been made. All of the existing vegetation information was extracted from the Umatilla National Forest's EVG database. The database name is: **1999veg**.

The remainder of this appendix describes each of the fields in the databases and their corresponding codes. Some fields were only used in certain databases, and those situations are noted in the field descriptions.

Polygon Number (**Poly** or **Stand_tag** are the database field names): For the historical databases, polygons were numbered consecutively using the Arc GIS software; for the existing vegetation database (1999veg), polygons are identified using the stand_tag moniker extracted from the EVG database.

Total Area (TotAc): Total acreage within the polygon boundary; calculated using the Arc GIS software. This field was only used in the historical databases.

National Forest Area (NfsAc): Acreage within a polygon comprised of National Forest System lands administered by the Umatilla National Forest; calculated using the Arc GIS software.

Private Area (PvtAc): Acreage within a polygon that is private land (e.g., lands that are not administered by the Umatilla National Forest); calculated using the Arc GIS software. This field was only used in the historical databases because no information about private land was included in the 1999veg database.

Data Source (Sour): Provides the data source for each record. [Note: this field was not used with the historical databases since all of their data was derived from a single source, e.g., a published map.]

Code	**Description**
10	R6 intensive stand examination that meets Regional accuracy standards
12	Regeneration stocking survey that meets Regional accuracy standards
21	R6 quick-plot stand examination; does not meet Regional accuracy standards
22	Regeneration examination; does not meet Regional accuracy standards
30	Quick plots with growth-sample trees on every third plot; meets R6 standards
33	Quick plots with growth-sample trees on every third plot; no fixed-plot used

Code	Description
A4	Range inventory
PI	Photo interpretation
WT	Walk through field exam

Subwatershed (SWS): Provides the predominant subwatershed for each polygon. Derived by overlaying the subwatershed layer with each of the historical and existing vegetation polygon layers (individually), and then using Arc's "identity" function to determine the subwatershed that occupies the majority of each polygon.

Subwatershed Group (Group): This derived field was based on data in the *Subwatershed* field. It was used for the HRV analyses. Each polygon in the 1999veg database was assigned to one of two subwatershed groups, as described below:

Code	Description
UMA	Subwatersheds occurring in the Umatilla watershed (all subwatersheds beginning with a 13)
MEA	Subwatersheds occurring in the Meacham watershed (they begin with an 89)

Elevation (Elev2): Mean elevation of the polygon, in feet; calculated by the Arc GIS software after gridding the polygon into 30-meter square pixels. Value is an average of the pixels within a polygon.

Slope Percent (SlpPct): Mean slope percent of the polygon; calculated by the Arc GIS software after gridding the polygon into 30-meter square pixels. Value is an average of the pixels within a polygon.

Aspect (Asp1; Asp2): Mean aspect of the polygon; calculated by the Arc GIS software after gridding the polygon into 30-meter square pixels. Value is an average of the azimuth calculations, in degrees, for the pixels within a polygon. The azimuth value (Asp1) was converted to a compass direction (Asp2) using this relationship:

Code	Description
LE	Level (sites with no aspect; slope percents <5%)
NO	North (azimuths >338° and ≤23°)
NE	Northeast (azimuths >23° and ≤68°)
EA	East (azimuths >68° and ≤113°)
SE	Southeast (azimuths >113° and ≤158°)
SO	South (azimuths >158° and ≤203°)
SW	Southwest (azimuths >203° and ≤248°)
WE	West (azimuths >248° and ≤293°)
NW	Northwest (azimuths >293° and ≤338°)

Plant Association (Ecoclass): The predominant plant association was recorded for each polygon in the 1999veg database. When a polygon's data was derived from a stand examination, the plant association recorded during the field exam was used; for polygons characterized using other data sources, one of two potential vegetation maps was used to assign a plant association (a recent PV map compiled by Karl Urban, or an historical map from the Forest's Resource Datacell Database (DD); see table 1). Plant associations were recorded using a 6-digit Ecoclass code (see Hall 1998). There are too many Ecoclass codes to list here. See table 2, Powell (1998), or Hall (1998) for a reference that relates each Ecoclass code to the plant association it represents.

Plant Association Group (PAG): This derived field was based on data in the *plant association* field. Refer to Powell (1998) for a description of how plant associations were combined into PAGs.

Code	Description
Cold Dry UF	Cold Dry Upland Forest PAG

Code	Description
Cold Wet HSM RF	Cold Wet High Soil Moisture Riparian Forest PAG
Cool Moist UF	Cool Moist Upland Forest PAG
Cool Very Moist UF	Cool Very Moist Upland Forest PAG
Cool Wet UF	Cool Wet Upland Forest PAG
Hot Dry UF	Hot Dry Upland Forest PAG
Hot Moist UW	Hot Moist Upland Woodland PAG
Nonforest	Nonforest vegetation types (no Ecoclass, PAG, PVG info available)
Warm Dry UF	Warm Dry Upland Forest PAG
Warm Moist UF	Warm Moist Upland Forest PAG
Warm Very Moist UF	Warm Very Moist Upland Forest PAG
Warm Wet MSM RF	Warm Wet Moderate Soil Moisture Riparian Forest PAG

Potential Vegetation Group (PVG): This derived field was based on data in the *plant association group* field. Refer to Powell (1998) for a description of how the PAGs were combined into PVGs.

Code	Description
Cold UF	Cold Upland Forest PVG
Dry UF	Dry Upland Forest PVG
Moist UF	Moist Upland Forest PVG
Moist UW	Moist Upland Woodland PVG
Nonforest	Nonforest vegetation types (no Ecoclass, PAG, PVG info available)
Wet RF	Wet Riparian Forest PVG

Structural Stage (Stage): Structural stages were derived using database queries. The queries used combinations of the overstory cover *(OvCov)*, overstory size *(OvSiz)*, understory cover *(UnCov)*, and understory size *(UnSiz)* fields in the existing (1999veg) and historical (1936veg and 1958veg) databases. Queries differed slightly by PVG. Tables 29 and 30 show the structural stage queries. Oliver and Larson (1996) and O'Hara and others (1996) provide further information about structural stages.

Code	Description
NF	Nonforest (no structural stage determined for nonforest polygons)
OFMS	Old Forest Multi Strata structural stage
OFSS	Old Forest Single Stratum structural stage
SECC	Stem Exclusion Closed Canopy structural stage
SEOC	Stem Exclusion Open Canopy structural stage
SI	Stand Initiation structural stage
UR	Understory Reinitiation structural stage
YFMS	Young Forest Multi Strata structural stage

Late-Old Structure (LOS): This field was calculated using an EVG query. It was not used during the ecosystem analysis, but was retained in the database to provide continuity with on-going planning efforts on the Walla Walla Ranger District.

Code	Description
NF	Nonforest (no LOS status determined for nonforest polygons)
No	Polygon did not qualify as LOS using the District's query
Yes	Polygon did classify as LOS using the District's query

Cover Types (CovTyp): These codes describe the predominant forest cover type for each polygon. Polygons were considered nonforest when the total canopy cover of trees was less than 10 percent; cover types were not determined for nonforest polygons. The cover type code represents similar stand composition based on floristics (tree species) and dominance (plurality of basal area or canopy cover; see Eyre 1980). Plurality was defined as 50% or more of the species composition – a polygon with 50% or more of the canopy cover in ponderosa pine was coded CP. Cover type codes are described below. [Note: this list shows the codes that were actually used; many other codes exist and would have been used if needed.]

Code	**Description**
BU	Burned area (used in 1936 only)
CA	Subalpine Fir
CC	Clearcut (used in 1958 only)
CD	Douglas-fir
CE	Engelmann Spruce
CJ	Western Juniper
CL	Lodgepole Pine
CP	Ponderosa Pine
CT	Western Larch/Tamarack
CW	Grand Fir
HC	Black Cottonwood
Mix	Mixed; < 50% of any one tree species
NF	Nonforest (cover types were not determined for nonforest polygons)
WP	Western white pine (used in 1958 only)

Total Canopy Cover (TotCov): Total canopy cover was recorded for polygons with a forest cover type code. Total canopy cover refers to the percentage of the ground surface obscured by plant foliage and, by definition, would not apply to polygons in which all of the trees are dead.

Cover Class (CovCls): This derived field was based on data in the *TotCov* field. It was used for the stand density analysis. Each forested polygon in the 1999veg database was assigned to one of five cover classes, as described below:

Code	**Description**
<=25	Live canopy (crown) cover is 25 percent or less
26-45	Live canopy cover is between 26 and 45 percent
46-65	Live canopy cover is between 46 and 65 percent
66-75	Live canopy cover is between 66 and 75 percent
>75	Live canopy cover is 75 percent or more

Stocking Class (Stocking): For both the 1936veg and 1958veg databases, it was possible to assign a stocking level to some of the forested polygons, as shown below:

Code	**Description**
L	Low stocking (10-40 percent)
M	Moderate stocking (41-70 percent)
H	High stocking (71-100 percent)

Canopy Layers (NLay): The number of canopy layers was recorded for all forested polygons in the 1999veg database, as described below:

Code	**Description**
1	1 layer present
2	2 layers present
3	Three or more layers present

Overstory Cover (OvCov): For polygons with a forest cover type code, the canopy cover associated with the overstory layer was recorded in this field. When added to the understory cover value, the total should equal the canopy cover of the polygon as a whole (as coded in the *TotCov* field). [Note: in multi-layered stands, the overstory is the tallest tree layer; the understory is the shortest one.]

Overstory Size Class (OvSiz): For polygons with a forest cover type code, the predominant size class for the overstory layer was recorded using these codes:

Code	**Description**
1	Seedlings; trees less than 1 inch DBH
2	Seedlings and saplings mixed
3	Saplings; trees 1–4.9” DBH
4	Saplings and poles mixed
5	Poles; trees 5–8.9” DBH
6	Poles and small trees mixed
77	Small trees 9–14.9” DBH
88	Small trees 15–20.9” DBH (code not in EVG)
8	Small trees and medium trees mixed
9	Medium trees 21–31.9” DBH
10	Medium and large trees mixed
11	Large trees 32–47.9” DBH
12	Large and giant trees mixed

Size Class (SizCls): For polygons with an overstory size class code, this derived field contains an aggregated size class designation that was used primarily for mapping (GIS) purposes.

Code	**Description**
ML	Medium-large trees are predominant (overstory size classes 8 through 12)
P	Pole-sized trees are predominant (overstory size classes 4 and 5)
SM	Small-sized trees are predominant (overstory size classes 6, 77, and 88)
SS	Seedling and sapling sized trees are predominant (overstory size classes 1 through 3)

Overstory Species (OvSp1, OvSp2): For polygons with a forest cover type code, one or two tree species were recorded for the overstory layer. Species were recorded in decreasing order of predominance. [Note: additional species codes (western white pine, quaking aspen, etc.) were available to the interpreters, but were not used.]

Code	**Description**
ABGR	Grand fir
ABLA2	Subalpine fir
ACGL	Rocky Mountain Maple (tree size)
ALNUS	Alder (species not determined; tree size)
ALRH	White Alder
ALRU	Red Alder
LAOC	Western Larch
PICO	Lodgepole Pine
PIEN	Engelmann Spruce
PIMO	Western White Pine
PIPO	Ponderosa Pine
POTR2	Black Cottonwood
PSME	Rocky Mountain Douglas-fir
SALIX	Willow (tree size)
TABR	Pacific Yew (tree size)

Understory Cover (UnCov): For polygons with a forest cover type code and two canopy layers, the canopy cover associated with the understory layer was recorded in this field. When added to the overstory cover value, the result should equal the total canopy cover of a polygon (as coded in the *TotCov* field). [Note: in multi-layered stands, the understory is the shortest tree layer; the overstory is the tallest one.]

Understory Size Class (UnSiz): For polygons with a forest cover type code and two canopy layers, the predominant size class for the understory layer was recorded in this field. Codes were the same as those described above for the overstory layer.

Understory Species (UnSp1, UnSp2): For polygons with a forest cover type code and two canopy layers, one or two tree species were recorded for the understory layer. Species were recorded in decreasing order of predominance, using the same species codes described above for the overstory layer.

Map Code (MapCode): This field was used in the 1900veg, 1936veg, and 1958veg databases. It provides the map attribute associated with each polygon. These map codes can be thought of as compilations of individual characteristics, e.g., type, stand size, stocking, age, and other features were combined into one attribute "string" that was used to label a polygon. Lookup tables were then used to decipher the map code and thereby "extract" the individual data items (type, size, etc.) out of the longer attribute string.

Harvest (Harvest): For both the 1936veg and 1958veg databases, it was possible to identify whether some of the polygons had been previously affected by timber harvest, as shown below:

Code	**Description**
Y	Timber harvest had occurred

Age (Age): For the 1936veg database only, it was possible to assign an age classification to some of the polygons, as shown below:

Code	**Description**
EA	Even-aged stand
UA	Uneven-aged stand

Purity (Purity): For the 1958veg database only, it was possible to assign a purity rating to some of the forested polygons, as shown below:

Code	**Description**
M	Mixed-species composition
P	Pure (single-species) composition

Treatment Opportunity (TO#1; TO#2): For the 1999veg database only, it was possible to assign a tentative treatment opportunity to some of the forested polygons. These fields represent one result from analysis of upland-forest issues such as "grassland replaced with forest," "inconsistent structure on dry-forest sites," etc.

Code	**Description**
CT	Commercial thinning is an apparent treatment opportunity
PCT	Noncommercial thinning is an apparent treatment opportunity
UR	Understory removal is an apparent treatment opportunity

Table 29: Methodology used to derive forest structural stages for the 1999veg database.

Order	PVG	OvCov	OvSiz	UnCov	UnSiz	Stage
1	Nonforest					NF
2	Cold UF	≥ 30	88, 8, 9, 10, 11	> 20		OFMS
3	Cold UF	≥ 30	88, 8, 9, 10, 11	≤ 20		OFSS
4	Dry UF	≥ 15	8, 9, 10, 11	> 10		OFMS
5	Dry UF	≥ 15	8, 9, 10, 11	≤ 10		OFSS
6		≥ 30	8, 9, 10, 11	> 20		OFMS
7		≥ 30	8, 9, 10, 11	≤ 20		OFSS
8	Dry UF	≥ 35	4, 5, 6, 77, 88	< 10		SECC
9	Dry UF	< 35	4, 5, 6, 77, 88	< 10		SEOC
10		≥ 70	4, 5, 6, 77, 88	< 10		SECC
11		≤ 20		≥ 70	2, 3, 4	SECC
12		≤ 20		< 70	2, 3, 4	SI
13			1, 2, 3, 4			SI
14		< 30	≥ 5	< 20		SI
15		< 30	≥ 5	≥ 20		UR
16	Dry UF	≥ 30	≥ 5	≥ 10		UR
17	Dry UF	< 30	≥ 5	≥ 10		YFMS
18		≥ 30	≥ 5	Blank		SEOC
19		≥ 30	≥ 5	< 10		UR
20		≥ 60	≥ 5	≥ 10		UR
21		< 60	≥ 5	≥ 10		YFMS

Sources/Notes: These queries were based on Hessburg and others (1999; page 11). Order is important for these calculations because if a polygon could meet more than one query option, a structural stage code should be assigned by the option with the lowest order number.

Table 30: Forest structural stages as related to canopy strata and tree size.

	SIZE CLASS OF UPPERMOST STRATUM		
NUMBER OF CANOPY LAYERS OR STRATA	SEEDLINGS/SAPLINGS (< 5" DBH)	POLES AND SMALL TREES (5 TO 20.9" DBH)	MEDIUM TREES (> 21" DBH)
1	Stand Initiation	Stem Exclusion	Old Forest Single Stratum
2	Not Applicable	Understory Reinitiation	Old Forest Multi Strata
3	Not Applicable	Young Forest Multi Strata	Old Forest Multi Strata

Sources/Notes: Adapted from Stage and others (1995). This generalized classification scheme was used when deriving forest structural stages for the 1936veg and 1958veg databases.

APPENDIX 2: PLANT SPECIES CODES

This appendix provides scientific and common plant names for the species codes that were used to name the plant associations and plant community types in table 2 (taken from Johnson and Clausnitzer 1992, and Johnson and Simon 1987).

CODE	SCIENTIFIC NAME	COMMON NAME
ABGR	*Abies grandis*	Grand (white) fir
ABLA2	*Abies lasiocarpa*	Subalpine fir
ACGL	*Acer glabrum*	Rocky Mountain maple
AGSP	*Agropyron spicatum*	Bluebunch wheatgrass
ALSI	*Alnus sinuata*	Sitka alder
ARCO	*Arnica cordifolia*	Heartleaf arnica
ARNE	*Arctostaphylos nevadensis*	Pinemat manzanita
ASCA3	*Asarum caudatum*	Wild ginger
ATFI	*Athyrium filix-femina*	Lady fern
BRVU	*Bromus vulgaris*	Columbia brome
CAGE	*Carex geyeri*	Elk sedge
CARO	*Carex rossii*	Ross sedge
CARU	*Calamagrostis rubescens*	Pinegrass
CELE	*Cercocarpus ledifolius*	Curlleaf mountain-mahogany
CLUN	*Clintonia uniflora*	Queencup beadlily
FEID	*Festuca idahoensis*	Idaho fescue
GYDR	*Gymnocarpium dryopteris*	Oakfern
HODI	*Holodiscus discolor*	Creambush oceanspray
JUOC	*Juniperus occidentalis*	Western juniper
LIBO2	*Linnaea borealis*	Twinflower
PHMA	*Physocarpus malvaceus*	Mallow ninebark
PICO	*Pinus contorta*	Lodgepole pine
PIEN	*Picea engelmannii*	Engelmann spruce
PIPO	*Pinus ponderosa*	Ponderosa pine
POMU	*Polystichum munitum*	Sword fern
POPU	*Polemonium pulcherrimum*	Polemonium
PSME	*Pseudotsuga menziesii*	Douglas-fir
PTAQ	*Pteridium aquilinum*	Bracken fern
PUTR	*Purshia tridentata*	Bitterbrush
SETR	*Senecio triangularis*	Arrowleaf groundsel
SPBE	*Spiraea betulifolia*	Birchleaf spirea
STAM	*Streptopus amplexifolius*	Twisted stalk
STOC	*Stipa occidentalis*	Western needlegrass
SYAL	*Symphoricarpos albus*	Common snowberry
SYOR	*Symphoricarpos oreophilus*	Mountain snowberry
TABR	*Taxus brevifolia*	Pacific yew
TRCA3	*Trautvetteria caroliniensis*	False bugbane
VAME	*Vaccinium membranaceum*	Big huckleberry
VASC	*Vaccinium scoparium*	Grouse huckleberry

APPENDIX 3: SUGGESTED STOCKING LEVELS

Recent concerns about forest health in the Blue Mountains (McLean 1992) have recognized the value of maintaining stand densities that promote high tree vigor and minimize damage from insects and pathogens. Thinning is effective at preventing or minimizing serious mortality from mountain pine beetle and, perhaps, western pine beetle. It can also prevent dwarf mistletoe from becoming a serious problem in even-aged stands of ponderosa pine (Cochran and others 1994). Managing stand density is a good example of integrated pest management, a strategy that involves using silviculture and other measures to reduce susceptibility or vulnerability to common harmful agents (Nyland 1996).

The tables in this appendix provide tree density recommendations by species and by plant association (plus an average for each PAG). They establish a "management zone" in which stand densities are presumed to be ecologically sustainable. To preclude serious losses (tree mortality) from insects, diseases, parasites, drought, and certain other disturbance agents, stand densities should be maintained at a level below the upper management zone.

Table 31: Suggested stocking levels for subalpine fir (SF).

	FULL STOCKING LEVEL				**UPPER MGMT. ZONE**				**LOWER MGMT. ZONE**			
PLANT ASSOCIATION	**TPA**	**BA**	**CC**	**ES**	**TPA**	**BA**	**CC**	**ES**	**TPA**	**BA**	**CC**	**ES**
ABLA2/MEFE	416	227	90	11.0	312	170	85	12.7	208	113	78	15.6
Mean: Cold Moist PAG	416	227	90	11.0	312	170	85	12.7	208	113	78	15.6
ABLA2/CAGE	372	203	88	11.6	279	152	83	13.4	186	101	76	16.4
ABLA2/VASC	365	199	88	11.7	274	149	83	13.6	183	100	76	16.6
ABLA2/VASC/POPU	365	199	88	11.7	274	149	83	13.6	183	100	76	16.6
Mean: Cold Dry PAG	367	200	88	11.7	276	150	83	13.5	184	100	76	16.5
ABGR/LIBO2	373	203	88	11.6	280	153	83	13.4	187	102	76	16.4
ABGR/VAME	412	225	90	11.0	309	169	85	12.8	206	112	78	15.6
ABGR/VASC-LIBO2	184	100	76	16.5	138	75	71	19.1	92	50	64	23.4
ABLA2/CLUN	416	227	90	11.0	312	170	85	12.7	208	113	78	15.6
ABLA2/LIBO2	335	183	87	12.3	251	137	82	14.1	168	91	75	17.3
ABLA2/TRCA3	382	208	89	11.5	287	156	84	13.3	191	104	77	16.2
ABLA2/VAME	265	145	83	13.8	199	108	77	15.9	133	72	70	19.5
Mean: Cool Moist PAG	338	184	86	12.5	254	138	81	14.5	169	92	74	17.7

Sources/Notes: All information in this table pertains to stands with a quadratic mean diameter (QMD) of 10 inches. The information would differ slightly for stands with other QMDs (Powell 1999). The full stocking level is equivalent to maximum stocking; the upper management zone is 75% of full stocking; the lower management zone is 67% of the upper management zone; TPA is trees per acre when the quadratic mean diameter is 10 inches; BA is basal area per acre; CC is canopy cover and was calculated using the "CE" equation from Dealy (1985); and ES is equilateral spacing – the spacing, in feet, that the trees per acre would have when spaced equilaterally apart (also referred to as triangular spacing). The TPA values were derived from Cochran and others (1994). The BA and ES values were calculated using equations and were based on the TPA values.

Table 32: Suggested stocking levels for grand fir (GF).

	FULL STOCKING LEVEL				UPPER MGMT. ZONE				LOWER MGMT. ZONE			
PLANT ASSOCIATION	**TPA**	**BA**	**CC**	**ES**	**TPA**	**BA**	**CC**	**ES**	**TPA**	**BA**	**CC**	**ES**
ABGR/VASC	368	201	90	11.7	276	151	85	13.5	184	100	78	16.5
Mean: Cold Dry PAG	368	201	90	11.7	276	151	85	13.5	184	100	78	16.5
ABGR/TABR/CLUN	560	305	98	9.5	420	229	93	10.9	280	153	85	13.4
ABGR/TABR/LIBO2	560	305	98	9.5	420	229	93	10.9	280	153	85	13.4
Mean: Cool Wet PAG	560	305	98	9.5	420	229	93	10.9	280	153	85	13.4
ABGR/GYDR	553	302	98	9.5	415	226	92	11.0	277	151	85	13.5
ABGR/POMU-ASCA3	486	265	95	10.2	365	199	90	11.7	243	133	83	14.4
ABGR/TRCA3	554	302	98	9.5	416	227	92	11.0	277	151	85	13.5
Mean: Cool Very Moist PAG	531	290	97	9.7	398	217	92	11.3	266	145	84	13.8
ABGR/CLUN	560	305	98	9.5	420	229	93	10.9	280	153	85	13.4
ABGR/LIBO2	516	281	96	9.9	387	211	91	11.4	258	141	84	14.0
ABGR/VAME	455	248	94	10.5	341	186	89	12.1	228	124	82	14.9
ABGR/VASC-LIBO2	494	269	96	10.1	371	202	90	11.7	247	135	83	14.3
Mean: Cool Moist PAG	506	276	96	10.0	380	207	91	11.5	253	138	84	14.1
ABGR/ACGL	461	251	94	10.4	346	189	89	12.1	231	126	82	14.8
Mean: Warm Very Moist PAG	461	251	94	10.4	346	189	89	12.1	231	126	82	14.8
ABGR/BRVU	560	305	98	9.5	420	229	93	10.9	280	153	85	13.4
Mean: Warm Moist PAG	560	305	98	9.5	420	229	93	10.9	280	153	85	13.4
ABGR/CAGE	560	305	98	9.5	420	229	93	10.9	280	153	85	13.4
ABGR/CARU	444	242	94	10.6	333	182	89	12.3	222	121	81	15.1
ABGR/SPBE	354	193	90	11.9	266	145	84	13.8	177	97	77	16.9
Mean: Warm Dry PAG	453	247	94	10.7	340	185	89	12.3	226	123	81	15.1

Sources/Notes: All information in this table pertains to stands with a quadratic mean diameter (QMD) of 10 inches. The information would differ slightly for stands with other QMDs (Powell 1999). The full stocking level is equivalent to maximum stocking; the upper management zone is 75% of full stocking; the lower management zone is 67% of the upper management zone; TPA is trees per acre when the quadratic mean diameter is 10 inches; BA is basal area per acre; CC is canopy cover and was calculated using the "CW" equation from Dealy (1985); and ES is equilateral spacing – the spacing, in feet, that the trees per acre would have when spaced equilaterally apart (also referred to as triangular spacing). The TPA values were derived from Cochran and others (1994). The BA and ES values were calculated using equations and were based on the TPA values.

Table 33: Suggested stocking levels for Engelmann spruce (ES).

PLANT ASSOCIATION	FULL STOCKING LEVEL				UPPER MGMT. ZONE				LOWER MGMT. ZONE			
	TPA	BA	CC	ES	TPA	BA	CC	ES	TPA	BA	CC	ES
ABLA2/VASC	366	200	88	11.7	275	150	83	13.5	183	100	76	16.6
ABLA2/VASC/POPU	366	200	88	11.7	275	150	83	13.5	183	100	76	16.6
Mean: Cold Dry PAG	366	200	88	11.7	275	150	83	13.5	183	100	76	16.6
ABGR/TABR/CLUN	426	232	91	10.9	320	174	86	12.5	213	116	79	15.4
ABGR/TABR/LIBO2	299	163	85	13.0	224	122	80	15.0	150	82	73	18.3
Mean: Cool Wet PAG	363	198	88	11.9	272	148	83	13.8	181	99	76	16.9
ABGR/POMU-ASCA3	469	256	92	10.4	352	192	87	12.0	235	128	80	14.6
ABGR/TRCA3	388	212	89	11.4	291	159	84	13.1	194	106	77	16.1
Mean: Cool Very Moist PAG	400	218	90	11.3	300	164	85	13.0	200	109	77	15.9
ABGR/CLUN	469	256	92	10.4	352	192	87	12.0	235	128	80	14.6
ABGR/LIBO2	399	218	90	11.2	299	163	85	13.0	200	109	78	15.9
ABGR/VAME	341	186	87	12.1	256	139	82	14.0	171	93	75	17.2
ABGR/VASC-LIBO2	349	190	87	12.0	262	143	82	13.9	175	95	75	17.0
ABLA2/CLUN	469	256	92	10.4	352	192	87	12.0	235	128	80	14.6
ABLA2/LIBO2	379	207	89	11.5	284	155	84	13.3	190	103	77	16.3
ABLA2/TRCA3	344	188	87	12.1	258	141	82	14.0	172	94	75	17.1
ABLA2/VAME	382	208	89	11.5	287	156	84	13.3	191	104	77	16.2
Mean: Cool Moist PAG	392	214	89	11.4	294	160	84	13.2	196	107	77	16.1
ABGR/ACGL	324	177	86	12.5	243	133	81	14.4	162	88	74	17.6
Mean: Warm Very Moist PAG	324	177	86	12.5	243	133	81	14.4	162	88	74	17.6
ABGR/BRVU	469	256	92	10.4	352	192	87	12.0	235	128	80	14.6
Mean: Warm Moist PAG	469	256	92	10.4	352	192	87	12.0	235	128	80	14.6

Sources/Notes: All information in this table pertains to stands with a quadratic mean diameter (QMD) of 10 inches. The information would differ slightly for stands with other QMDs (Powell 1999). The full stocking level is equivalent to maximum stocking; the upper management zone is 75% of full stocking; the lower management zone is 67% of the upper management zone; TPA is trees per acre when the quadratic mean diameter is 10 inches; BA is basal area per acre; CC is canopy cover and was calculated using the "CE" equation from Dealy (1985); and ES is equilateral spacing – the spacing, in feet, that the trees per acre would have when spaced equilaterally apart (also referred to as triangular spacing). The TPA values were derived from Cochran and others (1994). The BA and ES values were calculated using equations and were based on the TPA values.

Table 34: Suggested stocking levels for lodgepole pine (LP).

PLANT ASSOCIATION	FULL STOCKING LEVEL				UPPER MGMT. ZONE				LOWER MGMT. ZONE			
	TPA	**BA**	**CC**	**ES**	**TPA**	**BA**	**CC**	**ES**	**TPA**	**BA**	**CC**	**ES**
ABGR/VASC	277	151	71	13.5	208	113	66	15.6	139	76	59	19.0
ABLA2/CAGE	277	151	71	13.5	208	113	66	15.6	139	76	59	19.0
ABLA2/VASC	277	151	71	13.5	208	113	66	15.6	139	76	59	19.0
ABLA2/VASC/POPU	277	151	71	13.5	208	113	66	15.6	139	76	59	19.0
Mean: Cold Dry PAG	277	151	71	13.5	208	113	66	15.6	139	76	59	19.0
PICO/CARU	223	122	67	15.0	167	91	62	17.3	112	61	55	21.2
Mean: Cool Dry PAG	223	122	67	15.0	167	91	62	17.3	112	61	55	21.2
ABGR/CLUN	277	151	71	13.5	208	113	66	15.6	139	76	59	19.0
ABGR/LIBO2	277	151	71	13.5	208	113	66	15.6	139	76	59	19.0
ABGR/VAME	238	130	68	14.5	179	97	63	16.8	120	65	56	20.5
ABGR/VASC-LIBO2	277	151	71	13.5	208	113	66	15.6	139	76	59	19.0
ABLA2/TRCA3	277	151	71	13.5	208	113	66	15.6	139	76	59	19.0
ABLA2/VAME	255	139	69	14.0	191	104	64	16.2	128	70	57	19.8
Mean: Cool Moist PAG	265	144	70	13.8	199	108	65	15.9	133	73	58	19.5
ABGR/CARU	277	151	71	13.5	208	113	66	15.6	139	76	59	19.0
Mean: Warm Dry PAG	277	151	71	13.5	208	113	66	15.6	139	76	59	19.0

Sources/Notes: All information in this table pertains to stands with a quadratic mean diameter (QMD) of 10 inches. The information would differ slightly for stands with other QMDs (Powell 1999). The full stocking level is equivalent to maximum stocking; the upper management zone is 75% of full stocking; the lower management zone is 67% of the upper management zone; TPA is trees per acre when the quadratic mean diameter is 10 inches; BA is basal area per acre; CC is canopy cover and was calculated using the "CL" equation from Dealy (1985); and ES is equilateral spacing – the spacing, in feet, that the trees per acre would have when spaced equilaterally apart (also referred to as triangular spacing). The TPA values were derived from Cochran and others (1994). The BA and ES values were calculated using equations and were based on the TPA values.

Table 35: Suggested stocking levels for western larch (WL).

PLANT ASSOCIATION	FULL STOCKING LEVEL TPA	BA	CC	ES	UPPER MGMT. ZONE TPA	BA	CC	ES	LOWER MGMT. ZONE TPA	BA	CC	ES
ABGR/VASC	304	166	73	12.9	228	124	67	14.9	152	83	60	18.2
ABLA2/VASC	380	207	77	11.5	285	155	71	13.3	190	104	64	16.3
ABLA2/VASC/POPU	380	207	77	11.5	285	155	71	13.3	190	104	64	16.3
Mean: Cold Dry PAG	355	193	75	12.0	266	145	70	13.8	177	97	63	16.9
ABGR/TABR/LIBO2	302	165	72	12.9	227	124	67	14.9	151	82	60	18.3
Mean: Cool Wet PAG	302	165	72	12.9	227	124	67	14.9	151	82	60	18.3
ABGR/POMU-ASCA3	350	191	75	12.0	263	143	70	13.8	175	95	63	17.0
ABGR/TRCA3	398	217	77	11.2	299	163	72	13.0	199	109	65	15.9
Mean: Cool Very Moist PAG	374	204	76	11.6	281	153	71	13.4	187	102	64	16.4
ABGR/CLUN	410	224	78	11.1	308	168	73	12.8	205	112	65	15.7
ABGR/LIBO2	370	202	76	11.7	278	151	71	13.5	185	101	64	16.5
ABGR/VAME	410	224	78	11.1	308	168	73	12.8	205	112	65	15.7
ABGR/VASC-LIBO2	253	138	69	14.1	190	103	64	16.3	127	69	57	19.9
ABLA2/CLUN	410	224	78	11.1	308	168	73	12.8	205	112	65	15.7
ABLA2/LIBO2	410	224	78	11.1	308	168	73	12.8	205	112	65	15.7
ABLA2/VAME	382	208	77	11.5	287	156	72	13.3	191	104	64	16.2
Mean: Cool Moist PAG	378	206	76	11.6	283	155	71	13.5	189	103	64	16.5
ABGR/ACGL	351	191	75	12.0	263	144	70	13.8	176	96	63	16.9
Mean: Warm Very Moist PAG	351	191	75	12.0	263	144	70	13.8	176	96	63	16.9
ABGR/BRVU	410	224	78	11.1	308	168	73	12.8	205	112	65	15.7
Mean: Warm Moist PAG	410	224	78	11.1	308	168	73	12.8	205	112	65	15.7
ABGR/CARU	307	167	73	12.8	230	126	68	14.8	154	84	60	18.1
PSME/PHMA	256	140	69	14.0	192	105	64	16.2	128	70	57	19.8
PSME/SYAL	205	112	65	15.7	154	84	60	18.1	103	56	53	22.2
Mean: Warm Dry PAG	256	140	69	14.2	192	105	64	16.4	128	70	57	20.0

Sources/Notes: All information in this table pertains to stands with a quadratic mean diameter (QMD) of 10 inches. The information would differ slightly for stands with other QMDs (Powell 1999). The full stocking level is equivalent to maximum stocking; the upper management zone is 75% of full stocking; the lower management zone is 67% of the upper management zone; TPA is trees per acre when the quadratic mean diameter is 10 inches; BA is basal area per acre; CC is canopy cover and was calculated using the "CL" equation from Dealy (1985); and ES is equilateral spacing – the spacing, in feet, that the trees per acre would have when spaced equilaterally apart (also referred to as triangular spacing). The TPA values were derived from Cochran and others (1994). The BA and ES values were calculated using equations and were based on the TPA values.

Table 36: Suggested stocking levels for Douglas-fir (DF).

PLANT ASSOCIATION	Full Stocking Level TPA	BA	CC	ES	Upper Mgmt. Zone TPA	BA	CC	ES	Lower Mgmt. Zone TPA	BA	CC	ES
ABGR/VASC	274	149	80	13.5	206	112	75	15.6	137	75	69	19.2
ABLA2/VASC	366	200	85	11.7	275	150	80	13.5	183	100	74	16.6
ABLA2/VASC/POPU	366	200	85	11.7	275	150	80	13.5	183	100	74	16.6
Mean: Cold Dry PAG	335	183	83	12.3	252	137	78	14.2	168	91	72	17.4
ABGR/TABR/LIBO2	380	207	85	11.5	285	155	81	13.3	190	104	74	16.3
Mean: Cool Wet PAG	380	207	85	11.5	285	155	81	13.3	190	104	74	16.3
ABGR/CLUN	380	207	85	11.5	285	155	81	13.3	190	104	74	16.3
ABGR/LIBO2	380	207	85	11.5	285	155	81	13.3	190	104	74	16.3
ABGR/VAME	380	207	85	11.5	285	155	81	13.3	190	104	74	16.3
ABGR/VASC-LIBO2	347	189	84	12.0	260	142	79	13.9	174	95	73	17.0
Mean: Cool Moist PAG	372	203	85	11.6	279	152	80	13.4	186	101	74	16.5
ABGR/ACGL	241	131	78	14.4	181	99	73	16.7	121	66	67	20.4
Mean: Warm Very Moist PAG	241	131	78	14.4	181	99	73	16.7	121	66	67	20.4
PSME/ACGL-PHMA	277	151	80	13.5	208	113	76	15.6	139	76	69	19.1
Mean: Warm Moist PAG	277	151	80	13.5	208	113	76	15.6	139	76	69	19.1
ABGR/CAGE	301	164	82	12.9	226	123	77	14.9	151	82	70	18.3
ABGR/CARU	357	195	84	11.9	268	146	80	13.7	179	97	73	16.8
ABGR/SPBE	198	108	75	15.9	149	81	70	18.4	99	54	64	22.5
PSME/CAGE	281	153	80	13.4	211	115	76	15.4	141	77	69	18.9
PSME/CARU	264	144	79	13.8	198	108	75	15.9	132	72	68	19.5
PSME/HODI	255	139	79	14.0	191	104	74	16.2	128	70	68	19.9
PSME/PHMA	225	123	77	15.0	169	92	72	17.3	113	61	66	21.1
PSME/SPBE	371	202	85	11.6	278	152	80	13.4	186	101	74	16.5
PSME/SYAL	247	135	78	14.3	185	101	74	16.5	124	67	67	20.2
PSME/VAME	183	100	74	16.6	137	75	69	19.1	92	50	62	23.4
Mean: Warm Dry PAG	268	146	79	13.9	201	110	75	16.1	134	73	68	19.7

Sources/Notes: All information in this table pertains to stands with a quadratic mean diameter (QMD) of 10 inches. The information would differ slightly for stands with other QMDs (Powell 1999). The full stocking level is equivalent to maximum stocking; the upper management zone is 75% of full stocking; the lower management zone is 67% of the upper management zone; TPA is trees per acre when the quadratic mean diameter is 10 inches; BA is basal area per acre; CC is canopy cover and was calculated using the "CD" equation from Dealy (1985); and ES is equilateral spacing – the spacing, in feet, that the trees per acre would have when spaced equilaterally apart (also referred to as triangular spacing). The TPA values were derived from Cochran and others (1994). The BA and ES values were calculated using equations and were based on the TPA values.

Table 37: Suggested stocking levels for ponderosa pine (PP).

PLANT ASSOCIATION	FULL STOCKING LEVEL TPA	BA	CC	ES	UPPER MGMT. ZONE TPA	BA	CC	ES	LOWER MGMT. ZONE TPA	BA	CC	ES
ABGR/VASC	172	94	57	17.1	101	55	47	22.3	68	37	40	27.3
Mean: Cold Dry PAG	172	94	57	17.1	101	55	47	22.3	68	37	40	27.3
ABGR/LIBO2	686	374	83	8.6	162	88	56	17.6	109	59	48	21.5
ABGR/VAME	292	159	67	13.1	139	76	53	19.0	93	51	46	23.2
Mean: Cool Moist PAG	489	267	75	10.8	151	82	54	18.3	101	55	47	22.4
PSME/ACGL-PHMA	281	153	66	13.4	189	103	59	16.3	127	69	51	19.9
Mean: Warm Moist PAG	281	153	66	13.4	189	103	59	16.3	127	69	51	19.9
ABGR/CAGE	210	115	61	15.5	109	59	48	21.5	73	40	41	26.2
ABGR/CARU	316	172	68	12.6	154	84	55	18.1	103	56	47	22.1
ABGR/SPBE	255	139	64	14.0	147	80	54	18.5	98	54	47	22.6
PIPO/CAGE	201	110	60	15.8	83	45	43	24.6	56	30	36	30.1
PIPO/CARU	365	199	71	11.7	154	84	55	18.1	103	56	47	22.1
PIPO/CELE/CAGE	232	127	62	14.7	82	45	43	24.8	55	30	36	30.3
PIPO/ELGL	243	133	63	14.4	92	50	45	23.4	62	34	38	28.6
PIPO/PUTR/CAGE	204	111	60	15.7	70	38	40	26.8	47	26	33	32.7
PIPO/PUTR/CARO	243	133	63	14.4	92	50	45	23.4	62	34	38	28.6
PIPO/SYAL	318	173	68	12.6	218	119	61	15.2	146	80	54	18.6
PIPO/SYOR	260	142	65	13.9	135	74	52	19.3	90	49	45	23.6
PSME/CAGE	222	121	62	15.1	86	47	44	24.2	58	31	37	29.5
PSME/CARU	263	143	65	13.8	122	67	51	20.3	82	45	43	24.8
PSME/HODI	340	185	70	12.2	278	152	66	13.5	186	102	58	16.4
PSME/PHMA	274	149	66	13.5	167	91	56	17.4	112	61	49	21.2
PSME/SPBE	353	193	70	11.9	226	123	62	14.9	151	83	55	18.2
PSME/SYAL	273	149	65	13.6	151	82	54	18.3	101	55	47	22.3
PSME/SYOR	361	197	71	11.8	180	98	58	16.7	121	66	50	20.4
PSME/VAME	193	105	59	16.1	96	52	46	22.9	64	35	39	28.0
Mean: Warm Dry PAG	270	147	65	13.9	139	76	52	20.1	93	51	44	24.5
PIPO/AGSP	133	73	52	19.4	38	21	29	36.4	25	14	22	44.4
PIPO/CELE/FEID-AGSP	157	86	55	17.9	32	17	26	39.6	21	12	19	48.4
PIPO/FEID	194	106	59	16.1	63	34	38	28.3	42	23	31	34.5
PIPO/PUTR/FEID-AGSP	185	101	58	16.5	66	36	39	27.6	44	24	32	33.7
Mean: Hot Dry PAG	167	91	56	17.5	50	27	33	33.0	33	18	26	40.3

Sources/Notes: All information in this table pertains to stands with a quadratic mean diameter (QMD) of 10 inches. The information would differ slightly for stands with other QMDs (Powell 1999). The full stocking level is equivalent to maximum stocking; the upper management zone was determined using a process described in Cochran and others (1994); the lower management zone is 67% of the upper management zone; TPA is trees per acre when the quadratic mean diameter is 10 inches; BA is basal area per acre; CC is canopy cover and was calculated using the "CP" equation from Dealy (1985); and ES is equilateral spacing – the spacing, in feet, that the trees per acre would have when spaced equilaterally apart (also referred to as triangular spacing). The TPA values were derived from Cochran and others (1994). The BA and ES values were calculated using equations and were based on the TPA values.

APPENDIX 4: G.L.O. SURVEY NOTES PROJECT

Prepared by Martha King, Supervisor's Office

This project was based on work pioneered by Gean Davidson for both the Ochoco and Deschutes National Forests. The idea was to utilize General Land Office survey notes from the late 1800s to provide an estimate of historical vegetation conditions for the Umatilla/Meacham ecosystem analysis.

The Umatilla NF maintains copies of the GLO survey notes on microfiche, located in the Supervisor's Office in Pendleton. These notes cover a majority of the Umatilla Forest and range from the 1850s through the early 1900s. The GLO notes include references about a variety of conditions encountered along survey lines, including vegetation species (trees, shrubs, and grasses) and quality, bearing or witness trees (species, DBH, distance, and direction), stream locations and channel widths, and even human developments such as roads, trails, and homesteads. Some references were also made to old burn areas, spring and stock trough locations, stock trails and corrals, and even a few bear and beaver sightings.

This project began as a supplementary analysis tool for the Umatilla/Meacham watershed area. Hard copies of GLO survey notes were used in conjunction with the corresponding 7.5 minute topographic quad maps. A database was designed to include data on bearing trees, timber and undergrowth species and densities, soil types, river and creek sizes, and man-made developments.

Some data interpretation was necessary since many different crews were involved in the surveys, and because common names of plant species from the late 1800s may not coincide with the common names used today. However, this interpretation was kept to a minimum so as to not compromise the survey's usefulness.

Key terms used in the Umatilla/Meacham database are summarized below.

Human and Cultural Improvements:

CODE	DESCRIPTION
B	burn area
BVR	beaver dam
C	cattle area
H	homestead/lumber mill
H2O	spring/water trough
I	CTUIR boundary/Indian trail
R	railway line
S	sheep driveway/corral
STK	stock trail/corral (unknown stock)
T	trail/pack trail
W	wagon road/settlement road/stage road/toll road/road

Soil Type:

1	loam
2	sandy, loam
3	stony, gravel
4	stone, lava, rocky, poor, steep

Timber/Vegetation Density:

CODE	DESCRIPTION

---	no reference made <u>or</u> no reference to density but species was named
Dead	
Dense	dense, heavy, thick
Excellent	
Good	good, covered, fine, considerable
None	
Scatter	scatter, inferior, little, open, poor, scant
Some	

Timber/Undergrowth Species (common names in survey notes):

Alder	Fern	Red Fir
Arrowwood	Fir	Rosebrier
Balm	Grass	Sage
Barberry	Greasewood	Serviceberry
Birch	Hazel	Snow Brush
Black Pine	Hemlock	Spruce
Brush	Huckleberry	Sumac
Buckbrush	Larch	Sunflower
Cascara	Mahogany	Tamarack
Chaparral	Maple	Thimbleberry
Cherry	Mountain Laurel	Vine Maple
Chinquapin	Mullein	White Fir
Cottonwood	Ninebark	White Pine
Dogwood	Pine	Whortleberry
Elder	Pinegrass	Willow
Elk Grass	Redberry	Yellow Pine
		Yew

The GIS department converted the completed database into ARC-INFO. The GIS public land section survey (PLSS) layer was used to create unique node and line ID numbers which were linked to the corresponding legal description of each section line, mid-line points, and corners. Maps were then created using ARC-INFO to show vegetation distribution and density trends over the watershed area.

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