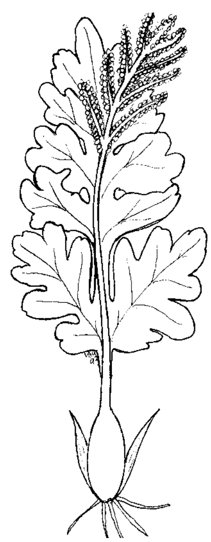
Umatilla and Meacham Ecosystem Analysis

Umatilla National Forest



Pinnate Grapefern
(Botrychium pinnatum)

April 2001

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INTRODUCTION

This report describes an ecosystem analysis of the Upper Umatilla River and Meacham Creek watersheds. The report summarizes findings from individual specialists' reports and watershed team discussions, and is intended primarily for use at the ranger district level. Although both watersheds are considerably larger than the size typically recommended for analysis (Federal Guide for Watershed Analysis 1995), the guide was used as a framework. A number of departures were made from previous ecosystem analyses to improve the content of the report and quality of the analyses. Significant changes included the following:

1. Vegetation analyses incorporated structural stages and plant association stratifications used in the Interior Columbia Basin Ecosystem Management Project (Hessburg et al. 1999).
2. Fish and aquatic habitat conditions were assessed by identifying *reference* subwatersheds within the analysis area that had not been significantly impacted by management activities. Aquatic parameters were compared among the reference and non-reference subwatersheds to assess the impacts of past management activities.
3. Subwatersheds were prioritized for restoration and management using an interdisciplinary evaluation system that identified concerns and restoration opportunities on a subwatershed basis. The process helped to integrate the results from individual specialist's analyses and ensure that restoration goals were coherent within an ecosystem framework.

SUMMARY OF FINDINGS

Key findings from this watershed analysis include the following:

1. The Upper Umatilla and Meacham watersheds are a critical source of relatively cool water for the entire Umatilla Subbasin.
2. Although the Umatilla River and Meacham Creek do not meet state water quality standards, they provide some areas of relatively high quality conditions for remnant and recovering fish populations.
3. The water temperature standard for bull trout (50° F) may not be achievable certain times of the year because of natural conditions. Proposed and achievable goal is between 55° and 60° F.
4. Protection of cold water, coldwater sources, and aquatic refuge areas may conflict with high priority vegetation management activities.
5. Bull trout populations are considered at risk of extirpation from the Umatilla Sub-basin because of their small population size, limited amount of satisfactory habitat, and genetic isolation from other populations.
6. Several subwatersheds have the potential to support large wildland fire events, primarily due to forest conditions characterized by over-stocked stands with dense understories.
7. Many stands in both watersheds have a high risk for infestation by western spruce budworm and Douglas-fir tussock moth. Significant areas along the Tollgate corridor

and North Fork Meacham Creek have been targeted for treatment (Tussock Moth EIS) if current infestations in the Blue Mountains spread in these areas. .

8. Eight native plant species in Umatilla Watershed and two in the Meacham Watershed have very limited populations and are considered to be at risk for extirpation from the watersheds. The greatest threat to these species is displacement by introduced plant species.

9. The amount of late-old forest habitat and late-old structure has declined in both watersheds over the last 36 years, and currently has a limited distribution and patch size. We estimated that old forest habitat consisted of around 48 percent of the analysis area in 1936, and currently comprises around 12 percent. The reductions cannot be explained entirely by timber harvest.

10. Snag and green tree densities meet or exceed Umatilla Land and Resource Management Plan guidelines. However, snags and green trees are not distributed evenly within the watersheds, and thus some areas are probably below Forest Plan guidelines.

11. There appears to be a significant loss of ponderosa pine stands.

12. In the past 40 years, the acreage occupied by early-seral forest types has declined considerably and the amount of forested vegetation has increased.

13. From the perspective of forested vegetation, the current mix of density classes is more sustainable now than it was in either 1936 or 1958.

14. As a result of changes in the analysis area over the last 63 years, some habitat components for management indicator species (MIS) are below historical benchmarks (e.g., pileated woodpecker) while others remain stable (e.g., elk, northern three-toed woodpecker, and marten).

15. Although the effects of cattle, sheep, elk and deer grazing/browsing have had significant deleterious impacts on riparian habitat in the analysis area, data to quantitate these effects are not available.

SITE CHARACTERIZATION OF THE UMATILLA AND MEACHAM WATERSHEDS

Location and Setting

The Umatilla-Meacham ecosystem analysis area is located on the Walla Walla Ranger District of the Umatilla National Forest. The analysis area lies on the west flank of the Blue Mountains in the headwaters of the Umatilla River subbasin (HUC #17070103), about 25 miles east of Pendleton, Oregon (Figure 1-1). Together, the two watersheds (Umatilla and Meacham) amount to about 200,700 acres, or about 313.5 square miles in area. About 70 percent of the analysis area is National Forest land (Figure 1-2). Other significant landowners include Boise Cascade, Confederated Tribes of the Umatilla Indian Reservation (CTUIR), and the State of Oregon. The study area accounts for approximately 14 percent of the area in the Umatilla River, and includes 10 subwatersheds in the upper Umatilla River watershed and 17 in the Meacham Creek watershed (Table 1-1, Figure 1-3).

Geology and Soils

The analysis area is typical of much of the northern Blue Mountains. Topography is characterized by uplifted, moderately dissected plateaus with long narrow ridges, steep escarpments, canyons, and narrow depositional valley bottoms. Elevations range from a low of 1,729 feet at the confluence of Meacham Creek with the Umatilla River, to a high of 5,817 feet in the Pot Creek subwatershed (89h). The upper elevation areas occur in the northeast, southeast and central portions of the analysis area. Elevational distribution of the National Forest land is similar in the two watersheds, with over 80 percent of the area between 3,000 and 5,000 ft. A small portion (1695 acres or 2 percent) in the Meacham watershed extends above 5,500 feet. About two-thirds of the analysis area is characterized by steep slopes (>=30%) that are highly dissected. About one-third of the analysis area contains slopes in excess of 50 percent. Drainages tend to run east-west in the Umatilla watershed and south to north in the Meacham watershed.

The analysis area has a relatively young, homogeneous geology and contains three formations of the Columbia River basalt group. The Grande Ronde basalt formation is the most widespread, while Wanapam and Saddle Mountains basalt formations exist as relatively minor components. Soils of the analysis area have been widely and significantly influenced by the deposition of Mt. Mazama volcanic ash. Although wind and water has eroded much of the ash deposits, they still have a strong influence on hydrology of this area. Ash deposits greater than 14 inches cover about 40 percent of the analysis area. Most of the deep (>20 inches), productive soils in the analysis area (48% of the National Forest acres) contain these ash deposits.

Figure 1-1. Location of the Umatilla and Meacham watersheds.

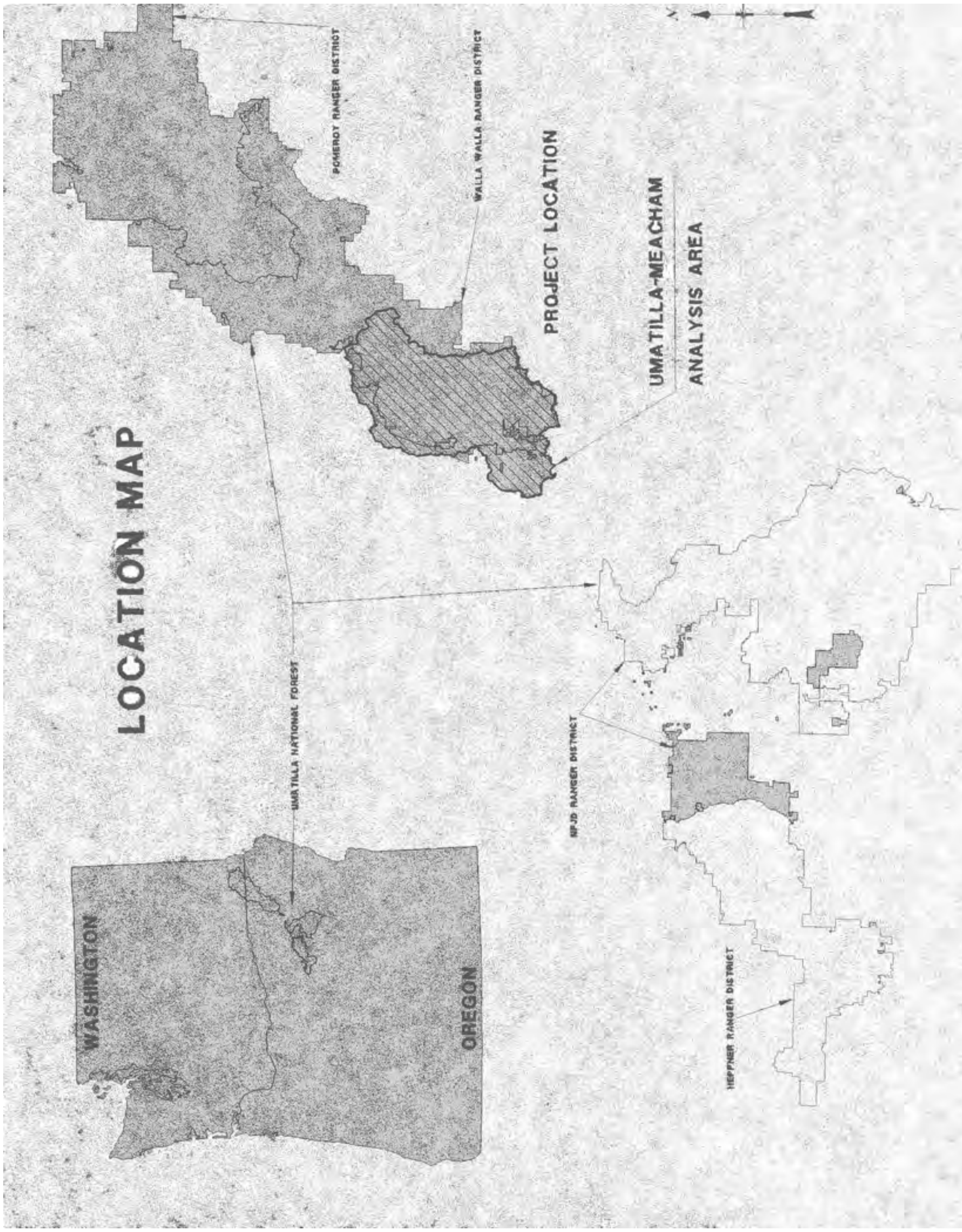

Table 1-1. Acres by subwatershed for the Umatilla-Meacham analysis area.

	SWS	USFS	% National Forest	CTU IRI	Private[1]	State	Boise Cascade	Total
Ryan Creek	13A	7874	94	0	338	0	0	8357
Lower Umatilla/Hagen	13B	2160	50	0	425	0	0	4361
Lower Umatilla/Bear	13C	6642	54	0	1128	0	0	12251
Lower North Fork Umatilla	13D	5888	72	0	1563	0	0	8214
Upper North Fork Umatilla	13E	11576	100	0	0	0	0	11576
Lower South Fork Umatilla	13F	3026	100	0	0	0	0	3026
Buck	13G	7050	100	0	0	0	0	7050
Thomas	13H	6688	100	0	0	0	0	6688
Spring	13I	5487	100	0	0	0	0	5487
Shimmiehorn	13J	6235	100	0	0	0	0	6235
Upper South Fork Umatilla	13K	9870	100	0	0	0	0	9870
Gibbon	13L	49	1	3226	0	0	0	3468
Total for Umatilla Watershed		72545	-	3226	3454	0	0	86582
Lower Meacham/Boston Canyon	89A	3387	63	2006	0	0	0	5393
Lower Meacham/Bonifer	89B	7148	62	2683	1672	0	0	11503
Camp Creek	89C	6675	99	0	40	0	0	6716
Middle Meacham	89D	6552	91	0	666	0	0	7218
Lower North Fork Meacham	89E	2088	62	0	1306	0	0	3394
Middle North Fork Meacham	89F	3120	99	0	19	0	0	3138
Upper North Form Meacham	89G	9287	100	0	0	0	0	9287
Pot Creek	89H	7951	100	0	0	0	0	7951
Bear Creek	89I	7805	96	0	326	0	0	8131
Upper Meacham/Wilbur	89J	1240	37	0	2098	0	0	3338
East Fork Meacham Creek	89K	4760	91	0	464	0	0	5224
Owsley Creek	89L	7179	99	0	75	0	0	7254
Upper Meacham/Short	89M	1699	66	0	877	0	0	2575
Butcher	89N	1900	37	0	3082	58	57	5098
Upper Meacham/Allen	89O	4920	51	0	4719	0	0	9638
Upper Meacham/Tod/Beaver/Sheep	89Q	170	1	579	13112	33	0	13893
Upper Meacham/Kamela	89R	0	0	0	4208	0	0	4208
Total for Meacham Watershed		75880	-					86582
Grand Total		148425						200542

1 Excluding Boise Cascade

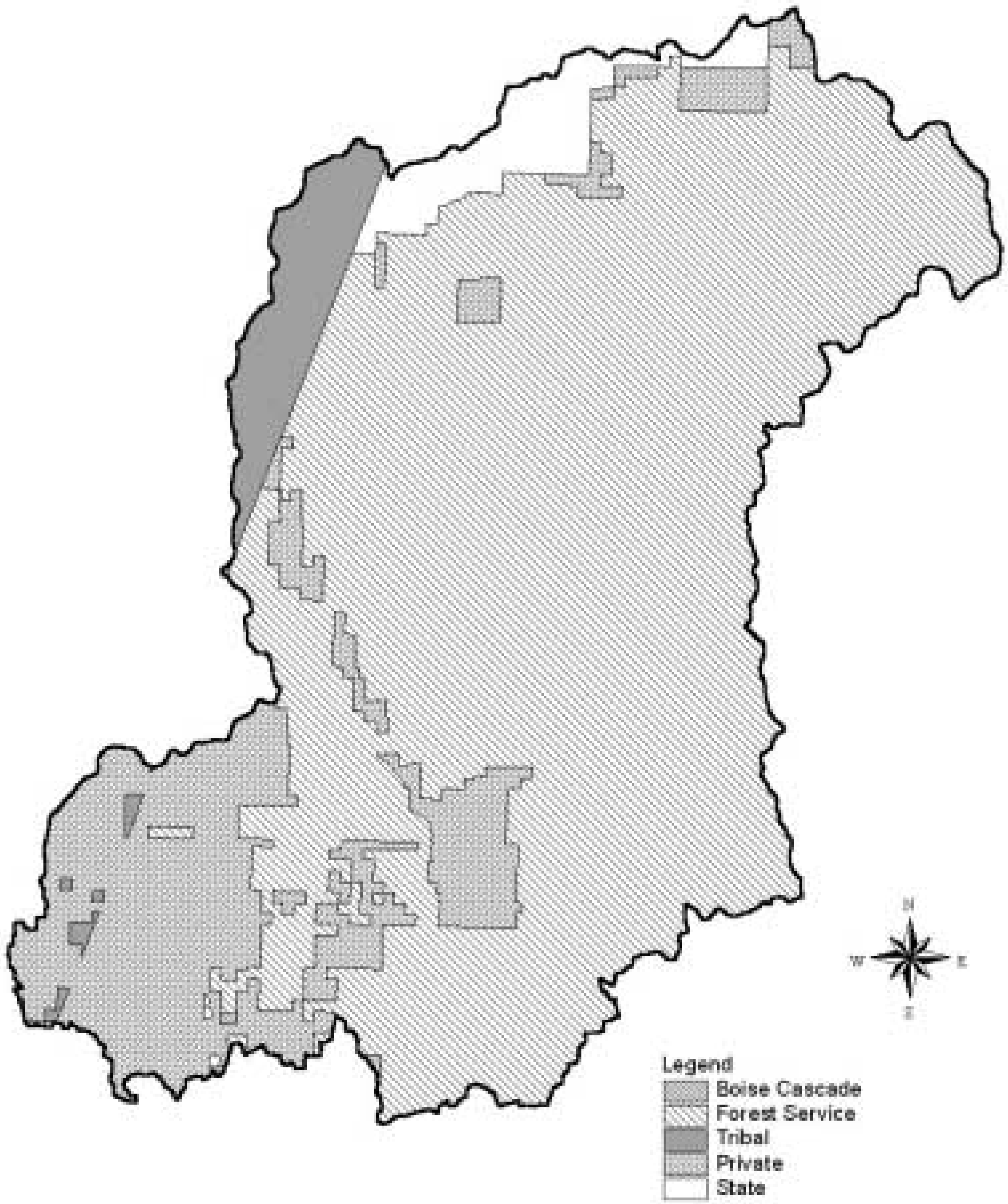

Figure 1-2. Map of the Umatilla-Meacham analysis area showing land ownership.

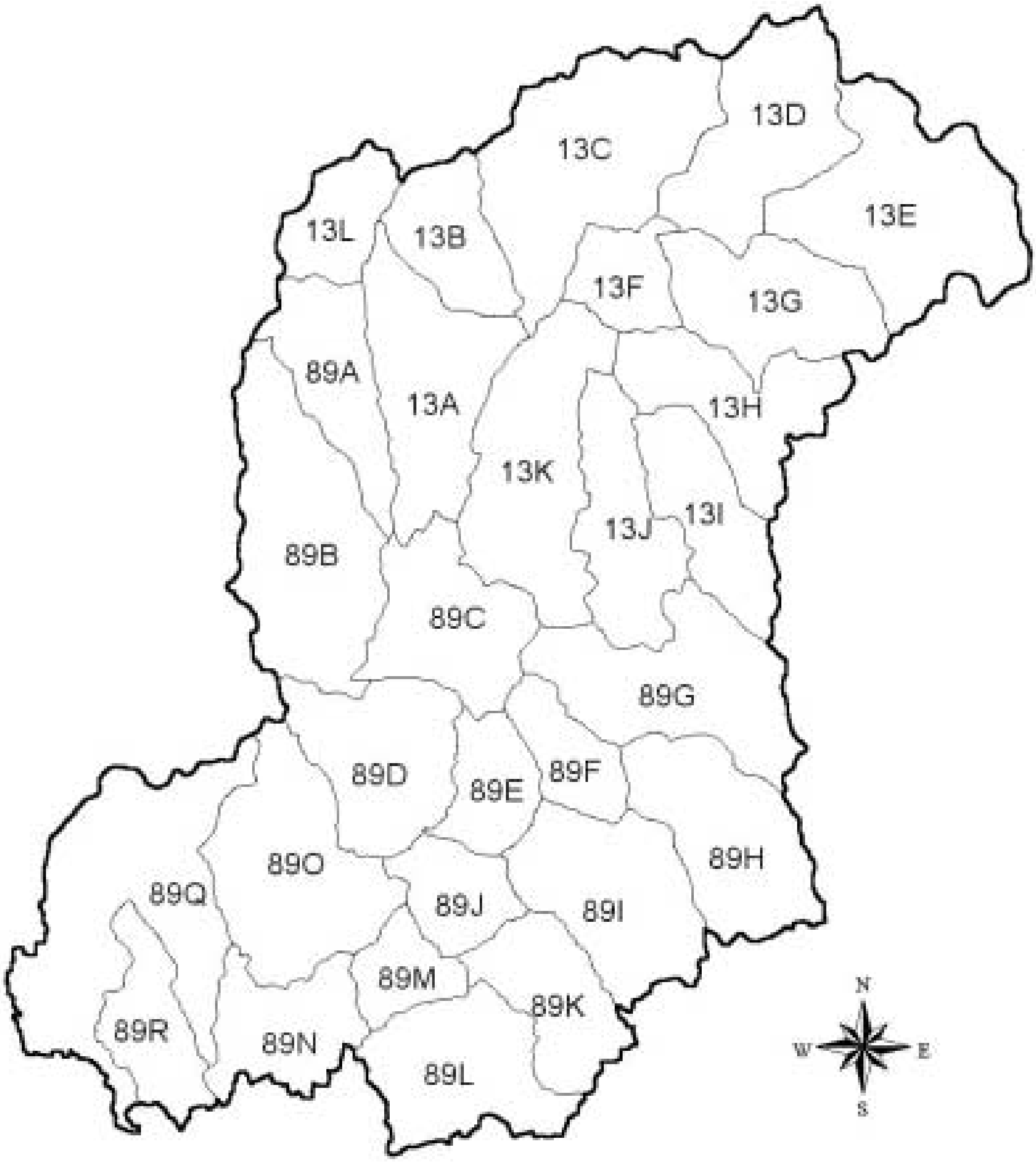

Figure 1-3. Map of the Umatilla-Meacham analysis area with subwatershed boundaries. Subwatershed prefix is 13 for Umatilla and 89 for Meacham

Climate and Hydrology

The climate of the northern Blue Mountains is dominated by maritime influences, and precipitation exceeds many other areas in the region. The analysis area is located at the southern end of the maritime-dominated climate zone where it begins a transition into the drier interior climate of the John Day basin. The climate in the upper Umatilla watershed exhibits strong seasonal variation in temperature and precipitation. Most precipitation is received between late fall and early spring, starting with rain and changing to snow as winter progresses. Average annual precipitation for Gibbon, located below the confluence of Meacham Creek and the Umatilla River (elev. 1,750 ft.), is 28.6 inches. High Ridge, located in the headwaters of the South Fork Umatilla River (elev. 4,980 ft.), receives 49.5 inches. Snow can accumulate throughout the watershed but is transient below 3,000 feet, and variable year to year between 3,000 and about 4,500 feet. The latter elevational band frequently receives rain on snow during the winter. Above 4,500 feet, snow persists through the winter months. Summers are typically warm and dry with occasional localized convective storms.

The two watersheds have significant differences in climate and associated hydrologic response. The Umatilla is a more moderate, slower-responding watershed due to its higher overall elevation and deeper soils. In contrast, the Meacham watershed, which is at a lower elevation and has steeper slopes and shallower soils, responds more rapidly to hydrological events. In addition, land uses that influence watershed response (e.g. streamside roads and railroad, harvest, grazing, and floodplain developments) differ between the watersheds as well.

Data from discharge gauges on the Umatilla River indicate that flow rates are stable over the long run. However, in recent years, damaging floods and water shortages have become a concern of downstream residents and water users in the watershed. Significant floods in the upper watershed occurred in 1947, 1965, 1975, 1986, and most recently, the winter of 1995. Years of significant drought include the 1930's, 1966, 1972, 1977, 1990, 1992, and 1994.

Peak flows in Blue Mountain watersheds result from two principal hydrologic processes, namely winter snowmelt during rainfall, and spring snowmelt. The former produces the largest events, and for the period of available records, over half of the annual peak flow events occurred in response to winter snowmelt during rain, or “rain-on-snow”. The majority of the annual discharge occurs between February and May. Specifically, 62.2 percent of the Umatilla and 72.2 percent of Meacham Creek discharge occur during this period. September is generally the lowest runoff month. Low flows generally occur in late summer, fall, and winter, when surface runoff and shallow subsurface reserves are depleted and flows are dependent on groundwater.

Water quality problems identified within the analysis area include: 1) elevated water temperatures in the main tributary streams; 2) local sedimentation in some headwater areas and main tributaries; and 3) decline in aquatic habitat diversity, particularly Meacham Creek. Targets for water quality and reduced pollution, or TMDLs, are being developed for the entire Umatilla subbasin. These targets focus on water temperature and sediment loads. A unique community-based watershed approach is being used in the development of TMDLs and management plans for the Umatilla subbasin (Clifton 1996).

Stream Network

The analysis area is drained by a network of over 1,300 miles of streams (Figure 1-4). Streams are classified as: 1) Class I - anadromous fish-supporting streams, 2) Class II - inland fish-supporting streams; 3) Class III - perennial streams without fish, and 4) Class IV - intermittent streams. The latter two classes make up for 90 percent of the total stream miles (Table 1-2). Compared to Forest averages, this analysis area has smaller proportion of fish-bearing stream (Class I and II), and about an average number of miles of intermittent stream (Table 1-2).

Table 1-2. Umatilla and Meacham watersheds stream miles.

StreamClass	Umatilla Watershed		Meacham Watershed		Combined	
	Miles	%	Miles	%	Miles	%
I	43	7	74	10	117	9
II	17	3	7	1	24	2
III	168	29	220	28	388	29
IV	356	61	472	61	828	61
Total	584	100	773	100	1357	100

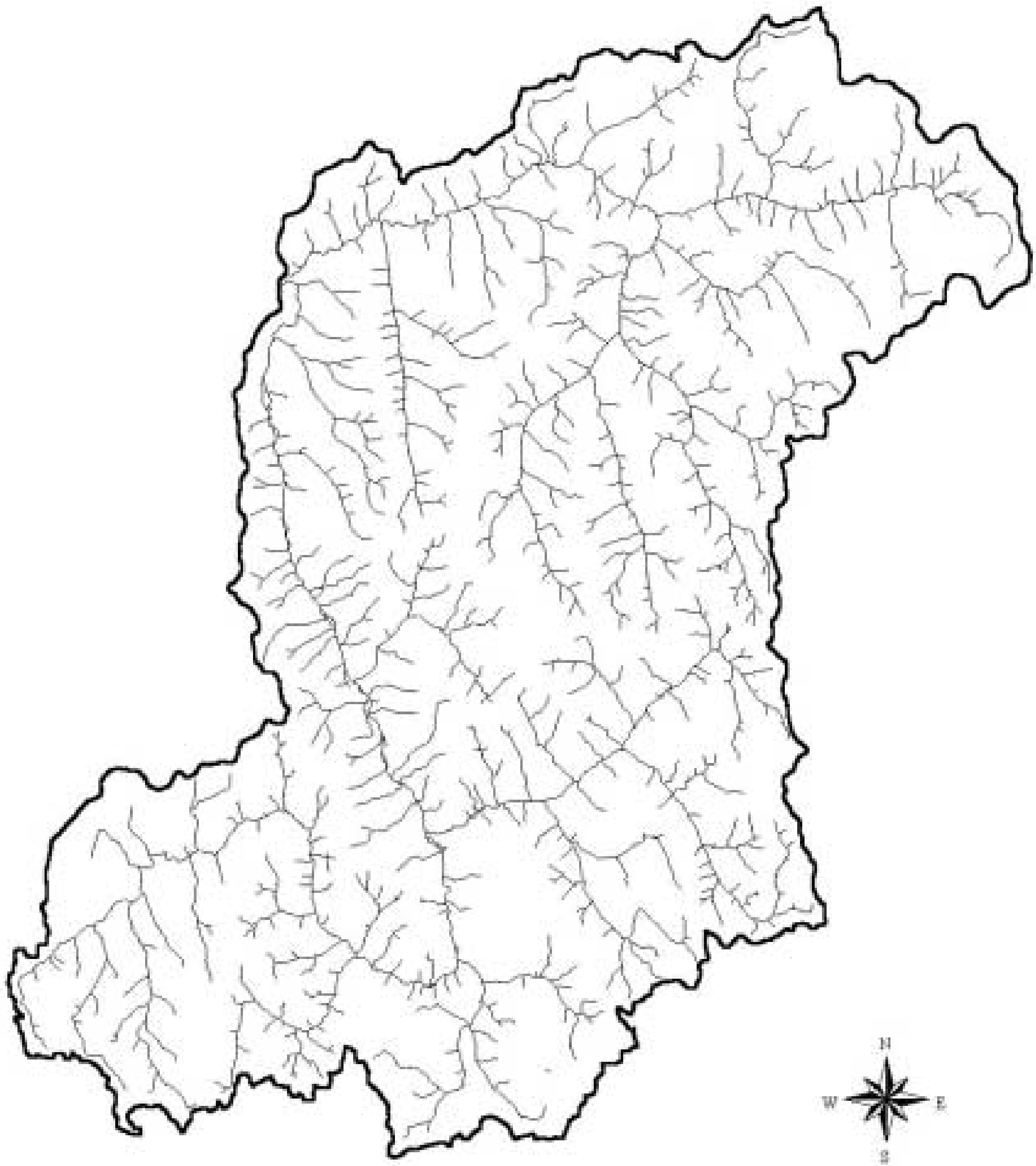

Figure 1-4. Map of streams in the Umatilla and Meacham watersheds.

Stream channel classification using the Rosgen (1994) system has been ongoing over the past several years as part of post-flood surveys and water quality monitoring activities (Table 1-3). This classification provides a framework to characterize streams and their behavior by measuring valley and channel morphology. Data from the surveys in the analysis area indicate that most streams are the B type, with moderately entrenched, narrow valleys, moderate width to depth ratios, and cobble-gravel substrate. B streams are considered relatively stable and have low sensitivity to disturbance. A smaller proportion of the streams are F type entrenched with narrow floodplains, moderate to high width-depth ratios, and gentle slopes. F streams are laterally unstable and have high bank erosion rates (Rosgen 1994). There are very small areas drained by C and E types. E type streams are low-gradient, meandering, with relatively broad valleys. Both C and E streams are considered less stable and more sensitive to disturbance.

Table 1-3. Rosgen stream types, Umatilla and Meacham watersheds.

Stream Name/Location	Drainage Area (mi^2)	Rosgen Stream Type
SF Umatilla, below Shimmiehorn	24	B4
SF Umatilla River, above Thomas	25	B4c
SF Umatilla , below Thomas	44	B3
SF Umatilla , middle reach	46	B4
SF Umatilla at old gage	48	B4c
SF Umatilla, near confluence	60	B4c
NF Umatilla, lower wilderness	30	F4
NF Umatilla at gage	31	B3c
Umatilla River at Corporation gage	91	F4
Umatilla River at USGS gage	131	F4
Meacham Creek nr Meacham	176	B4c
Meacham below N Meacham	77	C4c
Meacham at USGS gage	10	E6

Vegetation

The Umatilla River watershed supports many plant species reflecting a climate influenced by maritime conditions. The Umatilla watershed is one of the most floristically rich areas on the Forest. In contrast, the adjacent Meacham Creek watershed supports vegetation more typical of transitional conditions toward continental climates. Floristic richness is further enhanced by steep gradients in elevation, slope, and aspect. Although the topographic features, edaphic conditions and disturbance events can create abrupt ecotones, these same features can also produce broad transition zones between dominant vegetation types. The flattened ridge tops of the Umatilla River and Meacham Creek watersheds may support dense stands of timber or alternate patches of trees and interspersed grasslands. Shrubs are frequently found extending into the grasslands from the stands of trees, clearly demarcating the ecotone or transition zone. Most noticeable are the "stringers" of trees that occupy moist draws within grasslands, a vegetative pattern locally referred to as a "grass-tree mosaic". The ecotone between the grassland component and the tree component of this mosaic is dynamic and shifts with cycles of tree mortality, the loss of soil by wind and water erosion, and natural or human-induced alterations in the fire regime.

About 67 percent of the National Forest lands in the watersheds are forests and 33 percent are grasslands. The predominant cover type in the analysis area is classified as mixed conifer (about 94 percent of the forested area), followed by less than 5 percent each of grand fir (*Abies grandis*), ponderosa pine (*Pinus ponderosa*), and Douglas-fir (*Pseudotsuga menziesii*) cover types. Forests dominated by other species such as Engelmann spruce (*Picea englemenii*), lodgepole pine (*Pinus contorta*), subalpine fir (*Abies lasiocarpa*), or western larch (*Larix occidentalis*) are rare in the analysis area. The predominant grasslands are classified as dry meadows and bunchgrass grasslands, and are dominated by fescues (*Festuca spp*) and bluebunch wheatgrass (*Psuedorogneria spicata*). Shrublands are uncommon, although a diverse mix of shrubland types is present. Rocky areas with sparse (<15%) vegetative cover occur on more than 1,000 acres. These are classified as scablands.

The Umatilla River and Meacham Creek watersheds support many plant species of cultural significance to the Umatilla, Cayuse, Walla Walla, and Nez Perce tribes. Uses include but are not limited to food, medicine, clothing, fuel, and shelter. Of particular importance as a food source is big huckleberry (*Vaccinium membranaceum*), along with a number of species with edible roots and tubers.

Historically, fire has played a substantial role in shaping the landscape vegetation patterns and elements in the study area. Lightning is one of the primary weather elements influencing fire frequencies and regimes in both watersheds. It is thought that Native Americans and early settlers used fire extensively in the watersheds. Large fires occurred in the analysis area during the pre-settlement era. A range of fire regimes parallels the diversity of topography and vegetation within the analysis area. In the cooler, moist forest settings (42% of the area) and cold, dry (3% of the area) settings, fire tended to be low intensity and relatively small. Infrequent, moderate to high intensity fire characterize these settings, with stand replacement fires estimated to be on intervals of 50-200 years. In warmer, dryer forest settings (19%) of the analysis area, fire disturbances are typified by low to moderate intensity fires with an estimated 10-year return interval. Fire intensities may increase and stand replacement is possible under extreme weather conditions or high fuel levels. On grasslands (33% of the area), fires were generally light intensity and relatively small (less than 100 acres). High intensity fires generally coincided with periods of extreme droughts.

Like most areas in the Blue Mountains, fire suppression has strongly influenced the structure and composition of the forest vegetation within the watersheds. Most significantly, early seral species such as ponderosa pine, lodgepole pine and western larch have been replaced by late seral and climax species like Douglas-fir and grand fir. In addition, forest structure has changed from predominately low density, single story to high density, multi-story. Forests have also colonized grasslands, resulting in an overall decline in herbage production. There has been a substantial loss of hardwood tree species, particularly in riparian areas, resulting in a loss of forest tree diversity. The result of these vegetation changes has been an increase in fuel loads to the extent that forested areas are at significantly higher risk of experiencing stand replacing wildfires as compared to historical conditions.

Insects and diseases also have played a major role in shaping the current forest vegetation. Substantial, wide-ranging insect and disease outbreaks are common in the Blue Mountains and in the study area in recent years, due to changing forest species composition and other conditions.

Insects (and diseases) have probably been a significant factor in the reduction of older forest structure and stand densities in both watersheds. Risks remain relatively high for severe outbreaks of western spruce budworm, Douglas-fir tussock moth and Douglas-fir beetle.

Human activities have also influenced forest vegetation within the study area. Timber management has changed forest tree species composition, size, density and structure. These effects have been very significant for the old forest structure. In those areas where harvest occurred, large trees were typically replaced with planted or natural seedlings.

Aquatic Vertebrates

A variety of salmonid fishes inhabit the Umatilla River system within the study area. Three are of particular interest, namely, Chinook salmon, steelhead and bull trout. Other salmonid species include rainbow/redband trout, mountain whitefish, and possibly coho salmon. A wide variety of other fish species are found, including speckled dace, sculpins, suckers, redside shiners, northern pikeminnow, perhaps chislemouth chub, perhaps brown bullhead, and probably brook lampreys. The U.S. Fish and Wildlife Service, under authority of the endangered species act, has listed bull trout as Threatened and the National Marine Fisheries Service has listed the middle Columbia River ESU steelhead trout population as Threatened. The Blue Mountain Cryptochian *(Cryptochia neosa),* a caddis fly, is on the Region 6 sensitive species list.

The Oregon Department of Fish and Wildlife (ODFW) and the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) release hatchery raised steelhead and spring and fall chinook salmon into Meacham Creek and the Umatilla River within and below the analyses watersheds. ODFW and CTUIR are attempting to restore and rebuild fish runs (especially the chinook) that formerly spawned in the Umatilla River and its tributaries. Various fish runs were severely reduced by down-stream irrigation diversion dams and stream dewatering, which made the river impassable to salmon during the spring and fall chinook migration.

The Umatilla River is a primary recreational trout fishery and is heavily fished in the spring and summer. In years past, ODFW annually planted rainbow trout in the Umatilla River within the study area for recreational fishing. Due to concerns about competition of hatchery fish with native bull trout and possible genetic effects of the introduced rainbows on the native stocks, fish stocking has been discontinued.

Aquatic habitat conditions in the streams of the upper Umatilla River and Meacham Creek are highly variable, ranging from poor (e.g. Lower Meacham, Spring Creek) to very good (e.g. Pot Creek, North Fork Umatilla). Factors influencing habitat vary by stream, but in most cases high water temperature is a leading cause of poor habitat quality. Substantial investment in stream restoration, primarily pool development, has occurred in the lower stream reaches of the watershed. A primary influence on the aquatic condition in the Meacham Creek drainage is the Union Pacific Railroad, which lies within the Meacham Creek riparian area throughout most of the watershed. Many of the Umatilla riparian areas are strongly affected by roads, especially at lower elevations.

Terrestrial Vertebrates

The mosaic of forested and grassland landscapes present in the Umatilla and Meacham watersheds provides habitat for a wide diversity of terrestrial vertebrates, including 154 species of birds, 60 species of mammals, 7 reptile species, and 5 species of amphibians. Approximately

50 percent of the bird species known to nest within the analysis area are neotropical migrants. The area supports several species whose population levels are of concern at a provincial, state or national level including wolverine and lynx.

A high degree of habitat fragmentation is natural to this landscape, particularly in the grass-tree mosaic at mid- to low elevations. As a result, existing late/old forest habitat is fragmented as well, occurring primarily along narrow riparian corridors or on steep north facing slopes. More contiguous old forest stands occur in the mid and upper slopes of the roadless and wilderness areas in both watersheds. As in other forests of the Blue Mountains, acreage of older forests has declined due to the various disturbance mechanisms. Timber harvest is one of those processes but has played a relatively less important role when compared with other areas on the Forest and Blue Mountains province.

Because much of the analysis area is in roadless or wilderness status, many terrestrial species find refuge from habitat alteration and human disturbance in the deep and relatively inaccessible canyons of those areas. Wolverines have been seen, and lynx may occur in the headwaters areas. Foraging habitat for wolverine, potential habitat for lynx, and winter roost habitat for the bald eagle are found in the analysis area. All of the Forest's Management Indicator Species are either known to occupy the areas or have the potential to occur here.

The entire analysis area provides habitat for elk, with summer range at the higher elevations, and critical winter range at lower elevations. Big game habitat maintenance and enhancement are primary management goals for much of these areas. Difficulty of access provides security for elk and deer during hunting seasons, and during spring calving/fawning. Herd size, distribution, and winter movements of elk are primary concerns of managers in both watersheds. Road closure programs implemented over the last decade have further enhanced security and spring calving/fawning.

Human Activities and Uses

Historical Perspective

Describing the activities of prehistoric Native Americans within the watershed is difficult due to the lack of information. Of the approximately 115 cultural resource properties located within the Umatilla and Meacham watersheds, 49 are of Native American cultural affiliation. Examinations of these sites have revealed little, although activities would be expected to largely conform to the seasonal foraging routines characteristic of the Blue Mountains prehistory. In general, Native American adaptations in the Blue Mountain region were a mix of nomadism and sedentism. During the winter, base camps or villages were established along rivers and drainages, and groups subsisted primarily upon dried provisions and local game. From spring until fall, Indians ranged throughout their territory to exploit seasonally available resources and established temporary campsites near food or water sources and along trails (Hudson et al. 1978).

Various historical studies in the western United States have provided evidence for the use of fire by Native Americans. Fire was often the main tool for creating and maintaining desired vegetation, including the hundreds of plants and animals used by Native Americans for food, fiber, shelter, forage, and medicine. Use of fire in the Blue Mountains by Native Americans was likely similar to activities elsewhere in the West.

Since the settlement of Euro-Americans into the general area, activities and land uses tended to be similar to other areas in the northern Blue Mountains. The area has been influenced by a progression of often overlapping activities from early fur-bearing animal trapping followed by development and later improvements of trails and roads through the area used by settlers, construction and administration of the railroad through Meacham Canyon, extensive sheep and cattle grazing throughout the area, establishment of Forest Reserves, CCC construction and development of numerous administrative facilities, and timber harvest and additional road development. Many of the historic sites and legacies are a result of over 90 years of Forest Service management and the railroad development and administration.

Modern Day Land Uses and Activities

Both drainages are subjected to a variety of human activities. There are a number of permanent residences on private lands within the analysis area. Permanent residences in the Meacham watershed are concentrated in four areas, the town site of Meacham, Meacham Lake, Papoose Highlands located west of Meacham and in Meacham Canyon along the lower reach of Meacham Creek, including the town site of Duncan. Permanent residences in the Umatilla watershed are located along a 9-mile section of the Umatilla River from Meacham Creek to Bear Creek at the Bar M Dude Ranch. An estimated 90 people are permanent residents in the Meacham watershed, and about 85 people are permanent residents in the Umatilla watershed.

Grazing became a commercially important activity as settlers moved into northeastern Oregon. By the late 1800s, numerous large bands of sheep grazed in Umatilla County and specifically in the Umatilla and Meacham watersheds. The extensive heavy sheep grazing caused significant changes in soil condition and vegetative composition. Grazing slowly shifted from sheep to cattle, and cattle are now the predominant grazers on a total of 17 Forest Service allotments.

Trees have been harvested within the Umatilla and Meacham watersheds since the area around the Blue Mountains were settled by emigrants. Wood was cut for local construction, railroad activities, electrical power and fuel wood. Late in the 1950s and early 1960s, timber harvesting and associated management activities increased dramatically on the Umatilla National Forest and within the analysis area. Since this period, about 10 percent of the forested acres within the analysis area has been harvested. Relative to many other areas in the Blue Mountains, the area has experienced little logging activity.

Historically, elk and deer hunting has been the primary recreational activity in the Umatilla and Meacham watersheds. Typically, most of the 240 inventoried dispersed recreation sites are occupied during the fall hunting seasons. Elk hunting use has declined in recent years after regulations were changed to limit hunter numbers. The Umatilla and Meacham watersheds are used for a wide variety of other recreational activities. Trout fishing is popular in the spring, and summer activities include camping, auto touring, hiking, ATV riding, horseback riding, mountain biking, and swimming. Collecting morel mushrooms in the spring and huckleberries in late summer is also popular. Winter activities are largely centered in the Tollgate corridor and include alpine skiing, Nordic skiing, snowmobiling, snowplay, and winter camping. In 1995, the watersheds received an estimated total of 70,000 recreation visits that produced 65,000 visitor days of recreation use. Much of the dispersed recreation is concentrated around roads, trails and trailheads.

Umatilla Forks and Woodland are the only developed campgrounds in the watersheds. Other developed recreation sites include Buck Creek and Corporation Organization Camps, Spout Springs Ski Area, Recreation Residences in the Spout Springs area, and the Whitman Route Interpretive Site.

Umatilla National Forest Plan

About 75 percent of the National Forest acres are contained within three Forest Plan Management areas, namely C8, C4, and B1 (Table 1-4). Under the C8 strategy, maintaining wildlife habitat is the emphasis. Much of the area in the C8 strategy is winter range for deer and elk. Timber harvest is permitted on a non-scheduled basis if wildlife objectives are met. The roadless component of the management area is to remain roadless. Management area C4 also emphasizes big game and other wildlife habitat, but permits scheduled timber harvest. The B1 management area is wilderness and managed for wilderness values. A number of other management areas comprise about 5 percent or less of the area. These include management directions for scenic and recreation emphasis (A3, A4, A9), old growth protection (C1), riparian management (C5), a combination of timber harvest and wildlife (C4), and watershed evaluation (F3).

Table 1-4. Acres by Forest Plan management emphasis in the Umatilla and Meacham watersheds.

Management Area	Description	Total NF Acres	% of NF Acres
A3	Viewshed 1	1797	12
A4	Viewshed 2	5482	4
A5	Roaded Natural	156	<1
A6	Developed Recreation	552	<1
C1	Old Growth	4699	3
A9	Special Interest Area	338	<1
B1	Wilderness	20258	14
C4	Wildlife Habitat	41677	28
C5	Riparian	1671	1
C8	Grass Tree Mosaic	61470	41
E2	Timber and Big Game	8368	6
F3	High Ridge Evaluation Area	859	<1
Wallowa Whitman NF	---	1094.03	<1
Total		148425	

Wilderness (B1) and Roadless (C8) emphasis areas cover nearly 60 percent of the National Forest acres within the Umatilla and Meacham watersheds. Many activities like road building are thus prohibited over much of the analysis area. Although the Forest Plan permits timber harvesting in C8, these activities must be driven by wildlife objectives.

The North Fork Umatilla Wilderness covers about 20,300 acres and is located entirely within the Umatilla watershed. This wilderness is critical to maintaining flows of high quality water in the Umatilla River. This water is especially important to support native and introduced populations of anadromous fish and bull trout.

Hellhole and Horseshoe Ridge are two designated roadless areas (Umatilla Forest Plan, Appendix C) located within the analysis area and make up a substantial portion (47%, about 67,000 acres) of the National Forest acres in the two watersheds. Hellhole Roadless Area occupies a large portion of the central Umatilla drainage, and Horseshoe Ridge Roadless Area is located directly west of Hellhole along the east-facing slopes above Meacham Creek. The C8 management strategy for these roadless areas emphasizes wildlife habitat.

Table 1-5. Designated roadless area acres by management area in the Umatilla and Meacham analysis area.

Management Area	Horseshoe Ridge	Hellhole	Total
A4	---	2,245	2,245
A6	---	3	3
A9	---	281	281
C1	535	3,000	3,535
C4	127	11,070	11,197
C5	---	346	346
C8	5,330	44,243	49,573
Total NF Acres	5,992	61,188	67,180

The status of Owsley "Roadless Area" remains unclear. Recent re-mapping and land exchanges have apparently increased the acreage of Forest lands within the roadless area boundary increasing the size to an estimated 5,432 acres (the lower limit for consideration as future wilderness is 5,000 acres). Most of the acres are in Management Area C8.

The Forest Plan has been modified by two Regional amendments: PACFISH and Eastside Screens. PACFISH direction increases the size of riparian area buffers and limits management activities in the designated areas. The size of the buffer is dependent on the stream class. Some adjustments of riparian buffers are permitted based on watershed analysis. Eastside Screens are intended to preserve old forest habitat by prohibiting harvest of trees greater than 21 inches DBH. Both amendments are expected to be replaced with the implementation of the Interior Columbia Basin Ecosystem Management Project.

Tribal Rights and Interests

The Umatilla-Meacham analysis area lies immediately to the east and northeast of the Umatilla Indian Reservation. The entire analysis area is within the boundaries of lands ceded to the United States by the Confederated Tribes of the Umatilla Indian Reservation (CTUIR). On the ceded lands, tribal members retain the right to fish, hunt, trap, gather, and raise livestock. A number of sites are of cultural or spiritual significance to the Tribe. The Forest has a responsibility to honor treaty rights on these lands; honoring treaty rights includes protecting the natural resources on ceded lands so as to assure that treaty rights remain meaningful and consulting on Forest management actions.

ISSUES ADDRESSED IN THE ANALYSES

Development of issues for analysis was guided by input from the Walla Walla Ranger District and Forest staff. Additional input on issues was solicited from the Confederated Tribes of the Umatilla Indian Reservation, and the Oregon Department of Fish and Wildlife. The Federal Guide for Watershed Analysis stresses that watershed analysis is an informational undertaking, not a decision process (Federal Guide for Watershed Analysis 1995).

Watershed Analysis is an *issue-driven* process, with several core analysis topics specified in the Federal Guide (1995, Version 2.2, p. 12). Other watershed-specific problems or concerns were identified before the analysis by local managers and the watershed analysis team. In the case of the Umatilla and Meacham watersheds, the tremendous variability encompassed in the physical setting, large roadless areas, and the unique history of resource use were important considerations in the development and analysis of “issues”. An important factor in the analysis process was the considerable amount of overlap and interplay among issues that were generally considered singly, according to the “dominant” discipline involved. For example, the condition of riparian habitat, addressed by the Water, Fish and Aquatic Habitat analysis, has obvious importance for terrestrial plants and animals as well.

Issue I. Hydrology and Aquatic Habitat

The upper Umatilla watershed (including Meacham Creek) is the source area for downstream water supplies, offers important refuge habitat for native salmon, and provides a place of leisure and spiritual renewal for people. Water-dependent values within the watershed include plants, animals, recreational uses, and livestock. Water resource issues are not new but are of greater importance today. For example, increasing needs for municipalities, rural development, and agriculture may conflict with the needs of at-risk salmonid populations. Specific issues identified in scoping for this analysis are described below:

Degraded condition of in-stream habitats for anadromous (migratory) and resident fish

Low summer flows, high water temperatures, changes in channel structure, high sediment loads, insufficient pools, and shortages of in-stream large down wood are symptoms of reduced habitat quality. Such conditions are particularly evident in the mid and lower elevations of the analysis area. Water quality monitoring and stream inventories indicate that habitat conditions in some streams are so poor as to render them incapable of sustaining salmonid populations.

Past and present management (both public and private) of riparian and upslope lands continue to contribute to declines in both terrestrial riparian and aquatic habitat quality and quantity.

Riparian shrub cover and stream bank stability are thought to be below their ranges of natural variability in some parts of the analysis area, particularly in areas of historic and/or current logging, livestock grazing, road use and maintenance, and railroad operations. In the Umatilla-Meacham area, these same factors (with the exception of rail operations) have influenced the sustainability of upslope vegetative communities, which in turn can have important impacts on the downslope riparian community.

Current status of at-risk resident and anadromous fish

Four species of salmonid fish use this portion of the Umatilla River system; several other non-salmonid fish are part of the aquatic community. The bull trout, (a resident salmonid in this drainage, although migratory in other areas) was listed as an ESA threatened species on June 6, 1998. Mid-Columbia steelhead trout also found within the study area, were listed threatened under ESA in March 1999.

Actual or potential degradation of aquatic habitat caused by management activities.

Resource uses including harvesting and grazing in the riparian areas, livestock water developments, railroad-related activities, and municipal water withdrawal have contributed to resource degradation and reduced the resiliency of the riparian ecosystem.

Consumptive uses like sport fishing, tribal fishing and cultural uses.

These require the presence of relatively large numbers of fish. When fish numbers are low for other reasons, the consumptive use may risk depleting fish numbers to the extent that the population is further endangered by the use itself. Thus when fish populations become very low, need and desire for consumptive uses may conflict with regulations restricting take in order to protect the population for future use.

Actual or potential degradation of native fish stocks caused by introduction of hatchery raised fish, especially rainbow/steelhead and most particularly catchable sized rainbow trout.

Although the Forest Service manages access for fishing, it does not directly manage consumptive uses of fish nor introduction of hatchery fish into the Umatilla River system, so issues two and three above will not be addressed in this study. Other issues, outside the scope of this analysis but which may ultimately affect fish populations in the study area, include activities below the Forest boundary such as: agricultural and industrial water withdrawals, impediments to migration, and water quality degradation by agricultural or industrial activities.

Key Questions Water, Fish and Aquatic Habitat:

1) *What is the annual and seasonal runoff? Describe runoff variability and trends. Display low flow analysis, historic floods, flood frequency analysis. What were the effects of recent winter flooding?*
2) *What were the findings from the Umatilla Barometer watershed study?*
3) *What is the status of beneficial uses and water quality in the watershed?*
4) *What aspects of water quality are critical to aquatic-dependent beneficial uses (anadromous fish passage, spawning, rearing, and aquatic life)?*
5) *What additional water quality monitoring is needed, and how will data be used to guide/adjust management practices?*

6) *What effects have various land uses had on watershed conditions and water quantity and quality parameters?*

7) *What are the basic stream and riparian community types in the watershed, and how are they distributed?*

8) *What are the relationships between streamflow and riparian characteristics, recent flood effects, water quality status, and aquatic ecosystems?*

9) *What is the average annual flow and how does it vary over seasons?*

10) *What were the effects of recent winter flooding?*

11) *What were the results from the Umatilla Barometer watershed study and how will these results be used in management?*

12) *What is the status of beneficial uses and water quality in the watershed?*

13) *What aspects of water quality are critical to aquatic-dependent beneficial uses (anadromous fish passage, spawning, rearing, and aquatic life)?*

14) *What additional water quality monitoring is needed and how will data be used to guide/adjust management practices?*

15) *What effects have various land uses had on watershed conditions and water quantity and quality parameters?*

16) *What are the basic stream and riparian community types in the watershed, and how are they distributed?*

17) *What are the relationships between streamflow and riparian characteristics, recent flood effects, water quality status, and aquatic ecosystems?*

18) *How important are the fish populations in the Umatilla River and its tributaries to the fish metapopulation structure of the rest of the Umatilla River basin and the Columbia River basin?*

19) *What are the current conditions of the aquatic habitat in the Umatilla River and Meacham Creek watershed?*

20) *Which biophysical factors influence fish habitat in the Umatilla River and Meacham Creek and their tributaries?*

21) *Which streams or reaches in the Umatilla and Meacham watersheds are closest to meeting PACFISH and other Forest Plan direction and DFCs for stream conditions, aquatic habitat, and aquatic habitat diversity? How close are they?*

22) *What effects has timber harvest had on aquatic habitat? In which stream reaches and subwatersheds are these effects most evident?*

23) *Has grazing of riparian vegetation by livestock and/or wild ungulates in the Umatilla River Watersheds contributed to changes in water quality? If so, what have the changes been, where have they occurred and how severe are they?*

24) *Where and how has the current road network affected water quality and stream channel parameters important to fish and other aquatic organisms?*

25) *Where and how has the railroad affected water quality and stream channel parameters important to fish and other aquatic organisms?*

26) *How important are the effects of public fishing pressure on fish populations in the Meacham and Upper Umatilla watersheds? How does forest management affect public fishing pressure?*

27) *What is the risk of long-term negative effects to fish populations and other aquatic organisms as a result of large (>25% of a subwatershed), stand replacement type fires?*

28) *Do present fish population levels meet Forest Service objectives as stated in the Forest Plan?*

29) *Are quantities of resident and returning anadromous fish sufficient to fully seed the available spawning and rearing habitats?*

30) *Are Indian cultural needs for fish being met in the streams of the Meacham and Upper Umatilla watersheds?*

31) *Which of the streams or reaches in the Umatilla and Meacham watersheds would benefit most from special protection or restoration?*

32) *What attempts at in-stream fish habitat improvement have been made? How effective have they been? Are they adequate? Is there need for more?*

33) *Can fish, aquatic habitat, and water be better protected by adjustments to management protocols?*

34) *How important are the fish populations in the Umatilla River and its tributaries to the fish metapopulation structure of the rest of the Umatilla River basin and the Columbia River basin?*

35) *What are the current conditions of the aquatic habitat in the Umatilla River and Meacham Creek watersheds?*

36) *Which biophysical factors influence fish habitat in Umatilla River and Meacham Creek and their tributaries?*

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39) *What effects has timber harvest had on aquatic habitat? In which stream reaches and subwatersheds are these effects most evident?*

40) *Has grazing of riparian vegetation by livestock and/or wild ungulates in the Umatilla River watershed contributed to changes in water quality? If so, what have the changes been, where have they occurred and how severe are they?*

41) *Where and how has the current road network affected water quality and stream channel parameters important to fish and other aquatic organisms?*

42) *What is the risk of long-term negative effects to fish populations and other aquatic organisms as a result of large (>25% of a subwatershed), stand replacement type fires?*

43) *Which streams or reaches in the Umatilla and Meacham watersheds are closest to meeting PACFISH and Forest Plan DFC's for stream conditions, aquatic habitat, and aquatic habitat diversity? How close are they?*

44) *Which of the streams or reaches in the Umatilla and Meacham watersheds would benefit most from special protection or restoration?*

45) *Can fish, aquatic habitat, and water be better protected by adjustments to management protocols?*

46) *What attempts at in-stream fish habitat improvement have been made? How effective have they been? Are they adequate? Is there need for more?*

47) *Are quantities of resident and returning anadromous fish sufficient to fully seed the available spawning and rearing habitats?*

48) *How important are the effects of public fishing pressure on fish populations in the Meacham/Upper Umatilla watersheds? How does forest management affect public fishing pressure?*

49) *Where and how has the railroad affected water quality and stream channel parameters important to fish and other aquatic organisms?*

Issue II – Forest Vegetation Sustainability

Ecosystem components and processes are naturally dynamic over time and space. Thus the species composition and structural characteristics of plant communities will change from place to place and at varying rates, depending on site characteristics and the frequency and intensity of disturbance. Changes in vegetative communities tend to occur within a natural range of conditions, referred to in this document as the "Historic Range of Variability" (HRV). The combined effect of past timber harvest, suppression of the natural fire regime and heavy grazing prior to the 1930s has been to move some plant communities in the Umatilla and Meacham drainages beyond their historic extremes. The current situation gives rise to two primary issues

"Unhealthy" forest conditions

Changed forest and range conditions may contribute to reduced "sustainability" of current vegetative communities. There continues to be concern that some areas are at increased risk of large-scale disturbance/loss due to fire, insects, disease or other disturbances.

Forest and grassland communities outside their "natural" or historic range of variability

Is it possible to restore more ecologically appropriate vegetative composition to these lands? If so, how, and what are the associated costs?

Key Questions Related to Vegetation Sustainability:

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?*
6) *How do subwatersheds compare with respect to harvest and constructed road influences on sustainability of upland vegetation?*
7) *How do the Umatilla subwatersheds compare with respect to attributes that reflect inherent sensitivity to resource management?*
8) *What opportunities exist for restoring fire to its more appropriate ecological role?*
9) *What opportunity is there for the use of prescribed fire and or fire use for resource benefits*

Issue III - Terrestrial Biodiversity

Before humans began to significantly alter the landscape of the Blue Mountains, the rate and scale of environmental change allowed native plants and animals to gradually adapt to new conditions. Even when relatively large areas changed due to disturbances such as wildfires, there were enough other large "patches" of similar types; enough "redundancy" in the landscape, that the viability of species over the region as a whole was ensured. Over the past 100-150 years, however, both the pace and scale of change have accelerated in response to anthropomorphic. Many species, particularly "generalists" or highly mobile animals, have adapted to these changes. Other, with restrictive habitat requirements and/or limited mobility, has not been able to accommodate rapid changes in habitat structure and/or distribution. While some native species have declined in abundance or even disappeared from the local landscape, other non-native species, particularly exotic, invasive plants, have increased. These species often spread rapidly in new environments, displacing native plants. They are often extremely difficult and expensive to control once established. The ultimate result of all the above is a change in ecosystem structure, function and processes in the Blue Mountains. The following were identified as important considerations in the assessment of terrestrial biodiversity:

Maintenance of species/habitats of special concern

Several plant and animal species that occur within the analysis area are known to have declined in numbers or extent since the turn of the century. Examples include riparian hardwoods, old ponderosa pine forests, beaver, marten and wolverine. Future management practices will need to address these declines

Provision for variety of ecosystem composition, structure and function

Decades of fire suppression have increased the homogeneity of vegetative communities.

Maintenance of unique habitats and environments, thereby supporting animal species of limited distribution, and species that are threatened, endangered or sensitive.

Key Questions Related to Terrestrial Biodiversity

Species Habitats

1) *Have the types and proportions of habitats for terrestrial vertebrate species changed over the last century? If so, have these changes resulted in changes in terrestrial biodiversity?*
2) *Are there specific components of diversity in the Umatilla drainage that are "at risk"? In particular, severely reduced acreage of specific habitats, loss of habitat components; Threatened, Endangered or sensitive species; species having low "versatility"(i.e., species that are least able to successfully adapt to changing habitat conditions); and/or Neotropical Migrant Birds*

Species Habitats Late/Old Forests

1) *What species of animals are closely associated with old growth habitats in the Umatilla and Meacham drainages?*
2) *Where are old forest patches located? How large are they, and how much interior habitat do they provide? Do patch size and distribution provide for successful reproduction among dependent species?*
3) *Are there places where we might be able to speed the development of "future" old growth? Is this desirable?*

***Species Habitats Late/Old Forests Ungulate Populations and Habitat*:**

1) *What are current population levels and herd structures for wild ungulates in the Umatilla and Meacham drainages?*
2) *How does the current distribution and condition of habitat contrast with historic conditions?*
3) *Have management activities aimed at reducing elk use of adjacent private lands been successful?*

Issue IV – Vascular Plants

1) *What is the ratio of native to introduced species in the analysis area? Is this ratio an accurate indicator of historic variability in Floristic Biodiversity?*
2) *What are the culturally-significant (food) plant species of the analysis area? Are any of them "at risk" because of management activities? Are any of these species so limited in abundance and/or geographical amplitude that they may become major issues in the future?*
3) *What other plant species might be "at risk" in the analysis area and what are the ecological settings that support these potentially "at risk" species?*
4) *What are the occurrences of historically-listed or presently-listed sensitive plant species within the Umatilla and Meacham analysis area?*
5) *How might management activities occurring in the analysis area adversely impact plant species with an historic track of sensitivity?*

6) *What are the ecological distributions and habitat affinities of these species within the seven “ecological settings” selected for this analysis?*
7) *What are the floristic similarities between the plant species of one ecological setting and the other ecological settings?*
8) *What vascular plant species presently occur in the analysis area?*
9) *What is the floristic richness of the analysis area in comparison with the rest of the Walla Walla Ranger District, and with the Umatilla National Forest?*
10) *What are the ecological distributions and habitat affinities of these species within the seven "ecological settings" selected for this analysis?*
11) *What are the floristic similarities between the plants of one ecological setting and the other ecological settings?*
12) *What are the occurrences of historically-listed or presently-listed sensitive plant species within the analysis area?*
13) *How might management activities occurring in the analysis area adversely impact plant species with an historic record of sensitivity?*
14) *What noxious weeds occur in the analysis area and what are their affinities for ecological settings?*

CURRENT AND REFERENCE CONDITIONS FOR HYDROLOGY

Overview

The Umatilla River is a direct tributary of the Columbia River. It drains about 2,300 square miles of eastern Oregon. The part of the Umatilla River drainage analyzed for this report covers 200,671 acres, of which 114,060 acres are in the Meacham Creek drainage and 86,611 acres in the upper main stem of the Umatilla River, above the mouth of Meacham Creek (see Figures 1-1, 1-2). The analysis watersheds account for approximately 14 percent of the Umatilla River drainage area and supply 40-50 percent of the average flow of the river, before withdrawals.

The upper Umatilla and Meacham watersheds are valued for a variety of in-stream uses, and are relied on to produce water supplies for out-of stream municipal, industrial, and agricultural uses. Competing demands place a heavy toll on the watershed resources to the extent that many of the streams in the study area are not meeting state standards for water quality, and the subbasin as a whole is on a State schedule for establishing Total Maximum Daily Loads (TMDLs). Flooding in recent years caused numerous slumps, debris torrents, and channel adjustments in the lower portion of the analysis area. As a result, streams are adjusting to flood effects, and there have been increases in large wood and sediment via aggrading (filling) in some reaches and incising (cutting) in others.

Water resource issues at the subbasin scale are complex. They exist because water use for municipal supplies and irrigation compete with the needs of aquatic organisms. In addition, management effects on stream hydrology and aquatic habitats magnifies the effects of water removal (Oregon Water Resources Board 1988). Ongoing efforts by the local, citizen-based watershed council are evidence of the growing public interest in water resource issues and watershed management. Efforts to enhance and reestablish salmon runs in the Umatilla River are ongoing and include flow enhancement in the lower river (BOR-Umatilla Basin Project) and acclimatization facilities in the upper river (CTUIR and ODFW).

Analysis of River Flows

Two gages operated by the U.S. Geological Survey, Umatilla River above Meacham (#14020000), and Meacham Creek at Gibbon (#14020300) provide long-term records of stream discharge for the two major tributaries in the analysis area (Figures 2-1, 2-2). These data show that over the long term, average discharge for the Umatilla has not changed. However, periods of generally drier conditions are apparent in the 1930s, 1960s, and late 1980s. The record for the Meacham gage is too short to examine long-term trends, but the pattern of wetter and drier years follows that of the Umatilla gage for the same years. In addition, National Forest gauged streams include the Umatilla River at Corporation, North Fork Umatilla, South Fork Umatilla, and four small (60 - 292 ac) study watersheds in the High Ridge Evaluation area.

The long-term average annual discharge is 227 cubic feet per second (cfs) for the Umatilla; and 205 cfs for Meacham Creek. The monthly distribution of average annual runoff for the two main tributaries shows April as the month in which the largest percent of runoff occurs. Combining the four highest months (Feb-May) shows the majority (62.2 percent for the Umatilla, and 72.2 percent for Meacham Creek) of the mean annual discharge occurring during this period. September is generally the lowest runoff month.

Streamflow characteristics such as flow variability are a major factor influencing aquatic and riparian habitat. For example, sections of Meacham go dry in late summer, limiting migration and dispersal of aquatic organisms. Low flows occur in late summer, fall, and winter, when surface runoff and shallow subsurface reserves are depleted, and the river is dependent on groundwater sources. Low flows vary from stream to stream depending on the character of bedrock units and aquifer systems, and on land uses. Damaging floods and water shortages are ongoing concerns of downstream residents in the watershed. The largest floods in the upper watershed occurred in 1947, 1965, 1975, 1986, 1996 and 1997. Years of drought include the decade of the 1930s, 1966, 1972, 1977, 1990, 1992, and 1994.

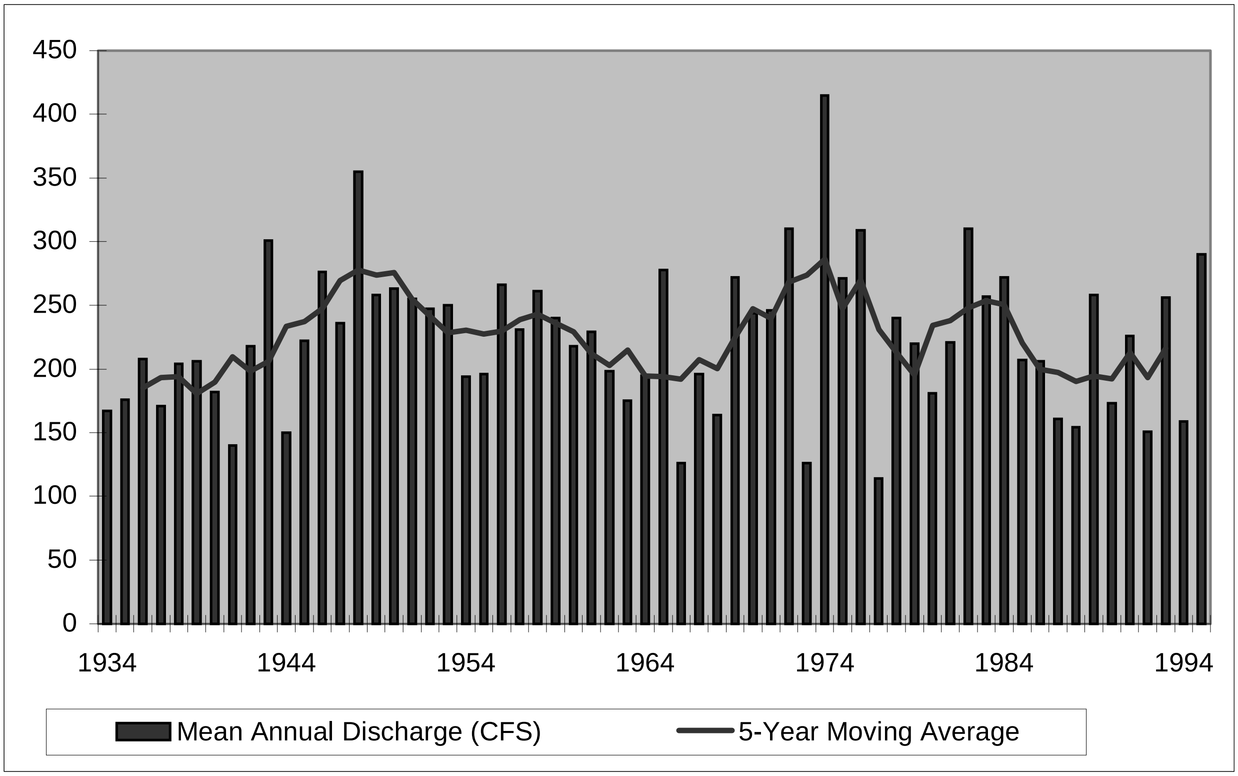


Figure 2-1. Mean annual discharge for the Umatilla River above Meacham (USGS Station 14020000). Smooth line is the 5-year moving average.

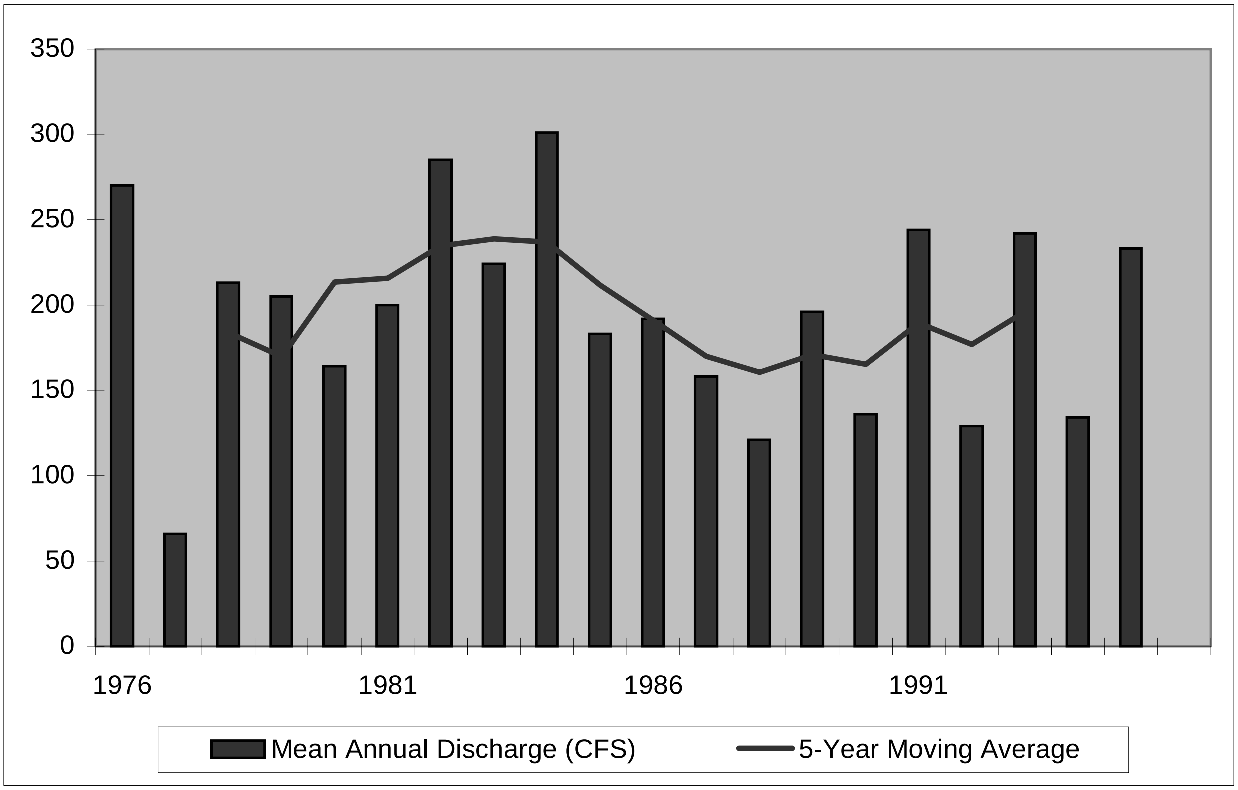


Figure 2-2. Annual Discharge for Meacham Creek above Gibbon (USGS Stations 14020300).

Effects of Recent Floods

In general, peak flows in Blue Mountains watersheds result from two principle hydrologic processes; winter snowmelt during rainfall, which produces the largest events, and spring snowmelt, which is an important annual occurrence. For the Umatilla River and Meacham Creek, over half of the annual maximum peak flow events occurred in response to winter snowmelt during rain, or “rain-on-snow”. Record peak flows in the analysis watersheds occurred in the winter of 1996 and resulted in major channel changes in the lower reaches of the South Fork Umatilla, main Umatilla, and Meacham Creek. Two separate runoff events occurred, one in November and a second in February. The November event followed a period of above-average fall rainfall capped by 2 inches rain and snow on the upper watershed in a 24-hour period. A more widespread high magnitude rain-on-snow event occurred the week of February 5, 1996. Flood effects consisted of upland shallow landslides, channel and floodplain erosion, and damage to facilities (roads, campgrounds, trails). More severe impacts occurred off-forest to small towns and farms in low-lying areas (Clifton 1996).

Results from the Barometer Watershed Study

The Umatilla Barometer watershed study was initiated in 1966 within the High Ridge Evaluation Area to study the effects of timber harvest on the climate and hydrology of four small catchments in the headwaters of Buck Creek, a tributary to the South Fork of the Umatilla. This study compared the effects of different silvicultural treatments on water yield, peak flow, timing of runoff, and other parameters (e.g. soil moisture and channel stability). Two episodes of timber harvest (1976 and 1984) using different harvest prescriptions were compared in three watersheds against a control (no treatment) watershed (Table 2-1). A report summarizing 30 years of climate, stream flow and two timber harvests was recently completed for the evaluation area (Helvey and Fowler 1997). These authors reported a number of interesting findings, including:

1) Small increases in peak stream flow after the second harvest was found on two of three treated watersheds. Sediment yields also increased following harvest in two treated watersheds, however, the level of response varied with the greatest response attributed to direct soil disturbance from skidding operations rather than from channel erosion caused by peak flow increases.
2) Water use by re-establishing vegetation may be greater than expected, accelerating "hydrologic recovery". This effect may have been compounded by out-of-basin snowdrift and possible groundwater interactions.
3) Some harvest practices used at the time of the study, such as large clearcuts and streamside harvest/skidding, are no longer in use making the results difficult to interpret in the context of current forest management practices.

Relationships between the calibration and treated watershed were not as strong as expected, due in part to the administrative nature of the study (less sampling) and to the climatic conditions of the calibration period (drier than long term average).

Table 2-1. High Ridge evaluation watershed acres and acres harvested in 1976 and 1984.

Watershed	Acres	Acres Logged		% Stand Removed			Harvest Method
		1976	1984	1976	1984	Total	
1	73	31	42	43	57	100	Clearcut
2	60	60	60	50	50	98	Shelterwood
3	132	0	0	0	0	0	Control
4	292	64	49	22	38	60	Patch-cut

Analysis of stream flow data showed no significant changes in annual water yield from the treated watershed after the 1976 harvest or from watershed 1 and 4 after the 1984 harvest. Yield from watershed 2 was significantly increased during 2 years after the second cutting. Peak flows increased on watershed 1 and 2, and peaks from watershed 4 occurred earlier, indicating earlier and elevated snowmelt runoff. The overall hydrologic response was modest despite extensive cutting which the authors attributed to one or more of the following factors: 1) relatively large error terms in the analysis; 2) water use by young, fast-growing vegetation; 3) below-average precipitation in the post-treatment period; 4) snow drift; and 5) groundwater seepage. Although the High Ridge study was terminated in 1996, three baseline monitoring sites on the main tributary streams (North Fork, South Fork, and Umatilla River) have been kept in operation and continue to provide data for monitoring efforts.

Compliance with State Water Quality Standards

Water quality standards and criteria have been established for the protection of beneficial uses, and describe thresholds or limits for various chemical, biological, and physical parameters. Beneficial uses of the Umatilla and Meacham watersheds, as defined by the State of Oregon, include domestic and industrial water supply, irrigation, livestock watering, anadromous fish passage, salmonid fish rearing and spawning, resident fish and aquatic life, wildlife, fishing, recreation, and aesthetic quality. Of all the uses (with the exception of drinking water which is treated), salmonid rearing and spawning and resident fish and aquatic life have the most stringent physical and biological requirements. Criteria are established for dissolved oxygen, habitat modification, pH, sedimentation, temperature, toxics, and turbidity.

Section 303(d) of the federal Clean Water Act requires states to identify streams not meeting water quality standards, even after the "best available technology" is applied. The State of Oregon 303(d) list, updated in 1998 (ODEQ), identified Meacham Creek, North Meacham, South Fork Umatilla, North fork Umatilla and the main Umatilla River as not meeting water quality standards (Table 2-2**)**.

Table 2-2. Streams not meeting state water quality standards in the upper Umatilla and Meacham watersheds.

Waterbody name	Segment boundaries	Parameter of Concern
UMATILLA		
Umatilla River	Wildhorse to Forks	temperature, pH, habitat modification, sedimentation, aquatic weeds
North Fork Umatilla	Mouth to Headwaters	temperature (Bull trout)
South Fork Umatilla	Mouth to Headwaters	temperature (Bull trout)
MEACHAM		
Boston Canyon	Mouth to Headwaters	habitat modification, sedimentation
Line Creek	Mouth to Headwaters	habitat modification, sedimentation
Meacham	Mouth to East Meacham	temperature, habitat modification
Meacham	East Meacham to Headwaters	temperature, habitat modification, sedimentation
North Meacham	Mouth to Headwaters	temperature, habitat modification
East Meacham	Mouth to Headwaters	temperature

TMDLs are currently being developed for temperature and sediment and will be released in draft by Spring 2001. The TMDL will include targets, load allocations, and management plans. The Umatilla TMDL process is a unique collaborative, community-based effort, with involvement from tribes (CTUIR), the local Watershed Council, Forest Service, other federal and state agencies and organizations, and Oregon DEQ.

On the National Forest lands, the principle water quality concern is the elevated summer water temperatures in the main tributary streams. Other problems include local sedimentation in headwater and main tributaries, and an overall decline in aquatic habitat quality and diversity (Clifton 1996, Crabtree 1996). Water quality problems are directly related to climate and stream flow characteristics, with peak water temperatures occurring during periods of low flow and high ambient temperatures. Streamside harvest, railroad, roads and crossings, livestock grazing, and recreation developments also contribute to elevated temperatures and to localized sedimentation. The Union Pacific Railroad corridor alongside Meacham Creek has a significant adverse impact on the streamside zone, reducing shade and reducing the channel complexity. There is also the potential risk of a chemical spill. Stream temperatures are also influenced by groundwater interactions. Two hot springs (Bingham and South Fork Umatilla at Buck Creek) may also contribute to localized, elevated temperatures in the Umatilla River.

Maximum summer water temperatures for 1992-1998 (Table 2-3) show that stream temperatures reach a maximum in late July when flows are lowest and air temperatures are at or near the seasonal maximum. The North Fork Umatilla generally has cooler water, with summer maximum in the high 50^{o}F range, compared to the South Fork of the Umatilla River with values in the high 60^{o}F range. Water in Meacham Creek is comparatively warmer, with values in the high 70^{o}F range. Factors contributing to variability among the streams include climate conditions, watershed characteristics, and streamside management. The South Fork Umatilla and Meacham Creek have valley-bottom roads and/or railroad tracks, which reduce streamside shade. Channel straightening, diking and removal of in-stream wood further exacerbate heating by removing protective cover and reducing base flows. These streams are especially vulnerable because of inherent watershed characteristics, as described by Crabtree (1996).

Table 2-3. Annual 7-day moving average of the daily maximum stream temperature (F).

Station Name	Elevation	Year							State Standard
		1992	1993	1994	1995	1996	1997	1998	
N Meacham Creek	2800	68	66	72	68	67	67	70	50
Umatilla River @ Corporation	2300	65	63	63	64	63	64		55
NF Umatilla @ gage	2400	60	58	60	57	59	60		50
SF Umatilla @ gage	2400	69	68	70	66	67	64	69	55
SF Umatilla above Shimmiehorn	2680	65	61	67	67		64		50
Shimmiehorn Creek	2680	63	60	63	61	63	64	65	50

Effect of Land Uses on Water Resources

As a first step to assess the effects of land uses on watershed conditions, each subwatershed in the analysis area was evaluated in terms of its hydrologic response to disturbance. Hydrologic response was determined from the combination of steep slopes, shallow soils, warm/hot aspects, and climate zone (Clifton 1996). Subwatersheds with high proportions of steep slopes, shallow soils, and warm/hot aspects in low to mid elevation zones are most hydrologically responsive. These include Umatilla subwatersheds 13B, 13C, 13F, and 13L; and Meacham subwatersheds 89B, 89D, 89E, 89F, 89J, and 89M. Subwatersheds with low proportions of steep slope, shallow soils, warm/hot aspects, in mid to high elevation zones are least hydrologically responsive. These include Umatilla subwatersheds 13E and 13G; and Meacham subwatersheds 89K, 89L, 89N, and 89R.

Levels of human disturbance were quantified using two measures, namely equivalent clearcut acres (ECA) and road densities. ECA is a commonly accepted method of identifying potential increases in peak flows resulting from the cumulative effects of harvest (Reid 1994). The percent of forested area in an equivalent clearcut condition provides an index of harvest extent and likelihood of increased peak flows. Age of harvest, cutting methods, and regrowth are accounted for in the procedure (Ager and Clifton 1995). Recently, the National Marine Fisheries Service Biological Opinion on the Umatilla Forest Land and Resource Management Plan (NMFS 1995) specified an ECA of 15 percent in the Snake River basin as a "level of concern". Road densities provide another measure of watershed conditions and cumulative effects. Roads alter surface hydrology through several mechanisms; intercepting subsurface runoff, concentrating surface runoff, and extending channel networks which increases watershed “efficiency.” Roads also accelerate erosion and sedimentation into streams (Megahan 1983). A road density “threshold”, or level of concern, was also identified in the NMFS BO at 2.0/mi^2. Road density alone does not indicate slope position, another critical factor. Valley bottom roads have the most direct effect on streams and riparian areas. Mid slope roads intercept subsurface runoff, extend channel networks, and accelerate erosion. Ridgetop roads can influence watershed hydrology by channeling flow into small headwater swales, accelerating channel development.

The analysis of ECA and road density revealed that all subwatersheds have relatively low levels of ECA (>15%), however, road densities are relatively high (>2.0 mi/mi^2) in subwatersheds 13E, 13H, 13I, 13J, 13K, 89K, and 89L (Table 2-4). When the watershed response analysis was combined with indicators of cumulative effects (ECA and road density), the analysis shows logging-related disturbance has occurred in the less responsive, higher elevations where hydrologic effects are moderated by climate.

Overall, ECAs are at relatively low levels, below 10 percent, indicating harvesting alone is not likely to be measurably changing water yields or peak flows. Effects from associated activities including skidding, landing areas, and road systems are still present in the landscape and are more likely a greater influence on runoff, erosion, and sedimentation. Hydrologic effects are complicated by interactions between factors that influence water flows. For example, opening size has variable effects on snow retention and release in the higher elevations. Small openings less than one tree height in diameter generally accumulate more snow and retain the snowpack later into spring, tending to delay runoff. In contrast, larger openings, which also accumulate more snow through drift, melt more rapidly due to higher exposure and thus tend to advance runoff. Furthermore, timber harvest and roads are the only activities that have been quantified. Effects from livestock grazing and recreation have not been quantified and incorporated into the analysis. Historic and current grazing uses include sheep, cattle, and horses, with sheep generally in the uplands, and cattle and horses in the valley-bottoms. Numbers of livestock peaked in the early 1900’s and have generally declined. Other land uses include recreational camping, fishing, hunting, and private developments (including private residences and a “dude” ranch). Impacts from activities are often concentrated in the lower reaches of the assessment area, along the Umatilla River. Other effects include the Union Pacific Railroad, which parallels Meacham Creek for much of its length. Valley-bottom roads, the railroad, and private land uses are the major hydrologic impacts in lower subwatersheds.

Subwatersheds with valley-bottom roads, railroad, and/or concentrated residential and recreational uses include 13B, 13C, 13F, 13H, 13L, 89A, 89B, 89D, 89J, 89M, 89O, and 89R.

Table 2-4. Subwatershed Equivalent Clearcut Acres and Road Density for Umatilla and Meacham Subwatersheds

Subwatershed	Total Acres	Area (Mi^2)	ECA	Forested NF Acres	% ECA Forested NF Land	Road Miles	Road Density Mi/Mi^2
13A	8,357	13.0	57.8	3,194	1.5	21.8	1.7
13B	4,361	6.8	0.0	1,040	0.0	5.3	0.8
13C	12,251	19.1	102.3	3,683	2.8	11.4	0.6
13D	8,214	12.9	58.6	3,746	1.6	15.5	1.2
13E	11,576	18.1	541.7	8,518	6.4	37.6	2.1
13F	3,026	4.7	0.0	0	0.0	3.5	0.7

Subwatershed	Total Acres	Area (Mi^2)	ECA	Forested NF Acres	% ECA Forested NF Land	Road Miles	Road Density Mi/Mi^2
13G	7,050	11.0	231	4,888	4.7	22.6	2.0
13H	6,688	10.5	179.5	4,494	4.0	36.4	3.5
13I	5,487	8.6	42.6	4,500	0.9	31.0	3.6
13J	6,235	9.7	40.4	4,764	0.8	25.8	2.6
13K	9,870	15.4	211.7	6,734	3.1	34.1	2.2
13L	3,468	5.4	0.0	0	0.0	2.8	0.5
89A	5,393	8.4	0.0	1,313	0.0	9.6	1.1
89B	11,503	18.0	146.3	2,577	5.7	16.3	0.9
89C	6,716	10.5	159.7	3,165	5.0	15.9	1.5
89D	7,218	11.3	0.0	2,768	0.0	11.3	1.0
89E	3,394	5.3	0.0	627	0.0	3.2	0.6
89F	3,138	4.9	0.0	1,598	0.0	1.4	0.3
89G	9,287	14.5	35.4	5,634	0.6	15.3	1.1
89H	7,951	12.5	45.5	4,862	0.9	9.7	0.8
89I	8,131	12.7	152.0	4,871	3.1	23.1	1.8
89J	3,338	5.2	42.7	465	9.2	6.4	1.2
89K	5,224	8.2	94.6	2,900	3.3	20.5	2.5
89L	7,254	11.4	440.2	4,730	9.3	30.3	2.7
89M	2,575	4.0	6.1	681	0.9	5.4	1.3
89N	5,098	8.0	27.8	1,340	2.1	14.4	1.8
89O	9,638	15.0	0.0	2,626	0.0	19.7	1.3
89Q	13,893	21.7	0.0	93	0.0	22.5	1.0
89R	4,208	6.6	0.0	0	0	6.3	1.0

Riparian and Channel Conditions

Riparian and wetland vegetation communities also vary considerably with elevation, slope, aspect, soil characteristics, and hydrologic conditions. There have not been systematic surveys of riparian vegetation. However, from reconnaissance and botany TES surveys, patterns of streamside vegetation can be inferred: Headwater streams are typically forested and large wood is an important physical in-stream element. Mid-elevation streams also occur in forested environments, but hardwoods like alder and willow are important for shade, bank stability, and organic inputs. Main valley streams were once mixed conifer-hardwood galleries with species such as black cottonwood prevalent. Large wood is readily transported during high flow events and is deposited as accumulations on bars or jams in mid-channel. The main valley streams (lower Umatilla, Meacham, and lower North and South Forks of the Umatilla) have been heavily impacted by roads, railroad, channel alterations (dikes), logging, and recreation.

Climate and hydrology are the dominant control on flow characteristics and, together with topography and vegetation, control channel patterns, valley forms, and quality of aquatic habitat. The higher elevation and deeper soils characteristics of the North Fork Umatilla moderate low flow volumes, and the east-west orientation of the stream provides topographic shading of the stream, producing an abundant area that produces cold water. In contrast, the South Fork Umatilla and Meacham drainages with lower elevations, shallower soils, and south to north orientation providing more solar exposure, produce lower, warmer late season flows. These conditions influence vulnerability to climatic extremes and human influences.

Channel conditions vary across the Umatilla and Meacham watersheds. Generally shade is lacking wherever streamside land uses are present, and channels may be wide and shallow or actively down-cutting if constricted by a road or dike. Deep pools and large wood are lacking, and there may be excessive fine sediment. Effects vary by stream type, activity, and other controls (microclimate and topographic effects). Headwater streams impacted by streamside roads and harvest may have disrupted channel courses and lack of large wood to trap and store sediment. Most of the main valley-bottom streams have adjacent roads, dikes, campgrounds, and trails, and, as a result, have lower sinuosity, and are lacking in shade, large wood, and adequate pools. In contrast, many of the mid-valley streams are in roadless or wilderness areas and have had little direct impact. These streams are cooler, have a higher frequency of large in-channel wood, and pool frequencies are higher.

Direct effects of recent flooding within the analysis area include shallow slides on valley sides, streams undercutting slopes causing slides, debris torrents in smaller tributaries, widening of main streams, and deposition of slumped material and uprooted vegetation in river bars. Other effects include damage to road systems, houses, and other infrastructure. From a watershed perspective, floods have both positive and negative impacts. Positive effects include the rapid importation of large wood into streams, which is one of the key missing habitat attributes in many Blue Mountain streams; and redistribution of channel bed materials, along with logs. The result is the creation and destruction of aquatic habitat. Over-bank flows add sediment to flood-plains, important for replenishing soils, adding nutrients, and improving moisture-holding capacity, all benefits for streamside habitats. Mobilization of channel bed materials releases nutrients, bacteria, and toxins stored in floodplain sediments, which can also be both positive and negative.

Watershed response to recent flood effects should be carefully monitored and compared with the 1965 and 1975 events. One of the key differences in recent events has been the human response to flooding. Active channel control has not occurred on the Forest as it did 20 and 30 years ago. Stream response to flooding will be monitored by establishment of permanently benchmarked reaches. Channel surveys include cross-section profiles, longitudinal profiles, measurement of bed particles, and mapping of reach characteristics. As of July 1996, eight survey reaches had been established on the North and South Forks of the Umatilla River, and below the confluence at the Forest boundary. Water quality monitoring at 12 locations in the Umatilla and Meacham watersheds within the National Forest streams is ongoing.

Water temperature monitoring will determine whether water temperatures increase where streamside and channel bar vegetation was washed downstream. In many reaches, channels appear wider and shallower, which will further exacerbate surface heating. Surface flows may also be reduced by the aggradation of channel beds, although this effect could offset surface water heating. Over the long term, re-vegetation of channel bars and stream banks, narrowing of channels, and improved water storage from over-bank sediments should cause stream temperatures to lower.

Inventory and classification of wetland vegetation and channel types is needed to characterize, stratify, describe current conditions, and identify restoration needs in non fish-bearing streams. Evaluation of channel cross-section data from the High Ridge study is needed to identify tributary response to timber harvest. Flood effects to stream and riparian ecosystems should be surveyed and assessed. Linkages with aquatic ecosystem function are also needed through analysis of stream survey data

CURRENT AND REFERENCE CONDITIONS FOR FISH AND AQUATIC HABITAT

Overview of Fish Resources

The upper Umatilla includes approximately 584 miles of streams, 227 miles of which are perennial and 59 miles fishbearing. Meacham Creek contains about 800 miles of streams, including 312 miles which are perennial and 86 miles that contain fish populations (Crabtree 1996). Salmonid fishes which use this part of the Umatilla River system include rainbow/redband trout (*Onchorhynchus mykiss,* Figure 3-1), anadromous steelhead (*Onchorhynchus mykiss*, Figure 3-2), spring chinook salmon (*Onchorhynchus tshawytscha*, Figure 3-3), and bull trout (*Salvelinus confluentis*, Figure 3-4). Other fish species found here include the mountain whitefish (*Prosopium williamsoni*), speckled dace (*Rhinichthys osculus ssp*.), sculpins (*Cottus sp*), suckers (*Catostomus sp.*) redside shiners (*Richardsonius balteatus*), northern squawfish (*Ptychochelius oregonensis*). Brown bullhead (*Ictalurus nebulosus*) and brook lampreys (*Lampetra richardsoni*) are also likely present, although they have not been documented.

In years past, Oregon Department of Fish and Wildlife (ODFW) annually planted about 6800 hatchery-raised rainbow trout in the Umatilla River from the Corporation Guard Station upstream to Thomas Creek (Tim Bailey, Oregon Department of Fish and Wildlife, personal communication). Due to concerns about competition of hatchery fish with native bull trout and possible genetic effects of the introduced rainbows on the native stocks, this practice has been discontinued.

Oregon Department of Fish and Wildlife and the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) release hatchery raised steelhead and spring and fall chinook salmon into Meacham Creek and the Umatilla River within and below the watersheds included in this analysis. These releases (especially the chinook) represent an attempt to restore and rebuild fish runs that formerly spawned in the Umatilla River and its tributaries. These runs were severely reduced by irrigation diversion dams and stream dewatering, which made the river impassable to salmon during the spring and fall chinook migration. Largely as a result of the passage problems, spring chinook were extirpated from the Umatilla River system sometime prior to 1942 (MacIntosh, Clarke and Sedell 1994). The present run of spring chinook in the Umatilla River was developed from Carson stock, which is raised at Bonneville and Umatilla hatcheries and then acclimated in ponds in the Umatilla River drainage before release into the river (Rowan 1995). Fall chinook in the Umatilla River system originated from the Spring Creek Tule stock, the Bonneville Upriver Bright stock and the Priest Rapids Upriver Bright Stock. The hatchery-raised summer steelhead are from an endemic broodstock and are targeted primarily at supplementation of the Meacham Creek run. Coho salmon from a Tanner stock are also released into the Umatilla River. It is likely that coho once inhabited the Umatilla River, and there are some concerns about impacts of coho to other species, especially steelhead, with which they probably compete.

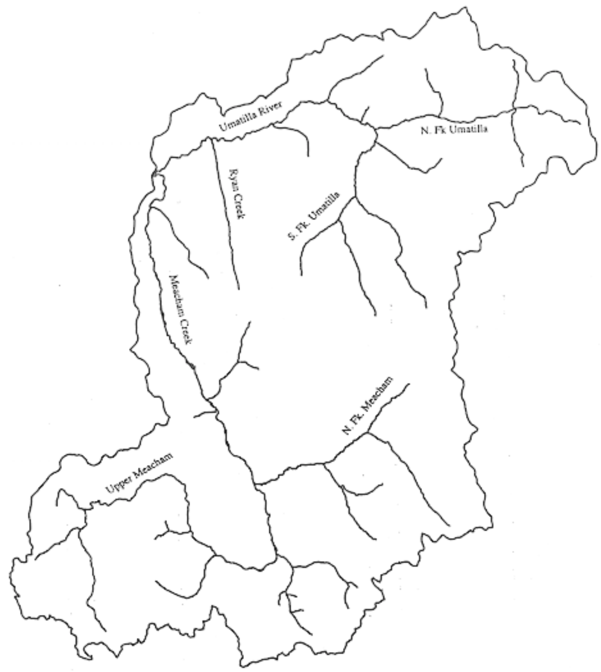


Figure 3-1. Range of rainbow trout in the Umatilla and Meacham watersheds.

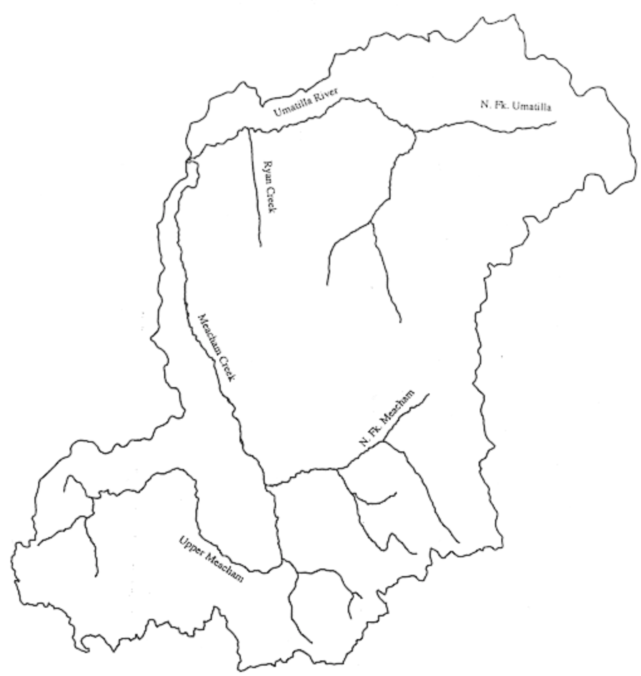


Figure 3-2. Range of steelhead in the Umatilla and Meacham watersheds.

Figure 3-3. Range of Chinook salmon in the Umatilla and Meacham watersheds.

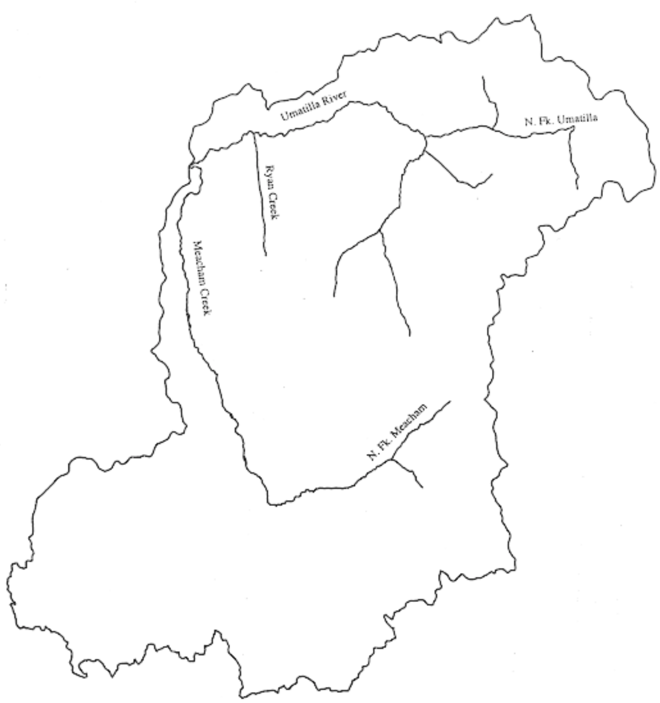


Figure 3-4. Range of bull trout in the Umatilla and Meacham watersheds.

Except for 1992 and 1998, Chinook re-introduction has been sufficiently successful to allow for a salmon sport fishing season since1990. A salmon sport fishing season is also anticipated for the year 2001 and is proposed by ODFW for the foreseeable future. The Umatilla River is also a primary recreational trout fishery for residents of the area, and it is heavily fished in the spring and summer.

The U.S. Fish and Wildlife Service, under authority of the endangered species act, has listed bull trout as Threatened, and the National Marine Fisheries Service has listed the middle Columbia River ESU steelhead trout population as Threatened. The Blue Mountain Cryptochian *(Cryptochia neosa),* a caddis fly, is on the Region 6 sensitive species list.

The listing of these fish species is indicative of the overall aquatic conditions within the watersheds. These conditions result from 100 years of management activities including grazing, road building, and logging that have slowly degraded important components of the aquatic habitat. The data of Heckeroth (1964), collected 35-40 years ago, are informative to qualitatively describe the degraded conditions at that time. He describes low summer stream flows and warm water temperatures as the most important factors limiting fish production. He found very little pool area (3.32% in the mainstem and 4.39% in the tributaries). Bull trout were present, but numbers were low. Rainbow/steelhead trout were the most common salmonid, and Meacham Creek was the most important tributary for steelhead production in the Umatilla River system. He found brook trout in private ponds about 10 miles above the mouth. He also observed whitefish, dace, cottids, shiners and suckers. Then, as now, the stream went subsurface in places, and there was little stream side shade below mile 22. Heckeroth noted logging roads running up the stream channels of some of the tributaries and sewage entering the stream from the railroad housing at the town of Meacham. Heckerroth's 1960's data are not comparable to more recent stream survey data and hence are not used to quantitate a reference condition. They do provide the basis to conclude that aquatic habitat conditions in the Meacham Creek system in the early 60's was apparently little different from today. Of course, by the early 60's there was already a railroad running almost the full length of the stream, and the area already had a history of many years of grazing and some timber harvest. Since those days, the grazing pressure has been reduced on at least part of the drainage (the National Forest portion), but there has been more road building and logging in the uplands.

Aquatic Data Sources

The earliest aquatic data recorded and published within the analysis area are those of Heckeroth's mentioned above. Because of significant differences in the data collection protocols between these and more recent data, Heckeroth's data were not used in the analysis of current and reference conditions.

Extensive stream surveys and water temperature monitoring have been completed in the past 10 years by the USFS, CTUIR, and ODFW, and these data form the basis for the analysis in this report (see Crabtree 1996 for details). Most of the Umatilla River and part of the Meacham Creek drainage were inventoried with USFS stream surveys between 1989-1995. These surveys used the Hankin & Reeves (1988) methodology. Much of the Meacham Creek drainage and a small part of the Umatilla drainage were inventoried by ODFW and CTUIR between 1991 and 1994. Most of the fish-bearing portions of streams in these two watersheds were surveyed within the past 12 years. ODFW fish surveys of the upper Umatilla River and North Fork Umatilla

River system were made in 1990. Tim Bailey of ODFW and Paul Kissner, Craig Contor, Gary Rowan and Todd Shaw CTUIR have provided important data for streams on non-USFS lands.

Temperature data were obtained from ODFW and CTUIR temperature monitors that collected data for summer months for periods as long as 10 years. Fish population survey data were obtained from ODFW CTUIR, and the USFS. Specifically, estimates of steelhead and chinook salmon redd counts were supplied by CTUIR. Bull trout redd counts were the result of a joint effort of the ODFW, CTUIR, and the fisheries staff at the Walla Walla Ranger District.

Analysis Methods

Estimates of Reference Conditions

The USFS data were used to estimate existing and reference conditions for a variety of aquatic habitat parameters. Because of differences in the data collection protocols between the USFS and ODFW/CTUIR surveys, some of the aquatic parameters are reported separately for the individual data sources. Stream survey and temperature data were analyzed to estimate existing conditions for a number of aquatic parameters including stream temperature, width/depth ratios, canopy cover, streambed substrate, woody debris, hiding/escape cover, and population sizes. Data from stream reaches within each subwatershed were averaged to characterize conditions on a subwatershed basis. The USFS SMART program was used to calculate many of the parameters. Existing conditions on both a reach and subwatershed basis were then compared to State and Federal standards (PACFISH and Oregon State DEQ) and reference conditions. The purpose of these comparisons is to identify subwatersheds or reaches that are significantly degraded.

Reference conditions were estimated using stream survey data from selected stream reaches that have been minimally, if at all, affected by past management activities. Data from the selected reference reaches were then averaged within each of the subwatersheds to generate a reference condition for the entire subwatershed. The reference reaches were within either the Umatilla Wilderness area or the roadless area in the Meacham watershed. Values for habitat parameters in these reaches serve as reference points for comparisons to more intensely managed subwatersheds. None of the subwatersheds in the analysis area has entirely escaped all management activities, since upland activities in one part of a subwatershed can have far-reaching effects on other areas. The following criteria were applied to select the reference subwatersheds.

1. The subwatershed was at least 50 percent national forest. Land management data is higher for national forest land than for private lands. The actual ownership of the selected subwatersheds exceeded 70 percent.
2. The equivalent clear-cut acreage (ECA, Ager and Clifton 1996) was less than 10 percent on the National Forest portion of the subwatershed.
3. No more than 5 percent of the area of the subwatershed has had timber harvest on slopes >30 percent.
4. The riparian road density was less than 0.6 miles of road per square mile of Riparian Habitat Conservation Area (RHCA), as defined by PACFISH.

5. Riparian road density was not more than 0.1 mile of riparian road per linear mile of stream. Riparian road was defined as any road within the PACFISH RHCA.

Seven subwatersheds met these criteria and were selected to estimate reference conditions (Table 3-1). Reaches were then selected within these subwatersheds to sample each subwatershed. Stream reaches with a significant exposure to adjacent roads were eliminated from the sample, leaving a total of 15 stream reaches in seven subwatersheds to estimate reference conditions. Stream survey data for eight parameters were averaged over these 15 reaches and standard deviations and critical values calculated. Critical values are one standard deviation above or below the mean value, depending on the variable. It should be noted that none of the selected reference stream reaches have been totally unaffected by 100 years of livestock grazing, timber harvest and road construction. The average of the reference reaches should be taken as examples of conditions that could be expected under sensitive management. Subwatersheds with averages for fish habitat parameters more than one standard deviation below (or above, depending on the parameter) the reference averages was considered to be severely degraded. Because of the small number of unmanaged reaches, they were not analyzed on a stream gradient basis. Thus stream gradient is not accounted for in calculation of the averages for the unmanaged reaches. Gradient most certainly affects the values for some of the parameters, like embeddedness and proportion of fine surface sediments.

Additional analysis was performed on stream temperature data obtained from long-term monitoring projects. Seven-day moving averages were calculated to assess conditions relative to PACFISH and Oregon State standards. Spawning season temperatures were also estimated.

Table 3-1. Data on ECA, road density, and harvest history for subwatersheds in the analysis area. Subwatersheds selected to represent reference conditions are shown in bold text. See text for definition of reference conditions. Upper Meacham and Lower North Fork Meacham could not be evaluated due to missing or invalid data

Subwatershed	Total Subwatershed Acres	National Forest as Percent of Watershed	Steep Harvested Acres as Percent of National Forest	ECA as Percent of National Forest	RHCA Road Density, mi/sq. mi.	RHCA Road Density: Road miles/ stream miles	Total road density **mi/sq.mi**
13A Ryan Creek	**8357**	**94**	**4.6**	**8.4**	**0.193**	**0.007**	**1.67**
13B Hagen	4361	50	0.2	0.0	1.907	0.064	0.77
13C Bear	12251	54	0.8	4.9	1.338	0.052	0.60
13D Lower NF Umatilla	**8214**	**72**	**2.1**	**3.9**	**0.292**	**0.011**	**1.20**
13E Upper NF Umatilla	**11576**	**100**	**1.7**	**9.1**	**0.581**	**0.025**	**2.08**
13F Lower SF Umatilla	3026	100	0.0	0.0	3.720	0.163	0.75
13G Buck Creek	7050	100	5.6	11.1	0.331	0.012	2.05
13H Thomas Creek	6688	100	15.9	12.1	4.342	0.152	3.48
13I Spring Creek	5487	100	31.8	28.2	4.758	0.171	3.65
13J Shimmiehorn Creek	6235	100	10.4	10.8	0.374	0.013	2.64
13K Upper SF Umatilla	9870	98.8	6.4	9.6	0.300	0.011	2.26
13L Gibbon	3468	1	0.0	0.0	1.531	0.058	0.51
89A Boston Canyon	5393	63	0.0	0.0	0.7000	0.032	1.13
89B Bonnifer	11503	62	0.3	0.0	1.071	0.044	0.91
89C Camp Creek	6716	99	3.6	1.4	1.000	0.037	1.52
89D Middle Meacham	7218	91	4.1	0.1	0.907	0.034	1.00
89E Lower NF Meacham	3394	62	3.8	0.2	0.066	0.003	0.61
89F Middle NF Meacham	**3138**	**99**	**0.2**	**0.0**	**0.000**	**0.000**	**0.29**
89G Upper NF Meacham	**9287**	**100**	**0.7**	**0.6**	**0.065**	**0.002**	**1.05**
89H Pot Creek	**7951**	**100**	**0.1**	**0.2**	**0.004**	**0.000**	**0.78**
89I Bear Creek	**8131**	**96**	**4.4**	**7.3**	**0.415**	**0.016**	**1.82**
89J Upper Meacham/Wilbur	3338	37	1.9	28.6	3.215	0.125	1.23
89K East Meacham	5224	91	6.5	8.5	0.637	0.023	2.50
89L Owsley Creek	7254	99	3.5	12.3	0.617	0.021	2.66
89M Upper Meacham/Short	2575	66	0.1	0.7	3.478	0.132	1.34
89N Butcher Creek	5098	37	0.8	2.2	2.257	0.084	1.78
89O Upper Meacham/Allen	9638	51	23.0	0.8	2.362	0.090	1.31
89Q Todd/Beaver/Sheep	13893	1	4.2	1.6	1.443	0.055	1.03
89R Upper Meacham	4208	0			0.044	0.002	0.96

State and Federal Standards

The Forest Service and the Bureau of Land Management jointly and in consultation with National Marine Fisheries developed PACFISH, which sets standards for a variety of habitat parameters in streams bearing anadromous fish. PACFISH water temperature standards are as follows:

1. No measurable increase in *maximum* water temperature from year to year.
2. Maximum water temperatures below 64°F within migration and rearing habitats and below 60ºF within spawning habitats.

The *maximum* water temperature standard in PACFISH is defined as the 7-day moving average of daily maximum temperature, measured over the warmest consecutive 7-day period. PACFISH also specifies standards for a variety of other habitat parameters (woody debris frequency, width/depth ratios). PACFISH riparian management objectives (RMO's) for pool frequency are dependent on stream width class (Table 3-2).

The Oregon State Department of Environmental Quality (DEQ) recently approved a new, and in some respects, more rigorous set of water temperature criteria which would apply to streams in the Umatilla and Meacham watersheds. These criteria state that the 7-day moving average of the daily maximum shall not exceed critical values (Table 3-3) unless specifically allowed under a Department-approved basin surface water temperature management plan

Table 3-2. PACFISH riparian management objective's (RMO's) for pool frequency by stream width class

Wetted Stream width (Ft)	10	20	25	50
Required Number of Pools per mile	96	56	47	26

Table 3-3. Water temperatures standards set by the Oregon State Department of Environmental Quality

Temperature (F)	Conditions
64	Always
55	Salmon spawning, egg incubation, fry emergence from egg and gravel
50	Oregon Bull Trout Present

Comparisons and Interpretation of Current and Reference Conditions

Aquatic parameters estimated from USFS (Table 3-4) and ODFW (Table 3-5) stream survey data showed wide variability among the reaches in the study area. Wide variation was also found among the reference reach values estimated with USFS data (Table 3-3, bold). Average values for the reference reaches along with standard deviations and critical values are in Table 3-6. Critical values are the thresholds where conditions are significantly degraded compared to the mean of the reference reaches. Averages for non-reference and reference subwatersheds calculated from the reach data also varied widely (Table 3-7). These data are discussed for each individual parameter below.

Table 3-4. Summary of aquatic parameters for stream reaches surveyed by USFS. Selected reference reaches are shown in bold.

Stream and Reach	SWS	Large Wood/ Mile	Medium Wood/ Mile	PACFISH Sized Wood/ Mile	Riffle Width/ Depth Ratio	PACFISH Pool Avg. Width/ Depth Ratio	Stream Widths per H&R Pools	H&R Pools per Stream Width	Percent Canopy Cover	Percent Embed-dedness	Domi-nant Sub-strate	Avg. Wetted Width	Reach Gradient	Pools/ mi	PACFISH RMO Pools/ Mile
Ryan Creek 1	13a	5	11	16	na	na	21.41	0.046	88	20	CO	14.7	3	16.78	na
Ryan Creek 2	**13a**	**15.0**	**62.0**	**77.0**	**11.8**	**6.0**	**14.30**	**0.070**	**85.0**	**8.0**	**CO**	**10.1**	**4**	**36.57**	**na**
Ryan Creek 3	13a	15.0	26.0	41.0	8.4	4.9	57.57	0.017	79.0	10.0	CO	4.3	8	21.33	na
Umatilla River 1	13c	4	22	26	na	na	17.71	0.056	19	15	CO	33.5	2	8.9	36
Coyote Creek 1	**13d**	**17.0**	**33.0**	**50.0**	**12.6**	**6.9**	**28.18**	**0.035**	**79.0**	**3.0**	**CO**	**12.4**	**5**	**15.11**	**na**
West Fork Coyote Creek 1	**13d**	**27.0**	**29.0**	**56.0**	**8.1**	**5.5**	**36.46**	**0.027**	**80.0**	**2.0**	**SB**	**8.6**	**10**	**16.84**	**na**
Johnson Creek 1	**13e**	**9.5**	**15.5**	**25.0**	**11.5**	**5.6**	**10.03**	**0.100**	**70.9**	**13.4**	**CO**	**9.4**	**9**	**55.98**	**na**
N.F. Umatilla River 1	**13d**	**21.4**	**15.0**	**36.4**	**18.0**	**9.5**	**18.64**	**0.054**	**47.0**	**8.0**	**CO**	**30**	**4**	**9.44**	**26**
NF Umatilla River 2	**13e**	**13.8**	**35.0**	**48.8**	**16.6**	**7.5**	**11.42**	**0.088**	**69.0**	**13.0**	**CO**	**17.6**	**4**	**26.27**	**na**
NF Umatilla River 3	**13e**	**49.2**	**62.6**	**111.8**	**10.4**	**6.9**	**19.07**	**0.052**	**63.5**	**41.6**	**CO**	**17.7**	**8**	**15.64**	**na**
NF Umatilla River 4	**13e**	**17.9**	**27.5**	**45.4**	**7.8**	**5.2**	**26.88**	**0.037**	**61.2**	**33.1**	**SB**	**11.4**	**10**	**17.23**	**na**
Woodward Creek 1	**13e**	**10.0**	**31.0**	**41.0**	**7.5**	**4.8**	**25.91**	**0.039**	**85.0**	**15.0**	**SB**	**4.9**	**15**	**41.59**	**na**
SF Umatilla R 2	13f	6	21	27	na	na	11.13	0.090	28	14	CO	90.6	2	15.6	26
Buck Creek 1	13g	20	36	56	na	na	16.28	0.061	84	19	CO	11.5	5	28.2	na
Thomas Creek 1	13h	30	8	38	na	na	6.72	0.149	54	14	CO	12.8	3	61.35	na
Spring Creek 1	13i	21	22	43	na	na	41.24	0.024	58	20	SB	6.6	5	19.4	na
Shimmiehorn Creek 1	13j	15	23	38	na	na	27.26	0.037	62	21	SB	11.6	4	16.7	na
SF Umatilla .3	13k	10	20	30	na	na	10.94	0.091	45	18	CO	23.1	2	20.9	47
SF Umatilla 4	13k	15	19	34	na	na	23.28	0.042	54	17	SB	13.5	5	16.8	na
NF Meacham 1	89e	7	12	19	na	na	20.13	0.050	19	na	CO	79.9	2	9.4	26
NF Meacham 2	**89f**	**13.0**	**16.0**	**29.0**	**23.6**	**7.7**	**14.51**	**0.069**	**25.0**	**> 35.0**	**CO**	**25.1**	**14.5**	**14.5**	**na**
Upper NF Meacham 1	**89g**	**42.0**	**84.0**	**126.0**	**17.9**	**8.2**	**7.03**	**0.142**	**79.0**	**4.0**	**CO**	**25.1**	**54.4**	**54.4**	**na**
Pot Creek 1	**89h**	**65.0**	**74.0**	**139.0**	**18.8**	**8.2**	**9.50**	**0.105**	**79.0**	**5.0**	**CO**	**16.4**	**33.9**	**33.9**	**na**
Pot Creek 2	**89h**	**49.0**	**117.0**	**166.0**	**15.7**	**6.9**	**10.22**	**0.098**	**84.0**	**12.0**	**CO**	**10.7**	**48.3**	**48.3**	**na**

Stream and Reach	SWS	Large Wood/ Mile	Medium Wood/ Mile	PACFISH Sized Wood/ Mile	Riffle Width/ Depth Ratio	PACFISH Pool Avg. Width/ Depth Ratio	Stream Widths per H&R Pools	H&R Pools per Stream Width	Percent Canopy Cover	Percent Embed-dedness	Domi-nant Sub-strate	Avg. Wetted Width	Reach Gradient	Pools/ mi	PACFISH RMO Pools/ Mile
Bear Creek 1	**89i**	**44.0**	**55.0**	**99.0**	**17.0**	**6.3**	**13.83**	**0.072**	**87.0**	**10.4**	**CO**	**11.1**	**34.4**	**34.4**	**na**
Meacham Cr. 1	89j	0	1	1	na	na	34.49	0.029	24	NA	CO	24.3	2	6.3	47
Meacham Cr. 2	89m	0	10	10	na	na	74.73	0.013	22	NA	GR	15.7	2	4.5	58

na=data not available

Table 3-5. Summary of aquatic parameters for stream reaches surveyed by ODFW and CTUIR.

							Substrate as % of Wetted Area				
Stream	Reach	Sub-watershed	Avg. Wetted Width	Reach Grad-ient	Pools/ mile	PACFISH RMO Pools/ Mile	Sand/Silt	Gravel	Cobble	Boulder	Bedrock
Umatilla River	RM 60.5-81.8	13L	29.5	0.7	18.05	26	21	38	28	11	2
Camp Creek	RM0-3.1	89C	9.8	2.9	75.13	na	18	32	26	19	5
Camp Creek	RM 3.1-3.3	89C	9.2	5.1	106.70	na	15	27	23	21	13
Camp Creek Tributary	RM 0-0.4	89C	4.6	5.9	166.18	na	11	38	28	23	1
Boston Canyon Creek	No Data	89A	7.9	5.9	46.55	na	0	26	41	9	7
Boston Canyon Tributary	No Data	89A	6.6	8.6	76.03	na	0	25	28	1	24
Line Creek	No Data	89B	4.9	9	89.28	na	0	34	33	3	1
Meacham Creek	mouth to res. boundary?	89B	33.1	1.3	16.15	26	7	43	40	9	1
Owsley Creek	1	89	8.2	1.5	14.94	96	5	20	50	23	3
Mill Creek	1	89Q	7.5	6.2	23.75	na	18	27	29	18	8
Mill Creek	2	89Q	6.6	3.1	9.2	na	18	36	35	10	0
Mill Creek	3	89Q	5.2	4.9	2.90	na	26	37	30	6	1
Mill Creek	4	89Q	6.9	2.5	1.42	na	49	36	12	2	0
Beaver Creek	1	89Q	7.9	1.6	12.04	96	29	27	28	7	9
Sheep Creek	1	89Q	7.5	5.8	6.48	na	21	30	31	15	4
Sheep Creek	2	89Q	5.6	2.5	11.12	na	38	35	25	2	0
Sheep Creek	3	89Q	5.6	1.3	9.05	96	56	36	4	0	0
Sheep Creek	4	89Q	6.9	1.7	2.97	96	79	16	2	0	1
Sheep Creek	5	89Q	4.3	4	1.29	na	85	11	5	0	0

Stream	Reach	Sub-watershed	Avg. Wetted Width	Reach Grad-ient	Pools/mile	PACFISH RMO Pools/Mile	Substrate as % of Wetted Area				
							Sand/Silt	Gravel	Cobble	Boulder	Bedrock
Beaver Creek	1	89Q	7.9	1.3	14.02	96	20	25	34	15	6
Beaver Creek	2	89Q	1.2	1.3	8.54	56	59	29	10	1	0
Beaver Creek	3	89Q	4.6	2	7.07	96	61	33	6	0	0
Little Beaver Creek	1	89Q	7.9	1.5	14.87	96	57	29	10	1	3
Little Beaver Creek	2	89Q	6.6	0.9	25.51	96	81	14	3	0	1
Little Beaver Creek	3	89Q	5.2	0.9	25.24	96	93	6	0	0	2
Little Beaver Creek	4	89Q	9.2	1.5	0.48	96	76	21	3	0	0
Two-Mile Creek	1	89Q	7.5	1.4	26.10	96	52	19	15	5	9
Two-Mile Creek	2	89Q	8.5	0.8	15.68	96	66	26	9	0	0
Two-Mile Creek	3	89Q	8.9	0.7	10.42	96	92	4	2	0	3
Two-Mile Creek	4	89Q	8.5	2.5	4.80	na	75	11	7	1	6
Two-Mile Creek	5	89Q	11.5	2.7	2.41	na	76	16	8	0	0
Meacham Creek Tributary	1	89R	3.6	3.9	26.91	na	48	36	12	4	0
Meacham Creek	3	89R	6.9	0.7	29.69	96	3	21	57	16	3
Meacham Creek	1	89M	21.0	1.5	7.74	47	3	6	48	23	19
Meacham Creek	2	89C	13.5	3.1	12.31	na	40	37	20	2	1
N.F. Meacham Creek	1	89E	23.6	1.8	9.66	47	13	26	49	9	4
N.F. Meacham Creek	2	89E	26.6	2.2	15.82	na	9	27	53	6	6
N.F. Meacham Creek	3	89F	29.0	2.6	15.21	na	12	22	47	7	13
N.F. Meacham Creek	4	89F	11.5	4.4	25.79	na	17	13	33	24	13
N.F. Meacham Creek	5	89F	9.2	7.7	11.32	na	6	13	40	25	17
East Meacham Creek	1	89K	8.2	2.6	20.55	na	10	14	57	17	2
East Meacham Creek	2	89K	8.2	8.7	17.71	na	8	16	43	27	6

na=data not available

Table 3-6. Averages and critical values for aquatic parameters calculated from USFS data collected in reference reaches. Critical values are defined as one standard deviation from the mean value.

Stream and Reach	Water-shed	Large Wood/Mile	Medium Wood/Mile	PACFISH Sized Wood/Mile	Riffle Width/Depth Ratio	PACFISH Pool Avg. Width/Depth Ratio	Stream Widths per H&R Pools	H&R Pools per Stream Width	Percent Canopy Cover	Percent Embedded -ness	Pools/ Mile
Average Value		29.1	48.2	77.3	14.7	6.9	17.20	0.075	72.3	11.1	31.6
Std.dev.				43.1	4.7	1.3	12.86	0.033	16.3	11.0	14.90
Critical value**				34.3	19.5	8.2	30.06	0.042	56.0	22.1	16.7

Table 3-7. Subwatershed average values for aquatic parameters measured in USFS and ODFW surveys. Shaded cells are data from USFS surveys that differ from the critical values listed in Table 3-6. ODFW data were not used to compare reference and non-reference reaches.

. Subwatershed	Riffles Avg. width/depth ratio	Stream Widths per pool	Percent Canopy cover	Fish Cover Class	Pool Residual Depth	Pacfish Wood per mile	Pacfish (pool) Width/depth	Percent Embed-dedness	ODFW Wood Pieces per mile	ODFW Volume (cu. M) per mile	Pools/ mile
13 Ryan Creek	12.9	26.6	84.68	2.0	1.18	47.56	5.72	12.6			26.20985
13B Hagen									24.1	33.8	
13C* Hagen	21.3	17.7	19.00	3.0	***3.50***	26.00	8.40	15.0			8.9
13D Lower N. Fk. Umatilla	14.3	25.2	61.98	2.0	***1.96***	44.22	7.94	5.4			12.498
13E Upper N. Fk. Umatilla	11.8	16.8	69.79	2.0	***1.33***	48.90	6.18	20.3			32.76202
13F Lower S. Fk. Umatilla	30.0	11.1	28.00	3.0	***3.40***	27.00	7.00	14.0			15.5
13G Buck Creek	14.6	16.3	84.00	2.0	1.00	56.00	6.90	19.0			28.2
13H Thomas Creek	22.5	6.7	54.00	2.0	***2.30***	38.00	5.80	14.0			61.35
13I Spring Creek	13.4	41.2	58.00	1.0	1.10	43.00	5.80	20.0			19.4
13J Shimmiehorn Creek	11.9	27.3	62.00	2.0	1.60	38.00	6.00	21.0			16.7
13K Upper S. Fk. Umatilla	21.7	19.8	51.43	1.6	1.56	32.86	7.03	17.3			18.0
13L Gibbon									25.5	45.7	18.0

. Subwatershed	Riffles Avg. width/depth ratio	Stream Widths per pool	Percent Canopy cover	Fish Cover Class	Pool Residual Depth	Pacfish Wood per mile	Pacfish (pool) Width/depth	Percent Embed-dedness	ODFW Wood Pieces per mile	ODFW Volume (cu. M) per mile	Pools/ mile
89A Boston Canyon									35.6	35.3	47.4
89B Bonnifer									24.1	29.8	22.3
89C Camp Creek									105.4	3104.2	83.0
89D Middle NF Meacham											13.1
89E Lower N. Fk. Meacham	33.8	17.3	19.00	3.0	1.33	19.00	10.00	> 35	59.6	44.5	9.4
89F Middle N. Fk. Meacham	23.6	14.5	25.00	3.0	***2.20***	29.00	7.7	> 35	144.1	164.9	14.5 18.1
89G Upper N. Fk. Meacham	17.9	***3.87***	79.00	2.0	1.00	***126.00***	8.20	4.0	222.5	257.5	54.4
89H Pot Creek	17.5	9.8	81.05	2.6	***2.30***	***150.09***	7.67	7.9			39.8
89I Bear Creek	17.3	13.8	***87.00***	2.0	1.10	99.00	6.30	10.4			34.4
89J Upper Meacham/Wilbur	24.2	34.5	24.00	3.0	***2.60***	1.00	9.40	< 35			6.3
89K East Meacham									153.5	114.0	18.7
89L Owsley Creek									207.1	260.9	14.9
89M/O Upper Meacham/Short	29.3	32.5	22.00	2.0	1.60	10.00	8.60	< 35			
89M Upper Meacham/Wilbur									9.8	14.7	7.8 4.5
89O Upper Meacham/Allen									66.2	22.1	12.3
89Q Todd/Beaver/Sheep									246.8	153.87	8.87
89R Upper Meacham									137.7	99.27	29.67
Mean[1]	14.7	17.2	72.3		1.4	77.3	6.9	11.1			

[1] Means are reach-length weighted. See Crabtree (1996) for more information on estimation of subwatershed means.

Riffle Width/Depth Ratios

Wetted width/depth ratios [WWDR] and wetted width/depth ratios in riffles [WWDRR] are indicative of susceptibility to heating and are directly related to fish hiding cover and mobility. In the Umatilla watershed, the lowest WWDRR was found for subwatershed 13E (11.8, Table 3-7). This subwatershed includes the upper North Fork of the Umatilla River and Johnson and Woodward creeks. Subwatershed 13J, Shimmiehorn Creek, has an almost identical WWDR of 11.9. The highest WWDRR in the Umatilla Watershed were found in subwatersheds 13L, main-stem Umatilla River between Meacham and Ryan creeks, 13B, main-stem Umatilla River between Ryan Creek and Bobsled Creek, and 13F, lower South Fork Umatilla River. Data for subwatershed 13L is from CTUIR stream survey reports, which include several miles of the river downstream of the subwatershed boundary and so may not accurately reflect conditions specific to that portion of the stream within the bounds of subwatershed 13L. Subwatershed 89A, Boston Canyon, contains the lowest WWDRR (11.6) in the Meacham watershed. The highest WWDRR was found in subwatershed 89O, Allen. Overall difference in WWDRR between unmanaged and more intensively managed subwatersheds, and between the Umatilla and Meacham watersheds was not statistically significant (Table 3-7).

Pool Width/Depth Ratios

Pool width/depth ratios (PWDR) are very important indicators of the quality of fish habitat. Lower width/depth ratios are preferable because they provide for better fish cover and mobility, and present less surface area to receive heat from solar insolation. PWDR were estimated using data from stream surveys and section seven (PACFISH) monitoring protocol (USDA Forest Service 1994). All Stream reaches surveyed by USFS teams had PWDR's of less than 10 (Table 3-4), which is within the PACFISH standard. On a subwatershed basis, the lowest PWDR in the Umatilla watershed was found in subwatershed 13A, Ryan Creek (5.72) and the highest was from subwatershed 13C, main-stem Umatilla (8.4, Table 3-7). Differences between reference and non-reference subwatersheds, and between the Umatilla and Meacham watersheds were not statistically significant. To test whether the lack of significance might be caused by the constructed pools in the more intensively managed, non-reference areas, the data were re-analyzed after omitting subwatersheds with constructed pools. The difference remained nonsignificant ($p = .22$)

Canopy Cover

On a subwatershed basis, data from USFS stream surveys showed that the reference subwatersheds had significantly ($p <0.05$) higher canopy cover than the non-reference subwatersheds (Table 3-7). In the Umatilla watershed, streams with highest canopy cover are either in the North Fork Umatilla Wilderness or Ryan Creek (Table 3-4). These are mostly small, narrow streams in steep walled, narrow, canyons that lack roads. The lowest canopy cover was found on the Umatilla River below the confluence with the North Fork. Low values were also observed on the South Fork Umatilla River between Thomas Creek and the North Fork confluence. These are both larger, wider streams in relatively broad valley bottoms with adjacent roads.

When the data are examined on a reach basis, (Figure 3-5, Table 3-4) it can be seen that stream canopy is inversely related to stream width. Thus the lower canopy along the relatively wide main-stem and the south fork of the Umatilla River might be caused by this inherent correlation in the data. Nevertheless, adjacent roads along these streams will always prevent the full development of streamside canopy. Streams like Spring Creek (Figure 3-5, upper square symbol), which has much lower canopy cover than others with streams of similar width, demonstrates the effects of roads on canopy. Spring Creek, and the subwatershed around it (13I), have high road density, and two roads (3145 and 3145040) closely parallel the stream course for much of its length. Although these are closed roads (Walla Walla Ranger District Access and Travel Management Plan, 1993), they still adversely affect canopy cover and stream shading in Spring Creek. In the Meacham watershed, roads and railroads along the streams also appear to adversely affect canopy cover. For instance, the second lowest canopy cover was found along the second reach of Meacham Creek in subwatershed 89M (lower square symbol, Figure 3-5). This subwatershed also has the highest riparian road density among all subwatersheds in the Meacham watershed (Table 3-1). The wetted width of USFS reach 2 of Meacham Creek is 15.7 ft, and the canopy is 22 percent. Most streams of that width in the analysis area have a much larger canopy cover in the range of 55 to 85 percent. The low canopy in this area is also likely the result of intense grazing in this area (CH2M Hill 1995).

ODFW and CTUIR survey data also show a correlation between stream wetted width and canopy cover (Figure 3-6). Three stream reaches shown in Figure 3-6 (square symbols) are not within National Forest boundaries, namely, the uppermost reach of Meacham Creek from the confluence with Sheep Creek to the source, reach 1 of Beaver Creek, from the mouth to the Meacham Lake spillway, and reach 3 of Two Mile Creek (the region where Interstate-84 crosses the creek). These were omitted from the reference condition analysis due to lack of road and land use data. The relative low canopy cover in along these reaches is probably the result of the adjacent railroad tracks. In addition, ODFW stream surveys reported heavy grazing along reach one of Beaver Creek.

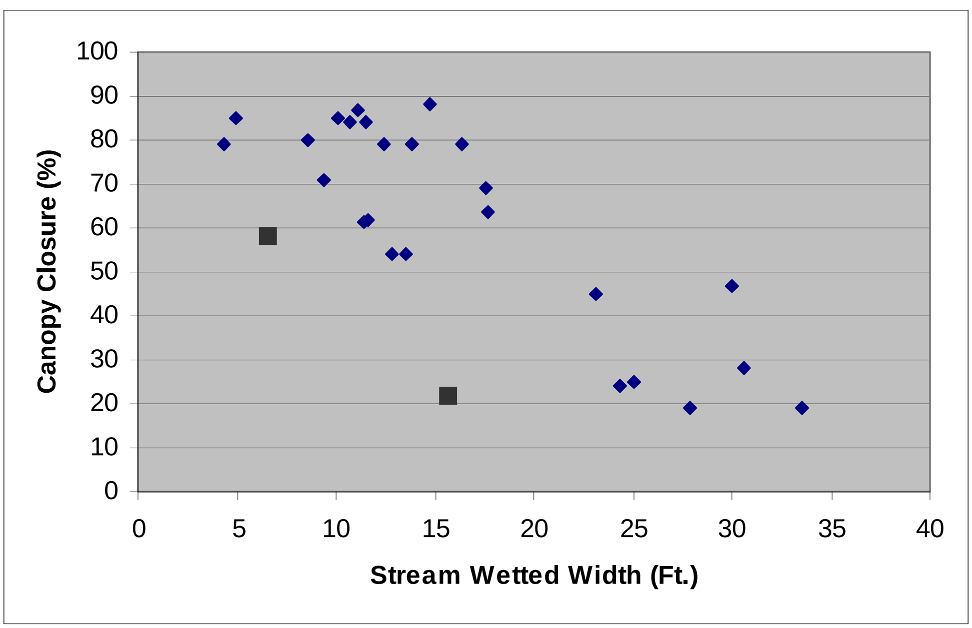


Figure 3-5. Canopy cover versus stream wetted width for reaches surveyed by the USFS in the Umatilla and Meacham in watersheds. Left rectangular marker is reach 1 of Spring Creek, right rectangular marker is reach 2 of Meacham Creek. (R^2 = -0.77, p<.05)

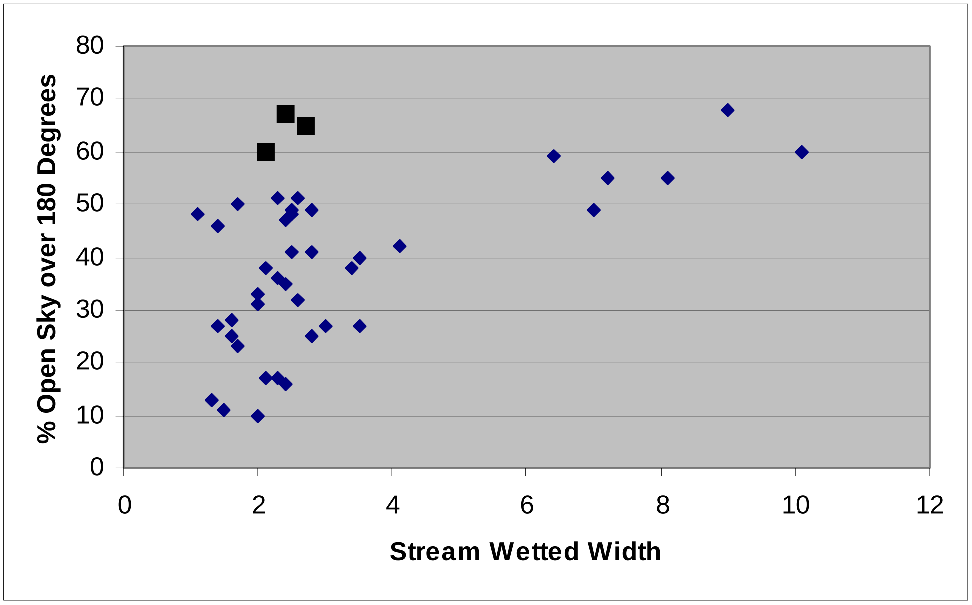


Figure 3-6. Non-shaded stream area versus stream width for reaches in the Meacham watershed. Data collected by ODFW and CTUIR. The three rectangular markers are reaches not within the National Forest.

Streambed Substrate

Two aspects of streambed physical characteristics were assessed, namely spawning substrate, and rearing substrate. For stream reaches surveyed by the USFS, substrate characteristics were measured by cobble embeddedness and dominant/subdominant particle size. In reaches surveyed by the ODFW and CTUIR, substrate quality was evaluated from percent surface fines and dominant/subdominant particle size. Some of the USFS data were excluded from analysis since early data were recorded as yes/no with respect to embeddedness using the 35 percent threshold. These data included Reach 3 of the upper Umatilla River, reaches 1 and 2 of North Fork Meacham Creek. Note also that these reaches all had embeddedness levels that exceeded the thresholds.

USFS stream survey data showed that only two subwatersheds (89e & 89f) had an average cobble embeddedness greater than the 35 percent threshold (Table 3-7). However, non-reference subwatersheds had a significantly ($p<.05$) higher embeddedness than reference subwatersheds. Despite the fact that few of the subwatersheds exceeded the threshold, the overall higher values for the non-reference subwatersheds may be impacting fish resources. For instance, Chapman and McLeod (1987), in their review of the effects of sediment on salmonids, concluded that cobble embeddedness as low as 25 percent in rearing areas can reduce intersticial habitat. The statistically significant difference in embeddedness between unmanaged and the rest of the subwatersheds suggest a relationship between intensity of management activities and fish. Total road density is strongly correlated ($p<.05$) with cobble embeddedness on a subwatershed basis (Figure 3-7). However, cobble embeddedness was not found to be correlated with RHCA road density. One interpretation of these results is that upland roads are very important in terms of sediment delivery to streams. If this is true, then one could argue that sedimentation from upland roads are not eliminated by PACFISH buffers (RHCAs). Sediment delivery from roads varies widely with the type of road construction and method of handling water discharge from the road surface (Brown 1991), so it is difficult to draw conclusions without additional data and analysis. RHCAs do, however, protect riparian areas and streams from a variety of other adverse impacts.

The ODFW and CTUIR survey data on streambed substrate measures percent surface fines and dominant/subdominant particle size. These data indicated that fine sediment (silt and sand) was the dominant substrate in 19 out of 42 stream reaches surveyed. Of these 19 reaches, 18 are in the Meacham watershed. With fine sediment as the dominant substrate, embeddedness in these reaches is probably also very high. Large increases in percentage of fine sediment in the substrate clearly will degrade fish habitat (Waters 1995). However, there does not seem to be any widely accepted threshold value for relating percent surface fines to degraded fish habitat. Neither does there seem to be any way to confidently relate *surface* particle size distribution to embeddedness.

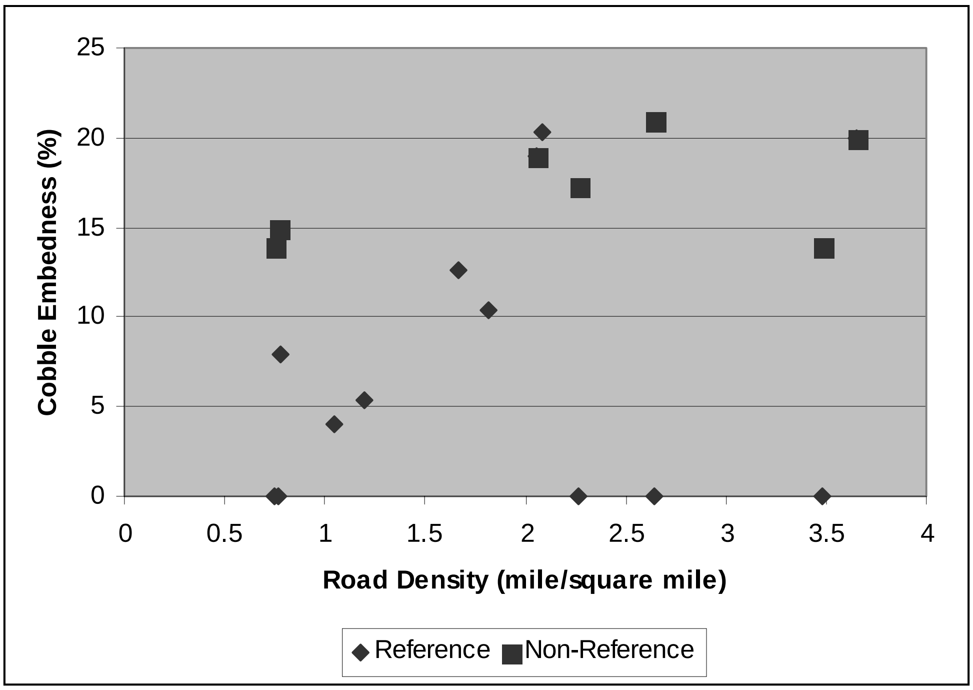


Figure 3-7. Average subwatershed road density versus cobble embeddedness. R^2 = 0.58. P < .05.

In relation to rearing habitat, the USFS survey data for the Umatilla watershed showed cobble or small boulder as the dominant substrate for all reaches. Cobble and small boulder substrates provide escape and hiding cover for juvenile fish and, therefore, should be considered excellent as rearing and overwintering substrate. However, when the interstices between the cobbles are filled with fine sediment, the substrate's utility as cover in nullified. Chapman and McLeod (1987), referring to Bjornn et al (1977), reported "at an embeddedness level of about 2/3, corresponding to about 30 percent fines in the substrate, all of the interstices in the substrate were filled with fines." All of the stream reaches in the upper Umatilla watershed are below that level (Table 3-4). USFS stream survey data for the Meacham watershed indicated cobble as the dominant substrate for seven reaches and gravel as dominant for one, namely reach 2 of main-stem Meacham Creek. Cobble is listed as subdominant for this reach.

ODFW and CTUIR substrate data for the Meacham watershed (Table 3-5) indicates cobble is the dominant substrate particle size in 12 of 42 reaches. Another eight reaches have gravel as the dominant substrate and cobble as subdominant. Substrate in these reaches should be a high quality component of salmonid rearing habitat. However, the Meacham watershed has many reaches with substrate of low value for salmonid rearing. More than half the substrate is silt and sand in 13 reaches. Very poor rearing substrate was found in subwatershed 89Q and 89R. In these subwatersheds fish must find other sources of cover during the early stages of development. These streams have low gradients and probably have always had higher levels of fine sediments in the substrate, and low rearing habitat quality. High quality rearing substrate within the Meacham Creek watershed was found in subwatersheds 89A, 89M and 89O (Table 3-7).

Cobble embeddedness bears a less direct relationship to quality of spawning habitat; since salmonids tend to flush at least some of the fine sediments from the gravel during redd construction. However, to the extent that high cobble embeddedness indicates a high sediment load for the stream, it also indicates a potential reduction in quality of spawning habitat. Sediment deposition during the time that eggs are in the gravel warrants the greatest concern, since sediment deposited over the redd can restrict the flow of water through the redd, reducing oxygen and metabolite flux (Hicks et. al., 1991). In excessive quantities, fine sediment could also form a cap over the redd, preventing the emergence of alevins from the gravel. Most of the stream surveys are made before salmonid spawning and after emergence of alevins, so none of the available data directly relates to the time when deposition of fine sediments would be of most concern.

One important component of spawning substrate is the presence of sufficient quantities of gravel-sized substrate. Although none of the stream reaches in the upper Umatilla watershed have gravel as the dominant substrate (Table 3-4), eight show gravel as a subdominant substrate (Table 3-4). One of these is reach 3 of the North Fork Umatilla. Its embeddedness is greater than 35 percent (Table 3-4), so it is probably marginal spawning habitat. However, for the remaining seven of the eight reaches, the substrate component of the spawning habitat appears very good (Table 3-4). Combining data from the USFS, ODFW and CTUIR surveys, the Meacham Creek watershed has gravel as the dominant substrate in nine and subdominant in 21 reaches (Table 3-4 and 3-5). Thus, in 30 out of 50 reaches, substrate appears to be a good quality component of spawning habitat.

In-Stream Woody Debris

Because of differences in data gathering methodology, only reaches surveyed with USFS Region 6 protocol can be readily compared to PACFISH standards for woody debris frequency. The USFS survey data indicated significantly ($p<.05$) higher frequency (pieces per mile) of PACFISH-sized wood in the reference (77.3) versus the non-reference (28.1) subwatersheds (Table 3-7). PACFISH standards for woody debris are sizes >12 inches diameter by 35 Feet long. In the Umatilla watershed, three subwatersheds (13C, 13F, 13K) had wood frequencies more than one standard deviation below the mean of the reference subwatersheds (Table 3-7). In the Meacham watershed, two subwatersheds, 89G and 89H, were more than one standard deviation above the mean, and four (89E, 89F, 89J, 89M) were more than one standard deviation below. In relation to PACFISH, all subwatersheds within the Umatilla watershed exceeded the PACFISH minimum of 20 pieces per mile (Table 3-7). In contrast, several subwatersheds (89M, 89J, and 89E) in the Meacham watershed are below the PACFISH minimum.

On a reach basis, the median value for woody debris frequency for all stream reaches surveyed by the USFS in the Umatilla River and Meacham Creek system was 41 pieces of large wood per mile. The overall range was from 1 to 166 with a length-normalized mean for all reaches of 53 pieces/mile**.** Of the 27 stream reaches surveyed with PACFISH protocols (i.e. USFS surveys), 23 meet or exceed the PACFISH RMO of 20 pieces of large wood per mile (Table 3-4). In the upper Umatilla River watershed, 18 out of 19 reaches met the PACFISH RMO. In the Meacham Creek watershed, 5 out of 8 reaches met the PACFISH RMO (Table 3-4).

Data from the 42 reaches surveyed by ODFW and CTUIR also indicated more woody debris in the Umatilla versus the Meacham watershed (Table 3-5). Reaches and subwatersheds covered by ODFW and CTUIR surveys cannot be related to either PACFISH or reference conditions since the minimum piece size was smaller (5.9 in. diameter and 9 ft. 10 in. long) than for the USFS surveys. However, four subwatersheds (89E, 89F, 89G, 89M) were at least partially surveyed by both ODFW and USFS teams, and the *ranking* of wood frequencies for these subwatersheds is the same for both data sets. Furthermore, wood frequency for three of these subwatersheds was more than one standard deviation below the mean of USFS unmanaged reaches. The best of these three was subwatershed 89F (Middle N.F. Meacham). It ranked twelfth among the 17 subwatersheds with surveys by USFS teams and fifth among 13 subwatersheds with surveys by ODFW/CTUIR teams. If this ranking holds for the remaining subwatersheds surveyed only by ODFW/CTUIR teams, at least seven out of the thirteen subwatersheds may well have woody debris frequencies more than one standard deviation below that of the least managed reaches.

Several of the non-reference subwatersheds exceeded the reference mean wood frequency. Wood frequency in subwatershed 89G was more than one standard deviation above the mean of USFS least managed reaches. Two subwatersheds surveyed by ODFW had wood frequencies higher than that of 89G. Based on the ranking, it also seems reasonable to conclude that these subwatersheds (89C, 89G, 89Q) most likely have in-stream wood frequencies more than one standard deviation above that of the least managed reaches. These subwatersheds include the reaches that Rasmussen (1993) considered to be in the best overall condition.

Many of the past land uses in the study area have reduced the sources of large woody debris for streams. Logging in riparian areas removed trees that would have become in-stream wood, and intensive grazing pressure has retarded the regeneration of riparian trees. Riparian roads and railroads have also been built on land that otherwise would be producing trees. Studies have found large woody debris to be either less frequent (Heifetz et al 1986) or of smaller size classes (Toews and Moore 1982; Bryant 1983) in watersheds or stream reaches with clearcuts. Over the short term, logging debris left behind may become in-stream woody debris, but will likely be of smaller size classes and not persist as long as larger pieces. On the Olympic Peninsula and in southwestern Washington, measurable contributions of new wood after harvest may not occur for 60 to 70 years (Grette 1985; Bilby and Wasserman 1989). In more arid eastern Oregon, it seems reasonable to conclude that significant new wood contributions would take even longer. Forests in the Umatilla River and Meacham Creek watersheds seem capable of producing more than 20 pieces of large woody debris per mile. In the context of watershed analysis, PACFISH allows for adjustment of RMOs to fit local conditions. If the average wood frequency of the least managed reaches is representative of the system capability, an RMO of 75 pieces of PACFISH sized wood per mile seems like a reasonable long-term goal for the Umatilla/Meacham system.

Hiding and Escape Cover for Fish

Fish cover data did not differ among reference and non-reference watersheds (Table 3-7). Except for Spring Creek (subwatershed 13I) and perhaps upper South Fork Umatilla (subwatershed 13K), there is little basis for distinction among subwatersheds. The low fish cover in subwatershed 13I is probably related to past intensive management activity as evidenced in the high road density and high equivalent clearcut acres (Table 3-5).

On a reach basis, USFS stream survey data indicated that 25 out of 27 of the sampled stream reaches in the analysis area system had a cover class of 2 (6 - 20%) or 3 (21 - 40%). Two reaches rated below cover class two (< 5% cover), namely Spring Creek (subwatershed 13I) and the uppermost reach of the South Fork Umatilla River (subwatershed 13K, Table 3-4).

ODFW and CTUIR reports do not give direct values for fish cover. They do, however, report a habitat complexity score (Table 3-8), based primarily on in-stream woody debris and its function as cover (Moore & Jones 1992). They also report bank undercutting and frequency of large boulders, both of which contribute to fish cover. Based on these parameters, a very coarse estimate of the fish cover for the areas surveyed revealed that watershed 89C, Camp Creek, and the upper Meacham Creek (89R) both have the best level of cover. The remaining subwatersheds as surveyed by ODFW/CTUIR had very low fish cover, as estimated from complexity.

Table 3-8. Summary of habitat parameters related to fish escape and hiding cover for reaches surveyed by ODFW and CTUIR teams in the Meacham watershed

USFS subwatershed code	ODFW habitat complexity score	Boulders as % of substrate	Undercut banks as % of channel length
89a	1.1	9	0.80
89b	1.2	8	0.82
89c	1.6	19	8.34
89e	1.2	7	0.42
89f	1.3	20	0.11
89k	1.2	22	0.44
89l	1.1	23	0.27
89m	1.1	16	.073
89o	1.1	23	0.20
89q	1.5	3	4.06
89r	1.4	2	7.38

Pool frequency

USFS stream survey data indicated large differences in pool frequency between the Umatilla and Meacham watersheds. The average pool frequency for most subwatersheds within the Umatilla watershed is within one standard deviation of the mean for the least managed reaches (Table 3-7). Only subwatershed 13I, Spring Creek, has an average pool frequency (as pools per stream width) that exceeds one standard deviation less than the mean of the reference reaches. The relatively high overall pool frequency for most of the subwatersheds in this watershed is at least partly explained by the presence of constructed pools in some of the subwatersheds (13C, 13F, 13H). In contrast, the Meacham watershed has eight subwatersheds that fall more than one standard deviation below the mean for the reference reaches (Table 3-7). Only one subwatershed, 89G, had a pool frequency more than one standard deviation above the mean of least managed reaches.

In relation to PACFISH, the pool frequency standards apply only to Rosgen Type C channels, and vary by stream width (Table 3-6). Rosgen types were inferred from stream gradient data by assuming that gradients <=2 are Type C channels. Under this assumption, 26 of 69 total reaches surveyed (ODFW and USFS) are probably type C and the minimum pool standards apply. Only one is in a reference subwatershed, and hence there is not a sufficient basis for comparison of reference and non-reference reaches in terms of PACFISH standards for pool frequency.

Another problem with comparing pool frequencies between PACFISH standards and USFS Region 6 (Hankin and Reeves type surveys) stream survey protocols, is the latter permits counting of only those habitat units whose lengths are greater than their widths and which extend across the full wetted width of the stream. Also, there is no minimum pool depth criteria. PACFISH monitoring protocol (Table 3-2) does not include the length or full wetted width criteria, and requires that all counted pools be at least 3 feet deep.

In the absence of comparable PACFISH standards to examine the USFS data, one could use the reference reaches as standards. However, it should be noted that in the current data, only reference subwatersheds and subwatersheds with constructed pools exceed the threshold estimated for reference reaches (0.042 pools per stream width). This is not surprising since pool frequency is highly dependent on factors such as stream gradient and wetted width. RMO's will need to take into account these factors to develop more reach-specific management objectives.

Residual pool depth

Residual pool depth values were only recorded in USFS surveys. The higher values for many of the reaches (Table 3-6) probably reflect extensive efforts to create pools via in-stream structures (Northrop, 1991, 1992). Comparison of the reference to non-reference subwatersheds showed that only 13G (Buck Creek), had significantly lower pool depth. In the Umatilla watershed, 8 of the 17 reaches surveyed by USFS teams had residual pool depths significantly greater than the mean residual pool depth of the reference reaches. Many of these have log or rock weir plunge pools that were constructed as habitat improvements. Many of these pools are deeper than the average pool depth for the reference reaches (Table 3-4), and thus a higher frequency of deeper pools are being created than existed under natural conditions

Pool Width Depth Ratios:

Six subwatersheds had an average pool width/depth ratio more than one standard deviation above the mean of unmanaged reaches (Table 3-7). Pools with relatively high width/depth ratios create less hiding and escape cover, and are more influenced by solar heating. Thus pools in these subwatersheds are degraded with respect to these habitat parameters.

Overall Pool Habitat:

Intense livestock grazing, road building, and removal of trees from the riparian zone inhibit natural pool forming processes (Meehan 1991), and, in the case of the Umatilla and Meacham watersheds, has probably resulted in a lower pool frequency, pool depth, and less habitat diversity. While pool frequency and depth are important components of high quality fish habitat, other habitat factors must also be of high. For example, water temperatures in lower Meacham Creek do not meet PACFISH RMO's (see next section) and in fact approach or surpass upper lethal limits for steelhead and rainbow trout. Higher pool frequencies created by constructed pools can only partially compensate for these lethal temperatures. Temperatures in the deepest part of pools are significantly colder than at the surface (See Crabtree 1996). These pools are probably intercepting some subsurface flow, and the deeper water is not subjected to solar heating. Adult salmon make extensive use of cool water refugia until spawning (Torgerson, Price, Li and Macintosh 1995). The full effect of constructed pools on fish survival will depend on a number of other factors that are important determinants of fish habitat, including late summer flow characteristics of the stream, the location of the pool, canopy, and hiding cover.

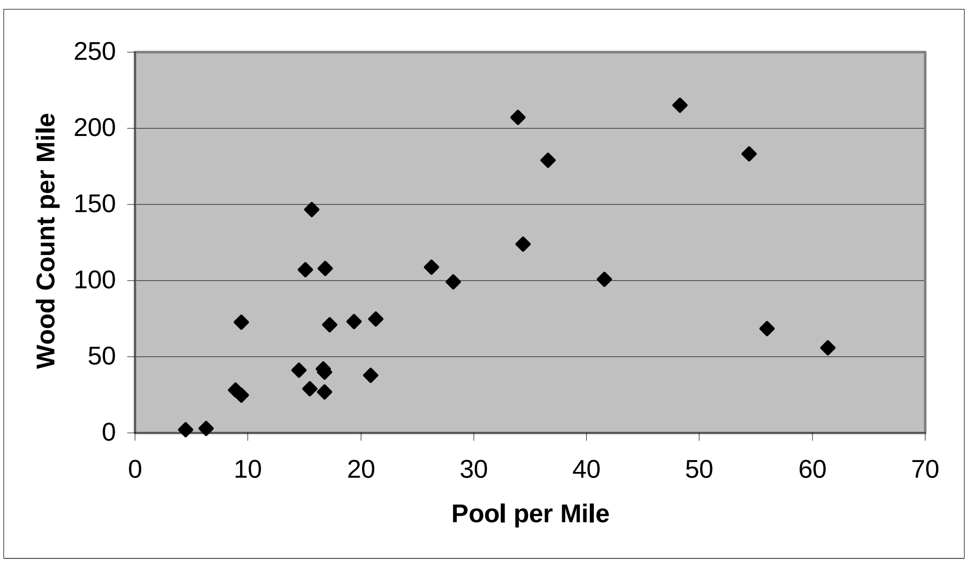


Figure 3-8. Correlation between woody debris and pool frequency in the Umatilla/Meacham system (minimum wood size: >6 inches x 20 feet long) (R^2 = 0.57, P < .05)

Stream woody debris is generally an important component in the pool formation process, and there is a significant correlation between woody debris frequency and pool frequency in the Umatilla and Meacham watersheds (Figure 3-8). However, it can be difficult in some situations to enhance woody debris in riparian areas. For instance, riparian land use patterns may conflict with the perpetuation of streamside forest vegetation. In addition, large woody debris can move at high flows and floods, and may cause extensive damage to roads and bridges. Thus there are situations when artificial pool habitat via instream structures may be appropriate. This seems to be the case for some of the lower reaches of Meacham Creek and parts of the Umatilla River.

Stream Temperature

Two temperature measurements were considered relevant to the analysis of thermal conditions within the study area. These are the annual maximum of the 7-day moving average for the maximum daily temperature (Table 3-9), and the average maximum daily temperatures during the spawning season, as measured from August 12 through August 18, 1993 (Table 3-10).

Table 3-9. Stream temperatures (ºF) in the Umatilla and Meacham watersheds. Data are annual maximum of the 7-day moving average of the daily maximum temperature.

Subwatershed	Stream & Location	Year					
		1990	1991	1992	1993	1994	1995
Outside study area	Umatilla River, RM 75.8 (below Meacham Cr.)			74.2	71.4	73.8	74.3
13l	Umatilla River, RM 79 (above Meacham Cr.)		71.2	72.1	69.3	72.6	
13l	Umatilla River, RM 81.7 (USGS gage)		71.3	74.0	70.1	73.1	70.3
13c	Umatilla River, RM 89.5 (Corporation)		63.7	65.0	63.1	63.1	64.1
13d	N. Fk. Umatilla River (USFS gage near mouth)			60.1	58.3	59.6	57.2
13k	S. Fk. Umatilla River (USFS gage above N. Fk.)			68.9	67.6	69.6	66.3
13k	S. Fk. Umatilla River (above Shimmiehorn)			64.8	61.0	66.9	
13i	Spring Creek			64.4			
13j	Shimmiehorn Creek (at mouth)	63.6	65.3	62.6	59.7	62.8	
13a	Ryan Creek, RM 1.3				63.9		
13c	Bobsled Creek				64.9		
13g	Buck Creek (at mouth)				57.7		
89b	Meacham Creek, RM 2 (USGS gage)			78.5	74.4	77.9	74.8
89b	Meacham Creek (reservation/USFS boundary)			79.4	74.7	77.8	76.3
89j	Meacham Creek, RM 13 (above N.F. boundary)				72.5[1]		
89c	Camp Creek					65.6[1]	
89f	N. Fk. Meacham (USFS boundary)			67.7	65.4	71.5	
89k	East Meacham Creek				64.4[1]		64.0[1]
89n	Butcher Creek				56.8[1]		58.3[1]

1 Sites where monitoring was discontinued in late July. Seven-day maximum temperature may not have been reached.

Table 3-10. Spawning season temperatures of a sample of Chinook salmon streams in the Umatilla and Meacham watersheds, recorded August 13-18, 1993. Data are the average of the maximum daily temperatures from August 12 through August 18, 1993

Stream	7-Day Average Maximum. Temperature (degrees F)
Lower South Fork Umatilla	62.3
Lower North Fork Umatilla	54.4
Umatilla at Corporation	58.1
Buck Creek	55.4
North Fork Meacham at NF boundary	60.1

In the upper Umatilla watershed (above the mouth of Meacham Creek), none of the stream reaches for which full season data were available met PACFISH or the new Oregon state standards for water temperature. Some, notably the North Fork of the Umatilla River (60.1 degrees F), Buck Creek (62.9 degrees F) and Shimmiehorn Creek (62.8 degrees F) were fairly close to PACFISH standards. In fact, temperatures in the North Fork of the Umatilla River were colder than PACFISH maxima in 3 years out of the 4 for which records are available. In these streams, when temperatures do exceed PACFISH standards, it will be by only a few degrees for a few days each year. Other streams in watershed 13, most notably the lower South Fork of the Umatilla River, were warmer than PACFISH maxima every year for which records are available.

Temperatures in main-stem Meacham Creek, on the other hand, have been warmer than PACFISH maxima by a wide margin in all years of record (Table 3-9). None of the streams in the Meacham creek drainage for which full summer records are available are within PACFISH standards.

Bull Trout have been reported in streams in both Meacham and the upper Umatilla watersheds. The strongest population resides in the North Fork of the Umatilla River. Perhaps it is not coincidental that this stream produces the strongest flow of consistently cool water of either watershed. Reports of bull trout in all other streams of these two watersheds cite observations of one or a few fish. The DEQ 50°F standard for water temperature should apply to those streams that host bull trout (North Fork Umatilla, South Fork Umatilla, Buck Creek, Shimmiehorn, Upper Mainstem Umatilla, Ryan Creek, North Fork Meacham, Pot Creek and mainstem Meacham below the Confluence with North Fork Meacham). These streams do not meet the less stringent PACFISH standard for anadromous fish, nor do they meet the DEQ standards for bull trout streams.

Even though these streams do not meet the DEQ standards for bull trout streams, they might meet the slightly less stringent requirements for chinook salmon. According to the DEQ standards, water temperatures in these streams should not exceed 55°F (7-day moving average of the daily maximum) during the time that chinook are spawning, or their eggs are in the gravel or the fry are emerging. In the Umatilla and Meacham watersheds, chinook salmon utilize a slightly smaller range than do bull trout (compare Figure 3-3 to Figure 3-4). Chinook spawn in North Fork Umatilla, mainstem Umatilla below the North Fork, and in lower mainstem Meacham from about mid-August through September. Temperatures in these streams usually begin to drop by mid-August and do not begin to warm up much till the following spring or summer. Therefore, the greatest likelihood of water temperatures exceeding DEQ criteria would be from about August 15 through mid September. Seven-day moving average maximum water temperatures on August 15, 1993 (Table 3-9) show that only the North Fork Umatilla River was within DEQ standards for salmon streams. The salmon spawning stream next closest to meeting the DEQ standards was North Fork Meacham Creek, but the daily maximum temperature of North Fork Meacham Creek did not consistently fall below 55°F until late September in that year. In fact, none of the streams in the Meacham Creek system, for which records are available, would meet DEQ standards for Chinook salmon waters. Even the North Fork Umatilla did not meet DEQ standards for salmon streams by August 15 in 1992 or 1994. Since 1993 was a relatively cool water year for this area, it seems reasonable to conclude that these streams probably do not meet DEQ standards for Chinook streams in most years.

Bjornn and Reiser (1991) state that 23.9 ºC (75ºF) is the lethal limit for steelhead and between 29.4 (84.9ºF) and 25.0ºC (77ºF) as the upper lethal limit for rainbow trout, depending on acclimation temperature. Although some salmonids can survive at relatively high, but sublethal, temperatures, most are placed in life threatening conditions when temperatures exceed 23 - 25ºC (73-77ºF). Temperatures in the south fork or the main-stem of the Umatilla River within the Forest boundary have not reached these temperatures in any years of record. However, vigor and productivity are usually reduced and susceptibility to disease increased when temperatures vary much from the optima. Bjornn and Reiser (1991) list preferred temperatures for Steelhead as 10 - 13ºC (50 - 55.4ºF). Temperature records are not available for many of the streams in the upper Umatilla watershed, but all of the lower reaches probably surpass these levels for at least a few days each year, and in some cases, for most of the summer. On the other hand, in the main-stem of Meacham Creek, below the forest boundary, temperatures reach life-threatening levels (for salmonids) most years. High pre-spawning mortality of chinook salmon in these streams, and in the main-stem Umatilla river downstream of the analysis area, is probably related to these elevated temperatures (personal communication, Paul Kissner, CTUIR). It seems reasonable to conclude that during mid and late summer in the lower reaches of the Meacham and Umatilla watersheds, all salmonids, and particularly bull trout, are probably existing at or near their maximum temperature tolerance levels.

Reference data are insufficient to establish clear links between high water temperatures and past management of the upper Umatilla and Meacham watersheds. However, the adverse effects of roads, timber harvest and grazing on aquatic habitats are well established (Meehan 1991; Platts 1991). Thus, where elevated temperatures or other poor quality habitat parameters exist in areas that have experienced road construction, timber harvest or grazing, it is likely that past management activities may have contributed to those conditions. Because of differences in various physical characteristics (soil depth, elevation, slope steepness, precipitation, it is reasonable to conclude that the South Fork of the Umatilla River and most of Meacham Creek have historically had higher water temperatures than the North Fork Umatilla. However, this difference is probably magnified by the domestic grazing, streamside roads, railroad, timber harvests, and other management activities.

Fish populations

Three Salmonid species; chinook salmon, steelhead and bull trout are of particular interest in these watersheds. All species have experienced declines relative to their historic population levels. Re-introduced chinook salmon are now returning and spawning in parts of the Umatilla River and Meacham Creek (Contor, Hoverson and Kissner, 1995). They are not yet spawning in numbers sufficient to ensure a self-sustaining population. Steelhead are probably doing somewhat better than chinook and utilize a wider range of streams, but hatchery supplementation is still practiced.

Huntington, Nehlsen and Bowers (1996) conducted a survey of anadromous salmonid stocks in the Pacific Northwest and Canada for the purpose of identifying healthy stocks of native salmonids. The present Umatilla River chinook stock are not native and thus were not considered. The steelhead stock, which is native, was not listed either because the run has diminished, or it is hatchery supplemented. The report does not list any of the runs in the analysis areas as "healthy stocks".

Bull trout are present in many of the streams in these watersheds, but records usually cite observations of only one or a few fish. Reproducing populations are known to exist only in the North Fork Umatilla, North Fork Meacham, and Pot Creek.

The Umatilla National Forest Land and Resource Management Plan (1990, Chapter 4) identifies one of the management goals as providing and maintaining a diverse, well-distributed pattern of fish habitats to assist in doubling anadromous runs in the Columbia River Basin by the Year 2000, in cooperation with Native American tribes, states, and other agencies. The goal applies to all areas dominated by riparian vegetation, including areas containing anadromous and resident fish habitat, perennial and intermittent stream courses, wetlands, and floodplains. The Forest Plan describes desired future conditions of the Forest after 10 years as "The number of rainbow trout on the forest will have increased as a result of habitat improvements and anadromous fish production will increase dramatically". Lacking long term historic data for fish numbers in the Umatilla River and Meacham Creek systems, it is not possible to substantiate changes in rainbow trout populations since development of the Forest Plan. Data from CTUIR monitoring of steelhead redd counts beginning in 1985 (Contor, Hoverson, Kissner 1995) show fluctuation in numbers of anadromous fish, but no dramatic increase. We are now near the end of the 10-year period of the Forest Plan and it is quite clear that the Forest has not reached the desired future condition with the Umatilla and Meacham watersheds. Since both rainbow trout and steelhead are identified by the Forest Plan as "management indicator species", it should follow that a lot of the other species using the aquatic habitat has not substantially improved either. The fact that rainbow trout and steelhead are probably the hardiest and most adaptable of all local native salmonid species, implies that they are probably a poor choice as management indicator species. By the time that rainbows begin to show the effects of habitat degradation, populations of other, more sensitive species may have already been severely damaged. Steelhead, on the other hand, spend most of their life cycle outside of the stream reaches on National Forest, and thus their population strength is more indicative of habitat conditions elsewhere. An organism more sensitive to habitat degradation, like bull trout, would be a better choice for a management indicator species. Certain aquatic insect species might be the best choice for an indicator species.

Survey data indicate that the population size of bull trout is below the necessary 50-100 redds/year (Rieman and McIntyre, 1993) for a secure, self-sustaining population. There are actually two reproducing populations, one in the North Fork Umatilla River (< 30 redds/year) and one in upper North Fork Meacham/Pot Creek (3 - 4 redds/year). Occasional single redds have been found in other streams in the drainage. The nearest sister population is in the South Fork of the Walla Walla River, separated from the mouth of the Umatilla River by the McNary Dam. The next nearest is the population in the North Fork of the John Day River, over 200 miles away separated by a long stretch of slack water behind the John Day dam. These conditions make it unlikely that the bull trout habitat in the Umatilla River system would be re-colonized should the local population be extirpated. These combined factors of isolation and small population size imply that the Umatilla Basin bull trout population is at high risk of extirpation (see Rieman and McIntyre 1993). For this reason and others, it seems preferable to manage and evaluate these streams primarily as bull trout habitat and secondarily as salmon/trout/steelhead habitat. If the bull trout subpopulations in both North Fork Umatilla and North Fork Meacham were strong and had an open connecting corridor between them the risk would be much reduced. Rieman and McIntyre (1996), in a study of spatial and temporal variability in bull trout redd counts, found that spatial heterogeneity in habitat, population demographics, or life history at the local scale are important to stability of regional populations. They recommended that conservation management should favor maintenance of multiple local populations relatively close together to facilitate dispersal and demographic support or individual populations and patches large enough and stable enough to insure local persistence in the face of environmental variability.

Efforts to strengthen the subpopulations in the upper Umatilla and Meacham watersheds and improve the corridor between them will enhance the long-term viability of both subpopulations and also of steelhead and chinook salmon and will also contribute to the long-term stability of regional populations of bull trout.

Fish Conservation Measures

Recommended Refuge Reaches

Given the overall conditions in the analysis area, it is appropriate to identify subwatersheds and specific stream for habitat protection for bull trout and the other salmonids. Subwatersheds that contain the best remaining habitat and also active spawning habitat of bull trout are 13D, lower North Fork Umatilla and Coyote Creek; 13E, the upper North Fork Umatilla; 89G, the upper North Fork Meacham; and 89H, Pot Creek. Two more subwatersheds, 13A, Ryan Creek, and 89I, Bear Creek are not known to contain currently used spawning habitat for bull trout also appear to contain some of the best remaining salmonid habitat. One additional subwatershed, 89F, has habitat that rates poorly from the stream survey statistics, but contains known bull trout spawning area. This subwatershed has had almost no management activity and is immediately downstream of two subwatersheds with excellent habitat. Three subwatersheds, 89G, 89H, and 89I should be identified as a refuge area. Four more watersheds contain aquatic habitat that is in fair to good condition and, given time and restoration efforts, these areas could also provide suitable habitat. These are 13G along Buck Creek, in 13J along Shimmiehorn Creek, in 89G along Camp Creek, and in 89L along Owsley creek. Refugia are shown in Figure 3-9.

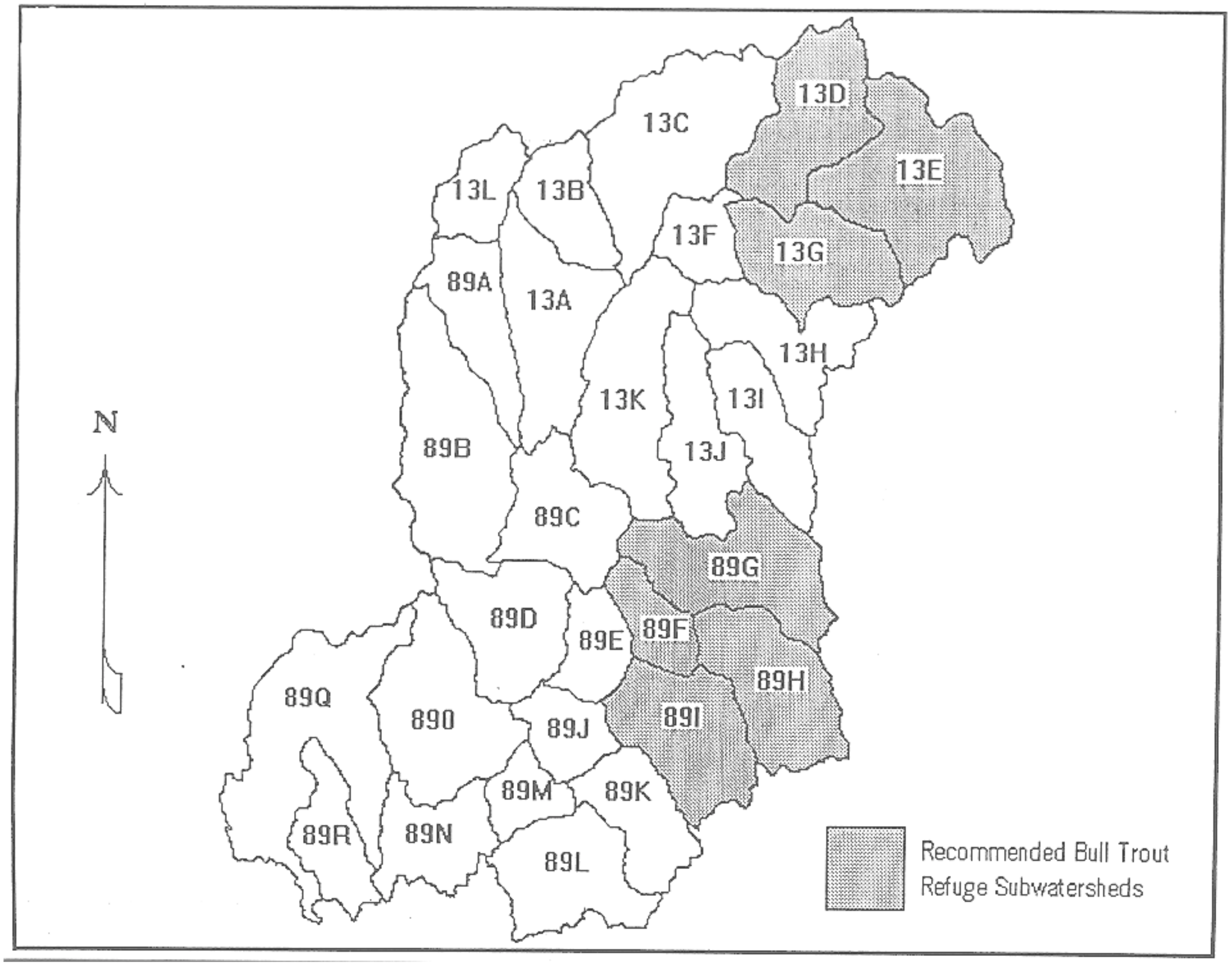


Figure 3-9. Umatilla & Meacham reference and refuge subwatersheds.

Migration Corridors for Bull Trout and Anadromous Salmonids.
The reproducing populations of bull trout in North Fork Umatilla and North Fork Meacham Creek must be considered at risk because of their small size and isolation from other segments of the larger metapopulation. Providing for continuous habitat between these populations is important. A corridor for these populations would consist of the portion of Meacham Creek downstream of the mouth of North Fork Meacham and reaches of the Umatilla River downstream of the mouth of North Fork Umatilla as far as the mouth of Meacham. Steelhead also use these stream channels to migrate to the reaches and tributaries where they spawn. Chinook salmon use these reaches for both spawning and migration. Both chinook and steelhead use these reaches for rearing. Protection and restoration of this migration habitat is essential to the long-term survival of the two bull trout populations and will also benefit the chinook salmon and steelhead. Most of this corridor is not on National Forest land. Management of these lands in ways that would protect and improve their function as migration corridors will require cooperation between state, private, tribal and federal agencies and landowners. Suitable migration habitat requires escape and hiding cover, holding water for rest during migration and while awaiting spawning conditions, and sufficient stream flow and appropriate water temperature during migration periods. The Forest Service could help support the bull trout populations by working to ensure that these needs are met on the National Forest portion of the stream. Meeting these needs on other parts of the stream is also essential and would require

efforts by other parties and cooperation of landowners. Some of the habitat needs in these stream reaches have already been addressed. In-stream structures, which can serve as holding water during migration, have been built on both private and National Forest land. More hiding and escape cover would likely improve migration and spawning success. The most effective way to provide this over the long term would probably be to plant appropriate tree species for shade and future woody debris, and severely restrict livestock access to the riparian zone.

Riparian Habitat Conservation Areas

Riparian Habitat Conservation Areas (RHCAs) serve as an important part of watershed management by providing several important functions or components to aquatic habitat. In-stream woody debris is produced within the RHCA of class one, two and three streams and is itself a component of several other important habitat parameters. Much of the woody debris for class four streams may come from outside of the PACFISH RHCA. In-stream woody debris functions as hiding and escape cover, a food source for some aquatic invertebrates and thus indirectly for fish, pool forming structure, helps trap sediment and agrade the stream channel, increase stream roughness and energy dissipation, and in general adds to habitat complexity.

Living trees within RHCAs provide shade to the stream and thus function importantly in maintaining low water temperatures. They also support insects, which may eventually serve as food for fish. The distance over which trees provide shade to the stream varies with tree height, hill slope, latitude and aspect. Geier-Hayes, Hays and Basford (1995) give a methodology for calculating tree shade length based on these parameters. Although this methodology was developed for silvicultural purposes (provision of sufficient shade to regeneration sites), it appears that it could be readily adapted to stream shading purposes. Generally, shade over the stream is provided by trees within one tree height of the stream channel. However, the specific RHCA widths necessary for this function could be calculated for various combinations of aspect and slope at the latitudes of the Umatilla and Meacham watersheds.

Erosion control and sediment trapping management activities such as timber harvest, roads and livestock grazing all hold the potential for contribution of excess sediment to streams. Leaving a strip of unmanaged land between management facilities or activities and the stream channel can help trap sediment before it enters the stream, provided that the sediment flow is non-channelized. A review by Belt et al. (1992) concluded that non-channelized sediment flow rarely travels more than 300 feet and that 200 to 300 feet wide filter strips are generally effective at protecting streams from sediment from non-channelized flow.

Riparian microclimate conditions may extend as far as three tree heights for at least one parameter (relative humidity, FEMAT, 1993). Other microclimate attributes appear to lose their riparian character within two tree heights or less from the stream bank. If vegetation is removed up to or within the riparian zone, an edge is created that may affect the interior microclimatic conditions of the riparian forest.

Of the three reasons cited above for establishing RHCAs, the third, a sediment filter strip, would usually be satisfied with a 300-foot wide buffer on each side of the stream channel. The first two are satisfied by a buffer width of one tree height. However, an additional tree height, a sort of buffer for the buffer, could help maintain microclimate conditions within the RHCA. This seems prudent, especially for the more arid, eastside forest types found in the Blue Mountains. Width for a functional microclimate buffer should be at least a second tree height beyond that needed for woody debris recruitment or stream shade.

Data of timber stand exams completed by Walla Walla Ranger District personnel (data supplied by Nancy Berlier, Silviculturist, Walla Walla Ranger District) revealed that the average maximum tree height in stands found in the canyon bottoms along Umatilla River and Meacham Creek was 104.4 feet (n = 69, std. dev. = 23.4. If a "functional" tree height is taken as the mean plus one standard deviation, RHCA widths based on tree heights would be 128.8 feet (single tree height) or 257.6 feet (two tree heights).

PACFISH specifies RHCA widths as two tree heights or 300 feet, whichever is greater, for fishbearing (class one and two) streams and one tree height or 150 feet, whichever is greater, for non-fishbearing perennial (class three) streams. Since the tree height figures are the smaller numbers, the linear distance criteria would apply here.

Most of the RHCA functions discussed above are just as important in class three streams as in class one or two streams. Wood is not needed here for fish habitat complexity, but its function in sediment detention and stream roughness are just as important in class three as in class one or two streams and certainly shade to maintain cool water temperatures is important in reaches upstream of fish bearing portions of streams. It is therefore difficult to understand why RHCAs should be narrower in class three than in class one or two streams. And the corollary question is: why should RHCAs be wider on class one or two streams, if the narrower version is adequate for the class three reaches?

The smaller PACFISH RHCA widths for intermittent (class four) streams are easier to understand, since these streams, by definition, do not flow during the time when shade is needed to moderate water temperature increases and because of their smaller sizes, smaller sized woody debris would meet the needs for sediment detention. However, class four streams should be just as vulnerable to sediment introduction to the stream channel as any other class of stream. Once sediment begins moving as channelized flow, it may travel a very long way, well into the class three or two or one streams. Wherever there is high risk of sediment production by management activities, it is difficult to see why class four streams would need less protection than any other.

It seems that the most effective design of Riparian Habitat Conservation Areas would account for local conditions, of both the stream and the terrestrial environment nearby, and also the type of contemplated management activity. Where water temperature is a concern, RHCA design would ensure ample shade to the stream. Where fish cover and habitat complexity are of concern, RHCA design would ensure that plenty of wood would remain available for present and future needs. Where non-channelized sediment flow is a concern, buffer width sufficient to prevent sedimentation of the stream channels would be assured.

RHCA implementation in these two watersheds could take one of two paths. Specifically, they could use the PACFISH RHCAs as they stand, or RHCAs could be designed specific to the needs of the aquatic and riparian habitat and the contemplated management in each subwatershed. For the latter, evaluations of habitat quality as presented in other parts of this document could be used to determine the habitat concerns specific to the stream, stream reach, or subwatershed, *including downstream reaches*. RHCA widths should then be designed to address these concerns. In addition, the following information should be considered in the construction of RHCAs:

1. Temperature is a concern for all streams in these watersheds. It is most serious outside of the North Fork Umatilla River.

2. Although woody debris frequencies meets PACFISH standards in many streams, more would be beneficial to fish and aquatic habitat in all of the streams in the area. It is probably impossible to produce too much woody debris in the riparian forests of the Blue Mountains.
3. Although sediment quantities are not yet exceeding levels that would mark degraded systems in most National Forest streams in these watersheds, some subwatersheds are close (13E, 13I, 13J, 89E, 89F) and some stream reaches are at levels that warrant attention.

   NOTE: The basis for this finding was questioned during a review of this document. In response, the Hydrology and Fish Specialist Reports were reviewed by the Forest Fish Biologist. He felt that there was support for this finding, although not overwhelming support. He also felt the case for including 89F in the list was weaker than for the other listed subwatersheds.
4. It is probably possible to address habitat and management concerns through a split RHCA with an inner zone of 150 feet in which all trees would be left for aquatic and riparian habitat needs, roads will not be built, livestock not grazed and in general management would be minimal, and an outer zone of another 150 feet in which some management might occur when it will improve the quality of riparian and aquatic habitat. In general, soil disturbing or compacting activities ought to be avoided. Retaining natural vegetation density for two tree heights (258 feet) would help maintain the riparian microclimate. For reasons given above, this split RHCA should be applied to class three as well as class one and two streams. RHCAs for class four streams should allow for adequate wood in the stream channel and should be particularly sensitive to risk of erosion and sedimentation. From the perspective of protection of aquatic and riparian resources, RHCAs on class four streams would most often be wider than PACFISH standards, especially on steeper slopes or where contemplated activities could expose or compact soil, remove natural obstructions to flow, or initiate channelizing of flow. In the suggested refuge subwatersheds, it would also seem prudent to allow wider RHCAs on class four streams to ensure extra security for the special values resident there.
5. Because roads often serve as extensions of the stream channel, wherever roads occur within the RHCA, the RHCA should be adjusted to begin at the upper cut slope of the road.

Other resource needs may also be addressed through design of RHCAs. For example, some fine tuning of some components of RHCAs might also allow them to serve well as wildlife habitat and migration corridors. Needs and recommendations of wildlife are presented in the wildlife section of this analysis.

Table 3-11. Summary of PACFISH compliance by subwatershed

Name (subwatershed)	Parameter			
	Temperature	Width/ depth	Pool Frequency	Wood Frequency
Ryan Creek (13a)	X		ND	
Hagen (13b)	X	?	?	?
Bear (13c)	X		X	
Lower N. Fk. Umatilla (13d)			X	
Upper N. Fk. Umatilla (13e)			ND	
Lower S. Fk. Umatilla (13f)	X		X	
Buck Creek (13g)			ND	
Thomas Creek (13h)	X		ND	
Spring Creek (13i)	X		ND	
Shimmiehorn Creek (13j)	X		ND	
Upper S. Fk. Umatilla (13k)	X		X	
Gibbon (13l)	X	ND	X	X
Boston Canyon (89a)	X	ND	ND	X
Bonnifer (89b)	X	ND	X	X
Camp Creek (89c)	X	ND	ND	
Middle Meacham (89d)	X	?	?	?
Lower. N. Fk. Meacham (89e)	X	X	X	X
Middle. N. Fk. Meacham (89f)	X		ND	
Upper N. Fk. Meacham (89g)	ND		ND	
Pot Creek (89h)	ND		ND	
Bear Creek (89i)	ND		ND	
Upper Meacham/Wilbur (89j)	X		X	X
East Meacham (89k)	X	ND	ND	ND
Owsley (89l)	ND	ND	X	Probably
Upper Meacham/Short (89m)	X		X	X
Butcher (89n)	?	ND	ND	ND
Upper Meacham/Allen (89o)	X	ND	ND	ND
Todd/Beaver/Sheep	X	ND	X	ND
Upper Meacham (89r)	ND	ND	X	ND

*Based on averages over the subwatershed, or values for the main-stem stream within the subwatershed, or extrapolation of values from upstream watersheds. Values for some tributaries within the subwatershed may not be reflected in this summary.
ND Indicates data not available in PACFISH units or PACFISH standards not applicable in this case.

CURRENT AND REFERENCE CONDITIONS FOR FOREST VEGETATION

Overview

This section describes the current forest vegetation in the Umatilla and Meacham watersheds and compares it to several reference conditions. The comparison of current and reference conditions were made to assess changes in forest vegetation since pre-settlement era, using forest stand metrics like stand density, structure, and species composition. Reference conditions were based on data from 1936, 1958, and an estimate of pre-settlement vegetation. Disturbance agents that have been responsible for vegetation changes, like fire, logging, insects and diseases are then discussed. The impacts of the human-caused disturbances on sustainability of forest vegetation is evaluated, along with assessment of the sensitivity of subwatersheds to future ground-disturbing activities.

As a whole, these data and analyses summarize changes in forest vegetation since pre-settlement times, and the various disturbance agents that have brought about these changes. Disturbance is an integral part of forest ecosystems in the Blue Mountains, and it is important to understand how recent changes the frequency and magnitude of disturbances have affected forest vegetation and dependent species within the analysis area. This promotes a better understanding of how forest management can operate to help restore the long-term balance between natural disturbance agents and forest vegetation, and ultimately maintain and enhance ecosystem function and diversity.

Comparison of 1937, 1958, and Current Forest Vegetation

Comparisons were made between current vegetation, 1936, and 1958 for three attributes: non-forest lands, forested cover type, structural stage, and specie cover type. Current vegetation conditions were derived from the Umatilla National Forest existing vegetation (EVG) database (Umatilla National Forest, GIS Data Dictionary, 1999). This database contains both photo interpreted and field-recorded stand exam information. The former were based on 1989-1990 resource photo-interpretation. The latter data from stand exams were collected between 1990-1998. Thus the data represents a composite view within the decade. It is heretofore referred to as the “current” vegetation. The 1936 and 1958 data were obtained from mapping completed by the Pacific Northwest Forest and Range Experiment Station in 1958 and 1936 (Powell 1999). The 1958 type maps were somewhat more detailed than the 1936, although both maps were created at a very broad scale. Direct comparison of these maps and current vegetation was made difficult by differences in the classification methodology and the coarse mapping standards of the historical maps. Thus comparisons are made with some level of uncertainty.

Changes in Forest versus Non-Forest Land Area

Of the approximately 147,700 acres of National forest land within the analysis area, about 48,800, or 33 percent is currently non-forest. These are mostly dry meadows or bunchgrass grasslands dominated by fescues and bluebunch wheatgrass. Shrublands are uncommon in the analysis area, although a large array of shrubland types is present. Areas of sparse vegetation (<15% cover) and rocky scablands cover slightly more than 1,000 acres. The abundance of non-forest vegetation is an interesting feature of the analysis area. Often, the non-forest vegetation occurs in a matrix of forest and grassland referred to as a *grass tree mosaic*. This condition is perpetuated edaphic or physiographic conditions (such as shallow soils on steep, southerly exposures); and disturbances like fire that allows grasslands to “hold its ground” against tree invasion.

The data indicate that there is slightly more (1,300 acres) forested area now than in 1958 (Table 4-1). Non-forest vegetation actually had a net increase in the Umatilla Watershed between 1958 and 1999, whereas the Meacham drainage experienced a substantial net decrease (Powell 1999). Neither the 1936 nor 1958 vegetation maps provided a detailed breakdown of non-forest vegetation types. Most of the non-forested area was classified as grassland in 1958, with the rock and sparse (scabland) types aggregating another 1,180 acres. In 1936, all of the non-forest vegetation was shown as a single non-forest cover type.

Forest Cover Types

Forest cover type was examined within the analysis area to determine changes in species composition over time. A cover type is based on a plurality of stocking, as measured by canopy closure. For example, a stand that is classified as grand fir must have at least 50 percent of the total canopy closure in grand fir. It may also contain an admixture of Douglas-fir, western larch, ponderosa pine, and other species. A stand in which one species does not have more than 50 percent of the total stocking is classified as a mixed conifer cover type.

The predominant forest types in the analysis area are Douglas-fir, constituting about 36 percent of the forested area (Table 4-1), and grand fir, which occupies about 29 percent of the forested area. Comparison of present-day and 1958 cover types (Table 4-1) showed that the predominant forest type in 1958 was also Douglas-fir (25% of the forested area), followed by the grand fir (18%) and ponderosa pine (13%) cover types. A direct comparison cannot be made between the 1958 and 1999 forest types cannot be made since the 1999 vegetation map did not include a “mixed” category. Even so, much of the vegetation typed as Douglas-fir, ponderosa pine, and western larch in 1958 was apparently reclassified as “mixed” forest in 1999. In 1936, the predominant cover type was mixed forest (36% of the forested area for which 1936 mapping was available), followed by the grand fir (14%) and ponderosa pine (10%). The most significant change between 1958 and 1999 is the decline in the acreage occupied by ponderosa pine, and to a lesser extent, western larch. 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). Minor forest types such as hardwoods (black cottonwood and aspen) have also declined between 1958 and 1999 (Table 4-1). This vegetation trend reflects the diminished role of fire, flooding (an important ecosystem process for obtaining cottonwood reproduction), grazing (Case, Kaufmann, and Boone 1997), and other disturbance processes that create the ecological niches required by early-seral hardwood species.

Table 4-1. Acres by forest cover types and percent cover type out of all lands for National Forest land in the Umatilla-Meacham analysis area. See Powell (1999) for additional information.

Code	Dominant Vegetation	1999	1999 %	1958	1958 %	1936	1936 %
BU	Burned area					24	
CA	Subalpine fir	1342		2,907		1,061	
CC	Clearcut			2			
CD	Douglas-fir	36,572		37,737		6,065	
CE	Engelmann spruce	1538		1,297			
CL	Lodgepole pine trees	452		1,732		1,072	
CP	Ponderosa pine trees	6723		19,257		14,468	
CT	Western larch trees	1160		7,790		2,664	
CW	Grand fir trees	28,966		27,265		20,767	
HC	Hardwoods			97		101	
Mix	Mixed conifer	21,905				53,190	
NF	Nonforested lands	48,822		50,154		48,626	
	Unclassified			156		356	
	Total Land	147,698					
	Total Forested Land	**98,876**		**98,084**		**98,326**	

Forest Size Classes

The predominant size class in the current vegetation is a mixture of small and medium trees, which occupies 46 percent of the forested area (Table 4-2). 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 percent of the forested acreage, poles and the lower-half of the small-tree class (5-14.9" DBH) on 15 percent, medium and large trees (21-47.9" DBH) on 3 percent, and seedlings and saplings (0-4.9" DBH) on the remaining 2 percent.

In contrast, 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.

Table 4-2. Acres of forest size classes for national forest lands in the Umatilla and Meacham analysis area. See Powell (1999) for description of data sources.

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

The data indicate that current size classes are more widely distributed compared to 1958 or 1936. This change may well be due to different mapping standards between the 1936, 1958 and the current maps. Specifically, the 1936 and 1958 mapping was coarser and may have been biased toward large trees. However, it is very likely that most of these changes are the result of timber harvesting and insect mortality. Commercial timber management has removed large-diameter trees and forest regeneration replaced them with stands of seedling-sized trees. In addition, 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). Mortality from wide-area outbreaks of defoliating insects (primarily budworm and tussock moth) also resulted in new stands of seedling and saplings.

Another important difference is that, in 1958, stands dominated by medium or large trees comprised 60 percent of the forested area; in 1936, medium or large trees occupied about 73 percent of the area. By 1999, the forested area supporting medium or large trees had apparently declined to 49 percent. The differences in mapping resolution mentioned above may well be responsible for this change. However, plant succession coupled with natural and human disturbances (insects, disease, fire, timber harvest) most likely played a significant role in reducing the abundance of large trees.

Forest Density

Density classes were calculated using percent canopy closure. For unknown reasons, a density class was not assigned to a substantial portion of the forested area in the 1936 and 1958 mapping. This makes comparisons difficult. The predominant current forest situation is moderate-density stands (those with 41-70% canopy cover), which occurs on 54 percent of the forested lands (Table 4-3). Low-density forests (10-40% canopy cover) occupy 31 percent of the forested area, with the remaining 15 percent supporting high-density stands (71-100% canopy cover). In contrast, 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.

Table 4-3. Acres of forest density classes for National Forest lands in the Umatilla and Meacham analysis area. See Powell (1999) for a description of data sources.

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

A comparison of the forest density data suggests that the mix of forest density classes is more uniformly distributed 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 1974-1974 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 (Powell 1999). From the perspective forest vegetation sustainability, 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.

Forest Structural Stages

Forest structure was classified using the ICBEMP structural classifications (Hessburg et al. 1999). The predominant upland-forest structure in the analysis area is understory reinitiation, a stage occupying 41 percent of forested lands (Table 4-4). 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%). In contrast, 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 1% of the area.

These data indicate that old forest structure is less common now than in 1958. In 1958, old forest structures comprised 63 percent of the forested area. By 1999, old forest had apparently declined to only 18 percent of the area. This change is probably due to several factors. First, there were 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. A key factor was also 90 years of fire suppression, which 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. Finally, disturbance processes, insect and disease outbreaks, windstorms, droughts, timber harvests and other disturbance events have occurred during the last 40 years. Many of those processes have reduced the distribution and abundance of old forest structural stages.

The data also indicate that the mix of forest structural stages is apparently more diverse now than in 1958 or 1936. As was discussed in the above discussion of forest size classes, the primary reasons for structural-stage changes were: 1) commercial timber management program removed large-diameter trees and replaced them with regenerated stands of seedling-sized trees; 2) 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); 3) 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 1936 and 1958 mapping was coarser and may have been biased toward large trees and their associated structural stages).

It is interesting to note that timber harvest alone cannot be used to explain a reduction in old forest structure. Since 1956, timber harvests have affected a relatively small proportion of the analysis area, about 10 percent of the forested land within the entire analysis area. In the Umatilla watershed, about 14 percent of the forested land has either had a regeneration harvest or an intermediate cut, and within the Meacham watershed the total is about 6 percent of the forested land. 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 (see Table 19 in Powell 1999).

Table 4-4. Acres by forest structural stages for the Umatilla-Meacham analysis area.

Code	Forest Structural Stage	1999		1958	1936
SI	Stand Initiation	18,068	9683	100	9,314
SEOC	Stem Exclusion, Open Canopy	4,361	23761	420	315
SECC	Stem Exclusion, Closed Canopy	2,262	6002	5,743	13,818
UR	Understory Reinitiation	40,921	688	26,591	1,864
YFMS	Young Forest, Multi Strata	15,625	17870	3,253	3,425
OFMS	Old Forest, Multi Strata	13,870	28821	42,652	57,389
OFSS	Old Forest, Single Stratum	3,769	11965	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	

Reference Conditions for Forest Vegetation

Reference conditions for vegetation were estimated using several methods and compared with current vegetation. Three factors were compared, namely, forest structure, species composition, and stand density. This comparison measures ecosystem changes that are free of major influence by Euro-American humans, providing an insight into the characteristics of sustainable ecosystems (Kaufmann and others 1994). This analysis may help managers to understand what an ecosystem is capable of, how historical disturbance regimes operated, and the underlying variation in ecosystem processes and functions. In other word, how are patterns, connectivity, seral stages, and cover types produced by ecological processes operating at a landscape scale (USDA Forest Service 1997).

Potential Vegetation

Potential vegetation describes the inherent productivity and is required to estimate several components of reference vegetation. Potential vegetation is classified in a hierarchy of levels from ecoclass at the finest level to potential vegetation group (PVG) at the coarsest. The PVG acres within the analysis area by each ecoclass group were derived from the Umatilla National Forest PVG Layer (Powell 1999). The Umatilla and Meacham watersheds contain 57 ecoclasses that represent 10 plant association groups, or *ecological settings* (Table 4-5). Most of the area is either non forest, cool moist, and warm dry (Table 4-6).

Table 4-5. Potential vegetation hierarchy for the Umatilla/Meacham ecosystem analysis area.

PVG	PAG	Abbreviation	Common Name of Vegetation Type	Area
		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
		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
		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
		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
	D t	PIPO/AGSP	Ponderosa Pine/Bluebunch Wheatgrass	470

PVG	PAG	Abbreviation	Common Name of Vegetation Type	Area
		PIPO/FEID	Ponderosa Pine/Idaho Fescue	354
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

Notes: "Pct" after a common name refers to a plant community type (a seral or successional plant community); all other vegetation types are plant associations. See Powell (1999) 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 4-6. Acres of upland-forest plant association groups by subwatershed (SWS) for National Forest Lands. See Powell (1999) for descriptions of classification system.

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	

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)
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

Stand Structure

The reference and current conditions for stand structures were compared using a process that has been termed *historical range of variation* (HRV). In this case, *historical* is defined as the conditions that existed under natural disturbance regimes (see Powell 1999).

The reference conditions for stand structure was defined as the proportion of each stand structure that existed under natural disturbance regimes. These data derived from Hall (1993), Johnson (1993), and USDA Forest Service (1995), as summarized in Blackwood (1998). This array of proportions was then compared to the current array of structures as determined from the EVG database. The comparison is done individually for groups of ecoclasses that experience similar natural disturbances (Plant association groups, or PAGs, Table 4-5). The difference between the expected proportions and the current array indicates long term changes in stand structures, and, in some cases, unsustainable conditions.

The HRV reference condition is intended to serve as a benchmark from which change can be measured; and 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 results from this kind of analysis to direct management objectives. A better approach is to use the results to understand 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.

The results of the comparison of reference and existing structures are shown individually for each watershed in Table 4-7. 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.

When the existing forest structures are compared to what might be expected given the potential vegetation in the study area, 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 below HRV for one or more of the watershed/PAG combinations. Stem exclusion closed canopy (SECC) and young forest multi strata (YFMS) are also below HRV for certain plant association groups. Understory reinitiation (UR) is consistently above HRV because it has a “surplus” for almost every watershed/PAG combination.

Table 4-7. Historical range of variability (HRV) analysis for forest structural stages.

PAG			Upland Forest Structural Stages							NFS Acres
			SI	SEOC	SECC	UR	YFMS	OFMS	OFSS	
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

Forest Density

Forest density was evaluated using the canopy cover percentages available from the 1999 EVG database, in conjunction with suggested stocking guidelines for Blue Mountain forests (Cochran and others 1994). The stocking guidelines use potential vegetation to determine sustainable stand densities. 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 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 (Powell 1999).

The results of the stocking analysis are provided in Table 4-8. It summarizes the National Forest acreage in each of five canopy-cover classes, by plant association group, for the two watersheds in the analysis area. The black cells show 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; and the results in Table 4-8 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.

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).

Table 4-8. Forest density analysis by watershed.

PAG		Area (NFS Acres) By Canopy Cover					Total Area	Over-Stocked
		11-25%	26-45%	46-65%	66-75%	>75%		
Meacham Watershed	CD	338	329	244	**53**	**196**	1,160	249
	CW	137	116	155	103	**99**	610	99
	CVM	56	297	928	318	**196**	1,795	196
	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	CD	98	185	396	**29**	**13**	721	42
	CW	374	727	1,871	1,366	**330**	4,668	330
	CVM	121	64	615	2,108	**59**	2,967	59
	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**				17	13
	Total	8,065	9,744	18,175	10,874	3,969	50,827	15,529

Species Composition and Vegetation Diversity.

An evaluation of species composition and vegetation diversity was centered on three issues: 1) grassland replaced with forest; 2) inconsistent structure on dry-forest sites; and 3) restoration of ponderosa pine and western larch. All three of these issues are related to vegetation diversity and the fact that landscapes in the Blue Mountains 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" that resulted from livestock grazing, fire suppression, and other anthropogenic changes that caused certain ecosystem components to be reduced or lost altogether.

The "grassland replaced with forest" factor (Table 4-9) relates to an implication derived from analysis of forest cover types. The grassland loss figures in Table 4-9 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 4-9 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 4-9 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 become 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 percent decline in ponderosa pine cover, and corresponding 35 percent to 230 percent increases in Douglas-fir/grand fir cover, between 1938 and 1987. Western larch cover also declined by 80 percent to 100 percent in those same watersheds (Lehmkuhl and others 1994).

Table 4-9. Summary of upland forest issues by subwatershed. See text for description of the issues.

SWS	Forest Damage	Grassland Replaced With Forest[1]	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

[1] Acres shown for the grassland replaced with forest are the gross acres changed, not the net acres changed shown on Table 4-1. Net acres considers both the change from grassland to forest and forest to grassland. Gross acres is all acres that have changed from grassland to forest, and does not consider that some acres in the watersheds have changed from forest to grassland. Mapping error between the coverages could also contribute to gross acres.

CURRENT AND REFERENCE FIRE REGIMES AND RISKS

Overview

Fire has played an important role in the Umatilla and Meacham watersheds, especially in the context of forest and rangeland succession and species composition. This section discusses the historical fire regime within the analysis area and the changes that have occurred in the vegetation to bring about the current fire conditions. Restoring fire to the ecosystem and using fire as a management tool is also discussed. A fire risk analysis is presented to assess the current probability of catastrophic fires in the analysis area.

Historical Fire Regime

The historical fire regime within the analysis area can be characterized using the potential vegetation. On the cool, moist ecological settings (42% of the analysis area), fires were generally low intensity and often smoldered through larger fuels until reaching a natural barrier. Stand replacement occurred in areas where fuels where were heavier and there were significant wind events. Fire ignitions were frequent, due to the number of lightning strikes the areas received. Most burns were relatively small and of low-severity. Larger fires burned infrequently, but often with moderate to high severity, with a mean fire interval of 50-200 years (Gast et al. 1991). Stand replacement events were not uncommon and were a function of fuels, topography and climatological conditions. Fires, therefore, have significantly influenced the structure and development of these stands. Fires created small patches on the landscape, thinning or destroying stands according to fuels and fire intensities. Additionally, the non-forested types, mountain meadow, shrubfields, parkland, and subalpine fescue-sedge may have been similarly influenced. A variable spatial and temporal landscape pattern emerged over time in these areas.

On the warm, dry ecological settings (19 percent of the analysis area) fire disturbance were typically low to moderate intensity fires with a 10-year return interval, (Hall 1976). These sites were typically stands of lodgepole pine and mixed conifer. Stand-replacing fires of variable size characterized the fire pattern on these sites. While there were many small fires, large fires occurred at 20-30 year intervals and affected 50 - 1000 acres (Agee, et al 1993). These fires usually effected greater than 70 percent of the basal area.

In the ponderosa pine stands in the analysis area (605 acres, 0.3 %), the low severity fire regime was dominant. Historically, fires were low intensity, rarely scorching the crowns of trees. Fire return intervals of 5 - 25 years were typical

Cold, dry settings experienced a moderate severity fire regime. This type represents less than 3 percent of the area fire frequency is not well documented for these types of forests. The average fire-return interval was probably in the range of 60 - 80 years, with areas surrounded by higher productivity forest at the lower end of the range. The magnitude of fire ranges from slowly burning logs across the forest floor to crown fires.

Grasslands occupy approximately 50,500 acres or 33 percent of the land base. Fire occurrence was a light intensity fire, possibly every 50 - 100 years with 0 to 100 acres in size. Any high-intensity fire depends on drought severity with possibly a fire frequency of 100 - 200 years and a range of 1 to 500 acres. Flat grasslands within the wet land, before European influence, were most likely burned off, yearly by Native Americans knowing the green-up that followed would attract foraging game animals. Fire is an important factor in the creation of subalpine meadows. According to Agee (1993), “Subalpine forests exist in a marginal environment for tree establishment and growth, so a fire disturbance that kills most or all of a stand can create almost permanent meadows or open parklands that persist for decades to centuries

Current Fire Regimes and Risks

Although Fire has historically been a major disturbance element across these landscapes (Agee 1993), the magnitude of disturbance has changed significantly in some plant communities due to the absence of fire for over 90 years. Where fire was once low intensity, high frequency, and sometimes very large, the effects were relatively negligible except in understory vegetation and fuels.

Current forest vegetative conditions are quite different from those existing at the turn of the century, mostly as a result of aggressive fire suppression and timber harvest. Along with changes in vegetation (and fuels) have come shifts in fire regimes. Many more forested acres are currently “at risk” from stand-replacement type wildfires than would have been the case 100 years ago; the extent of fire-resistant ponderosa pine and western larch are much reduced. A loss of hardwood vegetation along the streams has also occurred. Contemporary fires are not as expansive due to fire suppression, but the intensity and potency of fires has increased notably. While several fire starts occur annually within the Umatilla-Meacham analysis area, only a very small percentage build into large-scale high intensity fires. Managing this area for old growth conditions would mean that the risk for crown fire would remain high. The effects of these fires on older stands would be severe, usually leaving a nearly barren landscape before going out. This correlates directly with the increase in the amount of available fuels.

Crown fire susceptibility is a function of surface fuels and crown fuel load. It has been defined, for this analysis, in terms of potential for crown fire behavior. In closed canopy stands where there are sufficient ground fuels to provide a means for fire to enter the crowns, the susceptibility is high or extreme. The effect will be near-complete stand destruction. Where canopies are more open and surface fuels loads are lighter, susceptibility will be moderate or low. The effects can be measured as a percent mortality of the overall stand.

With the reduction of available fire suppression resources due to government downsizing and/or competing demands, during high activity wildfire seasons, it is realistic to expect an increase in the percentage of fires, which reach large-scale acreage. Due to the fuel’s buildup that has resulted from forest management practices, and almost 80 years of effective fire exclusion, higher severity fires will occur. A higher severity fire will result in increased mortality to the large tree component of stand, more dramatically altered wildlife habitats, higher percentage of soil exposure, and greater nutrient volatilization.

To quantify the current fire situation in turns of risk, the computer program PROBACRE was used to examine the risk of catastrophic fire within the analysis area. PROBACRE was developed for purposes of assessing the long-term risk associated with the level of protection provided to an area. The risk of concern centers on the chance that an area over time will receive catastrophic consequences from a single or series of wildfire events. PROBACRE accomplishes the risk assessment task in two ways. First, it calculates the probability of major single fire events. Second, it computes the long-term probability that combinations of fire events, both large and small, will result in total burned acres in excess of some number.

For the present analysis, probabilities were computed from information on the annual frequency of fires by size class for the Umatilla and Meacham watersheds. Probability estimates are based on the Poisson probability model. PROBACRE assumes that the frequency and distribution of fire sizes will remain constant over any assessment timeframe. Four acreage thresholds were tested. These thresholds consisted of 100, 1,000 and 5,000 and 10,000 acres respectively. The probability calculations are based on the fire planning data showing the performance of the protection organization in terms of expected annual frequency of fires by fire sizes (as indicated earlier). With these estimates of protection performance in an uncertain fire environment, the probabilities that burned area at fire intensity level 4-6 (high, severe, extreme) will exceed the acre thresholds over 20, 50, and 100 year time horizon is displayed below (Table 4-10). These estimates assume that the expected size to which a fire grows at any time of occurrence is independent of both the number of fires and burned acres that recently preceded it. Note that when the threshold acreage is set high, the risk of exceeding the threshold is overestimated because the fire behavior (and, hence, fire size) on average would be reduced in areas where fires had burnt earlier.

The results showed that, in regard to the three acreage thresholds tested, data in the lower portion of the table indicates a 0% chance of burning over 5, 10, or 25 percent of the area in either 50 or 100 years (Table 4-10).

Table 4-10. Results of fire simulation

20 Years

Size	Fire Frequency		Probability of Number of Fires Per Period					
Class	Annual	Period	None	1	2	3	4	>4
24	0.032	.8	0.449	0.359	0.143	0.038	0.007	.0014
240	0.013	0.325	0.722	0.234	0.038	0.004	0.0003	.0000
35,663	0.0009	0.225	0.798	0.179	0.020	0.001	0.00008	.0000
Probability of Exceeding			100	Acre Threshold in		25 Years	0.429	
Probability of Exceeding			1000	Acre Threshold in		25 Years	0.201	
Probability of Exceeding			5,000	Acre Threshold in		25 Years	0.201	
Probability of Exceeding			10,000	Acre Threshold in		25 Years	0.201	

50 Years

Size	Fire Frequency		Probability of Number of Fires Per Period					
Class	Annual	Period	None	1	2	3	4	>4
24	0.032	.6	0.202	0.323	0.258	0.138	0.055	.024
140	0.013	0.65	0.522	0.339	0.110	0.024	0.004	.000
35663	0.009	0.45	0.637	0.287	0.064	0.009	0.001	.000
Probability of Exceeding			50	Acre Threshold in		50 Years	0.675	
Probability of Exceeding			100	Acre Threshold in		50 Years	0.362	
Probability of Exceeding			1,000	Acre Threshold in		50 Years	0.362	
Probability of Exceeding			5,000	Acre Threshold in		50 Years	0.362	

100 years

Size	Fire Frequency		Probability of Number of Fires Per Period					
Class	Annual	Period	None	1	2	3	4	>4
24	0.032	3.2	0.041	0.130	0.209	0.222	0.178	.219
140	0.013	1.3	0.272	0.354	0.230	0.998	0.032	.010
35663	0.009	0.9	0.406	0.366	0.164	0.049	0.011	.023

Probability of Exceeding	50	Acre Threshold in	100 Years	0.913
Probability of Exceeding	100	Acre Threshold in	100 Years	0.593
Probability of Exceeding	1,000	Acre Threshold in	100 Years	0.593
Probability of Exceeding	5,000	Acre Threshold in	100 Years	0.593

Heavily stocked forest stands that are outside of the reference conditions for species composition and structure are the basis for concern that large, high intensity wildfires may occur in this area. The "Warm Dry" vegetation currently has the most serious potential for a destructive wildfire. The established vegetation on many of these sites is currently outside of its normal range of fire disturbance cycles. The Spring Mountain plot exemplifies what happens when the disturbance regime is interrupted by fire suppression. Plot data indicates a major shift in tree species from pine to true fir species that has resulted with the suppression of fire. In addition to the HRV analysis, forest vegetation diversity statistics and stand density figures all indicate a high risk for damaging wildfire in both watersheds.

Riparian areas and buffers pose particular problems for the management of fire and fuels. Generally, riparian areas are very productive sites and can generate higher fuel loadings than adjoining upland areas. Riparian areas react similarly to the cool, grand fir plant association grouping in that they tend to burn less frequently and more intensely. Burning during dryer than normal fire seasons can impact the riparian zones significantly. When uplands are being "actively" managed to reduce fuel loading, fire spread and intensity are manageable. If the riparian areas are avoided or buffered, conifers will continue to invade and fuel loadings will continue to increase. Under extreme fire conditions, the riparian corridors can support high intensity crown fires and act as a wick that carries fire upstream to adjacent upland stands in the Umatilla-Meacham watersheds.

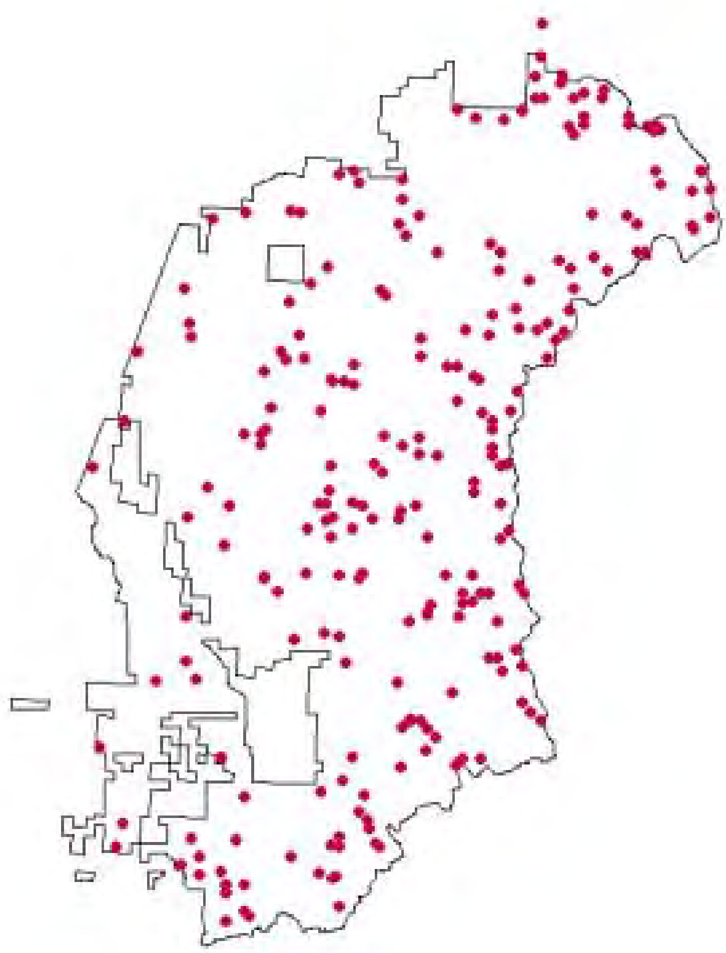
Recent Wildfire History

In the Spring Mountain area of the Spring subwatershed, a fire history plot revealed a mean fire return interval (MFRI) of 30.8 years with a range of 14 to 68 years (Holsapple 1996). Old documents and photographs indicate a large stand-replacing fire occurred in this part of the Blue Mountains around the turn of the century (Powell 1994). The most recent fire within the Spring Mountain fire history study area occurred in 1977, with the next most recent one in 1909. The period between 1909 and 1977 was the longest period between fires ever recorded on that site. Since 1970 (through 1994), a total of 198 fires have been recorded in the Umatilla-Meacham watersheds, equating to 0.5 fires per 10,000 acres per year on federally managed lands. Better than half of the fires (101) have occurred in "Cool Moist" PNV grouping (Table 4-11). Forty-one fires have occurred in the "Grassland" group, the largest being 35 acres. The "Warm Dry" potential natural vegetation grouping has had 30 fires. Historically, fires have been fairly evenly distributed across the watersheds (Figure 4-1). Fire records are incomplete for lands (particularly the western and southwestern portions of the watershed) in private ownership.

Table 4-11. Summary wildland fire occurrence on National Forest lands in the Umatilla and Meacham Watersheds

Potential Natural Vegetation Grouping	Acres Burned	Acres Burned by Fire Size Class				Number of Fires
		0-.25 Acre (A)	.25-10 Acres (B)	10-99 Acres (C)	100-299 Acres (D)	
Other Land	18.3	1.0	0.3	17.0	0	13
Cool Moist	16.0	9.5	6.5	0	0	101
Warm Dry	7.2	2.4	5.8	0	0	30
Lodgepole	0.3	0.3	0	0	0	3
Grassland	103.4	3.1	18.4	81.9	0	41
Ponderosa Pine	0.3	0.3	0	0	0	3
Cold Dry	0.8	0.8	0	0	0	7
Scabland	0.1	0.1	0	0	0	1
Shrubland	0.1	0.1	0	0	0	1

Figure 4-1. Summary wildland fire occurrence on National Forest lands in the Umatilla and Meacham Watersheds, 1970-1994.



Impacts of Fire on Riparian Zones

Fire generally has two types of impacts on riparian zones: 1) direct impacts associated with burning within the riparian zone; and 2) indirect, associated with burning at another location on the landscape, which affects sediment transport, biomass creation or removal, or water quality and quantity as it moves through the riparian zone. According to Agee (1992), "Fire has less effect in riparian systems than associated up slope forests, because these areas are more moist, have more deciduous vegetation, and have higher dead and live fuel moistures. Usually, riparian areas do not burn, or they burn at reduced intensity. Headwater riparian areas sometimes burn with higher than average intensity than surrounding slopes. This is due to the channeling effect of wind in an area of generally higher biomass than found elsewhere. Some of the hottest burn sites in the 1988 Dinkelman fire near Wenatchee occurred in riparian areas. There appears to be an interaction effect between fire, weather and riparian areas: under normal conditions, riparian areas burn much less than slopes, burn under extreme events, riparian areas may burn hotter."

The 1996 Tower fire on the Umatilla National Forest, North Fork John Day Ranger District, severely burned the Hideaway drainage, and it was reported by District resource personnel that the fish were blistered and died (Wilson 1996). Agee (1988) conceptually modeled the direct effects of various disturbance types on riparian systems. Fire's direct effects vary, partially based upon the width of the stream. Agee's work does not identify the specific widths of the streams in the size class of small, medium, and large, but the modeled effects are in relative terms.

From a water-resources perspective, the effects of fire in forest ecosystems are highly variable. The unpredictability of many fire effects upon water resources relates, in part, to the wide range of topographic conditions, site differences in soil characteristics, variation in fuel moisture and fuel loads, density of vegetation, various microclimates associated with a given slope, aspect and topographic position, and variability in weather patterns before, during, and after the occurrence of a fire. The result is a mosaic of fire severity and effects across a hillside or landscape (Beschta 1990).

Opportunities to use Prescribed Fire as a Management Tool

Deliberate use of fire in forested and rangeland ecosystems is nothing new in the Blue Mountains. Native Americans apparently burned portions of the Blue Mountains quite frequently, long before the advent of "modern" forest and range management practices (Evans 1990, Langston 1994). More recently, prescribed fire has been used in the analysis area to reduce both natural fuels and to treat residual fuels from management activities (slash). However, the percentage of prescribed burned acres is low in comparison to the total watershed acres. Many "high risk" subwatersheds have received little if any treatment by fire. Prescribed fire use in activity fuels has been focused on the "Cool Moist" stands and to some extent in the "Warm Dry." The use of prescribed fire in natural fuels has been focused on the "Grasslands" and "Warm Dry" groups.

The North Fork Umatilla Wilderness Prescribed Natural Fire Plan (7/94) defines a Fire Management Action Plan for wildfires that occur within the Wilderness. This document also influences wildfire and prescribed fire management, and silvicultural treatments of forest stands and fuels adjacent to the Wilderness. In the South Fork Umatilla Watershed, limited road access and steep topography in the north portion of the Hellhole Roadless area are the predominant influences on fire management activities. Near the center of the analysis area around Black Mountain, a substantial amount of roading, timber harvest, and subsequent fuel treatment has occurred.

Probably the highest priority for restoring fire as an appropriate disturbance mechanism is to maintain ponderosa pine and western larch occurring on Warm Dry sites. This may be done through successful use of prescribed fire. However, opportunities are limited since most acres of this type occur on private lands in the low elevation portions of the Meacham watershed. Cooperative projects with private owners and the Umatilla tribe should be pursued. As second priority, prescribed fire may be used to maintain ponderosa pine and larch on other sites where each currently persists; fire may have a role in restoring ponderosa pine to the Warm Dry sites where it has been lost. The next priority is to reduce encroachment of trees on grasslands. As a last priority, prescribed burning could be used to break up fuel continuities on the "Cool Moist" sites, an expensive and potentially high risk undertaking, given the high fuel loads and natural fire regime characteristics of the vegetative community. In the prioritization process, the ease and cost of treatments were considered.

Each subwatershed in the Umatilla and Meacham analysis area was evaluated and placed in a ranking of high, moderate or low as a priority for fuel treatment needs. This was accomplished by estimating the number of acres in each fuel treatment priority divided by the number of acres of Forest Service managed lands in each subwatershed. The number of acres treated by prescribed fire was also considered in developing the ranking. Maps actual acreages, percentages and indexes can be found in Holsapple 1996.

Given the interspersion of small pockets of pine and larch within large blocks of grasslands, prescribed burns focused on the grassland community may prove to be most economical. Such an approach would result in enhanced forage values for big game and other wildlife while moving small forested stands toward more sustainable conditions. Subwatersheds and their potential for use of fire to enhance sustainability are presented in Table 4-12.

Table 4-12. Ratings of subwatershed potential for fuel treatment to enhance sustainability.

Watershed	High	Medium	Low
Umatilla	13b, d, f	13a, c, e, g, h, i	13j, k, l
Meacham	89c, d, f, j	89a, b, e, k, l, m	89g, h, I, n, o, q, r

CURRENT AND REFERENCE CONDITIONS FOR FOREST INSECTS AND DISEASE

Recent Impacts of Insects

A variety of insects have a major impact on the forests within the analysis area. The Pacific Northwest Region's annual insect detection and damage surveys were used to assess insect activity for the recent past (Table 4-13). These data are collected via aerial surveys and used to create maps of insect and disease maps. Data from 1980 to 1998 were used to summarize major insect and disease epidemics in recent years (Table 4-13). Note that the areas in this table also include ownerships other than National Forest System lands.

Table 4-13: Area (acres) of insect activity in the Umatilla-Meacham analysis area, 1980-1998[1].

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

1. "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.

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. But 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 budworm susceptibility for major tree species of mixed-conifer forests is apparently related to their shade tolerance and successional status. The Umatilla and Meacham 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 and Meacham area was sprayed with 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).

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 and Meacham watersheds were not seriously defoliated until the latter half of the 1980s and the early 1990s. Portions of that outbreak were also treated with insecticides; some of the Umatilla and Meacham analysis area was sprayed with a bacterium called B.t. *(Bacillus thuringiensis)* in 1988 and 1992 (See Powell 1999, 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 and Meacham analysis 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). There was a major outbreak 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 40 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.

Assessment of Current Insect and Disease Risks

Tussock Moth Infestations in the Blue Mountains

An outbreak of the Douglas-fir tussock moth (*Orgvia pseudotsuga*) is anticipated for extensive areas of the Blue Mountains based on population projections from the Douglas-fir tussock moth early warning system (Douglas-fir tussock moth EIS 2000). About 130,000 acres on the Umatilla National Forest were identified as potential spray areas if larval population levels are verified to be at outbreak or sub-outbreak levels. Spray areas are stands that have greater that 60 percent canopy in host type that are also in areas of special concern. The latter includes areas where defoliation would result in the degradation of threatened or endangered fish or wildlife habitat, and recreation areas. About 30,000 acres within the Umatilla and Meacham watersheds met these criteria. These lands were concentrated in several areas, including the Tollgate corridor and North Fork Meacham Creek.

UPEST Analysis of Future Insect and Disease Risks

UPEST was used to calculate risk ratings 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. The risk-ratings (Table 4-14) show that susceptibility to Douglas-fir tussock moth and western spruce budworm are particularly high in the analysis area.

Table 4-14: Insect and disease risk ratings for the Umatilla and Meacham watersheds.

Insect or Disease	Risk Rating	Meacham	Umatilla
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%

SUMMARY OF FOREST MANAGEMENT ACTIVITIES AND THEIR EFFECTS

Overview

Timber harvesting and road building can bring about rapid and significant changes to landscapes and ecosystems. The magnitude of the changes can vary widely depending on the silvicultural prescription and the timetable over which the harvest spans. In an ecosystem context, these changes can be beneficial, or detrimental, depending on a wide array of factors. Adverse effects from ground-based timber harvest include degradation of soil characteristics and losses in productivity. For instance, roads intercept normal water movement within the soil and commonly divert the water to surface (overland) water movement. Changes in hydrologic processes increases the potential for surface soil erosion, reduces moisture availability for plant growth, and potentially accelerates the routing of water, along with suspended sediment, to streams.

Timber Harvest History

Significant timber harvest began in the Blue Mountains with the onset of Euro-settlement. Post-settlement effects gradually increased from about 1850 and became highly significant in modern times. In the analysis area, National Forest timber sales statistics for the combined watersheds show a rapid rise and peak in the 70's, dropping significantly in the 80's, and further yet in the 90's (Table 4-15). Road construction paralleled the timber sale program both in time and location. Overall, only a small proportion of the National forest acres in the analysis area have been affected by timber sale activity. More acres and a higher overall percentage of National Forest area has experienced harvest activities in the whole upper Umatilla watershed as compared to the Meacham watershed. A little less than one-third of the NF in the Umatilla watershed and only 18 percent of the Meacham Creek watershed has involved timber sales (Table 4-16). Note that on a subwatershed basis, there is wide variation in the acres affected. Of the harvested areas in the Umatilla watershed, almost half have had two or more sales, and more than half the harvested areas of the Meacham watershed have had two or more sales. For the combined watersheds, the area with 1-only timber sales is 47 percent of the total sale area, and that with >=2 timber sales are 53 percent of total sale area.

Table 4-15. Timber sale acres by periods of years for the combined Umatilla-Meacham watersheds (National Forest only). *Note some acres are represented in more than one year so these acres total (not given) more than the simple total of acres with one or more timber sales (shown below) in Table 4-16.

Time Period or decade	Timber sales (acres)
1990-94 (5 years)	4,091
1980-89 (10 years)	17,572
1970-78 (9 years)	26,374
1960-69 (10 years)	6,963
1958-59 (2 years)	983

Table 4-16. Overall summary data for NF timber sales (T.S.) in the Umatilla and Meacham watersheds

Watershed	All T.S. acres	All T.S. %NF	1-0nly T.S. acres	1-only T.S. (%NF)	>= 2 T.S. acres	>= 2 T.S. (%NF)
Umatilla	22,863	32%	12,092	17%	10,771	15%
Meacham	13,595	18%	5,165	7%	8,430	11%
Total	36,458	----	17,257	----	19,201	----

Effects of Harvesting and Roads on Forest Sustainability

While it is not possible to measure site-specific effects of harvest and road building in the present ecosystem analysis, it is possible to assess the relative impacts among the subwatersheds within the analysis area. To evaluate the effects harvest activities and road building, it was assumed that impacts were significant when timber harvest and road building exceed adopted standards or informal guidelines. Thresholds for soil conditions were interpreted from Forest Plan standards. Total road densities (open and closed) over 2 mi./sq. mi. were judged to be significant in terms of detrimental effects. For lack of data, it was assumed that all harvests were ground-based, and had equal effects on soils. This is clearly a worst-case scenario, a fact that should be considered in the interpretation of the data. Three attributes were chosen to measure the impacts of upland vegetation in each watershed: 1) Area (%) with only one timber sale; 2) Potential detrimental soil conditions; and, 3) Total road density. The level of impact identified for each subwatershed was based on the combination of the three attributes. (See Geist 1996 for further details.)

The results of this evaluation (Table 4-17) showed that only two subwatersheds in the Umatilla (13I and 13J) and three in the Meacham (89L, 89K, 89O) watershed were considered highly impacted. Total potential detrimental soil conditions ranged from 0-19 percent among the Umatilla subwatersheds and <1 to 21 percent among the Meacham subwatersheds. Those subwatersheds with 500 or more treated acres are 13E, 13H, 13I, 13J, and 13K; and 89K, 89L, and 89O (i.e., eight subwatersheds). Total road densities varied form 0.6 to 3.6 among the Umatilla subwatersheds and 0.2 to 2.6 among the Meacham subwatersheds. In the Umatilla there were two subwatersheds with road densities over 3.0 and four others over 2.0 and less than 3.0. In the Meacham watershed, there were only two subwatersheds with density values exceeding 2.0.

Table 4-17. Summary of impacts from harvest and roads in the Umatilla and Meacham Watersheds.

Impact	Subwatershed	Interpretation Notes
High	13 I, J	Excessive roads and compaction are both a concern.
Medium	13 H, K, E, G	13e and 13h had the highest potential treatable soil compaction acres.
Low	13 A, D, C, B, F, L	N/A
Higher	89 L, K, O	Detrimental compaction concerns exist for 89O, 89K, and 89L; excess road concerns in 89K
Medium	89 I, C, G, D, N, A	Excess road concerns in 89I
Lower	89 M, H, J, B, E, F, Q, R	Excess road concerns in 89H, J, E

Identification of Areas Most Sensitive to Forest Management

To assess the inherent sensitivity of subwatersheds to ground-disturbing activities, a combination of four attributes was used: 1) Deep volcanic ash; 2) Very shallow soils; 3) Steep slopes; and 4) Potential for increased mass failures through human activity (Geist 1996).

The results of this assessment (Table 4-18) showed that all of the Umatilla subwatersheds are higher and medium sensitivity groups because of the combination of limiting physical attributes over the whole area. All of the Meacham Creek subwatersheds are in the moderate and higher categories, with 11 subwatersheds in the Higher group and 5 in the Medium group. A higher sensitivity rating does not indicate exclusion of human activity, but does indicate that special consideration should be given to choosing appropriate management activities. Overall, these data indicate that a significant portion of the watersheds have physical characteristics that are sensitive to ground-disturbing activities.

Table 4-18. Summary of Meacham and Umatilla subwatersheds sensitivities and associated interpretations.

Concern	Subwatershed	Interpretation Notes
Higher	89A,B,C,D,E,F,G, H,I,J,M	Special grazing management attention, shallow soil rehabilitation, and channel stability appear very important in these SWSs.
Medium	89K,L,N,O,Q	Potential for shallow soil rehab also appears high in these SWSs.
Unknown	89R	All private land - inadequate information to assess
Higher	13 A,B,C,F,H,L	Special grazing management attention, shallow soil rehabilitation, and stream stability appear very important in these SWSs.
Medium	13 D,E,G,I,J,K	There may be a need for shallow soil rehabilitation.
Lower	None	

CURRENT AND REFERENCE CONDITIONS FOR FLORISTIC BIODIVERSITY

Overview

The study area supports a diverse array of plant species. Species encounter lists indicate that 671 species have been found in the Umatilla drainage, and 579 in the Meacham watershed (species checklist, Urban 1996). Of the plant species known to occur on the Walla Walla District, 72 percent are found in the Umatilla watershed and 62 percent in Meacham. Of the plant species known to occur on the Umatilla National Forest, 52 percent are found in the Umatilla and 45 percent are found in the Meacham drainage, respectively.

No historic records are available to which the present-day floristic richness of the Umatilla and Meacham analysis area can be compared. The watershed probably supports **more** plant species today than it did in the pre-settlement era. About 13 percent of the flora of the Umatilla watershed consists of species non-native to North America and 11 percent in the Meacham watershed. The issue of native plant species and introduced plant species is addressed below.

Floristic Richness and Potential Vegetation Groups in Ecological Settings

In terms of total floristic richness, riparian ecological settings support the highest numerical diversity in both drainages (Table 5-1).

Table 5-1. Floristic richness in the Umatilla and Meacham watersheds.

	Ecological Setting						
Watershed	Riparian/ Riverine	Steppe	Cool-Moist	Warm-Dry	Ponderosa Pine	Cold-Dry	Lodgepole Pine
Meacham	363	356	292	307	298	286	207
Umatilla	440	374	333	329	308	301	216

Another characteristic of the floristic composition and distribution of the Umatilla and Meacham watersheds is the number of plant species that exhibit habitat affinities in all seven of the ecological settings used for analysis purposes. In the Umatilla watershed, 75 species occur in all of the ecological settings. Of the 75 "ubiquitous" species, 42 are native and 33 are non-native. In the Meacham watershed, 72 species occur in all of the ecological settings; of the 72 "ubiquitous" species, 39 are native and 33 are non-native. The ponderosa pine ecological setting is not well represented in the Umatilla and Meacham analysis area at the present time.

As shown in the Forest’s other ecosystem analyses, a relatively high coefficient of floristic similarity exists between the ponderosa pine ecological setting and the warm, dry forest ecological Setting, dominated by Douglas-fir. In pre-settlement time, the ponderosa pine forest type probably occupied more acres than it does today. Selective removal of the dominant species (ponderosa pine) combined with fire suppression has resulted in a gradual conversion to the warm, dry forest type. In the Umatilla watershed, the 87 percent floristic similarities between the two ecological settings indicates that the understory plant species were historically similar and remain similar despite changes in the dominant species of the overstory (90% for Meacham).

Sensitive Plant Species: Presently-Listed and Historically-Listed

The Umatilla and Meacham watersheds have historically supported as many as 24 and 18 sensitive plant species, respectively. Through careful documentation associated with sensitive plant surveys, 19 Umatilla and 17 Meacham sensitive plant species have been recommended for delisting. The Oregon Natural Heritage Program has accepted these recommendations.

At the present time, five species in the Umatilla watershed and one in the Meacham appear on the Regional Forester's Sensitive Plant Species List (R-6 Sensitive Plant Species List, 1991). The presently-listed sensitive species of the Umatilla watershed are: lance-leaved grapefern (*Botrychium lanceolatum*), Mingan grapefern *(Botrychium minganense*), pinnate moonwort *(Botrychium pinnatum*), male fern *(Dryopteris filix-mas*), and Backs sedge *(Carex backii*). The presently-listed sensitive species of the Meacham watershed is the male fern (*Dryopteris filix-mas)*. This species occurs in the riparian zones of two subwatersheds of the Meacham watershed, 89G (Upper North Fork Meacham Creek) and 89H (Pot Creek). Three of these species appear to benefit from management activities. The ecological settings, microhabitats, and predicted or documented responses to selected management activities are shown in Table 5-2. Three of these species appear to benefit from management activities.

Table 5-2. Presently-listed Sensitive Plant Species of the Umatilla-Meacham Watersheds

Presently-listed Sensitive Species	Subwatershed of Occurrence	Ecological Setting	Microhabitat	Responses to Selected Management Activities and Potential Threats
Botrychium lanceolatum (Lance-leaved Grapefern)	13E (Upper N.Fk. Umatilla); and 13K (Upper S. Fk. Umatilla)	Cold, Dry Forest	30-year old plantations above 4,800 ft. elevation	Adjacent unharvested stands do not support this species. Apparently needs disturbance. Tolerates trampling by sheep (apparently not grazed by them).
Botrychium pinnatum (Pinnate Moonwort)	13E (Upper N.Fk. Umatilla); and 13K (Upper S. Fk. Umatilla)	Cold, Dry Forest	30-year old plantations above 4,800 ft. elevation	Adjacent unharvested stands do not support this species. Apparently needs disturbance for continued existence. Tolerates trampling by sheep; tolerates application of artificial fertilizers.
Botrychium minganense (Mingan Grapefern)	13E (Upper N.Fk. Umatilla); and 13K (Upper S. Fk. Umatilla)	Cold, Dry Forest	30-year old plantations above 4,800 ft. eleva-tion; moister site than previous two species	Adjacent unharvested stands do not support this species. Apparently needs disturbance for continued existence. Tolerates trampling by sheep; tolerates application of artificial fertilizers.
Dryopteris filix-mas (Male Fern)	13E (Upper N.Fk. Umatilla); and 13K (Upper S. Fk. Umatilla)	Principally Riverine but secondarily Cool, Moist Forest; minimum eleva-tion of 3,000 ft.	Usually in active stream channels or in ephemeral stream channels where water table is high.	Moderate adverse response to overstory removal; adversely impacted by alteration in subterranean hydrology
Carex backii (Back†s Sedge)	13D (Lower North Fork Umatilla)	Strictly riverine	Partially shaded gravelly stream banks along perennial streams	Scouring action of natural floods may imperil this population; competition from introduced species, particularly Velvet Grass (*Holcus lanatus*); trampling by fishermen or by hikers

Within the Umatilla watershed, the Ponderosa Pine Ecological Setting could potentially support 6 of the historically-listed species; the Warm, Dry Upland Forest, 9; the Cool, Moist Upland Forest, 9; the Lodgepole Pine Forest, 3; the Cold, Dry Upland Forest, 5; the Steppe, 8; and the Riverine ecological setting could potentially support 14 of the historically-listed species. In the Meacham watershed, the Ponderosa Pine Forest ecological setting could potentially support 8 of the historically-listed species; the Warm, Dry Upland Forest, 9; the Cool, Moist Upland Forest, 7; the Lodgepole Pine Forest, 2; the Cold, Dry Upland Forest, 6; the Steppe, 11; and the Riverine ecological setting could potentially support 10 of the historically-listed species.

In the Umatilla watershed, only one historically-listed species is of such limited distribution and abundance that it merits “species of special concern” or “species truly at risk” status. A small population of giant helleborine orchid, *Epipactis gigantea*, is located just within the boundary of the Forest above the Bar-M Ranch (Subwatershed 13C). A larger population of this orchid is found within the hot springs channel on land owned by the Bar-M Ranch below the Forest boundary. The orchid was delisted in Oregon in the 1980's because of its widespread distribution, but remains on the Washington Sensitive Species List (1994). Elsewhere on the Forest, this orchid is found within the Wenatchee Creek drainage of the Pomeroy Ranger District where it does not appear to be associated with geothermal springs.

The Quality of the Floristic Biodiversity of the Watershed: Native vs. Introduced Plant Species

Native versus introduced species status is based on whether a species is indigenous to North America or not. Ideally, this definition would be further refined to "native to the Pacific Northwest," or "native to Oregon," etc., to be more consistent with the conservation and preservation of genetic integrity of plant species that are truly "native."

Of the 671 plant species encountered in the Umatilla Watershed, 584 species or 87 percent are native. Within the Meacham watershed, of the 597 plant species, 571 or 98 percent are native. Results are similarly favorable when compared with other ecosystem analyses conducted on the Forest. Analysis of the ratio of native to introduced species by subwatershed indicates the greatest departure from the average occurs in Subwatershed 13D, the Lower North Fork of the Umatilla, and 89E in the Lower North Fork of Meacham.

Due in part to the documentation of non-native flora, the inference could be drawn that the analysis area is floristically more diverse today than historically. However, this inference may be misleading since any acreage now occupied by non-native species was--in the pre-settlement era--occupied by native species. In some instances, introduced species may have altered the native gene pools.

This analysis focused only on the numbers of native and introduced plant species, and did not address the issue of acreage occupied by introduced species and/or the displacement/diminished acreage occupied by native species. Documentation of historic conditions needed for this type of analysis does not exist.

Lists of native (to North America) species occurring within the ecological settings used in this analysis are provided in the Floristic Biodiversity Report (Urban 1996).

Culturally-Significant (Food) Species

Forty-eight native plant species with cultural significance as food plants for Native Americans have documented occurrences in the Umatilla drainage, and 42 in the Meacham analysis area. Because no written accounts exist which allow current scientific plant names to be linked to native Nez Perce, Walla Walla, Umatilla, and/or Cayuse plant names, standard references for the Paiute (Fowler 1992) and Warm Springs (Murphey 1959) tribes were used in building and maintaining the Forest-wide list of culturally-significant species. Medicinal plants were not explicitly addressed in this analysis because Native Americans found specific medicinal uses for virtually every plant species known to them.

Two species of culturally-significant sego (or mariposa) lillies, *Calochortus eurycarpus* (Mountain Mariposa) and *Calochortus macrocarpus* (Big-podded Mariposa Lily) abound on the other three districts of the Forest, but are conspicuously absent or greatly diminished from ridgetop steppe habitats in the analysis area. Uncontrolled grazing by sheep in the early 1900s is the suspected culprit.

Noxious Weeds/Invading Plant Species

All of the noxious weeds and new invader species listed by the Forest have been introduced into the United States during the "post-settlement" era. The Forest's noxious weed shows a consistent increase in the acres occupied by noxious weeds since the inception of the database in 1992. Part of this increase is due to an increased effort to map noxious weeds. Noxious weeds and introduced plant species occur within every subwatershed and ecological setting of the Umatilla and Meacham watersheds. Notable focal points from which noxious weeds and new invader species spread include the Oregon State Highway 204 corridor between Tollgate and Elgin and the heavily-used recreational areas in the vicinity of Umatilla Forks. In Meacham Creek watershed, the focal points include the Forest Road 31 corridor in the upper portions of the watershed (most notably in the vicinity of "the Knob" just opposite "Weed Spring"), the Whitman Overlook Park in the Owsley Creek subwatershed, and the Union Pacific Railroad corridor between the towns of Meacham and Gibbon. The focal points of noxious weed infestations are "strategically" situated and have the potential for rapidly penetrating into the anastomosing network of streams, recreational corridors, and roadways that will take them into virtually every unoccupied habitat, disturbed site, or created opening within the entire watershed.

Twelve species of noxious weeds from the Forest's noxious weed list have been documented in sensitive plant surveys conducted within the Umatilla watershed and 10 in Meacham. Several focal points for the spread of noxious weeds, particularly Spotted and Diffuse Knapweed, occur within the watersheds. Several "new invader" species have also been found within the Watersheds. Table 5-3 displays the current noxious species list and potential distribution by ecological setting for the Umatilla-Meacham area.

Table 5-3. Noxious Weeds identified in the Umatilla and Meacham analysis area and their affinities for ecological settings.

Taxon	Common name	PIPO forest	Warm, dry upland forest	Cool, moist upland forest	PICO forest	Cold, dry upland forest	Steppe	Riv.
Arctium minus	Common Burdock	1	2	2	0	1	0	3
Centaurea diffusa	Diffuse or Tumble Knapweed	2	2	1	1	1	3	1
Centaurea maculosa	Spotted Knapweed	2	2	1	1	1	3	1
Chrysanthemum leucanthemum	Oxeye Daisy	1	1	1	1	1	1	1
Cirsium arvense	Canada Thistle	1	1	1	1	1	1	1
Cirsium vulgare	Bull or Common Thistle	1	1	1	1	1	1	1
Cynoglossum officinale	Common Houndstongue	2	2	2	1	1	3	2
Daucus carota	Queen Anne's Lace	1	1	1	1	0	1	1
Equisetum arvense	Common or Field Horsetail	1	1	2	1	1	0	3
Onopordum acanthium	Scotch Thistle	1	1	1	1	0	1	1
Hypericum perforatum	Klamathweed	1	1	1	1	1	1	1
Senecio jacobaea	Tansy Ragwort	1	1	1	1	1	2	1
Verbascum thapsus	Flannel Mullein	2	2	1	1	1	3	1

Noxious weeds mimic fire behavior as they invade new territory, stagnate briefly, and then spread quickly to unoccupied habitats and niches. Once noxious weed species have become established and fairly common and widespread, the effort to track them, treat them, and eradicate them is relinquished. The list presented in Table 5-3 is somewhat misleading. From the species listed in the table, only four of the twelve species are presently tracked in the Umatilla watershed. In the Meacham watershed, only three of the ten species are presently tracked. The other species have become so widespread that the battle to eradicate them has been abandoned.

The species still tracked in the Umatilla watershed are Spotted Knapweed, Diffuse Knapweed, Common Burdock, and Tansy Ragwort; the (Spotted Knapweed, Diffuse Knapweed, and Scotch Thistle are still monitored in the Meacham watershed. Populations of Queen Anne's Lace (*Daucus carota*) in the Umatilla watershed are still small enough for effective control measures to be undertaken although this species is not tracked or has not been reported on official noxious weed sighting forms. Table 5-4 (below) shows geographic distribution across the Umatilla and Meacham analysis area by subwatershed.

Table 5-4. Distribution of Forest-listed noxious weeds in the Umatilla and Meacham watersheds showing the number of noxious weed species present in each subwatershed.

Subwatershed	Number of Noxious Weed Species on Official List (12 listed species occur in the Umatilla Watershed)	Remarks
13A Ryan Creek	10	
13B Lower Umatilla/Hagen	No Data	No Data
13C Lower Umatilla/Bear	7	
13D Lower North Fork Umatilla	8	Queen Anne's Lace encroaching from Umatilla Forks Campground
13E Upper North Fork Umatilla	9	Focal point for spread of both Knapweeds from State Highway 204 Corridor--Spout Springs to Horseshoe Prairie
13F Lower South Fork Umatilla	7	Focal point for spread of both Knapweeds from Forest Road 32 especially at S.Fk. Bridge
13G Buck Creek	9	
13H Thomas Creek	8	Tansy Ragwort present (Road 32)
13I Spring Creek 13J Shimmiehorn Creek	9	Tansy Ragwort present (Shimmiehorn)
13K Upper South Fork Umatilla	8	
13L Gibbon	No Data	No Data
89A Boston Canyon 89B Bonnifer	6	New Invaders Present
89C Camp Creek 89E Lower N. Fk. Meacham	9	Heavy Knapweed infestation in bottom of 89E
89F Middle N. Fk. Meacham	5	
89G Upper N. Fk. Meacham	4	
89H Pot Creek	2	
89I Bear Creek 89J Upper Meacham/Wilbur 89K East Meacham	7	Focal point for Knapweed at Road 31/3116 Junction
89L Owsley 89M Upper Meacham/Short	7	Scotch Thistle focus at Whitman Crossing Viewpoint apparently introduced by construction equipment
89D Middle Meacham 89N Butcher 89O Upper Meacham/Allen 89Q Todd/Beaver/Sheep	8	

CURRENT AND REFERENCE CONDITIONS FOR VERTEBRATE BIODIVERSITY

Overview

The Umatilla-Meacham analysis area provides a mosaic of forested and grassland habitats that support a wide variety of terrestrial vertebrates. Forested habitats make up approximately 70 percent of the analysis area and range from relatively contiguous stands of spruce and sub-alpine fir at the highest elevations, to forested stringers of fir, pine and larch in the canyon bottoms and sideslopes. North-facing slopes, in general, support colder moister forested habitats, while south-facing slopes are generally drier and grass-dominated, with occasional ponderosa pine, shrubby draws, and riparian hardwood communities. Generally, the lower to mid elevations of the landscape are "naturally fragmented". The majority of the forested habitat is in a mid structural stage, with little mature and old forest stages occurring in the landscape.

Most wildlife species occurring or having the potential to occur in the Umatilla and Meacham watersheds occurred historically in the drainage. Grizzly bear and gray wolves, once native to northeast Oregon and the Blue Mountains, can no longer be found in the area. Some species (bald eagle, wolverine, etc.) may have been widely distributed in the Blue Mountains and are now occur in limited numbers and at few locations. On the other hand, some species (e.g. elk, starlings, etc.) have increased in numbers and are widely distributed.

A total of some 260 terrestrial vertebrates species have the potential to occur in the area. This includes 154 birds, 60 mammals, 7 reptiles, and 5 amphibians. Among this group there are predators, carnivores, raptors, primary cavity excavators, and prey species. There are also 5 Forest Plan management indicator species, 1 threatened species, 1 proposed threatened species, 1 candidate species, 2 Regional Foresters' sensitive species, 11 Oregon State sensitive species, and numerous species of "interest".

Current and Reference Conditions for Vertebrate Habitat

Overall Condition & Distribution of Cover Types and Structure

A previous section of this report described the changes in vegetation between 1936, 1958 and present. These data are summarized here in the context of wildlife habitat. In the forested types, the most significant changes include a decrease in ponderosa pine stands (Table 6-1). The non-forest type, including grasslands and shrubs, has changed very little over the last 60 years. Shrub-dominated communities are scarce in most subwatersheds, although shrubs associated with forested stands are widespread throughout both drainages. The vegetation analysis also showed important changes in structural stages in both watersheds over the same time period (Table 6-2). The most obvious change since 1936 is the sharp increase in the amount of stand initiation (SI), young forest multi-strata (YFMS), and understory re-initiation (UR) structural stages. Conversely, large decreases occurred in the old forest single-stratum (OFSS) and old forest multi-strata (OFMS) structural stages since 1936. All structural stages are represented in the 1999 vegetative data, while the 1936 and 1958 data shows voids in stand initiation (SI) and or stem exclusion open-canopy (SEOC). Maps showing the distribution of structure stages for current and historical conditions can be found in Powell (1999). Overall, the changes in habitat composition since 1936 have resulted in a reduction of habitat diversity for the Umatilla-Meacham watersheds. These changes include blending habitats that lead to the loss of distinct habitat types, an imbalance of structural diversity, and the increasing number of small patches of habitat scattered across the landscape. Theses changes can lead to a reduction in habitat quality for many terrestrial vertebrate species that dependent on a variety of structures, distinct habitat types, and large patches of habitat to function over time in the landscape.

Late Old Structure

Of particular concern is the change in late-old forest habitat. Comparisons of habitat availability indicate that gross acres of late and old forest habitat have declined across both watersheds. While some declines occurred between 1936 and 1958, the greatest reduction in old forest habitat occurred after 1958 (Table 6-3). Old forest habitat types that have declined since 1936 include ponderosa pine (single-stratum) and grand fir (multi-strata). Some of these changes can be attributed to natural events like insect and disease, drought, wind-throw, and wildfire. However, the majority of change can be attributed to harvest of large overstory trees since the 1940's. Apparent changes in late and old structures (LOS) can be seen when comparing the late and old structure for 1936 and 1999 (Gobar and Boula 1996).

Other changes in old forest structure include the reduction in patch size and arrangement of old forest stands from historical conditions. In general, LOS in 1936 occurred in large patches, contained a large amount of interior habitat, connected to similar habitats, and occupied more than 70 percent of the forested area in the watershed. Present day, old forest habitat occurs in small patches, contain little interior habitat with patches that are widely scattered and rarely connected to similar habitats. They occupy less than 18 percent of the forested area in the Umatilla and Meacham watersheds. For wildlife species associated with old forest habitats, current conditions could result in larger home ranges, increased susceptibility to predation, and a greater amount of energy expended for survival. Ultimately these can lead to reduced or low population viability for some species. The higher historic levels of LOS may have supported larger populations of associated species than are present today.

Table 6-1*: *Habitat types as a percentage of total Forest Service land in the Umatilla and Meacham watersheds. Habitat is based on the based on dominant forest tree species.

Code	Dominant Vegetation	1999 %	1958 %	1936 %
CA	Subalpine fir	1	2	1
CD	Douglas-fir	24	26	4
CE	Engelmann spruce	1	1	0
CL	Lodgepole pine trees	<1	1	1
CP	Ponderosa pine trees	5	13	10
CT	Western larch trees	1	6	2
CW	Grand fir trees	20	19	14
Mix	Mixed conifer	15	NA	35
	Non Forest	33	34	33

Table 6-2. Forest structural stage composition in the Umatilla and Meacham watersheds for 1936, 1958, and 1999.

Structure Stage	*1936* *% of total area*	1958 % of total area	1999 % of total area
Non Forest (Grass/Shrub)	33%	34%	33%
Stand Initiation	6%	<1%	12%
Stem Exclusion Open-canopy	<1%	<1%	3%
Stem Exclusion Closed-canopy	9%	4%	2%
Young Forest Multi-strata	2%	2%	11%
Understory Re-initiation	1%	18%	28%
Old Forest Single-stratum	20%	13%	3%
Old Forest Multi-strata	27%	29%	9%

Table 6-3. Changes in acres of old forest habitat in the Umatilla and Meacham watersheds between 1936,1958, and 1999.

Forest Structure	Umatilla Watershed						Meacham Watershed					
	1936		1958		1999		1936		1958		1999	
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%
Old Forest Single-Stratum	20,471	28%	6,454	9%	2,302	3%	9,527	13%	12,854	17%	1,467	*2%*
Old Forest Multi-Strata	21,087	29%	29,901	42%	9,907	14%	19,591	26%	12,736	17%	3,963	*5%*
Total Old Forest	41,558	*57%*	36,355	*51%*	12,209	*17%*	29,118	*39%*	25,590	*34%*	5,430	*7%*

Additional data on old forest habitat is available from inventories conducted by the Audubon Society volunteers in the spring of 1992. These inventories examined the status of Forest Plan Old Growth Management Areas (C1). Eight of the 15 areas surveyed occurred in the Umatilla-Meacham watershed. Stands were surveyed for habitat condition and presence of pileated woodpeckers. Average size of the 15 designated areas was 370 acres. Of the areas surveyed, two were smaller than the 300-acre minimum size requirement for the management area (C1). Four of the areas surveyed included less than 300 acres of LOS. Despite limited harvest entry, all but one of the surveyed stands were characterized as either “fragmented” or “linear”, reflecting the characteristic vegetative pattern of the analysis area. Most of the LOS stands were either riparian stringers, or upland patches of old forest found in the roadless areas and wilderness. Interior habitats were limited or completely lacking in many stands. All areas surveyed were dominated by grand fir or Douglas-fir. Survey notes did not mention spruce budworm mortality; the high canopy closures and low dead tree densities suggest that budworm infestation was not a significant factor in these stands in 1992.

With the intent to improve LOS in the Umatilla-Meacham watershed, restoration should focus on increasing the amount of old forest habitat and expanding the size of old forest patches. The objective for LOS management in the Umatilla and Meacham watersheds should be to maintain 40 percent of the forested vegetation in the old forest stage (single stratum and or multi-strata). Existing old forest stands should be maintained to prevent further reductions of LOS in the watershed. Forested stands adjacent to existing LOS stands should be moved toward old forest conditions to increase old forest patch size. In the Umatilla Watershed, the increases could occur in the following subwatersheds: 13G, 13H, 13I, 13J, and 13K. In the Meacham watershed, the increases could occur in 89I, 89K, and 89L subwatersheds.

Snag and Down Wood Habitat

Historical information for dead wood (standing and down) habitats in the Meacham and Umatilla watersheds is scarce. In general, snags and down logs were most likely common in mixed conifer and true fir stands across both watersheds, but less common in fire-regulated pine communities. Densities fluctuated with the frequency of natural mortality and the frequency and intensity of large and small-scale disturbances, such as fires, insect and disease, ice storms, and drought that have historically occurred throughout the area.

Snag and down wood habitat was assessed using the USFS current vegetation survey (CVS) inventories from 1993-1995. The CVS inventory is a permanent plot grid system at 3.4 mile and 1.7 mile intervals that samples vegetative conditions across the National Forest. Each plot collects a variety of vegetative information including plant association, live trees, dead trees, down wood, along with the diameters and heights for each species tallied. The data used here were collected between 1993 and 1995, and included 311 forested points/subplots. Dead standing trees were tallied for each 2" diameter class then divided by the total number of plots sampled to arrive at an average DST density for each diameter class. Sample plots were stratified by potential vegetation groups (PVG) in the watershed and age classes were summed to arrive at size class groups for comparison with Forest Plan standards and guides.

Overall, dead standing trees were recorded in all size class from 2" to 50" in diameter at breast height (DBH). The density of all DSTs ranged from 0.4 to 2,180 trees per acres (TPA) (Table 6-4). In the Dry Forest PVG, DST occurred in all size classes from 2" to 38" and 46" DBH. Densities ranged from 0.4 to 500 TPA. For size classes less than 30" DBH, the average density for DST was greater than or equal to 0.1 TPA. The Moist Forest PVG had DST in all size classes from 2" to 50" DBH. Densities for this PVG ranged from 0.4 to 1,620 TPA. Size classes less than 30" DBH had an average DST density greater than or equal to 0.3 TPA. In the Cold Forest group, all size classes from 2" to 30" and 36" DBH contained DST. Densities ranged from 0.8 to 280 TPA. For size classes less than 30" DBH, the average density for DST were greater than or equal to 0.2 TPA.

Standards and guidelines for dead standing and down wood have evolved over the years as new information became available. Current Forest Plan direction for snag management is based on the Regional Forester's Forest Plan Amendment #2 (6/95) and Interim Snag Guidance for Salvage Operation (4/93). Forest interim guidelines for dead standing trees are identified in Table 6-4 below.

Table 6-4. Dead tree (snags) density, in the Umatilla-Meacham analysis area.

LMRP, Umatilla NF Guidelines		Umatilla-Meacham Watershed CVS Data	
Working Group	*Density*	*Potential Vegetation Group*	*Density*
Ponderosa pine	0.75 snags/ac. >10" dbh 1.36 snags/ac. >12" dbh 0.14 snags/ac. >20" dbh *2.25 snags/ac. Total*	*Dry Forest*	0.7 snags/ac. >10" dbh 2.6 snags/ac. >12" dbh 1.2 snags/ac. >20" dbh **4.5 snags/ac. Total**
South Associated (Mixed conifer)	0.75 snags/ac. >10" dbh 1.36 snags/ac. >12" dbh 0.14 snags/ac. >20" dbh *2.25 snags/ac. Total*	*Moist Forest*	7.6 snags/ac. >10" dbh 13.5 snags/ac. >12" dbh 5.0 snags/ac. >20" dbh **26.1 snags/ac. Total**
North Associated (Grand fir)	0.30 snags/ac. >10" dbh 1.36 snags/ac. >12" dbh 0.14 snags/ac. >20" dbh *1.80 snags/ac. Total*		
Lodgepole pine	1.21 snags/ac. >10" dbh 0.59 snags/ac. >12" dbh *1.8 snags/ac. Total*	*Cold Forest*	5.8 snags/ac. >10" dbh 27.4 snags/ac. >12" dbh **33.2 snags/ac. Total**
Subalpine Zone	1.21 snags/ac. >10" dbh 0.59 snags/ac. >12" dbh *1.8 snags/ac. Total*		

CVS snag densities were tallied for the watershed to compare average densities in the watershed with the Forest Plan standards and guidelines. As noted by the results on Table 6-4, snag densities appear to meet or exceed Forest Plan standards. However, DST densities are relatively lower in the dry forest group when compared to densities in the moist forest of cold forest groups, so results should be interpreted cautiously. In addition, it would be wrong to assume that snags are evenly distributed across the watershed. In the most pristine settings, snags are not evenly distributed in the landscape. Tree mortality generally occurs in groups, clumps, or patches.

Snag replacement trees are analyzed to determine if dead trees can be recruited (or maintained) throughout the life of the unit. As identified in current Forest Plan direction, “green” replacement trees (GRT) densities are based on the Regional Forester’s Forest Plan Amendment #2 (6/95) and Interim Snag Guidance for Salvage Operation (4/93). Forest interim guidelines for replacement trees are identified in Table 6-5.

Overall, replacement trees were recorded in size class from 2” to 48” and 54” DBH. The density of all green trees ranged from 0.4 to 12,100 trees per acres (TPA). In the Dry Forest group, GRT occurred in all size classes from 2” to 48” and 54” DBH. Densities ranged from 0.4 to 4,500 TPA. For size classes less than 30” DBH, the average density for GRT was greater than or equal to 0.8 TPA. The Moist Forest type had GRT in all size classes from 2” to 48” DBH. Densities for this PVG ranged from 0.4 to 6,900 TPA. Size classes less than 30” DBH had an average GRT density greater than or equal to 1.0 TPA. In the Cold Forest group, all size classes from 2” to 40” DBH contained GTR. Densities ranged form 0.4 to700 TPA. For size classes less than 30” DBH, the average density for GTR was greater than or equal to 0.9 TPA.

Table 6-5. "Green" replacement tree density, in the Umatilla-Meacham analysis area.

LMRP, Umatilla NF Guidelines		Umatilla-Meacham Watershed CVS Data	
Working Group	*Density*	*Potential Vegetation Group*	*Density*
Ponderosa pine	7.5 trees/ac. >10" dbh 13.6 trees/ac. >12" dbh 1.7 trees/ac. >20" dbh *22.8 trees/ac. Total*	*Dry Forest*	6.1 trees/ac. >10" dbh 17.4 trees/ac. >12" dbh 10.0 trees/ac. >20" dbh **33.5 trees/ac. Total**
South Associated (Mixed conifer)	5.6 trees/ac. >10" dbh 9.1 trees/ac. >12" dbh 1.1 trees/ac. >20" dbh *15.8 trees/ac. Total*	*Moist Forest*	13.1 trees/ac. >10" dbh 36.0 trees/ac. >12" dbh 16.3 trees/ac. >20" dbh **65.4 trees/ac. Total**
North Associated (Grand fir)	1.5 trees/ac. >10" dbh 6.8 trees/ac. >12" dbh 1.1 trees/ac. >20" dbh 9.4 trees/ac. Total		
Lodgepole pine	10.1 trees/ac. >10" dbh 4.3 trees/ac. >12" dbh *14.4 trees/ac. Total*	*Cold Forest*	14.2 trees/ac. >10" dbh 58.0 trees/ac. >12" dbh **72.2 trees/ac. Total**
Subalpine Zone	13.9 trees/ac. >10" dbh 5.3 trees/ac. >12" dbh *19.2 trees/ac. Total*		

Replacement trees, derived from CVS data, were tallied to compare average densities in the watershed with the Forest Plan standards and guidelines. As noted by the results on Table 6-5, "green" replacement tree densities meet or exceed Forest Plan standards. However, GRT densities were significantly lower in the dry forest group when compared to densities in the moist forest or cold forest groups, so caution should prevail when interpreting these results

Down wood densities were not calculated from CVS plots in the watershed, and data supporting down wood densities are not available. However, current Forest Plan direction, for down wood densities can be found in the Regional Forester's Forest Plan Amendment #2 (6/95).

Overall, the Forest Plan standards and guidelines appear to be satisfied or exceeded for all size class grouping for snags and replacement trees. However, as identified in the Forest Plan (4-57), snag densities are to be maintained "… for each logical harvest size unit (or no larger than 40 acres units)." While snag and replacement tree densities may appear to be above standards and guidelines across the watershed, densities may be far below standards in many locations and at the project level. Therefore, inventories will be conducted to assure Forest Plan standards and guidelines are being maintained at the project (treatment) level for dead standing wood, replacement trees, and down wood.

Riparian, Wetland, and Aspen Habitats

Historical information for riparian habitats, wetlands, and aspen stands in the Umatilla and Meacham analysis area is limited to anecdotal information from various journals and publications. Wetlands habitats were probably always limited in both size and distribution across the Blue Mountains, including the analysis area. However, many wet meadows, springs and seeps were probably larger prior to the impacts of unrestricted grazing in the late 1800s. Old photographs and remnant stands suggest that aspen was more widespread at the turn of the century than today, but still mostly occurred in small patches (<20 ac.). Riparian broadleaf communities of cottonwood, alder, and willows occurred along all the major stream and river corridors in the watershed.

The existing vegetation database used in this analysis did not contain riparian, wetland, and aspen communities. These communities do occur in the watershed on a limited basis, however, their extent is less than the 5-acre minimum stand size to be recognized in the vegetation database. The Umatilla drainage contains small wetlands (moist meadows), generally less than 5 acres in size. Broadleaf and aspen communities in the Umatilla watershed are extremely limited. The Meacham drainage also contains small wetlands (moist meadows), generally less than 5 acres in size. Broadleaf and aspen communities in the Meacham watershed are limited and occur in patches less than 2 acres in size.

With the intent to improve riparian, wetland, and aspen communities in the Umatilla and Meacham watersheds, restoration should focus on increasing the amount of habitat and the broadleaf composition in moist and wet areas along streams and seeps and in wet meadows. Communities currently in the watershed should be maintained and further degradation of the community should be prevented. Suitable sites adjacent to existing communities could be regenerated to expand and develop these wetland communities.

"Special/Unique" Habitats

Rocky outcrops and talus slopes within the drainage have changed very little since the early 1900's. Access to these areas and the availability of cover (conifer, shrubs, etc.) around and adjacent to these areas have probably changed. While the significance of cover around these sites is not clear, intuitively it affords a degree of security to move between areas and provides screening from an increasing human presence (i.e. roads, developments, etc.) that could have an impact on some species.

Assessment of Current and Reference Condition for Individual Species and their Habitats

Overview

Historic and current population estimates for most species in the watershed is not available. Historic information on populations and distribution is limited to anecdotal accounts from explorers, trappers, and pioneers passing through the region. The only reliable estimates for current populations are from the Oregon Department of Fish and Wildlife. Without population estimates, the evaluation of species distribution and their probable occurrence can only be derived through habitat modeling. The results and discussion that follow are based on a compilation of several data sources, with the intent to display obvious trends in habitat quality and quantity for a period of 60 years for a few selected species. Results of this evaluation should not be viewed as having statistical reliability and, therefore, interpreted cautiously. Table 6-6 identifies the parameters used to query various vegetative and topographic conditions for this analysis.

Table 6-6. Selected species with habitat indicators used to model current and historic habitat availability in the Umatilla-Meacham watersheds.

Species	Habitat[1]	Cover Type	Structural Stage	Canopy Cover	Other Habitat Features
Rocky Mountain Elk	SC	ABLA2, PIEN, PICO, ABGR, Mix, PSME	SECC, YFMS, UR, OFMS	>= 70%	Canopy Layers: 2 or 3
	MC	ABLA2, PIEN, PICO, ABGR, Mix, PSME, LAOC, PIPO		>= 40%	Canopy Layers: > 1
	F1	ABLA2, PIEN, PICO, ABGR, Mix, PSME, LAOC, PIPO, HC, NF, BU	SI, NF		
	F2	ABLA2, PIEN, PICO, ABGR, Mix, PSME, LAOC, PIPO, HC, BU	SEOC, UR, OFSS		
Pileated Woodpecker	R1	PIEN, ABGR, Mix, PSME, HC	OFMS		
	R2	PIEN, ABGR, Mix, PSME, LAOC, PIPO, HC	YFMS, OFSS, OFMS		
	F1	PIEN, ABGR, Mix, PSME, HC	OFMS		
	F2	ABLA2, PIEN, PICO, ABGR, Mix, PSME, LAOC, PIPO, HC	YFMS, UR, OFSS, OFMS		
Northern three-toed Woodpecker	R1	ABLA2, PICO	OFMS		Elev. >= 4,500 ft.
	R2	PIEN, Mix			
	F1	ABLA2, PIEN, PICO	OFMS, OFSS		
	F2	ABGR, Mix, PSME			
Pine Marten	R1	ABLA2, PIEN, PICO	OFMS	>= 40%	Elev. >= 4,000 ft.
	R2	Mix, PSME			
	F1	ABLA2, PIEN, PICO	YFMS, OFMS		
	F2	Mix, PSME	YFMS, OFSS, OFMS		
Primary Cavity Excavators	Primary	ABLA2, PIEN, PICO, ABGR, Mix, PSME, LAOC, PIPO, HC	OFSS, OFMS		
	Secondary		YFMS, UR		
Lynx	Potential	Cold Moist, Cold Dry, Cool Very Moist, Cool, Moist			Elev. >= 4,500 ft.
	R1	ABLA2, PIEN, PICO	OFMS	>= 50%	
	R2	ABGR, Mix, PSME			
	F1	ABLA2, PIEN, PICO	SECC, YFMS, UR, OFMS		
	F2	ABGR, Mix, PSME			
Wolverine	Reprod.	NF, Rock, Talus			Aspects: N, NE, NW, & E Elev. >= 5,000 ft.
	F1	ABLA2, PIEN, PICO, PSME	SEOC, SECC, YFMS, UR, OFSS, OFMS		Elev. >= 4,000 ft.
	F2	ABGR, Mix, LACO, PIPO, HC			
Northern Goshawk	R1	ABGR, Mix, PSME, LACO, PIPO	OFSS, OFMS	>= 40%	
	R2	ABLA2, PIEN, PICO			
	F1	ABGR, Mix, PSME, LACO, PIPO	SI, SEOC, SECC, YFMS, UR, OFSS, OFMS		
	F2	ABLA2, PIEN, PICO			

1 SC= Satisfactory Cover, MC= Marginal Cover, F1= Primary Foraging Habitat, F2= Secondary Foraging Habitat, R1= Primary Reproductive Habitat, R2= Secondary Reproductive Habitat, NF= NonForest HC= Cottonwood, BU= Burned Area

Management Indicator Species (MIS)

The Forest management indicator species that have the potential to occur in the Umatilla and Meacham watersheds are listed in Table 6-7 along with their representative habitat type. The habitat requirements of these species are presumed to represent those of a larger group of wildlife species. Habitat conditions for MIS, as well as all other wildlife species on the Forest, are managed to maintain viable populations (36 CFR 219.19).

In general, total habitat availability for most MIS has remained stable since 1936 in the Umatilla and Meacham watersheds, with the exception of the three-toed woodpecker (Table 6-8). Sharp declines in primary habitat, however, have occurred for all MIS in both watersheds. The changes from primary habitat to secondary since 1936, notes a loss or deterioration of habitat quality. Based on the parameters used in Table 6-8 this can be attributed to a reduction in large trees and the lack of distinct habitat types. A more specific discussion of historic and current habitat conditions for MIS on the Forest follows.

Table 6-7. Management Indicator Species expected to occur in Umatilla and Meacham watersheds.

Species	*Preferred Habitat Types*
Rocky Mountain elk	General forest habitat and winter ranges.
Pileated woodpecker	Dead/down tree habitat (mixed conifer) in mature and old stands.
Northern three-toed woodpecker	Dead/down tree habitat (lodgepole pine) in mature and old stands.
Pine marten	Mature and old stands at high elevations (>4000').
Primary cavity excavators	Dead/down tree (snag) habitat.

Table 6-8. Management Indicator Species in the Umatilla and Meacham analysis area and available habitat for 1936, 1958, and 1999.

	1936		1958		1999	
Species	Acres	%	Acres	%	Acres	%
Rock Mountain Elk						
Primary Habitat	*106,419*	*72%*	*110,128*	*74%*	*89,012*	*60%*
Secondary Habitat	*40,194*	*27%*	*37,165*	*25%*	*57,098*	*39%*
Total	146,613	99%	147,293	99%	146,110	99%
Pileated Wood pecker						
Primary Habitat	*56,327*	*37%*	*38,923*	*26%*	*13,861*	*9%*
Secondary Habitat	*19,636*	*13%*	*52,867*	*36%*	*60,323*	*41%*
Total	75,963	51%	91,790	62%	74,184	50%
Three Toed Woodpecker						
Primary Habitat	1,061	1%	3,537	2%	0	0%
Secondary Habitat	13,672	9%	12,570	8%	2,785	2%
Total	14,733	10%	16,107	11%	2,785	2%
Pine Marten						
Primary Habitat	1,061	1%	2,910	2%	30	<1%
Secondary Habitat	18,391	12%	10,096	7%	14,657	10%
Total	19,452	13%	13,006	9%	14,687	10%
Primary Cavity Excavators						
Primary Habitat	72,539	49%	88,536	60%	58,561	40%
Secondary Habitat	3,424	2%	3,253	2%	15,625	11%
Total	75,963	51%	91,789	62%	74,186	50%

Rocky Mountain Elk

The elk population in the analysis area in the late 1800s was lower than the present population. By the late 1800s, elk had been nearly extirpated from the Blue Mountains (Langston 1994). Rocky Mountain Elk were reintroduced in the early 1900s and have increased in numbers since that time.

Ninety-five percent of the Umatilla and Meacham analysis area is in the Mount Emily hunt unit. The Mt. Emily hunt unit encompasses the area between Pendleton, Weston, Elgin, and La Grande. Thirty-nine percent of the hunt unit is public land, so the Umatilla and Meacham analysis area is only a portion of the hunt unit. Figure 6-1 displays the trend in elk numbers in the Mt. Emily Unit since 1993. In general, ungulate populations (deer and elk) have remained stable over the last few years. Management objectives (MOs) for populations in the Mt. Emily unit (established in 1989) are 5,700 elk, and 1,950 deer. Generally, elk have remained within 10 percent of state management objective and deer within 20 percent of their objective.

Preferred habitat for elk consists of a mixture of forest and non-forest habitat types and a variety of forest structures to provide forage and cover for summer or winter usage. The Umatilla and Meacham analysis area contains both summer and winter habitats. Summer range (forest habitat) occurs in the upper end of the drainage at higher elevations. Winter range (grassland/grass tree mosaic habitat) occurs in the southwest portion of the watershed and at lower elevations. Approximately two-fifths of the analysis area consists of low elevation winter range.

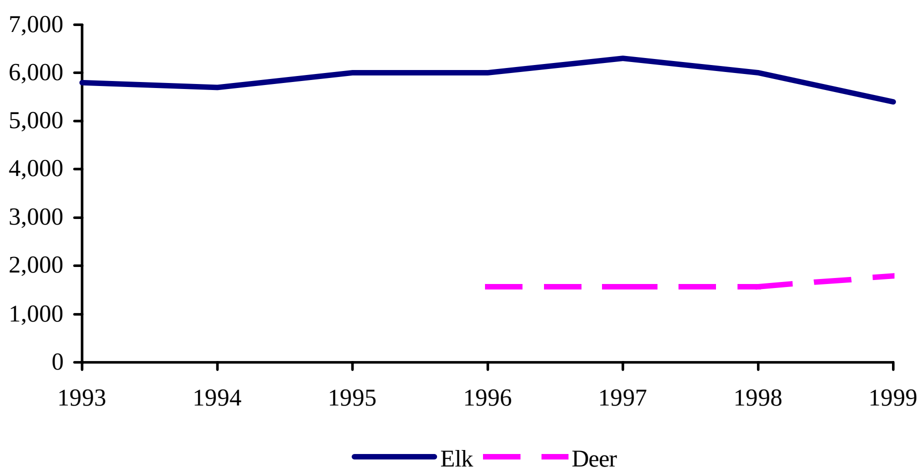


Figure 6-1. Elk and deer population trends in the Mt. Emily Unit

The overall trend in total habitat availability for elk has not changed significantly in the analysis area since 1936 (Table 6-8). However, the availability of primary habitat has changed from about 72 percent of the area in 1936 to approximately 60 percent at present. More specifically, Table 6-9 identifies a 50 percent decline in "key" satisfactory cover when compared to 1936 vegetation data in the Umatilla and Meacham watersheds. Since 1958, marginal cover has increased roughly 50 percent in the Umatilla watershed and about 200 percent in the Meacham watershed (Table 6-8). In the Umatilla watershed, the greatest reduction in satisfactory cover occurred in the following subwatersheds: 13B, 13C, 13E, 13F, 13G, 13H, 13J, and 13K. In the Meacham watershed, the greatest reduction in satisfactory cover occurred in 89G, 89H, 89I, and 89K.

Satisfactory and marginal cover in 1936 occurred in large patches and distinct blocks of habitat (Gobar and Boula 1996). Both cover types were widely dispersed across the landscape. Satisfactory cover occurred at low, mid and high elevations in 1936. At present, satisfactory cover occurs in smaller block and mostly limited to higher elevations while marginal cover is widely scattered and occurs at all levels of the landscape. Cover is "naturally" limited in the western sections of the watersheds. This portion of the watershed is primarily a "grass-tree" mosaic, with grass and shrubs dominate between drainages and ridges and conifer trees restricted to drains and ridge tops. While this analysis shows a declining trend for satisfactory cover, a site-specific analysis should be conducted to determine quantity, quality, and distribution of cover for each planning area. This analysis should take place at the subwatershed or management area level where activities take place.

Table 6-9. Changes in the availability of "key" habitats for Management Indicator Species in 1936, 1959 and 1999, in the Umatilla and Meacham watersheds.

	Umatilla Watershed						Meacham Watershed					
	1936		1958		1999		1936		1958		1999	
Species / Habitats	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%
Rocky Mountain Elk												
Satisfactory Cover	28,946	*40%*	36,197	*51%*	13,130	*18%*	19,533	*26%*	23,680	*31%*	8,992	*12%*
Marginal Cover	18,222	*25%*	9,529	*13%*	21,203	*30%*	8,370	*11%*	7,908	*10%*	22,056	*29%*
Forage	25,293	*35%*	25,230	*35%*	36,200	*50%*	46,249	*61%*	44,749	*58%*	44,529	*58%*
Pileated Wood pecker												
Reproductive (nesting)	37,797	*52%*	27,571	*39%*	9,898	*14%*	18,530	*25%*	11,352	*15%*	3,963	*5%*
Three Toed Woodpecker												
Reproductive (nesting)	0	*0%*	2,072	*3%*	0	*0%*	1,061	*1%*	812	*1%*	0	*0%*
Pine Marten												
Reproductive(natal den)	0	*0%*	2,247	*3%*	0	*0%*	1,061	*1%*	663	*1%*	0	*0%*
Primary Cavity Excavators												
Large Trees	42,144	*58%*	49,183	*69%*	30,749	*43%*	30,395	*40%*	39,353	*51%*	27,812	*36%*

In the Umatilla watershed, the availability of forage habitat for elk has increased approximate 40 percent since 1958, while in the Meacham watershed forage habitat has remained relatively stable. This most likely can be attributed to the large amount of "grass-tree" mosaic in the Meacham watershed and the limited amount of change to the forest structure. Increases in the Umatilla watershed can be attributed to past harvest practices that increase the grass and shrub component in the forest stand. The forage component in the Umatilla and Meacham watersheds appears to be plentiful in both summer and winter ranges.

Forage availability in 1936 occurred in large patches and was wide spread throughout the landscape (Gobar & Boula 1996, Rocky Mountain Elk Habitat 1936 map). In 1999, forage was also widely scattered but occurred in much smaller patches (Gobar & Boula 1996, Rocky Mountain Elk Habitat 1999 map). Winter range occurs primarily in the "grass-tree" mosaic portion of the watershed.

Even with good winter and summer range in the analysis area, some elk forage on private lands adjacent to NFS lands. Utilization off-Forest occurs mostly in the winter and spring, when forage is limited or at lower elevations where "green-up" occurs first. Typically, only small groups of elk are observed. However, larger groups do move onto private lands when the demand for green forage is greatest. Some of the off-Forest use is adjacent to NFS lands, but most of the use occurs 5-10 mile from the Forest boundary (personnel com. with ODFW and CTUIR personnel). While searching for forage, it is not unusual for elk to move outside of their normal range, and some herds have acquired a taste for wheat and alfalfa crops on nearby agricultural lands. Recent management actions to improve winter range implemented by the Forest Service, ODFW, and the CTUIR were intended to hold more elk on public lands and reduce impacts to agriculture lands. While these efforts have improved range condition and resulted in some success at reducing impacts, some elk will continue to seek green lush forage wherever it occurs, regardless of human ownership boundaries.

Roads open to motorized vehicles can further reduce the effectiveness of adjacent habitat for up to one-quarter mile on each side of a road. Road densities are generally low across the analysis area, but do include some localized high densities. Seasonal closures occur on a sizable portion of the winter range in the analysis area. High open road densities (>2.2 miles/sq.mi.) occur in the Spring (13I), the Shimmiehorn (13J), the Upper S.F. Umatilla (13K), and the E.F. Meacham Creek (89K) subwatersheds. The higher road densities coupled with reduced cover could lead to high elk vulnerability within the Shimmiehorn (13J) and the Upper S.F. Umatilla (13K) subwatersheds

With the intent to improve and maintain elk habitat in the Umatilla and Meacham analysis area, restoration should focus on increasing the amount of satisfactory cover and reducing road density. Standards for satisfactory and marginal cover are identified in the Forest Plan for each management area. A planning area analysis should be conducted to determine quantity, quality, and distribution of cover. This analysis should take place at the subwatershed or management area level where activities are expected to occur. In addition to restoring cover, every effort should be made to reduce open road densities in subwatersheds to less than 2 miles per square mile. Subwatersheds in the Umatilla watershed in need of restoration include 13E, 13J, and 13K. In the Meacham watershed restoration could occur in subwatershed 89K. Additional restoration activities should include maintenance of winter range habitat. Continuing prescribed burning in the grass-tree mosaic of Umatilla and Meacham watersheds will maintain forage quality and reduce potential impacts of foraging on private lands.

Pileated Woodpecker

Historic population densities and distribution of pileated woodpeckers in 1936 or 1958 are unknown. Based on the assessment of available habitat, this species would have occurred in the Umatilla and Meacham watersheds in sufficient numbers to maintain a population over time.

Current population status and distribution of pileated woodpecker in the Umatilla and Meacham analysis area is unknown. Formal inventories have not been conducted for these species, except for the presence/absence point count survey for pileated woodpeckers conducted by the Audubon

Society in 1992. This inventory observed pileated woodpeckers in all C1 Management Areas visited by the volunteers. Evidence of pileated woodpeckers (sightings, calls or drumming heard, recent cavity excavations) was noted in all stands surveyed, despite what appear to be "marginal" habitat conditions.

Preferred habitat for the pileated woodpecker consists of large blocks of grand fir and mixed conifer stands in late and old structural stages with large diameter snags and down wood. This habitat can be found in the mid and upper elevations of the Umatilla and Meacham analysis area. In general, the western part of the landscape is less suitable for pileated woodpecker than the eastern end.

Overall, the trend in total available habitat for the pileated woodpecker (Table 6-8) has remained relatively unchanged since 1936, except for a slight increase in 1958. However, the availability of primary habitat has decline dramatically, from about 37 percent of the watershed in 1936 to approximately 9 percent of the watershed in 1999. Meanwhile, secondary habitat has increased for the pileated woodpecker since 1936. The more specific analysis of "key" reproductive habitat (nesting), in Table 6-9, also identifies a declining trend. Since 1936, reproductive (nesting) habitat has declined roughly 75 percent in the Umatilla watershed and about 80 percent in the Meacham watershed. The greatest reduction in nesting habitat, in the Umatilla watershed occurred in subwatersheds 13D, 13G, 13H, 13I, 13J, and 13K. In the Meacham watershed, the greatest reduction in available reproductive habitat occurred in 89H, 89I, 89J, and 89L.

In 1936, primary reproductive habitat was available in large blocks, at mid and high elevations, and was well connected with similar habitat (Gobar and Boula 1996, Pileated Woodpecker Habitat 1936 map). Nesting habitat was widely dispersed across the eastern half of the landscape. In 1999, primary reproductive habitat occurs in a few small patches, limited to higher elevations, and occurs mostly in the north half of the landscape. Overall, the habitat quality for the pileated woodpecker in the Umatilla and Meacham analysis area is considered marginal because of sharp declines in the quantity and quality old forest, and the disjunctive distribution of the remaining primary reproductive habitat. The declines in pileated primary reproductive habitat parallel the declines in late and old structure since 1936.

With the intent to improve and maintain pileated woodpecker habitat in the Umatilla and Meacham analysis area, restoration should focus on increasing the availability of primary nesting habitat. Existing patches of nesting habitat should be maintained and used as building blocks to increase patch size. Large stands (>300 ac.) of grand fir and mixed conifer could be thinned from below to help move the stand to an LOS condition. Subwatersheds in the Umatilla watershed in need of restoration include 13H, 13I, and 13K. In the Meacham watershed, restoration could occur in subwatershed 89K and 89L.

Northern Three-toed Woodpecker

Historic population densities and distribution of the northern three-toed woodpecker in 1936 or 1958 is unknown. Based on the habitat availability assessment, it is assumed this species could have occurred historically in the Umatilla and Meacham analysis area, although not in great numbers. Current population status and distribution of the three-toed woodpecker in the Umatilla and Meacham analysis area is unknown. Formal inventories have not been conducted for this species, except for the presence/absence survey conducted by the Audubon Society in 1992. During that effort, volunteers did not find any evidence of three-toed woodpeckers in any of the C1 Management Areas visited.

Preferred habitat for the three-toed woodpecker consists of mature and old lodgepole pine stands with snags and down wood. This habitat can be found in the upper elevations of the Umatilla and Meacham analysis area primarily along the eastern boundary of the watershed. A relatively small amount of potential habitat occurs in the watershed.

The trend in total habitat availability for the three-toed woodpecker has declined since 1958, but little change has occurred since 1936 (Table 6-8). Because of the limited potential for habitat in the analysis area, primary habitat has remained somewhat stable since 1936. Secondary habitat has decreased from 8 percent of the watershed in 1958 to 2 percent of the watershed in 1999. Table 6-9 identifies the changes in "key" reproductive habitat (nesting) for the three toed woodpecker in the Umatilla and Meacham watersheds. In 1936 and 1999, reproductive (nesting) habitat was not identified in the Umatilla watershed. However, approximately, 2,000 acres of available habitat did occur in 1958. In the Meacham watershed, roughly 800 and 1,000 acres of nesting habitat remained available in the watershed between 1936 and 1958. Currently, reproductive habitat is not available in the Meacham watershed. Historical nesting habitat occurred in subwatersheds 89G and 89H of the Meacham watershed. These subwatersheds occur in a roadless management area, limiting the opportunities to improve habitat for the three-toed woodpecker.

Primary reproductive habitat in 1936 occurred in one large block at the eastern edge of the watershed at the highest of elevations (Gobar and Boula 1996). This habitat could be connected to similar habitat in the adjacent watershed, creating a larger block of habitat. A few scattered blocks of secondary nesting habitat occurred across the eastern half of the landscape. In 1999, secondary reproductive habitat occurred in a few small patches, limited to higher elevations, in the central and eastern portion of the landscape. Overall, the habitat quality for the three-toed woodpecker in the Umatilla and Meacham watersheds is considered poor to marginal, because of the limited habitat potential and declines in habitat quantity and quality of mature and old forest conditions. Other contributing factors include small patch size and poor distribution of remaining habitat. The changes in three-toed woodpecker reproductive habitat parallels the changes in late and old structure and changes in vegetative community composition in the analysis area since 1936.

With the intent to improve three-toed woodpecker habitat in the Umatilla and Meacham analysis area, restoration should focus on increasing the availability of primary nesting habitat. Little opportunity exists to improve habitat since most of the habitat potential occurs in roadless areas. In the long term, habitat could improve through prescribed burning in lodgepole pine stands to regenerate and develop the stand. In the Meacham watershed, restoration could occur in subwatersheds 89G and 89H.

Pine Marten

Historic population densities and distribution of pine marten in 1936 or 1958 are unknown. Based on the assessment of available habitat, this species could have occurred historically in the Umatilla and Meacham analysis area, but not in great numbers. Current population status and distribution of the pine marten in the Umatilla and Meacham analysis area is unknown. Formal inventories have not been conducted for this species, except for the presence/absence survey conducted by the Audubon Society in 1992. During that effort volunteers did not observe or see sign of pine marten in any of the C1 or C2 Management Areas visited.

Preferred habitat for the marten consists of high elevation (> 4000') stands of dense conifer and down wood often associated with streams. This habitat can be found primarily along the eastern boundary of the Umatilla and Meacham watersheds. A relatively small amount of habitat potential occurs in the watershed.

Overall, the trend in total available habitat for the pine marten, identified in Table 6-8, has remained relatively stable in area since 1936. Because of the limited potential for habitat in the analysis area, primary habitat has fluctuated little since 1936. Secondary habitat declined between 1936 and 1958, but increased to 10 percent of the watershed in 1999. Table 6-9 notes the changes in "key" reproductive habitat (denning) for the marten in the both watersheds. In 1936 and 1999, primary reproductive (natal denning) habitat was not identified in the Umatilla watershed. Approximately, 2,200 acres of reproductive habitat did occur in 1958. In the Meacham watershed, about 600 to 1,000 acres of reproductive habitat was retained in the watershed between 1936 and 1958. Currently, reproductive habitat is not available in the Meacham watershed. Historically, available denning habitat occurred in the upper end of subwatersheds 89G and 89H of the Meacham watershed. These subwatersheds occur in a roadless management area, thus limiting the opportunities to improve habitat for the pine marten.

Primary reproductive habitat in 1936 occurred in one large block at the eastern edge of the watershed and at the higher elevations (Gobar and Boula 1996, American Marten Habitat 1936 map). This habitat could be connected to similar habitat in the adjacent watershed, to create a larger block of habitat. Secondary reproductive habitat was limited to a few locations near the eastern boundary of the watershed. In 1999, secondary reproductive habitat was more widely scattered, in small patches, and at mid to high elevations. Overall, the habitat quality for the pine marten in the Umatilla and Meacham watersheds is considered poor to marginal, because of the limited habitat potential and declines in habitat quantity and quality. Other contributing factors include small patch size and poor distribution of remaining habitat. The change in pine marten reproductive habitat parallels the change in late and old structure and the change in vegetative community composition in the analysis area since 1936.

With the intent to improve pine marten habitat in the Umatilla and Meacham analysis area, restoration should focus on increasing the availability of primary reproductive habitat. Little opportunity exists to improve habitat since most of the habitat potential occurs in roadless areas. In the long term, habitat could be improve through prescribed burning in lodgepole pine stands to regenerate and develop the stand. In the Meacham watershed, restoration could occur in subwatersheds 89G and 89H.

Primary Cavity Excavators (PCE)

Included in the PCE group are 16 bird species capable of carving out cavities in dead standing trees, although some species are capable of creating cavities in green trees (Table 6-10). These species are important to the landscape because they provide cavities for secondary cavity nesters and users.

Table 6-10. Species of primary cavity excavators in the Umatilla and Meacham watersheds.

Common Name	Latin Name
Lewis' woodpecker	*Melanerpes lewis*
yellow-bellied sapsucker	*Sphyrapicus varius*
Williamson's sapsucker	*Sphyrapicus thyroideus*
downy woodpecker	*Picoides pubescens*
hairy woodpecker	*Picoides villosus*
white-headed woodpecker	*Picoides albolarvatus*
three-toed woodpecker	*Picoides tridactylus*
black-backed woodpecker	*Picoides arcticus*
northern flicker	*Colaptes auratus*
pileated woodpecker	*Dryocopus pileatus*
black-capped chickadee	*Parus atricapillus*
mountain chickadee	*Parus gambeli*
chestnut-backed chickadee	*Parus rufescens*
red-breasted nuthatch	*Sitta canadensis*
white-breasted nuthatch	*Sitta carolinensis*
pygmy nuthatch	*Sitta carolinensis*

The 1936 and 1958 population density and distribution of primary cavity excavators is unknown. Based on the assessment of available habitat, these species are assumed to have occurred historically in the Umatilla and Meacham watersheds in sufficient numbers to maintain their population over time. Current population status and distribution of primary cavity excavators in the Umatilla-Meacham watersheds is also unknown. Formal inventories have not been conducted for this group of species, except for the presence/absence survey conducted by the Audubon Society in 1992. During that effort volunteers did observe many of PCE species in the areas they visited (personnel com. with Rod Johnson, Walla Walla Ranger District).

Habitat for primary cavity excavators includes conifers stands in a variety of structural stages and the availability of dead trees in various size and decay classes. Primary habitat has the potential to provide snag greater than 16" dbh, while secondary habitat can provide snags greater than 8" dbh but less than 16" dbh. Potential habitat can be found throughout the Umatilla and Meacham analysis area, except for non-forest areas and regenerating forest stands (stand initiation, and stem exclusion).

The trend in total available habitat for primary cavity excavators (Table 6-8) has remained somewhat stable since 1936. However, primary habitat has declined 20 percent since 1936 and about 35 percent since 1958. On the other hand, secondary habitat has increased roughly 350 percent since 1936 or 1958. Table 6-9 identifies the changes in "key" large tree habitat for PCE in the Umatilla and Meacham watersheds. In the Umatilla watershed, the availability of large trees increased from 58 percent of the watershed in 1936 to 69 percent of the watershed in 1958. Currently, large tree habitat for PCE occupied about 43 percent of the watershed. In the Meacham watershed, available habitat rose from 40 percent in 1936 to 51 percent in 1958 and currently occupies about 36 percent of the watershed.

Overall, the quality of habitat in the Umatilla and Meacham watersheds for the primary cavity excavators is considered fair, because of the amount of habitat potential and the good distribution of habitat across the landscape. While the current number of snags may provide an abundance of habitat for PCE in the short term, the low proportion of mature and old forest structure suggests that large diameter snags could be limiting in the long term.

With the intent to improve primary cavity excavator habitat in the Umatilla and Meacham analysis area, restoration should focus on increasing the availability of large tree habitat throughout the landscape.

Threatened, Endangered and Sensitive (TES) Species

Federally listed threatened, endangered and Regional Forester's sensitive species with the potential for occurrence in the Umatilla watershed include one threatened, one proposed, one candidate, and two sensitive species. In addition, numerous species on Oregon State endangered, threatened, and sensitive species have the potential to occur in the watershed. Table 6-11 lists those species that could occur within the analysis area. Habitat requirement and current population levels are described below for each species.

Bald Eagle

Historic population density and distribution of bald eagles in the analysis area are unknown. However, it is assumed that both wintering and nesting eagles were common in the analysis area and occurred along the Umatilla River and lower portion of Meacham Creek

Current population densities and distribution of bald eagle in the Umatilla and Meacham watersheds are unknown. Wintering bald eagles are occasionally observed in the Meacham drainages and along the lower portion of the Umatilla drainage (pers. com. with ODFW and CTUIR). No records of nesting bald eagles in either the Umatilla or Meacham watersheds were found during the course of this analysis.

Preferred nesting habitat for bald eagles is predominately coniferous, uneven-aged stands with an old growth component and near a large body of water (rivers, lakes, etc.) that supports an adequate food supply (USDI 1986). The nest tree is characteristically one of the largest in the stand and usually provides an unobstructed view of a body of water. In Oregon, the majority of nests are within 0.5 miles of the shoreline (Anthony and Isaacs 1981).

Wintering eagles tend to perch on dominant trees that provide a good view of the surrounding area and close to a food source (carrion, fish, etc., USDI 1986). Communal night roosts are generally near a rich food source (high concentrations of waterfowl or fish) and in forested, uneven-aged stands with a remnant old growth component (Anthony et al. 1982 and Isaacs 1993). Communal winter roosts tend to be isolated from disturbance and offer more protection from the weather than diurnal roosts (USDI 1986).

Overall, the quality of nesting habitat for bald eagles in the analysis area is considered poor to marginal, because of the poor quality riparian habitat and the road and railway network that parallels the Umatilla River and Meacham Creek. Wintering habitat is fair along most of the major tributaries in the analysis area. This can be attributed to the amount of winter range adjacent to Umatilla River and Meacham Creek, providing a potential source of carrion and the availability of dominate trees in the area.

Opportunities to improve bald eagle habitat in the Umatilla and Meacham analysis area are limited. Most of the riparian habitat along the Umatilla River and Meacham Creek are privately owned. Forest Service ownership is generally greater than one-quarter mile away from sites with the potential for recovery. However, restoration could focus on recovery of riparian habitat along other tributaries where large tree development is suitable and appropriate. Cottonwood plantings at suitable locations along major stream courses could lead to the restoration of old forest structure in riparian ecosystems.

Canada Lynx

Historic population densities and distribution of lynx in 1936 or 1958 are unknown. Based on the assessment of available habitat, this species could have occurred historically in the Umatilla and Meacham watersheds but to a limited extent. Current population status and distribution of the lynx in the Umatilla and Meacham analysis area is also unknown. Formal inventories have not been conducted for this species. However, miscellaneous sighting have occurred near the north end of the analysis area in the last 10 years.

Preferred habitat for the lynx consists of high elevation (> 4500') stands of cold and cool forest types with a mosaic of structural stages for foraging and denning. This habitat can be found primarily along the northern and eastern boundary of the Umatilla and Meacham watersheds. A relatively small amount of habitat potential occurs in the watershed. However, habitat in this watershed could be connected to similar habitat in adjacent watersheds.

The 1936 and 1958 vegetative databases did not provide potential habitat coverage for those years. Therefore, the trend in historic available habitat cannot be analyzed. Currently, 14 percent of the analysis area contains suitable lynx habitat (Table 6-12). However, only 5 percent of this habitat is prime lynx habitat. Table 6-13 further identifies the "key" habitat components (foraging and denning) for lynx in each watershed. Most of the available habitat for lynx occurs in the Umatilla watershed. The majority of lynx habitat in the Umatilla watershed is foraging habitat; very little denning habitat occurs in this watershed. A relatively large amount of unsuitable habitat (7%) occurs in the Umatilla watershed. The Meacham watershed contains very little denning habitat and unsuitable habitat relative to the Umatilla watershed. Foraging habitat is the most abundant habitat component in the Meacham watershed.

Table 6-11. Threatened and endangered Species with the potential to occur in the Umatilla-Meacham analysis area.

Species	U.S. Fish and Wildlife Service	R-6 Regional Forester's Sensitive (1991)	Oregon State Status
western toad			Sensitive-Vulnerable
Columbia spotted frog	Candidate		Sensitive-Undetermined
tailed frog			Sensitive-Vulnerable
bald eagle	Threatened		Threatened
white-headed woodpecker			Sensitive-Critical
three-toed woodpecker			Sensitive-Critical
black-backed woodpecker			Sensitive-Critical
long-eared myotis			Sensitive-Undetermined
fringed myotis			Sensitive-Vulnerable
long-legged myotis			Sensitive-Vulnerable
western small-footed myotis			Sensitive-Undetermined
silver-haired bat			Sensitive-Undetermined
Townsend's big-eared bat		Sensitive	Sensitive-Critical
marten			Sensitive-Vulnerable
lynx	Proposed Threatened		
wolverine		Sensitive	Threatened

Table 6-12. Selected TES Species and Species of "Interest" in the Umatilla-Meacham Watersheds and available habitat for 1936, 1958, and 1999.

Species	1936		1958		1999	
	Acres	%	Acres	%	Acres	%
Canada Lynx						
Primary Habitat	*No Data*		*No Data*		*7,224*	*5%*
Secondary Habitat	*No Data*		*No Data*		*13,545*	*9%*
Total	No Data		No Data		20,769	*14%*
Wolverine						
Primary Habitat	*3,791*	*3%*	*19,024*	*13%*	*386*	*<1%*
Secondary Habitat	*82,599*	*56%*	*54,409*	*37%*	*78,326*	*53%*
Total	86,390	58%	73,433	49%	78,712	53%
Northern Goshawk						
Primary Habitat	*97,154*	*66%*	*92,018*	*62%*	*96,190*	*65%*
Secondary Habitat	*2,134*	*1%*	*5,218*	*4%*	*95*	*<1%*
Total	99,288	67%	97,236	66%	96,285	65%

Table 6-13. Acres of "key" habitats for TES species and species of "Interest" for 1936, 1958, and 1999, in the Umatilla and Meacham watersheds.

Species / Habitats	Umatilla Watershed						Meacham Watershed					
	1936		1958		1999		1936		1958		1999	
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%
Canada Lynx												
Denning	No		No		531	*1%*	No		No		409	*1%*
Foraging	Data		Data		7,305	*10%*	Data		Data		4,876	*6%*
Unsuitable					5,184	*7%*					2,478	*3%*
Wolverine												
Foraging (Primary)	970	*1%*	10,877	*15%*	155	*<1%*	2,821	*4%*	8,147	*11%*	231	*<1%*
Northern Goshawk												
Reproductive (Nesting)	37,794	*52%*	32,419	*45%*	12,209	*17%*	18,530	*25%*	24,310	*32%*	5,430	*7%*

In 1999, primary denning habitat did not occur in the Umatilla and Meacham analysis area. Secondary denning habitat was relatively limited to small patches scattered among foraging and unsuitable habitat (Gobar and Boula 1996). This habitat most likely was connected to similar habitat in the adjacent watershed, creating a larger block of habitat. Overall, the habitat quality for the lynx, in the Umatilla and Meacham watersheds, is considered poor to marginal, because of the limited amount of potential habitat and the large proportion of unsuitable habitat in the analysis area.

With the intent to improve lynx habitat in the Umatilla and Meacham analysis area, restoration should focus on reducing the amount of unsuitable habitat and increasing the availability of foraging and denning habitat.

Columbia Spotted Frog

Historic populations and distribution of spotted frog in the analysis area are unknown. However, it is assumed that the frogs occurred in the analysis area and in most of the wetland habitat across the area. Current population densities and distribution of spotted frogs is unknown. Spotted frogs have been observed at a few locations along the Umatilla River and just outside the analysis area (Karen Kronner, personnel com. 1998).

The preferred habitat for the frog consists of marsh and permanent ponds, and slow streams, usually with abundant aquatic vegetation. Flooded or wet meadows near a pond or stream can provide breeding habitat. Suitable habitat for the spotted frog can be found in the analysis area along the numerous streams and a few wet meadows or seeps. The limiting factor for spotted frogs in the area could be insufficient aquatic vegetation for cover and foraging.

With the intent to improve spotted frog habitat in the Umatilla and Meacham analysis area, restoration should focus on increasing and maintaining riparian and aquatic vegetation around moist and wet areas (streams, seeps and wet meadows). Wetland communities currently in the watershed should be maintained and prevented from further vegetative degradation. Suitable sites adjacent to wetland communities could be regenerated to expand and develop these communities.

Townsend's big-eared bat (Pacific western big-eared bat)

Historic population densities and distribution of big-eared bats in 1936 or 1958 are unknown. It is assumed the bat could of occurred in the analysis area historically, but to a limited extent. Current population status and distribution of the bat in the Umatilla and Meacham analysis area is unknown. However, a Townsend's big-eared bat a colony was located in the analysis area in 1997. The hibernaculum occurs in the attic of an old building on private land adjacent to the Umatilla River. This bat most likely frequents the Forest when foraging.

The Pacific western big-eared bat occurs in a wide variety of habitat including coniferous forests. Bat occurrence is strongly correlated with the availability of caves or cave-like roosting habitat (mines, buildings, etc. Perkins 1992). Individuals or small groups (3-5 individuals) of bats may day roost in hollow and creviced trees and snags for a limited time. The most significant roosts are those with large congregations of bats, summer maternity roosts, and winter hibernacula (ISCE 1995). These sites are highly sensitive to disturbance and human interference. Foraging occurs after dark in a variety of habitats including, open areas as well as forested areas. The bat forages within tree canopies and gleans insects from vegetation (Perkins 1992 and Nowak 1994). This bat can forage up to 8 miles from day roosts, but tends to forage within a few miles of colonial roosts (Perkins 1992). Potential habitat in the analysis includes out buildings, rocky areas with deep crevices, hollow trees, and snags near water. Suitable habitat would most likely occur adjacent to the Umatilla River and its major tributaries.

With the intent to improve bat habitat in the Umatilla and Meacham watersheds, restoration should focus on maintaining snag densities along the Umatilla River and its major tributaries. An inventory should be conducted along the Umatilla River and Meacham Creek to evaluate potential colonial roosts and hibernacula habitat. Buildings should be surveyed for potential bat roots prior to any renovation or reconstruction activities.

California Wolverine

Historic population densities and distribution of wolverine in 1936 or 1958 are unknown. The wolverine was probably never common in the analysis area, owing to the species' large territory size (Banci 1994) and the lack of natal denning habitat. The historic presence of wolverine in the watershed was mostly limited to foraging at best. Current population status and distribution of wolverine in the Umatilla and Meacham analysis area is unknown. Winter snow track surveys were conducted in 1991 and 1992, for wolverine, fisher, American marten and lynx across the District and just northeast of the analysis area. Verifiable sightings or tracks have yet to be documented; however, miscellaneous sighting have occurred on the District just north of the analysis area within the last 10 years.

The wolverine prefers high elevation conifer forest types, with a sufficient food source, and limited exposure to human interference (USDA 1994). Natal denning habitat includes open rocky slopes (talus or boulders) surrounded or adjacent to high elevation forested habitat that maintains a snow depth greater than 3 feet into March and April (USDA 1994). The wolverine is an opportunistic scavenger, with large mammal carrion the primary food source year-round. While foraging, they generally avoid large open areas and tend to stay within forested habitat at mid - high elevations (>3,000') and typically travel 18-24 miles to forage/hunt (USDA 1994).

Natal denning habitat does not occur in the Umatilla and Meacham analysis area. The nearest "potential" natal denning habitat is greater than 10 miles north of the analysis area. The majority of the analysis area is suitable for foraging, except for that portion in the grass-tree mosaic community.

The habitat assessment for wolverine was limited to foraging habitat since denning habitat was not available in the area. The trend for the total habitat availability for wolverine in the analysis area has remained relatively stable, but has ranged from a high of 58 percent in 1936 to a low of 49 percent in 1958 (Table 6-12). However, the availability of primary habitat (foraging) varies greatly, from 3 percent in 1936, to 13 percent in 1958, and currently less than 1 percent of the analysis area. Table 6-13 further documents the changes in "key" foraging habitat for wolverine in each watershed. Since 1958 nearly 100 percent declines in foraging habitat have occurred in both watersheds. However, current quantities of available foraging habitat are near 1936 quantities of available habitat.

In 1936, primary foraging habitat occurred in a few small to moderate blocks, scattered across the mid section of the analysis area (Gobar and Boula 1996). Secondary habitat was much more widespread and well connected to similar habitat over most of the area. In 1999, wolverine primary foraging habitat was scattered across the analysis area and occurred in very small patches. Secondary foraging habitat in 1999 was similar in distribution and connectivity to 1936 secondary habitat. Overall, the current habitat quality for wolverine in the Umatilla and Meacham analysis area is considered poor to marginal, because of the lack of natal denning habitat and the limited amount of primary habitat in the analysis area.

With the intent to improve foraging habitat for wolverine in the Umatilla and Meacham analysis area, restoration should focus on reducing road density and maintaining connectivity in forest habitat.

Neotropical Migratory Birds (NTMB)

Neotropical migrant birds include species which nest in North America and migrate to Central and South America for the winter. Over the past two decades, declines in many NTMB species have been noted, including many songbirds that nest in the Blue Mountains. Causes for the declines include habitat degradation in winter and summer habitats and the continued use of toxic pesticides in Latin America (Sharp 1992).

Neotropical migrants account for a significant portion of the avian biological diversity in the Umatilla and Meacham watersheds. Of the 154 species of birds known or suspected to occur in this analysis area, 76 (50%) are NTMBs. These species occupy a variety of habitats: 31 are closely associated with riparian habitats, and 31 species are associated with old growth. Only 18 of the NTMB species were strongly associated with stand initiation or stem exclusion.

The MAPS (Monitoring Avian Productivity and Survivorship) program, a cooperative effort between public and private organizations, was initiated in 1992 to provide trend data for diurnal land birds, including NTMBs. Two MAPS stations are located within the analysis area; one at Buck Mountain, the other at Coyote Ridge. Data highlight for 1992 through 1995 seasons include:

-30 different species were identified at Coyote Ridge and 32 at Buck Mountain.

-The overall species composition of the breeding community is relatively stable.

-Species richness is highest in meadows and habitats having a high degree of edge.

-The total abundance of songbirds remained relatively stable for the time period,

-Song bird productivity appears to be declining from 1992 levels.

In 1994, the Oregon and Washington Chapters of Partners In Flight (PIF) came together to analyze the status of NTMB in Oregon and Washington. That report (Andelman and Stock 1994) identified breeding NTMB in Oregon, habitat relations, and NTMB population trends. The analysis primarily relied on breeding bird surveys conducted across the state between 1968 and 1994. In addition, the Interior Columbia Basin Ecosystem Management Project (ICBEMP), assessed NTMB in the basin (Saab and Terrell. 1997). The ICBEMP assessment took the Oregon and Washington PIF assessment a step further, and assessed NTMB under various management themes. Table 6-14 contains NTMB breeding in the Umatilla-Meacham analysis area and identified in Andelman and Stock (1994, Table 4) as species with significant declining trends, and in and Saab and Terrel (1997, Table 6) as species of high concern to management.

Table 6-14. Neotropical migratory birds of "concern" in the Umatilla and Meacham analysis area.

Species	Primary Habitat for Breeding	Significant Declining Trends (Andelman and Stock 1994)	High Concern to Management (Saab and Rich. 1997)
American kestrel	Coniferous forest, Grassland,	X	
Band-tailed pigeon	Riparian,	X	
Mourning dove	Coniferous forest, Riparian	X	
Vaux's swift	Coniferous forest, Riparian	X	
Rufous hummingbird	Coniferous forest, Riparian	X	
Belted kingfisher	Riparian	X	
Williamson's sapsucker	Coniferous forest, Riparian	X	
Lewis' woodpecker	Coniferous forest, Riparian		X
Olive-sided flycatcher	Coniferous forest	X	X
Willow flycatcher	Riparian		X
Western wood-pewee	Coniferous forest, Riparian	X	
Violet-green swallow	Coniferous forest, Riparian	X	
Barn swallow	Riparian	X	
Rock wren	Grassland, Cliff, Rock, Talus	X	
Swainson's thrush	Coniferous forest, Riparian	X	
Varied thrush	Coniferous forest	X	
Orange-crowned warbler	Riparian	X	
Wilson's warbler	Riparian	X	
Hermit warbler	Coniferous forest		
Western tanager	Coniferous forest, Riparian	X	
Chipping sparrow	Coniferous forest	X	
White-crowned sparrow	Riparian	X	
Dark-eyed junco	Coniferous forest, Riparian	X	

Species	Primary Habitat for Breeding	Significant Declining Trends (Andelman and Stock 1994)	High Concern to Management (Saab and Rich. 1997)
Western meadow lark	Grassland	X	X
American goldfinch	Riparian	X	
Pine siskin	Coniferous forest		X

As noted in Table 6-14, most of these species are dependant on coniferous forests and riparian habitats. While these habitats occur in the analysis area, current habitat prohibits distinct habitat types, an imbalance of structural diversity, and the increasing number of small patches of habitat scattered across the landscape. Theses changes can lead to a reduction in habitat quality for many bird species that dependent on a variety of structures, habitat types, and large patches of habitat to function over time in the landscape.

With the intent to improve land bird habitat in the Umatilla and Meacham watersheds, restoration should focus on increasing vegetative composition and structural diversity. Reference the Habitat Composition and Riparian sections above for restoration activities that improve or maintain NTMB habitat.

Other Species of "Interest/Concern"

Historic information for birds, small mammals, reptiles and amphibians is almost totally anecdotal. As noted in the Ochoco National Forest Viable Ecosystems Management Guide (1994), higher water tables, more extensive riparian vegetation and aspen groves, and more beaver activity no doubt provided more suitable habitat for amphibians, waterbirds, songbirds, and riparian-associated small mammals such as shrews and mink, than do current conditions.

Black bear and cougar may actually be more common today than in the early 1900s, as a result of recovering deer herd densities and restrictions on hunting of predators. Coyotes are common throughout the Blue Mountains. Bobcats are trapped and occasionally observed in the analysis area, but population numbers and distribution are unknown.

Otters, thought to be extirpated, were recently sighted on the North Fork Umatilla (R. Johnson, pers. comm. 1995). Evidence of past and/or present beaver activity is found along the upper portion of Meacham Creek, the North Fork Umatilla and the South Fork of the Umatilla creeks. The Umatilla and Meacham drainages almost certainly lost the bulk of their beaver populations during the fur-trading era of the late 18th and early 19th centuries.

Blue and ruffed grouse persist in the analysis area, although no information on current population status or distribution is available. Re-introduction of the sharp-tailed grouse was undertaken at Zumwalt Prairie, on the adjacent Wallowa-Whitman National Forest in the early 1990s. Chukar, Hungarian partridge, and wild turkey were introduced by ODFW and are occasionally observed in the Meacham drainage (K. Blakely, ODFW, pers. comm., March 1996).

Historic population densities and distribution of the white-headed woodpecker are unknown. The white-headed woodpecker was probably never a common species, except perhaps in areas of extensive stands of mature ponderosa pine. However, based on assessment of historic habitat conditions, both species are assumed to have occurred in the Umatilla and Meacham watersheds in sufficient numbers to maintain a population over time. The current population of white-headed woodpeckers in the Umatilla and Meacham analysis area is unknown. Sightings of the white-headed woodpeckers are uncommon.

Northern Goshawk

Historic population density and distribution of the goshawk in 1936 or 1958 are unknown. Based on the assessment of available habitat, this species would have occurred historically in the Umatilla and Meacham watersheds in sufficient numbers to maintain a population over time. Current population status and distribution of goshawk in the Umatilla and Meacham analysis area is unknown. Goshawks have been observed recently in both the Umatilla and Meacham watersheds, but sightings are uncommon. The only known nest site was apparently abandoned when a harvest unit adjacent to the nest was logged and burned in the late 1980s. No new nests were ever located in the immediate area.

Preferred habitat for the goshawk consists of coniferous forests with variety of structural stages for nesting and foraging. Nesting sites consist of large trees, surrounded by dense overstory canopies with a relatively open understory and generally situated within one-quarter mile of a stream or other water source. The best foraging habitat occurs in a mosaic of structural stages scattered across the landscape. Goshawk habitat can be found in the mid and upper elevations of the Umatilla-Meacham analysis area.

Overall, the trend in total available habitat for the goshawk (Table 6-12) has remained relatively unchanged since 1936. Available primary and secondary habitat has remained relatively stable in the analysis area since 1936. The more specific analysis of "key" reproductive habitat (nesting), in Table 6-13, identifies a declining trend for each year in the Umatilla and Meacham watersheds. Since 1936, reproductive (nesting) habitat has declined roughly 70 percent in the Umatilla and Meacham watersheds. The greatest reduction in nesting habitat, in the Umatilla watershed occurred in subwatersheds 13D, 13G, 13H, 13I, 13J, and 13K. In the Meacham watershed, the greatest reduction in available reproductive habitat occurred in 89H, 89I, 89J, and 89L.

In 1936, primary reproductive habitat was available in large blocks, at mid and high elevations, and was well connected with similar habitat (Gobar and Boula 1996). Nesting habitat was widely dispersed across the eastern half of the landscape. In 1999, primary reproductive habitat occurred in small patches and widely scattered, patches area limited to mid elevations, and occurred mostly in the north half of the landscape.

Overall, the habitat quality for the goshawk in the Umatilla and Meacham analysis area is considered fair because primary reproductive habitat is not well distributed and quantity of old forest habitat is small. The declines in goshawk primary reproductive habitat parallel the declines in late and old structure since 1936.

With the intent to improve and maintain goshawk habitat in the Umatilla and Meacham watersheds, restoration should focus on increasing the availability and distribution of primary nesting habitat. Existing patches of nesting habitat should be maintained. Other stands should be moved toward a more mature or old structural class. Subwatersheds in the Umatilla watershed in need of restoration include 13H, 13I, and 13K. In the Meacham watershed, restoration could occur in subwatersheds 89K and 89L.

INTEGRATION OF FINDINGS AND IMPLEMENTATION

Overview of the Integration Process

A crucial part of ecosystem analysis is the integration of the results into a prioritized scheme of management opportunities and recommendations. Integration of information, concerns and priorities for the Umatilla and Meacham Ecosystem analysis evolved through a series of team-interactive work sessions where team members shared information about subwatershed attributes from their individual analyses. Each member contributed to construction of a matrix of important attributes within each issue, rating their level of concern (L, M, H, i.e., low, moderate, high) for conditions in each subwatershed. Using these, the team compiled a list of concerns (both positive and negative attributes) and management recommendations for each subwatershed. Next, attributes in each matrix were pared down to those considered to be "key attributes". These attributes were then used to rank subwatersheds for *action* **or** *conservation* **within each issue**. Refinement continued, with a tally of the number of times a subwatershed was listed in the action or conservation priorities. This process resulted in a final overall priority placement of each subwatershed. However, because so many subwatersheds surfaced as high priorities, new tables and maps of selected attributes were constructed to help the team decide which should receive highest overall validation priority for restoration action and conservation. Finally, a list of projects for each of the highest priority subwatersheds was generated from the sets of recommendations developed for each subwatershed.

Conservation concerns arise from the need to conserve high quality elements within one or more parts of some subwatersheds. These same subwatersheds may also have other portions with one or more high priority management opportunities. These apparently contradictory actions for a particular subwatershed must be viewed in terms of long-term goals for ecosystem sustainability.

Participation by Walla Walla Ranger District specialists facilitated the integration process. The exchange of information between team members and experienced local managers helped identify and resolve problems related to the implementation of the report's findings.

Ranking of Subwatersheds by Priority for Restoration

Subwatershed priorities by key attributes are presented in Tables 7-1 and 7-2. The priorities of subwatersheds organized by issues, are shown in the Tables 7-3 and 7-4. In the latter two tables, the listing of subwatersheds with high priority for action or conservation included nearly all the subwatersheds when listed across all issues. A few subwatersheds received a high action priority under two issues, and several subwatersheds were a high priority for action under one issue, but also had at least a portion of the area with high priority for conservation under another issue. Some subwatersheds were high conserve priority, but also had at least a portion of the area with some level of action priority (89A, 89E, 89J).

Table 7-1. Umatilla subwatershed management priorities by resource attribute.

Resource Category	Conserve (High Priority)	Project Action Priority		
		Low	Medium	High
Hydrologic Functions & Processes				
Quantity Changes	13E, G, J	A, E	D, H, K	I, F
Quality Changes	E, G, J	E, J, K	A, B, D, G	F, H, I
Channel and Riparian Areas Changed	A, E, J	J, G	A, D, K	B*, C, F
Fish Habitat				
Pool Habitat Quality		13F, H	C, K, D, L	A, E, G, I, J
Water Temperature				ALL
Substrate Quality	G	C, D, F	A, E, H	I, J, K
Fish Cover/Complexity			A, C, D, E, F, G, H, J	I, K
Forest Vegetation Sustainability				
Site/Soil Productivity				
Stand Damage		C, F, B	H, G, D, A	E, K, J, I
Stand Density		B, F, I	C, G, H, J	A, D, E, K
Fire Hazard Reduction		J, E	A, C, G, H	B, D, E, K
Noxious Weeds or New Invaders				
Botanical Biodiversity				
Floristic Biodiversity		13E		D
Sensitive Species	E, K, D	E, K		D
Vertebrate Biodiversity				
Terrestrial Species Diversity	13E, J	L, F, B	A, C, D, G	I, H, K
Terrestrial Habitat Diversity		F, L	A, B, I, K	C, D, E, G, H, J
Late Old Forest Structure	E, J	F	B, G, K, L	A, C, D, H, I

Table 7-2. Meacham Creek subwatershed management priorities by resource attribute.

Resource Category	Conserve (High Priority)	Project Action Priority		
		Low	Medium	High
Hydrologic Functions & Processes				
Quantity Changes	89G, H, I, K, L, R, N	G, H, I	C, K, L	J, N, R
Quality Changes	G, H, I	G, H, I	C, F, J	A, B, D, E
Channel and Riparian Areas Changed	G, H, I	D, E, J	A, C, E, H, K	B, D, F, I, L
Fish Habitat				
Pool Habitat Quality		89A, C	B, E, F, G, K, L, O, R	Q, E, G, I, J
Water Temperature				ALL
Substrate Quality	G, H	J, M	I	E, F
Fish Cover/Complexity			E, F, G, H, K, J, M	I, K
Forest Vegetation Sustainability				
Site/Soil Productivity				
Stand Damage		G, N, M, A, E, J	C, O, D, F, B	G, H, I, L, K
Stand Density		C, E, F, J, M, Q	I, A, N, K, O	L, G, D, H, B
Fire Hazard Reduction		N, O, Q, R	A, B, E, K, L, M	C, D, F, J, I
Noxious Weeds or New Invaders				
Botanical Biodiversity				
Floristic Biodiversity		89B, E, G, H		
Sensitive Species	G, H			D
Vertebrate Biodiversity				
Terrestrial Species Diversity Terrestrial Habitat Diversity	89G	A, D, E, F, M, N, R C, M, Q, R	B, C, J, L, Q A, D, E, F, K, L, N	H, I, K, O B, G, H, I, J, O
Late Old Forest Structure	G	D	A, B, C, K, M, N, O, Q, R	E, F, H, I, J, L

Table 7-3. Subwatershed priorities by issue for the Upper Umatilla Watershed

Issue	Conserve (High Priority)	Project Action Priority		
		Low	Medium	High
Veg. Sustainability		B,L	A,C,F,H,I,K	D,E,G,J
Fish/Water	A,D,E,G,J		H,K	B,C,F,I,L
Terrestrial Biodiversity	E,J,K	F,L	A,B,G	C,D,H,I

Table 7-4. Subwatershed priorities by issue for the Meacham Watershed

Issue	Conserve (High Priority)	Project Action Priority		
		Low	Medium	High
Veg. Sustainability		J,M,Q,R	A,B,D,E,F,K,N	C,G,H,I,L,O
Fish/Water	G,H,I,K,L	Q,R	C,F,J,M,O	A,B,D,E,N
Terrestrial Biodiversity	G,H	D,M,R	A,B,C,E,F,K,L,N, Q	I,J,O

Highest Priority Subwatersheds

Subwatersheds with high priority for restoration and/or conservation were further considered by constructing new tables and re-listing some key attributes. Those subwatersheds of concern for bull trout were automatically designated highest priority. Those subwatersheds chosen include many with 1,000 or more acres where vegetation sustainability may be threatened by excessive stem density (overstocking). The subwatersheds listed in Tables 7-5 and 7-6 were those selected by the team as the highest in overall priority for field validation of attributes analyzed and for subsequent planning of projects, based on validation results. It should be noted that the acreage figures are estimates, and will change after field validation of the vegetation and other data.

Table 7-5. Attributes for high priority subwatersheds in the Upper Umatilla Watershed.

Resource Attribute	Subwatershed				
	13c	13d	13e	13g	13i
Late-Old Structure	Restore	Maintain and Restore	Maintain	Maintain and Restore	Maintain and Restore
Bull Trout Reproduction	No	Yes	Yes	Yes	No
Chinook Spawning	Yes	Yes	No	No	No
Total Road Density (total miles in GIS)	<2.0	<2.0	2.1 (37 mi)	2.1 (23 mi)	3.6 (31 mi)
Riparian Road Density (mi/sq. mi)	1.3	0.3	0.6	0.3	4.6
Riparian Roads (mi/linear mile of stream)	0.1	<0.1	<0.1	<0.1	0.2
Water Quality Limited - Temp.	Yes	No	No	No	No
ECA (%)[1]	5	4	9	11	28
Hydrologic Response	High	Mod.	Low	Low	Mod.
Forest Sustainability -- Excess Density (acres)	2058	1569	2799	1712	658
Forest Sustainability -- Fir Encroachment (acres)	2063	637	371	865	736
Harvest of NF (%)	7	15	33	28	71
Compact. Abate. (acres)	155	102	699	348	594

[1] ECA is equivalent clearcut acres in percent, and was obtained from Clifton (1996).

Table 7-6. Attributes for high priority subwatersheds in the Meacham Watershed.

Resource Attribute	Subwatershed			
	89f	89g	89h	89i
Late-Old Structure*	Maintain and Enhance	Maintain and Enhance	Maintain and Enhance	Maintain and Enhance
Bull Trout Reproduction	Yes	Yes	Yes	Yes
Chinook Spawning	No	No	No	No
Hydrologic Response	High	Mod.	Mod.	Mod.
Total Road Density	<2.0	<2.0	<2.0	<2.0
Riparian Road Density (mi/Mi^2)	0	0.1	<0.1	0.4
Riparian Roads (mi/linear mile of stream)	0	<0.1	<0.1	<0.1
ECA (%)[1]	0	1	0	7
Water Quality Limited - Temp.	Yes	Yes	No	No
Forest Sustainability -- Excess Density (acres)	399	1255	1077	1182
Forest Sustainability -- Fir Encroachment (acres)	276	322	213	1409
Harvest of NF (%)	2	8	1	23
Compact. Abate. (acres)	0	113	0	254

[1]ECA is equivalent clearcut acres in percent, and was obtained from Clifton (1996).

Additional Fish/Aquatic Restoration/Conservation Considerations

Migration Corridor for Bull Trout and Anadromous Salmonids

The reproducing populations of bull trout in North Fork Umatilla and North Fork Meacham Creek must be considered at risk because they are small and isolated from other segments of the larger metapopulation. Maintaining a habitat corridor between them is therefore crucial. That portion of Meacham Creek downstream of the mouth of North Fork Meacham and that part of the Umatilla River downstream of the mouth of North Fork Umatilla as far as the mouth of Meacham serve as the corridor which bull trout must use to move between the two sub-populations in these watersheds.

Steelhead use the same stream channels to migrate to the reaches and tributaries where they spawn. Chinook salmon use these reaches for both spawning and migration. Both chinook and steelhead use the reaches for rearing. Protection and restoration of this migration habitat is essential to the long-term survival of the two bull trout populations and will also benefit the chinook salmon and steelhead.

Most of this corridor is not on National Forest land. Management of these lands in ways that would protect and improve their function as migration corridors will require cooperation between state, private, tribal and federal agencies and landowners. The major needs as far as migration habitat is concerned includes escape and hiding cover, holding water for rest during migration and while awaiting spawning conditions, and sufficient streamflow and appropriate water temperature during migration periods. The Forest Service could help support these at-risk bull trout populations by working to ensure that habitat needs are met on the National Forest portion of streams. Meeting these needs on stream reaches outside the National Forest is essential and would require cooperation with private landowners.

Some habitat needs in these stream reaches have been addressed. Instream structures, which can serve as holding water during migration, have been built on both private and National Forest land. Adding hiding and escape cover would likely improve migration and spawning success. The most effective way to provide for long-term improvement would probably be to plant appropriate tree species for shade and future woody debris and strategically manage livestock access to the riparian zone.

Considerations for Preservation of Late/Old Forest Structure

Management Direction for LOS

In the Land and Resource Management Plan (Umatilla National Forest 1990), "…old growth stands will be provided through dedicated forested units, managed lodgepole stands, riparian areas, and unroaded areas distributed throughout the Forest (4-6)". The dedicated old growth units are in mixed conifer and ponderosa pine types that have been identified and mapped as Management Area C1. Lodgepole pine habitat units are identified and managed according to the specifications listed in Management Area C2. In addition, the Forest Plan protects existing old growth/mature habitat in Management Areas A1, A2, A7, A8, C3A, C7, C8, D2, F2, and F4 (roadless, riparian, and other suitable areas outside wilderness). The old growth/mature habitat on the Forest is managed for those species with a strong affinity for that habitat condition (i.e. pileated woodpecker, marten, three-toed woodpecker, etc.). The size of old growth stands varies by management indicator species (MIS): pileated woodpecker, 300 acres; pine marten, 160 acres; and northern three-toed woodpecker, 75 acres. The distribution of stands differs for dedicated and managed stands, but average spacing is every 5 miles across the Forest. Units did not need to meet old growth/mature conditions at the time of selection. Forest-wide standards for old growth include the following: maintain habitat within suitable and/or capable conditions for the MIS, maintain the distribution of units throughout the Forest, and maintain sufficient amounts for (other) wildlife species. Essential to the management of old growth is field verification and tracking of units, stands, and surrounding areas.

Current LOS Situation

A variety of wildlife species on the Forest appear to demonstrate a high level of use and dependence on mature and old growth tree habitat. Management activities, disease and insect outbreaks have reduced much of the suitable old growth tree habitat once found in these watersheds. Based on historic records and current habitat assessments, the size and arrangement of late/old forest has declined greatly since 1936. Historic late/old forests typically occurred in large patches, contained a large amount of interior habitat, connected to similar habitats. Current late/old forests generally occur in small patches, contain little interior habitat, are widely scattered patches and seldom connect to similar habitats. As shown in Table 4-7, several plant association groups are below their historic range of variability for old forest structure. Current LOS stands are not uniformly or evenly distributed across the landscape.

The management of old growth habitat for wildlife species and other values continues to be an issue of controversy. Various public interests are divided on the amount of old growth habitat to retain on the Forest. A number of individuals have expressed concern about reductions of old growth/mature tree habitat. Based on this controversy and the current condition of old forest stands, one objective of forest management is to restore late/old forest conditions in this watershed and across the Forest.

Proposed LOS Strategy

Overall, the goal is to manage for a late and old forest condition well within the Historic Range of Variability (HRV) of the watershed. The following objectives lead to the restoration of the Late and/or Old Structural component in the watershed.

- Maintain existing LOS units/stands.
- Expand the LOS component in the watershed.
- Increase the patch size of LOS stands.
- Utilize existing LOS direction to implement the strategy.

Implementation

The purpose of this strategy is to increase the amount of late and old structure in the watershed as soon as possible and to restore this component firmly within the HRV. In order to have a significant and lasting affect on the watershed, enough acreage needs to be identified to make a difference in the structural composition of the watershed. A moderate level of restoration would provide a reasonable stockpile to thwart the continued erosion of the LOS component in the watershed due to insect, disease, fire, harvest, and stand dynamics. Once stands have developed, structural diversity in the watershed would resemble a more "desirable" condition. In addition, with a more diverse structural component the watershed would be more receptive to an array of cultural treatments increasing management options throughout the watershed. Targeting a moderate level of restoration also provides a firm foundation for the re-establishment of old growth habitat and wildlife species associated with LOS in the watershed and across the Forest. Maintaining the LOS component at a moderate level puts the District in a better position to manage the LOS component, once "optimal" levels are established (at some point in time) and hedges, the likelihood of going back and increasing the amount of LOS in the future if restoration were to occur at a lower level. Managing LOS at lower level essentially maintains the status quo in the watershed limiting management's flexibility, and potentially impeding the recovery of ecosystem processes and function.

Table 7-7 identifies the amount of LOS to restore in the watershed. The middle point of the HRV that is identified for each PAG, is simply a rounded value derived from the mean of the two extreme values of the historic range for the two structural classes. The HRV mid-point value represents a moderate level of LOS attainment. The Restoration Objective is the target value to be attained in the watershed. If possible, a restoration objective less than 150 acres, for any PAG, should be joined with a similar potential vegetation groups (PVG (i.e. Cold Forest, Moist Forest, Dry Forest, etc.)) in order to reduce the number of fragmented stands, increase interior habitat, and to approximate historic patch size.

Table 7-7. LOS restoration objectives for Plant Association Group in the Umatilla and Meacham watershed.

Plant Association Group	Old Forest Single Strata				Old Forest Multi Stratum			
	Historic Range of Variability	HRV Mid-point	Restoration Objective (Acres)		Historic Range of Variability	HRV Mid-point	Restoration Objective (Acres)	
			Umatilla	Meacham			Umatilla	Meacham
Cold, Dry	0-5 %	3%	22	35	10-40 %	25%	180	290
Cool, Wet	0-5 %	3%	140	18	30-60 %	45%	2,101	274
Cool, Very Moist	0-5 %	3%	89	54	20-40 %	30%	890	538
Cool, Moist	0-5 %	3%	741	547	10-30 %	20%	4,941	3,645
Warm, Very Moist	0-5 %	3%	103	118	20-40 %	30%	1,033	1,178
Warm, Moist	0-5 %	3%	55	55	10-30 %	20%	367	364
Warm, Dry	15-55 %	35%	4,365	6,883	5-20 %	13%	1,621	2,557
Hot, Dry	20-70 %	45%	8	363	5-15 %	10%	2	81
Total	N/A	N/A	5,523	8,072	N/A	N/A	11,135	8,927
Total	N/A	N/A	5,523	8,072	N/A	N/A	11,135	8,927

Implementation of this goal can be realized anytime a project is developed in the watershed. At that time, stands will be selected/identified in order to fully attain the restoration objective for the watershed (Table 7-7). Efforts would then focus on maintaining the existing LOS condition and/or moving stands toward an LOS condition as soon as possible.

Initially, all existing old forest patches or stands (old forest single strata or old forest multi stratum) are selected and conserved from anthropogenic disturbances such as timber harvest so they can serve as a corner stone for future networks. Then existing stands/patches can be used as stepping-stones to increase the quantity and improve the quality of LOS in the watershed. Forest Plan old growth units (C1 or C2) can be included if their existing condition is near an old forest condition.

The LOS component in the watershed can be expanded by identifying “new” stands or by building off existing stands to meet the restoration objective identified in Table 7-7. Mid-to late-seral patches (understory reinitiation and young forest multi strata stands), in close proximity to existing old forest patches can be selected as potential replacements. The mid-to late-seral patches should be examined on the ground to determine which old forest attributes they currently have, and to determine if cultural activities (thinning, etc.) could promote missing attributes more quickly than would occur by doing nothing. The distribution of desired future patch should be identified and determined 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 less aggressive treatments. 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 setting could be modeled using criteria described by Camp and others (1997).

In order to maximize interior habitat and mimic historic patch sizes large LOS patches/stands need to be developed. The intent is to create old forest patches/stands at least 300 acres in size, with their length not be more than 1.5 times their width. Where feasible, the focus should be on increasing the LOS component adjacent to LOS stands in order to obtain a larger patch size.

Apply the existing standards and guidelines in the Forest Plan and "Eastside Screens" to implement this strategy and manage LOS and old growth stands identified or selected in the watershed. LOS stands and old growth habitat needs to be connected with each other inside the watershed as well as to like stands in adjacent watersheds in a continuous network pattern by at least 2 different directions. Connective habitat consists of stands where medium (>10" DBH) or large (>20" DBH) diameter trees are common, and canopy closure is within the top 1/3 of the site potential. Connective stands should be at least 400 feet wide at their narrowest point, but a more desirable width of 800 to 1,200 feet is preferred.

Monitoring

All stands identified as LOS stands or targeted for LOS development will be verified by ground-truthing to determine current and potential condition. Current LOS stands and stands selected for development to a LOS condition will be identified in the stand database as such. The stand condition will be updated and tracked periodically in the database. Stands should be reviewed after cultural treatments and 3-5 years after treatments to evaluate the effects of treatment on the stand. A map should be developed for the watershed showing existing and potential LOS stands as well as all possible habitat connectivity in the watershed. The map should be available as needed and particularly during the development phase of the project.

Suggested Implementation Strategy and Subwatershed Projects List

1. Within the priority subwatersheds, find areas of National Forest where actions would fit validated conditions using the following maps and information:

- forested areas with density problems
- forested areas with fir encroachment problems
- all areas with slopes <30%
- areas with any timber sale history
- areas with slopes <30% that are uncut
- ECA
- stream reaches with Bull trout concerns
- check insect and disease maps for pest potential effect on priority

2. Review the sizes and locations of areas, by subwatershed, where forest vegetation sustainability concerns can be addressed and conflicting objectives can be resolved.

3. Re-list the remaining candidates, grouping them first geographically (other logical groupings may be needed later) - Reconsider the late-old/riparian network map and address those needs to maintain usability - consult the ECA map.

4. Check for road access limitations and Forest Plan conflicts

5. Re-examine the lists of potential projects (see Step 3 below) in light of funding timelines and availability. Consider which areas offer the greater combined gain for effort expended through joint efforts. Consider other priority-setting criteria. Develop an overall timetable to plan/schedule what areas and actions will take place, including the project environmental assessments. The following maps and data should be consulted in this process:

- Slope Map (Geist and Busskohl 1996)
- Slope-harvest map - Geist and Busskohl 1996)
- Areas with 1 timber sale (Geist and Busskohl 1996)
- Vegetation Sustainability - Fir encroachment map, Overstocked Stands map (Powell 1999)
- Non forest overlay map (GIS)
- ECA data (Clifton 1996)
- Bull trout reaches of concern (Crabtree 1996)
- Transportation, ATM maps (GIS)
- Water temperature maps (Clifton 1996)

High Priority Project List

13C Lower Umatilla/Bear

- Potential rehabilitation of detrimental soils estimated at 150 acres.
- Road maintenance, for drainage and erosion control and limiting riparian impacts (high priority)
- Riparian planting with native species, coordinated with CTUIR/ODFW
- Maintain/enhance marten habitat and bald eagle habitat through enhancement of riparian structure (large trees)
- Maintain/protect wet meadow habitat
- Remove fir from understories
- Restore grassland communities through removal of encroaching conifers
- Thin overstocked stands to accelerate growth of overstory trees and to reduce fire hazard
- Good opportunity for fire use on potential warm dry sites (22% of SWS) and grasslands (23%) of subwatershed
- Opportunity for Prescribed Natural Fire (PNF) in wilderness if protection standards can be met (887 acres in potential warm dry site)
- Mainstem riparian mostly private - little opportunity for action.
- Verify fishbearing status of Bear Creek and Bobsled Creek.
- Maintain existing old forest structure, restore old forest structure in CD, CM and WD ecological settings (prescribed fire possible tool in WD, use thinning and ITM in Cool YFMS)
- Protect/restore aspen communities (fencing probably first priority)

13D Lower North Fork Umatilla

- Restore floodplain function (road and recreation areas) below wilderness
- Potential rehabilitation of detrimental soil conditions: estimate 100 acres (low)
- Protect TES species
- Control noxious weeds
- Control introduced species proliferation (weeds/noxious weeds)
- Riparian planting
- Thin overstocked stands to accelerate growth of overstory trees and to reduce fire hazard
- Restore grassland communities through removal of encroaching conifers
- Restore Englemann spruce on appropriate sites
- Complete silviculture treatments to favor/increase pine/larch vigor levels
- Some potential use of prescribed fire on 9% of potential warm dry sites and grasslands (25%)
- Opportunity for prescribed natural fire in wilderness if protection requirements can be met
- Important part of bull trout refugia
- Fish habitat strategy - protect
- Maintain existing old forest structure
- Maintain/enhance old forest structure in CM (MS) and WD (MS) ecological settings, restore old forest structure in CD(MS) and WD(SS) ecological settings for pileated woodpecker, marten and goshawk habitat

- Maintain/enhance bald eagle habitat on the lower portion of the subwatershed
- Maintain/protect wet meadow habitat

13E Upper North Fork Umatilla

- Salvage/thin damaged/overstocked stands to accelerate growth of overstory trees and to reduce fire hazard
- Remove fir understories on Warm Dry and Ponderosa Pine sites--use interdisciplinary approach to select appropriate areas
- Potential for rehabilitation of detrimental soil conditions: estimate 700 acres. (highest)
- Road management (sidecasting) improvements
- Use Sabine's lupine (LUSA2) for erosion control on road cuts and shallow soils
- Maintain/enhance old forest structure in CM (MS) and WD (MS) ecological settings, restore old forest structure in CD(MS) and WD(SS) ecological settings for pileated woodpecker, marten and goshawk habitat
- Restore/enhance bald eagle habitat along the lower portion of the subwatershed
- Protect all remaining old growth.
- Restore grassland communities through removal of encroaching conifers
- Restore Englemann spruce, subalpine fir, western larch and lodgepole pine on appropriate sites
- Maintain/protect wet meadows
- Restore Calochotus eurycarpus (CAEU) and Calochortus macrocarpus (CAMA) on grassland sites
- Low potential for prescribed fire use on 3 percent of the potential warm dry sites
- Good potential for prescribed fire use on 24 percent of subwatersheds in potential grasslands and shrublands
- Opportunity for prescribed natural fire in wilderness.
- Important part of bull trout refugia
- Fish habitat strategy = protect/restore

13G Buck Creek

- Potential rehabilitation of detrimental soil conditions: estimated 350 ac.
- Riparian: Use LASA2 for erosion control on road cuts; plant yew, willow, alder appropriate if needed.
- Road maintenance/improvement
- Maintain/protect wet meadow habitat
- Salvage/thin damaged /overstocked stands
- Opportunity for prescribed fire use on potential warm dry and grassland sites
- Opportunity for use of prescribed natural fire in wilderness
- Recommend as part of Bull Trout refugia (protect/restore)
- Restore large tree structure in all ecological settings (evaluate potential for use of prescribed fire in PP and WD) to provide suitable reproductive habitat for MIS and bald eagle
- Protect remaining old growth as part of LOS strategy

13I Spring

- Headwater rehabilitation of downcuts
- Potential rehabilitation of detrimental soil conditions: est. 600 ac.
- ID potential rehabilitation of existing erosion sites on steep harvest areas (1,750 ac.)
- Riparian planting - Rocky Mtn. maple in headwall areas, LUSA, riparian alder, red dogwood
- Salvage/thin in damaged stands to accelerate growth of overstory trees and reduce fire hazard
- Opportunity for prescribed fire use on potential warm dry sites (16% of SWS) and grassland (16%)
- Investigate possibilities for road obliteration/road density reduction
- Reduce open road density to reduce elk vulnerability – monitor effectiveness of recent restoration work
- Restore ponderosa pine and western larch stand composition on appropriates sites
- Maintain/enhance existing habitat for pileated woodpecker, marten, goshawk with emphasis on riparian mature and old forest structure
- Restore reproductive habitat for northern three-toed woodpecker
- Protect remaining old growth as part of LOS strategy

89F Middle North Fork Meacham

- Protection/conservation emphasis
- Opportunity for prescribed fire use on potential warm dry sites (12%) and grasslands (47%)
- Maintain/protect areas of existing old forest as part of LOS strategy
- Restore old forest structure, consider use of prescribed fire in PP and WD ecological settings
- Restore aspen stands: maintain and expand existing clones
- Maintain/enhance habitat for pileated woodpecker, marten and goshawk along Meacham Creek
- Riparian planting

89G Upper North Fork Meacham

- Riparian planting: stream temperature improvement potential--use sitka alder
- Maintain /enhance habitat for pileated woodpecker and goshawk
- Reduce open road density
- Improve distribution of grassland communities
- Salvage/thin overstocked or damaged stands, consistent with other resource needs
- Some opportunity for prescribed fire use on potential warm dry sites (4%) and potential grasslands (34%)
- Restore subalpine fir and western larch stands on acceptable sites
- Restore pine communities on appropriate sites
- Restore habitat for three-toed woodpecker
- Maintain/protect areas of existing old forest as part of LOS strategy
- Restore old forest structure; consider use of prescribed fire in PP and WD ecological settings
- Part of recommended bull trout refugia (protect/restore)

89H Pot Creek

- Maintain/enhance habitat for MIS
- Riparian planting, mainly headwaters
- High priority for maintenance of fish habitat/water quality, part of recommended bull trout refugia
- Restore grassland lost to forest invasion
- Some opportunity for prescribed fire use on potential warm dry sites (3%) and potential grasslands (30%)
- Restore old forest structure, consider use of prescribed fire in PP and WD ecological settings
- Maintain/protect areas of existing old forest as part of LOS strategy
- Restore subalpine fir, lodgepole pine and western larch stands on acceptable sites
- Restore pine communities on appropriate sites

89I Bear Creek

- Assess road crossing situation for improvement needs
- Rehabilitation potential on detrimental soil condition (250 ac.)
- Priority area for water production
- Maintain/enhance fish habitat
- Riparian planting: ALSI sitka alder; willow SASI2; sitka burnet, Sabin's lupine (LUSA2) on steep slopes and roadcuts
- Restore old forest structure, consider use of prescribed fire in PP and WD ecological settings
- Maintain/protect areas of existing old forest as part of LOS strategy
- Restore reproductive habitat for pileated and three-toed woodpeckers and marten
- Maintain/enhance goshawk habitat (single story old forest, riparian emphasis)
- Maintain/protect wet meadow habitat
- Maintain/enhance wolverine foraging habitat
- Salvage/thin overstocked/damaged stands to accelerate growth of overstory trees and reduce fire hazard
- Remove fir understory on warm dry/pp sites
- Opportunity for prescribed fire use on potential warm dry site (21%) and potential grasslands (25%)
- Part of recommended bull trout refugia (protect/restore)

Possible Revisions of Forest Plan, Forest Policy, or Procedures

Riparian Management Objective:

PACFISH allows for modifications of Riparian Management Objectives based on local geology, topography, climate, and potential vegetation. The PACFISH standard for woody debris frequency is >20 pieces/mile, size greater than 12 in. by 35 ft. Given that the average frequency of PACFISH-sized woody debris in the least managed stream reaches of the upper Umatilla and Meacham Creek watersheds is about 77 pieces per mile, it seems appropriate to recommend adjustment of the RMO for woody debris frequency. Since woody debris tends to be unevenly distributed throughout the stream course, some subwatersheds may be much higher or lower than the mean and wood frequencies for individual stream reaches may vary even more. As noted previously, even the least managed subwatersheds vary considerably in woody debris frequency, but even allowing for one standard deviation less than the mean, a goal of more than 40 pieces of woody debris per mile seems reasonable for any subwatershed and an overall goal for the watershed should be higher, probably at or about the mean of the least-managed stream reaches, say 75 pieces per mile. In other words, the average for the entire watershed should be >75 pieces per mile, with no subwatersheds below 40 pieces per mile. The standard eastside PACFISH dimensions would be appropriate for this wood. Another way of looking at this is to observe that, since it is probably impossible to produce too much woody debris in these streams, barring extreme circumstances, wood should never be removed from the stream or the inner riparian zone in these watersheds. Exceptions to this would be those situations in which public safety and legal liability make it impractical to leave large woody debris in the stream channel.

Fishing access goals:

The Umatilla National Forest Land and Resource Management Plan states on page 4-8, third paragraph, that “The opportunity to catch fish will have increased” based partly upon “better access from roads.” Given the effects of roads upon stream channels and aquatic habitats, plans to construct more roads in or leading to riparian areas do not seem wise. At present and in the foreseeable future, it seems much more likely that best management practices will continue to include reducing the amount of roaded area on the Forest, especially in riparian areas. The Walla Walla Ranger District has already begun closing and obliterating some roads. It seems appropriate at this point to recommend deletion of the phrase “better access from roads” from page 4-8, paragraph three of the Forest Plan.

Fish population objectives:

The Umatilla National Forest Land and Resource Management Plan states on page 4-7, paragraph 7, that “10 years from now, significant increases in production of both anadromous and resident fish will have occurred on the Forest. Anadromous fish increases will be the highest and most noticeable...” and on page 4-8, third paragraph, that the number of rainbow trout on the forest will have increased. This statement is problematic for two reasons: 1) Without baseline numbers for comparison, progress is not measurable, and 2) There are so many other, off-forest factors that figure into the anadromous fish population equation (Dams, hatcheries, ocean fishing, Columbia River gillnet fishing, sport fishing), over which the Forest Service has no control, that population numbers are not really very useful as a measure of the Forest Service's progress. Most of the more accurate population census methods can be harmful to fish and would be inappropriate in streams with at risk species. Redd counts are an apparent exception to this and should be used for those species and in those locations where feasible. More appropriate overall would be values for specific habitat parameters. Parameters such as pool frequency, wood frequency, water temperature, canopy cover, habitat complexity and others could be useful measurements of progress. The Forest Plan does indicate that improved instream habitat is also part of the desired future condition for fisheries, but does not quantify them. PACFISH quantifies some parameters and these are therefore now official goals of the Umatilla National Forest. Some of these could be refined to make them more specifically applicable to the Umatilla National Forest and to the watersheds under consideration, and some refinements have been suggested in this document.

Design of RHCAs:

For reasons explained previously, it seems most reasonable to apply the same size RHCAs to perennial non-fish bearing streams as to fish bearing streams. The widths of these RHCAs should follow PACFISH standards for fish bearing streams except when site-specific analysis determines that different widths would be appropriate. Normally their width should be 300 feet on each side of the stream. Also, RHCAs for all perennial streams could be split into inner and outer zones to allow for different management strategies. Each zone would normally be 150 feet wide (or the average of the maximum tree height, reference FEMAT for how to determine this). Recommendations for the inner zone include:

- Retaining all trees, snags, and woody debris.
- Avoiding soil disturbing or compacting activities, and new road construction, except for occasional necessary crossings.
- Minimizing livestock grazing (livestock access for watering would ordinarily be provided).

Recommendations for the outer zone include:

- Maintaining riparian microclimate in the inner zone. (Probably by retaining natural or near natural vegetation density for at least one tree height beyond the true riparian.)
- Avoiding management activities that displace or compact soil, and new road construction, except for occasional necessary crossings.
- Protecting or improving aquatic and riparian habitat.
- Silvicultural activities such as thinning to accelerate tree growth, as long as activities do not lead to additional erosion or sedimentation of the stream channel, nor change the microclimate of the riparian community beyond the natural range for that site.

Projects should actively protect or improve aquatic and riparian habitat, and prescribed fire should be used to protect the habitat from the effects of severe wildfire.

Aquatic Management Indicator Species:[1]

Species selected as management indicator species ought to be especially sensitive to degradation of the environment. Rainbow trout/steelhead are specified as management indicator species for the Umatilla National Forest. They are probably the most hardy of the local salmonid species and as such are not effective indicators of degradation of the aquatic environment. Bull trout or some species of aquatic insects or amphibian would be much more useful in this capacity. Selection of a better management indicator species for aquatic environments should be based on consultation with biologists knowledgeable about streams and aquatic species common to the local area.

Terrestrial Management Indicator Species: [1]

Similar concerns arise among terrestrial management indicator species. The pileated woodpecker was selected as representative of species requiring snags and down wood in mature and old mixed coniferous forest, while "primary cavity excavators", from downy woodpeckers to flickers, were to represent the snag and down wood requirements of all other excavator species, as well as secondary cavity nesters. The white-headed woodpecker, having perhaps the most restrictive habitat requirements of all local excavator species (mature and old growth ponderosa pine), is poorly protected under this management scheme (Dixon 1995). Likewise, the flammulated owl, a secondary cavity nester associated with large pine snags, may not fare well under the current management scheme. Based on snag abundance analysis, many pine stands in the Umatilla and Meacham do not contain the minimum numbers of snags and logs required to support the Forest Plan management level of 40 percent, considered by Bull (1978) to be the *minimum* for continued viability of local populations. It is recommend that the white-headed woodpecker be added to the list of terrestrial management indicator species, representing species with a preference for mature and old growth ponderosa pine, and that Forest Plan direction specify protection of all remaining suitable habitat for this species. Snag and down log requirements should be met or exceeded in all timber sale planning, and monitoring of these habitat components fully funded and implemented.

1/ These discussion items/recommendations are retained for information purposes only. The revised Forest Planning Rule published in the Federal Register on November 9, 2000, replaces the concept of Management Indicator Species with Focal Species. At the time of Forest Plan revision, focal species will be identified as surrogates to measure ecological sustainability.
Focal species selected will:

- Represent the range of environments within the assessment area
- Represent habitats needed for many other species
- Play key roles in maintaining community structure or processes
- Are sensitive to the changes likely to occur in the area, and
- Serve as indicators of ecological sustainability

Fire Management

Use fire from naturally occurring ignitions in a safe, carefully planned and cost effective manner to benefit, protect, maintain and enhance the resources of the Umatilla National Forest; reduce future fire suppression cost; improve fire fighter safety; and to the extent possible, restore natural ecological processes and achieve management objectives in the Umatilla NF Land and Resource Management Plan (FSM 5140.2). This will be done after a Fire Use Management Plan is prepared (Umatilla NF Fire Management Plan Chapter 41) and implemented through a Wildland Fire Implementation Plan (FSM 5143.2).

Fuels Management

In dry forest settings where the fire regime is represented by frequent, low intensity fires, each treatment shall be designed to achieve watershed stand and fuel conditions such that, if impacted by a (head) fire under 90th percentile weather conditions, at least 70 percent of the basal area of overstory fire resistant trees within the watershed (predominant [emergent], dominant, and codominant trees) will survive. The definition of 90th percentile weather conditions will be based on an analysis of fire season conditions, calculated for mid-afternoon, over a period of 10 to 20 years at the closest fire weather station. The prescription to implement the treatment will be developed based on fire behavior modeling and predicted fire effects. Effects will be predicted using techniques such as FOFEM (first order fire effects model), FARSITE, and/or expert opinion.

Information Management

There needs to be the development of a mechanism to assure updating stream class and fish distribution information. The quality of an analysis and the effectiveness of management depend largely upon the quality and accessibility of information to analysts and managers. During the process of this analysis, information in GIS on stream class and fish distribution was found to disagree with information received from the Walla Walla district. Inconsistencies in data from different sources lead to confusion and loss of time in the analysis process. In some cases, the GIS information was out of date and was updated as part of the process of this analysis. However, there are still questions about the accuracy of some of the data. There does not seem to be a consistent organizational mechanism to ensure regular, frequent updating. Project driven, site-specific analyses would be facilitated, and accomplishment of Riparian Management Objectives (and probably most other management objectives) would be furthered over the long run by development of a mechanism to ensure such updating on a regular basis.

This watershed analysis was also hampered by problems with the organization and management of vegetation data on the Forest. Specifically, vegetation databases contained a mix of stand exam and photo-interpreted data, and because of errors in the database structures, it was very difficult to retrieve either of the data sources. These two types of data should be kept in separate tables.

Stream Survey Data

Nearly all of the streams in the Umatilla and Meacham watersheds have been surveyed, either by USFS, ODFW or CTUIR. This has provided the watershed analysis team with useful data and has facilitated a more complete and precise analysis than would otherwise be possible. However, the ODFW and CTUIR teams collect data using a very different protocol and, in most cases, different categories (e.g., wood sizes, canopy cover, substrate) than USFS crews. This makes integration of the information of the data from the two different sources very difficult, and direct comparisons of streams or reaches surveyed by the two methodologies nearly impossible. Uniform standards for data collection for at least some parameters could largely alleviate this difficulty. Agreements between the Fisheries Biologists and Hydrologists of the three agencies at a regional level would probably be the most effective way to accomplish this, but even at the District or Forest level, it might be possible to agree upon methods of recording or categorizing data that would at least make it convertible between agencies.

Several streams in the Umatilla and Meacham watersheds, which are mapped as fish bearing, have not yet been surveyed. There seems to be some question as to whether all of these streams are really fish bearing. Before management activities occur in drainage areas of these streams, their fish-bearing status should be verified and if fish bearing, they ought to be surveyed. If historical information indicates that they were once fishbearing, they should be accorded that status now. In the absence of historical information regarding fish bearing status, it may be prudent to consider, streams which appear to have good fish habitat as at least seasonally fish bearing. If they are not fish-bearing, their listed status on maps and databases should be changed. These streams include: Bear Creek and

Bobsled Creek (13C), Butcher Creek (89N), Hoskins Creek (partially surveyed, 89I), Duncan Canyon Creek (89D), three tributaries of Owsley Creek (89L), and Allen Creek (89O).

There also needs to be surveys of class three streams. Quality of water and habitat in class 1 and 2 streams is directly affected by the quality of the water entering from class 3 streams. Riparian and aquatic habitat management could be facilitated by knowledge of conditions in class 3 streams. This would require surveys of class 3 streams, but collecting data for only a subset of the parameters evaluated in the standard stream survey protocol, primarily those affecting water quality.

Satisfactory or Marginal Elk Cover and Sustainable Stands

A common and occasionally contentious issue is provision of elk thermal cover, particularly satisfactory elk cover. Satisfactory elk cover is defined as "a stand of coniferous trees at least 12 m (40 ft) tall and exceeding an average of 70 percent crown closure" (Thomas and others 1979) and capable of obscuring 90 percent of a standing elk at 200 feet or less (LRMP 1990, 4-57). The concern about satisfactory elk cover centers on sustainability--are the stand densities required to attain 70 percent crown closure biologically feasible and ecologically sustainable? The answer to that question depends on stand composition. For ecological settings with the capability to support a wide range of species (CD, CM, and WD), the shade-tolerant, late-seral species can occur at sustainable densities that are high enough to provide satisfactory elk cover. However, the early-seral, shade-intolerant species cannot occur at densities high enough to provide satisfactory elk cover and still be considered healthy or sustainable (with one apparent exception western larch for the CM ecological setting). For the PP and LP ecological settings, it does not appear that satisfactory thermal cover is biologically sustainable because the SDI values associated with 70 percent canopy cover meet or exceed the maximum SDI values for those settings. When considering losses from insects, diseases, drought, and certain other disturbances, stand densities should be maintained at a stocking density below the upper management zone. Marginal elk cover is defined as a stand of trees 10 or more feet high with an average canopy cover of at least 40 percent and capable of obscuring 90 percent of an elk at a distance of 200 feet (Thomas, USDA Forest Service 1990). Data indicate that the basal areas and stand density indexes associated with 40 percent canopy cover are generally low, and would pose little or no risk from a forest health standpoint. The guidelines for elk cover should be reviewed in light of more recent sustainability concepts for forest stand and more recent findings in cover requirements for elk.

Data Gaps

Hydrology Data Gaps and Information Needs

Data on private land harvest and roads are not available. As a result, ECA and road density values for subwatersheds with significant proportions of private lands may not be representative of actual values.

Livestock grazing, recreational uses, and private land uses are not quantified. This means there are limitations to our ability to fully evaluate the cumulative effects of land management on watershed function. A complete cumulative effects analysis would quantify these uses and assess impacts.

Integrated riparian and stream channel inventories are a vital component absent in current Forest management programs. The R-6 Stream Inventory protocol is geared towards aquatic habitats in

Class 1 and 2 (fish-bearing) streams. There are no current inventories of Class 3 or 4 streams. In addition, information on streamside vegetation communities is needed to address management issues in these critical habitats. Crowe and Clausnitzer's (in review) wetlands classification should be used to identify existing plant communities and likely plant associations. Identification of watershed restoration needs could be a part of an integrated inventory, and are an essential part of field validation and implementation of the recommendations in this report.

Recommendations for long-term management of the Umatilla Barometer Watershed are pending completion of a data analysis contract currently underway.

Lastly, there is a need for continued vigilance towards analyzing the backlog of hydrometeorological data, and avoidance of the temptation to collect more/new data without sufficient monitoring plans in place.

Fire and Fuels Information

Estimates of fuels conditions are often made based on vegetation, prior activity, slope, elevation, aspect, etc. Using this approach to developing predictive models for fire behavior is 0imprecise at best. In the case of the Umatilla-Meacham analysis, conclusions were based on estimated conditions, without field verification.

Good predictive models require accurate, field-verified fuels profiles, as well as information on stand structure, weather, and topography. When properly stored in GIS, this information can be used to develop models that result in more accurate fire growth predictions.

Lack of Population Information for Terrestrial Vertebrates

Baseline information on which to assess the population status of terrestrial wildlife were available only for elk and deer, with some very limited presence/absence information for the pileated woodpecker. Quantitative historical information on wildlife populations (again with the exception of deer and elk) is almost totally lacking. Without this information, it is extremely difficult to predict the future viability of local vertebrate populations. Estimates, predictions of future status, and management recommendations contained in this report are, therefore, based almost totally on analysis of habitat conditions only.

Future Conditions

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 percent 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.

COMPREHENSIVE LIST OF SUBWATERSHED CONCERNS AND OPPORTUNITIES FOR RESTORATION

13A Ryan Creek

Attributes/Concerns:

- Higher proportion of area in steep slopes
- Higher sensitivity to ground-disturbing activities
- Intermediate hydrological response, Equivalent Clearcut Acres are at moderate level
- Intermediate/moderate water quality - <u>not</u> water quality limited
- Moderate road density/low riparian road density
- Higher levels of timber sale activity. Half the area cut was on slopes steeper than 30 percent
- Fish species present: bull trout, redband trout
- Better fish habitat in the upper one-half of subwatershed
- Noxious weed levels high (especially on winter range), primarily adjacent to ridge-top roads
- Little old forest structure, especially single story (but within HRV)
- High levels of young trees compared to Historical Range of Variability
- Changes in distribution and patch size of grassland communities
- Moderate tree damage levels due to forest pathogens
- Intermediate levels of overstocked stands (approximately 1,000 acres)
- Good huckleberry area (cultural)
- Fire protection of private lands
- Low wildfire occurrence
- 231 acres of prescribed fire use (18 acres in warm dry potential)
- 78 acres of C1 old growth
- Remnant aspen stands
- Change in size and distribution of habitat patches for pileated and three toed woodpeckers, marten, goshawk and bald eagle

Recommendations/Opportunities:

- Protect/conserve water quality: road erosion control, riparian planting (cottonwood lower sections)
- Rehabilitation of detrimental soil conditions: estimate 300 acres potentially treatable
- Fish habitat - <u>protect strategy</u>, especially upper reaches, lower reaches (private) need improvement (limited access)
- Improve old forest structure - consider prescribed fire and thinning to restore single storied stands
- Land exchange lower reaches and/or coordination with private landowners
- Use of LUSA2 (sabin's lupine) on scab/shallow soils (headwater area seed source)
- Thin/stocking level control (caveat: wildlife, etc. cover concerns, may conflict)
- Potential to use prescribed fire on potential warm dry sites (16% SWS) and grasslands (46% SWS)
- Improve grassland community distribution (prescribed fire, removal of encroaching conifers)
- Maintain/enhance existing reproductive habitat for MIS species: need to develop techniques for maintaining "healthier" stands of firs and mixed conifers for pileated woodpecker habitat
- Maintain existing old forest structure
- Protect/restore aspen communities (fencing)

13B Lower Umatilla/Hagen1

Attributes/Concerns:

- Higher acreages of steep slopes, high sensitivity, and shallow soils
- Rapid hydrological response
- Low total road density, but roads present are valley bottom roads (both public (county) and private)
- 1995/96 flood effects present - upland side channels released debris into mainstem streams
- Water quality limited - main stem (temp., ph, hab. mod. sed.)
- Directly adjacent to key fish habitat - chinook, redband, steelhead
- Chinook spawning habitat
- Bull Trout/Chinook migration corridor
- Inadequate information on plants
- Changes in size and distribution of habitat patches for bald eagle
- 277 acres of C1 old growth
- High percentage of overstocking
- Fire protection for adjoining private lands
- Low wildfire occurrence in last 25 years

Recommendations/Opportunities:

- Road maintenance for drainage and erosion control and limiting riparian impacts
- Manage road location, maintenance (County)
- Use native plant species including cottonwoods
- Maintain/enhance bald eagle winter habitat through protection of large and medium DBH trees along Umatilla River and tributaries
- Thin overstocked stands to enhance growth and reduce fire hazard
- Twenty-four percent of subwatersheds in potential warm dry site - good opportunity for prescribed fire use or mechanical treatment of stands to maintain open stands.
- Another 20 percent of watershed is in potential grasslands, which will also benefit from the use of fire.
- Need additional information on noxious weeds and introduced species.
- Maintain existing old forest structure.

13C Lower Umatilla/Bear

Attributes/Concerns:

- Higher acres sensitivity to ground disturbing activities
- Limited timber management potential - few acres of <30% slope
- Higher (rapid) hydrology response - flood effects evident
- Higher coverage of shallow soils
- Road density low, but valley bottom roads significant
- Water quality limited (temperature, ph, habitat modification, sedimentation)
- Critical spawning habitat, especially chinook
- Steelhead, whitefish habitat
- Bull Trout/Chinook migration corridor
- Huckleberry grounds
- Orchids at thermal area
- Native/introduced plant species imbalance (hot springs)
- Change in size and distribution of habitat patches for pileated and three toed woodpeckers, marten,

goshawk and bald eagle
- Old forest structure below HRV or at low end of range in CD, CM and WD ecological settings
- Moist meadows
- Remnant aspen stands. Many stands overstocked
- Reduction in grassland community distribution
- Protection of private and developed lands within and adjoining FS lands.
- Twenty-two percent of subwatershed on warm dry site: potential for future destructive fires.
- Low fire occurrence in last 25 years
- 20% of subwatershed is wilderness

Recommendations/Opportunities:

- Potential rehabilitation of detrimental soils estimated 150 ac.
- Road maintenance, for drainage and erosion control and limiting riparian impacts (high priority)
- Riparian planting with natives
- Maintain/enhance marten habitat and bald eagle habitat through enhancement of riparian old forest structure
- Maintain/protect wet meadow habitat
- Remove fir from understories
- Restore grassland communities through removal of encroaching conifers
- Thin overstocked stands to accelerate growth of overstory trees and to reduce fire hazard
- Good opportunity for fire use on potential warm dry sites (22% of SWS) and grasslands (23%) of subwatershed
- Opportunity for Prescribed Natural Fire (PNF) in wilderness if protection standards can be met (887 acres in potential warm dry site)
- Mainstem riparian mostly private - little opportunity for action.
- Verify fishbearing status of Bear Creek and Bobsled Creek.
- Maintain existing old forest structure, restore old forest structure in CD, CM and WD ecological settings (prescribed fire possible tool in WD, use thinning and ITM in Cool YFMS)
- Protect/restore aspen communities (fencing first priority)

13D Lower North Fork Umatilla

Attributes/Concerns:

- Moderate sensitivity to ground disturbing activities
- Moderate hydrological response
- Cold water source
- Water quality limited – temperature (Bull Trout)
- Steelhead, chinook, bull trout (strongest bull trout population in Umatilla/Meacham) together; 13e
- Stream substrate quality high
- Aquatic habitat is among best in analysis area
- High numbers of TES plant species
- High introduced species numbers
- High noxious weed concentrations
- High (good) species richness (diversity)
- Moist meadows
- Very high amounts of overstocking
- Good potential to maintain remnant pine/larch
- Protection of private and developed lands both within and adjacent to FS lands

- Moderate to high fire occurrence in last 25 years. Five human-caused fires
- Fifty-one percent of the subwatershed is in Wilderness
- Reduction in grassland community distribution
- Change in size and distribution of habitat patches for pileated and three toed woodpeckers, marten, goshawk and bald eagle
- Old forest structural stage below HRV in CD (MS) and WD (SS) ecological settings
- 183 acres of C1 old growth

Recommendations/Opportunities:

- Restore floodplain function (road and recreation areas) below wilderness
- Potential rehabilitation of detrimental soil conditions: estimate 100 acres (low)
- Protect TES species
- Manage noxious weeds
- Control introduced species proliferation (weeds/noxious weeds)
- Riparian planting
- Thin overstocked stands to accelerate growth of overstory trees and to reduce fire hazard
- Restore grassland communities through removal of encroaching conifers
- Restore Englemann spruce on appropriate sites
- Complete silviculture treatments to increase pine/larch vigor levels
- Some potential use of prescribed fire on 9% of potential warm dry sites and grasslands (25%)
- Opportunity for prescribed natural fire in wilderness if protection requirements can be met
- Important part of bull trout refugia
- Fish habitat strategy - protect
- Maintain existing old forest structure
- Maintain/enhance old forest structure in CM (MS) and WD (MS) ecological settings, restore old forest structure in CD(MS) and WD(SS) ecological settings for pileated woodpecker, marten and goshawk habitat
- Maintain/enhance bald eagle habitat along the North Fork
- Maintain/protect wet meadow habitat

13E Upper North Fork Umatilla

Attributes/Concerns:

- Moderate sensitivity to ground disturbing activities
- High road total density and highest total miles, but most are ridgetop roads
- Low riparian road density
- ECA is moderate (9.1%)
- Least hydrological response
- Water quality limited (Bull Trout)
- Strongest bull trout population in Umatilla/Meacham (together with 13d)
- High aquatic productivity potential but high risk (aquatics)
- Aquatic habitat among best in analysis area
- Culturally significant plant species
- Low noxious weed levels
- Reduction in grassland community distribution
- Change in size and distribution of habitat patches for pileated and three toed woodpeckers, marten, goshawk and bald eagle
- Best marten habitat in the watershed

- Change in size and distribution of subalpine fir, western larch, and lodgepole pine communities
- Moist meadows
- High amount of fir encroachment
- Very high amounts of stand damage
- High overstocking potential on warm, dry sites
- Protection of developed sites - summer homes and private lands within and adjacent to subwatersheds
- Moderate fire occurrence in last 25 years.
- Seven human-caused fires.
- 125 acres of untreated slash from past harvest
- 47 acres prescribed fire use
- 52 percent wilderness
- 384 acres of potential warm dry site within wilderness

Recommendations/Opportunities:

- Higher timber management potential but conflicts with aquatic/cold water refuge
- Salvage/thin damaged/overstocked stands to accelerate growth of overstory trees and to reduce fire hazard
- Remove fir understories on Warm Dry and Ponderosa Pine sites--use interdisciplinary approach to select appropriate areas
- Potential for rehabilitation of detrimental soil conditions: estimate 700 ac. (highest)
- Road management (sidecasting) improvements
- Use Sabine’s lupine (LUSA2) for erosion control on road cuts and shallow soils
- Maintain/enhance old forest structure in CM (MS) and WD (MS) ecological settings, restore old forest structure in CD(MS) and WD(SS) ecological settings for pileated woodpecker, marten and goshawk habitat
- Restore/enhance bald eagle habitat along the North Fork
- Protect all remaining old growth.
- Restore grassland communities through removal of encroaching conifers
- Restore Englemann spruce, subalpine fir, western larch and lodgepole pine on appropriate sites
- Maintain/protect wet meadows
- Restore *Calochotus eurycarpus* (CAEU) *and Calochortus macrocarpus* (CAMA) on grassland sites
- Low potential for prescribed fire use on 3 percent of the potential warm dry sites
- Good potential for prescribed fire use on 24 percent of subwatersheds in potential grasslands and shrublands
- Opportunity for prescribed natural fire in wilderness.
- Important part of bull trout refugia
- Fish habitat strategy = protect/restore

13F Lower South Fork Umatilla

Attributes/Concerns:

- High (possibly highest?) sensitivity to ground disturbing activities
- Predominantly steep slopes
- High riparian road density
- Rapid (high) hydrological response
- Streamside canopy cover low, in-stream wood limited
- Pool habitat “good” due to constructed pools, but high temperatures limit utility of pool habitat
- Steelhead, bull trout habitat

- Water quality limited – temperature (Bull Trout)
- Thermal barrier below Buck Creek , potential impacts to stream temperatures unknown
- Noxious weeds high
- High recreation, other use area
- High amounts of overstocked stands
- Moderate amount of grassland encroachment
- Protection of private land to the north
- Low fire occurrence in last 25 years
- 569 acres of potential warm dry site, high potential for future destructive wildfires on these sites (45% of subwatershed)
- Forty-one percent wilderness
- Change in size and distribution of habitat patches for goshawk and bald eagle

Recommendations/Opportunities:

- Manage developed and dispersed recreation to reduce impacts on watershed
- Stream shade needed to moderate water temperatures. Riparian planting, Redosier dogwood, also willow, alder (by reach).
- Tributary culvert/passage needs fixing
- Road location, maintenance, etc (standard rdx.)
- Collect data on thermal springs (temperature, chemical analysis)
- Thin overstocked stands to accelerate growth of overstory trees and to reduce fire hazard
- High potential for prescribed fire use both within and out of the wilderness
- Opportunity for prescribed natural fire in wilderness area once protection concerns are met
- Restore reproductive habitat for the goshawk and bald eagle along the SF Umatilla
- Protect all remaining old growth.

13G Buck Creek

Attributes/Concerns:

- Moderate sensitivity to ground disturbing activities
- Low hydrological response
- Moderate road density
- Low riparian road density
- Moderate ECA (11%), stable slopes
- Includes High Ridge study area (closed)
- Rainbow/steelhead, bull trout present, chinook rearing area
- Good fish habitat (upper one-quarter of subwatershed) - among the better subwatersheds in the analysis area in terms of aquatic habitat
- Culturally significant plants
- Change in size and distribution of habitat patches for pileated and three toed woodpeckers, marten, goshawk and bald eagle
- Good marten habitat
- Old forest structural stage below HRV (or at low end of range) in CD (MS), CM (MS), PP (MS,SS), and WD (MS,SS)
- Change in size and distribution of subalpine fir, western larch, and Englemann spruce communities
- Relatively good timber management potential
- High stand damage
- Moderate stand density

- Moist meadows
- Low historic fire occurrence in last 25 years
- Some potential for large destructive wildfires originating in warm dry potential settings
- 91 acres untreated slash
- 247 acres treated by prescribed fire (14 acres warm dry)
- 59% in Wilderness
- 921 acres in warm dry potential site within Wilderness

Recommendations/Opportunities:

- Potential rehabilitation of detrimental soil conditions: estimated 350 ac.
- Riparian: Use LASA2 for erosion control on road cuts; plant yew, willow, alder appropriate if needed.
- Road maintenance/improvement
- Maintain/protect wet meadow habitat
- Salvage/thin damaged /overstocked stands
- Opportunity for prescribed fire use on potential warm dry and grassland sites
- Opportunity for use of prescribed natural fire in wilderness
- Recommend as part of Bull Trout refugia (protect/restore)
- Restore old forest structure in all ecological settings (evaluate potential for use of prescribed fire in PP and WD) to provide suitable reproductive habitat for MIS and bald eagle
- Protect all remaining old growth.

13H Thomas

Attributes/Concerns:

- Moderate hydrological response
- Larger acreage of high sensitivity to ground disturbing activities
- High overall road density *and* high riparian road density
- Moderate ECA (12%)
- High potential detrimental soil condition
- >1000 ac. of past harvest on steep slopes
- Channel condition moderate
- Stream-side canopy cover on the low side
- Statistically high quality pool habitat, but limited utility due to high temperatures
- Rainbow/steelhead, bull trout, chinook rearing
- Culvert passage problems (2)
- Road effects on fish/aquatics (sedimentation, loss of shade, channel alteration)
- Serious noxious weed problem, particularly along roads
- Large percentage of young trees
- Moist meadow
- >30% of subwatershed in Wilderness
- 91 acres of untreated slash
- 388 acres of prescribed fire use (76 in warm dry)
- 375 acres in warm dry site potential within Wilderness
- High overstocking on warm dry sites
- High fire occurrence in last 25 years - 8 human caused fires
- 248 acres of C1 old growth
- Change in size and distribution of habitat patches for pileated woodpecker, goshawk and bald eagle

- Old forest structural stage below HRV (or at low end of range) in CD (MS), CM (MS), PP (MS,SS), and WD (MS,SS)
- Good quality wolverine habitat
- Change in size and distribution of ponderosa pine communities

Recommendations/Opportunities:

- Potential rehabilitation of detrimental soil condition: estimated 600 ac.
- Check for rehabilitation potential for erosion/sediment from steep harvest areas
- Monitor/measure fish structure effectiveness
- Plant CEVE and LUSA2 road cuts
- Streambank shade needed to moderate water temperature, recommend riparian planting of willow, alder, RUPA thimble berry, redosier dogwood, LUSA, RUPA, BEDC
- Higher priority and opportunity for watershed restoration, include roads, landings, skid trails (road closures)
- Fix culvert/fish passage
- Maintain/protect wet meadow habitat
- Thin overstocked stands to accelerate growth of overstory trees and reduce fire hazard. Coordinate thinning plans with other resource specialists to avoid conflict
- Opportunity for prescribed fire use in potential warm dry sites (12%) and grasslands (31%)
- Opportunity for prescribed natural fires in wilderness
- Restore ponderosa pine stands using prescribed fire where appropriate
- Restore old forest structure in all ecological settings (evaluate potential for use of prescribed fire in PP and WD) to Provide suitable reproductive habitat for MIS and bald eagle
- Protect all remaining old growth.
- Maintain/enhance wolverine habitat

13I Spring

Attributes/Concerns:

- Moderate sensitivity to ground disturbing activities
- Moderate hydrological response
- Highest (28%) ECA
- Highest road density (third highest road miles), highest riparian road density
- Headwater downcutting
- High detrimental soil condition potential
- 45% of past timber sales on steep slopes
- Ninety percent of available timber on slopes <30% has been cut
- Erosion potential on steep slopes (due to harvest)
- Steelhead/rainbow trout present
- Low pool frequency, low fish cover
- Change in size and distribution of habitat patches for pileated and three toed woodpeckers, marten, goshawk and bald eagle
- Changes in elk cover habitat availability, elk vulnerability high (road density)
- High quality wolverine habitat
- 238 acres of C1 old growth
- Old forest structural stage below HRV (or at low end of range) in CD (MS), CM (MS), PP (MS, SS), and WD (MS, SS)
- Moderate timber management potential

- High stand damage
- Huckleberry culturally significant
- (grazing) PSAR?
- Noxious weeds
- Fire history plot taken within subwatershed
- Moderate wildfire occurrence in last 25 years (5 human, 5 lightning)

Recommendations/Opportunities:

- Headwater rehabilitation of downcuts
- Potential rehabilitation of detrimental soil conditions: est. 600 ac.
- ID potential rehabilitation of existing erosion sites on steep harvest areas (1,750 ac.)
- Riparian planting - Rocky Mtn. maple in headwall areas, LUSA, riparian alder, red dogwood
- Salvage/thin in damaged stands to accelerate growth of overstory trees and reduce fire hazard
- Opportunity for prescribed fire use on potential warm dry sites (16% of SWS) and grassland (16%)
- Investigate possibilities for road obliteration/road density reduction
- Reduce open road density to reduce elk vulnerability – monitor effectiveness of recent restoration work
- Restore ponderosa pine and western larch stand composition on appropriates sites
- Maintain/enhance existing habitat for pileated woodpecker, marten, goshawk and bald eagle, with emphasis on riparian mature and old forest structure
- Restore reproductive habitat for northern three-toed woodpecker
- Protect all remaining old growth.

13J Shimmiehorn

Attributes/Concerns:

- Good Huckleberry population
- Noxious weeds established and spreading
- Intermediate to low hydrological response
- Cold water supply tributary
- Moderate sensitivity to ground disturbing activities
- Highest potential mass failure due to past management activity
- Highest percentage of very shallow soils
- Special Interest (Geologic) Area
- 11% (moderate) ECA
- Road density moderate/high (relative to others in the analysis area), but riparian road density low
- Moderate timber management potential
- High stand damage
- Plantation species and genotype appropriateness in question
- Steelhead, rainbow, and some bull trout present
- Moderate aquatic habitat condition
- Elk cover limited across entire subwatershed
- Open road density high; elk vulnerability increased as result
- Change in size and distribution of habitat patches for pileated and three-toed woodpeckers, goshawk, marten and bald eagle
- High quality wolverine habitat
- Moist meadows, remnant aspen stands

- Change in size and distribution of Englemann spruce and lodgepole pine stands
- 23 acres of C1 old growth
- Moderate fire occurrence in last 25 years
- Relatively high fire frequency
- 23 acres prescribed fire since 1986
- 362 acres untreated slash

Recommendations/Opportunities:

- Road maintenance/improve, reduce road density (to reduce elk vulnerability)
- Potential rehabilitation of detrimental soil conditions: est. 500 ac.
- High priority for (watershed) management emphasis for high quality water source
- Reduce stocking levels for disease control, etc.
- Tree species mix adjustments (disease)
- Ridge trail maintenance/reopen unmaintained/closed trails?
- Fertilize areas with high root disease levels to reduce risk to healthy trees
- Limited opportunity for prescribed fire use warm dry sites (7%) grasslands (1%)
- Plan management of Special Interest Area (Geologic)
- Maintain/enhance existing habitat for pileated woodpecker, marten, goshawk and bald eagle, with emphasis on riparian mature and old forest structure
- Restore reproductive habitat for northern three-toed woodpecker
- Protect/restore aspen stands and wet meadows (fencing may be first priority)
- Maintain/enhance high elevation wolverine habitat
- Maintain/enhance existing elk cover
- Protect all remaining old growth.
- Restore spruce and lodgepole stands on appropriate sites

13K Upper South Fork Umatilla

Attributes/Concerns:

- Sensitive plants present
- Water quality limited – temperature (Bull Trout)
- Moderate road density
- Moderate ECA
- Intermediate hydrological response
- Low riparian road density; roads mostly ridgetop
- Moderate sensitivity to ground disturbing activities
- Moderate timber management opportunities
- High stand damage
- Warm dry HRV imbalance - fourth highest warm dry ac. (13%)
- Higher fire occurrence; small private holdings; no prescribed fire
- Higher proportion of grass ('58) to forest ('91) (tree †encroachment†)
- Steelhead/rainbow, bull trout present, chinook rearing area
- Stream-side canopy cover and in-stream wood on the low side,
- Elk hunting camp(s) common along stream bottom
- Elk vulnerability high as result of limited cover and high open road density
- Most wet meadow habitat in Umatilla watershed
- Change in size and distribution of habitat patches for pileated and three-toed woodpeckers, goshawk,

marten and bald eagle
- High quality wolverine habitat
- 341 acres of C1 old growth
- Change in size and distribution of Englemann spruce stands
- High amount of stand damage
- Protection of private lands within subwatershed (117 acres)
- Moderate fire occurrence in last 25 years
- Potential for destructive wildfire on potential warm dry sites (1,793 acres)
- Some untreated activity slash (519 acres)
- 110 acres treated with fire since 1986
- 519 acres of slash untreated

Recommendations/Opportunities:

- Potential rehabilitation of detrimental soil conditions: est. 475 ac
- Road erosion control opportunities
- Riparian planting (water temp)
- Prescribed fire for treatment warm dry imbalance
- Improve elk camp along creek bottom
- Reduce open road density (water quality, elk vulnerability)
- Maintain/protect wet meadow habitat
- Salvage/thin in damaged/overstocked stands to accelerate growth of overstory trees and reduce fire hazard
- Good opportunity to use prescribed fire on potential warm dry sites (18%) and grasslands (26%)
- Maintain/enhance existing habitat for pileated woodpecker, marten, goshawk and bald eagle, with emphasis on riparian mature and old forest structure
- Protect all remaining old growth.
- Restore reproductive habitat for northern three-toed woodpecker
- Maintain/enhance wolverine habitat
- Maintain/enhance existing elk cover (coordinate with thinning priorities)
- Restore spruce stands on appropriate sites

13L Gibbon

Attributes/Concerns:

- No plant information
- High hydrological response (low elevation steep, etc.)
- High sensitivity to ground disturbing activities
- No harvest information
- Valley bottom road
- All three salmonids present
- Chinook spawning, Bull Trout and Chinook and steelhead migration corridor
- Water quality limited (temperature and pH)
- State fire protection adjacent
- Winter bald eagle habitat
- Mostly non-FS lands - fire
- Protection of private lands

Recommendations/Opportunities:

- River road improvement plan with county/tribal, private landowners

89A Lower Meacham/Boston Canyon

Attributes/Concerns:

- Limited timber management potential
- Warm Dry imbalance (below HRV)
- Higher sensitivity to ground disturbing activities
- Low road density (moderate density in riparian corridor)
- Railroad in/along drainage
- Noxious weeds
- Water quality limited (temperature, habitat, sedimentation)
- Elk winter range
- Potential bald eagle winter roost habitat
- Loss of grassland acres, conversion to forested
- Low fire occurrence last 25 years
- Protection of adjacent private lands - fire
- 37 percent of watershed has had recent prescribed burns (Stumbaugh)
- 2,000 acres of subwatershed treated with prescribed fire since 1986 (mostly in grasslands)
- 309 acres of C1 old growth
- Potential for prescribed fire use (or reuse) on potential warm dry sites (8%) and grasslands (38%)
- Water quality limited - high water temperatures
- Stagnant aspen stands in stringers
- Poorer fish habitat (Meacham reach)
- Bull trout migration corridor; chinook and steelhead spawning/migration

Recommendations/Opportunities:

- Restore pine and larch on Warm Dry sites where appropriate
- Stream shade needed to moderate water temperatures. Recommend riparian planting, cottonwoods appropriate
- Maintain/improve winter range condition through additional burning and fertilization
- Maintain/protect wet meadow habitat
- Restore floodplain function (cooperative effort with CTUIR, ODFW, UPRR)
- Restore bald eagle habitat along Meacham Creek
- Restore old forest structure; consider use of prescribed fire in PP and WD settings
- Protect all remaining old growth, both within ***and outside*** network.

89B Lower Meacham/Bonifer

Attributes/Concerns:

- Railroad and road on mainstem
- High hydrological response
- Higher sensitivity to ground disturbing activities

- Lower road density
- Culturally significant plant (Bitterroot)
- Migration passage for salmonids
- Bull trout migration corridor, chinook and steelhead migration and spawning
- High stream temperature
- Old forest structure below HRV (or at low end of range) for CD (MS), CM (MS), PP (MS and SS) and WD (MS and SS)
- Change in size and distribution of habitat patches for the bald eagle
- Wet meadows
- Decadent aspen stands
- Water quality limited (temperature, habitat, sedimentation)
- Winter range for deer, elk
- 94 acres of C1 old growth
- Limited timber management potential
- 14% is C8 (Forest Plan) and warm dry
- Overstocking on warm dry sites
- Fire protection of private lands (homes/railroads) adjacent to FS lands and intermixed with FS lands
- Low fire occurrence in last 25 years - 1-17 acre railroad fire
- Potential for destructive wildfire on Warm Dry sites (1,628 ac.)
- Low fire treatment acres to date
- 241 acres of prescribed fire use (76 ac. in warm dry potential vegetation)

Recommendations/Opportunities:

- Riparian planting: cottonwoods appropriate for stream shading, etc. to reduce water temperatures
- Opportunities for cooperation in railroad management
- Opportunity for prescribed fire use on potential Warm Dry sites (14%) and grasslands (36%)
- Aspen rehabilitation: maintain and expand known clones
- Use thinning to improve stand composition and structure in Warm Dry communities
- Maintain/improve big game winter range
- Restore floodplain function (cooperative effort – CTUIR, ODFW, UPRR)
- Restore old forest structure; consider use of prescribed fire in PP and WD settings
- Protect all remaining old growth, both within ***and outside*** network.
- Restore aspen stands: maintain and expand existing clones

89C Camp Creek

Attributes/Concerns:

- Higher sensitivity to ground disturbing activities
- Intermediate road density
- Noxious weeds
- Moderate timber potential
- Larger number of acres of stand damage; high mortality in C8(?)
- Intermediate hydrological response
- Steelhead habitat
- Good basic aquatic habitat
- Camp Creek road in poor condition
- Old forest structure below HRV (or at low end of range) for CD (MS), CM (MS),

- PP(MS and SS) and WD (MS and SS)
- Change in size and distribution of habitat patches for northern three toed woodpecker, goshawk and bald eagle
- High quality wolverine habitat PP(MS and SS) and WD (MS and SS)
- Wet meadow
- Fire protection of private lands within (77 acres) and adjacent to SWS (railroad)
- Low fire occurrence in last 25 years
- Potential for destructive wildfire on potential warm dry site (2,113 acres)
- 133 acres of untreated slash
- 504 acres have been treated by prescription since 1986 (8% SWS), 70 acres warm dry
- Opportunity for prescribed fire use on potential warm dry sites (24%) and grasslands (26%)
- Change in size and distribution of western larch and ponderosa pine stands
- 412 acres of C1 old growth

Recommendations/Opportunities:

- Potential rehabilitation of detrimental soil conditions: estimate 300 ac.
- Riparian planting needed, but cottonwood inappropriate
- Road maintenance/improvement/obliteration (Camp Creek Road)
- Maintain/protect wet meadow habitats
- Salvage/thin in areas with high stand damage
- Fish habitat strategy - protect/restore
- Rehabilitate eroded road slopes - use (ASRE2) milk vetch
- Restore western larch on appropriate sites
- Restore stand composition on ponderosa pine sites
- Restore old forest structure; consider use of prescribed fire in PP and WD settings
- Maintain/enhance habitat for three-toed woodpecker in mixed conifer stands (maintain large overstory firs and keep canopy closure high)
- Maintain/improve big game winter range
- Restore/enhance bald eagle winter roost habitat along Meacham Creek
- Restore reproductive habitat for northern goshawk
- Maintain/enhance wolverine habitat
- Protect all remaining old growth, both within ***and outside*** network.

89D Middle Meacham

Attributes/Concerns:

- Horseshoe Ridge Roadless Area
- Higher sensitivity
- Higher potential mass failure
- Riparian railroad location
- Low road density but Meacham Creek road is valley-bottom
- High hydrological response
- Water quality limited (temperature, habitat, sedimentation)
- Low stand damage
- High proportion Warm Dry and out of balance, high ABGR mix
- High tree density in the warm dry

- Anadromous habitat - spawn and passage
- High grass to forest conversion acreage
- Introduced plant (plus noxious weeds) species
- Bald eagle winter habitat winter range
- Protection of private lands (railroad and homes) 667 acres within and to the northwest
- Low fire occurrence in last 25 years
- Potential for destructive wildfire on potential warm dry sites (29%) of subwatershed
- 562 acres of C1 old growth (13% of watershed)
- 22 acres of prescribed fire use (5 in warm dry)

Recommendations/Opportunities:

- Riparian planting: upper end of cottonwood range
- Maintain winter range
- Restore grassland lost to forest encroachment
- Opportunity for prescribed fire use on warm dry sites (29% of SWS) and grasslands (36%)
- Maintain/enhance existing old growth structure: management options range form no action to thinning from below or prescribed fire
- Protect all remaining old growth, both within ***and outside*** network.
- Restore bald eagle habitat along Meacham Creek

89E Lower North Fork Meacham

Attributes/Concerns:

- Among highest sensitivity
- High hydrologic response
- Water quality limited – temperature, habitat
- Low ECA and road density (data limited)
- Beaver active
- Private land: road construction
- Existing roads
- Maintain riparian mostly on private land - riparian road
- Anadromous/rainbow present: among poorest fish habitat
- Change in size and distribution of habitat patches for the pileated woodpecker
- Old forest structure below HRV (or at low end of range) for CD (MS), CM (MS), PP(MS and SS) and WD (MS and SS)
- Noxious weeds
- Cultural plants (bitterroot) on top
- Low damage levels
- Higher proportion grass to forest conversion.
- Boise Cascade - heavy logging plans, roads
- Fire protection of private lands within land adjacent to FS lands (to south)
- Low historic fire occurrence in last 25 years. However 35 acres has burned (most in any SWS)
- 374 acres of prescribed fire since 1986 (11% SWS) (27 acres of warm dry sites)
- Limited timber management opportunity

Recommendations/Opportunities:

- Encourage beaver
- Upper end of cottonwood range, use other species in riparian planting
- Opportunity for prescribed fire use on potential warm dry sites (8%) and grasslands (40%)
- Restore old forest structure, consider use of prescribed fire in PP and WD ecological settings
- Maintain/restore reproductive habitat for pileated woodpecker
- Protect all remaining old growth, both within ***and outside*** network.

89F Middle North Fork Meacham

Attributes/Concerns:

- Higher sensitivity
- High hydrological response
- Water quality limited – temperature, habitat
- Very low road density; no timber harvest
- Limited timber management opportunities
- Steelhead, rainbow, bull trout spawning
- The average low quality fish habitat is probably largely natural
- Changes in size and distribution of habitat patches for the pileated woodpecker, marten, goshawk and bald eagle
- Old forest structure below HRV (or at low end of range) for CD (MS), CM (MS), PP(MS and SS) and WD (MS and SS)
- Remnant aspen stands
- Fire protection of private lands (18 acres)
- Low historic fire occurrence in the last 25 years

Recommendations/Opportunities:

- Protection/conservation emphasis
- Opportunity for prescribed fire use on potential warm dry sites (12%) and grasslands (47%)
- Maintain/protect all areas of existing old forest within ***and outside*** network
- Restore old forest structure; consider use of prescribed fire in PP and WD ecological settings
- Restore aspen stands: maintain and expand existing clones
- Maintain/enhance habitat for pileated woodpecker, marten and goshawk, and for bald eagle along Meacham Creek
- Riparian planting

89G Upper North Fork Meacham

Attributes/Concerns:

- Culturally significant TES plants
- High floristic richness
- Among highest sensitivity
- Moderate hydrological response
- Water quality limited – temperature, habitat
- Aquatic habitat: good canopy cover, pool frequency, wood frequency

- Steelhead, rainbow present, potential bull trout
- Waterfall - fish blockage
- Bull trout spawning
- Elk vulnerability (open road density too high)
- Changes in size and distribution of habitat patches for the pileated and three toed woodpeckers, marten, goshawk and bald eagle
- Old forest structure below HRV (or at low end of range) for CD (MS), CM (MS), PP (MS and SS) and WD (MS and SS)
- 427 acres of C1 old growth
- Changes in size and distribution of subalpine fir, western larch and ponderosa pine
- Short-term timber management potential
- High stand damage (insects and disease)
- High % of acres overstocked
- Loss of grassland to tree encroachment
- Moderate fire occurrence in last 25 years
- 35 acres of prescribed fire use

Recommendations/Opportunities:

- Riparian planting: stream temperature improvement potential--use sitka alder
- Maintain /enhance habitat for pileated woodpecker and goshawk
- Reduce open road density
- Improve distribution of grassland communities
- Salvage/thin overstocked or damaged stands, consistent with other resource needs
- Some opportunity for prescribed fire use on potential warm dry sites (4%) and potential grasslands (34%)
- Restore subalpine fir and western larch stands on acceptable sites
- Restore pine communities on appropriate sites
- Restore habitat for three-toed woodpecker
- Restore/enhance bald eagle habitat along Meacham Creek
- Maintain/protect all areas of existing old forest within ***and outside*** network
- Restore old forest structure; consider use of prescribed fire in PP and WD ecological settings
- Part of recommended bull trout refugia (protect/restore)

89H Pot Creek

Attributes/Concerns:

- Higher sensitivity to ground disturbing activities
- Cold water supply area
- Intermediate hydrological response
- Low ECA
- Low road density
- Sensitive plants, high floristic richness
- Gray rock area - geologic
- Among highest stand damage (insects and disease)
- Among best subwatersheds for fish habitat
- Bull trout redd (spawning), steelhead, rainbow present

- Changes in size and distribution of habitat patches for the pileated and three toed woodpecker, marten, goshawk and bald eagle
- Old forest structure below HRV (or at low end of range) for CD (MS), CM (MS), PP (MS and SS) and WD (MS and SS)
- 291 acres of C1 old growth
- Timber management potential short term
- Changes in size and distribution of subalpine fir, western larch and ponderosa pine
- Changes in size and distribution of grassland communities
- Moderate wildfire occurrence in last 25 years

Recommendations/Opportunities:

- Maintain/enhance habitat for MIS and bald eagle
- Riparian planting, mainly headwaters
- High priority for maintenance of fish habitat/water quality, part of recommended bull trout refugia
- Restore grassland lost to forest invasion
- Some opportunity for prescribed fire use on potential warm dry sites (3%) and potential grasslands (30%)
- Restore old forest structure; consider use of prescribed fire in PP and WD ecological settings
- Maintain/protect all areas of existing old forest within ***and outside*** network
- Restore subalpine fir, lodgepole pine and western larch stands on acceptable sites
- Restore pine communities on appropriate sites

89I Bear Creek

Attributes/Concerns:

- Higher sensitivity to ground disturbing activities
- High potential mass wasting from activity
- Intermediate road density
- ECA: low/mod
- Moderate hydrological response
- Riparian road density moderate/low
- Headwater road crossings
- Cold water source
- Fish habitat condition=average
- Bear Creek trail may be in need of improvement
- Steelhead/rainbow present
- Knapweed on Road 31
- Plant species of concern concentrated in high elevations
- Moderate/low present grazing pressure (sheep)
- Changes in size and distribution of habitat patches for the pileated and three toed woodpecker, marten, goshawk and bald eagle
- Old forest structure below HRV (or at low end of range) for CD (MS), CM (MS), PP (MS and SS) and WD (MS and SS)
- Goshawk nesting site
- High quality wolverine habitat
- Wet meadows

- Moderate to good timber management potential
- Very high amount of stand damage, overstocking, fir encroachment
- Wildfire protection of private lands (328 acres)
- Moderate occurrence of wildfires in the last 25 years
- Potential for destructive wildfire on potential Warm Dry sites (1,738 acres)
- 356 acres of fuel treated by mechanical means since 1986
- 144 acres of Warm Dry treated by mechanical means since 1986

Recommendations/Opportunities:

- Assess road crossing situation for improvement needs
- Rehabilitation potential on detrimental soil condition (250 ac.)
- Priority area for water production
- Maintain/enhance fish habitat
- Riparian planting: ALSI sitka alder; willow SASI2; sitka burnet, Sabin's lupine (LUSA2) on steep slopes and roadcuts
- Restore old forest structure; consider use of prescribed fire in PP and WD ecological settings
- Maintain/protect all areas of existing old forest within ***and outside*** network
- Restore reproductive habitat for pileated and three-toed woodpeckers and marten
- Maintain/enhance goshawk habitat (single story old forest, riparian emphasis)
- Maintain/protect wet meadow habitat
- Restore habitat for bald eagle along Meacham Creek
- Maintain/enhance wolverine foraging habitat
- Salvage/thin overstocked/damaged stands to accelerate growth of overstory trees and reduce fire hazard
- Remove fir understory on warm dry/pp sites
- Opportunity for prescribed fire use on potential warm dry site (21%) and potential grasslands (25%)
- Part of recommended bull trout refugia (protect/restore)

89J Upper Meacham/Wilbur

Attributes/Concerns:

- Boise Cascade holdings - heavy logging plans/activity; Hoskins operations
- High hydrological response
- Highest ECA (28%) of NFS (smaller NFS %)
- Moderate road density
- High riparian road density
- Higher sensitivity to ground disturbing activities
- Railroad in riparian corridor
- Noxious weeds new invader in RR right of way
- Rainbow/steelhead, chinook, bull trout passage
- Water quality limited
- Bald eagle winter habitat
- Changes in patch size and distribution for three-toed woodpecker
- Changes in patch size and distribution for grassland communities
- Old forest structure below HRV (or at low end of range) for CD (MS), CM (MS), PP (MS and SS) and WD (MS and SS)
- Low timber management opportunities

- Protection of private lands (2,101 acres)
- Moderate fire occurrence in last 25 years
- Potential for large destructive wildfire on potential warm dry sites (890 acres)
- 244 acres of fuels treated by mechanical means since 1986

Recommendations/Opportunities:

- Coordinate with private: limited FS opportunities
- Cottonwood appropriate for riparian restoration in lower stream reaches
- Mitigation recommended for railroad, other private
- Restore grassland lost to forest encroachment
- Opportunity for prescribed fire use on potential warm dry sites (27%) and grasslands (29%)
- Maintain/protect all areas of existing old forest within ***and outside*** network
- Restore old forest structure; consider use of prescribed fire in PP and WD ecological settings
- Maintain/enhance habitat for three-toed woodpecker

89K East Fork Meacham

Attributes/Concerns:

- Intermediate hydrological response
- Low/moderate ECA
- Moderate/high road density, riparian road density moderate
- Water quality limited (temperature)
- Moderate sensitivity to ground disturbing activities
- Higher potential mass waste from activity
- Second highest potential detrimental soil condition (84 ac.)
- High stand damage (insects and disease)
- All four fish species present
- Good fish habitat
- Wetland/spring habitat
- Changes in size and distribution of habitat patches for goshawk
- Old forest structure below HRV (or at low end of range) for CD (MS), CM (MS), PP (MS and SS) and WD (MS and SS)
- 179 acres of C1 old growth
- Remnant aspen stands
- Elk vulnerability high due to high open road density and low cover quality
- High quality foraging habitat for wolverine
- Changes in size and distribution of western larch and ponderosa pine
- Moderate to good timber management potential
- Moderate amount of overstocking and fir encroachment
- Protection of private lands (470 acres)
- Highest fire occurrence in last 25 years
- Potential for destructive wildfire on warm dry sites (1,348 acres)
- 495 acres of fuels treated by mechanical means since ✞86
- 77 acres of warm dry treated by mechanical means since ✞86
- 206 acres of untreated slash since 1986

Recommendations/Opportunities:

- Increase populations and soil benefits, plant AGSP, FEID, LUSA2, TRPL
- Road crossing improvements (upper tributaries)
- Potential rehabilitation of detrimental soil conditions: est. 450 ac.
- Maintain/enhance elk cover, reduce open road density to lower vulnerability
- Protect spring areas
- Thin overstocked stands, and/or remove fir understories, consistent with all resource needs
- Opportunity for prescription fire use on potential warm dry sites (26%) and potential grasslands (26%)
- Maintain/protect all areas of existing old forest within ***and outside*** network
- Restore old forest structure, consider use of prescribed fire in PP and WD ecological settings
- Restore aspen stands: maintain and expand existing clones
- Maintain/enhance habitat for goshawk and wolverine

89L Owsley Creek

Attributes/Concerns:

- Moderate sensitivity to ground disturbing activities
- Intermediate hydrological response
- Second highest potential of rehabilitation of detrimental soil condition (ac.)
- Highest overall road density
- Low riparian road density
- Extensive pond construction
- Springs/wetlands
- Grass to forest conversion acres high?
- Culturally significant camas root (Fox Prairie) scotch thistle (Whitman Overlook)
- All four species fish (chinook juvenile rearing) present
- Aquatic habitat quality good
- 314 acres of C1 old growth
- Changes in size and distribution of habitat patches for goshawk and marten
- High quality foraging habitat for wolverine
- Better/best timber management potential
- High stand damage (insects and disease)
- Moderate amount of overstocking
- 141 acres of potential ponderosa pine (most in watershed)
- Changes in size and distribution of ponderosa pine stands
- Moderate wildfire occurrence in the last 25 years
- Potential for destructive wildfire in potential Warm Dry sites (2,456 acres)
- 479 acres of untreated slash
- 318 acres of prescribed fire use since 1986 (43 acres of warm dry treated)
- 101 acres of fuels treated by mechanical means (50 acres of warm dry)

Recommendations/Opportunities:

- Potential rehabilitation of detrimental soil conditions: est.570 ac.
- Road density reduction, road improvement
- Pond erosion control, etc.
- Maintain springs

- Prescribed fire opportunities
- Opportunity to plant sabin's lubine (LUSA2) and Yakima milkvetch (ASRE2)
- Maintain existing quality and quantity of fish habitat
- Thin/salvage damaged/overstocked stands to accelerate growth of overstory trees and reduce fire hazard
- Opportunity for prescribed fire use on potential Warm Dry sites (34%) and grasslands (24%)
- Protect existing old forest structure, within ***and outside*** the network, enhance size and quality of old forest patches where feasible
- Improve composition of pine stands on appropriate sites
- Restore reproductive habitat for marten and goshawk
- Maintain/enhance wolverine habitat

89M Upper Meacham/Short

Attributes/Concerns:

- Large private holdings
- High hydrological response
- Low/moderate road density **-** railroad and lower valley road (highest riparian density)
- Water quality limited (temperature, habitat, sedimentation
- Higher sensitivity to ground disturbing activities
- All four fish species present
- Fish habitat condition generally poor
- Very limited timber management potential
- Moderate/high amount of overstocking of timbered stands
- Protection of private lands from fire (907 acres) and adjacent private lands to the west and north
- Moderate occurrence of wildfire since 1970
- Potential for destructive wildfires in warm dry site (519 acres)
- 127 acres of C1 old growth

Recommendations/Opportunities:

- Limited NFS opportunities **-** coordination with private landowners needed
- Thin overstocked stands, especially on dryer sites
- Opportunity for prescribed fire use if protection of private lands can be maintained (20% SWS warm dry and 24% grasslands)
- Protect existing old forest structure, within ***and outside*** the network, enhance size and quality of old forest patches where feasible

89N Butcher

Attributes/Concerns:

- Poor (private) road condition (upper end OK)
- Moderate sensitivity to ground disturbing activities
- Intermediate road density
- Private holdings, erosion
- High riparian road density

- Noxious weeds
- Listed as anadromous habitat; no stream survey or fish distribution data available
- Limited timber management potential
- High overstocking on Warm Dry sites
- High amount of fir encroachment
- Fire protection of private lands (884 acres) and adjacent private lands
- 91 acres treated by fire since '86 (12 acres Warm Dry)
- Low fire occurrence in last 25 years
- Potential for destructive wildfires on potential warm dry sites (893 acres)
- 55 acres of potential ponderosa pine
- 106 acres of C1 old growth

Recommendations/Opportunities:

- Noxious weed treatment
- Thin overstocked stands
- Understory removals for stands with fir encroachment (larch and pine sites)
- Opportunity for prescribed fire use if protection of private lands can be assured.
- Warm dry (17%) grasslands (9%)
- Need stream surveys - Butcher Creek
- Protect existing old forest structure within ***and outside*** network, enhance size and quality of old forest patches where feasible

89O Upper Meacham/Allen

Attributes/Concerns:

- Moderate sensitivity to ground disturbing activities
- Highest percentage potential detrimental soil condition
- Low/intermediate road density
- Riparian road density high (railroad and road)
- Most harvest on steep slopes
- Poor fish habitat
- Water quality limited (temperature, habitat, sedimentation)
- All four fish species present
- Beaver activity
- Meacham point source pollution
- Private holdings
- Riparian canopy lacking on private lands within SWS
- Old forest structure below HRV (or at low end of range) for CD (MS), CM (MS), PP (MS and SS) and WD (MS and SS)
- 178 acres of C1 old growth
- Wet meadow
- Low wildfire occurrence in last 25 years
- Moderate timber management potential
- Protection of private lands (1952 acres)
- Potential for destructive wildfire in warm dry sites (1647 acres)
- Change in size and distribution of habitat patches for goshawk
- Change in size and distribution of ponderosa pine stands

- Reduction in grassland community distribution
- Remnant aspen stands

Recommendations/Opportunities:

- Potential rehabilitation of detrimental soil conditions: est. 500 ac.
- Identify potential erosion/sediment on steep harvest areas
- Use Sabine's lupine (LUSA2) in shallow soils rehabilitation
- Riparian planting
- Private opportunity - willows, yew (lower)
- Land exchanges
- Maintain quantity and quality of big game winter range
- Maintain/protect wet meadow habitat
- Salvage/thin damaged stands to accelerate overstory tree growth and reduce fire hazard
- Restore lost grasslands
- Opportunity for prescribed use in warm dry sites (17%) and grasslands (14%)
- Maintain/enhance existing habitat for goshawk and bald eagle, with emphasis on riparian mature and old forest structure
- Maintain/protect all areas of existing old forest within ***and outside*** network
- Restore old forest structure; consider use of prescribed fire in PP and WD settings
- Restore pine stands on appropriate sites

89Q Upper Meacham/Tod/Beaver/Sheep

Attributes/Concerns:

- Railroad, road: riparian location
- Intermediate road density
- Little NFS 160 ac. (190 ac. land exchanges?)
- Poor road condition, especially Sheep Creek
- Water quality limited (temperature, habitat, sedimentation)
- Active eroding banks
- Poorer fish habitat
- All four fish species present
- Winter range for elk
- Changes in size and distribution of habitat patches for goshawk and pileated woodpecker
- Originally a meadow stream, now degraded
- Wet meadows
- Highest amount of overstocking and fir encroachment
- Mostly private lands
- No fire history information

Recommendations/Opportunities:

- Cooperative activities to restore floodplain function
- Maintain winter range
- Maintain/restore wet meadows
- Little opportunity for prescribed fire use
- Thin overstocked stands accelerate overstory tree growth and reduce fire hazard

- Understory removals on fir-encroached sites, consistent with other resource needs
- Restore reproductive habitat for pileated woodpecker and goshawk

89R Upper Meacham

Attributes/Concerns:

- No Umatilla NFS ownership.
- Poor stream condition, eroding banks, sediment
- RR
- Pipelines
- No info (fire or fuels related)

Recommendations/Opportunities:

- Limited NFS direction
- Private coord.
- State wayside?

LITERATURE CITED

Agee, J.K. 1988. Successional dynamic in forest riparian zones. In forestry interactions: pp31-45. Inst. Resour. Countr 59. University of Washington, Seattle, WA.

Agee, J.K. 1990. The historical role of fire in Pacific Northwest forest. Natural and Prescribed fire in Pacific Northwest forest: pp.25-38. Oregon State University Press, Corvallis, OR.

Agee, J.K. 1993. The Fire Ecology of Pacific Northwest Forest. Island Press, Covelo, CA.

Agee, J.K. 1994. Fire Ecology of Pacific Northwest Forests, Island Press, pp 250-279, 320-350.

Ager, A., McGaughey , R., Hatfield, D. 1995a. Operations manual for UTOOLS. USDA Forest Service, Pacific Northwest Region, Portland, OR. UMANUAL.DOC program distributed with UTOOLS microcomputer software. 78p.

Ager, A., Scott, D., Schmitt, C. 1995b.
UPEST: Insect and disease risk calculator for the Forests of the Blue Mountains. USDA Forest Service, Umatilla and Wallowa-Whitman National Forests, Pacific Northwest Region, Pendleton, OR. Unpublished draft document. 25p.

Ager, A., Clifton, Catherine.

Banci, V. 1994. Wolverine. Chaptr. 5 In: American marten, fisher lynx and wolverine in the western United States. USDA Forest Serv., Rocky Mtn. Forest and Range Expre. Sta., Gen. Tech. Rept. EM-254.

Belt, G.H., O'Laughlin, J., Merril, T. 1992. Design of forest riparian buffer strips for the protection of water quality: analysis of scientific literature. Idaho forest, wildlife and range policy analysis group, report no. 8 Univ. of Idaho, College of Forestry, Wildlife and Range Sciences. Moscow, ID.

Beschta, R.L. 1990.., Effects of fire on water quality and quantity. Prescribed and natural fire in Pacific Northwest forest, chapt 17. Oregon State University Press, Corvallis ,OR.

Betts, B.J., Wisseman, R.W. 1995. Geographic range and habitat characteristics of the Caddisfly *Cryptochia neosa*. Northwest Science. 69:46-51

Brown, E.R., and others. 1985. Management of fish and wildlife habitats in forests of western Oregon and Washington. U.S. Forest Serv., Portland, OR. 664 pp.

Block, W.M., Morrison, M.L., Reiser, M.H. eds. 1993. The northern goshawk: ecology and management. Studies in Avian Biology, no. 16, Cooper Ornithological Society. 136pp.

Boula, K.M., Crabtree, D. 1996. Old Growth/Riparian Management Emphasis Network. Network Development Process. Umatilla-Meacham Ecosystem Analysis. Report on File Umatilla National Forest. 19 p.

Bull, E. 1996. The effect of management on American martens. Natural Resource News, Blue Mountains Natural Resources Institute, 6(2): Spring 1996.

Bull, E., Holthausen, R. 1993. Habitat use and management of pileated woodpeckers in northeastern Oregon. J. Wildl. Manage. 57(2):335-345.

CH2 M Hill, 1995. Blue Mountains Project, Cumulative Impacts Assessment. Union Pacific Railroad.

Carlson, C.E., Fellin, D.G., Schmidt, W.C. 1983. The western spruce budworm in northern Rocky Mountain forests; a review of ecology, insecticidal treatments and silvicultural practices. In: O'Loughlin, J.; Pfister, R.D., eds. Management of Second-Growth Forests: The State of Knowledge and Research Needs. Symposium Proceedings; 1982 May 14; Missoula, MT. Missoula, MT: Montana Forest and Conservation Experiment Station, School of Forestry, University of Montana: 76-103.

Carolin, V.M., Coulter, W.K. 1971. Trends of western spruce budworm and associated insects in Pacific Northwest forests sprayed with DDT. J. of Economic Ent. 64 (1): 291-297.

Clifton, C. 1996. Ecosystem Analysis of the Umatilla and Meacham Watersheds, Watershed Hydrology. Report on File Umatilla National Forest. 52 p.

Contor, C.R., Hoverson, E., Kissner, P. 1995. Umatilla Basin Natural Production Monitoring and Evaluation; Annual Progress Report 1993-1994. Confederated Tribes of the Umatilla Indian Reservation. Tribal Fisheries Program, Pendleton, OR.

Cooper, C.F. 1961. The ecology of fire. Scientific American. 204: 150-158.

Crabtree, D.M. 1996. Upper Umatilla River and Meacham Creek Watersheds Ecosystem Analysis, Fish and Aquatic Habitat. Report on File Umatilla National Forest. 101 p.

Daniel, T.W., Helms, J.A., Baker, F.S. 1979. Principles of silviculture. Second edition. New York, NY: McGraw-Hill. 500 p.

Deeming, J.E., Burgan, R. E., Cohen, J. D. The National Fire Danger Rating System – 1978. GTR INT-39. USDA-FS, Intermountain Research Station, Ogden UT.

Dobkin, D. 1994. Conservation and management of neotropical migrant landbirds in the northern Rockies and Great Plains. Univ. Idaho Press. Moscow, ID.

Dobkin, D., Sharp, B. 1993.

Douglas-fir Tussock Moth EIS. 2000. USDA Forest Service. PNW. Portland, OR. 205 p.

Doyle, A. 1990. Use of riparian and upland habitats by small animals. J. Mamm. 71(1):14-23

Eastside Forests Scientific Panel. 1994. Interim protection for late successional forests, fisheries and watersheds, National Forests east of the Cascade Crest, Oregon and Washington. 245

pp. The Wildlife Society

Eaton, C.B., Beal, J.A., Furniss, R.L., Speers, C.F. 1949. Airplane and helicopter spraying with DDT for spruce budworm control. Journal of Forestry. 47:823-827.

Everett, A.E., A.E. Camp, and R. Schellhaas, Building a New Forest With Fire Protection In Mind, Paper presented at the Fire Protection Working Group Technical Session at the SAF National Convention held in Portland Maine, October 28- November 1, 1995.

Fellin, D.G. 1983. Chemical insecticide vs. the western spruce budworm: after three decades, what's the score? Western Wildlands. 9 (1):8-12.

Federal Guide for Watershed Analysis--Ecosystem Analysis at the Watershed Scale. 1995. Version 2.2. Portland, OR: Regional Ecosystem Office. 26 p.

FEMAT--Forest Ecosystem Management Assessment Team. 1993. Forest Ecosystem Management: an Ecological, Economic, and Social Assessment. USDA Forest Service, USDI Fish and Wildlife Service, US Dept. Of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, USDI National Park Service, USDI Bureau of Land Management, Environmental Protection Agency.

Fire Related Considerations and Strategies in Support of Ecosystem Management, 1993, USDA Forest Service Staffing Paper

Fowler, C.S. 1992. In the Shadow of Fox Peak: An Ethnoggraphy of the Cattail-Eater Northern Paiute People of Stillwater Marsh. United States Department of the Interior. Fish and Wildlife Service. U.S. Government Printing Office.

Gast, W.R., Jr, D. W. Scott, C. Schmitt, D. Clemens, S. Howes, C. G. Johnson, Jr., and others. 1991. Blue mountains forest health report- "New perspectives in forest health." USDA – Forest Service, Pacific Northwest Region.

Geist, J.M., Ecosystem Analysis of the Upper Umatilla River and Meacham Creek Watersheds – Site, Geology, Soil, and Forest Harvest Attributes in Relation to Sustainability of Vegetation. Report on File Umatilla National Forest. 51 p.

Gobar, C.F., Boula, K.M. 1996. Umatilla and Meacham Analysis Areas Terrestrial Vertebrate Biodiversity. Report on file Umatilla National Forest. 83 p.

Gruell, G.E. 1985. Fire on the early western landscape: an annotated record of wildland fires 1776-1900. Northwest Science. 59 (2): 97-107.

Hall, F.C. 1976. Fire and vegetation in the Blue Mountains: Implications for land managers. Tall Timber Fire Ecology Conf. Proc. 14:155-70.

Hall, F.C., 1991. Ecology of Fire in the Blue Mountains of Eastern Oregon, unpublished paper on file.

Hessburg, P.F., Smith, B.G., Miller, C.A., and others. Modeling Change in Potential Landscape Vulnerability to Forest Insect and Pathogen Disturbances: Methods for Forested Subwatersheds Sampled in the Midscale Interior Columbia River Basin assessment. USDA Forest Service, PNV Forest and Range Experiment Station. PNW-GTR-454.

Hickman, J.C. (Editor). 1993. The Jepson Manual: Higher Plants of California. University of California Press, Berkeley.

Hudson, L., Ayers, G.G., Gauzza, G.F. 1978. Cultural Resource Overview of the Malheur, Umatilla, and Wallowa-Whitman National Forests: Northeast Oregon/Southeast Washington. Cultural Resource Consultants Inc. Sandpoint, ID.

Interior Columbia Basin Ecosystem Management Project. 1996.

Johnston, V.R. 1970. The ecology of fire. Audubon. 72: 76-119.

Kozlowski, T.T. and C.E. Ahlgren,1974. Fire and Ecosystems, Academic Press, pp 139-177, 279-303.

Langston, N. 1994. The General Riot of the Forest Landscape; Environmental Change in the Blue Mountains. Ph.D. Dissertation. Univ. Washington, Seattle. 241 pp.

MacIntosh, B.A., Clark, S.E., Sedell, J.R.. 1994. Summary Report for Bureau of Fisheries Stream Habitat Surveys. Umatilla, Tucannon, Asotin, and Grande Ronde River Basins, 1934-1942. Pacific Northwest Research Station, USDA-Forest Service, Oregon State University, Corvallis, OR. BPA Project no. 89-104.

Maruoka, K.R. 1994. Fire History of *Pseudotsuga menziesii* and *Abies grandis* Stands in the Blue Mountains of Oregon and Washington, Master of Science Thesis, University of Washington.

Meehan, W.R. editor. 1991. Influences of forest and rangeland management on salmonid fishes and their habitats. American Fisheries Society, Special Publication 19.

Mithcell, V.L. 1976. The regionalization of climate in the western United States. Journal of Applied Meteorology. 15:020-927.

Morris, W.G. 1934. Lightning storms and fires on the National Forest of Oregon and Washington. USDA-FS Pacific Northwest Range and Experimental Station, Portland , OR.

Murphy, E. 1959. Indian Uses of Native Plants. Mendocino County Historical Society. Fort Bragg, California 95437.

Naimen, R.J., and others. 1993. The role of riparian corridors in maintaining regional biodiversity. Ecol. Applic. 3(2):209-212.

Noss, R. 1992. Biodiversity in the Blue Mountains: a framework for monitoring and assessment. Paper presented at Blue Mountains Biodiversity Conf., Walla Walla, WA. May, 1992.

Plummer, F.G. 1912. Lightning in relation to forest fires. Bulletin No. 111. Washington, DC: U.S. Department of Agriculture, Forest Service. 39 p.

Powell, D.C. 1994. Effects of the 1980s western spruce budworm outbreak on the Malheur National Forest in northeastern Oregon. Technical Publication R6-FI&D-TP-12-94. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 176 p.

Powell, D.C. 1999. Upland Forest Vegetation Analysis. Umatilla-Meacham Ecosystem Analysis. Report on File Umatilla National Forest. 110 p.

Rieman, B.E., McIntyre, J.D. 1993. Demographic and habitat requirements for conservation of bull trout. Gen. Tech. Rep. INT-302, Ogden UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 38 p.

Rieman, B.E., McIntyre, J.D. 1996. Spatial and temporal variability in bull trout redd counts. North American Journal of Fisheries Management 16: 132-141.

Robbins, W.G., Wolf, D.W. 1994. Landscape and the intermontane Northwest: an environmental history. General Technical Report PNW-GTR-319. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 32 p.

Rosgen D.L. 1994. A classification of natural rivers. Catena 22:169-199.

Ross, R.N., Moore, M.R. 1965. Watershed analysis: Umatilla River Barometer Watershed. Report on file Umatilla National Forest, Pendleton, Oregon. 145 p.

Rowan, G.D. 1995. Minthorn Springs Creek Summer Juvenile Release and Adult Collection Facility; Annual Report, 1994. Confederated Tribes of the Umatilla Indian Reservation, Department of Natural Resources, Fisheries Program. Pendleton, OR.

Sharp, B. 1992. Status report of neotropical migrants in the Pacific Northwest. USDA Forest Serv., Pacific Northwest Region, Portland, OR.

Spangenberg, N.E. 1971. Umatilla Barometer Watershed survey-analysis-plan. Report on file Umatilla National Forest, Pendleton, Oregon. 98 p.

Swanson, F.J., Jones, J.A., Wallin, D.O., Cissel, J.H.0. 1994. Natural variability - implications for ecosystem management. In: Jensen, M.E.; Bourgeron, P.S., editors. Volume II: Ecosystem management: principles and applications. Gen. Tech. Rep. PNW-GTR-318. Portland, OR: U.S. Dept. of Agric., Forest Service, PNW Res. Station: 80-94.

Thomas, J.W., and others. 1979. Wildlife Habitats in managed forests, the Blue Mountains of Oregon and Washington. USDA Forest Serv., Agric. Handbook no. 553.

Torgerson, T.R., Powell, D.C., Hosman, K.P., Schmidt, F.H. 1995. No long-term impact of carbaryl treatment on western spruce budworm populations and host trees in the Malheur National Forest, Oregon. Forest Science. 41(4): 851-863.

Union Pacific Railroad Engineering Services. 1993. Blue Mountain Project. Union Pacific Railroad; Omaha.

Urban, K. 1996a. Floristic Biodiversity and Related Ecological Issues of the Meacham Creek Watershed Ecosystem Analysis Area. Report on File Umatilla National Forest. 64 p.

Urban, K. 1996b. Floristic Biodiversity and Related Ecological Issues of the Umatilla River Watershed Ecosystem Analysis Area. Report on File Umatilla National Forest. 72 p.

Washington Dept. Fish and Wildlife. 1995. Priority Habitat Management Recommendations: Riparian. WEFW, Priority Habitats and Species Div., Olympia, WA.

Western Forest Health Initiative, 1994, USDA Forest Service State and Private Forestry.

Wicklum, D., Davies, R.W. 1995. Ecosystem health and integrity? Canadian Journal of Botany. 73: 997-1000.

Wickman, B.E., Mason, R.R., Thompson, C.G. 1973. Major outbreaks of the Douglas-fir tussock moth in Oregon and California. Gen. Tech. Rep. PNW-5. Portland, OR: USDA, Forest Service, Pacific Northwest Forest and Range Experiment Station. 18p.

Wilson, E.O. 1988. Biodiversity. National Academy Press.

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.

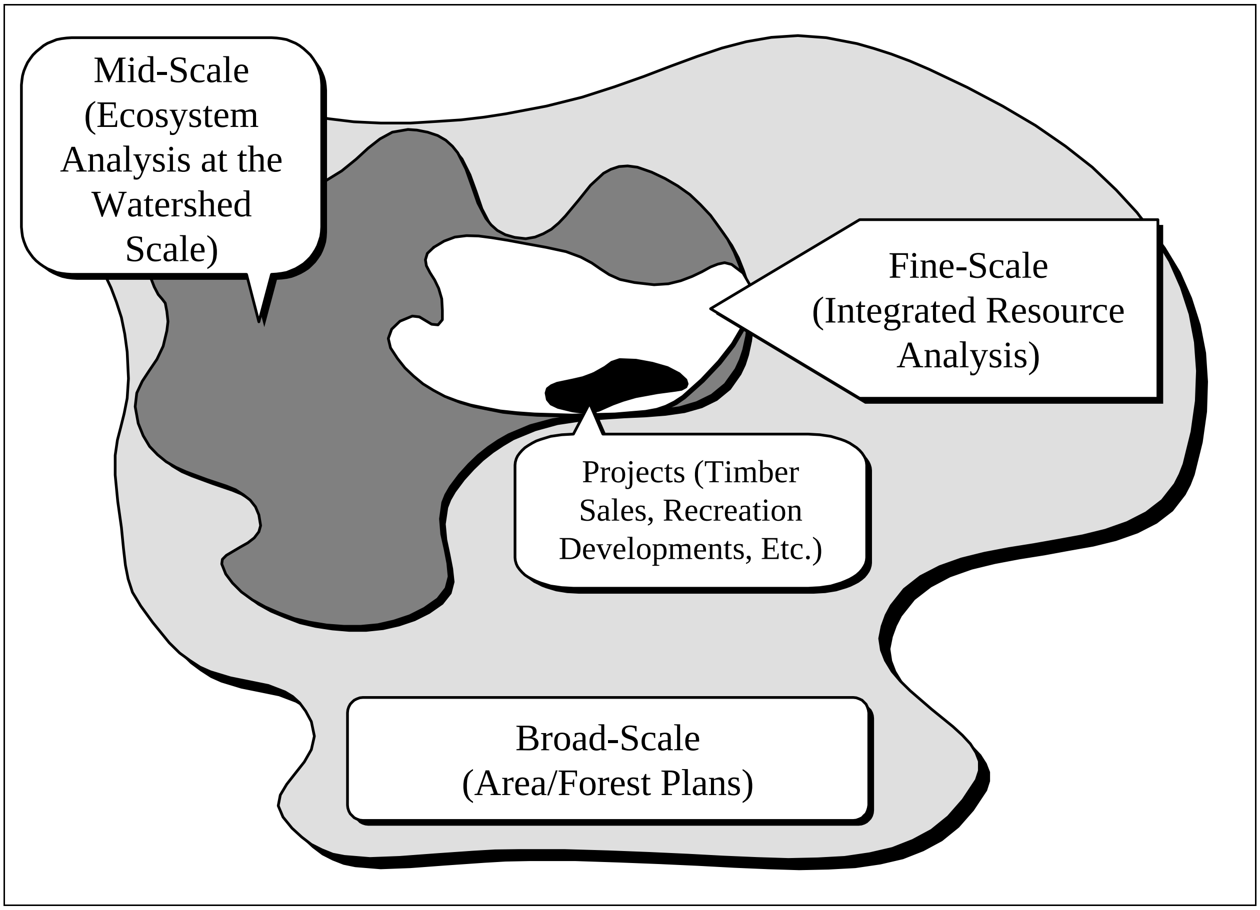


Figure 1 – Analysis scales, showing that "ecosystem analysis at the watershed scale" is considered to be a mid-scale process.

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.

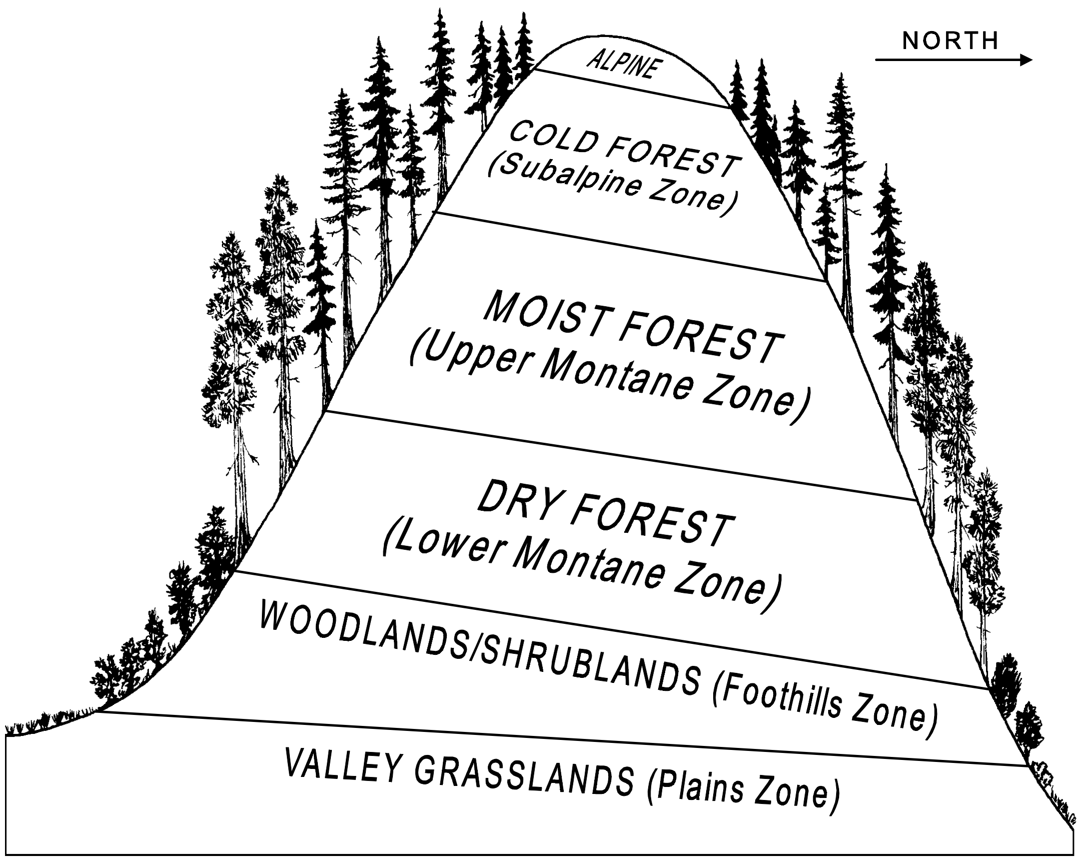


Figure 2 – Vegetation zones of the Blue Mountains. Vegetation types tend to occur in zones as one moves up or down in elevation. In the Northern Hemisphere, a south-facing slope receives more solar radiation than a flat surface, and a north-facing slope receives less. Thus the same temperature conditions 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.

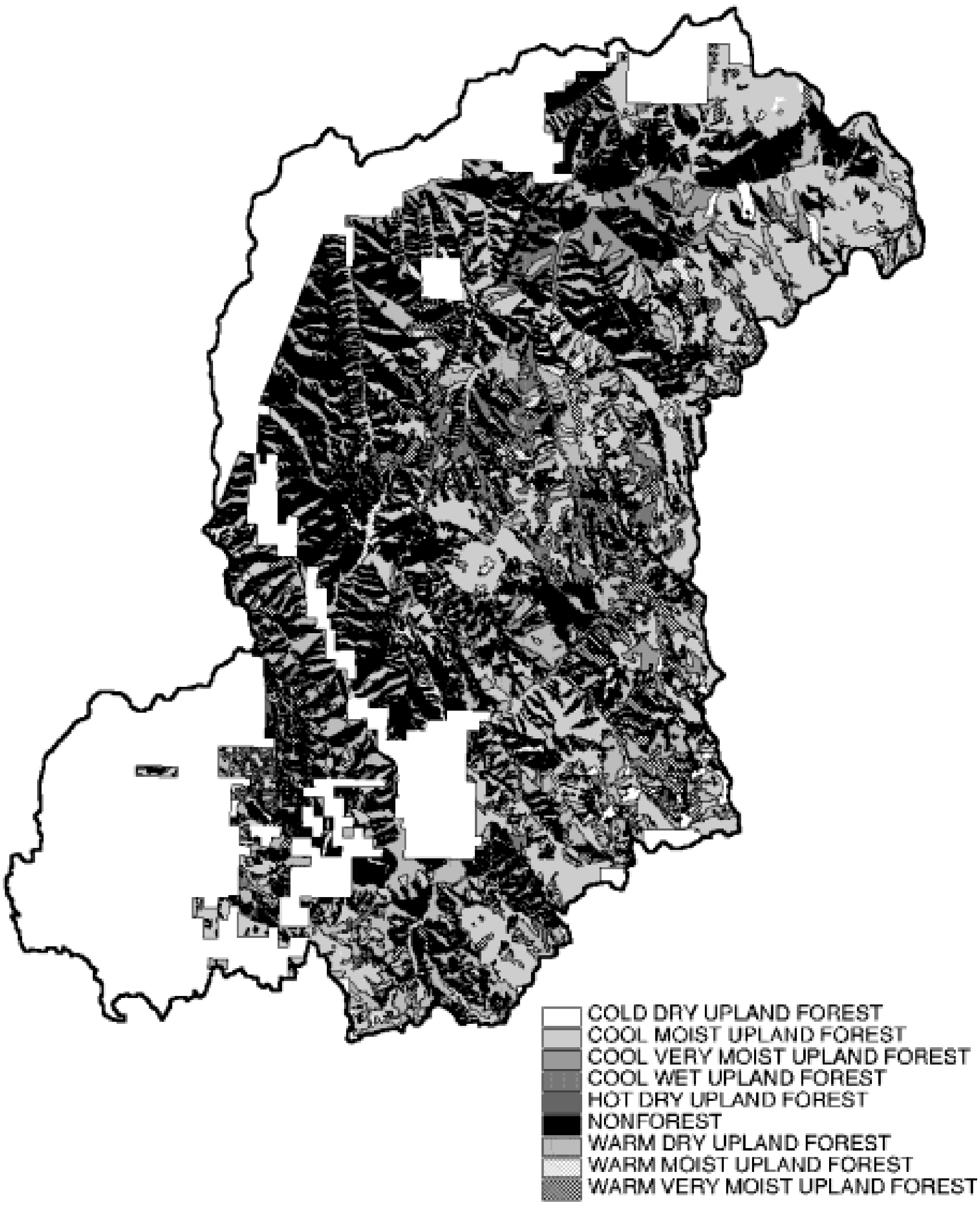


Figure 3 – Plant association groups (PAGs) for the Umatilla/Meacham analysis area. See table 2 for additional information about the upland-forest plant associations (Ecoclasses) that were aggregated to form these plant association groups.

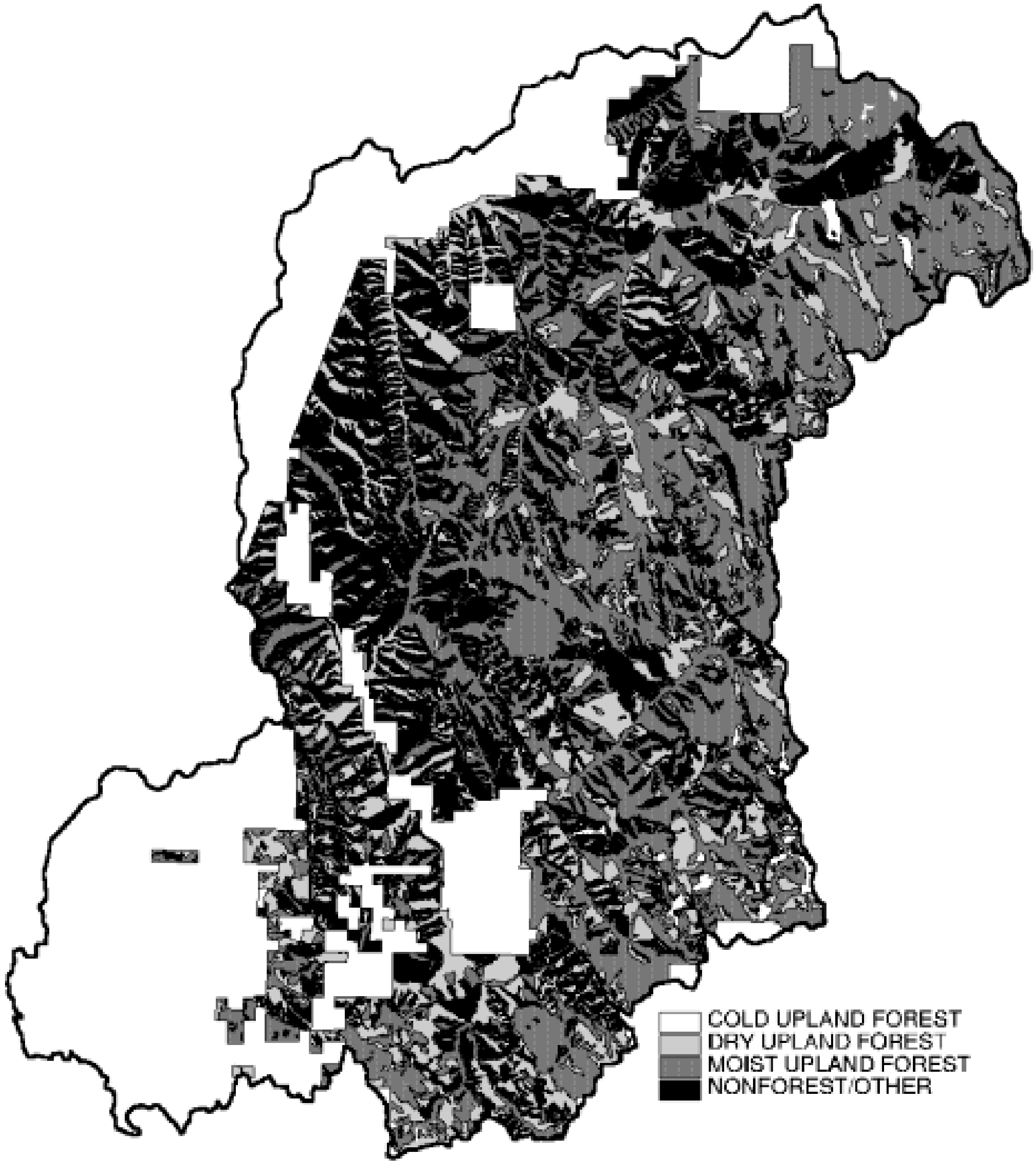


Figure 4 – Potential vegetation groups (PVGs) for the Umatilla/Meacham analysis area. See table 2 for additional information about the upland-forest plant association groups (PAGs) that were aggregated to form these potential vegetation groups.

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.

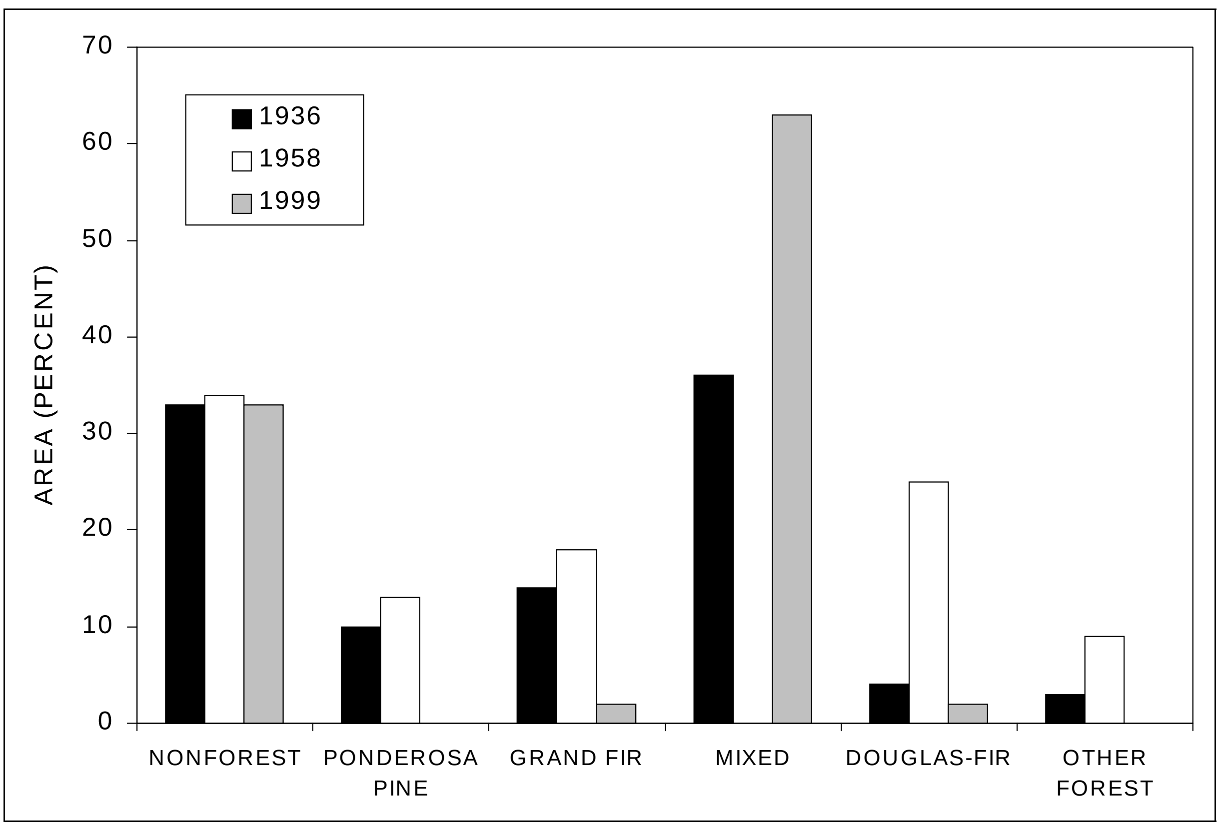


Figure 5 – Forest cover type percentages through time ("other forest" includes any type not shown separately).

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.

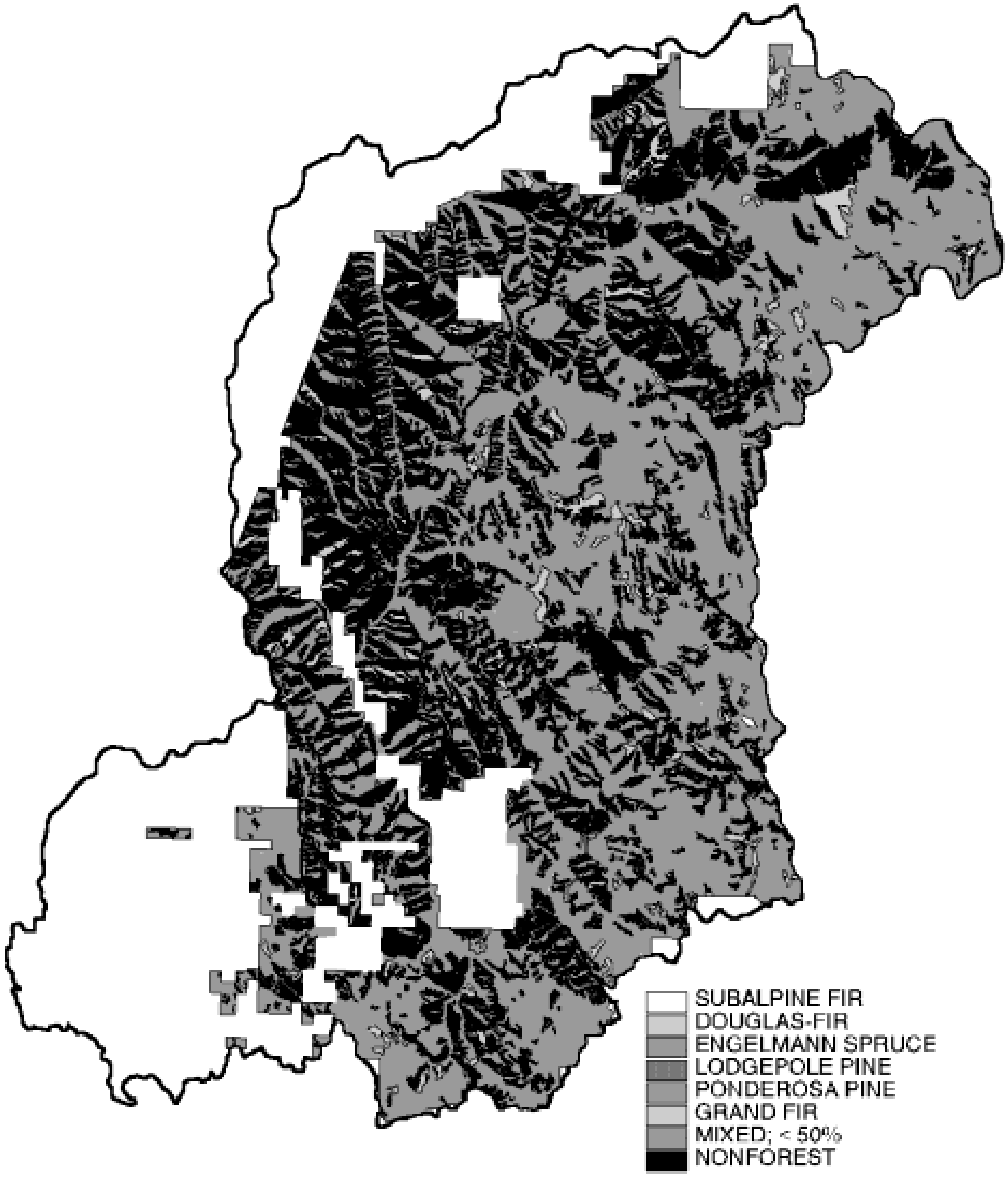


Figure 6 – Upland forest cover types of the Umatilla/Meacham analysis area (see table 5 for more information about the cover-type codes and their derivation).

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			Nonforest Lands		
	1999	1958	Change	1999	1958	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.

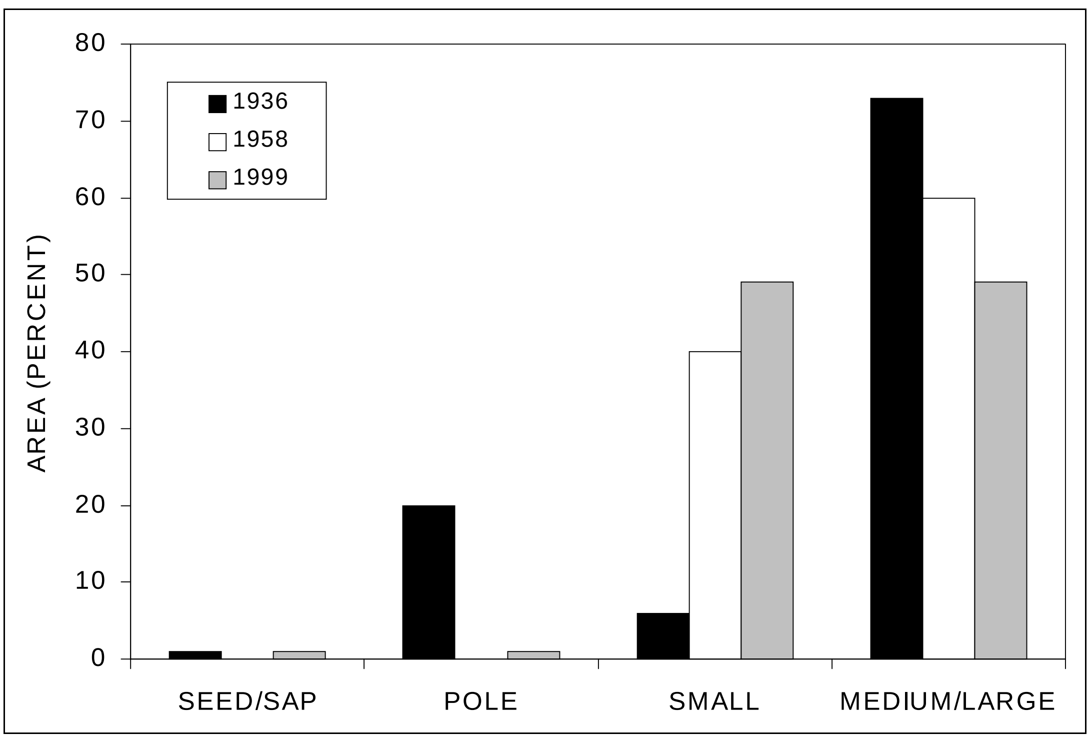


Figure 7 – Forest size class percentages through time. “Seed/sap” includes size classes 1 through 3, “pole” includes 4 and 5, “small” includes 6, 77, and 88, and “medium/large” includes classes 8-12.

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.

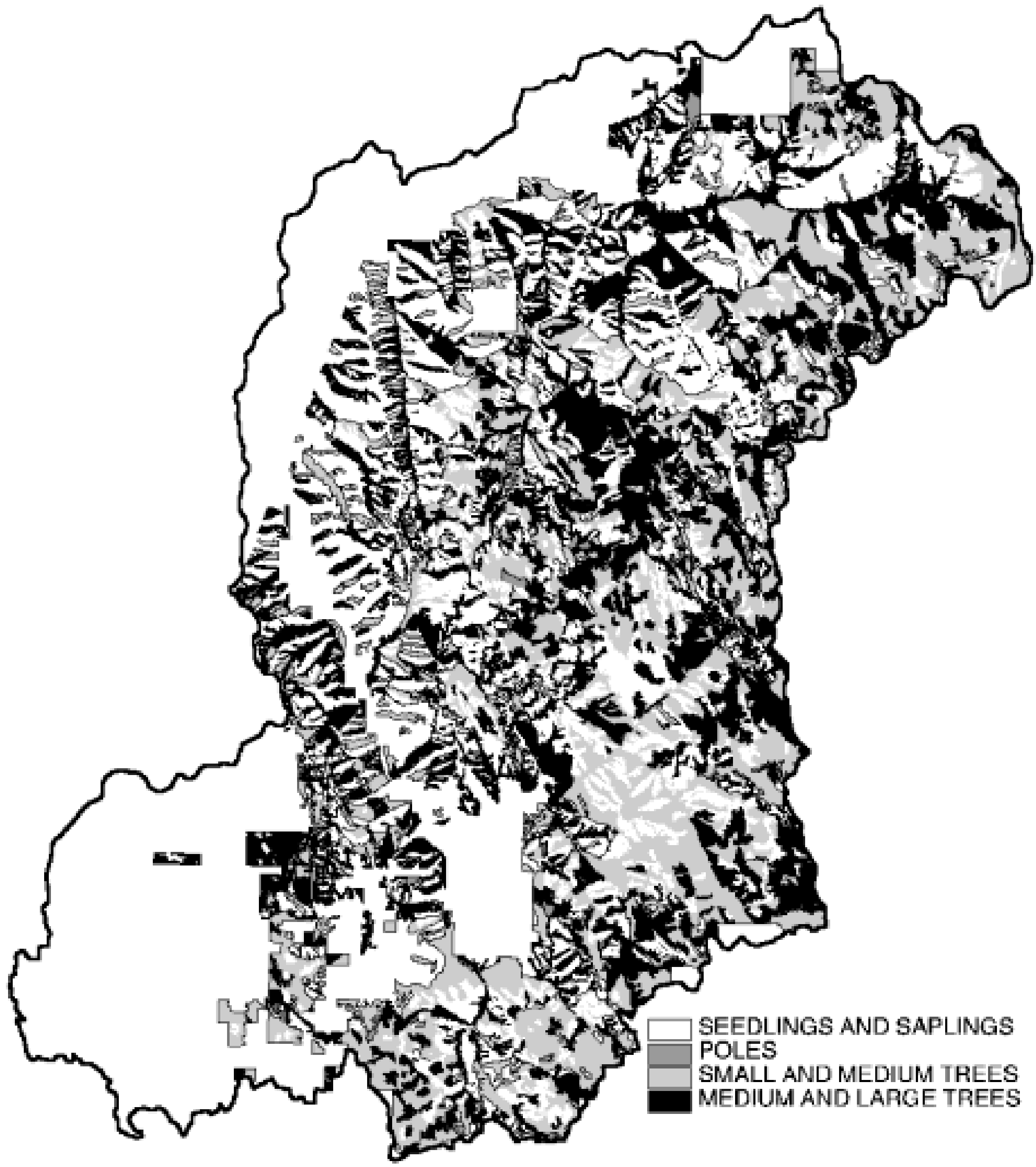


Figure 8 – Upland forest size classes (overstory layer only) for the Umatilla/Meacham analysis area. Note that "seedlings and saplings" includes size classes 1 through 3, poles includes classes 4 and 5, "small and medium trees" is classes 6, 77, and 88, and medium and large trees includes classes 8 through 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.

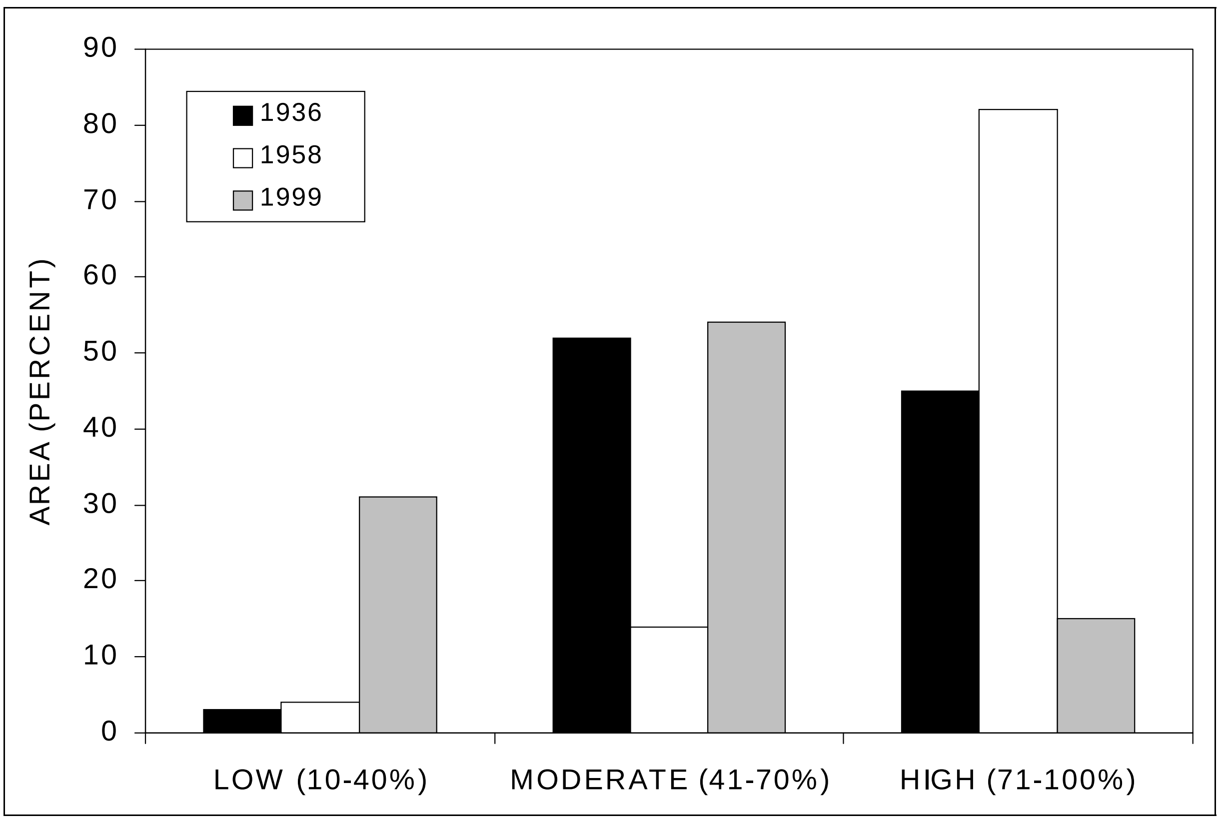


Figure 9 – Forest density class percentages through time.

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.

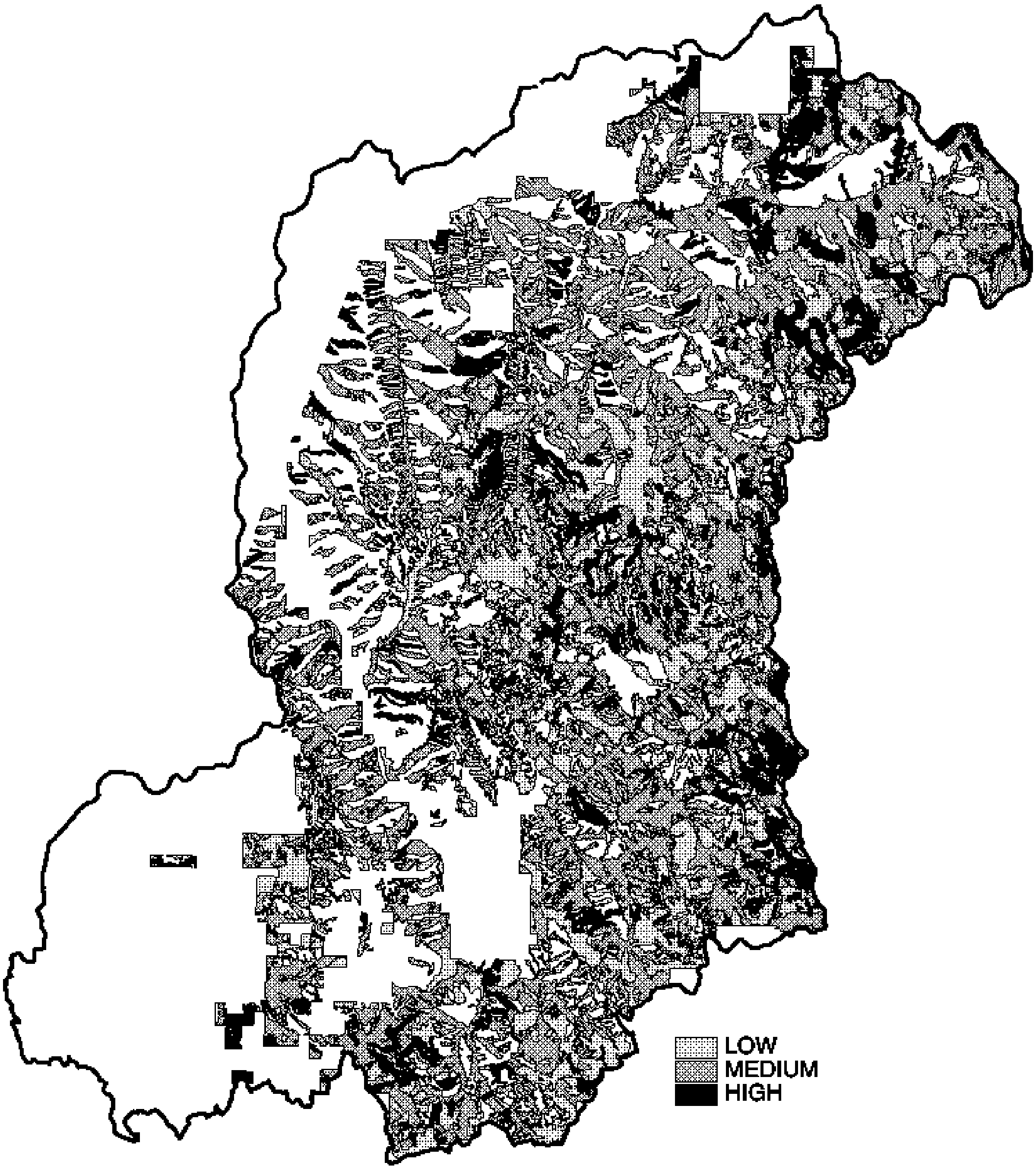


Figure 10 – Upland forest density classes for the Umatilla/Meacham analysis area (see table 10 for more information about the density-class codes and their derivation). Note that the low-density class includes forests with 10 to 40 percent canopy cover, medium includes 41 to 70 percent canopy cover,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

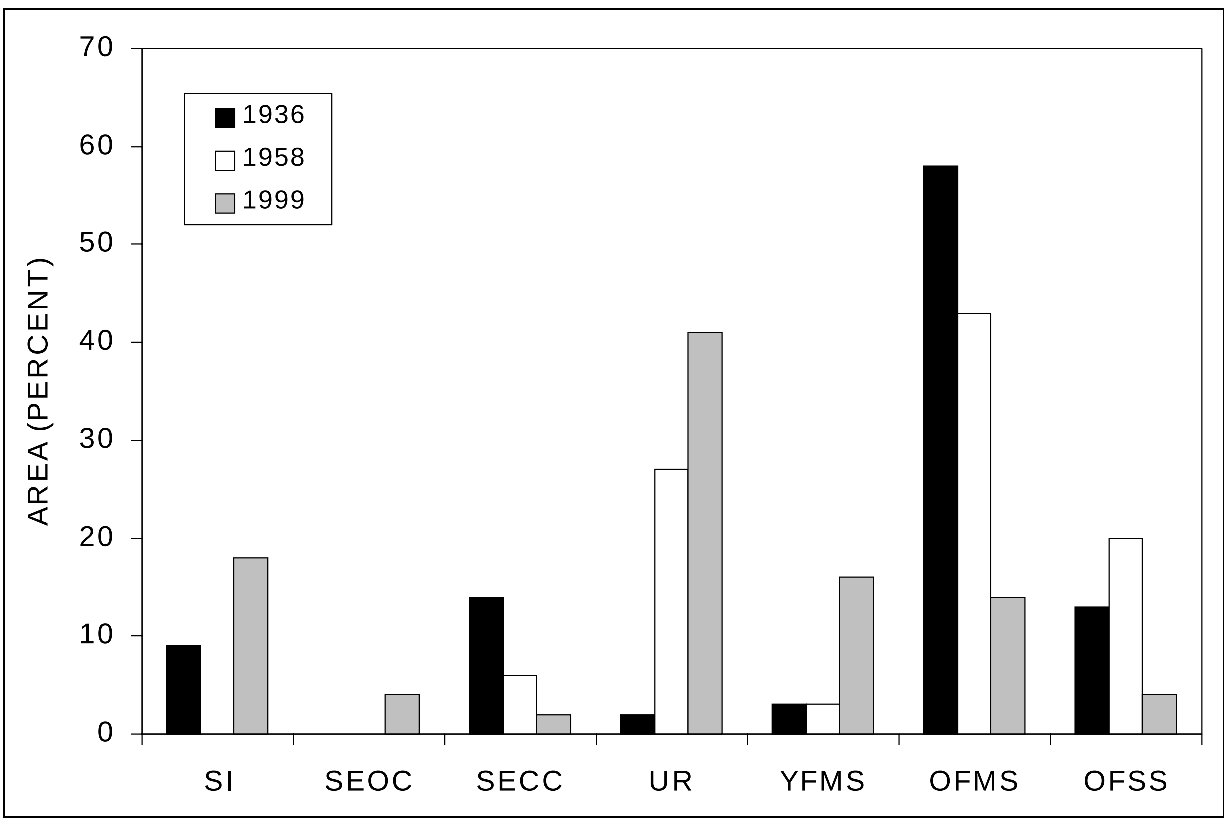


Figure 11 – Forest structural stage percentages through time.

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.

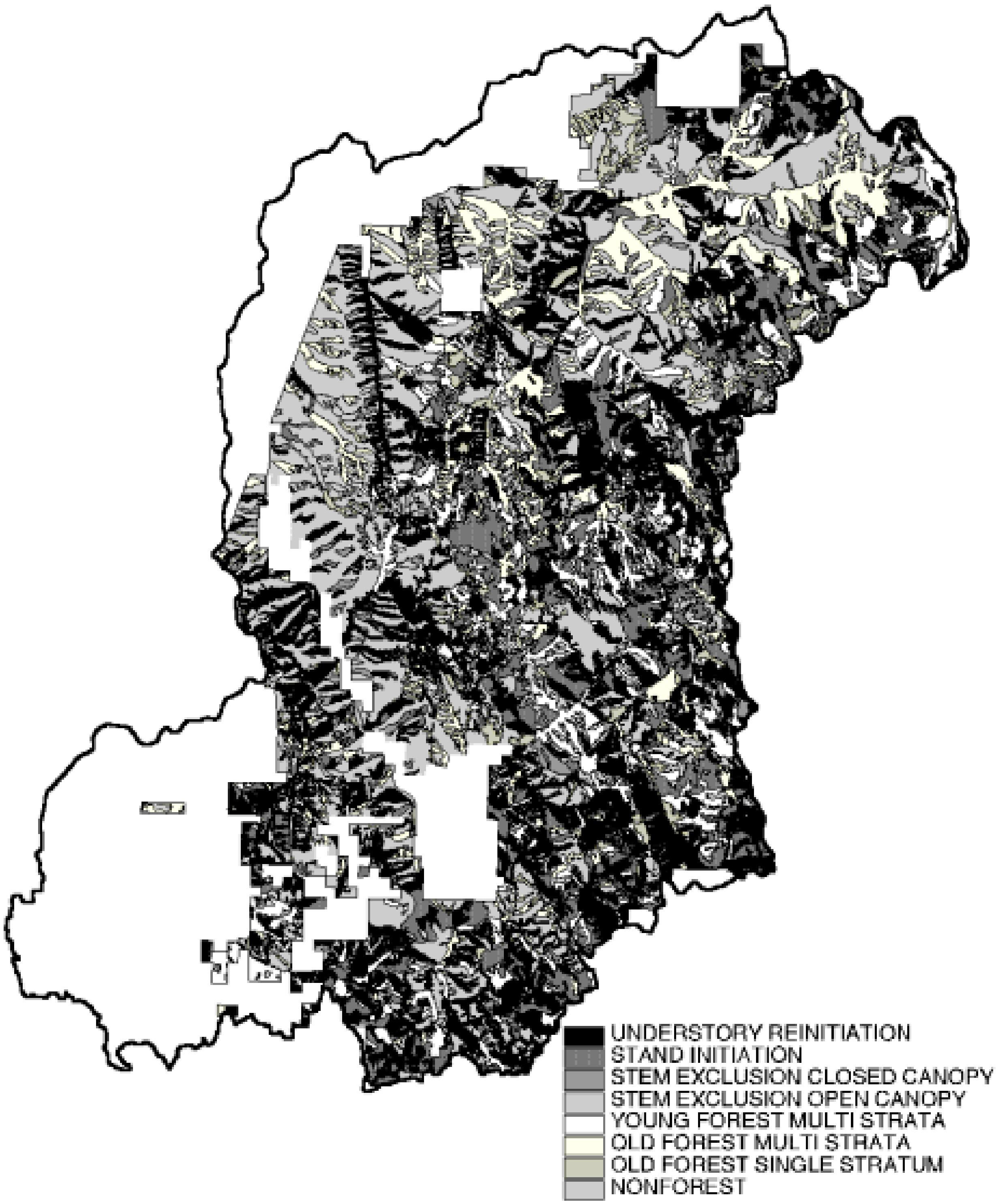
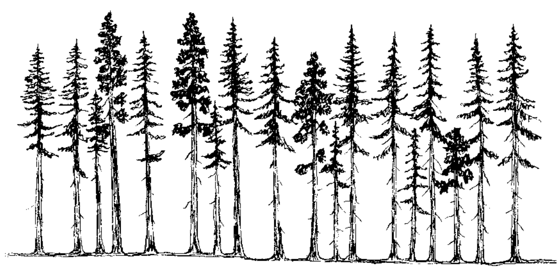
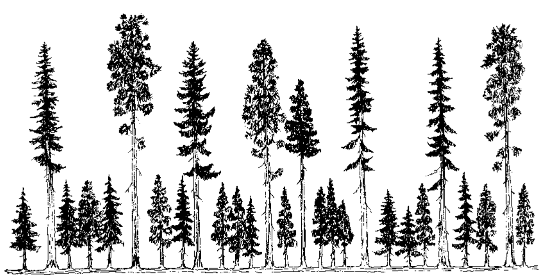


Figure 12 – Upland forest structural stages for the Umatilla/Meacham analysis area (see tables 12 and 14 for more information about the structural-stage codes and their derivation).

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).

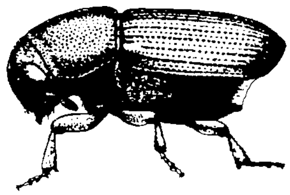
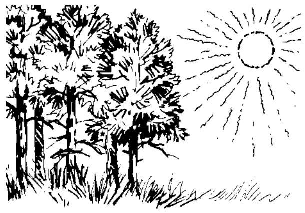
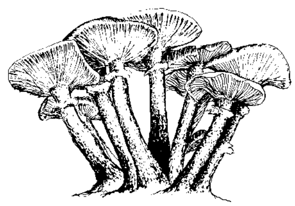
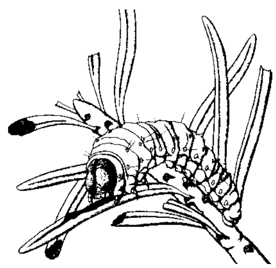
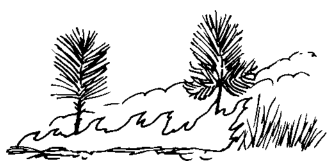
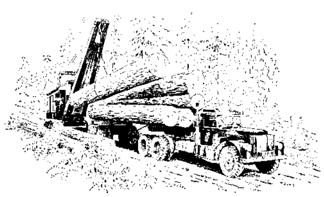
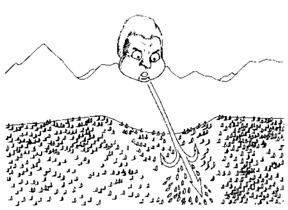
Disturbances frequently have a renewal effect by helping to recycle nutrients. Fire used to be the predominant recycling force in forests of the Interior Northwest because it consumed fallen needles and branches, rejuvenated many herb and shrub species while selecting against others, thinned young tree 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).

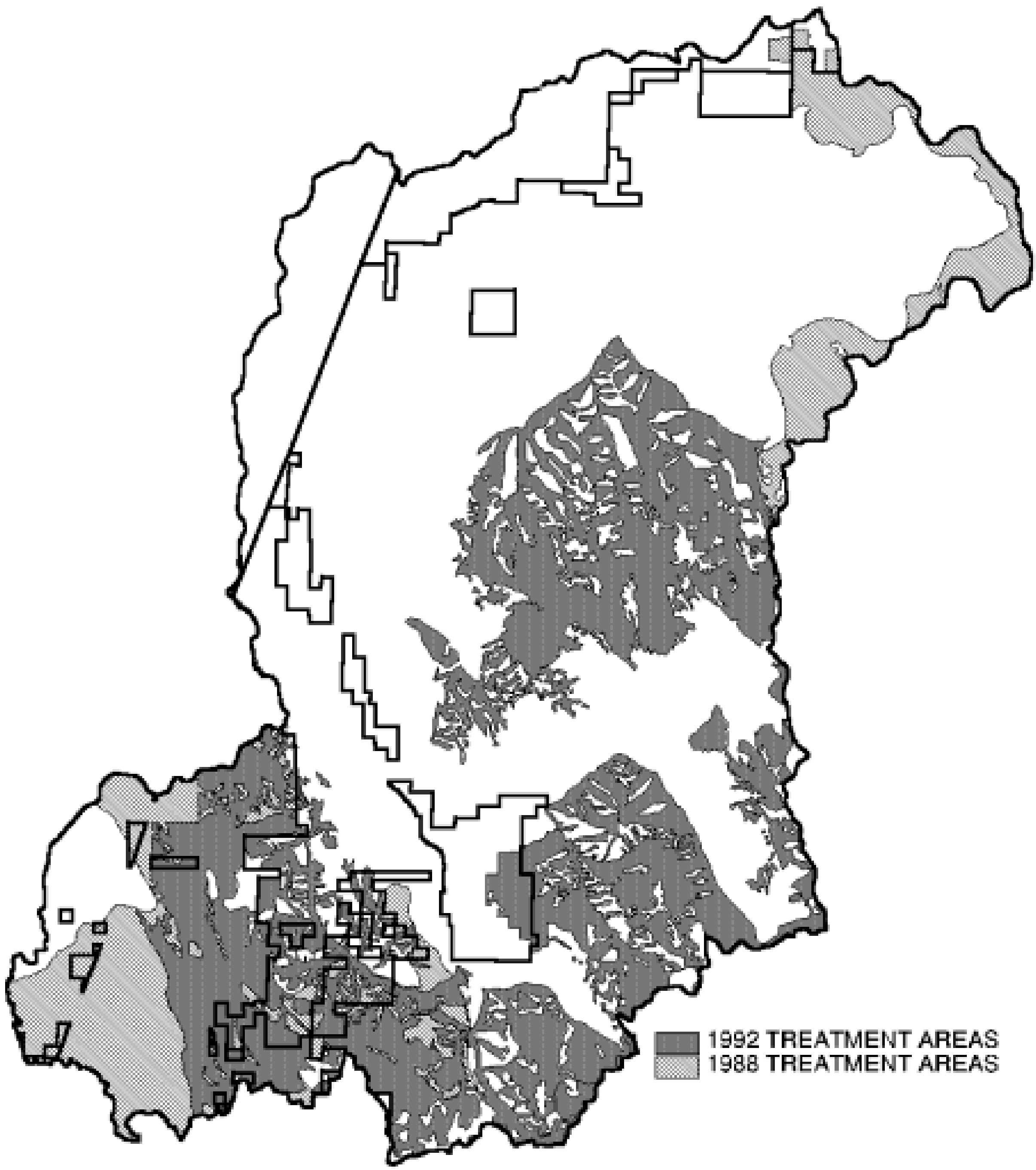


Figure 13 – Areas treated with *Bacillus thuringiensis* (B.t.) in 1988 or 1992 to control western spruce budworm. By the mid 1980s, B.t. was the insecticide of choice because of its low risk to the environment and human health. It directly affects a narrow range of organisms – only butterflies and moths 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%).

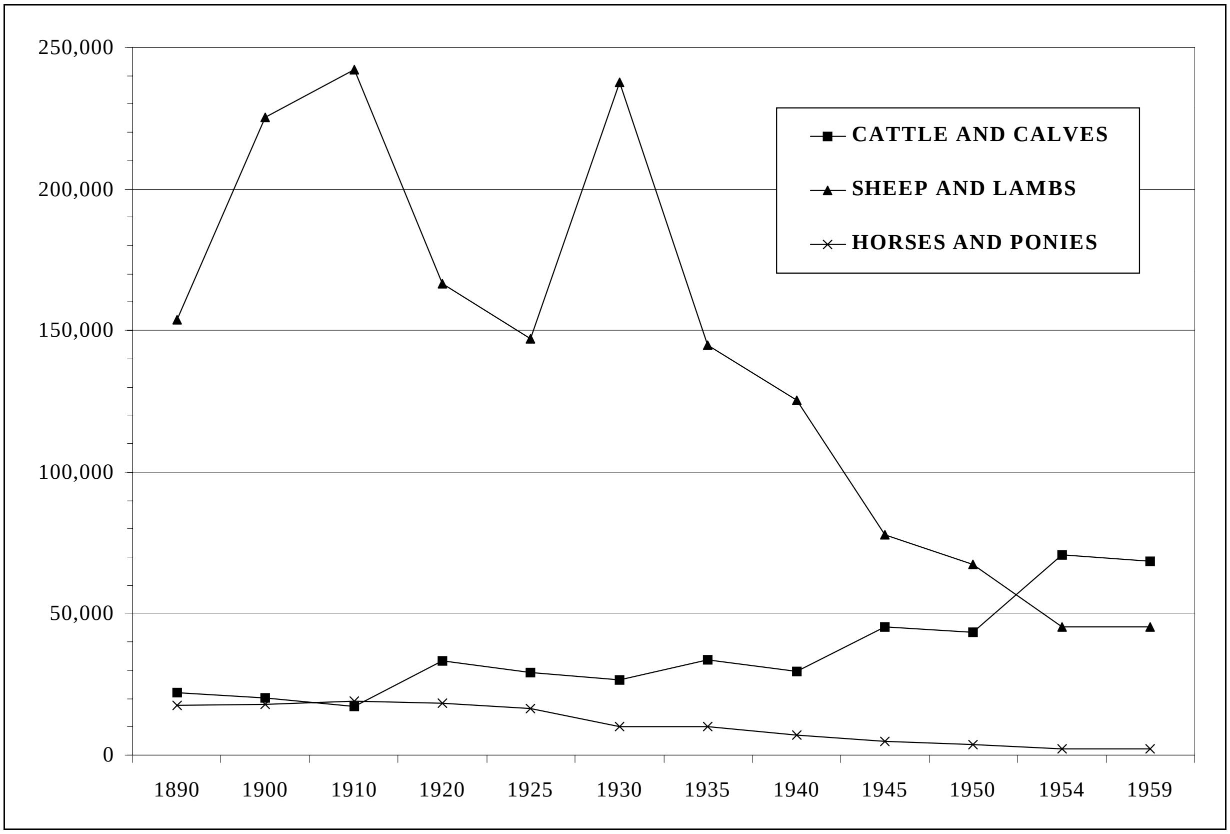


Figure 14 – Number of grazing animals for Umatilla County, Oregon (taken from Bureau of Census records).

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.

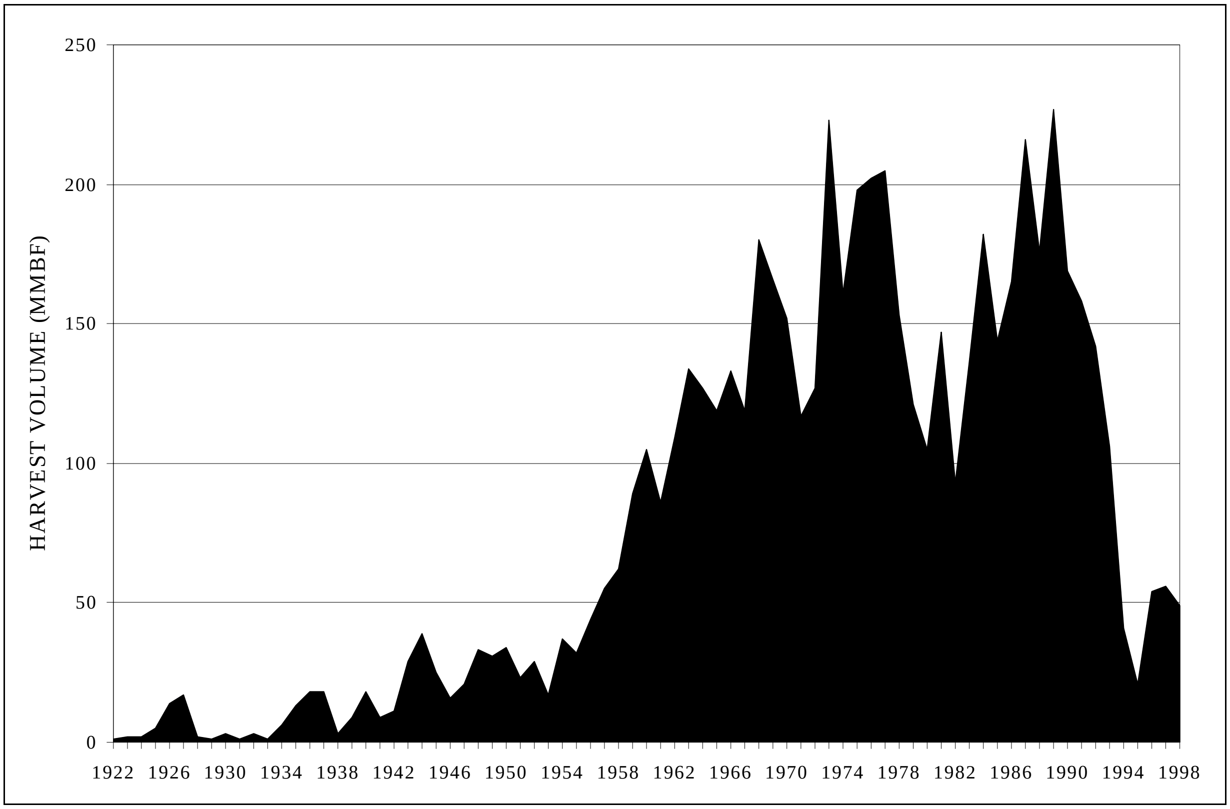


Figure 15 – Timber harvest history for the Umatilla National Forest, 1922-1998. Since 1993, timber harvest has declined dramatically on the Umatilla NF, and that trend is also true for the analysis area.

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.

		AREA (NFS Acres) BY CANOPY COVER					TOTAL	OVER-
	PAG	11-25%	26-45%	46-65%	66-75%	>75%	AREA	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 upland-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).

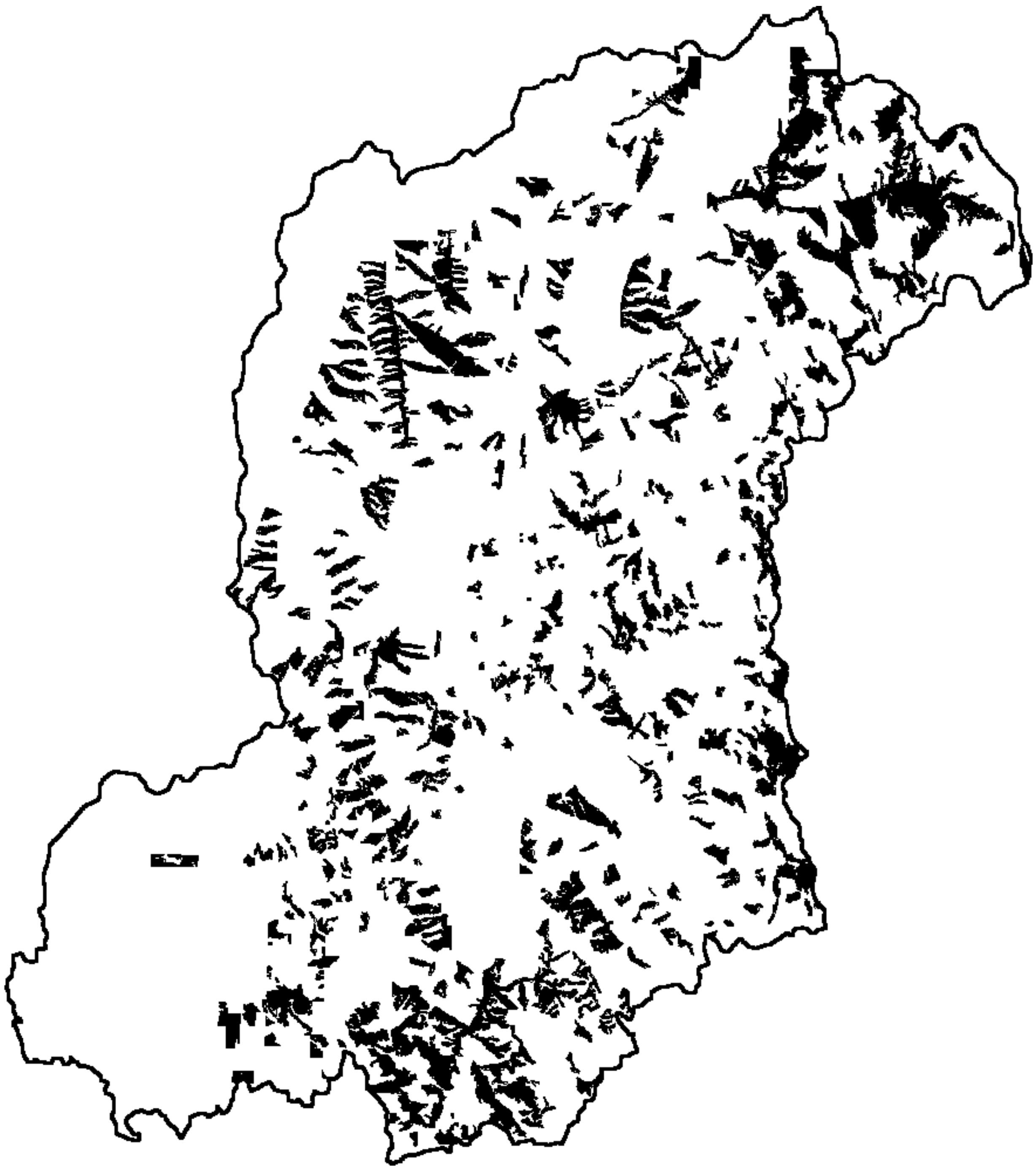


Figure 16 – Overstocked areas that apparently represent a noncommercial thinning treatment opportunity (see table 27). This map relates primarily to the "forest density" issue, but secondarily to the "inconsistent structure on dry-forest sites," and "restoration of ponderosa pine and western larch" issues. 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.).

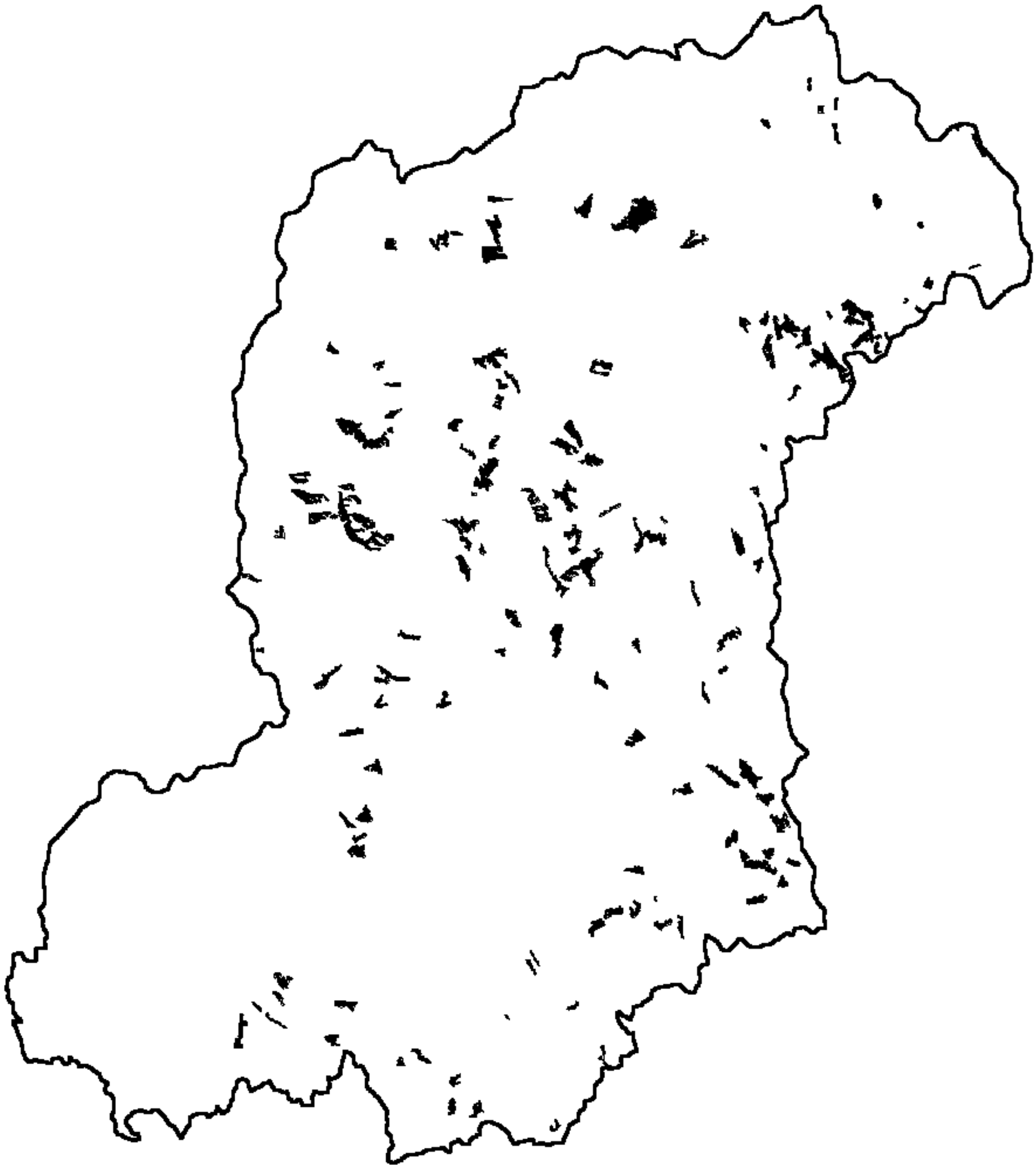


Figure 17 – Overstocked areas that apparently represent a commercial thinning treatment opportunity (see table 27). This map relates primarily to the "forest density" issue, but secondarily to the "inconsistent structure on dry-forest sites," and "restoration of ponderosa pine and western larch" issues. 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		SI	SEOC	SECC	UR	YFMS	OFMS	OFSS	NFS Acres
			UPLAND FOREST STRUCTURAL STAGES							
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.

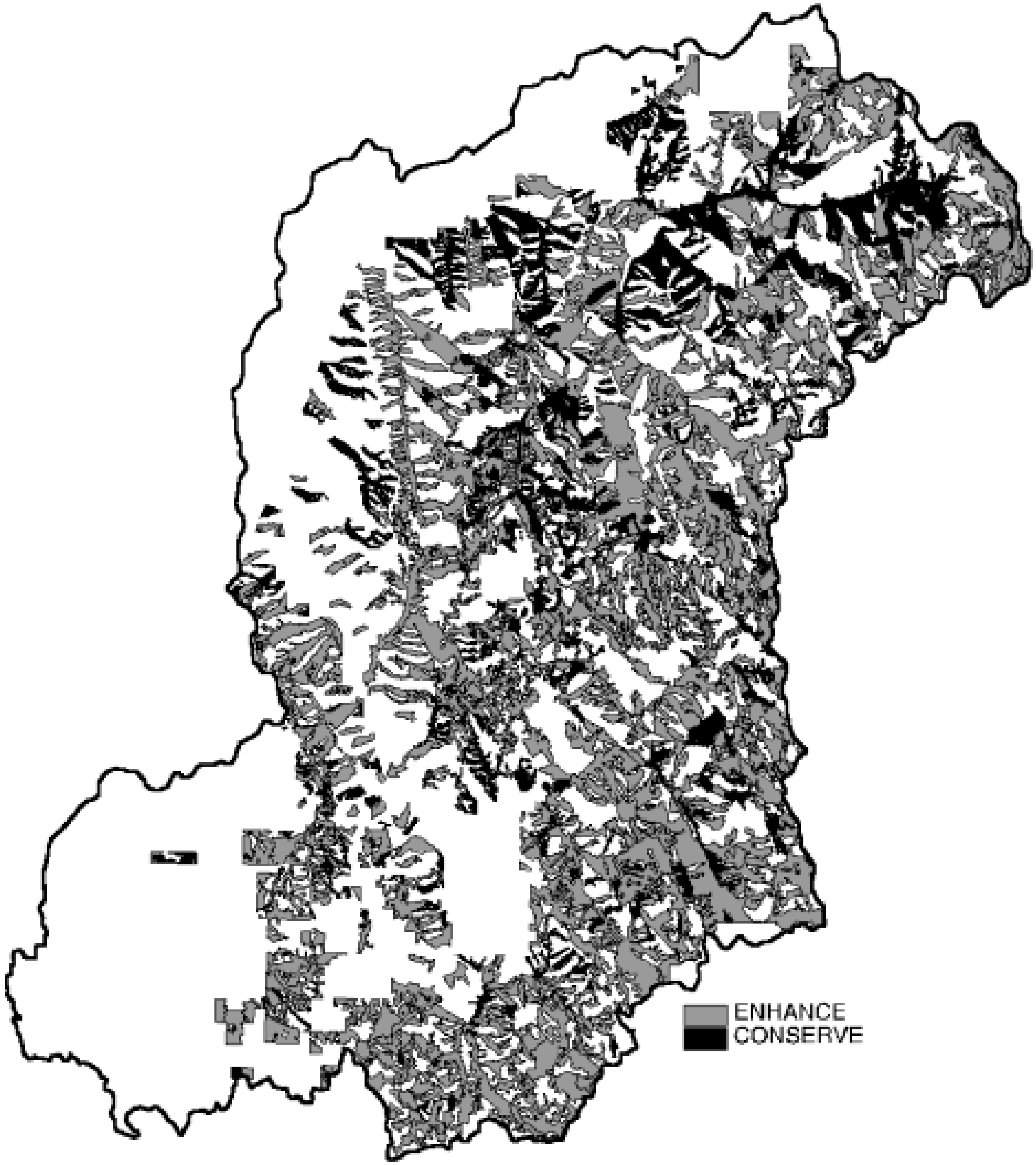


Figure 18 – Upland-forest patches that could contribute to an old forest network. The "enhance" patches are mid- to late-seral structures (the "young forest multi strata" and "understory reinitiation" stages) that could receive cultural treatments (thinnings, etc.) as a way to produce large-diameter 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.

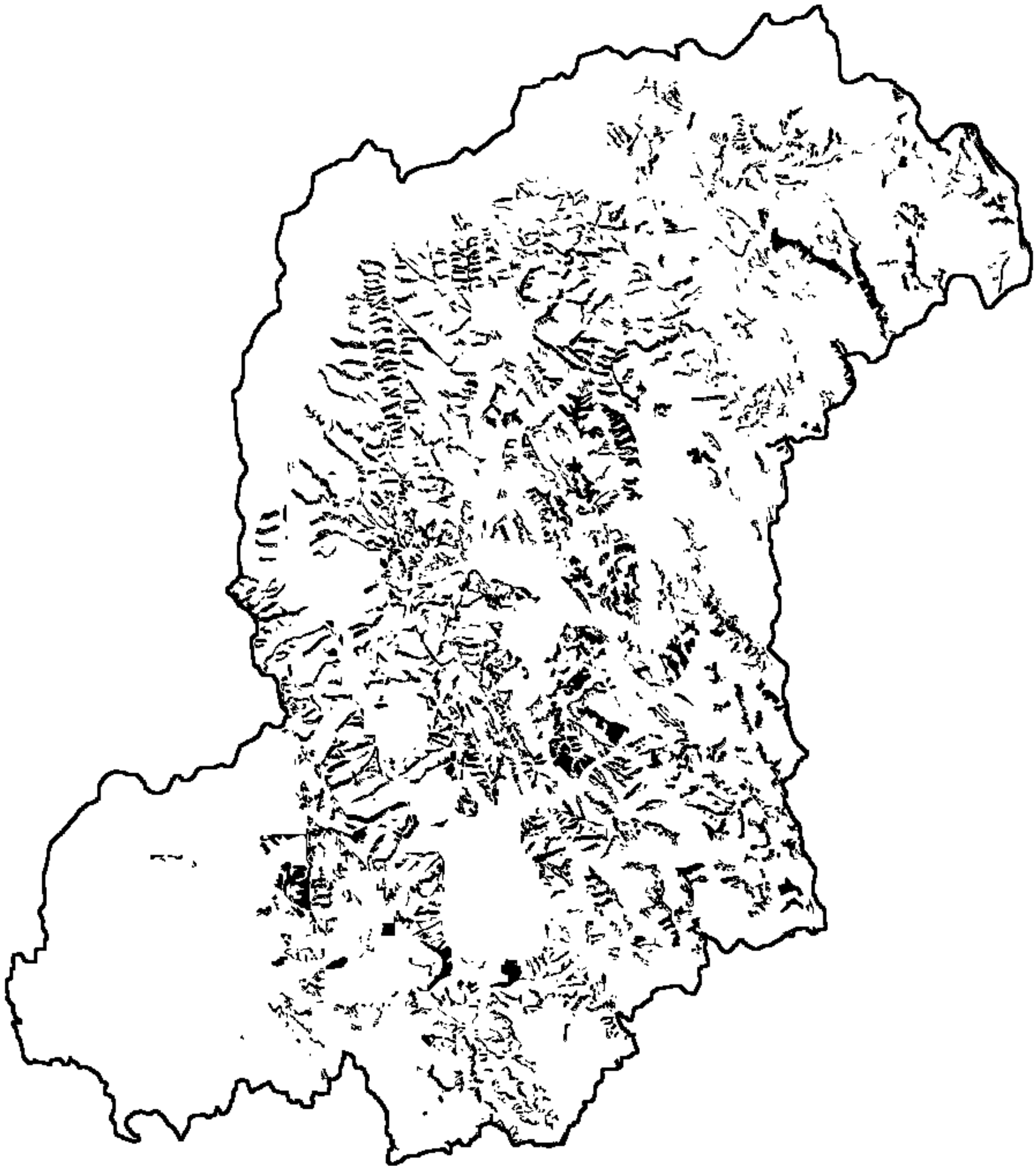


Figure 19 – Areas mapped as grassland in 1958 that were classified as a forest type in 1999. This map relates to the "grassland replaced with forest" issue. These areas apparently represent a "tree removal" treatment opportunity if the grassland loss is considered to be undesirable based on Forest Plan 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.

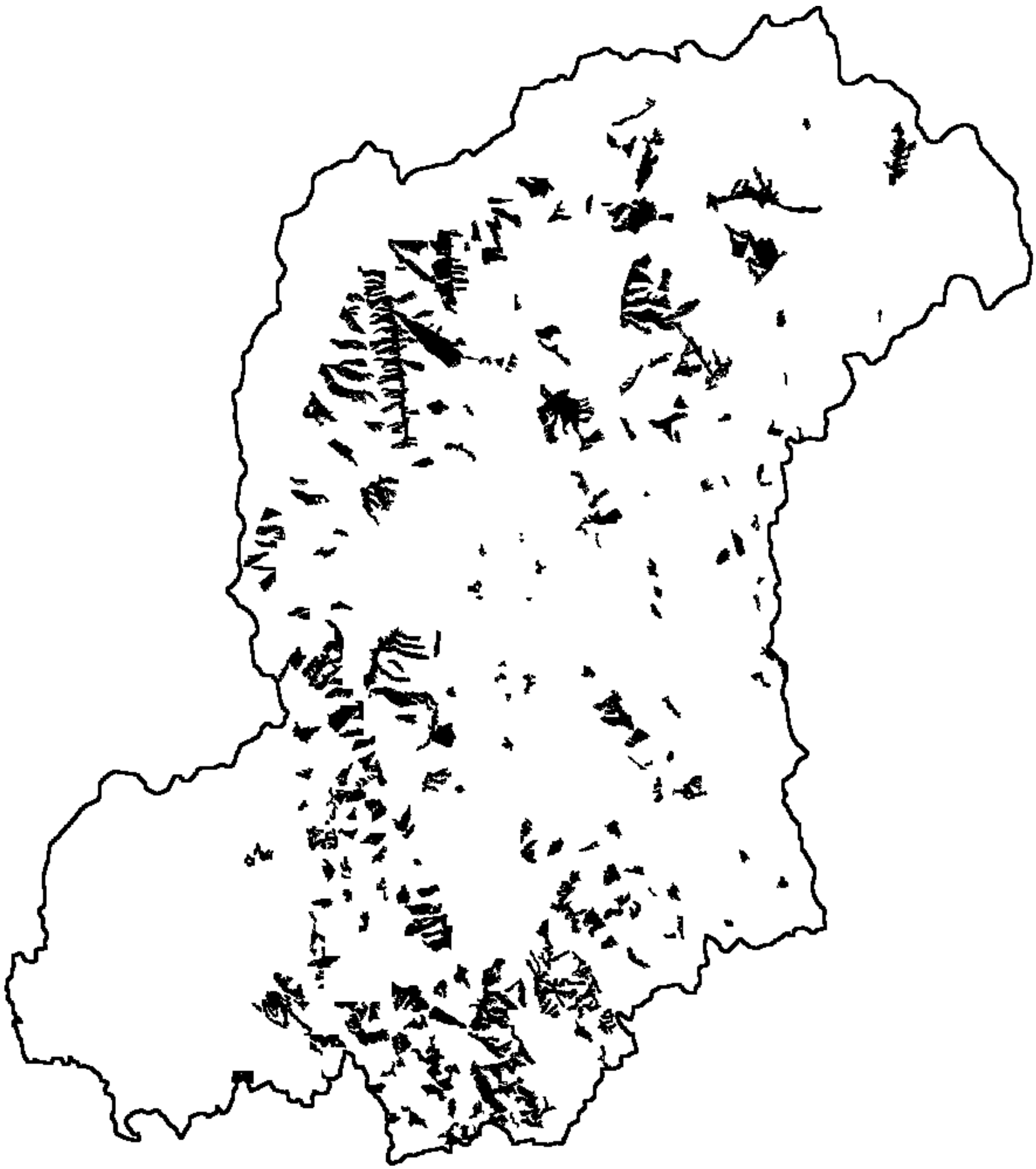


Figure 20 – Overstocked, multi-layered stands that apparently represent an understory removal treatment opportunity (see table 27). This map relates primarily to the “inconsistent structure on dry-forest sites” issue, but secondarily to the “restoration of ponderosa pine and western larch” issue. Note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

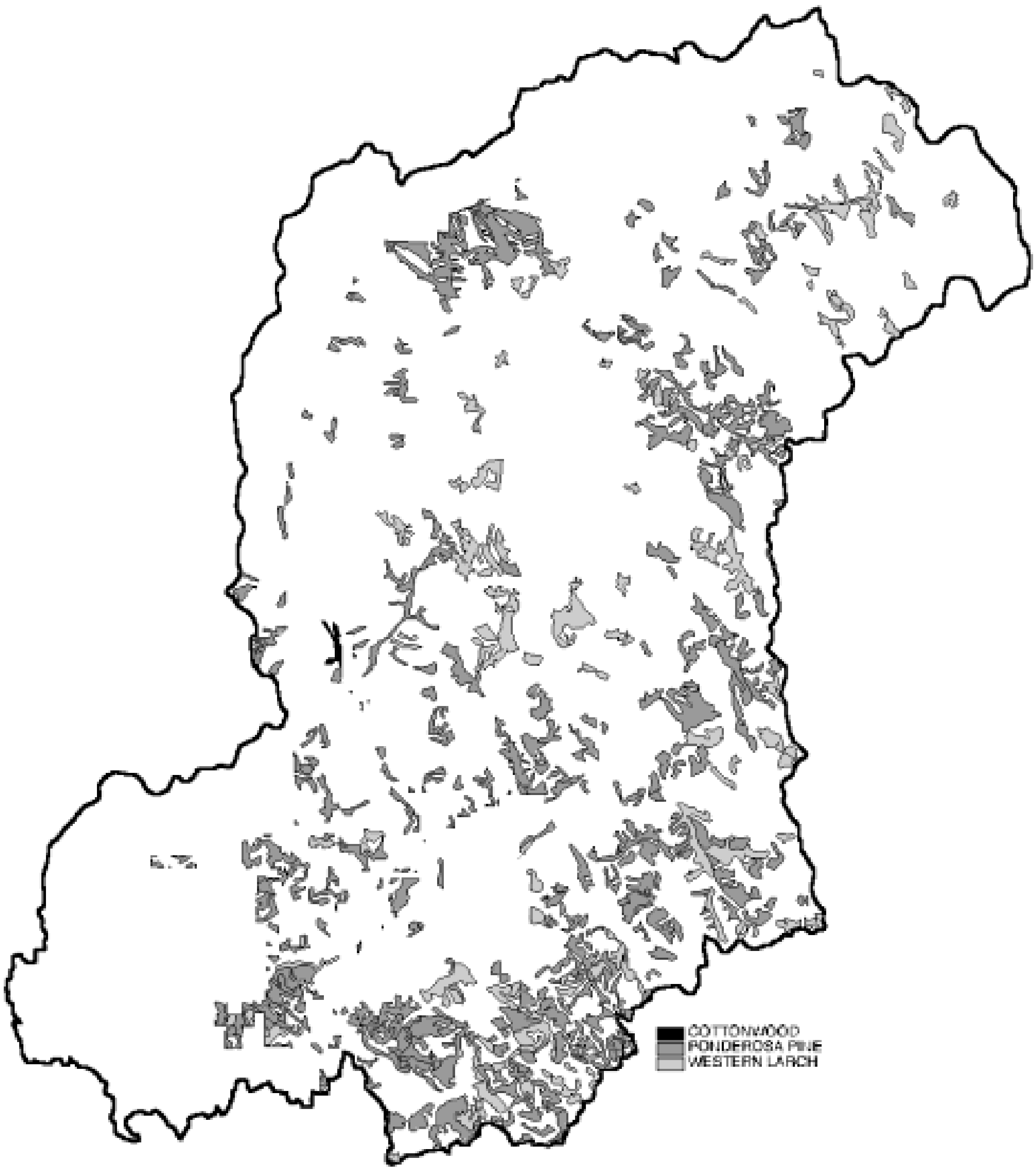


Figure 21 – Areas mapped as ponderosa pine, western larch, or black cottonwood forest cover types in 1958. This map relates primarily to the "restoration of ponderosa pine and western larch" issue, but also illustrates one aspect of the "limited vegetation components" issue (loss of cottonwood). Do these 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).

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	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
Arrowwood
Balm
Barberry
Birch
Black Pine
Brush
Buckbrush
Cascara
Chaparral
Cherry
Chinquapin
Cottonwood
Dogwood
Elder
Elk Grass

Fern
Fir
Grass
Greasewood
Hazel
Hemlock
Huckleberry
Larch
Mahogany
Maple
Mountain Laurel
Mullein
Ninebark
Pine
Pinegrass
Redberry

Red Fir
Rosebrier
Sage
Serviceberry
Snow Brush
Spruce
Sumac
Sunflower
Tamarack
Thimbleberry
Vine Maple
White Fir
White Pine
Whortleberry
Willow
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.

LITERATURE CITED

Agee, James K. 1993. Fire ecology of Pacific Northwest forests. Washington, DC: Island Press. 493 p.

Agee, James K. 1996. The influence of forest structure on fire behavior. In: Proceedings of the seventeenth annual forest vegetation management conference; 1996 January 16-18; Redding, CA: 52-68.

Ager, Alan. 1998. UPEST: insect and disease risk calculator for the Blue Mountains. Unpublished Report. Pendleton, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region, Umatilla National Forest. 21 p.

Alexander, Robert R. 1985. Major habitat types, community types, and plant communities in the Rocky Mountains. General Technical Report RM-123. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 105 p.

Allaby, Michael, editor. 1998. The concise Oxford dictionary of ecology. Second edition. New York, NY: Oxford University Press. 440 p.

Allen, E.T. 1906. Inspection report for the Wenaha Forest Reserve. Unpublished Typescript Report. [Place of Publication Unknown]: U.S. Department of Agriculture, Forest Service. 38 p. On file with: Umatilla National Forest, Supervisor's Office, 2517 SW Hailey Avenue, Pendleton, OR 97801.

Arno, Stephen F.; Harrington, Michael G.; Fiedler, Carl E.; Carlson, Clinton E. 1995. Restoring fire-dependent ponderosa pine forests in western Montana. Restoration & Management Notes. 13(1): 32-36.

Bailey, Robert G. 1996. Ecosystem geography. New York: Springer-Verlag. 204 p.

Barrett, James W. 1979. Silviculture of ponderosa pine in the Pacific Northwest: the state of our knowledge. General Technical Report PNW-97. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 106 p.

Beukema, Sarah J.; Kurz, Werner A. 1996. Vegetation dynamics development tool user's guide. Version 2.0. Vancouver, BC: ESSA Technologies, Ltd. 80 p.

Blackwood, Jeff D. 1998 [December 11]. Historical percentages for use with HRV analyses. 2430/2600 Memorandum to District Rangers. Pendleton, OR: U.S. Department of Agriculture, Forest Service, Umatilla National Forest, Supervisor's Office. 8 p.

Bright, George A. 1914. The extensive reconnaissance of the Wenaha National Forest. Unpublished Typescript Report. [Place of Publication Unknown]: U.S. Department of Agriculture, Forest Service. 84 p. On file with: Umatilla National Forest, Supervisor's Office, 2517 SW Hailey Avenue, Pendleton, OR 97801.

Brockley, R.P.; Trowbridge, R.L.; Ballard, T.M.; Macadam, A.M. 1992. Nutrient management in interior forest types. In: Chappell, H.N.; Weetman, G.F.; Miller, R.E., editors. Forest fertilization: sustaining and improving nutrition and growth of western forests. Contribution No. 73. Seattle, WA: University of Washington, College of Forest Resources: 43-64.

Brookes, Martha H.; Campbell, Robert W., editors. 1978. The Douglas-fir tussock moth: a synthesis. Technical Bulletin 1585. Washington, DC: U.S. Department of Agriculture, Forest Service, Science and Education Agency. 331 p.

Buckhorn, W.J. 1948. Defoliator situation in the fir stands of eastern Oregon and Washington. Unpublished Typescript Report. Portland, OR: U.S. Department of Agriculture, Forest Insect Laboratory. 21 p. On file with: Umatilla National Forest, Supervisor's Office, 2517 SW Hailey Avenue, Pendleton, OR 97801.

Camp, Ann; Oliver, Chad; Hessburg, Paul; Everett, Richard. 1997. Predicting late-successional fire refugia pre-dating European settlement in the Wenatchee Mountains. Forest Ecology and Management. 95: 63-77.

Carlson, Clinton E.; Fellin, David G.; Schmidt, Wyman C. 1983. The western spruce budworm in northern Rocky Mountain forests: a review of ecology, insecticidal treatments and silvicultural practices. In: O'Loughlin, J.; Pfister, R.D., eds. Management of second-growth forests: the state of knowledge and research needs. Symposium proceedings; 1982 May 14; Missoula, MT. Missoula, MT: Montana Forest and Conservation Experiment Station, School of Forestry, Univ. of Montana: 76-103.

Carlson, Clinton E.; Wulf, N. William. 1989. Silvicultural strategies to reduce stand and forest susceptibility to the western spruce budworm. Agriculture Handbook No. 676. Washington, DC: U.S. Department of Agriculture, Forest Service, Cooperative State Research Service. 31 p.

Carolin, V.M.; Coulter, W.K. 1971. Trends of western spruce budworm and associated insects in Pacific Northwest forests sprayed with DDT. Journal of Economic Entomology. 64(1): 291-297.

Case, Richard L.; Kauffman, J. Boone. 1997. Wild ungulate influences on the recovery of willows, black cottonwood and thin-leaf alder following cessation of cattle grazing in northeastern Oregon. Northwest Science. 71(2): 115-126.

Cissel, J.H.; Swanson, F.J.; McKee, W.A.; Burditt, A.L. 1994. Using the past to plan the future in the Pacific Northwest. Journal of Forestry. 92(8): 30-31, 46.

Cochran, P.H.; Barrett, James W. 1993. Long-term response of planted ponderosa pine to thinning in Oregon's Blue Mountains. Western Journal of Applied Forestry. 8(4): 126-132.

Cochran, P.H.; Barrett, James W. 1995. Growth and mortality of ponderosa pine poles thinned to various densities in the Blue Mountains of Oregon. Research Paper PNW-RP-483. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 27 p.

Cochran, P.H.; Dahms, Walter G. 1998. Lodgepole pine development after early spacing in the Blue Mountains of Oregon. Research Paper PNW-RP-503. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 24 p.

Cochran, P.H.; Geist, J.M.; Clemens, D.L. [and others]. 1994. Suggested stocking levels for forest stands in northeastern Oregon and southeastern Washington. Research Note PNW-RN-513. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 21 p.

Cochran, P.H.; Hopkins, W.E. 1991. Does fire exclusion increase productivity of ponderosa pine? In: Harvey, Alan E.; Neuenschwander, Leon F., compilers. Proceedings – management and productivity of western-montane forest soils. Symposium proceedings; 1990 April 10-12; Boise, ID. General Technical Report INT-280. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station: 224-228.

Cook, James E. 1996. Implications of modern successional theory for habitat typing: a review. Forest Science. 42(1): 67-75.

Cooper, Charles F. 1961. The ecology of fire. Scientific American. 204: 150–158.

Coville, Frederick V. 1898. Forest growth and sheep grazing in the Cascade Mountains of Oregon. Bulletin No. 15. Washington, DC: U.S. Department of Agriculture, Division of Forestry. 54 p.

Cryder, W.W. 1915. Annual planting report, Umatilla National Forest. Typescript Memorandum. Heppner, OR: U.S. Department of Agriculture, Forest Service, Umatilla National Forest. 2 p. On file with: Umatilla National Forest, Supervisor's Office, 2517 SW Hailey Avenue, Pendleton, OR 97801.

Daniel, Theodore W.; Helms, John A.; Baker, Frederick S. 1979. Principles of silviculture. Second edition. New York, NY: McGraw-Hill Book Company. 500 p.

Daubenmire, R. 1961. Vegetative indicators of rate of height growth in ponderosa pine. Forest Science. 7(1): 24-34.

Daubenmire, Rexford. 1968. Plant communities, a textbook of plant synecology. New York: Harper and Row. 300 p.

Dealy, J. Edward. 1985. Tree basal area as an index of thermal cover for elk. Research Note PNW-425. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 6 p.

DeByle, Norbert V. 1985. Wildlife. In: DeByle, Norbert V.; Winokur, Robert P., editors. Aspen: ecology and management in the western United States. General Technical Report RM-119. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 135-152.

Delong, S. Craig; Tanner, David. 1996. Managing the pattern of forest harvest: lessons from wildfire. Biodiversity and Conservation. 5: 1191-1205.

Dodson, Stanley I.; Allen, Timothy F.H.; Carpenter, Stephen R. [and others]. 1998. Ecology. New York: Oxford University Press. 433 p.

Dolph, R.E., Jr. 1980. Budworm activity in Oregon and Washington, 1947-1979. Publication R6-FIDM-033-1980. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region, State and Private Forestry, Forest Pest Management. 54 p.

Dunster, Julian; Dunster, Katherine. 1996. Dictionary of natural resource management. Vancouver, BC: UBC Press. 363 p.

Eaton, C.B.; Beal, J.A.; Furniss, R.L.; Speers, C.F. 1949. Airplane and helicopter spraying with DDT for spruce budworm control. Journal of Forestry. 47: 823-827.

Evans, John W. 1990. Powerful rockey: the Blue Mountains and the Oregon Trail, 1811-1883. Enterprise, OR: Eastern Oregon State College, Pika Press. 374 p.

Evans, R.M. 1912. General silvical report; Wallowa and Minam Forests. Unpublished Typescript Report. [Place of Publication Unknown]: U.S. Department of Agriculture, Forest Service. 54 p. On file with: Umatilla National Forest, Supervisor’s Office, 2517 SW Hailey Avenue, Pendleton, OR 97801.

Everett, R.; Hessburg, P.; Lehmkuhl, J. [and others]. 1994. Old forests in dynamic landscapes: dry-site forests of eastern Oregon and Washington. Journal of Forestry. 92(1): 22-25.

Eyre, F.H., editor. 1980. Forest cover types of the United States and Canada. Washington, DC: Society of American Foresters. 148 p.

Fellin, David G. 1983. Chemical insecticide vs. the western spruce budworm: after three decades, what’s the score? Western Wildlands. 9(1): 8-12.

Ferguson, Dennis E. 1991. Allelopathic potential of western coneflower *(Rudbeckia occidentalis)*. Canadian Journal of Botany. 69: 2806-2808.

Ferguson, Dennis E.; Boyd, Raymond J. 1988. Bracken fern inhibition of conifer regeneration in northern Idaho. Research Paper INT-388. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 11 p.

Forman, Richard T.T.; Russell, Emily W.B. 1983. Evaluation of historical data in ecology. Bulletin of the Ecological Society of America. 64: 5-7.

Foster, H.D. 1906. Report on the silvics of the Wenaha Forest Reserve, Washington and Oregon. Unpublished Typescript Report. [Place of Publication Unknown]: U.S. Department of Agriculture, Forest Service. 39 p. On file with: Umatilla National Forest, Supervisor’s Office, 2517 SW Hailey Avenue, Pendleton, OR 97801.

Foster, H.D. 1907. Report on the silvics of the Blue Mountains (E) National Forest, Oregon. Unpublished Typescript Report for July-September. [Place of Publication Unknown]: U.S. Department of Agriculture, Forest Service. 1 p. On file with: Umatilla National Forest, Supervisor's Office, 2517 SW Hailey Avenue, Pendleton, OR 97801.

Fremont, John C. 1988. The exploring expedition to the Rocky Mountains. Washington, DC: Smithsonian Institution Press. 319 p.

Gannett, Henry. 1902. The forests of Oregon. Professional Paper No. 4, Series H, Forestry, No. 1. Washington, DC: U.S. Department of Interior, Geological Survey. 36 p (and map).

Gardner-Outlaw, Tom; Engelman, Robert. 1999. Forest futures: population, consumption and wood resources. Washington, DC: Population Action International. 68 p.

Gast, William R., Jr.; Scott, Donald W.; Schmitt, Craig [and others]. 1991. Blue Mountains forest health report: "new perspectives in forest health." Portland, OR: US Department of Agriculture, Forest Service, Pacific Northwest Region, Malheur, Umatilla, and Wallowa-Whitman National Forests.

Gedney, Donald R. 1963. Toward complete use of eastern Oregon's forest resources. Resource Bulletin PNW-3. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 71 p.

Graham, David A.; Mounts, Jack; Almas, Dewey. 1975. 1974 cooperative Douglas-fir tussock moth control project; Oregon, Washington, Idaho. Unnumbered Report. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 74 p.

Gruell, George E. 1980. Fire's influence on wildlife habitat on the Bridger-Teton National Forest, Wyoming. Research Paper INT-235. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 207 p.

Gruell, George E. 1983. Fire and vegetative trends in the northern Rockies: interpretations from 1871-1982 photographs. General Technical Report INT-158. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 117 p.

Gruell, George E. 1985. Fire on the early western landscape: an annotated record of wildland fires 1776-1900. Northwest Science. 59(2): 97-107.

Gruell, George E.; Schmidt, Wyman C.; Arno, Stephen F.; Reich, William J. 1982. Seventy years of vegetative change in a managed ponderosa pine forest in western Montana – implications for resource management. General Technical Report INT-130. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 42 p.

Haig, Irvine T.; Davis, Kenneth P.; Weidman, Robert H. 1941. Natural regeneration in the western white pine type. Technical Bulletin No. 767. Washington, DC: U.S. Department of Agriculture. 98 p.

Hall, Frederick C. 1973. Plant communities of the Blue Mountains in eastern Oregon and southeastern Washington. R6 Area Guide 3-1. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 62 p.

Hall, Frederick C. 1976. Fire and vegetation in the Blue Mountains – implications for land managers. In: Proceedings of the annual Tall Timbers fire ecology conference No. 15; 1974 October 16-17; Portland, OR. Tallahassee, FL: Tall Timbers Research Station: 155-170.

Hall, Frederick C. 1993. Structural stages by plant association group: Malheur and Ochoco National Forests. Unpublished Report. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 5 p.

Hall, Frederick C. 1998. Pacific Northwest Ecoclass codes for seral and potential natural communities. General Technical Report PNW-GTR-418. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 290 p.

Hall, Frederick C.; Bryant, Larry; Clausnitzer, Rod [and others]. 1995. Definitions and codes for seral status and structure of vegetation. General Technical Report PNW-GTR-363. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 39 p.

Hansen, A.J.; Spies, T.A.; Swanson, F.J.; Ohmann, J.L. 1991. Conserving biodiversity in managed forests: lessons from natural forests. BioScience. 41(6): 382-392.

Harley, F.W. 1918. Letter from District Ranger to Forest Supervisor; subject: Klamath – fires. Orleans, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Region, Klamath National Forest. 3 p.

Harlow, William M.; Harrar, Ellwood S.; Hardin, James W.; White, Fred M. 1996. Textbook of dendrology. Eighth edition. New York: McGraw-Hill. 534 p.

Harvey, Alan E. 1994. Integrated roles for insects, diseases and decomposers in fire dominated forests of the inland western United States: past, present and future forest health. Journal of Sustainable Forestry. 2(1/2): 211-220.

Haufler, Jonathan B. 1994. An ecological framework for planning for forest health. Journal of Sustainable Forestry. 2(1/2): 307-316.

Hedrick, D.W.; Young, J.A.; McArthur, J.A.B.; Keniston, R.F. 1968. Effects of forest and grazing practices on mixed coniferous forests of northeastern Oregon. Technical Bulletin 103. Corvallis, OR: Oregon State University, Agricultural Experiment Station. 24 p.

Helms, John A., editor. 1998. The dictionary of forestry. Bethesda, MD: The Society of American Foresters. 210 p.

Hessburg, Paul F.; Mitchell, Russel G.; Filip, Gregory M. 1994. Historical and current roles of insects and pathogens in eastern Oregon and Washington forested landscapes. General Technical Report PNW-GTR-327. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 72 p.

Hessburg, Paul F.; Smith, Bradley G; Salter, R. Brion. 1999. Using estimates of natural variation to detect ecologically important change in forest spatial patterns: a case study, Cascade Range, eastern Washington. Research Paper PNW-RP-514. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 65 p.

Hunter, Malcolm L., Jr. 1990. Wildlife, forests, and forestry: principles of managing forests for biological diversity. Englewood Cliffs, New Jersey: Regents/Prentice Hall. 370 p.

Irwin, Larry L.; Cook, John G.; Riggs, Robert A.; Skovlin, Jon M. 1994. Effects of long-term grazing by big game and livestock in the Blue Mountains forest ecosystems. General Technical Report PNW-GTR-325. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 49 p.

Johnson, Charles G. 1993. Ecosystem screens. File designation 2060 memorandum. Baker City, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region, Wallowa-Whitman National Forest. 4 p (and exhibits).

Johnson, Charles Grier, Jr.; Clausnitzer, Rodrick R. 1992. Plant associations of the Blue and Ochoco Mountains. Publication R6-ERW-TP-036-92. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region, Wallowa-Whitman National Forest. 164 p.

Johnson, Charles G., Jr.; Clausnitzer, Roderick R.; Mehringer, Peter J.; Oliver, Chadwick D. 1994. Biotic and abiotic processes of eastside ecosystems: the effects of management on plant and community ecology, and on stand and landscape vegetation dynamics. General Technical Report PNW-GTR-322. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 66 p.

Johnson, Charles G., Jr.; Simon, Steven A. 1987. Plant associations of the Wallowa-Snake Province. Publication R-6 ECOL-TP-225B-86. Baker, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region, Wallowa-Whitman National Forest. 272 p (plus appendices).

Johnston, Verna R. 1970. The ecology of fire. Audubon. 72: 76-119.

Kaufmann, Merrill R.; Graham, Russell T., Boyce, Douglas A., Jr. [and others]. 1994. An ecological basis for ecosystem management. General Technical Report RM-246. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 22 p.

Kay, Charles E. 1994. Aboriginal overkill: the role of Native Americans in structuring western ecosystems. Human Nature. 5(4): 359-398.

Keane, Robert E.; Arno, Stephen F.; Brown, James K. 1989. FIRESUM – an ecological process model for fire succession in western conifer forests. General Technical Report INT-266. Ogden, UT: U.S. Dept. of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 76 p.

Keen, F.P. 1937. Climatic cycles in eastern Oregon as indicated by tree rings. Monthly Weather Review. 65(5): 175-188.

Kent, W.H.B. 1904. The proposed Wenaha Forest Reserve, Washington and Oregon: examination and report. Unpublished Typescript Report. [Place of Publication Unknown]: U.S. Department of Agriculture, Bureau of Forestry. 22 p. On file with: Umatilla National Forest, Supervisor's Office, 2517 SW Hailey Avenue, Pendleton, OR 97801.

Kimmins, J.P. 1997. Forest ecology; a foundation for sustainable management. Second edition. Upper Saddle River, NJ: Prentice Hall. 596 p.

Lanner, Ronald M. 1984. Trees of the Great Basin: a natural history. Reno, NV: University of Nevada Press. 215 p.

Lehmkuhl, John F.; Hessburg, Paul F.; Everett, Richard L. [and others]. 1994. Historical and current forest landscapes of eastern Oregon and Washington. Part 1: Vegetation pattern and insect and disease hazards. General Technical Report PNW-GTR-328. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 88 p.

Leopold, Aldo. 1933. Game management. New York: Charles Scribner's Sons.

Long, James N.; Dean, Thomas J. 1986. Sapwood area of *Pinus contorta* stands as a function of mean size and density. Oecologia. 68: 410-412.

Mandzak, John M.; Moore, James A. 1994. The role of nutrition in the health of inland western forests. Journal of Sustainable Forestry. 2(1/2): 191-210.

McLean, Herbert E. 1992. The Blue Mountains: forest out of control. American Forests. 98(9/10): 32, 34-35, 58, 61.

Millar, Constance I. 1997. Comments on historical variation & desired condition as tools for terrestrial landscape analysis. In: Proceedings of the sixth biennial watershed management conference. Water Resources Center Report No. 92. Davis, CA: University of California: 105-131.

Minore, Don. 1979. Comparative autecological characteristics of northwestern tree species – a literature review. General Technical Report PNW-87. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 72 p.

Monleon, Vicente J.; Cromack, Kermit, Jr.; Landsberg, Johanna D. 1997. Short- and long-term effects of prescribed underburning on nitrogen availability in ponderosa pine stands in central Oregon. Canadian Journal of Forest Research. 27: 369-378.

Morgan, Penelope; Aplet, Gregory H.; Haufler, Jonathan B. [and others]. 1994. Historical range of variability: a useful tool for evaluating ecosystem change. Journal of Sustainable Forestry. 2(1/2): 87-

111.

Munger, Thornton T. 1917. Western yellow pine in Oregon. Bulletin No. 418. Washington, DC: U.S. Department of Agriculture. 48 p.

Noss, Reed F.; Cooperrider, Allen Y. 1994. Saving nature's legacy: protecting and restoring biodiversity. Washington, DC: Island Press. 416 p.

Nyland, Ralph D. 1996. Silviculture: concepts and applications. New York: McGraw-Hill Companies, Inc. 633 p.

O'Hara, Kevin L.; Latham, Penelope A.; Hessburg, Paul; Smith, Bradley G. 1996. A structural classification for Inland Northwest forest vegetation. Western Journal of Applied Forestry. 11(3): 97-102.

O'Laughlin, Jay; Maynard, Bob; Fitzgerald, Steve [and others]. 1998. Seven suggestions for revising ICBEMP. Journal of Forestry. 96(10): 42-46.

Oliver, Chadwick Dearing. 1981. Forest development in North America following major disturbances. Forest Ecology and Management. 3: 153-168.

Oliver, Chadwick D.; Irwin, Larry L.; Knapp, Walter H. 1994. Eastside forest management practices: historical overview, extent of their applications, and their effects on sustainability of ecosystems. General Technical Report PNW-GTR-324. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 73 p.

Oliver, Chadwick, D.; Larson, Bruce C. 1996. Forest stand dynamics. Update edition. New York, NY: John Wiley & Sons, Inc. 520 p.

Patterson, J.E. 1929. The pandora moth, a periodic pest of western pine forests. Technical Bulletin No. 137. Washington, DC: U.S. Department of Agriculture. 19 p.

Peterson, E.B.; Peterson, N.M.; McLennan, D.S. 1996. Black cottonwood and balsam poplar managers' handbook for British Columbia. FRDA Report 250. Victoria, BC: B.C. Ministry of Forests, Research Branch. 116 p.

Pfister, Robert D.; Arno, Stephen F. 1980. Classifying forest habitat types based on potential climax vegetation. Forest Science. 26(1): 52-70.

Pitman, Gary B.; Perry, David A.; Emmingham, William H. 1982. Thinning to prevent mountain pine beetles in lodgepole and ponderosa pine. Extension Circular 1106. Corvallis, OR: Oregon State University, Extension Service. 4 p.

Plummer, Fred G. 1912. Lightning in relation to forest fires. Bulletin No. 111. Washington, DC: U.S. Department of Agriculture, Forest Service. 39 p.

Powell, David C. 1994. Effects of the 1980s western spruce budworm outbreak on the Malheur National Forest in northeastern Oregon. Technical Publication R6-FI&D-TP-12-94. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 176 p.

Powell, David C. 1998. Potential natural vegetation of the Umatilla National Forest. Unnumbered Report. Pendleton, OR: U.S. Department of Agriculture, Forest Service, Umatilla National Forest. 31 p.

Powell, David C. 1999. Suggested stocking levels for forest stands in northeastern Oregon and southeastern Washington: an implementation guide for the Umatilla National Forest. Technical Publication F14-SO-TP-03-99. Pendleton, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region, Umatilla National Forest. 300 p.

Pyne, Stephen J. 1982. Fire in America: a cultural history of wildland and rural fire. Princeton, NJ: Princeton University Press. 654 p.

Quigley, Thomas M.; Arbelbide, Sylvia J., technical editors. 1997. An assessment of ecosystem components in the interior Columbia Basin and portions of the Klamath and Great Basins: volume 2. General Technical Report PNW-GTR-405. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 4 volumes: 337-1055.

Reaves, Jimmy L.; Shaw, Charles G., III; Martin, Robert E.; Mayfield, John E. 1984. Effects of ash leachates on growth and development of *Armillaria mellea* in culture. Research Note PNW-418. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 11 p.

Reaves, Jimmy L.; Shaw, Charles G., III; Mayfield, John E. 1990. The effects of *Trichoderma* spp. isolated from burned and non-burned forest soils on the growth and development of *Armillaria ostoyae* in culture. Northwest Science. 64(1): 39-44.

Regional Ecosystem Office. 1995. Ecosystem analysis at the watershed scale. Version 2.2. Portland, OR: Regional Ecosystem Office. 26 p.

Robbins, William G. 1997. Landscapes of promise: the Oregon story, 1800-1940. Seattle, WA: University of Washington Press. 392 p.

Rose, Robin; Chachulski, Caryn E.C.; Haase, Diane L. 1998. Propagation of Pacific Northwest native plants. Corvallis, OR: Oregon State University Press. 248 p.

Rowe, J. Stan. 1992. The ecosystem approach to forestland management. Forestry Chronicle. 68(1): 222-224.

Safranyik, Les; Nevill, Ralph; Morrison, Duncan. 1998. Effects of stand density management on forest insects and diseases. Technology Transfer Note No. 12. Victoria, BC: Natural Resources Canada, Canadian Forest Service, Pacific Forestry Center. 4 p.

Sampson, R. Neil; Adams, David L.; Hamilton, Stanley S. [and others]. 1994. Assessing forest ecosystem health in the Inland West. Journal of Sustainable Forestry. 2(1/2): 3-10.

Sankela, W.E.; Lynch, D.L. 1936. Legend and type definitions; forest type map for Umatilla and Union Counties, Oregon. Unnumbered Published Map. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest Experiment Station, Forest Survey Unit. 5 p.

Schier, George A.; Jones, John R.; Winokur, Robert P. 1985. Vegetative regeneration. In: DeByle, Norbert V.; Winokur, Robert P., editors. Aspen: ecology and management in the western United States. General Technical Report RM-119. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 29-33.

Schmitz, J.M. 1906. Report on an examination of the proposed addition to Wenaha Forest Reserve, Oregon. Unpublished Typescript Report. [Place of Publication Unknown]: U.S. Department of Agriculture, Forest Service. 9 p. On file with: Umatilla National Forest, Supervisor’s Office, 2517 SW Hailey Avenue, Pendleton, OR 97801.

Scott, Joe H. 1998. Fuel reduction in residential and scenic forests: a comparison of three treatments in a western Montana ponderosa pine stand. Research Paper RMRS-RP-5. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 19 p.

Seidel, K.W. 1987. Results after 20 years from a western larch levels-of-growing-stock study. Research Paper PNW-RP-387. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 18 p.

Seidel, K.W.; Cochran, P.H. 1981. Silviculture of mixed conifer forests in eastern Oregon and Washington. General Technical Report PNW-121. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 70 p.

Sheehan, Katharine A. 1996. Defoliation by western spruce budworm in Oregon and Washington from

1980 through 1994. Technical Publication R6-NR-TP-04-96. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 9 p (plus appendices).

Shindler, Bruce; Reed, Michelle. 1996. Forest management in the Blue Mountains: public perspectives on prescribed fire and mechanical thinning. Corvallis, OR: Oregon State University, Department of Forest Resources. 58 p.

Smith, Kan; Weitknecht, Robert H. 1915. Windfall damage on cut-over areas, Whitman National Forest. Unpublished Typescript Report. [Place of publication unknown]: [U.S. Department of Agriculture, Forest Service]. 85 p. On file with: Umatilla National Forest, Supervisor's Office, 2517 SW Hailey Avenue, Pendleton, OR 97801.

Stage, Albert R.; Hatch, Charles R.; Rice, Thomas M. [and others]. 1995. Calibrating a forest succession model with a single-tree growth model: an exercise in meta–modelling. In: Skovsgaard, J.P.; Burkhart, H.E., editors. Recent advances in forest mensuration and growth and yield research. Symposium proceedings; 1995 August 6-12; Tampere, Finland. Danish Forest and Landscape Research Institute: 194-209.

Starker, T.J. 1915. Recommendations for cutting inferior species on the Whitman National Forest, Oregon. Annual Silvical Report. Sumpter, OR: U.S. Department of Agriculture, Forest Service, Whitman National Forest. 10 p. On file with: Umatilla National Forest, Supervisor's Office, 2517 SW Hailey Avenue, Pendleton, OR 97801.

Starker, T.J. 1916. Instructions for marking timber in the western yellow pine region, Pacific Northwest District. Annual Technical Report. Sumpter, OR: U.S. Department of Agriculture, Forest Service, Whitman National Forest. 11 p. On file with: Umatilla National Forest, Supervisor's Office, 2517 SW Hailey Avenue, Pendleton, OR 97801.

Steele, Robert; Geier-Hayes, Kathleen. 1995. Major Douglas-fir habitat types of central Idaho: a summary of succession and management. General Technical Report INT-GTR-331. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 23 p.

Swezy, D. Michael; Agee, James K. 1991. Prescribed-fire effects on fine-root and tree mortality in old-growth ponderosa pine. Canadian Journal of Forest Research. 21: 626-634.

Taylor, Alan H.; Skinner, Carl N. 1998. Fire history and landscape dynamics in a late-successional reserve, Klamath Mountains, California, USA. Forest Ecology and Management. 111: 285-301.

Thomas, Jack Ward, technical editor. 1979. Wildlife habitats in managed forests: the Blue Mountains or Oregon and Washington. Agriculture Handbook No. 553. Washington, DC: U.S. Department of Agriculture, Forest Service. 512 p.

Thompson, Gilbert; Johnson, A.J. 1900. Map of the state of Oregon showing the classification of lands and forests. Washington, DC: U.S. Department of the Interior, Geological Survey. 1:1,000,000; [Projection unknown]; 29" x 23"; thematic. On file with: Umatilla National Forest, Supervisor's Office, 2517 SW Hailey Avenue, Pendleton, OR 97801.

Torgersen, Torolf R.; Powell, David C.; Hosman, Kevin P.; Schmidt, Fred H. 1995. No long-term impact of carbaryl treatment on western spruce budworm populations and host trees in the Malheur National Forest, Oregon. Forest Science. 41(4): 851-863.

Tucker, G.J. No date. Historical notes on early day cordwood production in the Meacham area. Unpublished Typescript Report. [Place of publication unknown]: U.S. Department of Agriculture, Forest Service. 1 p. On file with: Umatilla National Forest, Supervisor's Office, 2517 SW Hailey Avenue, Pendleton, OR 97801.

Tucker, Gerald J. 1940. History of the northern Blue Mountains. Unpublished Report. [Pendleton, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region, Umatilla National Forest.] 170 p.

Turner, Monica G. 1998. Landscape ecology: living in a mosaic. In: Dodson, Stanley I.; Allen, Timothy F. H.; Carpenter, Stephen R. [and others]. Ecology. New York: Oxford University Press: 77-122.

U.S. Department of Agriculture, Forest Service. 1990. Land and resource management plan: Umatilla National Forest. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. Variable pagination.

U.S. Department of Agriculture, Forest Service. 1995. Revised interim direction establishing riparian, ecosystem and wildlife standards for timber sales; Regional Forester's Forest Plan Amendment #2. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 14 p.

U.S. Department of Agriculture, Forest Service. 1997. Considering all things: summary of the draft environmental impact statements. R6-P&EA-UP-007-97. [Place of publication unknown]: U.S. Department of Agriculture, Forest Service; U.S. Department of the Interior, Bureau of Land Management. 57 p.

Veblen, Thomas T.; Lorenz, Diane C. 1991. The Colorado Front Range: a century of ecological change. Salt Lake City, UT: University of Utah Press. 186 p.

Voller, Joan; Harrison, Scott, editors. 1998. Conservation biology principles for forested landscapes. Vancouver, BC: UBC Press. 243 p.

Waring, R.H. 1987. Characteristics of trees predisposed to die. BioScience. 37(8): 569-574.

Weaver, Harold. 1943. Fire as an ecological and silvicultural factor in the ponderosa pine region of the Pacific slope. Journal of Forestry. 41: 7-14.

Weidman, R.H. 1936. Timber growing and logging practice in ponderosa pine in the Northwest. Technical Bulletin No. 511. Washington, DC: U.S. Department of Agriculture. 91 p.

Weitknecht, Robert H. 1917. Yellow pine management study in Oregon in 1916. Unpublished Typescript Report. [Place of publication unknown]: U.S. Department of Agriculture, Forest Service. 46 p. On file with: Umatilla National Forest, Supervisor's Office, 2517 SW Hailey Avenue, Pendleton, OR 97801.

White, Peter S. 1979. Pattern, process, and natural disturbance in vegetation. Botanical Review. 45(3): 229-299.

Wickman, Boyd E.; Mason, Richard R.; Thompson, C.G. 1973. Major outbreaks of the Douglas-fir tussock moth in Oregon and California. General Technical Report PNW-5. Portland, OR: USDA, Forest Service, Pacific Northwest Forest and Range Experiment Station. 18 p.

Worster, Donald. 1996. Nature's economy: a history of ecological ideas. Second edition. Cambridge, UK: Cambridge University Press. 507 p.

Wright, Henry A. 1978. The effect of fire on vegetation in ponderosa pine forests: a state-of-the-art review. College of Agricultural Sciences Publication No. T-9-199. Lubbock, TX: Texas Tech University, Department of Range and Wildlife Management. 21 p.