Desolation Ecosystem Analysis

Umatilla National Forest

July 2, 1999

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Introduction

In many respects, the Desolation Watershed is one of the most diverse watersheds on the Umatilla National Forest.

Desolation Creek drains into the North Fork John Day River about 1 mile northeast of Dale, Oregon. The elevation at the bottom of the watershed is about 2800 feet. The watershed climbs toward the southeast to some of the highest points on the Umatilla Forest, over 7600 feet.

Geology and soils are complex. Some types found in Desolation are uncommon on the rest of the Umatilla National Forest.

Water is generally clear and cold, but Desolation Creek does not meet State Water Quality Standards for temperature. Even so, fish habitat is good, and streams in the Desolation watershed support a wide variety of fish species. The watershed's special importance to fish was recognized during development of the Forest Plan, when almost half of the watershed was selected to be managed under a strategy that emphasizes high quality fish habitat.

Forested vegetation patterns reflect a wide range in elevation, aspect, soils, and moisture conditions. For much of the south half of the Umatilla National Forest, vegetation is generally dominated by the dry forest types, but in the Desolation watershed, it is balanced well between dry, wet and cold potential vegetation groups. Fire is an important disturbance process in this watershed, and its influence on vegetation patterns is visible in many areas.

Unlike the remainder of the Forest, meadows are a significant component on the Desolation landscape, providing habitat for unique plants, and adding to the diversity of wildlife habitat.

A wide variety of habitats for wildlife is present. Well known for its large elk herd, habitat conditions are also present for potential occurrences of such rare species as wolverines, peregrine falcons and bald eagles.

Social values in the watershed are high. An abundance of both motorized and non-motorized recreation use occurs throughout the year. The Desolation watershed contains one of only two areas on the Umatilla NF managed as a scenic area. It is apparent why this area was selected to be managed as a scenic area, after experiencing the panoramic vistas from ridges along the southern end of the watershed.

Historically the watershed has been important in economic terms. It has supported grazing of domestic livestock since the early 1800s. Numerous mine locations are scattered throughout the area, indicative of mining activities dating back to the 1800s. Numerous timbers sales have occurred on the National Forest land in the watershed. About 18 percent of the watershed is in private ownership, and much of that land has been roaded and harvested.

Summary of Findings

The following summary is meant to provide a very brief listing of "key" findings of this ecosystem analysis.

1. Achievable target maximum standard water temperature for tributaries to Desolation Creek should be in the range of 55º to 60º F.

2. Desolation Watershed is a high-concentration area for sensitive plant species, especially *Botrychium* spp., one of which may be a new-to-science species.

3. Desolation Watershed contains some of the most significant meadow habitat found on the Forest. Non-native seeded grasses occupy a high proportion of cover in the meadows.

4. Riparian obligate plant species are under-represented, and the amount shrubs have been significantly reduced throughout the watershed.

5. Current noxious weed infestation rates are relatively low. Aggressive treatment of known sites now, coupled with prevention measures, and identification and treatment of new sites, could virtually eradicate noxious weeds from the watershed.

6. Opportunities for use of natural fuels treatments are limited in the moist and cold forest types.

7. Old forest structure is currently very much below historic levels.

8. The existing C1/C2 Old Growth network contains no old forest (as defined in the Desolation Vegetation Database).

9. Reproductive habitat for pileated woodpeckers and American martin has become so rare that the long-term persistence of local populations is uncertain; the watershed may no longer support a successfully reproducing population of northern three-toed woodpeckers.

I. Characterization

Characterization is the first step in a six-step process for Ecosystem Analysis at the Watershed Scale (EAWS) (Regional Ecosystem Office 1995). The purpose of Characterization is to identify the dominant physical, biological, and human processes or features of the watershed that affect ecosystem functions and conditions. Relationships between ecosystem elements and those occurring in the river basin or province are identified. The most important land allocations, plan objectives, and regulatory constraints influencing resource management in the watershed are identified.

General Information

The Desolation watershed comprises 69,672 acres of diverse landscapes, including both National Forest and private lands, located east and south of Highway 395, southeast of Dale, Oregon (Figure 1). Privately owned lands comprise about 18 percent of the total area, mostly at lower elevations at the western end of the watershed. Nine subwatersheds are recognized in this analysis, ranging in size from 4,455 to 10,815 acres (Figure 2, Table 1).

The Desolation Watershed Analysis Area encompasses a relatively large elevation gradient, from 7,765 ft. at the headwaters (Sunrise Butte) to 2810 ft. at the confluence of Desolation Creek and the North Fork John Day (NFJD) River. The NFJD subbasin (HUC# 17070202) is about 2,520 mi^2 in size and is important in terms of overall water quality and flow contribution to the John Day River. Desolation Creek, a northwest-flowing tributary, joins the NFJD near the town of Dale, Oregon (Figure 1).

The Integrated Scientific Assessment for Ecosystem Management for the Interior Columbia Basin (USDA-USDI, 1996) characterized the ecological integrity of the 164 subbasins in the interior Columbia River Basin. The North Fork John Day Subbasin ratings are as follows: **Forest Integrity - Low; Aquatic Integrity - Moderate; Hydrologic Integrity - Moderate; Composite Ecological Integrity - Low.** Integrity ratings reflect the relative level of ecological functions and processes that are present and operating within the subbasin, relative to the Basin (USDA-USDI, 1996). Moderate ratings for Hydrologic and Aquatic Integrity suggest that these resources, while not in dire straits, are certainly not in “optimal” condition. The low ratings for Forest Integrity and Overall Ecological Integrity imply definite problems, and suggest an initial direction for investigation of conditions at the watershed scale.

Table 1. Desolation Acres by Subwatershed

Watershed	Subwatershed (SWS)	Total Acres	Private Land (Acres)
Lower Desolation	36A	7,156	4,150
Lower Desolation/ Wassen	36B	8,731	4,832
Kelsay	36C	6,546	682
Middle Desolation/ Bruin	36D	10,815	2,916
Junkens / Beeman	36E	4,455	--
Upper Desolation/ Battle	36F	10,261	--
Upper Desolation/ Howard	36G	6,511	--
North Fork Desolation	36H	8,058	--
South Fork Desolation	36I	7,139	98
	Total	69,672	12,678

Figure 1. Desolation Ecosystem Analysis Area Map

Figure 2. Desolation Subwatersheds

Forest Plan Management Areas and Land Uses

A variety of uses and values characterize the Desolation watershed, as evidenced by the number of Forest Plan Management Strategies assigned to the area (Table 2, Figure 3). A brief description of each Area designation and its management goals follows:

A3, Viewshed 1: Manage the area seen from a primary travel route, use area or water body, where forest visitors have a major concern for the scenic qualities, as a natural appearing landscape.

A4, Viewshed 2: Manage the area seen from a primary travel route, use area or water body, where forest visitors have a major concern for the scenic qualities, as a natural appearing to slightly altered landscape.

A6, Developed Recreation: Provide recreation opportunities that are dependent on the development of structural facilities for user conveniences where interaction between user and evidence of others is prevalent.

A7, Wild and Scenic Rivers: Manage classified wild and scenic river segments to appropriate standards as wild, scenic, or recreational river areas, as defined by the Wild and Scenic Rivers Act, and amended by the Omnibus Oregon Wild and Scenic Rivers Act of 1988.

A8, Scenic Area: Protect or enhance the unique natural characteristics of landscapes noted for their scenic beauty.

B1, Wilderness: Manage to preserve, protect, and improve the resources and values of the Forest Wildernesses, as directed by the Wilderness Act of 1964.

C1, Dedicated Old Growth: Provide and protect sufficient suitable habitat for wildlife species dependent upon mature and/or overmature forest stands, and promote a diversity of vegetative conditions for such species.

C2, Managed Old Growth: Provide and protect sufficient suitable habitat for wildlife species dependent upon mature and/or overmature lodgepole pine forest stands, and promote a diversity of vegetative conditions for such species.

C3, Big Game Winter Range: Manage big game winter range to provide high levels of potential habitat effectiveness and high quality forage for big game species.

C4, Wildlife Habitat: Manage forest lands to provide high levels of potential habitat effectiveness for big game and other wildlife species with emphasis on size and distribution of habitat components (forage and cover for elk, and snags and dead and down materials for all cavity users). Unique wildlife habitats and key use areas will be retained or protected.

C5, Riparian Fish and Wildlife: Maintain or enhance water quality, and produce a high level of potential habitat capability for all species of fish and wildlife within the designated riparian habitat areas while providing for a high level of habitat effectiveness for big game.

C7, Special Fish Management: Maintain and enhance water quality and produce high levels of anadromous fish habitat on an area-wide basis.

Table 2. Forest Plan Management Areas in the Desolation Watershed

MANAGEMENT AREA	ACRES	PERCENT
A3	257	0.4
A4	3133	4.5
A6	23	0.0
A7	36	0.1
A8	13,281	19.1
B1	777	1.1
C1	1,947	2.8
C2	1,043	1.5
C3	3,894	5.6
C4	171	0.2
C5	165	0.2
C7	32,066	46.2
Private	12,678	18.2
Malheur NF	200	0.3

The importance of the watershed to fisheries protection is evidenced by the high proportion of the area included in C7--Special Fish Management (46% of the watershed), and the absence of management areas emphasizing commodity production.

Portions of the Jumpoff Joe and Greenhorn Mountain* Roadless Areas (Numbers 14249 and 14350, respectively) are located within the Desolation analysis area. The Umatilla portion of these roadless areas encompass 9,948 acres, or approximately 14 percent of the total Desolation analysis area (Table 3, Figure 4).

A land exchange aimed at Forest Service acquisition of the privately owned lands at the west end of the drainage is pending (L. Vore, Wallowa-Whitman NF, pers. Comm. 12/98).

Table 3. Desolation Analysis Area Roadless Acres by Subwatershed

SUBWATERSHED	ROADLESS ACRES	% OF SWS IN ROADLESS
36E	1,076	24
36G	2,317	36
36H	99	1
36I	6,456	90
TOTAL	9,948	---

**Note: A discrepancy in acres between the GIS database and Forest Plan Appendix C for the Greenhorn Roadless area has yet to be resolved*

Federal Trust Responsibilities To Indian Tribes

In 1855, three treaties which affect the Umatilla National Forest were signed between the United States Government and several Indian tribes. The treaty with the Walla Walla, Cayuse, and Umatilla tribes, and bands of Indians in Washington and Oregon Territories (today referred to as the Confederated Tribes of the Umatilla Indian Reservation) was signed on June 9, 1855. On June 26, 1855, a treaty was signed with the Tribes of Middle Oregon (these groups are now known as the Confederated Tribes of the Warm Springs Indian Reservation).

In each of these treaties, the tribes ceded certain traditional lands to the U.S. Government. The Desolation Watershed is within the ceded lands of the Confederated Tribes of the Warm Springs Reservation. It is also within the area of interest of the Confederated Tribes of the Umatilla Indian Reservation, the Burns Paiute Tribe, and the Nez Perce Tribe (Interior Columbia Basin Ecosystem Management Project, Eastside Draft Environmental Impact Statement).

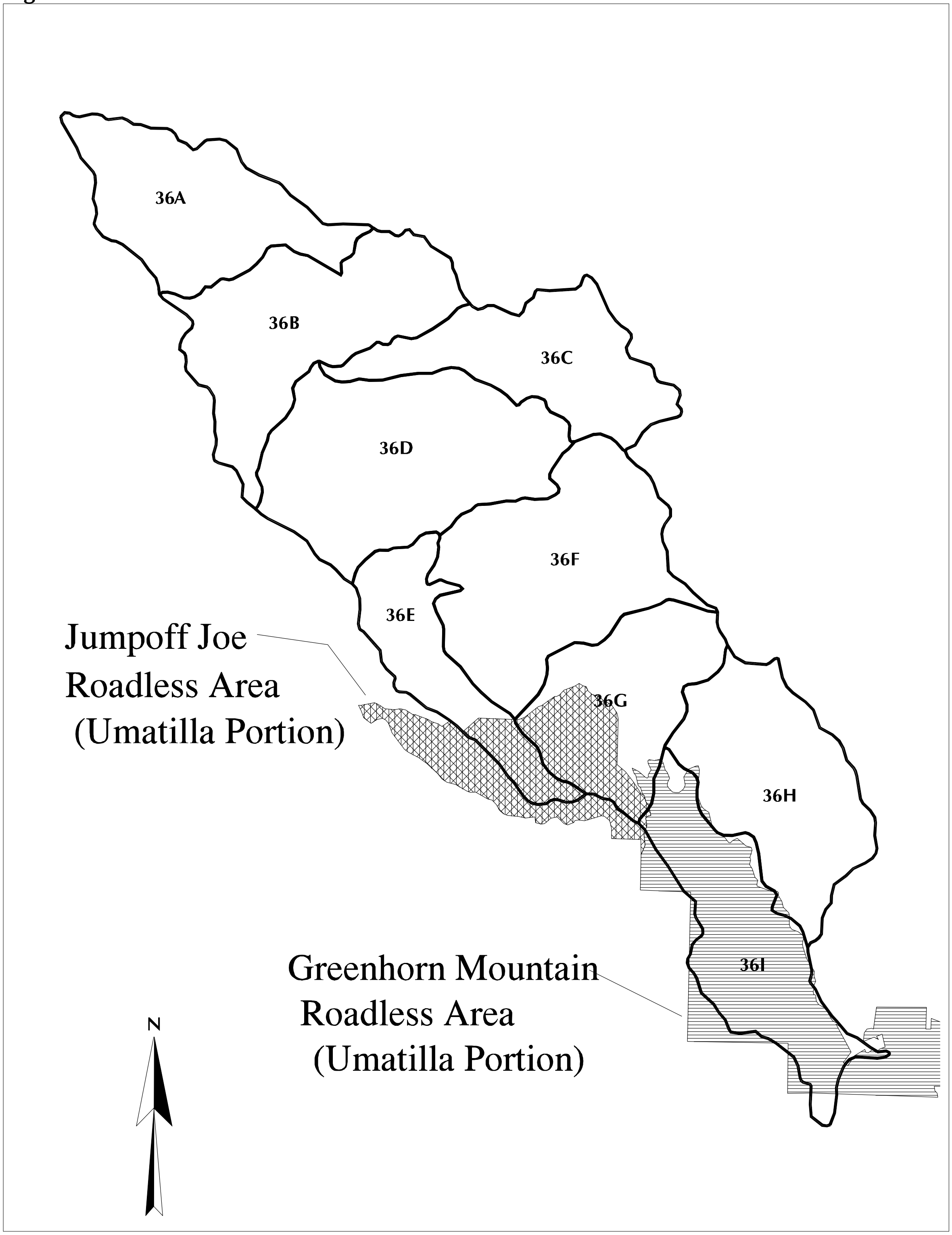
Reservation lands were retained by the tribes. The treaty also provided the Native Americans with exclusive rights to take fish in the streams running through and bordering the reservation, rights in common with citizens of the United States at all other usual and accustomed stations, and the right to erect suitable buildings for curing the fish. The privilege of hunting, gathering roots and berries, and pasturing their stock on unclaimed lands in common with citizens was also retained.

Treaties and executive orders after 1971 obligate the United States and its agencies to certain trust responsibilities. This responsibility has been generally referred to as the federal trust responsibility. In addition to obligations in treaties and statutes, the Forest Service has an obligation to consult with Federally recognized Indian Tribes on a Government-to-Government basis throughout our planning process.

Indian Tribes having rights to fish, hunt, gather, graze livestock or trap on National Forest Lands also have the implied right to have associated resources (habitat) protected from degradation. The Forest views this ecosystem analysis as the beginning of the consultation process at the technical level with local tribal governments. The identification of treaty rights, treaty protected resources and other tribal concerns is the first step. This information will be used when developing specific projects. When consultation with tribes indicates a concern or conflict with the proposed action and that conflict is related to treaty rights or other rights or interests, those issues will be addressed in the site specific NEPA analysis. Depending on the character of the issues, they may be addressed in several different ways. An issue may be used to develop alternatives to the proposal, to develop mitigation measures or could be used by the decision maker in selecting among the alternatives. In all cases, tribal governments will be involved throughout the planning process.

Figure 3. Desolation Management Areas

Figure 4. Roadless Areas within the Desolation Watershed



Soils and Geology

General

The Desolation drainage lies within portions of three subsections of the ecological unit hierarchy adopted by the Forest Service:

> Ukiah Mountain Slopes-- moderately dissected mountains on Grande Ronde and Picture Gorge Basalts; cool, dry and very dry forests dominated by ponderosa pine, Douglas-fir, and western larch; cool, moist forests dominated by grand fir; and cold, moist subalpine forest dominated by subalpine fir.
>
> Wallowa-Elkhorn Mountains-- high, ice-sculpted mountains dominated by granitic and diorite; cold and usually moist soils; subalpine coniferous forests and alpine meadows.
>
> John Day Clarno Mountains-- moderately dissected mountain slopes with coniferous forest on John Day and Clarno geologic formations.

Slopes in the Desolation watershed are dominantly gentle to moderate, with the relatively large alluvial/colluvial/glacial till meadow complexes as dominant features (Figure 5).

Geology

The geology of the Desolation area is some of the most complex on the Umatilla National Forest (Table 4 and Figure 6). It is dominated by volcanic massive flow materials, with metabasalts/andesites, tuffs and breccias from these materials, in the central portion of the drainage. The lower sections have extensive (old) landslide and debris flow deposits, much of it materials from the volcanic mass flows. The large area of geologic landslide contributes to the rolling topography that is more typical in this drainage.

A variety of other rock types occur in lesser amounts within the drainage including some granodiorite (granitics) in the headwaters region, and some bedded sedimentary units primarily of argillite, and some sandstone. Metamorphosed volcanics and sedimentary rock types are common throughout the water-shed. Serpentinite is exposed in some areas, primarily in the headwaters. Perhaps the most significant geologic material in the drainage are the fairly extensive glacial till deposits in the central and upper reaches of the watershed. This, in combination with associated alluvial deposits, provides significant volumes of unconsolidated rock material able to store large volumes of water. Mazama volcanic ash has been overlain, reworked and redeposited in footslope and drainage areas. The ash deposits further enhance the water-holding capacity of the soils and unconsolidated materials prevalent in the watershed.

Soils

Soils are moderately deep and of volcanic origin, both as residual parent material and from volcanic ash fallout, primarily from Mount Mazama. Considerable variety exists due to mixed geologic units, as indicated earlier, and erosional processes, including alpine glaciation moving and mixing materials (Table 5). The extensive deep alluvial and glacial till-derived soils are particularly important due to their water holding capacity and productive potential. These are most evident in the meadows in the watershed. Soils in Desolation are generally cold except for the lowest elevations which support Warm, Dry plant associations. Deep soils at upper elevations generally maintain adequate available soil moisture throughout most of the growing season while those at lower elevation in the drainage will usually dry enough to induce stress in trees and understory vegetation in late summer.

Figure 5. Slope Map of Desolation Watershed

Table 4. Geologic Types found in the Desolation Watershed.

GEOLOGIC TYPE	DESCRIPTION	ACRES	% OF TOTAL
Kji	Granitics	3,857	5.5%
Pzsv	Metasediments & Volcanics	47	0.1%
QTg	Terrace & Other Gravels	498	0.7%
Qal	Alluvial Deposits	1,412	2.0%
Qg	Glacial Till Deposits	2,928	4.2%
Qls	Landslide & Debris Flow	12,973	18.6%
TRPv	Massive Flow Volcanics	15,749	22.6%
TRPzg	Gabbro & Similar Rocks	319	0.5%
TRPzs	Sedimentary, Part Metamorphic	1,450	2.1%
TRPzu	Ultramafic Including Serpentinite	7,676	11.0%
Tca	Clastic Sed., Bedded Sed. & Andesite	11,860	17.0%
Tcg	Grande Ronde Basalt	1,207	1.7%
Tci	Imnaha Basalt	601	0.9%
Tcp	Picture Gorge Basalt	8,048	11.6%
Tcw	Wanapum Basalt	897	1.3%
Tsfj	John Day Volcanics	151	0.2%
	Total	69,673	100.0%

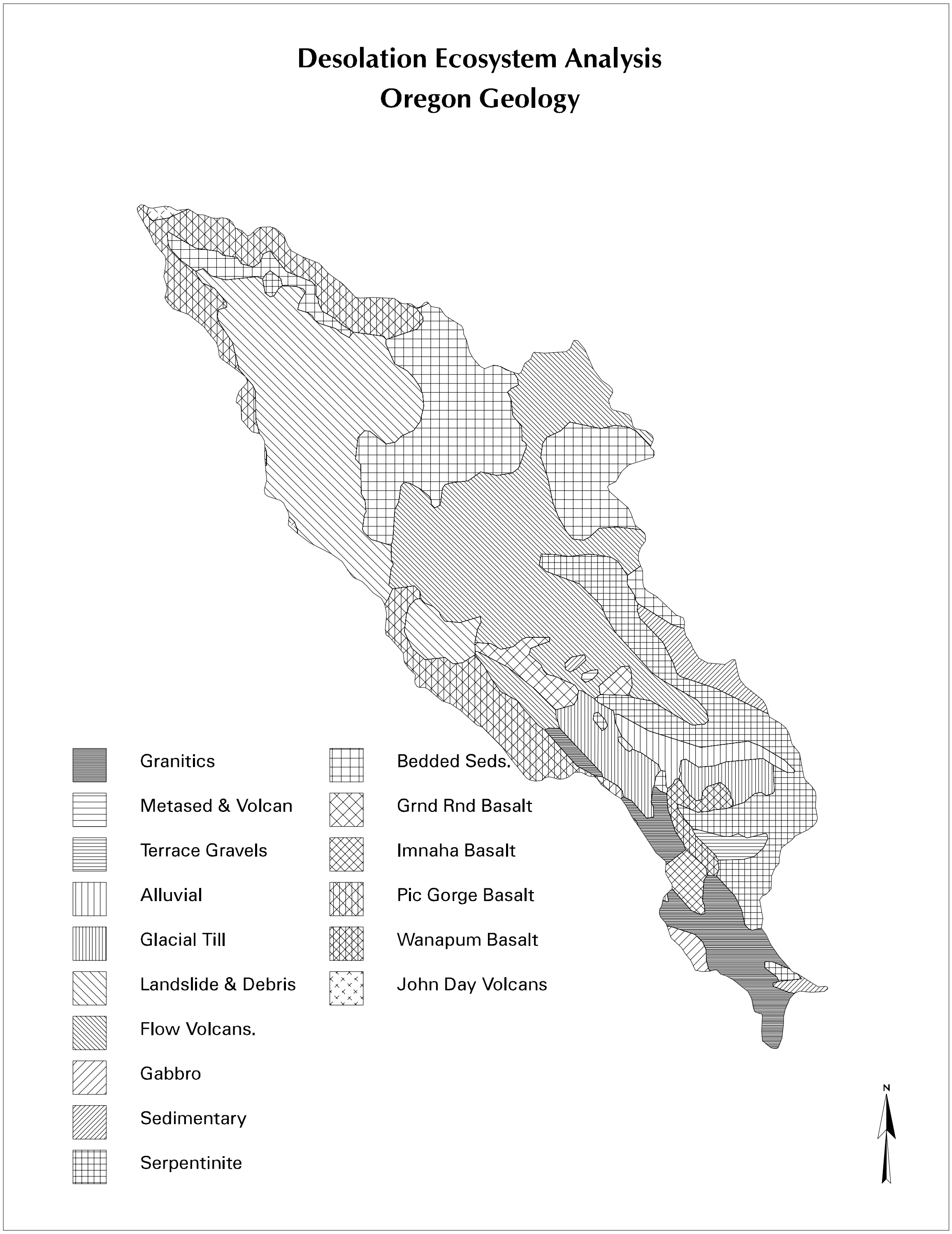
Source: State of Oregon Geology Map

Table 5. Dominant Soil Units & Key Characteristics.

UMATILLA SRI MAP UNIT #	DEPTH	SURFACE TEXTURE	MINERAL ASH (IN)	ACRES	WATERSHED %
Groups: 66, 67, 366, 367, 675, 662, 672	Deep	Silt Loam	12-40	13,967	20
Groups: 46, 48, 469, 348, 487	Mod. deep	Silt Loam	10-30	8,178	12

The largest acreage of soils are Udivitrands, mostly deep, which are typically volcanic ash over substrate of basalt, andesite or tuffaceous/pyroclastic sediments, and are found in the central portions of the drainage on the volcanics mentioned earlier. Subsoils developed in basalts (or andesites) are often a clay loam texture which tends to produce lateral water flow as water percolates downward through the soil profile. Moderately deep variations of these same soil types are also fairly extensive, but classification changes somewhat to Haploxeralfs, indicating drier conditions on southern aspects and/or lower elevations.

Figure 6. Desolation Geologic Types



Second in acreage are residual soils overlain with volcanic ash, shallow to moderately deep, formed in the metavolcanics and metasediments. These are Vitrixerands or Udivitrands depending on soil moisture regimes. The longer dry-season (Xeric) soils are at lower elevations and south and southwest aspects, with the (Udic; less than 90 days dry) somewhat more moist soils at higher elevations or north aspects. A smaller acreage of deep Haploxerolls or Haploudolls formed in the colluvium and alluvium typical of the meadow complexes and footslopes. Soils formed in tuffaceous sandstones and argillites are also found in relatively minor acreages in the central portions of the drainage. The granitic derived soils, most with considerable ash caps or mixed as colluvium, are found mostly in the headwaters of South and North Fork Desolation Creeks.

The soils formed in glacial till tend to be somewhat less extensive than the amount of till material since the till is often covered with alluvial sediments, particularly of volcanic ash. They tend to be deep and moderately well to somewhat poorly drained with thick, dark brown to black surface horizons. Subsoils will often have clayey horizons with gray, mottled colors.

Erosion Processes

The dominant erosion processes in the Desolation watershed result from interactions between climate, geology, topography, and land uses. Generally, surface erosion is considered the dominant erosion process, with mass wasting playing a secondary role; however, some unstable areas, prone to slumping and sliding, occur in the watershed (mostly in the Landslide and Debris Flow geologic type, found in subwatersheds 36A, B, D and E; see Figure 6). Surface erosion rates are highest on steeper slopes lacking vegetative cover, in unconsolidated or easily eroded deposits. Streambank erosion is also an important source of sediment to streams. Sediment concentrations in Desolation Creek are generally highest during spring snowmelt, however, occasional spring and summer storms increase sediment levels in streams.

The glacial tills and landslide materials are relatively young and are still establishing a drainage network. These processes tend to produce ongoing stream migration, adjustments and downcutting activity typical of geologically young landscapes.

Land uses including livestock grazing, roads, timber harvest, mining, and recreation trails and camps often accelerate natural erosion rates. Wildfires, especially in combination with runoff-generating storm events, may also contribute to increased erosion and sedimentation rates.

Watershed Hydrology

Climate

The Desolation watershed has a continental climate characterized by seasonal extremes of temperature and precipitation. Annual precipitation increases with elevation from less than 20 inches near the mouth of Desolation to over 40 inches in the headwaters (Figure 7). Most precipitation falls as rain and snow beginning in late fall, through winter (accumulating as snowpack), into spring (Figure 8). Convectional spring and summer storms produce isolated, often intense, thunderstorms. The pattern and occurrence of storms is affected by topography and the direction of prevailing winds. Temperatures follow general elevational and seasonal patterns with lower average temperatures at higher elevations. January is the coldest month and August the warmest month.

Hydrology

Few published streamflow records are available for Desolation Creek. Some summary data are available from a gaging station operated on Desolation Creek (near Dale) between 1949 and 1958; but apparently no data was collected between 1958 and the early 1980s. Streamflow data collected since 1980 has yet to be analyzed.

Monthly distribution of discharge shows a strong spring maximum reflecting the contribution of melting snow to overall water yields (Figure 9). Desolation Creek has slightly higher average unit discharge (0.9 cfsm[2]) compared to average discharge at other nearby gages (the North Fork John Day near Dale and Camas Creek near Ukiah both have unit discharges of 0.8 cfsm).

Figure 7. Average Annual Precipitation.

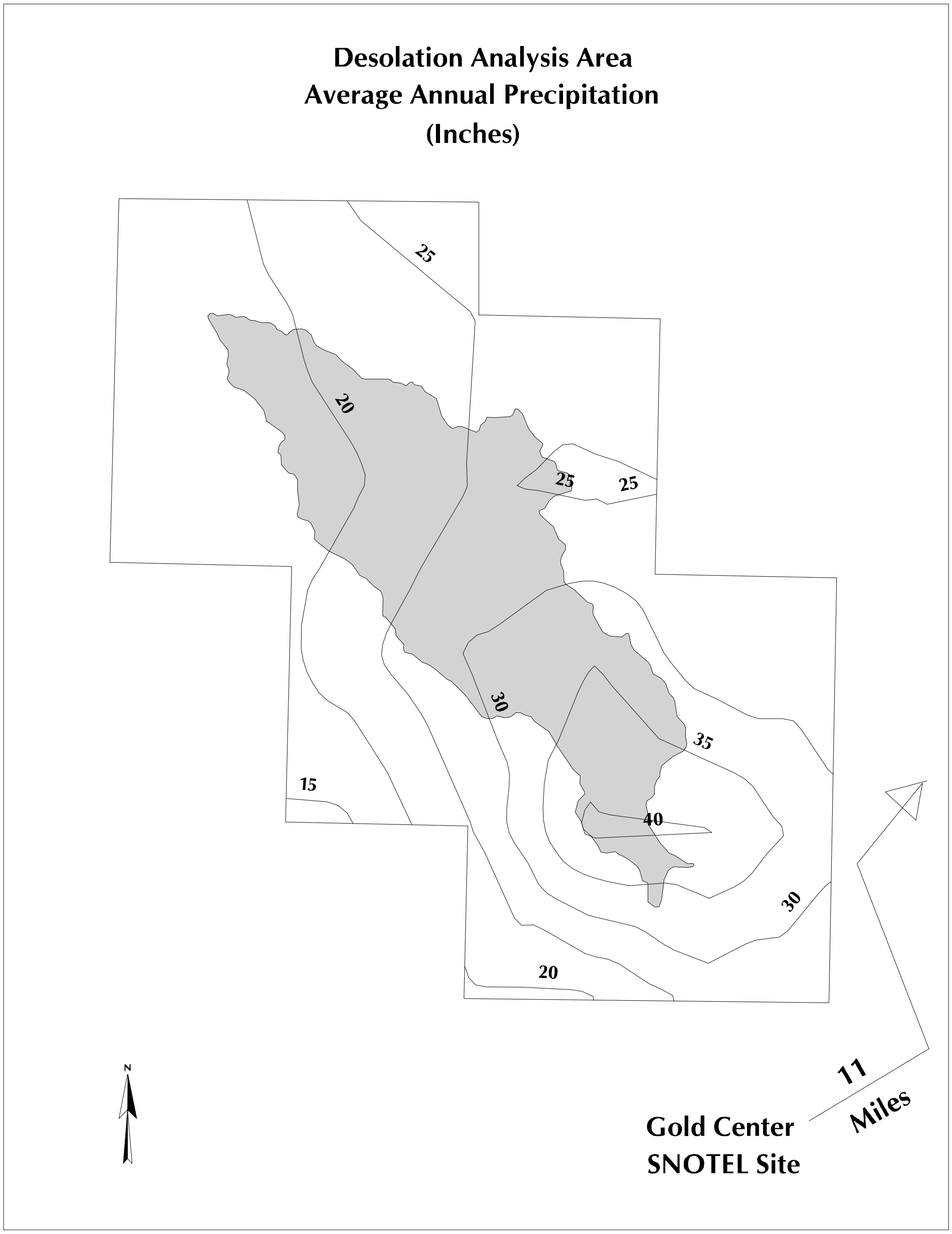
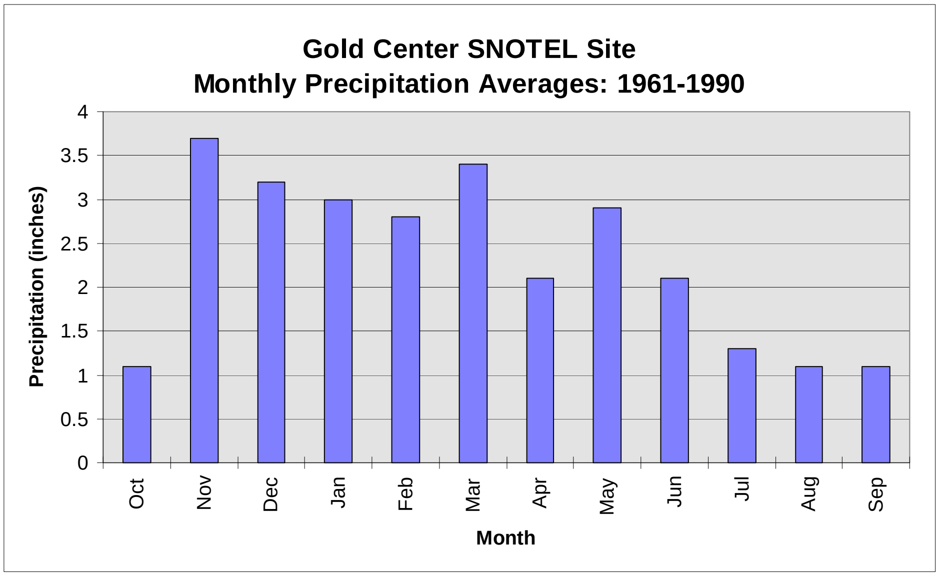


Figure 8. Gold Center SNOTEL Site - Average Monthly Precipitation.



Recorded maximum flows ranged from 414 cfs in 1959 to 1240 cfs in 1958 (Figure 10). Nine of the thirteen years with recorded peaks occurred in the months of May or June, during snowmelt runoff. Low flows ranged from 4.1 to 8.4 cfs, occurring between September and November.

Overall, Desolation Creek streamflows reflect the seasonal patterns of precipitation accumulation and temperature, with a winter snow accumulation, spring runoff peak, and fall baseflows.

Figure 9. Desolation Creek Average monthly streamflow.

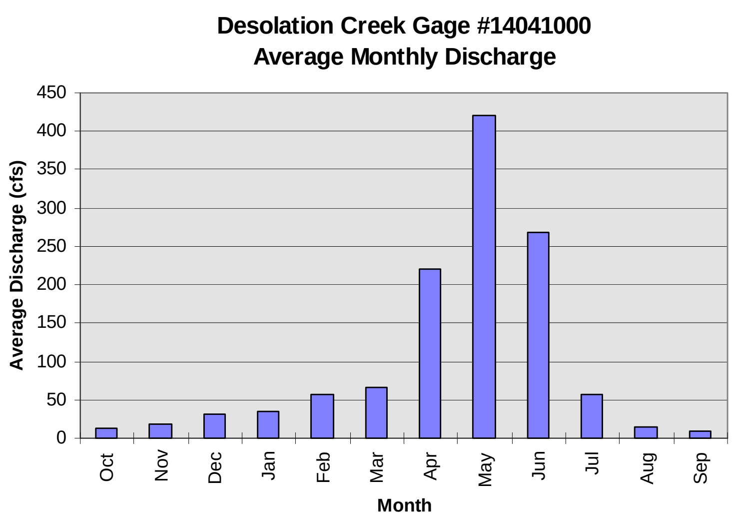
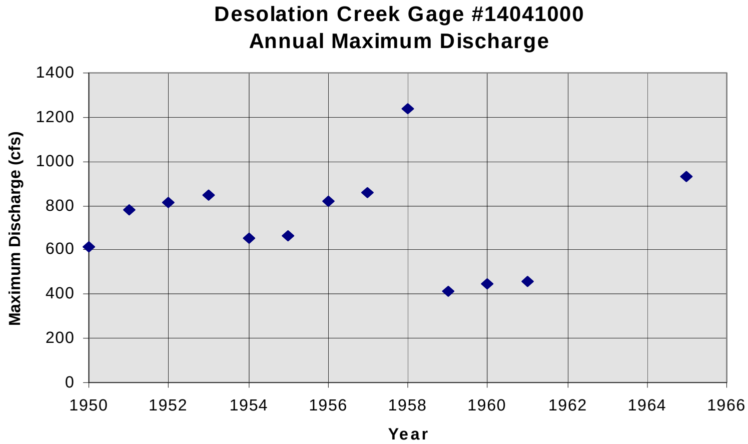


Figure 10. Desolation Creek Annual Maximum Streamflow.



Stream Channels and Riparian Areas

Desolation Creek flows from its origins in the Greenhorn Mountains, in a northwesterly-direction, to the North Fork of the John Day River (Figure 11). Major tributaries include the North and South Forks, Battle Creek, Junkens Creek, and Kelsay Creek. There are approximately 249 miles of stream, classified as follows:

> *Class 1*--streams that directly support anadromous fishery or public supply watershed;
> *Class 2* –support resident fish or important tributaries to a public supply watershed;
> *Class 3*--perennial streams that do not support fish or contribute to a public water supply; and
> *Class 4*--intermittent, seasonal streams

Compared to National Forest averages, Desolation Creek supports more miles of fish-bearing streams and has fewer miles of intermittent streams (Table 6). Some classification errors are apparent in the Bruin subwatershed. Overall, stream mapping and classification are at best an approximation of actual stream miles and fishery present.

Stream density, in miles per square mile of stream, is a measure of the degree of dissection of the watershed by the stream network. Stream density is related to runoff efficiency, that is, higher densities indicate more rapid collection and delivery of precipitation and runoff. The average stream density for the Desolation watershed is 2.3 miles per square mile which is low compared to other watersheds in the Blue Mountains. Low densities may reflect a real characteristic of the watershed, as in the case of recently glaciated landforms which have younger stream systems, or the data may underrepresent actual stream miles because of mapping assumptions.

Table 6. Miles of Stream by Stream Class, Compared to Forest Averages, Desolation Watershed.

Subwatershed	SWS#	Class 1	Class 2	Class 3	Class 4	TOTALS
Lower Desolation	36A	5.3		3.9	14.7	23.9
Wasson	36B	7.5		6.2	10.5	24.2
Kelsay	36C	13.3		1.2	11	25.5
Bruin	36D	9.6		36.1*	*	45.7
Junkens	36E	5.0		7.9	6.7	19.6
Battle	36F	12.0		6.0	17.4	35.4
Howard	36G	5.9	0.8	8.9	9.6	25.2
North Fork Desolation	36H	10.4	5.3	6.1	8.4	30.2
South Fork Desolation	36I	2.7		6.0	10.9	19.6
Watershed Totals		71.7	6.1	82.3	89.2	249.2
Percent		28.7	2.4	33.0	35.8	100
Forest Average (%)		11.0	4.0	24.0	61.0	100

* GIS data classification error

Stream channel morphology reflects climatic conditions, hydrology, landforming processes, and land uses occurring in the watershed. Channel morphology ranges from steep, confined headwater channels with coarse substrate (upper/lower South Fork Desolation, Battle, Junkens), to sinuous channels in glacially-modified U-shaped alluvial meadows (North Fork/South Fork Desolation), to mainstem Desolation Creek, a moderate gradient cobble-dominated stream. Riparian meadows in the upper watershed (North Fork and South Fork) are unique morphologic and biologic settings in the watershed (see Botanical discussion).

Water Quality

In general, the quality of water in the Desolation watershed is thought to be good, however, monitoring in recent years has detected water temperatures exceeding the state standard (1996) for bull trout. Streams in and downstream of Desolation Creek listed on Oregon's 1998 303(d) list:

- Desolation Creek, mouth to North/South confluence, temperature (bull trout)
- North Fork John Day River, Middle Fork to Granite, temperature (bull trout)

Sediment and aquatic habitat impairment may also be water quality concerns based on recent observations and data. Streamflow and water quality monitoring has been periodic; some streamflow records are available for the 1950's, and there has been a more recent emphasis on water temperature monitoring. Miscellaneous water quality sampling at these and other stations in the watershed occurred between 1972 and 1981, (data were input into STORET, the national water data bank maintained by the Environmental Protection Agency).

Figure 11. Desolation Streams

Water Rights and Uses

A variety of water rights and uses occur in the Desolation watershed. There are approximately 20 water rights (mostly spring and pond developments for livestock) on the National Forest filed with the Oregon Water Resources Department (OWRD). An additional 17 water sources (culvert outlets, ponds) have been identified by the Forest for road maintenance and fire protection needs. Three water rights are on file with OWRD for the Dale Work Center, which has its intake/source downstream from Desolation Creek, on the NFJD River.

There are two small lakes in the upper watershed; Lost Lake and Jump-Off Joe. Lost Lake was modified in 1991 to increase storage from 4 to 7.5 acres.

Forest Overstory Vegetation

Potential Natural Vegetation (PNV)

Mountainous areas such as the Desolation watershed have steep environmental gradients, which means that site conditions vary in response to changes in landform, elevation, climate, soils, slope exposure, geology, and a variety of other biophysical factors. Any unique combination of biophysical factors results in a slightly different environment, usually expressed as a change in temperature and moisture conditions. In the Desolation analysis area, temperature and moisture regimes vary with changes in elevation and aspect.

The climax plant community (i.e., the PNV) associated with a particular set of environmental conditions (temperature and moisture) is called a *plant association*. Sites that can support similar plant associations are grouped together as a *plant association group* (PAG). Similarly, closely related plant association groups can be aggregated into *potential vegetation groups* (PVG; cold forest, moist forest, dry forest). The ultimate result is a taxonomy or hierarchy of potential natural vegetation, ranging from plant associations at the lowest level to potential vegetation groups at the highest level (Tables 7 and 8). Figure 12a shows the location and distribution of upland forest PVGs in the Desolation watershed; Figure 12b provides the same information for PAGs.

Table 7. Selected characteristics of potential vegetation groups (PVGs) for upland forests for the Desolation Watershed.

PVG	Area (Acres)	Distur-bances	Fire Regime	Patch Size	Elevation (Feet)	Slope (Percent)	Typical Aspects
Dry Upland Forest	16,719	Harvest Fire Insects	Low	433 (4-12809)	4508 (2971-6792)	15 (1-57)	Southwest West South
Moist Upland Forest	24,705	Harvest Fire Insects Diseases	Mixed	473 (1-7216)	5424 (2984-7278)	15 (0-52)	North Northeast Northwest Level
Cold Upland Forest	23,449	Wind Insects Fire Diseases	High	655 (1-7888)	6125 (4395-7632)	17 (1-58)	Northeast North Southwest West

Sources/Notes: Areas, elevations, slope percents, and aspects were summarized from the 97veg database (see Appendix for more information). See Fire and Fuels section for description of fire regime ratings.

Table 8. PVGs, PAGs, and vegetation types for upland forests/woodlands of the Desolation area.

PVG/PAG	Abbreviation & Common Name of Vegetation Type (Association/Community Type)	Area
Cold Forest : Cold Dry		
	Grand Fir/Grouse Huckleberry	6,657
ABLA2/CAGE	Subalpine Fir/Elk Sedge	1,675
ABLA2 subalpine parks	Subalpine Fir subalpine parklands	641
ABLA2/VASC	Subalpine Fir/Grouse Huckleberry	10,091
PICO(ABGR)/VASC/CARU	Lodgepole Pine (Grand Fir)/Grouse Huck./Pinegrass	1,990
PICO(ABLA2)/VASC	Lodgepole Pine (Subalpine Fir)/Grouse Huckleberry	2,322
PICO subalpine parks	Lodgepole Pine subalpine parklands	61
Cool Dry		
ABLA2/CARU	Subalpine Fir/Pinegrass	12
Moist Forest: Cool Moist		
ABGR/CLUN	Grand Fir/Queen's Cup Beadlily	357
ABGR/LIBO2	Grand Fir/Twinflower	2,261
ABGR/VAME	Grand Fir/Big Huckleberry	9,119
ABGR/VASC-LIBO2	Grand Fir/Grouse Huckleberry-Twinflower	2,168
ABLA2/CLUN	Subalpine Fir/Queen's Cup Beadlily	102
ABLA2/LIBO2	Subalpine Fir/Twinflower	1,699
ABLA2/VAME	Subalpine Fir/Big Huckleberry	7,783
PICO(ABGR)/VAME	Lodgepole Pine (Grand Fir)/Big Huckleberry	746
PICO(ABGR)/VAME-LIBO2	Lodgepole Pine (Grand Fir)/Big Huck.-Twinflower	42
PICO(ABLA2)/VAME	Lodgepole Pine (Subalpine Fir)/Big Huckleberry	216
Warm Moist		
ABGR/BRVU	Grand Fir/Columbia Brome	212
Dry Forest : Warm Dry		
ABGR/CAGE	Grand Fir/Elk Sedge	1,669
ABGR/CARU	Grand Fir/Pinegrass	2,867
PIPO/CAGE	Ponderosa Pine/Elk Sedge	2,011
PIPO/CARU	Ponderosa Pine/Pinegrass	1,950
PIPO/CELE/CAGE	Ponderosa Pine/Mountain-mahogany/Elk Sedge	416
PIPO/PUTR/CAGE	Ponderosa Pine/Bitterbrush/Elk Sedge	61
PIPO/SPBE	Ponderosa Pine/Birchleaf Spirea	128
PIPO/SYAL	Ponderosa Pine/Common Snowberry	1,235
PSME/CAGE	Douglas-fir/Elk Sedge	1,448
PSME/CARU	Douglas-fir/Pinegrass	2,769
PSME/SPBE	Douglas-fir/Birchleaf Spirea	97
PSME/SYAL	Douglas-fir/Common Snowberry	842
PSME/VAME	Douglas-fir/Big Huckleberry	413
Hot Dry		
PIPO/AGSP	Ponderosa Pine/Bluebunch Wheatgrass	537
PIPO/PUTR/FEID-AGSP	Ponderosa Pine/Bitterbrush/Idaho Fescue-Bluebunch Wheatgrass	276
Moist Woodland		
Hot Moist		
JUOC/CELE/CAGE	Western Juniper/Mountain-mahogany/Elk Sedge	48
JUOC/FEID-AGSP	Western Juniper/Idaho Fescue-Bluebunch Wheatgrass	172

Sources/Notes: Adapted from Powell (1998). The “Area” column is the total acreage for the vegetation type in the Desolation area (summarized from the DesoPNV database). Area values will not sum to the total for the analysis area because non-forest types (grassland, herbland, shrubland) and riparian forests are not included in this summary.

Figure 12a. Potential vegetation groups (PVGs) for upland forests of the Desolation analysis area.

Figure 12b. Plant association groups (PAGs) for upland forests of the Desolation analysis area.

Insects and Disease

Populations of bark beetles in ponderosa pine and Douglas-fir have maintained high endemic levels for several years due to a number of factors favorable to the beetles: defoliator-weakened trees, moisture stress from prolonged drought, overstocked stands, several mild winters, and a series of stand-replacing fires that have provided abundant beetle habitat, among others.

Fire and Fuels

The frequency and intensity of wildfires that have resulted in today's forest landscape reflect the interaction of fire regimes, lightning frequency and forest stand condition (Figure 13). The three dominant fire regimes within the watershed are described below. Insect and disease conditions are characterized above. Finally, the Desolation Watershed Analysis Area is within the highest fire occurrence zone on the Forest in terms of number of fire starts.

Fire Regimes

Dry Forests
Low intensity-short return interval fires dominate dry forests. Fire sustains early seral species, such as ponderosa pine, and thins a large proportion of the seedlings and saplings that become established between fires. The result is that a majority of this forest type should be open, single storied stands.

Moist Forests
Fire regimes are complex in these forests, and are often referred to as a mixed fire regime, indicating that fires often burn with a combination of low to moderate intensity surface fire, and patches of high intensity fire. The patches of high intensity, stand replacing fire occur when changes in surface fuels; stand density, and/or topography come together to increase fire intensity. Because of the variation in these factors, patch sizes resulting from this type of fire regime is likely to be highly variable.

Cold Forests
The cold forest fire regime is characterized as high intensity-low frequency. Tree species in these forests show little resistance to fire, but, in the case of lodgepole pine, can quickly reclaim a site after a fire. The late seral species of these forests, such as subalpine fir and Engelmann spruce, are very susceptible to crowning and/or torching, which produces fires that spread rapidly via spotting or crowning runs.

Figure 13. Desolation Watershed Analysis Area

Understory and Non-Forest Botanical Resources

The Desolation Watershed encompasses a wide variety of habitat types ranging from hot, low elevation, south facing steppes and ponderosa pine forests in the northwest corner, to cooler subalpine fir, whitebark pine, and open, almost alpine meadow habitats at higher elevations in the southeast portion of the watershed.

The extent and ecological significance of its meadow habitat sets this watershed apart from all the other watersheds on the Forest. Chains of large and small meadows and spring/seep areas follow the upper half of the mainstem of Desolation Creek, and its north and south forks. Small meadows and seeps are found along most of the mid- to upper elevation, year-round creeks, and throughout mid- and upper elevation forests. The largest meadow area is Desolation Meadows (approximately 200 acres). The only other meadow area on the District (and possibly the Forest) of comparable size is the Trout Meadows area (located about 10 miles north of the town of Granite). That meadow system, however, is intensively grazed by sheep, with subsequently lower plant diversity.

The meadows and riparian complexes are potential habitat for all of the currently listed Sensitive plant species known to occur on the North Fork John Day Ranger District, as well as some Sensitive species not currently included on the Regional Forester's List. The meadows have been grazed by livestock for over 100 years, sometimes at extremely high stocking rates (eg., 20,000 sheep in Desolation Meadows, R. Fitzgerald, NFJD Ranger District., pers. comm.). Many of the meadows have been reseeded to non-native species to try to mitigate grazing and other resource damage. This has further displaced many native plant species.

Stocking rates for livestock have declined markedly since the 1950, and Condition and Trend studies initiated in the late 1950s show improvements in range condition (T. Thompson, NFJD Ranger District, pers. comm.). However, complete recovery of shrub and aspen communities has been prevented by the combination of continued grazing by livestock and increased browsing from elk and deer populations.

Floristic Richness

Based on botanical surveys of 56,265 acres (about 90 percent of the National Forest acres), 723 species of vascular plants are known to occur within the Desolation watershed. These include 16 trees, 67 shrubs, 509 forbs, 86 grasses, and 44 "grasslike" species (sedges and rushes). A complete listing is found in the Botanical specialist report in the Appendix.

The unsurveyed portions of the watershed are located in the scenic/roadless area in Subwatershed 36I: The area is mostly high elevation, with complex geology and soils (including pockets of serpentine). Species seldom found, or unknown to the rest of the District or Forest could be found there. Most of the unsurveyed area was burned in the Summit fire in 1996.

No “official” surveys have been conducted for fungus or bryophyte species, and our information on their presence and distribution is virtually nonexistent.

Culturally-significant Plants

Culturally significant food plants, as well as medicinal plants and other plants and products that could be classified as "Special Forest Products" (non-timber plants and products with commercial exploitation potential) are present in the watershed. The amount of use, plants utilized, and areas of utilization is undocumented.

Noxious Weeds

Currently being tracked and treated by the North Fork John Day Ranger District are 14 noxious weed sites, composed of spotted knapweed, diffuse knapweed, houndstongue, bastard toadflax, and tansy ragwort. The sites cover a total of 63 acres, and range in size from ¼ acre to 17 acres.

Historically-listed and Presently-listed Sensitive Plant Species

Occurring within the watershed are seven plants currently on the Regional Forester's List of Sensitive Plant Species. Two species are proposed for addition to that list when it is next updated.

Also found within the watershed are two species on the Oregon Natural Heritage Program (ORNHP) lists, but not on the Regional Forester's List, 14 historically listed sensitive species, and one (possibly two) new species that have not yet been described.

Most of the aforementioned species grow in meadow or riparian habitats. Four of the historically listed species grow in old, late seral forest habitats, two grow on high elevation, open habitats and one grows on predominantly serpentine rock outcrops.

Fish and Aquatic Habitat

Aquatic Species

Desolation Creek is a tributary of the North Fork John Day River, which is in turn a tributary of the John Day and the Columbia Rivers (Figure 14). The John Day River is the largest Columbia River tributary without major dams or reservoirs to act as passage barriers for migrating salmonids, and it supports the largest remaining wild stock of spring chinook salmon (*Oncorhynchus tshawytscha*) in the Columbia River Basin.

The North Fork John Day River and its tributaries account for about 70 percent of the salmon production in the John Day Basin. The John Day River Basin once supported substantial runs of both spring and fall chinook salmon and summer steelhead (*Oncorhynchus mykiss*). Fall chinook now appear extinct, and spring chinook runs have declined to between 2000 and 5000 fish (Northwest Power Planning Council, 1989). Recent steelhead runs have averaged from 15,000 to 40,000 fish. Other reports, based on steelhead spawning surveys in the John Day Basin, indicate that steelhead numbers have been declining by about 15 percent per year since 1985 (Federal Register, 1996)**.**

Desolation Creek supports six species of salmonids. These include five of the seven species identified by the Interior Columbia Basin Ecosystem Management Project (ICBEMP) as key salmonids (fish viewed as important indicators of aquatic integrity). Desolation Creek appears to be centered in an area of ICBEMP Key Salmonid diversity in the John Day Basin (Figure 15). In addition to chinook salmon and steelhead (and the conspecific redband trout), Desolation Creek contains bull trout (*Salvelinus confluentis*), brook trout (*Salvelinus fontinalis*), west slope cutthroat trout (*Oncorhynchus clarki* ssp) and mountain whitefish (*Prosopium williamsoni*).

The U.S. Forest Service Region Six lists bull trout, mid-Columbia steelhead, mid-Columbia chinook salmon and redband as Sensitive species. On March 10, 1998, the National Marine Fisheries Service proposed listing steelhead as Threatened under the Endangered Species Act (Federal Register, 1998a). A decision is due in February of 1999. The United States Fish and Wildlife Service listed bull trout as Threatened under the Endangered Species Act on June 10, 1998 (Federal Register, 1998b).

The blue mountain cryptochian, *Cryptochia neosa*, classified in 1984 by the US Fish and Wildlife Service as a Category 2 candidate for the Federal Threatened and Endangered Species List, has been found in several tributaries of Desolation Creek. C*ryptochia* has recently been found to be more widespread than was previously thought. Some scientists have recommended that its status be changed from Category 2 to Category 3C (Betts and Wisseman 1995). Category 3C is for “taxa proven to be more abundant or widespread than was previously believed and/or those that are not subject to any identifiable threat” (Federal Register, 1984). The blue mountain cryptochian is a Region 6 Sensitive Species.

The Desolation Creek Watershed contains about 249 miles of streams (Figures 16 and 17). The Umatilla National Forest streams database indicates that perennial streams comprise about 160 of these miles, and 78 are fish-bearing. About 72 miles of Desolation Creek streams host anadromous fish during some part of their life cycle.

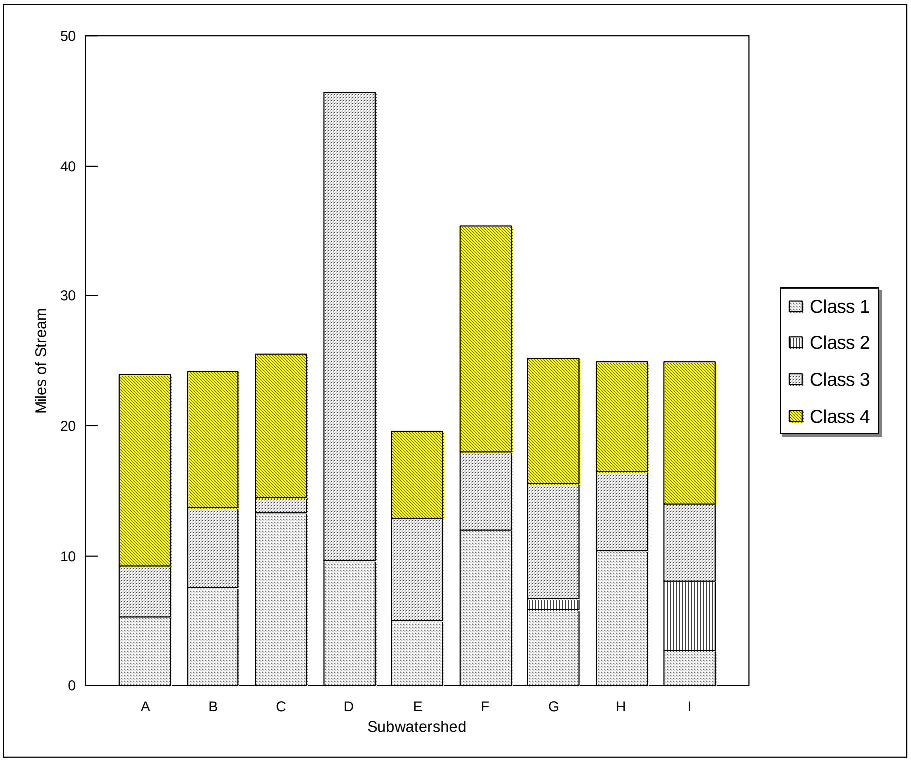
(Note: for one subwatershed (36D -- Bruin) the database shows surprisingly high mileage for class three (perennial, non-fish-bearing) streams and no class four (seasonally intermittent) streams. This is almost certainly a GIS error).

Figure 14. John Day Sub-basins and Aquatic Integrity.

Figure 15. North Fork John Day Tributaries and Key Salmonids.

Figure 16. The Desolation Creek Watershed

Figure 17. Distribution of Stream Classes Within Desolation Creek



Management Constraints

Excluding private lands, C2, C3 and C4 designations, 51,887 acres, or 74 percent of the Desolation drainage is included in some type of conservative management strategy, indicating the importance of the fisheries and scenic resources in this watershed.

In 1996, the Umatilla National Forest determined that Desolation Creek, including both its North and South Forks, was eligible as a Wild and Scenic River under the Wild and Scenic Rivers Act. Eligibility determinations begin a process which may or may not eventually culminate in designation of the stream as a Wild and Scenic River. However, once a stream is determined to be eligible, it must be managed to maintain its eligibility, pending Congressional approval. Its free flowing characteristics and all outstandingly remarkable values must be maintained. Wild and Scenic River eligibility could thus place additional constraints on the management of the Creek, particularly those stretches outside of the C7 or A8 management areas.

Regional requirements for PACFISH (1995) management strategies, and the presence of Sensitive aquatic species impose further scrutiny of activities in the Desolation Watershed. Most recently, the listing of bull trout as Threatened under the Endangered Species Act (ESA) introduces additional regulatory constraints on management options for the area, since any activity that could result in "taking" of a listed species is generally prohibited, or at minimum requires consultation with the listing agency.

Other regulatory constraints include the listing of Desolation Creek as "water quality limited" by The Oregon Department of Environmental Quality and parts of the following: The National Forest Management Act (NFMA), the Federal Land Policy Management Act (FLPMA), the Oregon and California Lands Act (O & C Act), the National Environmental Policy Act (NEPA), the Clean Water Act (CWA), and federal trust responsibilities to Indian tribes.

Past Management and Human Uses

Recent management activities in the Desolation Creek watershed have included timber harvest and regeneration, cattle grazing, road construction and use, mining, fire suppression, and prescribed fire.

Historically, the Umatilla and Warm Springs tribal groups used Desolation Creek at Desolation Meadows as a traditional fishing site.

The watershed supports some sport fishing, primarily at Jump-Off Joe and Lost lakes. Both developed and dispersed, user-created campsites are common within riparian corridors throughout the drainage.

Special Circumstances

Because: 1) the John Day River basin is the largest stream system without major dams or reservoirs in the Interior Columbia River Basin; 2) it is relatively low in the Columbia River system ("only" three dams between the mouth of the John Day and the ocean); and 3) it still retains runs of natural wild chinook salmon and steelhead; the North Fork John Day River probably represents the best hope for maintenance and restoration of natural salmon and steelhead runs of any managed stream system on the Umatilla National Forest (and perhaps the best hope for any stream in the Interior Columbia Basin). Although Desolation Creek is not currently, and may never have been, an important chinook salmon spawning stream, it does support chinook *rearing*, as well as year-round habitat for redband, steelhead and bull trout. Moreover, the quality of Desolation Creek's water affects downstream habitat in the North Fork and mainstem of the John Day River.

Terrestrial Wildlife

Habitat

Approximately 9 percent of the Desolation watershed is included in Management Areas having specific emphasis on habitats for terrestrial wildlife, including Management Areas C1-Dedicated Old Growth (1,947 ac; 2%), C2-Managed Old Growth (1,043 ac; 1%), C3-Big Game Winter Range (3,894 ac; 5%), C4-Wildlife Habitat (171 ac; <1%), and C5-Riparian (165 ac; <1%).

Habitats in the Desolation watershed range from subalpine forest, sheer rock faces and talus slopes at the upper elevations, through mid-elevation stands of true firs and mixed conifers to open pine stands and rocky scablands in the lower portion of the drainage. An abundance of water-influenced habitats; stream corridors, seeps, wet meadows, and occasional aspen stands, make the Desolation drainage especially valuable to terrestrial vertebrates. Desolation Meadows provides an uncommonly large expanse of wet meadow habitat for this area of the Blue Mountains.

Management practices (timber harvest, grazing, fire suppression, etc.) over the past 50 years, along with natural disturbances, have contributed to changes in forest structure and composition. Resultant changes in habitat quality and quantity include reductions in habitat patch size, distribution and connectivity.
Late/old forest structure is almost gone.

Dead standing tree and down wood densities vary across the landscape. Densities range from very high in areas of insect or fire-induced mortality, to very low in the intensively-managed ponderosa pine stands in the lower drainage (mostly private).

The Desolation drainage provides extensive areas of habitat for Rocky Mountain elk, one of the Forest's Management Indicator Species. In the lower drainage, Case Ridge and Onion Flats provide important winter forage for large numbers of both elk and mule deer. Sharp's Ridge, which forms the southwestern boundary of the Analysis area, is a major migratory corridor for elk and deer in their seasonal movements between winter and summer ranges. Winter road closures and forage fertilization in high-use areas have enhanced the quantity and quality of winter range habitat. Calving habitat within the drainage is found in areas that provide abundant cover and forage. Numerous springs, seeps and wet meadows provide critical islands of green forage during the dry late summer/early fall months.

Approximately 11 percent of the watershed was burned by wildfire in 1996, changing the configuration and distribution of habitats. Some old forest stands, mostly in the South Fork Desolation drainage, were lost in the 1996 fires. While some areas within the fire boundary experienced stand-replacement fire, other areas were effectively underburned, and many islands of unburned, green forest remain. Expected changes in habitat composition and use resulting from wildfire are discussed in the Current Conditions section.

Species

A wide variety of terrestrial wildlife species occurs in the Desolation analysis area. Approximately 192 species of terrestrial vertebrates have the potential to occur within the drainage, including 5 amphibians, 7 reptiles, 122 birds, and 58 mammals (see Wildlife Specialist Report in the Appendix for a complete species list).

Approximately 47 percent of the bird species that nest within the drainage are Neotropical Migrants (species that winter in Central or south America). Several species of raptors, including the goshawk and great gray owl, occur in the drainage. Osprey nest in large snags along Desolation Creek.

Forest carnivores, including cougar, black bear, bobcat, coyote and marten, are present. Winter tracking surveys have not resulted in location of lynx or wolverine within the Desolation drainage; however, wolverine have recently been confirmed on the District (see TES discussion below).

Management Indicator Species

All Forest Management Indicator Species (MIS) (pileated woodpecker, pine marten, northern three-toed woodpecker, Rocky Mountain elk, and primary cavity excavators) have been observed in the Desolation watershed.

Threatened, Endangered, and Sensitive Species

One Threatened and one Endangered species have the potential to occur in the Desolation area: the bald eagle and the peregrine falcon. The area supports foraging habitat, as well as limited areas of suitable nesting habitat for the peregrine falcon. Bald eagles are common winter residents along Desolation Creek; nesting habitat is considered marginal.

The Region 6, Regional Forester's Sensitive Species includes several species which are known or have the potential to occur in the Desolation area (Table 9). A wolverine was recently observed in the nearby North Fork John Day Wilderness (Michael McVeigh, NFJD R.D., July, 1998). Habitat capable of supporting lynx (proposed for Threatened and Endangered Species listing) is present in the Desolation watershed. No tracks or observations of lynx have been recorded in the drainage, however, there have been sightings to the south of the Desolation drainage on the neighboring Malheur National Forest.

Table 9. Threatened, Endangered and Sensitive Species with potential to occur in the Desolation Analysis Area.

SPECIES	U.S. FISH AND WILDLIFE SERVICE	R-6 REGIONAL FORESTER'S SENSITIVE	STATE STATUS (OREGON)
western toad			Sensitive-Vulnerable
Columbia spotted frog	Candidate		Sensitive-Undetermined
tailed frog			Sensitive-Vulnerable
bald eagle	Threatened	Sensitive	Threatened
peregrine falcon	Threatened	Sensitive	Endangered
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

Heritage Resources

Archaeological

American Indian artifacts occur in low density throughout the Desolation Watershed. Lithic artifacts found within the watershed include scrapers and projectile points, as well as a full range of stone flakes and cores. No artifact class is well represented in the watershed. No dense scatters of lithics have been noted in the watershed, with only one known Native American site having greater than 10 artifacts. The types and distribution of lithic artifacts fit within the patterns of hunting deposits from other areas, although none of the located sites are large enough to make definitive statements as to their function. No ground stone was found, although various plant processing activities would have been performed in conjunction with game procurement. No evidence indicates the area was inhabited on more than a seasonal basis.

Time relevant artifacts found thus far in the watershed indicate that the uplands were probably not occupied before the Middle Holocene. Based on the few time-marking projectile points identified, the heaviest use of the area occurred from approximately 4500 to 500 years ago.

Historical

Historic features and isolates within the Desolation Watershed are representative of many key themes in the region's history. Features relating to gold mining are the most heavily represented site type. In some cases, decades of historic use have resulted in superimposed features. Stock raising has been a longstanding activity in the area. Various U.S. Forest Service administrative sites are present, ranging from guard stations to telecommunications lines. Hunting camps are common in the area.

Recreation/Wilderness

Recreation

The analysis area is located in a relatively remote yet roaded portion of the North Fork John Day Ranger District. Recreation Opportunity Spectrum (ROS) categories include "Semi-Primitive Motorized", "Roaded Natural', "Roaded Modified", and "Semi-Primitive Non-Motorized".

A wide diversity of recreation activities such as snowmobiling, horseback riding, hiking, mountain biking, motorcycle/all terrain vehicle trail riding, hunting, fishing, and camping occur in this area. Welch Creek Campground/Trailhead serves as the primary developed camping and picnicking location during the summer months. This campground has five individual/group campsites with an estimated 2500 RVDs (Recreational Visitor Days) per year.

A portion of the Vinegar Hill-Indian Rock Scenic Area is located within the watershed.

Wilderness

A small area (777 acres) on the northeast boundary of the Desolation Watershed is within the North Fork John Day Wilderness.

Wild and Scenic Rivers

In 1996, the Umatilla National Forest completed a Wild and Scenic River eligibility determination for a number of rivers and streams. The eligibility of the rivers as a Wild and Scenic River was determined under the provisions found in Section 5(d) of the Wild and Scenic Rivers Act. Desolation and South Fork Desolation Creeks were found to be eligible. The Forest grouped the eligible streams into river systems for a suitability study. Desolation, including both South Fork and North Fork, is one of the river systems. The outstanding remarkable values identified for the Desolation System (headwaters of North Fork and South Fork Desolation to North Fork John Day River) are: fisheries, wildlife, recreation, botanical/ecological, and hydrologic. River segments found eligible are classified as either Wild, Scenic or Recreational, based on the level of development and access in the river corridor. The mainstem, north and south forks of Desolation Creek were found to meet minimum eligibility requirements in various classifications (Table 10).

Table 10. Wild and Scenic Rivers Classification Analysis Summary - Desolation Creek

ATTRIBUTE	SEGMENT 1	SEGMENT 2	SEGMENT 3	SEGMENT 4
Water Resource Development	Free of impoundment	Free of impoundment	Free of impoundment	Free of impoundment
Shoreline Development	Essentially primitive. Little or no evidence of human activity	Substantial evidence of human activity.	Evidence of timber harvest; forest appears near natural from riverbank	Some development. Substantial evidence of human activity.
Accessibility	Generally inaccessible except by trail.	Accessible in places by road. Roads generally inconspicuous.	Accessible in places by road.	Readily accessible by road.
Water Quality	Meets or exceeds federal criteria or approved state standards; waters unpolluted.	Meets or exceeds federal criteria or approved state standards; waters unpolluted.	Meets or exceeds federal criteria or approved state standards; waters unpolluted.	Meets or exceeds federal criteria or approved state standards; waters unpolluted.
Classification	**Wild**	**Recreation**	**Scenic**	**Recreation**

Administrative Sites

Two guard stations are located within the watershed. The Battle Creek Guard Station has been renovated through the cooperative efforts of the Desolation Riders. The Desolation Riders have an agreement with the Forest Service to use Battle Creek Guard Station while working on trails. Desolation Guard Station has received some maintenance work through the efforts of the Sumpter Snowmobile Club.

An 80-foot lookout tower is located on Desolation Butte. Visitors are allowed to climb the lookout when it is staffed.

Minerals

The North Fork John Day Ranger District encompasses 661 claims filed within the boundaries of the district. However, only about 40 claims have approved plans of operation that grant them authority to extract minerals. The remaining claims are either inactive or only involved with exploration and testing. Placer and lode claims are the two primary forms of mining activity on the North Fork John Day Ranger District. Most of the claims are recognizable visually with structures, equipment, adits, settling ponds, stamp mills, living quarters or other disturbances. Some claims have no trace of activity. As some claims become active, others are in the process of reclamation, therefore, the number of claims fluctuates from season to season. Moderate levels of activity have been observed in previous years, but due to increasing operation costs, it has become more difficult for many claim holders to continue operations. Substantial levels of activity exist on privately owned lands.

Evidence of historic placer mining is found in several areas of the Desolation drainage, especially in the Junkens Creek, Welch Creek, and Skinner Creek areas. The Donaldson Mine (T9S R34E, Section 30) in the South Fork Desolation drainage is still shown on the Umatilla National Forest Visitor Map but has been inactive for several decades. One active mining claim and three abandoned mines are located within the watershed.

Rangeland Resources

While the term "rangelands" may be interpreted to mean grasslands, shrublands or high desert (at least in Oregon), the term "Rangeland Resources", as used in this document, applies primarily to the forage resources available to domestic livestock. In Desolation, the bulk of these resources are found in forested settings. The Desolation drainage supports approximately 53,580 acres of useable forage for domestic livestock (and wild ungulates), and includes upland forests, wet meadows and riparian areas, and some areas of open grass/scabland (Table 11).

The Desolation Watershed contains portions of two grazing allotments for domestic cattle that are administered by the Umatilla National Forest: Central Desolation Cattle Allotment and Indian Creek Sheep Allotment. Acres by allotment within the watershed are shown in the following table.

Table 11. Range Allotment Acres in the Desolation Watershed.

RANGE ALLOTMENT/PASTURE	TOTAL ACRES	WITHIN DESOLATION WATERSHED
Central Desolation Cattle/Deep Canyon	3,765	371
Central Desolation Cattle/Case	1,528	56
Central Desolation Cattle/Outlaw	5,339	975
Central Desolation Cattle/Ridge	816	123
Central Desolation Cattle/Turner	5,561	2,773
Indian Creek Cattle/Bully Creek	18,541	6,620
Indian Creek Cattle/Indian Creek	21,058	5,479
Indian Creek Cattle/Battle Creek	24,069	20,178
Indian Creek Cattle/Meadow	18,338	17,006
TOTAL	99,015	53,581

II. Issues and Key Questions

Identification of issues and key questions is the second step in the six-step process for ecosystem analysis at the watershed scale. The purpose of step 2 is to focus the analysis on key elements of the ecosystem that are most relevant to the management questions and objectives, human values, or resource conditions within the watershed. Key questions are formulated from indicators commonly used to measure or interpret the key ecosystem elements (Regional Ecosystem Office 1995). Key questions were used to focus the analysis. While answers to key questions are not always stated as such, and are not contained in a single section, all questions are addressed at some point in the analysis.

Water Quality and Fisheries

Water Quality

Recognized beneficial uses in the John Day Basin that occur in the Desolation watershed are: public and private domestic water supply, livestock watering, anadromous fish passage, salmonid fish rearing and spawning, resident fish and aquatic life, wildlife and hunting, water contact recreation, and aesthetic quality.

Past and current land uses and recent extreme events (fire and storms) have altered the physical integrity in the watershed to the extent that some upland areas are experiencing elevated erosion levels. Streams within the watershed are experiencing increased sediment loads and warm temperatures in the late summer; and channel adjustments are occurring. Efforts to improve aquatic habitat by constructing artificial instream structures on main Desolation Creek and Kelsay Creek have, to some extent, improved physical aquatic habitat. However, in some cases, instream structures are accelerating streambank erosion.

The goal of water quality standards is to establish thresholds of beneficial use support. Some standards are numeric, such as water temperature (64° F general, 55° F chinook salmon spawning, and 50° F bull trout), while others, such as sediment are narrative (“deleterious amounts”). Standards that apply to the Desolation watershed include temperature, sediment, habitat, and flow.

Desolation Creek has been identified by the state as not meeting water temperature standards (from mouth to headwaters) and is listed on Oregon’s 1998 303(d) list of Water Quality Limited streams for water temperature (bull trout). In addition, Wild and Scenic Rivers eligibility includes a water quality criterion of meeting or exceeding state standards.

Thus, the primary water quality issues in the Desolation drainage are elevated water temperatures, increased sediment loads, and channel instability.

Key Questions

1. What are the principle physical characteristics of the Desolation watershed, and how are they related to erosion processes, stream conditions, and water quality?

2. How are past and current land uses influencing background erosion, sediment, channel morphology, and water quality?

3. What are the combined effects of recent fires and precipitation events, together with land uses, on erosion processes, stream conditions, and water quality?

4. What management actions can be taken to offset adverse cumulative effects and improve watershed conditions?

Fisheries

As mentioned previously, Desolation Creek hosts six species of salmonids. Four are listed as Sensitive Species by the Regional Forester, and five are ICBEMP Key Salmonids. One species (bull trout) has been listed under the Endangered Species Act (ESA) as Threatened, and one (steelhead) is proposed for listing as Threatened. In addition to the native species, Desolation Creek also contains exotic brook trout and westslope cutthroat trout. Westslope cutthroat trout are probably exotic to this watershed, but are also an ICBEMP Key Salmonid. The Umatilla National Forest's Land and Resource Management Plan recognizes the importance of Desolation Creek's fisheries resource by classifying nearly half of the watershed as C-7, Special Fish Management Area (Figure 3).

The presence of ESA Threatened and Proposed listed species, and USFS Sensitive species predetermines that fisheries will be an issue in Desolation Creek watershed. Furthermore, biological, environmental, and Tribal interests in the status of native, wild fish, and the status of chinook salmon throughout the Columbia Basin assure that the status of chinook salmon will be an issue in the North Fork John Day Basin (Huntington et al. 1996, Confederated Tribes of the Umatilla Indian Reservation, 1995).

Other professionals familiar with the area (USFS, ODFW, CTUIR, Warm Springs Tribes) support fisheries as an issue. Responses of fisheries professionals contacted were in the context of Desolation Creek's setting in the John Day River basin. That is to say, the identified issues (particularly the first three) apply to the entire John Day basin, including Desolation Creek.

The fisheries and aquatic habitat issues of greatest concern are:

1. Status of the native wild chinook salmon runs. (All surveyed parties agreed that this was the number one biological issue.)

2. Status of the steelhead run, because of their cultural and nutritional importance to the tribes. (Both tribal biologists rated this as the #2 issue)

3. Status of bull trout. (In discussions by phone, ODFW considered this as #2 issue, because of their reduced range and numbers and potential for hybridization with introduced brook trout. Warm Springs gave this as #3 because of the bull trout's function as an indicator of water quality.)

4. Status of Desolation Creek on the State 303(d) list as issue number four (Warm Springs fisheries biologist).

5. Presence of exotic fish species in some streams of the watershed, particularly brook trout, and their potential to hybridize with bull trout.

6. Aquatic habitat quality, especially as it relates to chinook and bull trout. ODFW personnel expressed particular concern over the quality of the aquatic habitat on private lands in the downstream reaches of Desolation Creek.

7. Gully and channel erosion in Desolation Meadows, which affects water quality and aquatic habitat.

8. Management of Riparian Habitat Conservation Areas (RHCAs). RHCA management can profoundly affect water quality, aquatic habitat, economics, and complexity of forest management.

Even though Desolation Creek is not now, and may never have been, an important chinook spawning stream, most of the fisheries professionals contacted considered the status of chinook to be the most important issue in an analysis of Desolation Creek. This probably is a result of its location within the North Fork John Day River drainage and the special value many biologists, fishermen, and tribal members place on the John Day River chinook salmon population.

However, because of its relatively small size, Desolation Creek may be more important as a bull trout refuge and for steelhead production than for chinook salmon spawning. The primary effect of Desolation Creek on the status of chinook in the John Day Basin would be as rearing habitat for juveniles spawned elsewhere, and to a lesser extent through the quality of the water it contributes to the system.

Key Questions

The following key questions were derived from the above issues.

1. What is the present status of bull trout and the salmon and steelhead runs in the John Day River Basin, and in Desolation Creek?

2. What is the quality of the aquatic habitat in the Desolation Creek watershed and how does it affect the status of the native salmonids in the watershed?

3. How have National Forest Management and other human activities affected fish populations and the quality of aquatic habitat in the Desolation Creek watershed?

4. What adjustments to management protocols could best protect and improve the quality of the aquatic habitat in the Desolation Creek watershed?

5. What additional information is needed in order to most effectively manage fish habitat in the Desolation watershed?

Vegetation Sustainability

A recent survey conducted by Oregon State University found that residents of the Blue Mountains perceive their forests to be unhealthy (Shindler and Reed 1996). In response to high levels of concern about forest health, both from the scientific community and the general public, the primary issue used in this analysis was **forest sustainability**.

The term *Sustainable Forest* as used in this document implies forest *ecosystems* (as opposed to simply the coniferous tree overstory) that maintain their complexity while providing for human needs (O'Laughlin and others 1994). This means that sustainable forests contain insects, pathogens, parasites, and other tree-killing agents, but dead and dying trees are not so abundant as to jeopardize the long-term survival of the forest or its dependent flora and fauna.

Key Questions

The upland forest vegetation (i.e. trees) analysis was designed to respond to these key questions:

1. How do current forest conditions compare to those that existed historically?

2. Are current forest conditions considered to be ecologically sustainable over the long term?

3. If current forest conditions are considered to be unsustainable, how could they be changed in order to create a more sustainable situation?

4. How have disturbance processes shaped existing forest conditions, and what role might we expect them to play in the future?

Understory and Non-Forest Botanical Resources

The issue of vegetation sustainability pertains to non-forest plants as well as to forest overstory vegetation (trees). For example, not much is known about the biology of *Botrychium spp.* The plants are very small and difficult to find. Some species are rare, or may even be unique to the Desolation watershed.

The invasion of noxious weeds, as well as introduced grasses, threatens the sustainability of native, non-forest species.

The increasing awareness of and demand for native plants for medicinal purposes has the potential of greatly impacting plants with medicinal properties, and could threaten their sustainability.

Key Questions

The following questions were addressed in analysis of the botanical resources (excluding forest tree species) in the Desolation Watershed:

Floristic Biodiversity

1. What vascular plant species presently occur in the Desolation Creek Analysis Area?

2. What is the floristic richness of the Desolation Creek Analysis Area in comparison with the rest of the North Fork John Day Ranger District, and within the Umatilla National Forest?

3. 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?

Sensitive Species

1. What are the occurrences of historically-listed or presently-listed sensitive plant species within the Desolation Creek Analysis Area?

2. How might management activities occurring in the Analysis Area adversely impact plant species with an historic track of sensitivity?

3. What other plant species might be "at risk" in the Analysis Area?

Noxious Weeds

1. What noxious weeds occur in the Analysis Area, and what are their affinities for ecological settings?

Culturally and Economically Significant Plants

1. What are the culturally significant plant species in 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?

2. What plant species may come under harvesting pressure as "Special Forest Products"?

3. What native plant species could be important for revegetation projects within the watershed?

Terrestrial Vertebrate Biodiversity

Wildlife issues in the Desolation Watershed center on the availability, distribution and condition of important habitat types, the effects of management and recent fires on those habitats, and the resultant status of wildlife populations.

Key Questions

Habitat Quantity and Quality

1. How have important habitat types, including late/old coniferous forest, riparian hardwood forest (aspen and cottonwood) and wet meadows, changed since historical times in terms of patch size, distribution, and connectivity?

2. How has human manipulation of the Desolation landscape affected wildlife habitat quality?

3. How might habitat conditions and patterns be restored to be more "ecologically sustainable", keeping in mind the community of terrestrial vertebrates that currently occupies the watershed?

4. What was the net effect of the Bull and Summit fires on habitats of terrestrial vertebrates within the watershed? Are there habitats in need of restoration and/or protection-particularly in light of the 1996 fires?

Terrestrial Vertebrate Populations

1. What terrestrial vertebrate species occur in the watershed?

2. How has human manipulation of the Desolation landscape affected wildlife populations?

3. How does wildlife community composition relate to habitat composition and availability?

4. Are there species at risk of "local extirpation? If so, can risks be lessened through management?

5. What is the status of Management Indicator Species/Sensitive/Listed Species within the watershed?

6. What is the level of risk to terrestrial vertebrates (and their habitats) of additional large, stand-replacement fires?

III. Current Conditions

Description of current conditions is the third step in the six-step process for ecosystem analysis at the watershed scale. The purpose of step 3 is to develop information (more detailed than was done for characterization in step 1) relevant to the issues and key questions identified in step 2. The current range, distribution, and condition of key ecosystem elements are documented in this step (Regional Ecosystem Office 1995).

Soils and Geology

Erosion/Mass Wasting

Table 12, Geologic Hazard, lists (by USGS quad) areas that have been identified in the Umatilla National Forest Soil Resource Inventory (SRI) as areas of higher potential for unstable soils or landforms. Unstable sites are either the geologic landslide unit identified as 'Qls', or 'SRI slump' which are identified with spot symbols on the maps. This information is not yet available as a GIS layer. Therefore, the total acres indicated are for the entire quad and may not necessarily be within the Desolation boundary. Individual quads may be viewed in hard copy form in order to locate specific areas. The 'SRI slump' locations may be also found in the SRI on the appropriate map.

Table 12. Geologic Hazard Acreage

QUAD	TOTAL ACRES	LOCATION	TYPE
72	3241	*	Qls SRI slump
73	3332	*	QLS Sri slump
74	407	*	Sri slump
80	214	*	Sri slump
81	1201	*	Qls Sri slump
82	499	*	Qls
84	-	*	
85	32	*	Sri slump

**Geologic hazard maps are not in the GIS system: Acre totals are for entire quad, not just within Desolation. Specific locations can be viewed manually or after input into GIS.*

On a drainage-wide basis, the Desolation watershed is has somewhat lower erosion potential largely due to the preponderance of gentle slopes. Area tallies of Soil Resource Inventory (SRI) interpretation-based erosion potentials were not included in this document. Mapping of the Desolation watershed via the Ecological Unit Inventory for the Blue Mountains is largely complete and is being processed. As this information becomes available, more accurate assessment of erosion potentials will be possible using the new data and mapping. This will be more useful at a project-level analysis. The dominant erosional process within the Desolation drainage is overland surface erosion. Mass wasting activity is evident in some areas due to the young age of the geologic units and unconsolidated materials. The large unit of landslide and debris flow mapped in the lower watershed are most unstable.

Much of the current erosion is a result of the various wildfires in the drainage. Areas of moderate to high fire severity are most susceptible to intense rainstorm events and spring runoff. Isolated summer downpours have initiated some overland flow and surface erosion within the fire areas. Areas which have not received these intense storms have begun vegetative recovery with little erosion. Large-scale fires (like Summit) have the greatest potential to initiate slumping or landslides. There are some smaller areas of slumping mapped as part of the Umatilla SRI. These geologic landslide areas have a higher likelihood of (at least) small-scale mass failures when subjected to large disturbances such as fire or major storms, or management activity.

Field observations have determined that construction of transportation systems (roads and trails) for timber management and recreation activities have caused erosion to occur. Little accelerated erosion has been observed outside of transportation networks. However slight, the erosion resulting from transportation systems within the drainage adds to the erosion caused by mining, grazing, fires, etc., to produce a cumulative effect of increased erosion (levels). This is discussed further in the Watershed hydrology section.

The prominence of volcanic ash surfaces, other medium textured volcanic-source soil surfaces, and unconsolidated materials indicates relatively higher erosion potentials on the steeper slopes in the drainage. The large areas of gentler slopes helps reduce overall erosion risk, although even gentle slopes can erode easily in many of these materials.

Productivity

A way of assessing comparative basic productivity levels by soil type and plant association types is available for project needs but is not included in this document. Generally, some of the more productive sites on the south end of the Umatilla are found in the Desolation drainage.

Most of the management activity within the drainage that has had an effect on soil productivity are related to road building and harvest operations. The private land in the watershed appears to have had more impacts but there is little hard data to quantify observable effects. The sections on harvest activity and roads provide a indicator of relative effects to productive potentials.

Effects from fire also have affected productivity potentials in the watershed, at least for the short term. Nutrient and soil losses due to increased erosion levels, and areas of moderate to high fire intensity (severity), are assumed for the fire areas identified and discussed in the Current Conditions section. Short-term release of otherwise unavailable nutrients has allowed considerable increases in grass and forb growth in the fire areas, and should provide an enhanced nutritional environment for tree seedlings planted or sprouting shortly after the fire.

Watershed Hydrology

Past and present management activities and recent watershed-scale disturbances (fire and storms) are influencing runoff and erosion, channel conditions, and water quality to the extent that many miles of Desolation Creek and its tributaries are not in optimum condition. Observed impacts include accelerated upland erosion in some of the burned areas and on roads, and channel erosion especially in grazed meadows. Measured impacts include elevated water temperatures from the North Fork-South confluence to the mouth, including most tributaries. Some effects may be occurring because of past activities, for example, beaver trapping in the early 19th century and livestock grazing, beginning in the late 19th century and continuing to the present. Some effects are the result of ongoing activities, specifically the road system. Recent wildfire and storms are also contributing to watershed impairment.

Management Activities and Fire Effects

Current levels of timber harvest and roads, when interpreted with field inventories and water quality monitoring, are reasonable indicators of watershed and stream conditions. High levels of harvest and roads or moderate levels in sensitive areas increase the likelihood of accelerated erosion, change in peak flows, channel adjustments, and adverse impacts to water quality and aquatic habitat. Recent wildfires also have the potential to impact watershed conditions; several subwatersheds were burned in August of 1996 (Table 13, Figure 18).

Road density is a measure of the extent of roads in an area; all roads on the Forest transportation management system were included in the analysis. Roads have several impacts on watershed function; including reduced infiltration, increased runoff and erosion, extension of the channel network (increasing the "efficiency" of watershed runoff), reduced vegetative cover in streamside areas, and increased sediment delivered to stream channels. Road densities in Desolation subwatersheds range from 0.1 mi/mi^2 in South Fork Desolation to 2.9 mi/mi^2 in Battle Creek. All Desolation subwatersheds have "high" densities (1.7 to 4.7 mi/mi^2, as defined in the ICBEMP Status of Scientific Findings) except for Howard and South Fork Desolation (Table 13).

Percent Equivalent Clearcut Acres (ECA) is a measure of the extent of harvested openings in a watershed, at some level above which increases in water yields and peak flows would be expected (Table 13). The procedure accounts for harvest method and vegetative recovery typical in the Blue Mountains (Ager and Clifton, 1995). The level of percent ECA above which measurable increases in flows will occur has not been established in the Desolation watershed; however, based on an administrative study in a nearby watershed (upper Umatilla), current harvest levels would not be expected to cause increased peak flows (Helvey and Fowler, 1996).

Wildfires that occurred in 1996 have increased the potential for peak flow increases and area susceptible to accelerated erosion in the Howard, North Fork Desolation, and South Fork Desolation watersheds. Wildfire impacts on streamflows, erosion, water temperature, and sediment have been previously documented (Helvey, 1979, Helvey, 1980, Beschta, 1987). The majority (70%) of the South Fork Desolation subwatershed burned in a low-moderate intensity fire. Most of the burn was of a low intensity which is a "cooler" ground fire that leaves most of the organic matter in place. Peak flow increases would be more likely where areas burned at moderate or high intensity. Fifteen percent of the South Fork Desolation watershed experienced moderate burn intensity; these acres are most likely to exhibit increased streamflows as a result of 1996 wild fire.

Intense spring and summer storms struck over previously burned areas in the Desolation watershed in 1998. Field observations indicate accelerated upland erosion (sheetwash and rill) in areas of high precipitation intensity and low ground cover. For example, fine sediment from hillslopes was delivered to the upper South Fork Desolation Creek meadows, and transported downstream. Channel changes from recent high flows were observed through the South Fork Desolation to the mouth. Other fire-related effects reflect past fire suppression activities, actions taken to put out the fire, and post-fire salvage operations. The greatest impacts usually result from mechanical fireline construction and ground-based logging.

No data were available for the four analysis subwatersheds in private ownership; results are valid only for National Forest lands (Table 13).

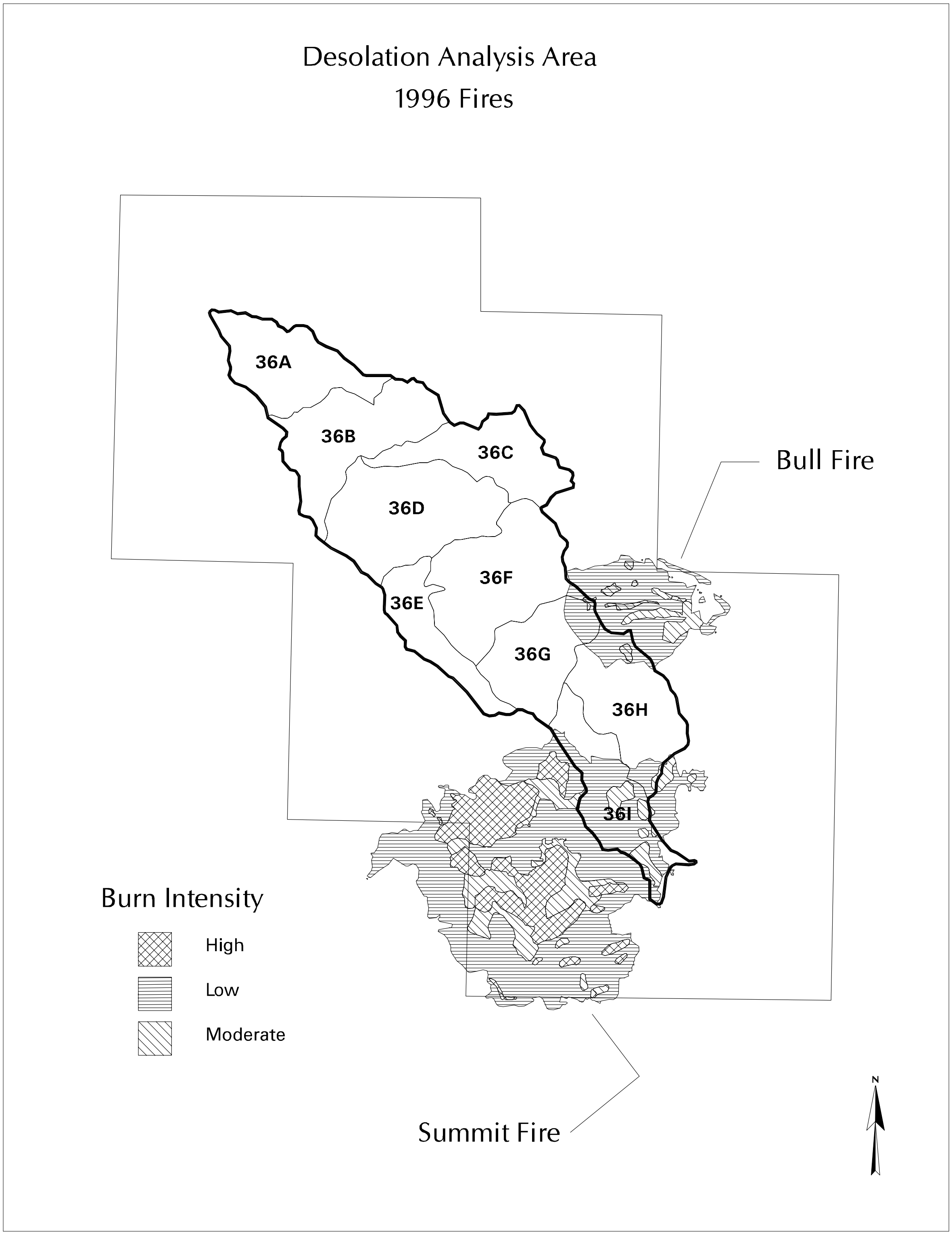
Table 13. National Forest Roads, Harvest, and Recent Fires by Subwatershed**.**

Subwatershed	SWS Area (Mi^2)	Road Miles[2]	Road Density (Mi/Mi^2)	NF Forested Acres[2]	ECA Acres	ECA %	Percent SWS Burned
Lower Desolation [1](36A)	11	18.5	1.7	5125	8	0.2	0
Wassen [1](36B)	14	30.4	2.2	7978	136	1.7	0
Kelsay [1](36C)	10	27.4	2.7	6142	395	6.4	0
Bruin (36D)	17	40.4	2.4	9567	485	5.1	0
Junkens/Beeman (36E)	7	13.2	1.9	3571	191	5.4	0
Battle (36F)	16	47.1	2.9	9685	813	8.4	1
Howard [3](36G)	10	13.7	1.4	6119	116	1.9	13
North Fork Desolation [3](36H)	13	36.5	2.8	7316	350	4.8	20
South Fork Desolation [3](36I)	11	1.5	0.1	5781	0	0.0	70
TOTALS	109	228.8	2.1				

Notes:
[1] subwatersheds with private ownership; data only for publicly-managed lands.
[2] Road miles are publicly-owned roads; Forested acres are National Forest potentially forested.
[3] Subwatersheds with area burned in 1996 Bull and Summit fires.

Other management activities in Desolation watershed include livestock grazing, mining, and recreation. Of all management activities, grazing has the widest possible range of watershed effects. These include upland soil compaction and displacement, physical damage to streambanks from trampling, loss or reduction in vegetation from herbivory, and increases in nutrients and bacteria from animal wastes. Cattle grazing has been ongoing in the Desolation watershed since the late 19th century. Forest Service records indicate cattle numbers peaked in the 1950's and have declined since then. There are no records available on sheep use but their numbers probably peaked earlier in the century as cattle moved to dominance. Overall, current conditions in the watershed reflect present and past livestock grazing use. Grazing impacts have been observed and monitored at key areas in the Desolation watershed.

Figure 18. Area of 1996 wildfires in the Desolation drainage.



The BLM-Forest Service "Proper Functioning Condition" assessment was conducted by Ranger District personnel on five stream reaches in 1995 (Table 14). Observer notes indicate some streams had evidence of grazing, logging, and road impacts.

Table 14. "Proper Functioning Condition" riparian survey results (1995).

		RATING				
STREAM NAME	**SURVEY REACH (MI)**	**PFC**	**FAR**	**NF**	**TREND***	**ACTIVITY/ IMPACT**
Battle	0.5	X			S	G/L
Kelsay	0.5		X		D	G/M;L/L
Kelsay	0.2		X		D	G/M;R/M
L Kelsay	4.0	X			S	G/L;L/L;R/L
North Fork Desolation	0.3	X			S	G/M

* Rating: PFC=Proper Functioning Condition; FAR=Functioning at Risk; NF=Not functioning
**Trend Code: S=Stable; I=Improving; D=Degrading
***Activity Codes: G=Grazing, L=Logging, R=Roads / Impact Codes: L=Low, M=Moderate, H=High

Mining is a lesser and more localized activity in Desolation watershed. Mining activities have been ongoing in the watershed on a limited basis, with localized effects, since the 1800's. Currently, one active lode mine and three inactive placer mines are located within the watershed. Several other lode and placer mines occur on private lands within the watershed; their status is unknown. Placer mining typically disturbs stream channel deposits, leaving waste rock in mounds, as tailings. Mining has occurred in subwatersheds 36E Junkens/Beeman; 36F Battle; 36H North Fork Desolation; and, 36I South Fork Desolation (private, headwaters).

Recreation uses involve developed and dispersed camping, and motorized and nonmotorized trails use. These activities have localized effects which can include upland and streambank compaction, and vegetation alteration. Increased runoff and erosion is occurring on some sections of trail and campsites. Trails in riparian areas are also problem sites; minor shade loss in the trail right-of-way as well as increased erosion and sediment delivered to streams may occur.

Several aquatic habitat enhancement projects, typically log-rock weirs, were installed on Desolation Creek between 1985 and 1989, and on Kelsay Creek in 1996/1997 to improve pool habitat for late summer fish survival. Field surveys in 1997 found some of the structures to be impairing channel and riparian function by accelerating bank erosion.

Processes

Watershed-scale disturbances, including recent fire and floods are influencing runoff, erosion, and channel processes; land uses are, in some areas, accelerating impacts. Increased water yields and peak flows accelerate erosion rates and delivery of sediment to stream channels. Streams adjust to changes in streamflow and sediment loads by cutting and filling. The South Fork Desolation is an example of a stream system responding to a watershed-scale disturbance (the Summit Fire) in the absence of land use impacts (Table 15). The North Fork Desolation Creek has multiple land use impacts and watershed-scale disturbance. The North Fork Desolation channel in the meadow downcut sometime in the past 50 years and has actively-eroding banks. Increased peak flows from cumulative effects could accelerate bank erosion.

Table 15. Desolation Subwatersheds by Burn Intensity (BAER).

WATERSHED	SWS	TOTAL ACRES IN SWS	LOW BURN INTENSITY ACRES	MOD. BURN INTENSITY ACRES	HIGH BURN INTENSITY ACRES	TOTAL BURNED ACRES	% BURNED
Lower Desolation	36A	7,156	-----	-----	-----	-----	-----
Lower Desln / Wassen	36B	8,731	-----	-----	-----	-----	-----
Kelsay	36C	6,546	-----	-----	-----	-----	-----
Middle Desln / Bruin	36D	10,815	-----	-----	-----	-----	-----
Junkens / Beeman	36E	4,455	-----	-----	-----	-----	-----
Upper Desln / Battle	36F	10,261	124	28	0	152	1.5
Upper Desln / Howard	36G	6,511	837	30	0	867	13.3
North Fork Desolation	36H	8,058	1,437	193	0	1,630	20.2
South Fork Desolation	36I	7,139	3,942	1,059	0	5,001	70.1
	TOTALS	69,672	6,340	1,310	0	7,650	11

Cumulative Effects

The combined effects of land uses and recent disturbance have increased upland erosion and sedimentation rates. Some stream reaches have unstable and eroding streambanks. Effects are most pronounced in areas previously overgrazed by livestock, adjacent to roads and at road-stream crossings, and in moderately burned areas that have experienced high intensity spring storms.

Cumulative impacts to water quality include elevated stream temperatures from loss of streamside shade, channel changes, and lowered baseflows. Overall, climatic and hydrologic conditions control water temperatures: maximum stream temperatures typically occur in August, during low flow when air temperatures are at maximum. Stream temperature monitoring on tributaries and the mainstem of Desolation Creek show maximum summer water temperatures ranging from 56 degrees Fahrenheit on Junkens Creek (1993) to 83 degrees Fahrenheit on Desolation near the mouth (1995). Junkens and South Fork Desolation are the coldest tributaries, Kelsay Creek is the warmest (Table 15). Desolation Creek at the mouth ranging from 68 to 80 degrees Fahrenheit. Desolation Creek does not appear to consistently contribute cooler water to the NFJD, but is likely to be influencing NFJD water temperatures. In 3 out of 4 years of monitoring, Desolation Creek contributed cooler water than Camas Creek, a major tributary downstream.

Table 16. Maximum Water Temperatures on the North Fork John Day River, Camas Creek, Desolation Creek, and Tributaries: Annual 7-Day Moving Average of the Daily Maximum (degrees Fahrenheit).

STATION	SWS	1992	1993	1994	1995	1996	1997
NFJD @ Big Cr			71	76		74	72
NFJD @ Camas Cr					72	76	
Camas Creek			74		77	78	78
Desolation near Mouth	36A		70	80	83	68	74
Kelsay @ FSB	36C	74	67	72	68	73	72
Kelsay above exclosure	36C				68	65	65
Kelsay @ 5505 road	36C	70	73				
Desolation @ ISCO	36D		69			73	73
Bruin @ mouth	36D		67		60		
Junkens @ mouth	36E		56	59		68	60
Battle @ mouth	36F		60	64	62	*	*
Sponge @ mouth	36F			70	65		
Howard @ mouth	36G		66	69	73		
North Fork Desolation @ mouth	36H		63	69	65		
North Fork Desolation below exclosure	36H				62	66	63
North Fork Desolation above exclosure	36H				59	62	*
South Fork Desolation @ mouth	36I		58	68	59	62	61

* sensor problems

Forest Overstory Vegetation

Forest Cover Types

This section describes forest cover types as they *currently exist on the landscape*, regardless of whether they represent the potential natural (“climax”) community or a seral stage resulting from wildfire, timber harvest, windstorms, or another disturbance.

Table 17 summarizes forest cover types for the Desolation ecosystem analysis area (data are current as of 1997 and reflect post-fire conditions for the Bull and Summit wildfire areas). The predominant forest cover type is grand fir (38% of the analysis area), followed by lodgepole pine (21%), Douglas-fir (12%), and subalpine fir (8%). Forests dominated by whitebark pine, western larch or western juniper are rare, occupying less than 3 percent of the analysis area in aggregate.

Table 17. Forest cover types of the Desolation ecosystem analysis area (1997).

CODE	COVER TYPE DESCRIPTION	ACRES	PERCENT
CA	Forests with a predominance of subalpine fir trees	5,667	8
CB	Forests with a predominance of whitebark pine trees	116	<1
CD	Forests with a predominance of Douglas-fir trees	8,203	12
CE	Forests with a predominance of Engelmann spruce trees	2,916	4
CJ	Forests with a predominance of western juniper trees	21	<1
CL	Forests with a predominance of lodgepole pine trees	14,598	21
CP	Forests with a predominance of ponderosa pine trees	3,902	6
CT	Forests with a predominance of western larch trees	1,501	2
CW	Forests with a predominance of grand fir trees	26,459	38
CX	Forests with a mixed composition; < 50% of one species	1,921	3
Other	Non-vegetated and non-forested cover types (see appendix 1)	4,232	6

Sources/Notes: Summarized from the 97veg database (see appendix 1 for more information). Acreage figures include private land located within the analysis area. Forest cover types are based on a plurality of stocking and are seldom pure – the grand fir type (CW), for example, has a predominance of grand fir trees (50% or more) but also contains minor proportions of ponderosa pine, Douglas-fir and other species.

The Desolation analysis area contains a relatively high proportion of forests dominated by Engelmann spruce and subalpine fir, which is unusual for the Umatilla National Forest. A large acreage of spruce-fir forest reflects the fact that about 20 percent of the Desolation area occurs above 6,000 feet, and those elevations typically support Engelmann spruce, subalpine fir, whitebark pine, and other species commonly found in the subalpine vegetation zone.

Canopy Cover

Very little of the Desolation analysis area has been recently examined using field surveys such as stand examinations. Consequently, quantitative data suitable for characterizing stand density (such as trees per acre or basal area per acre) is unavailable. Lacking these data, canopy cover values derived from interpretation of aerial photography were used for analyses that required information about stand density.

Table 18 summarizes existing canopy cover for forests of the Desolation ecosystem analysis area (data are current as of 1997 and reflect post-fire conditions for the Bull and Summit wildfire areas). The predominant situation is low-density forest (≤40% canopy cover; 48% of the analysis area), followed by moderate density (41-55% cover; 23%) and high density (56-70%; 19%). Very high density forest (>70% canopy cover) is rare, occupying only 3 percent of the analysis area.

Table 18. Forest canopy cover classes of the Desolation ecosystem analysis area (1997).

CODE	CANOPY COVER DESCRIPTION	ACRES	PERCENT
≤40	Live canopy (crown) cover of trees is 40 percent or less	33,668	48
41-55	Live canopy cover of trees is between 41 and 55 percent	16,190	23
56-70	Live canopy cover of trees is between 56 and 70 percent	13,142	19
>70	Live canopy cover of trees is greater than 70 percent	2,304	3
Other	Non-vegetated and non-forested cover types (see appendix 1)	4,232	6

Sources/Notes: Summarized from the 97veg database (see appendix 1 for more information). Acreage figures include private land located within the analysis area.

Forest Canopy Layers

Table 19 summarizes existing forest canopy layers for the Desolation ecosystem analysis area (data are current as of 1997 and reflect post-fire conditions for the Bull and Summit wildfire areas). The predominant situation is a two-layer stand structure (71% of the analysis area), followed by single-layer forest (19%) and a highly-complex layer structure (3 or more layers; 4%).

Table 19. Forest canopy layers of the Desolation ecosystem analysis area (1997).

CODE	CANOPY LAYER DESCRIPTION	ACRES	PERCENT
1	Live canopy (crown) cover of trees occurs in l layer (stratum)	13,467	19
2	Live canopy cover of trees occurs in 2 layers or strata	49,194	71
3	Live canopy cover of trees occurs in 3 or more layers or strata	2,643	4
Other	Non-vegetated and non-forested cover types (see appendix 1)	4,232	6

Sources/Notes: Summarized from the 97veg database (see appendix 1 for more information. Acreage figures include private land located within the analysis area.

Forest Size Classes

The Desolation analysis used size class definitions that reflect tree size (using diameter rather than height). Table 20 summarizes forest size classes for the Desolation ecosystem analysis area (data are current as of 1997 and reflect post-fire conditions for the Bull and Summit wildfire areas). It shows that the predominant overstory size class is small trees ranging from 9 to 15 inches in diameter (49% of the analysis area), followed by poles and small trees mixed (21%), and small trees ranging from 15 to 21 inches in diameter (10%). Forest overstories dominated by large or medium trees (those with diameters of 21 inches or more), or saplings (trees from 1 to 5 inches in diameter) are rare; each of those size classes occupies 1 percent or less of the Desolation area.

Table 20. Forest size classes of the Desolation ecosystem analysis area (1997).

CODE	SIZE CLASS DESCRIPTION	ACRES	PERCENT
1	Seedlings; trees less than 1 inch in diameter	1,559	2
2	Seedlings and saplings mixed	1,403	2
3	Saplings; trees from 1 to 4.9 inches in diameter	228	<1
4	Saplings and poles mixed	439	<1
5	Poles; trees from 5 to 8.9 inches in diameter	1,853	3
6	Poles and small trees mixed	14,625	21
77	Small trees; trees from 9 to 14.9 inches in diameter	34,317	49
88	Small trees; trees from 15 to 20.9 inches in diameter	7,035	10
8	Small trees and medium trees mixed	2,805	4
9	Medium trees from 21 to 31.9 inches in diameter	344	<1
10	Medium and large trees mixed	689	1
11	Large trees from 32 to 47.9 inches in diameter	7	<1
Other	Non-vegetated and non-forested cover types (see appendix 1)	4,232	6

Sources/Notes: Summarized from the 97veg database (see appendix 1 for more information). Acreage figures include private land located within the analysis area. Forest size classes are based on the predominant situation and are seldom pure – the pole size class (5), for example, has a predominance of pole-sized trees (50% or more) but may also contain minor proportions of other size classes. For multi-layered stands, this information pertains to the overstory layer (tallest stratum) only.

Forest Structural Stages

Table 21 summarizes forest structural stages for the Desolation ecosystem analysis area (data are current as of 1997 and reflect post-fire conditions for the Bull and Summit wildfire areas). The predominant structural stage is *stand initiation* (52% of the analysis area), followed by *young forest multi strata* (13%), *stem exclusion open canopy* (10%) and *understory reinitiation* (10%). Old forest structures (*old forest multi strata* or *old forest single stratum*) are rare, occupying one percent or less of the analysis area.

Table 21. Forest structural stages of the Desolation ecosystem analysis area (1997).

CODE	STRUCTURAL STAGE DESCRIPTION	ACRES	PERCENT
OFMS	Old Forest Multi Strata structural stage	781	1
OFSS	Old Forest Single Stratum structural stage	800	1
SECC	Stem Exclusion Closed Canopy structural stage	5,195	7
SEOC	Stem Exclusion Open Canopy structural stage	7,021	10
SI	Stand Initiation structural stage	35,944	52
UR	Understory Reinitiation structural stage	6,761	10
YFMS	Young Forest Multi Strata structural stage	8,802	13
Other	Non-vegetated and non-forested cover types (see appendix 1)	4,232	6

Sources/Notes: Summarized from the 97veg database (see appendix 1 for more information). Acreage figures include private land located within the analysis area. Veg Table 8 describes the forest structural stages.

Landscape Patches

Landscape patterns affect how living organisms use large land areas. Characteristics of landscape patterns, such as connectivity or the quality and quantity of edges between different landscape elements, can be measured and analyzed to reveal how well different plant and animal species may survive or move through an area. "FRAGSTATS," "UTOOLS" and other computer programs have been developed to aid in the analysis of landscape characteristics (Ager 1997, McGarigal and Marks 1995).

Due to time and computer constraints, it was not possible to complete a robust analysis of landscape patterns for the Desolation watershed. However, a rudimentary analysis was completed using the UTOOLS program (Ager 1997). For the Desolation analysis, two categories of forest vegetation were included in the analysis: cover types (which reflect plant composition at a broad scale) and structural stages (which represent how that composition is arranged in both a vertical and horizontal sense).

Table 22 summarizes patch characteristics for forest cover types and structural stages for the Desolation analysis area (data are current as of 1997 and reflect post-fire conditions for the Bull and Summit wildfires). Lodgepole pine has the most cover type patches in the Desolation landscape, followed by grand fir and then Douglas-fir. The largest patches are those comprised of *grand fir*; ranging in size from 3 to 15,475 acres, with an average patch size of 401 acres. *Grand fir forest* would be considered the matrix from a plant composition standpoint.

Table 22 also shows that the *stem exclusion open canopy* structural stage has the most patches in the Desolation watershed (excluding the non-forest patches (NF) that were ignored in terms of the structural stage analysis), followed by *stand initiation* and then *young forest multi strata*. The largest patches are those comprised of young, single-layer forest (*stand initiation*), range in size from 1 to 21,544 acres. Average patch size is 476 acres. Thus, *stand initiation* would be considered the matrix from a structural viewpoint.

Table 22. Patch analysis for the Desolation analysis area (1997 conditions**).**

PATCH TYPE	NUMBER OF PATCHES	MINIMUM PATCH SIZE	AVERAGE PATCH SIZE	MAXIMUM PATCH SIZE	TOTAL ACRES
Cover Types					
CA	28	1	192	3,119	5,667
CB	1	21	21	21	21
CD	63	3	130	997	8,203
CE	15	21	194	1,015	2,916
CJ	1	117	117	117	117
CL	77	1	189	3,792	14,598
CP	24	7	162	2,096	3,902
CT	41	4	36	246	1,501
CW	66	3	401	15,475	26,459
CX	15	23	128	453	1,921
Total	331				65,305
Structural Stages					
OFMS	14	1	56	252	781
OFSS	22	2	36	129	800
SECC	49	1	106	796	5,195
SEOC	100	1	70	1,305	7,021
SI	75	1	476	21,544	35,944
UR	35	2	193	2,344	6,761
YFMS	60	2	146	1,728	8,802
Total	503				65,305

Sources/Notes: Based on information contained in the 97veg database (see appendix 1 for more information), including private land located within the analysis area. Refer to Veg Table 5 for a description of the cover type codes; refer to Veg Table 9 for a description of the structural stage codes. Patches were calculated using the UTOOLS program (Ager 1997).

Forest Disturbances

Table 23 summarizes forest disturbances for the Desolation ecosystem analysis area (data are current as of 1997 and reflect post-fire conditions for the Bull and Summit wildfire areas). The predominant disturbances (totalling 55% of the watershed) have been associated with timber harvest – clearcuts (15% of the analysis area), partial cuts (16%, including sanitation/salvage), and thinnings (11%) could all be distinguished on recent aerial photography for the analysis area. Wildfire was also a common disturbance (13% of the analysis area). Although insects and diseases were not specifically noted, they have been important disturbance agents in the past. Some portion of the timber harvest occurred in response to insect or disease problems, such as removal of insect-killed trees (sanitation/salvage harvest).

Table 23. Forest disturbances of the Desolation ecosystem analysis area (1997).

CODE	DISTURBANCE DESCRIPTION	ACRES	PERCENT
CC	Recent clearcut timber harvest	1,943	3
CR	Old clearcut, now regenerated	8,256	12
FI	Evidence of recent fire	8,850	13
PC	Recent partial cutting timber harvest (selection, seed-tree, etc.)	2,283	3
PR	Old partial cut, now regenerated	8,187	12
SS	Evidence of sanitation/salvage timber harvest	848	1
TH	Evidence of a thinning silvicultural treatment	7,442	11
Blank	No discernible evidence of disturbance (on air photos)	27,495	40
Other	Non-vegetated and non-forested cover types (see appendix 1)	4,232	6

Sources/Notes: Summarized from the 97veg database (see appendix 1 for more information). Acreage figures include private land located within the analysis area.

Table 24 summarizes overstory mortality for the Desolation area (data are current as of 1997 and reflect post-fire conditions for the Bull and Summit wildfire areas). Sixty-nine percent of the analysis area has forests with low overstory mortality (10 or fewer dead trees per acre). Approximately 25 percent of the analysis area currently supports forests with moderate, high, or very high overstory mortality.

Table 24. Forest overstory mortality of the Desolation ecosystem analysis area (1997).

CODE	OVERSTORY MORTALITY DESCRIPTION	ACRES	PERCENT
L	Low overstory mortality; 10 or fewer dead trees per acre	47,653	69
M	Moderate overstory mortality; 11-20 dead trees per acre	12,356	18
H	High overstory mortality; 21-60 dead trees per acre	2,315	3
V	Very high overstory mortality; greater than 60 dead trees/acre	2,980	4
Other	Non-vegetated and non-forested cover types (see appendix 1)	4,232	6

Sources/Notes: Summarized from the 97veg database (see appendix 1 for more information). Acreage figures include private land located within the analysis area.

A computerized model was used to estimate current risk (susceptibility) for 14 insects and diseases present in the analysis area. Results of the analysis are summarized in Table 25.

Table 25. Insect and disease risk ratings for Desolation watershed.

INSECT OR DISEASE	RISK RATING	1997 (ACRES)
Douglas-fir Beetle	High	27,812
	Moderate	1,505
	Low	37,022
Douglas-fir Dwarf Mistletoe	High	15,727
	Moderate	7,088
	Low	43,524
Fir Engraver	High	19,220
	Moderate	1,100
	Low	46,019
Indian Paint Fungus	High	8,937
	Moderate	32,727
	Low	24,657
Mountain Pine Beetle (Lodgepole Pine)	High	2,892
	Moderate	1,736
	Low	61,711
Mountain Pine Beetle (Ponderosa Pine)	High	736
	Moderate	691
	Low	64,912
Ponderosa Pine Dwarf Mistletoe	High	7,811
	Moderate	4,400
	Low	54,128
Mixed Conifer Root Diseases	High	28,614
	Moderate	37,359
	Low	366
Schweinitzii Root and Butt Rot	High	38,836
	Moderate	26,779
	Low	724
Spruce Beetle	High	0
	Moderate	0
	Low	56,499
Western Spruce Budworm	High	49,206
	Moderate	12,768
	Low	2,828
Tomentosus Root and Butt Rot	High	3,109
	Moderate	143
	Low	63,087
Douglas-fir Tussock Moth	High	0
	Moderate	52,176
	Low	14,163
Western Larch Dwarf Mistletoe	High	16,226
	Moderate	14,005
	Low	36,108

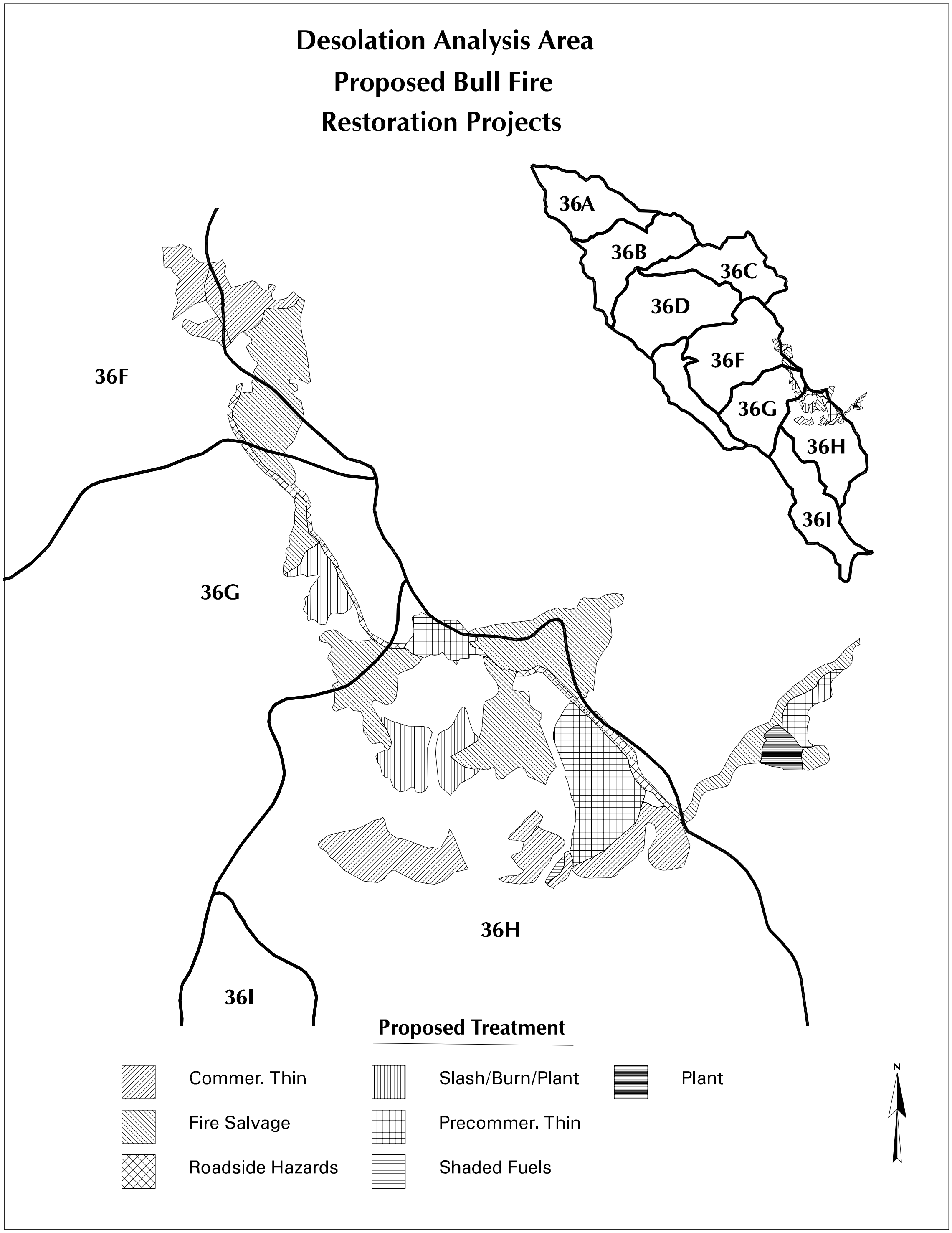
Near-Term Proposed Projects

Several types of proposed vegetation treatments are included in the Environmental Assessment for the Bull Fire Restoration Project. Proposed treatments included in the preferred alternative (as currently developed) are shown in Table 26 and Figure 19.

Table 26. Proposed Bull Fire Restoration Projects within Desolation Analysis Area.

SWS	Proposed Treatment	Acres
36F	Commercial Thinning	86
36F	Fire Salvage	90
36F	Roadside Hazards	9
	Subwatershed Sub-total	185
36G	Fire Salvage	109
36G	Roadside Hazards	34
36G	Slash/Burn/Plant	68
	Subwatershed Sub-total	211
36H	Commercial Thinning	328
36H	Fire Salvage	352
36H	Roadside Hazards	42
36H	Slash/Burn/Plant	132
36H	Precommercial Thinning	284
36H	Desolation Guard Station Fuels	5
	Subwatershed Sub-total	1,143
	Watershed Total	1,539

Figure 19. Proposed Bull Fire Restoration Projects.



Fire/Fuels

The intense burning conditions of the 1996 fires necessitated extensive use of fire-fighting tools such as heavy mechanized equipment (dozers), and aerially-applied fire retardant (outside of wilderness or roadless areas). Although these tools can increase productivity and efficiency of fire suppression efforts, their use is not without risk. Dozer-constructed fireline can create erosion pathways that require extensive mitigation. Exotic plant species (e.g., annual grasses, nitrogen fixing forbs) are often seeded to reduce erosion potential. Aerially-applied fire retardant can be deadly to fish if it reaches a stream or other fish-bearing water source.

Past management practices, and the intense burning conditions affected the behavior of the Bull and Summit (Umatilla National Forest portion) fires. Large areas of relatively homogenous stand structures resulted in extensive areas for the fires to move across, as well as fewer opportunities for effective suppression.

The severity of fire in the moderate-high severity natural fire regimes is not beyond what might be expected, from a historical perspective. There are still extensive areas within the mixed fire regime area with homogenous stand structures of multiple canopy layers and overstocked conditions which will continue to increase the fuels loading as interstand mortality occurs.

As the Desolation Watershed Analysis Area is assessed for fire and fuels concerns in the immediate future, the impact of past fire occurrence and potential for additional fires in the future must be considered. It is commonly thought that the concerns associated with high fuel loads or dense multistoried forest structure would no longer be a factor in management within areas recently impacted by wildfire, such as Bull or Summit Fires. This is partially correct; a large amount of the available fuel has been consumed by the wildfire, and in areas of moderate to high intensity burning, the multistoried forest structure is gone. The new issue is how to manage (within the fire areas and outside) recovering stands in such a way as to avoid setting the stage again for this flammable mix of available fuel and forest structure that promotes the development of crown fires over such an extensive area.

The low severity natural fire regime sites within the drainage have not been as heavily impacted by wildfire in the last few decades. A large portion of this area is private land that has been harvested extensively, and fuels treated. These areas have greater amounts of road access for suppression resources. Areas within this fire regime are lacking in the single-storied stand structures, dominated by early seral species such as ponderosa pine, which would exist in a natural disturbance regime.

Understory and Non-Forest Botanical Resources

Floristic Richness

The total number of species present in Desolation is the highest of any watershed analyzed to date, even though this watershed is the second smallest analyzed. This is attributable in part to more diversity in the watershed, and in part to more, better and/or more recent species lists than the other watersheds.

The ratios of percentages of natives/introduced plant species in watersheds analyzed so far on the Umatilla National Forest are within a fairly narrow range (5.2%). Desolation has the second lowest proportion of introduced species overall (88.2%/11.8%). The proportion of introduced grasses is much higher than the proportion of introduced plant species as a whole (36.47% introduced/total grasses in the watershed, compared to 11.22% introduced/total plant species in the watershed-Table 27). Not only are the proportions of introduced grass species high, their overall cover is a large proportion of the total grass cover.

It is not uncommon to find drier meadows composed of *Poa pratensis* (Kentucky bluegrass), and slightly moister ones completely dominated by *Alopecurus pratensis* (meadow foxtail), both introduced species. Additional introduced grasses present in the watershed include, *Phleum pratense* (timothy), *Poa compressa* (Canada bluegrass), various *Agropyron* species (wheatgrass), *Bromus* species (bromes) and *Arrhenatherum elatius* (tall oatgrass) in road cuts, closed roads, and timber sale units, and the ubiquitous *Dactylis glomerata* (orchard grass).

Table 27. Comparisons between numbers, percentages, and types of plants between the Desolation Watershed, the North Fork John Day Ranger District, and the Umatilla National Forest as a whole.

Forest	District	Watershed
1323 total species	*988 total species*	*723 total species*
1124 natives (85%)	867 natives (87.75%)	638 natives (88.2%)
199 introduced (15%)	121 introduced (12.25%)	85 introduced (11.8%)
27 trees	*19 trees*	*16 trees*
22 natives (81.5%)	17 natives (89.5%)	16 natives (100%)
5 introduced (18.5%)	2 introduced (10.5%)	0 introduced (0%)
123 shrubs	*92 shrubs*	*67 shrubs*
116 natives (94.5%)	89 natives (96.75%)	65 natives (97%)
7 introduced (5.5%)	3 introduced (3.25%)	2 introduced (3%)
943 forbs	*702 forbs*	*509 forbs*
809 natives (87.75%)	623 natives (88.75%)	457 natives (89.75%)
134 introduced (14.25%)	79 introduced (11.25%)	52 introduced (10.25%)
143 grasses	*111 grasses*	*86 grasses*
91 natives (63.6%)	74 natives (66.67%)	55 natives (63.9%)
52 introduced (36.4%)	37 introduced (33.33%)	31 introduced (36.1%)
86 "grasslikes"	*63 "grasslikes"*	*44 "grasslikes"*
86 natives (100%)	63 natives (100%)	44 natives (100%)
0 introduced (0%)	0 introduced (0%)	0 introduced (0%)

Culturally-Significant Plants

One hundred and nine species of plants that either currently or historically occurred in the Desolation watershed have (had) some use for food or medicinal purposes. A complete listing of these species is found in Appendix FLOR1.

Prior to white settlement, huckleberry (*Vaccinium* spp.), serviceberry (*Amelanchier alnifolia*), chokecherry (*Prunus virginiana*), bitter cherry (*Prunus emarginata*), and elderberry (*Sambucus cerulea*) were widespread, large, highly productive, and made up a significant portion of Native Americans' food source (see Kay 1994 for a more complete discussion and further references).

Ungulates have had a major impact on these shrubs. They are favored browse species for native ungulates, and are often eaten by cattle. Other than the plants found adjacent to major roads, where traffic tends to frighten the elk and deer away, most elderberry plants observed have few leaves and badly chewed stems by early to mid-summer. It is rare to find a serviceberry or chokecherry over a couple of feet tall - they can reach 20-30 feet tall under the best conditions, and 10 feet in harsher sites. It is almost impossible to find any of them with fruit. The loss of fruiting berry bushes has undoubtedly impacted birds that rely on berries for fall and winter food.

Willow and alder have been virtually eliminated from the watershed as a result of the loss of beaver and extreme grazing pressure. It is still present in occasional patches, usually heavily browsed, but large willow thickets are gone from the watershed and the District as a whole.

Special Forest Products

Special Forest Products (SFP) include plants collected for use as medicinals or foods, in addition to boughs and trees for Christmas decorations, floral greens, mosses, lichens, pine cones, live trees and plants for landscaping, and many other plants are collected for floral and ornamental purposes. Some of these products have international markets, with medicinal plants, mushrooms, floral greens, and beargrass being shipped to Europe and Asia.

Mushrooms, especially morels and, to a very small extent, huckleberries are currently the only Special Forest Product plants that are known to be collected in quantity in Desolation watershed. The watershed is too far away from major population centers to have the collection pressures currently being experienced by more “urban” forests on the west side of the Cascades, but demand is increasing, and likely to continue. There have been occasional requests for restoration planting propagation material and medicinal plants, such as Pacific yew (*Taxus brevifolia*) for cancer-treating taxol, and valerian (*Valeriana sitchensis*) as an effective sleep aid and doubtful aphrodisiac.

Assessing the biological impacts of special forest products collection without botanical personnel or even baseline data of what is present would be difficult, at best.

Some research is being done on the ecological implications of mushroom harvests. Because the array of plants and products is potentially so huge, and because of limited funding, ecological effects are often a best guess. Mosses and lichens can be particularly problematic, since sensitive species can grow intermixed with common species. Without specific bryophyte training and microscopes, most botanists, let alone the general public, can't distinguish the various species. Almost all work done on identifying which bryophyte and lichen species are sensitive has been done on the west side of the Cascades. Information for east side species is lacking. Even if a species is identified, the status of its population may not be known.

Massive collecting of bryophytes may have significant ecological effects. Some lichens shelter blue-green, nitrogen fixing algae. Nondescript soil lichens in desert communities have been shown to be the major source of nitrogen input in desert systems (B. Ryan, R. Rosentreter, BLM, pers. comm., 1998). Lichens are very slow growing. Growth measurements vary from a centimeter or two per year in rapid growing species, to millimeters per decade in slow growing species. Most occur in older communities, and the arboreal species need to have a nearby source of propagules for the lichens to reestablish once the stands have matured enough to support them, which often takes 200-400 years (B. McCune, R. Rosentreter, BLM, pers. comm., 1998).

For medicinal plants, the long term overall situation can be grim. High value medicinal plants that are difficult to grow commercially are almost always collected to or near extinction. American ginseng and Echinacea are examples of plants not native to the Umatilla that are already overcollected in other parts of the United States. The rarer the plant is, the more the price goes up. Although ginseng is being grown commercially, the opinion in Asia (where most of it is marketed) is that the wild-collected plants are far superior, and therefore are worth more.

While hard to predict exactly which plants could experience high collection pressure, there are a few broad categories of effects that give plants the potential to become commercially viable:

1. Toxicity is one indicator. Any plant that stimulates the immune system, or fights viruses or bacteria is and/or could experience heavy demand, especially if it was shown to be effective against cancer or HIV.

2. Aphrodisiacs, and plants with sedative, euphoric, energizing or antidepressive properties.

3. Plants that can effectively reduce the need for insulin or treat specific types of diabetes. The commercial demand for these plants hasn't developed yet and the research is still fairly spotty, but with diabetes rapidly increasing in the US population , the research will eventually be done and any plant that shows commercial potential will be in demand.

4. A final category is plants with similar chemical makeup to plants that are already commercialized, but themselves don't have a commercial demand yet. As the known commercial species is depleted or more specific research is done, these "alternative" plants will come under increased harvesting pressure.

The following is a partial listing of plants that are found in the Desolation watershed, and are commonly commercially available in general drug store herb sections and smaller health food stores. Massive quantities of these are grown or collected, but it is unknown where or whether or not the amounts are sustainable. Larger health food stores or specialty herb suppliers could easily triple this species listing:

Hypericum perforatum (St. John's Wort)
cascara (*Rhamnsu purshiana*)
dandelion (*Taraxacum officinale*)
nettle (*Urtica dioica*)
juniper berry (*Juniperus* spp.)
valerian (*Valerian* spp.)
red clover (*Trifolium pratense*)
scullcap (*Scutellaria* spp.)
yellow dock (*Rumex crispus*)
mullein (*Verbascum thapsus*)
strawberry leaf (*Fragaria* spp.)
huckleberry leaf (*Vaccinium* spp.)
gentian root (*Gentiana* spp.)
cleavers (*Galium* spp.)
sanicula (*Sanicula* spp.)
burdock (*Arctium minus*)
chickweed (*Stellaria medea*)
elderberry (*Sambucus* spp.)
ladyslipper (*Cypripedium* spp,)
horsetail (*Equisetum* spp.)
hawthorn (*Crataegus* spp.)
red raspberry (*Rubus idaeus*)
uva ursi (*Arcostaphylos uva-ursi*)
astragalus, Chinese (*Astragalus* spp.)
wild cherry bark (*Prunus virginiana*)
rose hips (*Rosa* spp.)
horehound (*Marrubium vulgare*)
chicory root (*Cichorium intybus*)
coltsfoot leaf (*Petasites* spp.)

The following are plants that currently have, or are expected to have commercial collecting demands that could jeopardize the resource if collected on a large scale:

Orchids. Some of these have already been commercialized. These have some of the tiniest seeds in the vascular plant world, and must immediately form a mycorrhizal connection after germination to survive. They only grow in very particular habitats, and none of them are found in large quantities on the Forest. We have the potential to have a Federally Listed plant species, *Spiranthes diluvialis*, on this Forest. Any proposal to collect orchids should be carefully scrutinized (see Recommendations).

Ligusticum canbyi root. Related to *Ligusticum porteri*, or oshá (which has a long record of use in the Southwest (and is becoming hard to find there) as an antiviral and antibacterial), and *L. wallichii* (which is used clinically in China for lowering blood pressure, and during labor and delivery). Researchers are starting to show a great deal of interest in this plant for pharmaceutical uses. This plant is also a very important cultural plant to the local Tribes, and they should be consulted before any commercial harvesting, especially on a large scale, is contemplated. This plant is a "wildling" that so far has not grown in cultivation. Most of the plants on the Forest are present but widely scattered along some creek sides and meadows, almost nowhere in large numbers, and would likely not be sustainable if subjected to large-scale commercial collecting.

Gentian root. Already commercialized. Collected from wild plants in the genera *Gentiana*, *Gentianopsis*, and *Gentianella*, which are all higher elevation meadow or alpine plants. Some plants have been cultivated, but they are a difficult group to grow in settings outside of their natural high elevation haunts. These plants are present but seldom encountered on this Forest, and likely would not be sustainable if commercially collected.

Wild cherry bark, elderberry. Both of these are available commercially, though which species was not stated. These are also culturally significant plants. Both of these shrubs are present on the Forest, but because of browsing pressure almost nowhere in large size or large numbers, and because of this commercial collecting would likely not be sustainable.

Valerian. Available commercially, and the Forest has already had a commercial collecting permit request for this species. This plant grows in meadows and moist forest habitats, and could be cultivated, although most of the plants in the commercial trade are wildcrafted. More common on the North half of the Forest than the South, it maybe could withstand personal use collecting or an infrequent and very small commercial request, but likely not large-scale commercial harvest.

Scullcap. A mild sedative useful for stress relief that is showing up in more and more commercial herbal blends, as well as used by itself. It is unknown whether the commercial plants are wildcrafted and/or cultivated. There are two species (we have one of them on the Forest) usually used in the commercial trade, but they all work more or less interchangeably. *Scutellaria galericulata*, one of the two most commonly utilized commercial species, is occasionally on the Forest growing in small numbers in water in small streams and some ponds. Our other two *Scutellaria* species are usually found on somewhat to fairly steep harsh sun baked slopes. While fairly common in their preferred habitat, their extremely small size would make collection of thousands to millions of whole plants necessary to be commercially viable, and collecting on that scale in the fairly fragile habitat they grow in would likely lead to extirpation of the plants locally, as well as potentially cause soil disturbance, slope instability, and erosion.

Cascara. *Rhamnus purshianus*. The bark of this small tree, known also as chittim or shittim bark, for years was the only good laxative available, and there is still a high demand for it. While most of the bark collected comes from the west side of the Cascades, it is becoming scarce and there have been an increasing number of requests for information on collecting it from the Umatilla National Forest. The Forest has so few of these trees present that commercial collecting would potentially extirpate the species.

Baneberry. *Actaea rubra*. While not in common use (the berries are very poisonous and the entire plant has the reputation of being poisonous), this plant has similar medicinal uses to black cohosh (*Cimicifuga elata* in the west and *Cimicifuga racemosa* in the east). The demand for black cohosh is rapidly increasing, and the western species at least grows in a limited area of west Cascades old-growth forests with intricate mycorrhizal and pollination connections, and has not been successfully cultivated on a commercial scale. Black cohosh probably cannot sustain the collection pressure it is currently under in the wild, and as it is depleted, the demand may turn to baneberry to take its place.

Arnica spp. *Arnica montana* (from Europe) is the main commercial species, but all of the species are more or less interchangeable, and *Arnica cordifolia* is the most likely native to take up any increased collection pressure. Usually the flowers are used commercially, but the leaves and roots can also be used. These plants are mostly used externally for bruises, muscle and joint soreness, and arthritis, and with the population aging and arthritis becoming more common, the demand may increase. Since it is a fairly common species, limited commercial collection of the flowers could probably be done on a sustainable basis (leaving enough to reseed), but huge demand and/or root collection could detrimentally affect the species.

Arrow-leaf balsamroot. *Balsamorhiza sagittata.* This plant is a mild immunostimulant, similar to *Echinacea*. Echinacea is experiencing a tremendous growth in use, with increased mainstream acceptance and many herbal blends containing the plant. While it is slowly coming under cultivation, the majority of the plants used are wildcrafted, and they are becoming rare in their natural habitat. *Balsamorhiza* species may be the "old growth" of the grass steppe--efforts by members of the Oregon Native Plant Society to propagate them have found that a plant has to be at least 10 years old before it first blooms.

St. John's wort. *Hypericum perforatum* The "Prozac of the vegetable kingdom", *Hypericum* has an established history of use in Europe, especially Germany, and is rapidly gaining acceptance in this country. It can treat many forms of depression without the side-effects usually encountered in prescription medications. It is also considered a highly invasive noxious weed. Some efforts are being made to cultivate it, but many people don't want to plant a crop they may never be able to get rid of if the demand goes away. Because it is a noxious weed, commercial collection will bring increased scrutiny of the Forest's noxious weed program in general and herbicide spraying in particular. While overcollecting may help control the plant, increased commercial value may prompt some people to spread the seed widely through the Forest, making the invasiveness problem worse.

Fernleaved desert parsley. *Lomatium dissectum* root. A strong anti-microbial (effective against most gram-positive bacteria and many influenza viruses) and a mild immunostimulant, this plant is extremely useful for treating the flu, pneumonia, bad colds, and has the potential to help with HIV treatment. This, combined with the growing immunity of many microbes to antibiotics almost guarantees a potential strong commercial interest in this plant. The plants are sporadic and localized and grow in steep, dry, hot talus slopes and in rock fissures, making collection difficult. Talus slopes aren't a habitat easily duplicated in cultivation, so all the plants collected are wildcrafted. Already a sensitive species on the Idaho Natural Heritage Program lists, this plant probably would not survive commercial-scale collection.

Pipsissewa and Pyrola. Both of these plants have similar pharmacologies, and both grow in relatively undisturbed forest floors under dense canopy coverage. They are both mycorrhizal (especially the *Pyrola* spp.), so don't transplant, and cultivation would require duplicating the fungal and root components of the forest floor. Pipsissewa (*Chimaphila* spp.) is currently being collected by the semi-truck loads for use as a flavoring in root beer and other soft drinks. While in the appropriate habitats these plants are fairly common, the delicate interdependence of species within the community and their slow growth means that recovery from collection impact would be difficult, and large-scale collections would deplete the species.

Pink elephant's heads. *Pedicularis* spp., especially *P. groenlandica*. One of the most showy and well-loved of our native wildflowers, and an effective sedative for children and tranquilizer for adults. Not in common commercial use---yet. The entire aboveground flowering plant is collected. The meadows that they grow in are usually fairly pristine, extremely diverse, and are saturated with water when the plants are in flower, so collecting could have a tremendous trampling impact on all the plants present in the habitat. While currently relatively common, large-scale commercial collection could devastate the species.

Noxious Weeds

Fourteen noxious weeds have been identified in the watershed. Of those, five species are currently being treated, and population status/spread monitored (Table 28).

Table 28. Noxious Weeds in the Desolation Watershed

ALPHA CODE	SPECIES	COMMON NAME
AGRE	Agropyron repens	quackgrass
CEMA	*Centaurea maculosa*	*spotted knapweed*
CEDI	*Centaurea diffusa*	*diffuse knapweed*
CHLE2	Chrysanthemum leucanthemum	oxeye daisy
CIAR	Cirsium arvense	Canada thistle
CIVU	Cirsium vulgare	bull thistle
CYOF	*Cynoglossum officinale*	*hound's tongue*
DACA4	Daucus carota	wild carrot; Queen Anne's lace
EQAR	Equisetum arvense	western horsetail
HYPE	Hypericum perforatum	common St. John's wort
LIDA	*Linaria dalmatica*	*bastard toadflax*
PORE	Potentilla recta	sulfur cinquefoil
SEJA	*Senecio jacobaea*	*tansy ragwort*
VETH	Verbascum thapsus	common mullein

Species in *italics* are currently tracked and treated on the NFJD Ranger District
Source: Noxious Weed Policy and Classification System, Oregon Department of Agriculture, Noxious Weed Control Program, 1996.

Equisetum arvense is on the Oregon list of noxious weeds even though it is a native plant. It can be highly invasive on disturbed sites under ideal conditions, but has not shown "noxious weed characteristics" (extreme invasiveness and displacement of the native vegetation) on the Umatilla National Forest. It is very good at holding soil in place, making it a useful plant to have along road cuts and portions of some stream banks. It is one of the very few plants that will grow on the edge of highly mineralized mining ponds, which could make it extremely useful for mine reclamation.

Centaurea maculosa, *Centaurea diffusa*, *Chrysanthemum leucanthemum*, *Daucus carota*, *Linaria dalmatica*, *Potentilla recta*, and *Verbascum thapsus* tend to grow in open, gravelly or rocky areas, dry meadow and "scab flats". These are often initial colonizers of disturbance areas if the seed source is present. They will grow in all other habitats, but tend to be spindly if they don't get any sun, and can be out-competed by better adapted vegetation in very wet habitats.

Agropyron repens, *Cirsium arvense*, *Cynoglossum officinale*, *Equisetum arvense*, and *Senecio jacobaea* prefer good soil, and some moisture or shade. They will grow in any habitat with enough moisture, including apparently dry road edges where the water runoff from the road is enough to sustain them.

Cirsium vulgare and *Hypericum perforatum* will grow almost anywhere the seeds land. They tend to be small and stunted in deep shade or extremely dry habitats, large and robust with good soil and adequate moisture.

Botrychium spp.

Botrychium species, commonly known as moonworts or grapeferns, are small upright ferns usually with a common stalk bearing one leaf and one spore cluster that looks like a tiny green grape cluster when immature. While a few species are relatively common with circumboreal distribution, most of the smaller ones have only been described in the last 10-15 years as botanists started purposefully looking for these tiny, hard-to-find plants.

The Desolation watershed contains all 11 of the 12 *Botrychium* species present on the Umatilla National Forest (the twelfth is most likely present but its identity is unconfirmed). Within the watershed, Desolation Meadows contains the fifth most significant population in the world of *Botrychium* spp. as of 1994 (Dr. Herbert Wagner, pers. comm.). These populations occur in drier, warmer, and more stressed sites than other major regional population centers (the Wallowa Mountains of Oregon and the Colville National Forest in Washington). *B. crenulatum* is represented by a population of a single plant on the Umatilla National Forest, and *B. paradoxum* is represented by a population composed of a single plant in Desolation Meadows and one other small population on the Walla Walla Ranger District.

Six *Botrychium* species are currently on the Regional Forester's List of Sensitive Plant Species for Oregon. Sensitive species include *Botrychium pinnatum*, *B. lanceolatum*, *B. paradoxum* (one plant, only known from approximately seven locations in the world as of 1994), *B. crenulatum* (one plant on the Forest, which is on the northwestern edge of its range), and *B. minganense*.

One, and possibly two "new to science" *Botrychium* species occurring in the watershed were discovered after the Regional Forester's List was last updated in June, 1991. *"Botrychium glaucum* sp. nov.", found in Desolation Meadows in 1992, is also known from six plants on the Walla Walla Ranger District and a possible but unconfirmed population on the Wenatchee National Forest (Dr. David Wagner, pers. com. 1996). Although originally determined to be a legitimate new species, isoenzyme studies determined that this "new species", is very similar to *B. pedunculosum*, which is present on the Wallowa-Whitman National Forest, but has not been documented from the Umatilla National Forest. If the Desolation watershed plants are indeed *B. pedunculosum*, they represent a morphologically distinct dry site form, as opposed to the typical *B. pedunculosum.* If the Desolation watershed plants are not *B. pedunculosum*, then they may prove to be a new-to-science species found almost exclusively on the Umatilla National Forest, with almost all the plants present in the Desolation watershed.

Botrychium fenestratum sp. nov. is currently being described by Dr. Wagner, and is suspected to be present in Desolation Meadows. It is currently found on the Colville National Forest, the Wallowa-Whitman National Forest, and on the Walla Walla District of the Umatilla National Forest. The voucher specimen for the suspected *B. fenestratum* from Desolation Meadows is currently deposited at the Oregon State University herbarium, although it has yet to be confirmed.

Historically-listed and Presently-listed Sensitive Plant Species

Table 29 presents the most recent information on listed plant species in the Desolation watershed:

Table 29. Historic and Presently Listed Plant Species of the Desolation Watershed

SCIENTIFIC (COMMON) NAME	REGIONAL FORESTER'S IST[1]	ORNHP LIST[2]	DISTRICT OCCURR.[3]
Allium validum (Pacific onion)	HSO		H, N, P, W
Botrychium crenulatum (crenulate moonwort)	PSO, PSW	List 1	N
Botrychium fenestratum sp. nov.			N?, W
"Botrychium glaucum sp. nov." (Desolation meadows moonwort), or		List 3	N, W
Botrychium pedunculosum (stalked moonwort)[4]		List 1	N, W
Botrychium lunaria (moonwort grapefern)	HSO, PSW	List 2	N
Botrychium minganense (Mingan grapefern)	PSO, HSW	List 2	N, W
Botrychium montanum (mountain grapefern)	PSO, PSW	List 2	N, W
Botrychium paradoxum (two-spiked moonwort)	PSO, PSW	List 1	N, W
Botrychium pinnatum (pinnate grapefern)	PSO, PSW	List 2	N, W
Botrychium simplex (least moonwort)	HSO, PSW		N, W
Calypso bulbosa (calypso orchid)	HSO		H, N, P, W
Carex interior (inland sedge)	Proposed	List 2	N
Carex subnigricans (nearlyblack sedge)	Proposed	List 3	H, N, P, W
Castilleja glandulifera (glandular Indian-paintbrush)	HSO	List 4	N
Corallorhiza trifida (yellow coral root)	HSO		H, N, P, W
Cypripedium montanum (mountain ladyslipper)	HSO	List 4	H, N, P, W
Gentianella tenella ssp. tenella (Dane's dwarfgentian)		List 2	N-extirpated
Hierochloe odorata (sweetgrass)		List 3	H, N
Lupinus polyphyllus var. burkei (Burke's lupine)	HSO		H, N, P, W
Lycopodium annotinum (stiff clubmoss)	HSO	List 4	N, W
Penstemon pennellianus (Pennell's penstemon)	HSO, HSW		N, P, W
Polystichum lemmonii (Shasta fern)	HSO	List 4	N
Ribes hudsonianum (stinking currant)	HSO		H, N, P, W
Ribes oxycanthoides ssp. cognatum (Umatilla gooseberry)	HSO, PSW		H, N, P, W
Trifolium plumosum (pussy clover)	HSO		H, N, W

[1] HSW = historically sensitive in Washington PSW = presently sensitive in Washington HSO = historically sensitive in Oregon PSO = presently sensitive in Oregon)
[2] Oregon Natural Heritage Program, 1998. List 1 is threatened or endangered throughout range. List 2 is threatened, endangered, or extirpated from Oregon, secure elsewhere. List 3 is review. List 4 is watch.
[3] N=North Fork, W= Walla Walla, P=Pomeroy, H=Heppner
[4]This plant is either an extreme dryland form of Botrychium pedunculosum, or a new species. see discussion below.

In addition, *Delphinium stachydeum* has low enough population numbers that it should be listed, but it has not because the genus Delphinium is difficult to key and there is resistance to adding them to sensitive species lists.

Extirpated Species

Within the last 15 years, three species, each represented by a single population on the Forest, and all three of them within about 6 miles of each other, were extirpated from the Forest due to management activities. Two of these were sensitive species:

> *Gentianella tenella* ssp. *tenella* (slender gentian). (Regional Forester's List for Washington, ORNHP List 2--threatened, endangered, or possibly extirpated from Oregon, but more common or stable elsewhere). Only known occurrence on the Umatilla National Forest was along Desolation Creek, where it was collected and brought in to Karl Urban for identification by some of the people installing rock and log fish structures in the creek. The plant apparently was extirpated during the fish structure construction.
>
> *Ranunculus oresterus* (Blue Mt. buttercup). (Regional Forester's List for Oregon, ORNHP List 4--taxa of concern which are not currently threatened or endangered. These are either very rare but currently secure, or else declining in numbers and habitat but still too common to be proposed as threatened or endangered). Only known occurrence on the Umatilla National Forest was just outside the Desolation Watershed at Olive Lake. The population was extirpated when the road was moved back from the edge of the lake, and through the marshy area where it grew. While more common on the Wallowa-Whitman National Forest, this population represented the westernmost edge of its distribution.
>
> *Menyanthes trifoliata* (common buckbean). Only known occurrence on the Umatilla National Forest was at Lost Lake, and was extirpated when heavy equipment went in to try to raise the lake level so that stocked fish could survive the winter.

The only place *Carex scopulorum* is found on the Forest is on gravel bars along one stretch of Desolation Creek, and the only place on the Forest *Betula nana* is found (and is severely browsed) is in Desolation Meadow. In addition, two of our sensitive plant species (*Botrychium paradoxum* in the watershed and *B. crenulatum* on the Forest) are represented by one population each, with one plant in that population. Historically listed *Botrychium lunaria* is represented by one possible population on the Forest (the identity needs to be confirmed with the new plant keys), which is east of the Desolation watershed. These plants are tiny and hard to see, having one stalk that in a good year gets up to 4" tall in the midst of the meadow grasses and forbs. Any misplaced management activity, from large disturbances like bulldozing in roads or fire lines to seemingly insignificant ones like digging a soil test hole or putting in a fencepost or tent stake, if done on the spot where these plants occur, would extirpate the species from the watershed and/or Forest.

Fish and Aquatic Habitat

Fish Populations

Spring chinook salmon rarely spawn in Desolation Creek, and then only during years when streamflows are high (Mike Gray, pers. comm.,1997). However, Oregon Department of Fish and Wildlife surveys (ODFW, 1995) have found juvenile chinook throughout the lower two-thirds of the mainstem (Figure 20). Additionally, USFS snorkeling surveys report juvenile chinook in the lower 1.5 miles of the South Fork of Desolation Creek (P. Howell, pers. comm., 1998). This confirms its use as juvenile chinook rearing habitat, but the stream's small size in late summer makes it only marginal as chinook spawning habitat (John Sanchez, pers. comm., 1998).

Rainbow trout and steelhead also spawn and rear in Desolation Creek and some of its tributaries (Figure 21). Oregon Department of Fish and Wildlife has stocked catchable sized rainbow trout in Desolation Creek for some years. The practice was discontinued by 1995.

The John Day River stock of spring chinook salmon has declined over the years to the point that it is not presently a strong, healthy stock (Huntington et al, 1996). Nevertheless, it is still the strongest wild, native, stock in the interior Columbia Basin. Although specific fish figures for population strengths of salmonids in the Desolation Creek watershed are not available, anadromous subpopulations most likely reflect the same declines as seen in the remainder of the Basin. Numbers of resident rainbow/redband trout are probably somewhat more stable, but the native strains have likely been altered by introduced hatchery fish and numbers may have been reduced by habitat alteration.

The Desolation Creek bull trout population probably consists of a few migratory individuals in the mainstem and a small resident population in the South Fork and lower North Fork of Desolation Creek (Figure 20). Bull trout were apparently once widespread in the John Day River system, but now are restricted to about 25 percent of their former range (Buchanan, Hanson and Hooton 1997), occupying primarily the higher elevation and upper headwaters streams. Presently, stronger populations inhabit the upper North Fork of the John Day River and some of its tributaries and the Upper Mainstem of the John Day River above Prairie City (P. Howell, USFS, pers. comm., 1998). The extent of genetic interchange between these populations and Desolation Creek bull trout is not known at this time.

A few brook trout also occupy the Desolation Creek watershed (Figure 22). Brook trout are exotic to the John Day Basin but are classified in the same genus (*Salvelinus*) as bull trout and may cross with bull trout. Such crosses have been observed in the North Fork John Day River (P. Howell, USFS, pers. comm., 1997) and ODFW surveys (1990) report a bull trout X brook trout hybrid from the South Fork of Desolation Creek. These crosses produce sterile hybrids, and reduce the biotic potential of the bull trout population. This is cause for concern in this watershed.

The South Fork of Desolation Creek contains some west-slope cutthroat trout (P. Howell, USFS, pers. comm., 1999) and ODFW also reports finding a cutthroat in the upper mainstem of Desolation Creek (above the mouth of Battle Creek). Native west-slope cutthroat trout inhabit the upper mainstem of the John Day River. Cutthroat are known to have been introduced to Desolation Creek (J. Sanchez , USFS, pers. comm., 1999). Cutthroats are probably interfertile with rainbow/redband trout, and may have crossed with the resident species and altered the gene pool.

Figure 20. Chinook and Bull Trout Distribution

Figure 21. Distribution of Steelhead/Rainbow/Redband Trout

Figure 22. Brook Trout Distribution

Habitat

Oregon Department of Fish and Wildlife biologists inventoried fish habitat in the mainstem of Desolation Creek from the mouth to the confluence of the north and south forks in 1994. U. S. Forest Service contract teams surveyed most of the major tributaries in the summers of 1992 and 1993. Because of differences in the survey protocol, some of the data gathered by the two agencies is not directly comparable, but pool frequencies and riffle depth/width ratios can readily be converted to equivalent units.

Pool Frequency

Pool frequency is one of several commonly used measures of salmonid habitat quality. In this watershed, average pool frequencies appear generally highest in the South Fork of Desolation Creek (subwatershed 36I, Figure 23) and lowest in the Junkens subwatershed (subwatershed 36E), although pool frequency of single reaches of other streams may be even lower (Figures 24, 25).

Large Wood Frequency

Large wood frequency is another parameter commonly used as a habitat quality indicator. Among the Desolation Creek tributaries, streams in subwatershed 36C (Kelsay) have the highest average large wood frequency (Figure 26) and 36f (Battle) the lowest.

Riffle Depth/Width

Subwatershed 36C also shows the highest riffle depth/width ratios (Figure 27) while mainstem Desolation Creek has the lowest average values for this parameter. Riffle depth/width ratios may vary widely between reaches in the same stream or subwatershed. For example riffle depth/width ratio of reach one of Kelsay Creek is about half that of reach two or of Little Kelsay Creek (Figures 28, 29).

Water Temperature

One of the most important salmonid habitat parameters in the Blue Mountains is probably water temperature. Over the period of record, (1992-1997) maximum water temperatures in the Desolation watershed have varied from 56 to 80 degrees Fahrenheit with Junkens Creek and South Fork Desolation usually showing the coolest temperatures, and Kelsay Creek and Desolation near the mouth, the warmest (refer to Table 16).

Figure 23. Average Pool Frequencies in Desolation Mainstem and Subwatersheds.

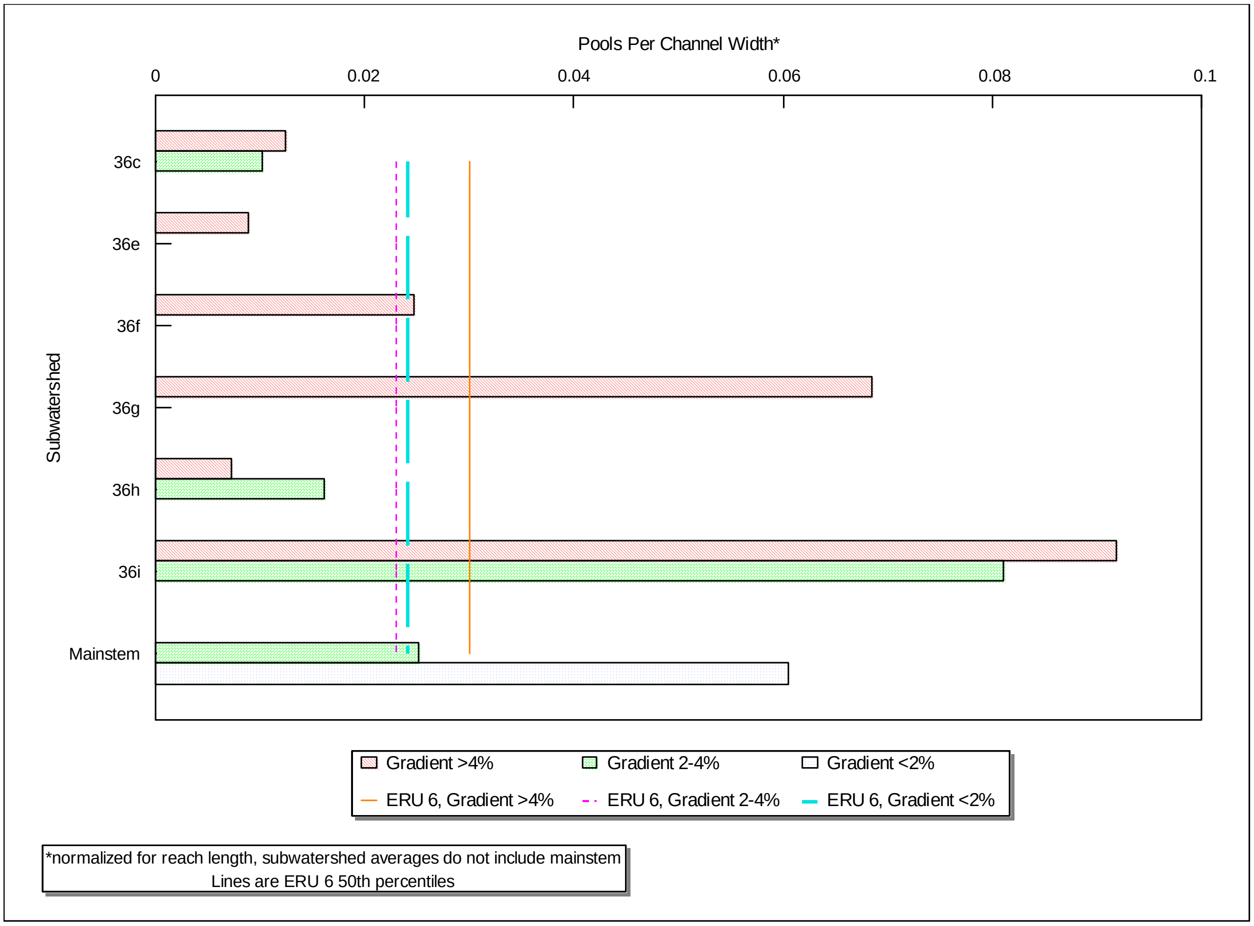


Figure 24. Total Pool Frequency in Desolation Creek, Moderate Gradient Tributaries.

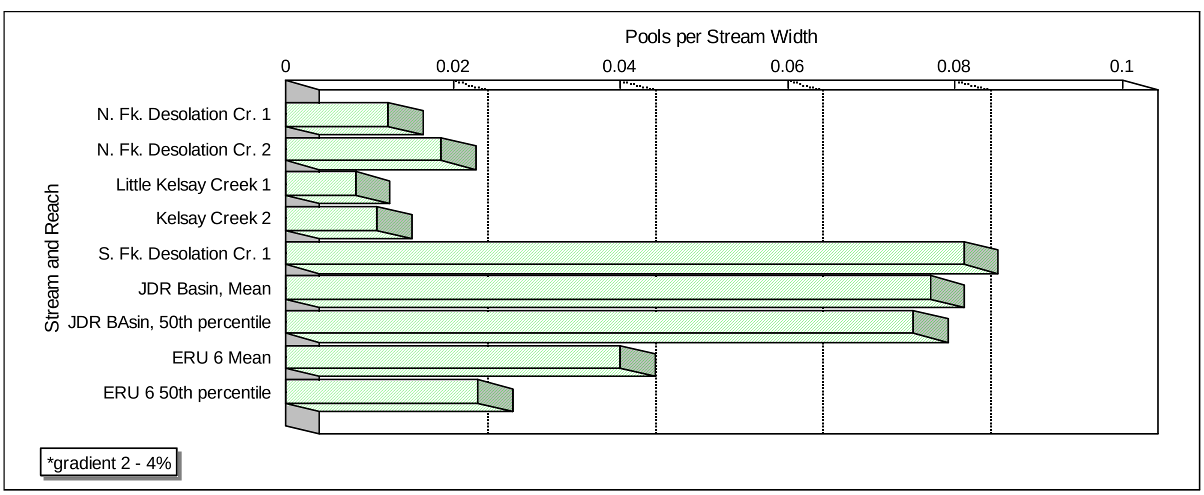


Figure 25. Total Pool Frequency in Desolation Creek High Gradient Tributaries.

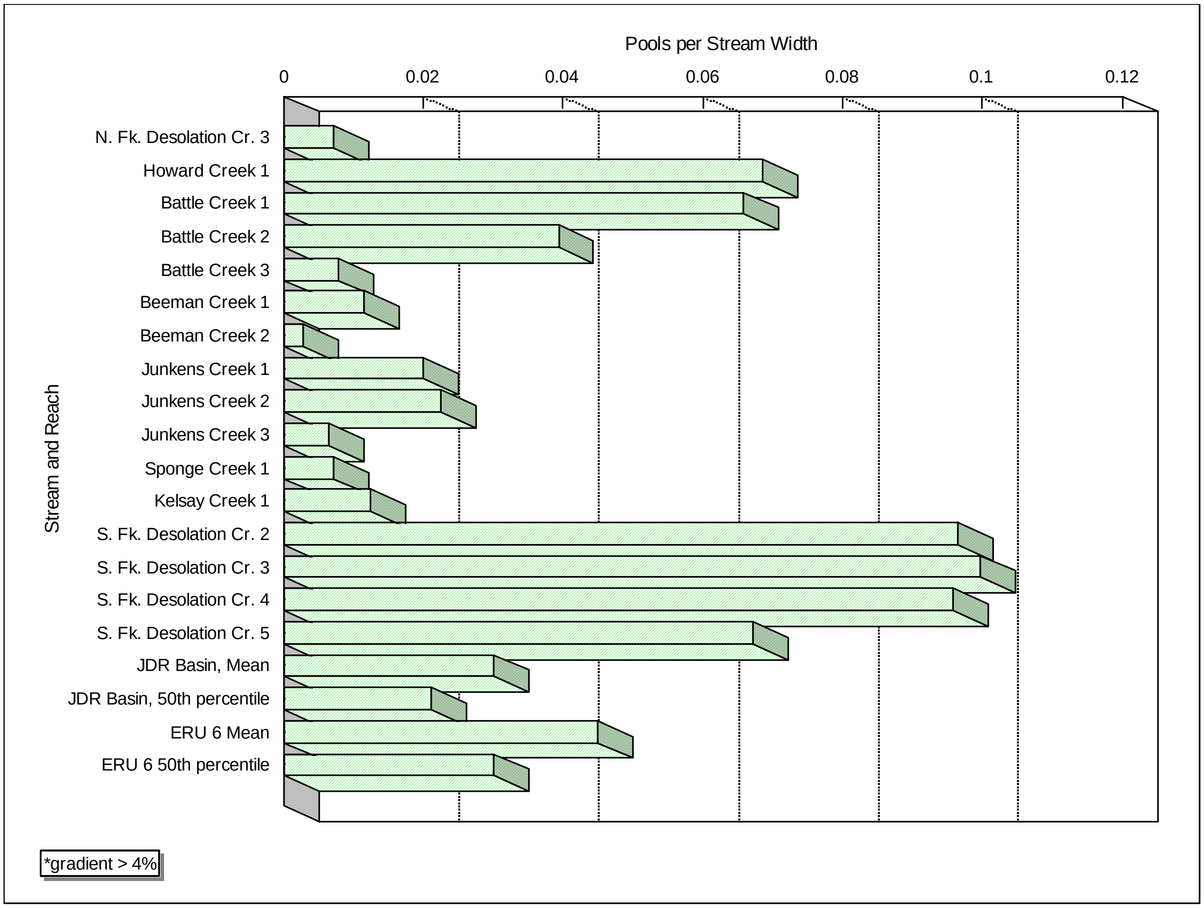


Figure 26. Average Large Wood Frequency in Desolation Creek Tributaries.

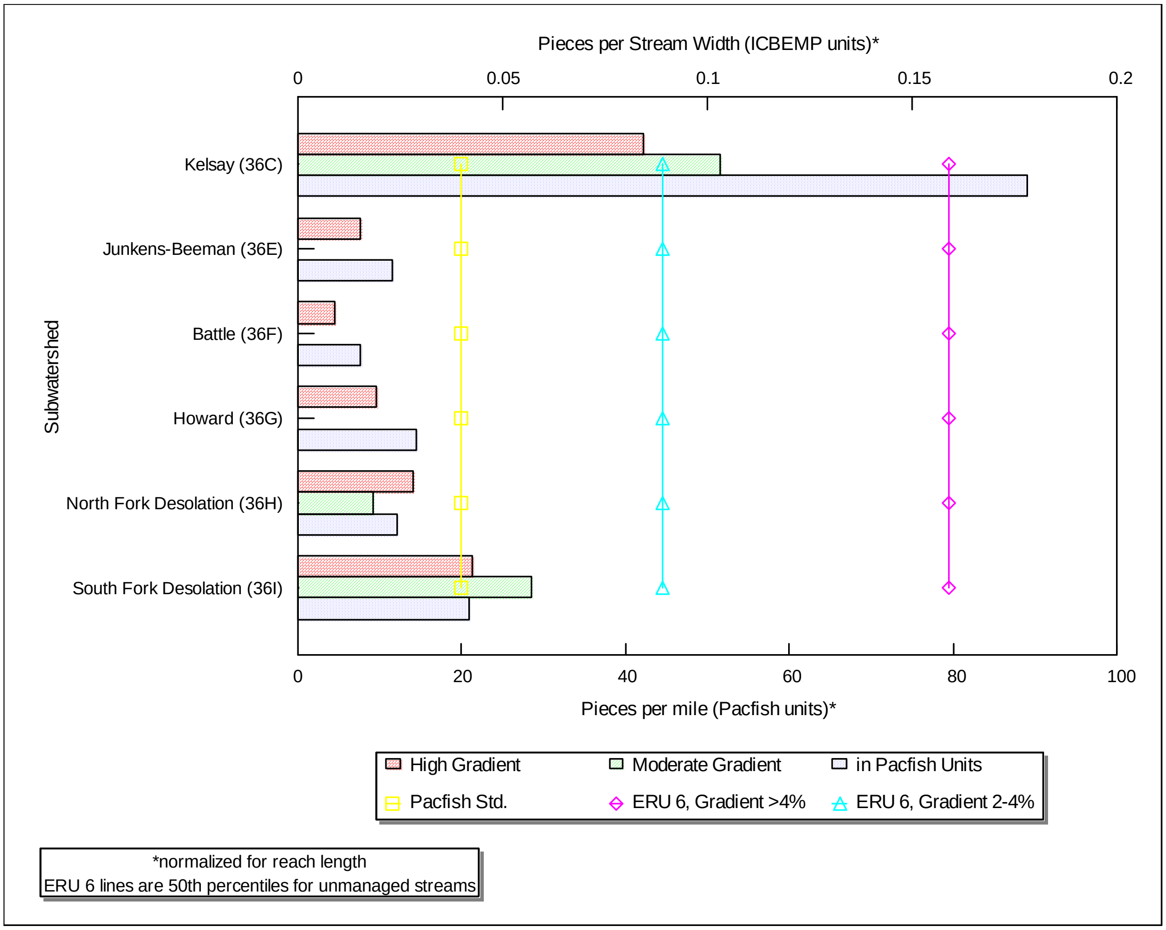


Figure 27. Desolation Mainstem and Subwatersheds, Average Riffle Depth/Width Ratios by Gradient Category.

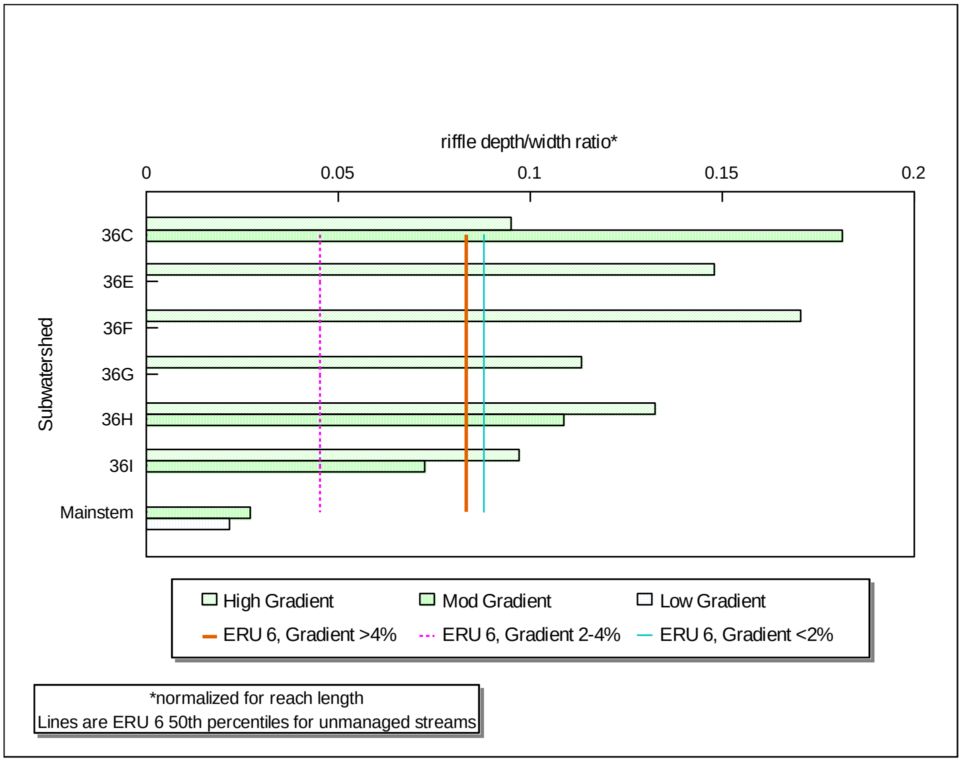


Figure 28. Riffle Depth/Width Ratios in Desolation Creek Tributaries, Gradient 2-4%.

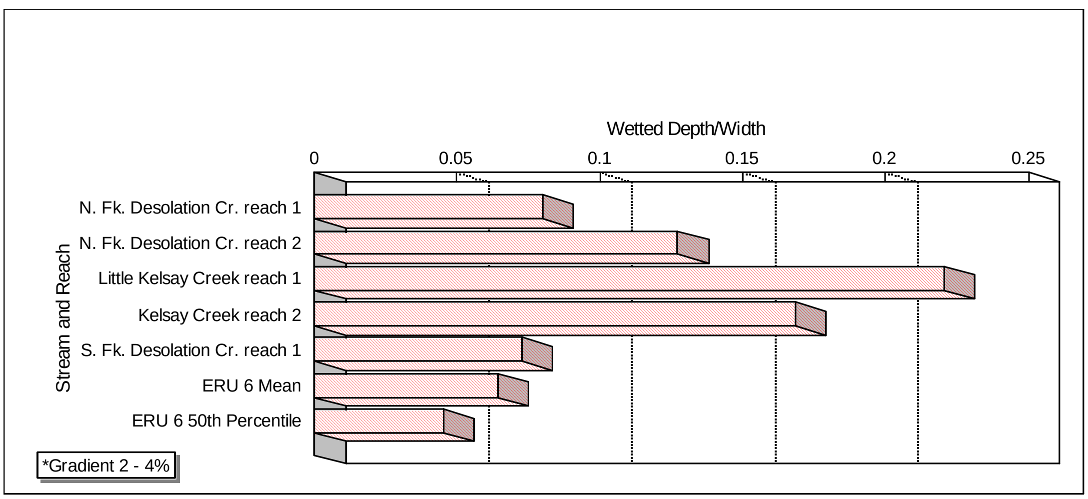
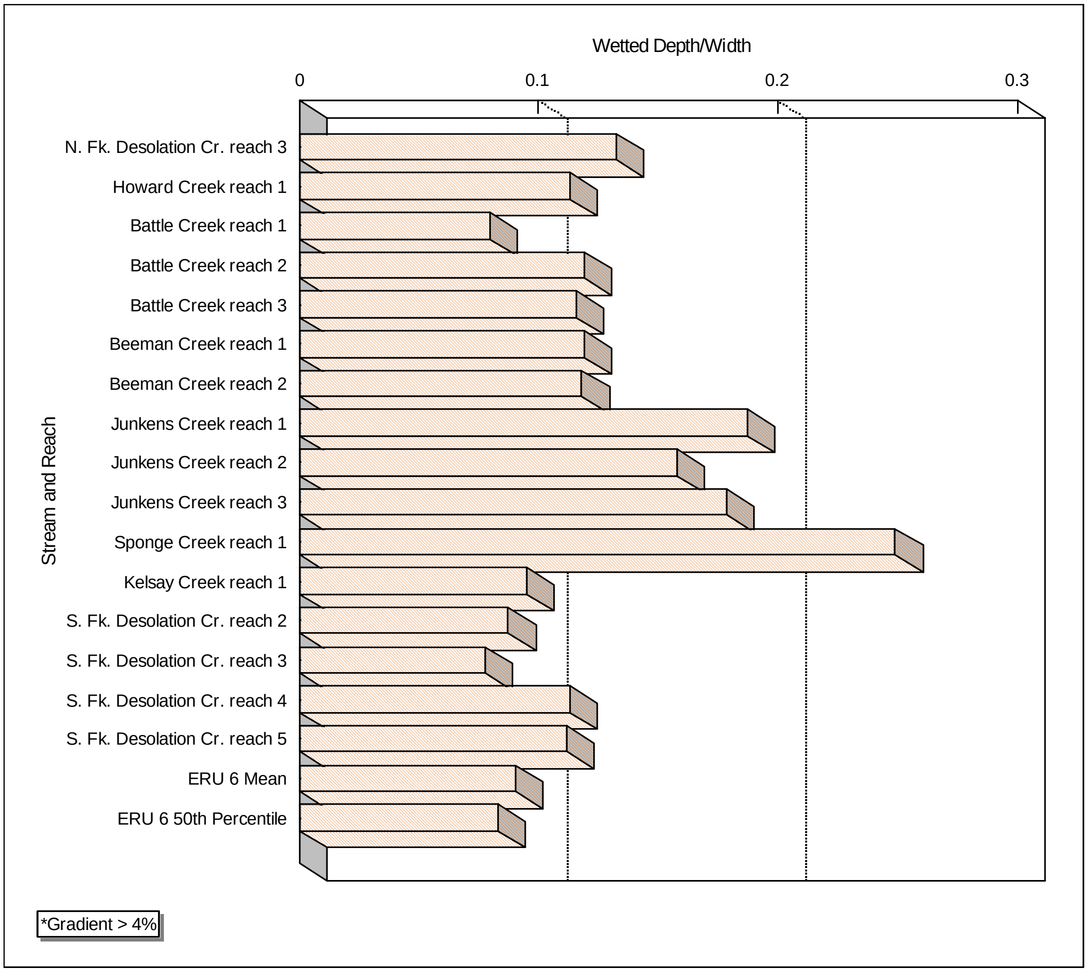


Figure 29. Riffle Depth/Width Ratios in Desolation Creek Tributaries, Gradient >4%.



Sediment

Large proportions of fine sediments can also indicate poor quality salmonid habitat. Stream survey records gave fine sediments as either dominant or subdominant in all three surveyed reaches in subwatershed 36C (Table 30). Subwatershed 36E (Junkens-Beeman) had two reaches with fine sediment listed as dominant or subdominant and 36F, 36H, and 36I each had one reach with fine sediment as either dominant or subdominant. ODFW reports of mainstem Desolation Creek surveys did not show fine sediment as dominant in any of the 19 reaches listed.

Fish Passage Barriers

USFS stream survey reports list several fish passage barriers and possible fish passage barriers created by management in Desolation Creek tributaries as of the 1992-93 field season. Causes of these barriers are given in Table 31 below.

Table 30. Substrates in Desolation Creek Tributaries.*

STREAM	REACH	SUBWATERSHED	DOMINANT	SUBDOMINANT
N. Fk. Desolation Cr.	1	36h	cobble	small boulder
N. Fk. Desolation Cr.	2	36h	sand & silt	gravel
N. Fk. Desolation Cr.	3	36h	cobble	gravel
Howard Creek	1	36g	gravel	cobble
Battle Creek	1	36f	small boulder	cobble
Battle Creek	2	36f	no data	no data
Battle Creek	3	36f	cobble	small boulder
Beeman Creek	1	36e	cobble	cobble
Beeman Creek	2	36e	sand & silt	gravel
Little Kelsay Creek	1	36c	sand & silt	no data
Junkens Creek	1	36e	cobble	gravel
Junkens Creek	2	36e	cobble	small boulder
Junkens Creek	3	36e	gravel	sand & silt
Sponge Creek	1	36f	sand & silt	gravel
Kelsay Creek	1	36c	small boulder	cobble
Kelsay Creek	2	36c	gravel	sand & silt
S. Fk. Desolation Cr.	1	36I	cobble	gravel
S. Fk. Desolation Cr.	2	36i	cobble	small boulder
S. Fk. Desolation Cr.	3	36i	cobble	small boulder
S. Fk. Desolation Cr.	4	36i	cobble	small boulder
S. Fk. Desolation Cr.	5	36i	sand & silt	gravel

*None of the reaches of mainstem Desolation Creek had sand or silt as the dominant or subdominant substrate.
**Substrate size categories: sand <0.08in, Gravel = 0.08 - 2.5 in, cobble = 2.5 - 10 in, small boulder = 10 - 40 in, large boulder > 40in.

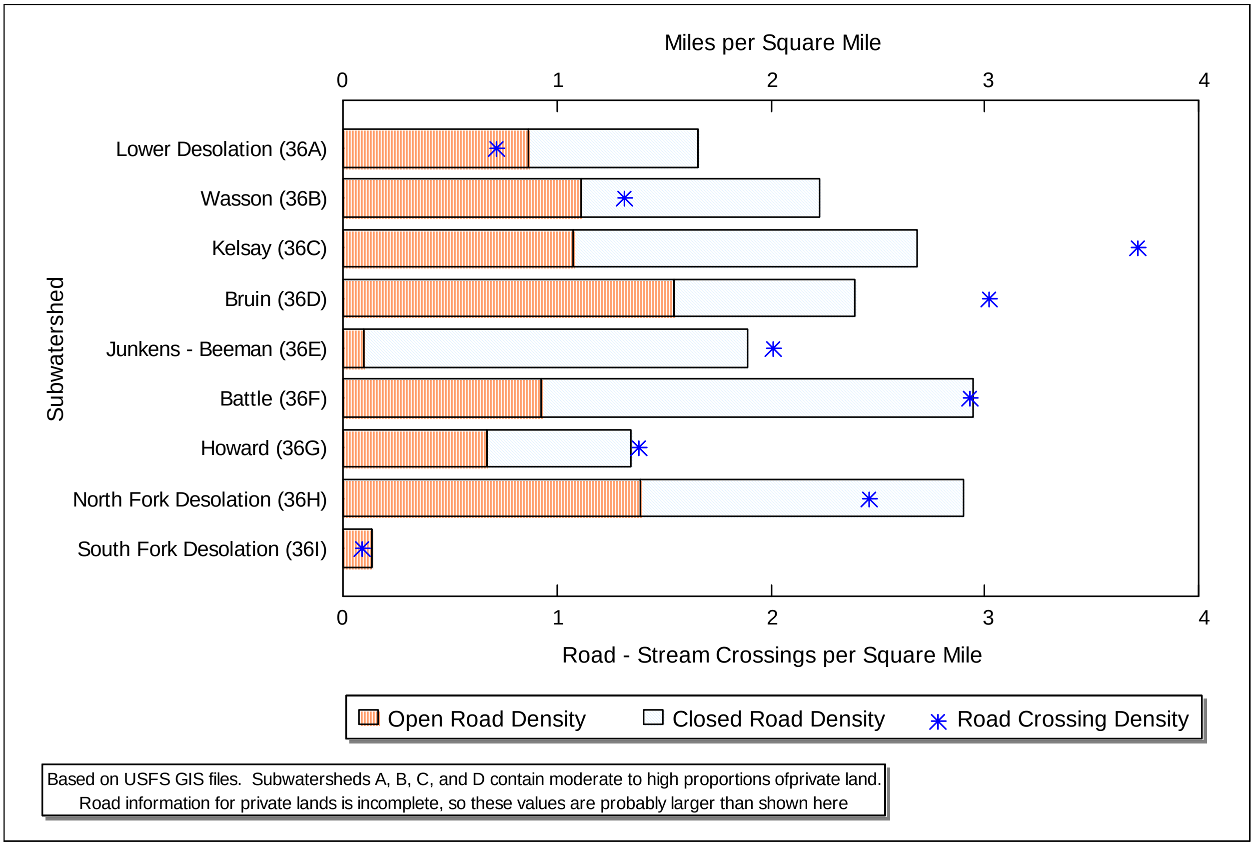
Table 31. Possible Anthropogenic Fish Passage Barriers in Desolation Creek Tributaries.*

STREAM NAME	NSO**	HABITAT UNIT NUMBER**	CAUSE OF BARRIER
Beeman Creek	73	C1	Steep gradient in culvert
Howard Creek	32	C1	Jumping height to culvert
Junkens Creek	5	C1	Steep gradient & swift, shallow current at culvert exit
Junkens Creek	75	C2	1.5ft. drop into culvert (exit jump)
Junkens Creek	98	C3	3 ft. jump onto rocks, no pool below
Junkens Creek	125	C4	No pool below culvert. One ft. jumping height
N. F. Desolation Tributary #1	2	C1	Clogged culvert

*From USFS stream survey data as recorded in the SMART database.
**NSO & Habitat Unit Number = habitat unit identifying codes used for recording USFS stream survey observations.

Management
Road density over the watershed averages 2.1 miles per square mile (Table 13 and Figure 30). The highest road density (2.94 miles/mile2) is in subwatershed 36F (Battle). The lowest (0.137 miles/mile2) is in subwatershed 36I (South Fork Desolation). Subwatersheds with large proportions of private land may contain more roads than indicated by Forest Service databases: road density in these subwatersheds may be higher than shown in Figure 30.

Figure 30. Desolation Creek Watershed; Various Measures of Road Density



Because differences among reaches in factors such as gradient or riparian vegetation may also affect aquatic habitat parameters, simple correlations between road density and habitat parameters may be inappropriate. It is nevertheless interesting to note that streams in subwatersheds with the lowest road - stream crossing density (South Fork Desolation) also have the highest pool frequencies (Figure 23), and subwatersheds with higher crossing densities also have generally lower pool frequencies.

Aerial photos suggest extensive timber harvest in this watershed. A review of stream survey narrative reports indicates that, in the past, timber was often harvested right down to the stream bank, and that this practice has resulted in degraded fish habitat.

The Indian Creek cattle allotment includes much of the watershed. Stream survey reports suggest that past livestock management resulted in considerable degradation of fish habitat in the Desolation Watershed. New allotment management plans have recently been developed to address some of these problems.

Over 18 percent (12,677 acres) of the watershed is in private ownership. Little data is available concerning management practices on private lands in the watershed. ODFW personnel mentioned condition of the aquatic habitat on the private land at the lower end of the watershed as a matter of special concern.

The Desolation Creek drainage is a popular big game area. Hunters have established dispersed camps along mainstem Desolation Creek, especially near the mouths of the tributaries entering from the North. These have degraded aquatic habitat quality. The North Fork John Day Ranger District has attempted to mitigate the effects of these camps by moving them back from the stream, and "hardening" heavily-used sites (see Recommendations section).

The drainage contains both active and abandoned mines. None of them are known to cause water quality degradation.

Some man-made habitat improvement structures have been installed in the mainstem of Desolation Creek and in Kelsay Creek. A headcut stabilization structure has been installed in upper South Fork of Desolation Creek.

Terrestrial Wildlife

Habitat Structure and Quality

Late/Old Forest Habitat

Old forest habitat availability is quite limited. For several species, reproductive habitat is currently at extremely low levels. Only 1,581 total acres of forest having late/old structure remain in the Desolation drainage, accounting for approximately 2.4 percent of the currently forested acres within the analysis area (Table 32).

Compounding the overall lack of old forest acres is the extreme *fragmentation* of old forest stands, and a concurrent enlargement of patch size in the stand initiation structural stage. While some degree of fragmentation is a natural feature of forests in the Blue Mountains (resulting from fire, insects and/or disease, etc.), today's highly fragmented old forest stands are largely a function of human manipulation; through harvest, roading and/or the altered plant communities that result from fire suppression.

Table 32. Old Forest Acres, Desolation Watershed, 1997.

PVG	Structural Stage	Total 1997 Acres
Cold Upland Forest	OFMS	264
	OFSS	632
	Total	896
Dry Upland Forest	OFMS	300
	OFSS	75
	Total	375
Moist Upland	OFMS	217
	OFSS	93
	Total	310
Grand Total		**1581**

Current Strategies for Old Forest Management/Protection

The goal of C1 old growth management, as stated in the Umatilla Forest Plan, is to provide and protect sufficient suitable habitat for wildlife species dependent upon mature and/or overmature forest stands, and promote a diversity of vegetative conditions for such species. The final C1 network included both suitable (mature/overmature forests) and capable areas (currently younger stands expected to become old growth). Desired future conditions for old growth areas, as described in the Forest Plan, includes areas characterized by "stands of naturally appearing overmature trees", with multiple tree canopies in two or more age classes, and an abundance of standing and down dead wood. Stands having these characteristics are recognized as contributing to forest biodiversity and aesthetic values. Forest Plan management direction specifies that activities are not allowed except to enhance or perpetuate old growth forest habitat conditions (Umatilla Forest Plan, pg. 4-144).

The *goal* of C2 Management Areas was identical to that of the C1 strategy, but aimed at mature and overmature lodgepole pine forests. In these areas, however, management activities were expected and intended to be used to move stands towards maturity. C1 and C2 areas established under the Forest Plan currently include approximately 2,037 acres, of which virtually none is currently in the "old forest" structural stage (as described in the Desolation vegetative database (Figure 31 and Table 33).

An intensive field review of the C1 and C2 areas in the Desolation watershed was conducted during the summer of 1995. Results of that review indicated that conditions within individual old forest reserves varied widely: most did not provide adequate habitat for target species; due to small patch size, high degree of fragmentation of old forest within and among reserve areas, high levels of mortality, or a combination of factors (Table 2, Old Forest Conservation Strategy).

Pileated, black-backed and three-toed woodpeckers have all been observed in the drainage, however, no quantitative information is available on the status of these species (i.e. nesting locations, reproductive success, population size etc.). In the course of the C1/C2 inventory, sign of recent or past use by pileated woodpeckers was noted in fewer than half of the C1 areas. In the C2 areas, evidence of use by three-toed woodpeckers was found in only 38 percent of the units. This is attributable to the lack of overlap between identified C1 areas and old forest stands (Figure 31; E. Larson, 1995; Desolation Old Growth Survey, on file at NFJD Ranger District).

As it became clear that the original network identified in the Forest Plan was not providing adequate habitat quantity or quality, revisions were made. However, those changes were never formalized in a Forest Plan amendment, and thus did not have any "official" standing. Table 33 displays the current status of the "revised" old growth network. The current network contains about 1,475 fewer acres than the original network established under the Forest Plan.

Figure 31. C1/C2 Network - Old Forest Comparisons, Desolation Watershed, 1997.

Table 33. Revised Old Growth Network, Desolation Watershed [1]

NETWK #	SWS	STAND #	SS	ACRES	PAG	PVG	#LAYERS	%COVER
1232	B	89	UR	11	WD	D	2	45
		122	NF	5	HD	DUG		
		146	UR	97	WD	D	2	55
		199	UR	83	WD	D	2	55
		268	YFMS	17	CM	M	2	50
Total Ac.				**213**				
2278	**C**	186	RHW	5	WW			
		191	SI	37	CM	M	2	30
		194	SI	55	CD	C	3	20
		252	SI	47	CD	C	2	50
		267	SI	14	CM	M	2	35
Total Ac.				**158**				
1273	**D**	337	UR	40	WD	D	3	55
		360	YFMS	132	CM	M	2	65
Total Ac.				**172**				
1283	**D**	439	SEOC	20	WD	D	2	20
		451	YFMS	67	CD	C	2	45
		458	SI	43	CD	D	2	45
		468	SI	25	WD	D	3	25
		499	SI	20	CD	C	2	35
Total Ac.				**175**				
2222	**D**	396	UR	62	CM	M	2	35
		442	SI	54	WD	D	2	30
		466	ROCK	7				
		477	UR	10	CM	M	2	35
		482	SI	40	CM	M	2	35
		488	SI	99	CM	M	2	35
		508	UR	23	WD	D	2	45
		525	SECC	12	WD	D	2	40
		537	YFMS	46	CM	M	2	65
Total Ac.				**353**				
1293	**E**	618	SEOC	11	WD	D	2	20
		626	YFMS	38	CM	M	2	65
		639	SI	100	CD	C	2	65
		664	YFMS	37	CD	C	2	65
Total Ac.				**186**				
1303	**E**	670	SI	54	CM	M	2	60
		672	SI	8	CD	C	2	10
		673	SI	8	CD	C	2	10
		677	YFMS	75	CM	M	2	60
		691	SI	5	CD	C	1	10
		692	SI	21	WD	D	2	45
		695	SI	32	WD	D	2	35
Total Ac.				**203**				
1265	**F**	523	SEOC	26	CD	C	1	35
		534	SI	11	CD	C	2	65
		544	SI	10	CD	C	1	10
		459	YFMS	228	CM	M	2	60
Total Ac.				**275**				
1543	**H**	863	SI	90	CD	C	1	10
		872	SI	150	CM	M	2	20
		882	ROCK	10				
		885	SI	33	CD	C	2	20
		896	SI	19	CM	M	2	10
Total Ac.				**302**				
Total Network Acres				**2,037**				

[1]Data Source: North Fork John Day Ranger district GIS map and associated data tables.

Dead Standing and Down Wood and Green Tree Replacement Resources

Snags, green tree replacements and down wood resources were inventoried within the Desolation drainage as part of the Continuous Vegetation Survey (CVS) plots. Based on data compiled from the inventory, snag densities appear to be in good supply, in all size classes, *at the watershed scale.* In the Bull and Summit fire areas, snag densities are currently quite high, but the opposite may be true within the decade, as salvage operations and/or blowdown occur. In the unroaded portion of the Summit Fire (South Fork Desolation), burned snags are already beginning to fall, resulting in very high densities of large and small down logs. Black-backed and three-toed woodpeckers were observed foraging in these burned stands in September, 1998. Existing snag and green tree replacement levels in the drainage (based on CVS plot data) are compared to Umatilla Forest Plan standards and proposed ICBEMP guidelines in Tables 34 and 35.

Table 34. Dead standing (snags) tree densities in the Desolation Watershed.

PVT	LMRP, UMATILLA NF		DESOLATION WATERSHED	
	Working Group	*Density*	*Working Group*	*Density*
Dry Forest	*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*	1.0 snags/ac. >10" dbh 4.4 snags/ac. >12" dbh 3.3 snags/ac. >20" dbh **8.7 snags/ac. Total**
Moist Forest	*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*	10.8 snags/ac. >10" dbh 10.3 snags/ac. >12" dbh 3.3 snags/ac. >20" dbh **24.4 snags/ac. Total**
Cold Forest	*Lodgepole pine*	1.21 snags/ac. >10" dbh 0.59 snags/ac. >12" dbh 1.8 snags/ac. Total	*Cold Forest*	4.7 snags/ac. >10" dbh 11.6 snags/ac. >12" dbh **16.3 snags/ac. Total**
	Subalpine Zone	1.21 snags/ac. >10" dbh 0.59 snags/ac. >12" dbh 1.8 snags/ac. Total		

Table 35. Densities for “Green” tree replacement in the Desolation Watershed

PVT	LMRP, Umatilla NF		Desolation Watershed	
	Working Group	Density	*Working Group*	Density
Dry Forest	*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*	7.6 trees/ac. >10" dbh 17.3 trees/ac. >12" dbh 4.4 trees/ac. >20" dbh **29.3 trees/ac. Total**
Moist Forest	*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*	15.4 trees/ac. >10" dbh 19.7 trees/ac. >12" dbh 6.5 trees/ac. >20" dbh **41.6 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		
Cold Forest	*Lodgepole pine*	10.1 trees/ac. >10" dbh 4.3 trees/ac. >12" dbh 14.4 trees/ac. Total	*Cold Forest*	12.6 trees/ac. >10" dbh 28.6 trees/ac. >12" dbh **33.4 trees/ac. Total**
	Subalpine Zone	13.9 trees/ac. >10" dbh 5.3 trees/ac. >12" dbh 19.2 trees/ac. Total		

Riparian Habitats

Inventoried aspen stands in the Desolation watershed (Figure 32, circled polygons) are generally small in size (less than 1 acre), spatially discontinuous, and consist of a deteriorating mature overstory. The larger and healthier remaining stands are located at the mouths of Howard and Sponge Creeks. In other areas, single trees or very small clumps are all that remain of historic clones.

Aspen restoration includes treatments to mimic natural disturbance and stimulate re-sprouting, such as removal of conifer encroachment, underburning, root ripping, and creation of natural refugia with existing slash. Natural regeneration may also be augmented by transplanting root suckers from nearby stands or by outplanting nursery stock. To date, none of these treatments have been applied to aspen stands in the Desolation drainage, although “buck and pole” fence exclosures were built in 1995 around the Park and Howard Creek stands to protect aspen regeneration from browsing by cattle and wild ungulates. All other aspen stands in the drainage are currently unprotected.

In 1997, an isozyme study was conducted to determine landscape patterns of genetic diversity in aspen stands on the North Fork John Day Ranger District. Information from this study is being used to devise gene conservation strategies, and to develop stand prescriptions and prioritize stands in need of cultural treatment or protective measures. Three aspen stands in the Desolation drainage were included in this study: Desolation Creek, Howard Creek, and Park Creek. Results from the study indicate that the Desolation and Park Creek stands are genetically quite similar. As with most other aspen stands on the east side of the NFJD District, they each were comprised of one genotype (monoclonal). The Howard Creek stand, however, is comprised of at least two clones: one inside the fence exclosure, and a second large clonal cluster outside the fence. When compared with other aspen stands on the District, none of the sampled Desolation stands were genetically unique or considered high priority for gene conservation protection.

Compared with other drainages on the southern end of the Forest, black cottonwood is relatively abundant in the Desolation watershed, even at higher elevations (Figure 32, stippled areas; not to scale). Individual trees appear to be relatively healthy, and stands are generally a mix of older trees with young stem recruitment.

In 1998, a black cottonwood gene bank was established at Clarno, OR, in cooperation with the BLM and other eastside R-6 National Forests. The purpose of the gene bank is to preserve native black cottonwood germplasm and to produce high quality planting materials for restoration projects. Cuttings from 57 black cottonwood on the North Fork John Day RD have been established at the Clarno facility thus far. Of these, 23 clones originated from parent trees in five subwatersheds in the Desolation drainage. Material for outplanting projects will become available starting in Spring 1999.

Desolation and Kelsay meadows provide important (and scarce) wet meadow conditions for riparian-associated species. Review of older aerial photos indicates that the wet meadows along Desolation and Kelsay Creeks are being slowly encroached upon by the surrounding coniferous forest in the absence of stand-replacement fire.

Figure 32. Riparian Hardwood Stands, Desolation Watershed.

Roads
Roads affect terrestrial wildlife and their habitats in a variety of ways. Direct mortality from collision with vehicles or hunting are certainly the most obvious, but other effects can be much more subtle and difficult to quantify. High road densities and their related disturbance may cause individuals or local populations to leave an area entirely. Roads create access for an increasing number of humans intent on hunting, gathering, recreation, timber harvest etc. These uses can increase wildlife displacement, vulnerability to mortality, habitat fragmentation and the spread of noxious weeds.

Total road densities in the Desolation drainage vary widely from one subwatershed to another, but in general are fairly low compared to other areas of the District. Total and Open road densities are reported by Subwatershed in Table 36. Road densities are miles of road per square mile. The Very Low rating for SWS 36E reflects the large Roadless area in that subwatershed. Open road densities could increase in the short term if roads are re-opened for salvage harvest in the Bull fire area.

Table 36. Total and Open Road Densities, Desolation Analysis Area.

SUBWATERSHED (36)	TOTAL ROAD DENSITY (MI/MI^2)	OPEN ROAD DENSITY (MI/MI^2)
A: Lower Desolation	1.66	0.87
B: Wasson	2.23	1.11
C: Kelsay	2.68	1.08
D: Bruin	2.39	1.55
E: Junkens/Beeman	1.89	0.10
F: Battle	2.94	0.93
G: Howard	1.35	0.67
H: North Fork Desolation	2.9	1.39
I: South Fork Desolation	0.14	0.14

Trails in the watershed are open to Off Road Vehicles (OHVs), as well as mountain bikes, hikers and horses. These trails, located along several tributary streams and Sharp's Ridge (a major elk migration corridor), have some potential for disturbance and fragmentation, depending on the season and intensity of use. Concern was voiced by ODFW personnel that OHV closures, as currently managed, do not meet the stated intent of protecting wildlife habitat (C. Foster, ODFW, pers. comm. 9/98).

Species
Most species known to occur or having the potential to occur historically still occur within the Desolation drainage, with some notable exceptions. Grizzly bear and wolves were native to northeastern Oregon, and survived in the Blue Mountains until the 1930s. Some species have probably declined in numbers (i.e. bald eagles, some Neotropical birds), while others have become established or increased in number (starlings, species that thrive in early forest structural stages).

Lacking either historic or current estimates of population sizes for individual species, only an indirect assessment of the health of terrestrial wildlife communities was possible. The results and discussion that follow were based on a compilation of several disparate forms of available data, the intent being to display the most obvious changes in habitat quantity and quality over the last 60 years. Results of this analysis should not be viewed as having statistical significance. Table 37 shows the evaluation criteria used to formulate Paradox queries for this analysis. Current conditions are summarized in Table 38. Relative changes in habitat availability for individual species, based on queries illustrated in Table 37, are summarized in the Reference Conditions section.

Table 37. Selected species and habitat indicators used to model current and historic habitat availability in the Desolation Watershed.

SPECIES	HABITAT	COVER TYPES	STRUCTURAL STAGES	MINIMUM PATCH	OTHER HABITAT FEATURES
Rocky Mountain Elk	F	ABLA2, PSME, PIEN, PICO, LAOC, PIPO, ABGR, MixConf., MM, MS, MW, SS	SI, SEOC, OFSS, NF		
	WR	FM, GB, MD, SD, SL, ST, GX	NF		<4,500' Elev.
	MC	ABLA2, PSME, PIEN, PICO, LAOC, PIPO, ABGR, MixConf.	SECC, UR, YFMS, OFMS	>40 Ac.	Canopy Cover 40-69%
	SC	ABLA2, PSME, PIEN, PICO, LAOC, PIPO, ABGR, MixConf.	SECC, UR, YFMS, OFMS	>250 Ac.	Canopy Cover >70%, 2 or 3 Layers
Pileated Woodpecker	F	PSME, PIEN, LAOC, PIPO, ABGR, MixConf.	YFMS, OFSS, OFMS		
	R	PSME, PIEN, ABGR, MixConf.	OFMS	>40 Ac.	
Northern Three-toed Woodpecker	F	ABLA2, PSME, PIEN, PICO, ABGR, MixConf.	OFMS, OFSS		>4,500' Elev.
	R	ABLA2, PICO, MixConf.	OFMS	>20 Ac.	
Pine Marten	F	ABLA2, PSME, PIEN, PICO, MixConf.	YFMS, OFSS, OFMS		>4,000' Elev., Canopy Cover >40%
	R	ABLA2, PSME, PIEN, PICO, Mix Conf	OFMS	>30 Ac.	Habitat next to streams
Wolverine	F	ABLA2, PSME, PIEN, PICO, ABGR, MixConf	SEOC, SECC, UR, YFMS, OFSS, OFMS		>4,000' Elev.
	R	NT, NR	N/A		Aspect: Level, N, NE, E, NW
Lynx	F R	ABLA2, PSME, PIEN, PICO, MixConf ABLA2, PSME, PIEN, PICO, MixConf	SI, UR, SEOC, OFSS, OFMS OFSS, OFMS		>5,500' Elev.
Northern Goshawk	F	PSME, PIEN, PICO, LAOC, PIPO, ABGR, MixConf	SI, SEOC, SESCC, UR, YFMS, OFSS, OFMS		
	R	PSME, PIEN, PICO, LAOC, PIPO, ABGR, MixConf	OFSS, OFMS	>20 Ac.	

F=Foraging, WR=Winter Range, MC=Marginal Cover, SC=Suitable Cover, R=Reproductive

Management Indicator Species

Pileated Woodpecker, American Marten

These two species are closely associated with old forest habitats. Both have very large home range sizes and are dependent on snags and down logs for either food, reproductive habitat, and/or escape from predators. Habitat for martens is further limited by elevation and an affiliation for riparian habitats—thus the estimates of habitat shown here are probably overly generous.

Northern Three-toed Woodpecker

Three- toed woodpeckers depend on a different type of old forest habitat at higher elevations than pileated woodpeckers. Less of this forest type (lodgepole and mixed fir/lodgepole) is naturally available in the drainage; this natural scarcity, compounded by management (harvest and salvage) makes nesting habitat for northern three-toed woodpeckers almost non-existent in the drainage.

Primary Cavity Excavators

This group includes a number of large and small woodpeckers having a variety of habitat requirements. Analysis capabilities were not adequate to assess current habitat conditions for this group.

Rocky Mountain Elk (and mule deer)

Located completely within the Desolation Hunting Unit (administered by ODFW), approximately 30 percent of the watershed is delineated as Winter Range, with 600-700 elk wintering in the Case Ridge and Onion Flats areas. During severe winters, these animals may move as far south as Ritter or Sumpter. Approximately 2000 elk summer in the watershed, at elevations above 6,200 feet. South Fork Desolation Meadow stills provides good summer habitat, despite the loss of some of the adjacent timber in the Summit fire, as evidenced by numerous beds in the long meadow grasses and heavy ungulate use of the South Fork trail (field review, 9/98).

Elk numbers are currently near ODFW Management Objectives for the Desolation Unit. Mule deer numbers continue to be slightly below Management Objectives for the unit. The recent fires in the watershed are expected to improve forage conditions for deer and elk in the next few years.

Sharp's Ridge is an important migration corridor for elk moving up and down the drainage between summer ranges high in the watershed and wintering areas at Case Ridge, Onion Flats, and the Bridge Creek Wildlife Management Area (managed by ODFW). As noted above, a recreational trail open to OHVs runs the length of Sharp's Ridge where it forms the analysis area boundary.

High quality calving habitat, probably some of the best on the North Fork John Day District, occurs in the drainage, especially in moist riparian habitats of tributary streams (particularly Sponge and Howard Creeks), and the South Fork Meadows. While the Summit fire did affect calving habitat around South Fork meadows, ODFW personnel expect elk to return to calving habitat there in the near future (C. Foster, ODFW, pers. comm. 9/98).

Mule deer are highly migratory in this area and, therefore, very difficult to census (C. Foster, ODFW, pers. comm. 9/98). It is estimated that perhaps 1,000 mule deer winter in the Desolation Unit, sharing important winter ranges with elk. During especially hard winters, Desolation deer will move to lower elevations along the Middle Fork John Day.

Table 38. 1997 Potential Habitat Availability for Selected Species, Desolation Analysis Area.

SPECIES	HABITAT COMPONENT	1997 ACRES
Rocky Mtn. Elk	F[1]	45,647
	W R	2,030
	M C	17,208
	S C	4,331
Pileated Woodpecker	F	7,552
	R	608
No. 3-toed Woodpecker	F	1,103
	R	114
American marten	F	5,044
	R	275
Lynx	F	14,551
	R	275
Wolverine	F	24,758
	R	26
No. Goshawk	F	58,296
	R	1,204

F=Foraging, WR=Winter Range, MC=Marginal Cover, SC=Suitable Cover, R=Reproductive
[1] "Foraging" habitat acres are inclusive of reproductive habitat.

Other Species of Concern

Neotropical Migrant Birds

This group includes bird species which nest in North America and migrate to the neotropics for the winter. Over the past two decades, declines in many of these species, including many songbirds, have been noted. Causes for the declines include habitat degradation and predation by domestic cats in North America, compounded by both habitat destruction and continued use of toxic chemicals in Central and South America (Sharp 1992).

Neotropical migrants account for a significant portion of the avian biological diversity in the Desolation Creek watershed. Of the 122 species of birds known or suspected to occur in the Desolation Analysis Area, 57 species, or approximately 47 percent, are NTMBs. Neotropical migrants occupy a variety of habitats within the area: 40 species are associated with riparian habitats, while 32 species use old growth. Twenty-eight species of NTMBs select aspen groves for nesting or foraging habitat. Twenty-nine species use sapling/pole stands for either nesting or foraging. Nineteen species use the stand initiation structural stage: many of these are generalist or edge-associated species. (See the Terrestrial Vertebrate Appendix for a list of all NTMB species in the analysis area with their habitat associations).

The status of several Desolation area NTMBs is of concern (Table 39). Breeding Bird Survey trends for five species that occur in the drainage (of nine total) are significantly negative (indicative of declining populations).

Table 39. Neotropical bird species of local concern, Desolation Ecosystem Analysis Area.

SPECIES	NEGATIVE BREEDING BIRD SURVEY TRENDS	SIGNIFICANTLY NEGATIVE TRENDS
Hammond's flycatcher	X	
Chipping sparrow	X	
Olive-sided flycatcher	X	
American kestrel	X	
Cooper's hawk	X	
Mountain bluebird	X	
Mourning dove	X	
Western wood peewee	X	
Northern oriole	X	
American goldfinch	X	
Swainson's thrush	X	
Ruby-crowned kinglet		X
Turkey vulture		X
Calliope hummingbird		X
Red-eyed vireo		X
Tree swallow		X

An increasing number of studies indicate that fragmentation of forested habitats, and overgrazing of grassland habitats can have serious detrimental impacts on NTMBs (Dobkin 1994). Both fragmentation and the lingering effects of streamside grazing are concerns within the Desolation watershed, and could affect the ability of NTMBs to successfully reproduce in the area.

Goshawk

Currently, only about 1200 acres of suitable goshawk nesting habitat remain in the drainage. District Wildlife Observation records note the presence of goshawks in the analysis area, and a single adult bird was observed near Onion Flats during a 1996 WA field trip, however, standardized field surveys in 1995 failed to locate either nests or individual birds.

Wolverine

Wolverine have very large territories, require isolated rocky areas for their natal dens, and demonstrate a marked aversion to human disturbance (Banci 1994). A few acres of rock outcrops and talus located along the southern boundary of the Analysis Area above South Fork Desolation Creek provide the only potential reproductive habitat in the drainage; however, this habitat type extends further south outside the watershed boundary. Annual winter surveys have yet to reveal any evidence of wolverine within the drainage.

Lynx

The Canada lynx is a medium-sized, long-legged cat similar in appearance to the bobcat, but having large paws (helpful when hunting in deep snow), long, dark ear tuffs, and a distinctive "ruff" around the face (Koehler and Brittell 1990). The range of the lynx formerly included much of Washington and Oregon; the species is now very rare in Oregon (Region 6 memorandum 12/98). Preferred habitat for the lynx is coniferous forests, especially Engelmann spruce, subalpine fir and lodgepole pine (Koehler and Brittell 1990, Banci 1994). Mature and old forests provide cover for denning, escape cover and shelter. Lynx tend to avoid open spaces, preferring to travel in corridors that provide hiding cover. The primary prey of lynx is the snowshoe hare. In the Desolation drainage, subwatersheds at the higher elevations have the potential to support lynx (C. Foster, ODFW, pers. comm. 1998).

Recreation

Over 200 dispersed campsites are located on National Forest land throughout the watershed. About 100 additional campsites are located on private land. Dispersed campsites are used throughout the spring, summer and fall months, especially during the mushroom and big game hunting seasons. The entire watershed provides an estimated 40,000 RVDs annually.

Within the watershed, there are seven trailheads, and 45.2 miles of trail (21.3 miles of non-motorized and 23.9 miles of motorized). Depending on the weather, trail use generally begins in late May or early June, and tapers off by mid-November. Peak use occurs from mid-July to the end of October. Two factors have lead to an increase of motorized use within the Desolation area: 1) all trails were shown on the 1994 District Access and Travel Management Plan, and 2) use of all terrain vehicles (ATVs) by recreationists, mushroom pickers, and hunters has increased.

Welch Creek Campground, because of its location, has become the main staging area for Off Highway Vehicles (OHVs). All motorized trails in the Desolation system are accessible from this trailhead. Changes in Oregon Department of Transportation regulations have opened most Level II and Level III maintenance roads to OHV use, increasing the number of available road miles.

Use of Scenic Area trails has increased since 1990. The highest use period is traditionally from late August to late October, which coincides with big game bow and rifle hunting seasons. Horse and mountain bike use has increased throughout the summer season.

Winter recreation activities are popular. The North Fork John Day Winter Recreation Plan designates over 50 miles of snowmobile trails. The Ranger District has a volunteer agreement with the Sumpter Snowmobile Club who annually grooms primary routes through the area.

Jumpoff Joe Lake is a secluded 5-acre lake located in the Junkens-Beeman SWS (36E). A short, one-quarter mile trail provides access. Special fishing regulations apply to this lake, and it receives quite a bit of use during the summer season. No developed camping or picnicking sites are located near the lake. The lake has an estimated 800 annual RVDs.

Lost Lake is another small (7 ac.), secluded lake, located in the North Fork Desolation SWS (36H). ODFW stocks the lake with trout. In 1990, the size and depth of the lake were expanded. The ROS setting for the lake is “Semi-Primitive Non-Motorized”. The road and trail accessing the lake were designated for non-motorized use in 1992. The lake is now about 3 miles from an open road. Four tent sites and a hiking trail are located around the lake. The lake has an estimated annual 300 RVDs. RVDS are expected to increase after the trout population in the lake stabilizes.

Scenic Area (Management Area A8)

One licensed outfitter guide is permitted to provide day trips into the Scenic Area. While the Scenic Area is experiencing increased recreational use in the summer months, the largest concentration of recreational visitors occurs during the big game hunting seasons. The Scenic Area has an estimated 8,000 annual RVDs.

Minerals

Currently, there is one active mine, and three mining claims in need of restoration, on National Forest System land in the Desolation Watershed. The Portland Mine (T9S R34E, Section 34) is on private land in South Fork Desolation Subwatershed (36I).

Active Claim:
Claim Name: Hard Luck
Status: Active
Type: Lode
Stream: no stream nearby
Subwatershed: 36E Junkens/Beeman
Location: T8S, R32E, Section 24
Date of Plan of Operation: Notice of Intent
Activities Approved under the Plan of Operation: none
Reclamation Plan: Efforts to begin solving some of the impact problems should include: repairing facilities at mines with free-flowing contaminants, repairing hillsides with extreme erosion potential, continue water quality studies, and continue to monitor active claims for compliance with approved operating plans.

Rangeland Resources

Two allotments have area within the Desolation Watershed; Central Desolation and Indian Creek. Small portions of all five units of Central Desolation (Case, Ridge, Deep Canyon, Outlaw, and Turner, with Turner and Outlaw accounting for most of the area). All four of the Indian Creek units have area within the watershed. These are the west units, Bully and Indian, and the east units, Battle and Meadows. Virtually all of the east units are inside the watershed and only the east 1/4 to 1/3 of the west units are inside.

Central Desolation (Outlaw and Turner units): One hundred eighty8eight cow/calf pairs are permitted between 6/1 to 9/30 under a deferred rotation system (the sequence is reversed each year so each unit receives early rest every other year). The current Allotment Management Plan (AMP) was completed in 1981; however, there is no formal EA. Ten-year permits were issued to the permittees in 1990 and 1992.

Indian Creek: There are 888 cow/calf pairs permitted 6/16 to 9/30. Meadow Unit is in the second year of a 10-year rest. There are 496 pairs in Bully Unit until 8/16 when they move into Battle Unit until 9/30. There are 392 pair in low (east half) of Indian Unit until 7/16 when they are moved to the high (west half) until 9/30. There is no division fence in the Indian Unit so compliance to these dates are dependent on the range rider. A new 10-year permit was issued to each of the permittees in 1996 with a permit issuance EA approved in 1996.

IV. Reference Conditions

Description of reference conditions is the fourth step in the six-step process for ecosystem analysis at the watershed scale. The purpose of step 4 is to explain how ecological conditions have changed over time as a result of human influence and natural disturbances. A reference or benchmark is developed for later comparison with current conditions and with key management plan objectives (Regional Ecosystem Office 1995).

Watershed Hydrology

Reference conditions provide a measure of watershed potential, unfortunately, few records of past conditions are available for comparison. Historic changes in North Fork Desolation meadow were observed on sequential aerial photographs; changes in road location, development of drainage ditches, and change in vegetation composition provide evidence of historic change in the hydrology and morphology of the meadow. Pre-development (1930's) - the channel was probably narrower and more sinuous, with vegetated banks. The water holding capacity in the meadow was greater; with shallow subsurface storage, cooler water, and higher baseflows.

1958 streamflow information includes the following:

Average annual discharge: 101 cubic feet per second (cfs)
Unit discharge, a measure of unit area runoff: 0.9 cfs per square mile
Average annual water yields for the same period: 73,142 acre feet

Role of beaver - John Week's 1832 journal did not report any beaver trapped in the North Fork John Day on a Hudson's Bay-sponsored expedition through the region. Lack of reference to beaver, an important part of the Hudson Bay Company's fur trade, indicates either that beaver had already been trapped out by the time of Weeks's journey, or there were few to begin with (Haines 1971). Beaver may have played a role in the formation and maintenance of meadows in the Desolation watershed. Beaver recolonization may have been prevented in part by development of the domestic livestock industry.

The South Fork Desolation subwatershed is a reference area for watershed response to fire in the absence of land use impacts. Summer storms in 1997 in the headwaters accelerated upland erosion and channel sedimentation rates. Increased storm-generated peak flows resulted in stream channel changes, overbank flows, deposition of bars, and bank erosion. Water temperatures do not appear to be increased by loss of streamside shade. Increased summer baseflows caused by decreased evapotranspiration rates (tree mortality) may be offsetting shade loss.

Compared to other nearby NFJD watersheds, some areas of Desolation Creek watershed have generally better streamflows, channel conditions and water quality. This is in part because of higher elevations and the greater water-holding capacity of recently glaciated landforms in headwater basins. Fewer land use impacts also occur in some tributaries, and overall cumulative effects from logging and roads are at lower levels than other similar-sized watersheds, for example Camas Creek and Wall Creek.

Forest Overstory Vegetation

Forest Cover Types

Previous EAWS efforts used historical cover-type mapping to characterize reference conditions (USDA Forest Service 1937). Historically, forest cover types were often named for an economically important species (such as ponderosa pine) that might be present at a fairly low level of abundance, ignoring a more abundant but less valuable species. For that reason, aerial photography was used to derive unbiased information about historical cover types for the Desolation watershed.

Table 40 summarizes historical forest cover types for the Desolation ecosystem analysis area. The predominant forest cover type in 1939 was lodgepole pine (37% of the analysis area), followed by Douglas-fir (19%), grand fir (17%) and subalpine fir (11%). Forests dominated by whitebark pine or western juniper were less common in 1939 than in 1997, since neither forest type was identified on the historical aerial photography.

Table 40. Forest cover types of the Desolation ecosystem analysis area (1939).

CODE	COVER TYPE DESCRIPTION	ACRES	PERCENT
CA	Forests with a predominance of subalpine fir trees	8,003	11
CB	Forests with a predominance of whitebark pine trees	0	0
CD	Forests with a predominance of Douglas-fir trees	12,916	19
CE	Forests with a predominance of Engelmann spruce trees	485	1
CJ	Forests with a predominance of western juniper trees	0	0
CL	Forests with a predominance of lodgepole pine trees	25,624	37
CP	Forests with a predominance of ponderosa pine trees	3,620	5
CT	Forests with a predominance of western larch trees	1,509	2
CW	Forests with a predominance of grand fir trees	12,021	17
CX	Forests with a mixed composition; less than 50% of one species	2,391	3
Other	Non-vegetated and non-forested cover types (see appendix 1)	3,084	4

Sources/Notes: Summarized from the 39veg database (see appendix 1 for more information). Acreage figures include private land located within the analysis area. Forest cover types are based on a plurality of stocking and are seldom pure – the grand fir type (CW), for example, has a predominance of grand fir trees (50% or more) but also contains minor proportions of ponderosa pine, Douglas-fir and other species.

Sediments collected from Lost Lake, which is located in the upper (southeastern) portion of the analysis area, indicate that forest composition has remained remarkably stable in the Desolation watershed. Fossil and pollen evidence showed that lodgepole pine, western larch, Douglas-fir, grand fir, subalpine fir, and Engelmann spruce were common conifers after the Mount Mazama volcano erupted about 7,600 years ago. White pines, however, were not common in the fossil/pollen record. About 4,000 years ago, a moist climatic regime apparently prevailed and lodgepole pine, spruce, and firs were abundant. Dwarf mistletoe pollen was also present in the sediments; dwarf mistletoe was probably parasitizing lodgepole pines (Mehringer 1997).

Canopy Cover

Table 41 summarizes historical canopy cover for forests of the Desolation ecosystem analysis area. It shows that the predominant situation in 1939 was very high-density forest (>70% canopy cover; 59% of the analysis area), followed by high density (56-70% cover; 23%) and then low-density (≤40% cover; 8%). Moderate-density forest (41-55% canopy cover) was relatively uncommon in 1939, occupying only 6 percent of the analysis area.

Table 41. Forest canopy cover classes of the Desolation ecosystem analysis area (1939).

CODE	CANOPY COVER DESCRIPTION	ACRES	PERCENT
≤40	Live canopy (crown) cover of trees is 40 percent or less	5,284	8
41-55	Live canopy cover of trees is between 41 and 55 percent	4,108	6
56-70	Live canopy cover of trees is between 56 and 70 percent	16,329	23
>70	Live canopy cover of trees is greater than 70 percent	40,848	59
Other	Non-vegetated and non-forested cover types (see appendix 1)	3,085	4

Sources/Notes: Summarized from the 39veg database (see appendix 1 for more information). Acreage figures include private land located within the analysis area.

Canopy Layers

Table 42 summarizes historical forest canopy layers for the Desolation ecosystem analysis area. It shows that the predominant situation in 1939 was a two-layer stand structure (64% of the analysis area), followed by single-layer forest (25%). A highly-complex layer structure (three or more canopy layers) was relatively uncommon, occupying only 6 percent of the analysis area.

Table 42. Forest canopy layers of the Desolation ecosystem analysis area (1939).

CODE	CANOPY LAYER DESCRIPTION	ACRES	PERCENT
1	Live canopy (crown) cover of trees occurs in l layer (stratum)	17,531	25
2	Live canopy cover of trees occurs in 2 layers or strata	44,830	64
3	Live canopy cover of trees occurs in 3 or more layers or strata	4,208	6
Other	Non-vegetated and non-forested cover types (see appendix 1)	3,085	4

Sources/Notes: Summarized from the 39veg database (see appendix 1 for more information). Acreage figures include private land located within the analysis area.

Forest Size Classes

Table 43 summarizes historical forest size classes for the Desolation ecosystem analysis area. The predominant overstory size class in 1939 was a mixture of small and medium trees ranging from 9 to 32 inches in diameter (50% of the analysis area), followed by medium trees (21 to 32 inches DBH; 20%) and then small trees ranging from 9 to 21 inches in diameter (15%). Forest overstories dominated by seedlings (trees less than 1 inch DBH), saplings (trees from 1 to 5 inches in diameter) or poles (5 to 9 inches in diameter) were rare, occupying less than 8 percent of the analysis area in aggregate.

Table 43. Forest size classes of the Desolation ecosystem analysis area (1939).

CODE	SIZE CLASS DESCRIPTION	ACRES	PERCENT
1	Seedlings; trees less than 1 inch in diameter	0	0
2	Seedlings and saplings mixed	30	<1
3	Saplings; trees from 1 to 4.9 inches in diameter	1,722	2
4	Saplings and poles mixed	1,746	2
5	Poles; trees from 5 to 8.9 inches in diameter	2,272	3
6	Poles and small trees mixed	1,356	2
77	Small trees; trees from 9 to 14.9 inches in diameter	5,355	8
88	Small trees; trees from 15 to 20.9 inches in diameter	4,897	7
8	Small trees and medium trees mixed	35,029	50
9	Medium trees from 21 to 31.9 inches in diameter	13,856	20
10	Medium and large trees mixed	307	<1
11	Large trees from 32 to 47.9 inches in diameter	0	0
Other	Non-vegetated and non-forested cover types (see appendix 1)	3,085	4

Sources/Notes: Summarized from the 39veg database (see appendix 1 for more information). Acreage figures include private land located within the analysis area. Forest size classes are based on the predominant situation and are seldom pure – the pole size class (5), for example, has a predominance of pole-sized trees (50% or more) but may also contain minor proportions of other size classes. For multi-layered stands, this information pertains to the overstory layer (tallest stratum) only.

Forest Structural Stages

Table 44 summarizes historical forest structural stages for the Desolation watershed. It shows that the predominant structural stage in 1939 was old forest (49% of the analysis area consisted of either of the two old forest structural stages), followed by stem exclusion closed canopy (18%), young forest multi strata (16%) and then stand initiation (16%). The understory reinitiation and stem exclusion open canopy structural stages were rare, occupying 2 percent or less of the area.

Table 44. Forest structural stages of the Desolation ecosystem analysis area (1939).

CODE	STRUCTURAL STAGE DESCRIPTION	ACRES	PERCENT
OFMS	Old Forest Multi Strata structural stage	15,390	22
OFSS	Old Forest Single Stratum structural stage	18,946	27
SECC	Stem Exclusion Closed Canopy structural stage	12,641	18
SEOC	Stem Exclusion Open Canopy structural stage	72	<1
SI	Stand Initiation structural stage	7,427	11
UR	Understory Reinitiation structural stage	1,184	2
YFMS	Young Forest Multi Strata structural stage	10,909	16
Other	Non-vegetated and non-forested cover types (see appendix 1)	3,085	4

Sources/Notes: Summarized from the 39veg database (see appendix 1 for more information). Acreage figures include private land located within the analysis area. See Veg Table 8 for information about structural stages.

Landscape Patches

Table 45 summarizes patch characteristics for historical cover types and structural stages for the Desolation analysis area. Douglas-fir had the most cover type patches in the Desolation landscape, followed by grand fir and then lodgepole pine. The largest patches, however, were those comprised of lodgepole pine, averaging 434 acres in size and ranging up to 18,126 acres. In terms of cover type characterization, lodgepole pine forest would be considered the "matrix" forest type.

Table 45 shows that the *stand initiation* structural stage accounted for the largest *number* of forest patches in the Desolation watershed in 1939, followed by *old forest single stratum* and then *young forest multi strata*. However, the *largest* patches were those comprised of old forest (*old forest multi strata* and *old forest single stratum*), averaging 214-223 acres in size and ranging up to 4,840-6,271 acres. In terms of landscape characterization, *old forest* would be considered the "matrix".

Table 45. Patch analysis for the Desolation analysis area (1939 conditions).

	PATCH TYPE	NUMBER OF PATCHES	MINIMUM PATCH SIZE	AVERAGE PATCH SIZE	MAXIMUM PATCH SIZE
Cover Type	CA	23	1	348	6,400
	CB	0	0	0	0
	CD	85	3	152	3,087
	CE	10	3	48	273
	CJ	0	0	0	0
	CL	59	1	434	18,126
	CP	35	4	103	1,421
	CT	22	5	68	502
	CW	80	6	150	2,027
	CX	20	12	119	471
	Total	334			
Structural Stage	NF	85	1	36	589
	OFMS	72	9	214	6,271
	OFSS	85	3	223	4,840
	SECC	69	1	183	2,815
	SEOC	3	19	24	31
	SI	117	1	63	838
	UR	12	11	98	423
	YFMS	73	1	149	2,009
	Total	516			

Sources/Notes: Based on information contained in the 39veg database (see appendix 1 for more information), including private land located within the analysis area. Refer to Veg Table 16 for a description of the cover type codes; refer to Veg Table 19 for a description of the structural stage codes. Patches were calculated using the UTOOLS program (Ager 1997).

Forest Disturbances

Table 46 summarizes historical forest disturbances for the Desolation watershed. It shows that the analysis area had little or no evidence of recent disturbance in 1939, or at least none that could be distinguished on the historical aerial photography. Although the effects of long-past wildfire were evident in the landscape pattern of the watershed (the distribution and configuration of lodgepole pine patches, for instance), there was no recent disturbance other than a minor amount of timber harvest (<1% of the analysis area affected by partial cutting). Although insects and diseases were not specifically noted, they were important disturbance agents historically (Veg Table 14).

Table 46. Forest disturbances of the Desolation ecosystem analysis area (1939).

CODE	DISTURBANCE DESCRIPTION	ACRES	PERCENT
CC	Recent clearcut timber harvest	0	0
CR	Old clearcut, now regenerated	0	0
FI	Evidence of recent fire	0	0
PC	Recent partial cutting timber harvest (selection, seed-tree, etc.)	182	<1
PR	Old partial cut, now regenerated	0	0
SS	Evidence of sanitation/salvage timber harvest	0	0
TH	Evidence of a thinning silvicultural treatment	0	0
Blank	No discernible evidence of disturbance (on aerial photographs)	66,387	95
Other	Non-vegetated and non-forested cover types (see appendix 1)	3,085	4

Sources/Notes: Summarized from the 39veg database (see appendix 1 for more information). Acreage figures include private land located within the analysis area.

What impact did disturbances have on tree mortality in the Desolation watershed? Table 47 summarizes overstory mortality for the Desolation area. Not unexpectedly, it shows that disturbances had little or no impact on forest conditions, as least when using overstory tree mortality as a criterion of impact. Ninety-six percent of the analysis area had forests with low overstory mortality (10 or fewer dead trees per acre) in 1939 – which includes all of the forested area, since the remaining 4 percent of the Desolation watershed was not forested.

Table 47. Forest overstory mortality of the Desolation ecosystem analysis area (1939).

CODE	OVERSTORY MORTALITY DESCRIPTION	ACRES	PERCENT
L	Low overstory mortality; 10 or fewer dead trees per acre	66,569	96
M	Moderate overstory mortality; 11-20 dead trees per acre	0	0
H	High overstory mortality; 21-60 dead trees per acre	0	0
V	Very high overstory mortality; greater than 60 dead trees/acre	0	0
Other	Non-vegetated and non-forested cover types (see appendix 1)	3,085	4

Sources/Notes: Summarized from the 39veg database (see appendix 1 for more information). Acreage figures include private land located within the analysis area.

Fire and Fuels

To determine how a future forested setting may react to disturbance, a basic understanding is needed of the disturbances with which vegetation evolved. In the case of fire, we need to know what is the natural fire disturbance regime. Fire regimes are generally defined by some combination of fire intensity and frequency. For natural fire regimes, this is defined in a historical sense, generally pre-1900's (Agee, 1996). Agee (1996) identifies a generalized system for classifying fire regimes into high, mixed, and low categories of fire severity (although this system uses similar naming structure, it is not the same system as defined by the Burned Area Emergency Rehabilitation process). Low severity fire regimes typically had low intensity, frequent fires. High severity fire regimes had infrequent but stand replacing fires, and the mixed severity fire regimes (also called mixed severity) had complex combinations of high, low, and mixed severity fires.

A strong correlation exists between Potential Vegetation Groups and the natural (historic) fire regimes, due to the relative constancy of climatic conditions and physical characteristics of the sites, as well as the plant species likely to occur by seral stage. The three PVGs of forested vegetation display the three generalized fire regimes discussed above. Historically, low severity fire regimes probably dominated the Dry Forest Potential Vegetation Group, high severity fire regimes were prevalent in the Cold Forest Potential Vegetation Groups, and Moist Forest Potential Vegetation Group were subject to the more complex, mixed severity fire regime. Historic Fire Regimes and related acreages are summarized in Table 48.

Table 48. Summary of Historic Fire Regimes for Forest Potential Vegetation Groups.

PVG	Fire Severity Regime	Average Fire Return Interval (Years)	Acres
Dry Forest	Low	3-20 yrs.	16,936
Moist Forest	Mixed	25-250 yrs.	24,918
Cold Forest	High	75-300 yrs.	23,429

The low severity fire regime for the Desolation analysis area is expected to have naturally been present on 16,936 acres or 26 percent of the area. A fire history study done in the Blue Mountains in 1994 specifically identifying sites in the warm/dry potential vegetation groups, located a study plot near the Desolation Analysis Area. This study indicated a mean fire return interval of 9.9 years, in a Douglas-fir/pinegrass plant association, with a fire return interval range of 3-20 years (Maruoka, 1994).

The mixed severity fire regime for the Desolation Analysis Area is expected to have naturally occurred on 24,918 acres or 38 percent of the area. The more complex mixed fire regime results in a wide variation in the range of years in the mean fire return interval. Arno (1980) indicated a range of 25-250 years in the grand fir stands in the northern Rocky Mountains. In a fire history study closer to the Desolation Analysis Area, Bork (unpublished) found mean return intervals of 50-200 years in grand fir stands. The wide variation is generally considered to be a result of topographic settings and aspect which modify the fire regime within these more mesic sites. The likely result in this fire regime is a mosaic of seral stages, stand compositions and stand densities. Although many stands within this group would be highly susceptible to crown fire, a natural variation in stand structure and composition would limit the extent of these events.

The high severity fire regimes for the Desolation analysis area are expected to have naturally occurred on approximately 23,429 acres or 36 percent of the area. These areas are likely to be the least impacted due to past management practices. As the fire return intervals were naturally long, extending the interval between fire events through fire suppression would have lesser effects in these areas. Other management activities, such as timber harvest, have occurred to a lesser extent in these areas. When fire did occur naturally in this regime area, it was often stand replacing, even if the fire intensities were not that great, because of the low resistance to fire in the tree species found in these areas, e.g. subalpine fir, lodgepole pine, and Engelmann spruce. Mean fire return intervals of 75-300 years are likely, and a wide variety of age classes in areas discernible across the landscape are likely to result.

Understory and Non-Forest Botanical Resources

Floristic Richness

A comparison of introduced species between the Desolation Watershed and other areas on the Umatilla National Forest shows:

Ratio Native:Introduced Species in Desolation Watershed:	7.49 : 1
Ratio Native:Introduced Species on the NFJD Ranger District:	7.16 : 1
Ratio Native:Introduced Species on the Umatilla National Forest:	5.65 : 1

(1997 plant numbers)

The Desolation watershed has a larger proportion of natives to introduced plants than the North Fork John Day Ranger District or the Forest as a whole. This indicates that the watershed is still in a more "pristine" condition as far as current species composition is concerned. The Botanical Resources Program started tracking relative cover after most of the surveys in this watershed were completed, so the cover proportions of natives to introduced plant species is not known.

No baseline data exists for the community composition and plant species present before white settlement. The earliest reference available is photo interpretation from 1939 aerial photos, which is approximately 110 years after the first significant impacts from Euro-American encroachment (removal of beaver) and well after the worst of the grazing degradation. These are of only limited use. While stand composition can be estimated, and any recent fires, road building, or logging can be detected, it is impossible to determine the cover or composition at the scale of shrubs, forbs, or grasses.

Occasional mention of plants is made in the General Land Office survey notes, settler's and early explorer's diaries, and other historic documents, but these sources are widely scattered, and thus not readily available. Very few of these authors were botanists, so what mention of plants there is tends to be of the larger, showier, and namable plants (i.e., trees and shrubs), and the mention was by common rather than scientific (Latin) name. This makes it hard to interpret because many of the common names have changed in the last 100 years.

The best source of accurate historic data for plant species that were present is old herbarium records from the early explorers and botanists. These records are scattered across the United States and Europe, and it may be at least a decade or two before databases are in place to query plants for specific herbarium voucher locations.

The combination of logging and the exclusion of fire from the Blue Mountains has allowed the once open park-like stands of large ponderosa pines that the settlers so admired to progress to thick, overstocked stands of pine and fir or only fir, which are less drought tolerant and succumbs to insect attack during drought. Some areas have changed so much in the last 200 years that looking at them now gives no clue as to what they once were like. The loss of beaver by over-trapping by the early 1800s undoubtedly had extensive repercussions in plant community types, structure, and extent. Beaver dams, along with the riparian areas and meadows they helped create, slowed runoff, stored water, trapped sediment, stored nutrients for aquatic and later terrestrial life forms, and created important riparian habitat for wildlife that is otherwise in short supply in a region this dry.

Not only are the proportions of introduced grass species high (see Current Conditions), their overall cover is a large proportion of the total grass cover. It is not uncommon to find drier meadows composed of *Poa pratensis* (Kentucky bluegrass), and slightly moister ones completely dominated by *Alopecurus pratensis* (meadow foxtail), both introduced species.

When the Blue Mountains were first settled, the bunchgrasses were so thick that cattle could survive the winter without being fed hay. As more domestic ungulates were imported and the lower meadows were overgrazed, the high mountain meadows took on an increased importance as summer range. With the range open to all by law, competition led to races to be first up to the mountain meadows after snowmelt, and since occupation meant possession, herders and ranchers were unwilling to move their stock until nothing was left but dust and rock.

By the 1880's, the range was severely degraded, and by the mid to late 1890's, range wars broke out over control of grazing. By the 1930's one cattle owner commented "when the first settlers came to the country there was an abundance of fine grass. The valleys were covered with tall meadow grass that was cut and stored for winter feed. The open hillsides all had a heavy stand of bunchgrass and scarcely any sagebrush. Now, it was all cheatgrass and scablands" (Langston, 1995). The few native grasses that survived this onslaught have been further displaced by competition from non-native grasses used in attempts to revegetate the degraded areas.

The number of riparian obligate plants (including most of the many sedges) found in the watershed is very low, only 30 out of 723 species, or only a little over 4 percent. There are many odd aquatic plants that only show up in and along the edges of ponds, lakes, and creekside pools, and even the most common of these are either very rarely encountered or absent from the watershed. Some of these, such as *Sagittaria spp*. and many of the small "duckweeds", provide valuable wildlife food. Lack of habitat is part of the reason-- with the loss of beaver dams, much of their habitat was also lost.

There is some potential habitat left, but the streamsides and pond edges are usually too unstable or trampled to support them: Lost Lake's margins and bottom have been altered with heavy machinery and bentonite. Most of these plants have tiny seeds designed to get caught in the mud on birds feet and be transported between potentially distant wet habitats, so if conditions are right they can spread into appropriate habitats. Without baseline data of plants present in pre- or early settlement times, it can't be absolutely shown that these plants were present, but it is highly likely that they were, and if so, they have been lost over time with changes in management.

So what was the historic variability in floristic biodiversity? How does present plant composition vary from this? With the available information these questions can't be fully answered.

Culturally Significant Plants

As mentioned above, there is virtually no written information available about what and how many plants were present in the Desolation watershed in pre-settlement times. There was, and probably still is, a rich oral tradition and intimate knowledge of the plants present among the Native American communities that have lived in this area for tens of thousands of years. Clues to pre-white settlement usage patterns of the areas can be found in archaeological sites present in the watershed, and by tentative extrapolation of what plants are present now, how widespread might they have been, and what uses are known for them.

One hundred and nine species of plants known from general references for food purposes are found within the watershed. This list does not include many "minor" plants which were supplementary to the Native Americans' diets because of small size of seed, fruit, or root, difficulty of collection, limited plant distribution, limited use, maturity at a time when a major food plant was being harvested, or simply because there is no written documentation that they used the plant for food.

Plants helped shape the cultures of the people and played a large part of the subsistence of Native Americans. On the Columbia plateau, 50-70 percent of food came from gathering roots, berries, and seeds (only 30-50 percent came from hunting and fishing: Hunn, 1981, in Ackerman, 1995). The Columbia plateau was a major trade area, linking the coastal, inland, and Great Plains people; surplus food, basketry and other handmade items were important trade commodities (Langston, 1995, Ackerman, 1995).

Plants also had uses other than food. Ethnographic data of traditional cultures shows that the people had some use for almost every plant that grew in their territory. Most plants had some medicinal use, and in cultures without stores, plants were also used for houses, mats, baskets, containers, tools, hunting equipment, clothing, fuel, personal hygiene, games, cordage, boats, and almost any other physical need or activity of the people. Plants often figured prominently in or were part of the religion and ceremonies.

Noxious Weeds

Since all but one of our noxious weeds are plant species introduced after settlement from other continents, and the one "native noxious weed" is only a problem with disturbance under ideal conditions (which aren't present within the watershed), there were essentially no noxious weeds in the watershed before white settlement.

Historically-listed and Presently-listed Sensitive Plant Species

The historic extent and frequency of our sensitive plant species is unknown. There is no baseline data to compare our current populations to, and virtually no scientific literature and very little anecdotal knowledge of the effects of management activities or changes in community composition on our presently or historically listed sensitive plant species. In addition, some plant species may have been extirpated from the area or became completely extinct before any plant surveys were done in the area.

Fish and Aquatic Habitat

Historical Data

The earliest data available at this writing came from surveys done by ODFW in 1963 & 1964. Information available includes area of spawning gravel, pool counts, and pool/riffle ratios (Table 49). Because the protocol used to gather the information is not known at this time, it is not now advisable to make direct numerical comparisons to more recently collected data. It might be feasible to compare ranking of streams, based on quality of habitat parameters, between these earlier and more recent surveys.

Table 49. Historical Stream Survey Data.

Desolation Creek Watershed Data from 1963 - 1964 ODFW surveys		
Stream	**Riffle to Pool Ratio (percentage)**	**Pools/mile**
Mainstem Desolation Creek	88 to 12	51.8
Kelsay Creek	89 to 11	68.8
Bruin Creek	93 to 7	54.0
Beeman Creek	88 to 12	96.0
Battle Creek	87 to 13	106.3
Sponge Creek	84 to 16	116.7
North Fork Desolation	71 to 29	118.8
South Fork Desolation	77 to 23	85.8

Comparison to Unmanaged Areas

The Interior Columbia Basin Ecosystem Management Project (ICBEMP) assembled stream habitat survey data from a large number of sources and summarized this information by River Basin and by Ecological Reporting Units (ERU's) (McKinney et al, 1996). McKinney et. al. also broke down this information by three stream gradient categories and by management status (managed or unmanaged).

This has proven very useful, as it permits comparison of Desolation Watershed streams and reaches, by gradient category, to their unmanaged equivalents in the same general geographic area. The condition of an unmanaged reach is presumed by some to represent the optimum potential of the system.

A serious weakness of the ICBEMP summaries is that some gradient -- management categories are represented by only one, or very few, surveyed reaches. This is more often true for comparisons to the John Day River Basin than for ERU 6 (the Blue Mountains). For this reason, comparisons in this report most often utilize the ERU 6 values.

PACFISH

In 1995, the USDA Forest Service and the USDI Bureau of Land Management jointly and in consultation with the National Marine Fisheries Service produced a document commonly referred to as "PACFISH" which contains some standards for a variety of aquatic habitat parameters for streams bearing anadromous fish. PACFISH standards have the status of amendments to the Forest Plan, in effect are both Forest Plan and Regional standards.

PACFISH standards (called 'interim objectives" in the PACFISH document) for habitat parameters utilized in this report are reproduced below:

<u>Pool Frequency</u>

Table 50. PACFISH interim objectives for pool frequency (varies by channel width).*

Wetted Width in Feet	10	20	25	50	75	100	125	150
Number of Pools per Mile	96	56	47	26	23	18	14	12
*applies only to low-gradient (<=1%), C-type (Rosgen) channels.								

Large Woody Debris Frequency
Minimum of 20 pieces per mile of wood larger than 12 inches in diameter, and greater than 35 feet long.

Width/Depth Ratio
Maximum of 10, calculated as mean wetted width divided by mean depth. This could be converted to a depth/width ratio as presented in the data summaries produced by the ICBEMP (McKinney et al, 1996) as a minimum of 0.10. However, the Pacfish width/depth ratio was specified as measured in pools (USDA Forest Service, 1994), while the ICBEMP depth/width ratio is specified as measured in riffles. While the width/depth ratios of pools might be useful for evaluating fish habitat quality, the measurements in riffles are more useful from a hydrologic perspective. Stream survey records contain measurements of depth and wetted width of both pools and riffles, so either quality could be calculated, but since Pacfish standards are for low gradient (≤ 1%) C-type channels, they would not apply to most Desolation watershed streams.

Water Temperature
Criteria are:

a) No measurable increase in maximum water temperature.*

b) Maximum water temperatures* below 64° Fahrenheit within migration and rearing habitats, and below 60° Fahrenheit within spawning habitats of anadromous fish.

*Seven-day moving average of daily maximum temperature measured as the average of the maximum daily temperature of the warmest consecutive seven-day period.

Terrestrial Wildlife

Habitats

Old Forest Habitat

In 1939, approximately 49 percent of the Desolation watershed supported stands of "old forest". Estimated acres of old forest for 1939 are presented in Table 51.

Table 51. Old Forest Acres, Desolation Watershed, 1939.

PVG	STRUCTURAL STAGE	TOTAL ACRES
Cold Upland Forest	OFMS	2,892
	OFSS	3,486
	Total	**6,378**
Dry Upland Forest	OFMS	8,480
	OFSS	6,754
	Total	**15,234**
Moist Upland	OFMS	4,017
	OFSS	8,706
	Total	**12,723**
Grand Total		**34,335**

Dead Standing and Down Wood Habitat
No quantitative information on snags or down wood exists for this area, however, “overstory mortality” was estimated through photo interpretation. All forest polygons were estimated to have “low overstory mortality” (where “low” = <10 trees/acre).

Wetland, Riparian, and Aspen Habitat
Riparian hardwoods may have been much more abundant historically than today, however, very little information on species composition or condition is available.

Roads
Aerial photos taken in 1939 show very few roads. Road impacts to big game and other wildlife were probably minimal until the 1970s, when road construction, associated with timber harvest and recreation intensified.

Big Game Species

Historic accounts of wildlife populations in the Blue Mountains are limited, and sometimes contradictory, particularly in regards to big game populations. Mule deer, elk, black and grizzly bear, pronghorn antelope, cougar and big horn sheep were native to the Blues (Irwin et al. 1994, Gildemeister 1992). Wild goats may have inhabited the steep canyons; but most biologists concur that the species is not probably native to the area. Oral histories collected by Gildemeister (1992) suggest that moose also occupied the area at one time (there was at one time a bag limit for moose in Oregon). Small numbers of bison bones have been recovered in the eastern Blue Mountains, but archaeologists suspect that these old bones got to the area as butchered carcasses via tribal hunting trips or by trade with Rocky Mountain tribes.

By the 1880s, big game populations in the Blues (particularly elk) were beginning to collapse under the combined pressures of market hunting, competition with domestic livestock, and habitat alteration (Irwin et al. 1994, Langston 1994). By the turn of the century, both elk and mule deer had been nearly extirpated from all of northeast Oregon (Skovlin 1991, Langston 1994 , ODFW 1936). In response, the newly organized Game Commission closed all elk hunting seasons, and imposed a $1000 fine for poaching (ODFW 1936, Irwin et al. 1994).

With hunting banned, The Commission then set about re-establishing elk in the Blues. Between 1910 and 1920, transplants of Rocky Mountain elk from Yellowstone National Park occurred in various areas of the Blue and Wallowa Mountains. Transplants met with varying degrees of success, but the infusion of new animals, along with the hunting closure, averted total extinction, and herds eventually began to increase. Elk occupying the Desolation area today are probably decendants of a small group of elk released in the Elkhorn Mountains (south and east of Desolation) and a remnant native herd that managed to survive the late 1800s in roughly the same area.

By 1933, elk numbers were rebounding. Upward population trends continued for elk and mule deer through the 40s, 50s and 60s. While increased numbers of huntable animals pleased sportsmen and tribal hunters, controversy quickly developed between game managers and local ranching communities (Irwin et al. 1994). The Game Commission was aware of the problem as early as 1936, when a report to the Governor stressed the need for both "sufficient winter range" for the elk and "equitable" methods of compensation to land owners for damage to their alfalfa and hay crops.

Competition between wild ungulates and domestic livestock, and conflict between public and private interests continued for decades, and eventually led to the establishment of the Bridge Creek Wildlife Management Area south of Ukiah, Oregon, in 1961. Situated south of Camas Prairie, on a very large open plain which falls off to form the headwaters of several North Fork John Day tributaries, the management area provides almost 15,000 acres of winter habitat for elk and deer.

Other Game Species, Furbearers and Predators

Almost all other big game and fur-bearing species in northeastern Oregon (with a few noteable exceptions) have declined since the late 1880s. As early as 1936, researchers stated that "wild life is diminishing in Oregon in spite of the fact that the natural habitat, for the state as a whole, is capable of sustaining many times the present wild life population"

A review of census summaries from a 1936 Oregon Game Commission report shows low numbers for the Umatilla National Forest of many species known to occur in the Desolation drainage. Beaver, marten, otter and mink are mentioned as species whose numbers had substantially declined by 1936, (State Planning Board 1936). All of these species have historically occupied the Desolation area, and still do, although numbers, distribution and population health are largely unknown. Evidence of past and present beaver activity is found along the mainstem and a few tributaries of Desolation Creek.

The wolverine, although probably never abundant, most likely occurred within the Desolation drainage. Because the wolverine is largely a carrion eater, the decimation of big game herds in the late 1800s may have also led to declines in wolverine numbers by the turn of the century. Habitat alteration, and perhaps more importantly, increased human disturbance have resulted in continued habitat degradation for this species in the Blue and Wallowa Mountains.

Lynx may also have occurred in the western Blue Mountains, as evidenced by tracks found on the Malheur NF in the early 1990s. Like the wolverine, lynx are wide-ranging predators with very large territories and an aversion to humans. Unlike the wolverine, however, the lynx preys on smaller mammals, is not generally a carrion feeder, and is more likely to use young-forest habitats.

Grizzly bears and wolves occurred in the Blue Mountains into the early 1900s. The last confirmed grizzly shooting in northeastern Oregon occurred in the Wallowa Mountains in the 1930s (C. Puchy, ODFW, pers. comm. 1995). ODFW has considered the wolf extirpated from the Blues since the early 1900s; however wolf and wolf/hybrid sightings continue to be reported occasionally.

Mountain goats were released in the Elkhorn Mountains (southeast of Desolation) in the 1980s (ODFW, pers. comm.). There have been several sightings of goats since that time, including a confirmed sighting of two goats in the adjacent North Fork John Day Wilderness in August, 1994 (M. Hampton, Umatilla NF, pers. comm.). One goat was seen near Pearson Guard Station in August 1998, and two were seen in the North Fork John Day Wilderness in November, 1998 (K. Hancock, Umatilla NF, pers. comm., Aug. 1998).

The 1936 state report also included records of predators taken on and adjacent to the National Forests, for the years 1933-1935. For the Umatilla National Forest, 4,781 coyote, 31 bobcat, 138 black bear, and 2,196 porcupine were killed by government hunters, Forest Service personnel, and private land owners. Curiously, no mountain lion were reported taken on the Umatilla National Forest during that period (5 were reported taken on the Malheur, 1 on the Whitman) compared to more than 200 taken on Forests west of the Cascades during the same period.

Beaver
The British Hudson's Bay Company first established a monopoly on the beaver fur trade in the Northwest. Where the company controlled an area, beaver harvest occurred on a fairly sustainable basis, but with competition from the American's Northwest Company, both companies fiercely overtrapped. The Hudson's Bay Company decided on a policy of rapid overtrapping south of the Columbia River to create a "fur desert" to keep the Americans out. Within 30 years of the white traders first coming to the Blue Mountains, the beaver had nearly vanished (Langston, 1995).

Small Mammals, Birds, Reptiles and Amphibians
With the exception of Gildemeister's 1992 oral history accounts, little information is available on the occurrence or relative abundance of non-hunted vertebrate species. Henry Spaulding's 1839 accounts include references to occurrence of bald eagles in the Wallowas during the summer months, where the birds fed on spawning salmon. This summer presence suggests a nesting population. Information collected by biologists on the neighboring Ochoco NF included references to eagles and hawks being "common" around the turn of the century. Bounties were still being paid on golden eagles well into the 1900s.

Some records are available for upland game birds. Valley and mountain quail, ruffed, blue and sharp-tailed and sage grouse are native to the Blue Mountains, and all may have occurred in the Desolation drainage. Accounts in Gildemeister recall abundant populations, with market hunting prevalent. In 1910, for example, a dozen sharp-tail grouse brought $3.00 at the Union Hotel (Gildemeister 1992).

Market hunting in the late 1800s and early 1900s was responsible for enormous losses in upland gamebird populations in many parts of the US, and probably impacted species in the Blue Mountains. The sharptailed grouse was almost extinct by 1936 (State Planning Board 1936), and has since been extirpated from the Blue Mountains. Re-introductions were begun in the 1990s.

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

Threatened, Endangered, and Sensitive Species
Bald eagles were probably more common in the drainage historically, as large diameter trees and salmon were more abundant than today. Peregrine falcons were probably never common, as the limited amount of nesting habitat has not changed in availability or condition. Undisturbed riparian habitats no doubt supported higher densities of amphibians. Extensive stands of old forest, more aspen, and periodic fires would have contributed to higher (albeit dynamic and somewhat transitory) populations of the various woodpecker species now residing on the Sensitive list. More old forest and healthier riparian habitats probably supported higher densities of marten as well. Wolverine and lynx, at the southern limit of their ranges, were probably never “abundant” in this area. However, before roads, timber harvest livestock grazing, hunting and OHV use changed the character of the watershed, much of the Desolation drainage probably provided good foraging habitat for these wide-ranging carnivores.

Management Indicator Species

All Management Indicator Species were present historically, and with the exception of elk, were probably more abundant in 1939 than they are today, based on the comparison of potential habitats found in Synthesis and Interpretation.

Mining

Mining of placer gold deposits began in northeastern Oregon in 1862. The principal gold-mining regions of Oregon owe their discovery to the wave of prospectors that invaded California in 1849, and from there spread through all the mountain areas of the West.

Rangeland Resources

Both the Indian and Central Desolation allotment areas have been used for grazing domestic livestock since the early 1800s. From 1890 until about 1905, some 2000 horses ran yearlong on Case Ridge and in the Indian Creek drainage (immediately to the south of Desolation). About 6000 sheep and numerous cattle also grazed the area during the summer and early fall during the same period. These conditions prevailed until 1909 or 1910 when sheep use shifted to other areas and the horses were sold. The dual was extremely heavy, and the year-round use by horses contributed significantly to depleted range conditions, at least in the lower portions of the Desolation drainage. Severe overuse occurred again after the First World War.

Actual use figures are not available for the Indian Allotment prior to 1912, or prior to 1937 for Central Desolation.

Indian Allotment

The Indian Creek Cattle and Horse Association was recognized by the District Forester in Portland in 1913. The association grazed an area which are now the Bully and Indian Units (pastures). There was little change in management of the Indian allotment until a 1947/48 range inventory revealed overstocking and downward trends in most forage species. As a result of the survey, a new management plan was adopted by the Association in 1948. The same year, portions of Desolation Meadows, which had long been used by sheep, was opened to cattle on a temporary basis. The meadows were formally added to the allotment in 1950.

In 1962, a deferred rotation system of grazing and turn-on dates was determined by range readiness, and significant improvement in the condition of the range began. The Battle Creek Unit was transferred from Central Desolation to Indian Creek in 1966. In 1984 a 4-pasture rest rotation grazing system was adopted, meaning a different pasture was rested each year. In 1991, the grazing system was changed again with rotation from Bully/Indian Units to Battle/Meadows Units, then back to Bully/Indian Units ,with no rest and a modified deferment. The current system (see Current Conditions) was adopted in 1996.

Table 52. Summary of Use Records - Indian Creek Cattle Allotment

YEAR	NF AVERAGE CATTLE NUMBER	PRIVATE AVERAGE CATTLE NUMBER	SEASON	AVERAGE HEAD MONTHS (NF ONLY)	TOTAL ACRES
1912 - 1917	601	--	04/05-10/31	3,906	----
1918 - 1922	928	--	05/01-10/31	5,572	---
1923 -1949	868	57	05/16-10/31	4,757	56,986
1950 -1954	702	45	05/20-10/31	3,658	62,537
1955 - 1965	674	45	06/01-10/15	3,072	62,736
1966 - 1983	865	32	06/01-10/15	3,451	86,760
1984 - 1995	825	51	06/01-09/30	3,343	86,760
1996 - 1997	814	74	06/16-09/30	3,108	68,706

There are virtually no records for this allotment on condition and trend prior to a 1947 analysis, when a survey crew classified the allotment as follows:

- 80% of area in poor condition
- 19% of area in fair condition
- 1% of area in good condition
- 84% of entire usable range was trending downward; 16% trending upward (vegetation types trending downward were mostly open timber, grassland, and sagebrush types)
- 70% upward trend in the meadow type

The survey recommended a 40 percent reduction in cattle. The forest supervisor attempted to carry out the reduction in 1954 but permittees appealed. The two parties eventually compromised with a reduction in season and a full-time range rider. In 1949, Desolation Meadows, previously classed as good with an upward trend, was starting to show signs of a downward trend.

A 1953 allotment inspection reported most meadows at 100 percent utilization. In 1954, use in the Desolation Ridge and Creek areas was reported as extremely heavy.

Inspections for 1954 - 1956 reported that Kelsay Creek was under-used due to poor distribution.

In 1956, Battle Creek use was heavy but not to the extent of 1955, Lower Sponge Meadow was overused, and Desolation Meadows was considered underused.

A detailed inspection in 1958 reported on six creek/meadow areas within the Desolation watershed. Summarized results included the following:

- Summit Camp - Denuded desirable vegetation on adjacent dry areas, use on meadow beyond that considered proper.

- Upper South Fork Desolation Meadow - Adjacent hillsides denuded, heavy rains the past summer starting erosion channels.

- Sponge and Howard Creeks - Tufted hairgrass meadows along these streams from moderate to heavy.

- North Fork Desolation Meadow - Use is like in former years, the dry parts overused and the wet parts under used. There is active cutting on stream banks along creek in meadow.

- Big Spring Meadow - Less than 10% use. Lack of use difficult to explain.

- Starveout Creek - The lower meadows on waived land were heavily overused, upper meadows moderate to light.

As a result of the above inspection, water spreading was recommended in drier areas, and draining in wet areas of Desolation Meadows to increase forage production. Some water spreading ditches were built around 1961.

Based on an analysis conducted in 1961, the allotment was classified as follows:

- 6% of the area in very poor condition
- 18% of the area in poor condition
- 66% of the area in fair condition
- 10% of the area in good condition

Between 1960 and 1965, permittees cooperated in the construction and betterment of more than 50 miles of fence, and about 25 water developments. Several revegetation projects were also completed during this time including seeding on Sharps Ridge. In 1968, '69, and '70, 15-day extensions were approved. based on utilization data (the key areas were mostly upland sites). The extensions did not result in overuse of the forage resource.

In 1970, heavy use was reported on Desolation Creek outside of the Meadows, South Fork Desolation Creek below South Fork Meadows, Summit Camp, and in Kelsay Meadows as a result of poor distribution and late removal of cattle from units (moderate use overall). In 1973, overuse was again recorded on Kelsay Meadows. Reconnaissance utilization mapping in 1971, '73, and '74 showed heavy use on Desolation Creek and some areas of over-use.

Central Desolation Allotment

The Central Desolation Cattle Association was also formed in 1913. In addition to the land within the current allotment boundary, the area grazed from 1946 to 1966 included what is now Battle Unit of the Indian Creek, and most of the private land. Approximately half of the Desolation watershed is within this area. In 1946, 46,000 acres carrying four bands of sheep were added to the allotment, but records do not give the location. At the same time, the allotment was transferred from sheep to cattle. A 4-pasture deferred rotation system was adopted in 1966 (AMP). In 1981, a 5-pasture rest rotation system was established, which is still in effect today.

Table 53. Summary of Use Records - Central Desolation Allotment (NF & Private)

YEAR	AVERAGE NUMBER OF CATTLE	SEASON	AVERAGE HEAD MONTHS	USABLE ACRES
1937 - 1944	719	05/16-10/31	3,794	13,357
1946 - 1951	1,207	05/16-10/31	6,643	44,604
1952 - 1957	1,222	05/21-10/20	6,110	44,604
1958 - 1963	1,215	06/01-10/20	5,661	44,604
1964 - 1965	1,204	06/01-10/20	5,722	25,217
1966 - 1970	432	06/01-09/30	1,728	14,375
1971 - 1975	514	06/01-09/30	2,056	16,997
1976 - 1997	445	06/01-09/30	1,780	11,002

Within the Desolation Watershed, very little historic information exists on forage utilization, condition and trend, or improvements, since most of the Central Desolation Allotment was and is under private management.

In the 1951 AMP (may have been a 1946 analysis) a condition and trend analysis was conducted on the allotment. The results follow:

- Meadow type: 36% poor, 64% fair (62% up, 2% unchanged, 36% down)
- Open grassland type: 100% poor (30% up, 3% unchanged, 67% down)
- Browse type: 97% poor, 3% fair (77% up, 0% unchanged, 23% down)
- Open timber type: 69% poor, 31% fair (21% up, 66% unchanged, 13% down)

The problem indicated in the 1951 AMP was poor distribution. Concentration areas were used too heavily, while other areas showed under use. Lower Kelsay Creek, Kelsay Creek, Park Creek, Battle Creek, and Bruin Creek were under used. This was due mostly to inaccessibility. Cattle remained in many areas season long, including Jones Meadow, Park Meadow, and Lower Kelsay Meadow, giving the land no opportunity to improve.

V. SYNTHESIS AND INTERPRETATION

Synthesis and interpretation of information is the fifth step in the six-step process for ecosystem analysis at the watershed scale. The purpose of step 5 is to compare current (step 3) and reference (step 4) conditions for key ecosystem elements, to explain significant differences, similarities, or trends, and to examine their causes. The capability of the ecosystem to achieve key management plan objectives is also evaluated in this step (Regional Ecosystem Office 1995).

Soils and Geology

While surface materials are quite erodible, relatively gentle slopes within the watershed help reduce overall erosion hazards. Large amounts of unconsolidated materials, of relatively young age, create large areas of risk for mass movement. These are most evident in the lower drainage within the landslide areas (Qls), and some of the upper headwaters of steep slopes. Productivity levels are generally high due to considerable amounts of deeper soils and favorable water availability. Glacial activity and resulting tills, in combination with volcanic ash deposits, have created alpine environments in places with high, wet meadow complexes. Desolation, Kelsay and other wet meadow systems provide favorable subsurface water storage and release.

Watershed Hydrology

Riparian Management

Riparian management concerns were persistent throughout the analysis, with many as yet unanswered questions. Moreover, the lack of adequate inventories and classification of riparian communities, precludes specific integration between resource areas. General management concerns and areas of potential conflict are presented below.

Riparian areas are essential landscape components in the maintenance and restoration of water quality and aquatic habitat. Riparian areas provide many other key functions including unique habitats for plants and wildlife. As a result of past and current land uses many riparian communities in the Desolation watershed are not in optimum condition. Streamside roads, logging, and grazing have altered vegetation communities, and stream channel morphology. Recent fires have also had a pronounced impact in the upper watershed.

Riparian areas are strongly affected by upslope conditions and activities. Current vegetation conditions in both burned and unburned areas reflect past management policies of fire suppression, and timber harvest. Concerns include recovering historic stand conditions and fire regimes to more sustainable levels throughout the watershed.

Riparian shrub communities were probably more extensive prior to grazing and fire management. The potential recovery of shrub communities is complicated by the impacts of continued livestock and ungulate grazing and the need to maintain future sources of large in-channel wood, which has many physical and biological functions. Active management within designated Riparian Habitat Conservation areas was considered, with the assumption that any actions in RHCAs must benefit riparian functions in some way.

Cumulative Effects

Water yield and peak flow increases, elevated erosion, sedimentation, and channel changes are more likely in watersheds with higher combined levels of harvest, roads and burned areas. Subwatersheds with increased risk of cumulative effects are: 36C, 36F, 36G, 3H, and 3I.

Wild and Scenic River Eligibility

The Wild and Scenic River Eligibility determination reported Desolation Creek as having excellent water quality, one of the "values" rated in the analysis. However, analysis of cumulative effects showed that water quality in Desolation is not at optimum. This result does not affect the Recreation or Scenic determination since impairment is not due to water quality conditions that affect aesthetic values (turbidity or nuisance algae). However, unless a water quality management plan is developed, South Fork Desolation may not meet one criterion for designation as "Wild", which requires meeting state standards. Elements of such a plan are contained in the Recommendation section of this report. Water temperatures in excess of standards represent natural conditions in South Fork Desolation Creek, and should not affect the determination for Wild and Scenic eligibility.

Forest Overstory Vegetation

Forest Cover Types

Table 54 and Figure 33 illustrate changes in forest cover types between 1939 and 1997. Stands dominated by lodgepole pine were much more abundant in 1939 than in 1997. The most likely reason for a reduction in the lodgepole pine cover type was a mountain pine beetle outbreak during the late 1970s and early 1980s that killed mature lodgepole pine throughout the central Blue Mountains (Gast and others 1991). After bark beetles killed the overstory trees, new stands were often dominated by shade-tolerant, late-seral species that had previously regenerated beneath the shade-intolerant, early-seral lodgepole pines. Since grand fir is a shade-tolerant, late-seral species, this scenario could help explain why the grand fir cover type increased by 120 percent (more than doubling in area) between 1939 and 1997.

The 500 percent increase in Engelmann spruce from 1939 to 1997 may have actually occurred, or the increase could merely be a reflection of the improved 1997 photography. Spruce seldom occurs in pure stands. Mixed stands with a substantial spruce component may have existed in 1939, but would have been more difficult to discern on the low resolution photography of that era. Alternatively, fire suppression over the last 90 years has tended to blur the historical zonation of forest vegetation. Engelmann spruce is one species that has expanded its range to lower elevations as a result of fire suppression, so its apparent increase in abundance may be real.

The decrease in Douglas-fir is probably related to the landscape-level disturbances occurring over the last 60 years, particularly with respect to outbreaks of defoliating insects (Douglas-fir tussock moth and western spruce budworm), and bark beetles (primarily Douglas-fir beetle).

Table 51 indicates that two new forest cover types became established sometime between 1939 and 1997 – western juniper (CJ) and whitebark pine (CB). It is probable that western juniper did indeed become established during that period. Small areas of whitebark pine, however, were already present in 1939, but do not show up in the historic vegetation database. These areas were either too small to be distinguished, or were misidentified on the historical aerial photography, which was small-scale (1:20,000) and of lower resolution than modern film.

Western juniper trees are relatively common on hot dry sites at low elevations in the analysis area. Historically, juniper abundance and distribution was largely controlled by fire, since it has low fire resistance (Agee 1993) and would seldom survive any but the lowest-intensity burns. It is possible that the small amount of western juniper cover type identified in 1997 is a consequence of fire suppression.

Comparison of acres of non-forested cover types (grassland, shrubland, forbland/meadows, etc.) indicate an increase between 1939 and 1997. The reasons for this change are many and varied: in some cases, the effect of timber harvest or wildfire resulted in areas that currently have less than 10 percent canopy cover of trees, which caused them to be coded as a non-forest cover type. Eventually, those areas will support trees once again as plant succession progresses. In other instances, the better resolution and smaller scale of the 1995-1997 aerial photography allowed more of the "patchy" non-forest vegetation to be delineated as separate polygons (typically ranging from 1 to 3 acres). That level of detail or refinement was seldom possible on the coarser photography used for the 1939 characterization.

Although the percentage comparisons do represent substantial change in the species composition of the forest canopy, those changes are probably within the historic range of variation for species composition. Fluctuations in cover types have always occurred in response to forest disturbances, and are now occurring again in response to the Bull and Summit wildfires and other recent disturbance events. For example, one expected consequence of wildfires in the Desolation watershed is a future short-term (30-50 years) reduction in the subalpine fir, Engelmann spruce and grand fir cover types, and an increase in the lodgepole pine, western larch, and subalpine grassland cover types.

Table 54. Changes in Forest Cover Types, 1937-1997.

		1939		1997		
Cover Type	**Predominant Tree Species**	**Total Acres**	**% of Forested Acres**	**Total Acres**	**% of Forested Acres**	**% Change in Total Acres**
CA	Subalpine fir	8,003	12	5,667	8	-29%
CD	Douglas-fir	12,916	20	8,203	12	-36%
CE	Engelmann spruce	485	<1	2,916	4	500%
CL	Lodgepole pine	25,624	40	14,598	21	-43%
CP	Ponderosa pine	3,620	6	3,902	6	+8%
CT	Western larch	1,509	2	1,501	2	-1%
CW	Grand fir	12,021	19	26,459	38	120%
CX	Mixed	2,391	4	1,921	3	-20%
CB	Whitebark pine	0	0	116	<1	N/A
CJ	Western juniper	0	0	21	<1	N/A
Other	Non-forested	3,084	N/A	4,232	N/A	37%

Figure 33. Comparison of Cover Type Abundance, 1939-1937.

Forest Canopy Cover, Stand Density

Recently-developed stocking guidelines (Cochran and others 1994) were used to analyze stand density levels and infer whether they were ecologically sustainable. By using the stocking guidelines in conjunction with potential natural vegetation (PAGs) and information about the seral status of forest vegetation, it was possible to determine the acres that would be considered overstocked, and to compare results for reference and current conditions (Table 55 and 56). Details of the stand density analysis, which was used to help formulate treatment recommendations and opportunities, are found in the Silviculture Specialist's Report.

Table 55. Stand density analysis; 1939 forest conditions.

PAG	SS	TREE SPECIES	LMZ COVER	UMZ COVER	TOTAL AREA	OVER-STOCKED
					(Acres)	
Cold Dry Upland Forest	ES	LP	59	66	12,709	11,736
	MS	DF	72	78	2,357	216
	LS	SF	76	83	7,333	1,292
Cool Moist Upland Forest	ES	LP	58	65	11,129	10,565
	MS	DF	74	80	3,636	982
	LS	SF	74	81	11,042	2,556
Hot Dry Upland Forest	LS	PP	26	33	1,059	394
Warm Dry Upland Forest	ES	PP	43	51	5,855	5,242
	MS	DF	68	75	1,072	1,012
	LS	DF	68	75	10,376	3,075
TOTAL					66,568	37,070(56%)

Sources/Notes: Summarized from the 39veg database (see appendix 1 for more information). Acreage figures include private land located within the analysis area. ES refers to early seral; MS refers to mid seral; LS refers to late seral (see Hall and others 1995). Tree species codes, lower management zone (LMZ) values, and upper management zone (UMZ) values are described in appendix 2. The LMZ and UMZ figures are canopy cover values and refer to a "management zone" in which stand densities are considered to be ecologically sustainable (Cochran and others 1994). The "total area" figure shows the acreage of each PVG/SS combination in the analysis area; the "overstocked" value is the acreage with a canopy cover value that exceeds the "UMZ cover" figure and would therefore be considered overstocked.

Table 56. Stand density analysis; 1997 forest conditions.

PAG	SS	TREE SPECIES	LMZ COVER	UMZ COVER	TOTAL AREA	OVER-STOCKED
					(Acres)	
Cold Dry Upland Forest	ES	LP	59	66	9,677	1,484
	MS	DF	72	78	2,426	0
	LS	SF	76	83	11,315	63
Cool Dry Upland Forest	MS	DF	72	78	11	0
Cool Moist Upland Forest	ES	LP	58	65	6,304	325
	MS	DF	74	80	4,052	0
	LS	SF	74	81	14,424	366
Hot Dry Upland Forest	LS	PP	26	33	690	308
Warm Dry Upland Forest	ES	PP	43	51	3,402	358
	LS	DF	68	75	12,844	0
Warm Moist Upland Forest	ES	PP	55	62	44	44
	MS	DF	68	75	94	0
TOTAL					65,283	2,948 (4.5%)

Sources/Notes: Summarized from the 97veg database (see appendix 1 for more information). Acreage figures include private land located within the analysis area.

ES = early seral; MS = mid seral; LS = late seral (Hall and others 1995).

Tree species codes: (LMZ) = lower management zone values, (UMZ) = upper management zone values (see appendix 2). The “total area” figure shows the acreage of each PVG/SS combination in the analysis area; the “overstocked” value is the acreage with a canopy cover value that exceeds the “UMZ cover” figure and would therefore be considered overstocked.

It is interesting that approximately 56 percent of the Desolation watershed would be considered overstocked in 1939, as compared to only 4.5 percent in 1997, yet this apparent overstocking was not reflected in high levels of insect or disease damage for that time period (Tables 46 and 47). The high stocking levels, however, may have presaged the widespread bark-beetle outbreaks that occurred across the southern Umatilla National Forest in the mid to late 1940s (Buckhorn 1948), and an intense spruce budworm outbreak that began in 1944 and continued until 1958 (Dolph 1980).

High-density forest (canopy cover greater than 70%) was much more common in 1939 than in 1997 (Table 57). Conversely, low-density forest (canopy cover of 40% or less) is much more abundant currently than it was historically. Forest disturbances, both natural and human-caused, have contributed to substantial reductions in stand density through time. In some instances, clearcutting, lethal wildfire, or another major disturbance killed an entire stand, with the newly-regenerated, post-disturbance forest often having a lower density (canopy cover) than the original one. In other cases, partial-cutting timber harvests, spruce budworm defoliation, or a similar disturbance killed some trees but not the entire stand, thereby reducing the stand density (canopy cover).

Table 57. Comparison of Canopy Cover, 1939-1997.

LIVE FOREST COVER DESCRIPTION	1939		1997		
	ACRES	%	ACRES	%	% CHANGE IN ACRES
40 % or less	5,284	8	33,668	48	537
41% to 55%	4,108	6	16,190	23	294
56% to 70 %	16,329	23	13,142	19	-20
Over 70 %	40,848	59	2,304	3	-94

Forest Canopy Layers

Stands with two canopy layers were slightly more common in 1997 (71%) than in 1939 (64%, Table 58). Single-layer stands were more abundant in 1939 than in 1997, indicating that stand structure has become slightly more complex. Stands with three or more canopy layers have been relatively stable through time, occupying 4 percent of the watershed in 1939 and 6 percent in 1997.

Table 58. Comparison of Canopy Layers, 1939-1997.

CANOPY LAYER DESCRIPTION	1939		1997	
	ACRES	%	ACRES	%
Live tree canopy cover occurs in l layer	17,531	25	13,467	19
Live tree canopy cover occurs in 2 layers	44,830	64	49,194	71
Live tree canopy cover occurs in 3 or more layers	4,208	6	2,643	4
Non-vegetated and non-forested cover types	3,085	4	4,232	6

Forest Size Classes

Stands comprised of large-diameter trees were more common in 1939 than in 1997 (Table 59, Figure 34). In 1939, 85 percent of the analysis area had stands with trees in the small or medium size classes (9”to 31.9” DBH); by 1997, the percentage had declined to 65 percent (based on size class 77 and greater). The largest change in size class distribution was in the range of seedlings to poles, with a 182 percent increase in acres from 1939 to 1997.

Table 59. Comparison of Forest Size Classes

Size Class Description	1939 Acres	1939 %	1997 Acres	1997 %	% Change in Acres
Seedlings-Poles Small Trees	7,126	10	20,107	29	182
Small Trees (9" - 20.9" DBH)	45,281	65	44,157	64	-2
Medium Trees (21" - 31.9" DBH)	14,163	20	1,033	1	-93
Large Trees (32" - 47.9" DBH)	0	0	7	<1	N/A

Primary causes of size-class changes include selective timber harvest of large diameter trees (Powell 1994); selective killing of large-diameter trees by some species of bark beetles (Gast and others 1991); and recent, stand-replacing wildfires initiating new stands that are now dominated by small, seedling-size trees.

Figure 34. Forest Size Classes, 1939 and 1997.

Forest Structural Stages

When analyzing current conditions with respect to structural stages, it is often helpful to put them in an historical context. Structural stages are inclusive – any particular point on a stand's developmental pathway can be assigned to a structural stage. They are also universal – every forest stand eventually passes through a series of structural stages, although not every stand passes through all of the stages or spends an equal amount of time in any particular stage. For those reasons – inclusiveness and universality – structural stages are an ideal framework for comparing current and reference conditions.

A technique was recently developed to compare current and reference conditions – the historical range of variation (HRV) (Morgan and others 1994). Although debate on the concept continues (B. Wales, ICBEMP Science Team, pers. comm. 1999), some managers consider HRV to be an indicator of ecological sustainability. After identifying historical ranges for a particular variable, managers can then infer which ecological processes may have been important for creating and sustaining those conditions. HRV may be most valuable as a reference point or benchmark.

A key premise of HRV is that native species are adapted to, and have evolved with, the natural disturbance regime of an area. As such, ecosystem elements occurring within their historical range are believed to represent diverse, resilient, productive, and sustainable situations (Swanson and others 1994). Since structural stages represent different points in the development of a forest, they can serve as a valueable framework for assessing the condition of habitat for native wildlife, fish and understory flora.

An HRV analysis was completed for the Desolation watershed. It was based on two primary factors – forest structural stages and potential natural vegetation (as represented by PVGs). Potential natural vegetation was important for explicitly recognizing that all forest stands will not occupy every structural stage, and that different types of forest (dry, moist, cold) will not spend the same amount of time in any particular stage.

Results of HRV comparisons are provided in Table 60. Table 60 also summarizes current and historic percentages of each structural stage, by PVG, for two groupings of subwatersheds in the Desolation analysis area. Results are also provided for the watershed in its entirety. Subwatershed groupings were developed because it was recommended that an HRV analysis be conducted on land areas of 15,000 to 35,000 acres (USDA Forest Service 1994).

The Desolation watershed has a pronounced elevational gradient spanning almost 5,000 feet (2,971 to 7,632 feet), resulting in a well-balanced mix of upland forest PVGs. Unfortunately, partitioning the watershed into two smaller groups essentially disrupted the good balance. For that reason, the HRV analysis pertaining to the whole watershed is considered to be the most accurate, even though it pertains to an area that exceeds 35,000 acres.

When considering the entire Desolation watershed, the HRV analysis for current structural stages (Table 60) shows that ***old forest*** structure is deficient for all PVGs. ***Young forest multi strata*** is also deficient for the dry forest PVG. The ***stand initiation*** structural stage exceeds the historical range**,** often by a considerable amount, for all three of the PVGs. ***Stem exclusion* and *understory reinitiation*** also exceed the historical range in the dry forest PVG.

By comparison, in 1939, ***old forest*** structure exceeded the historical range in the dry forest PVG. The ***young forest multi strata*** structural stage was deficient for the dry forest PVG. The percentage of all other stages occurred within their historical ranges. Table 61 and Figure 35 illustrate changes in proportions of the watershed in each structural class between 1939 and 1997.

Table 60. HRV analysis and comparisons for structural stage percentages; 1939 and 1997 forest conditions.

GROUP	PVG		SI	SE	UR	YFMS	OF	ACRES
LOWER	Cold UF	HRV	5-20	5-35	1-25	10-40	5-40	
		1997	**74**	3	8	13	2	5,062
		1939	6	**46**	1	7	41	4.019
	Moist UF	HRV	1-10	5-25	1-20	20-50	10-60	
		1997	**50**	10	**27**	13	0	10,185
		1939	7	10	3	21	59	10,064
	Dry UF	HRV	5-15	5-30	1-10	5-25	5-70	
		1997	16	**60**	**22**	0	3	13,613
		1939	6	9	1	0	**85**	14,592
UPPER	Cold UF	HRV	5-20	5-35	1-25	10-40	5-40	
		1997	**75**	8	1	12	4	18,367
		1939	20	31	1	23	26	18,378
	Moist UF	HRV	1-10	5-25	1-20	20-50	10-60	
		1997	**61**	3	3	32	2	14,733
		1939	9	18	4	26	43	15,742
	Dry UF	HRV	5-15	5-30	1-10	5-25	5-70	
		1997	**65**	31	4	0	0	3,323
		1939	**17**	3	0	4	77	3,772
Total	Cold UF	HRV	5-20	5-35	1-25	10-40	5-40	
		1997	**75**	7	2	12	4	23,429
		1939	17	33	1	20	28	22,397
	Moist UF	HRV	1-10	5-25	1-20	20-50	10-60	
		1997	**56**	6	13	24	1	24,918
		1939	8	15	3	24	49	25,806
	Dry UF	HRV	5-15	5-30	1-10	5-25	5-70	
		1997	**26**	**54**	**18**	0	2	16,936
		1939	8	7	1	1	83	18,364

Sources/Notes: Summarized from the 97veg database (see appendix 1 for more information). Current percentages include private land located within the analysis area.

(HRV) = Historical percentages / (PVG) = Potential vegetation group

"Group" = SWS grouping developed for the HRV analyses

"Total" = HRV situation for entire analysis

SE = stem exclusion (SEOC + SECC) / OF =old forest (OFMS + OFSS).

Shaded cells indicate those instances where the current percentage (1939) is above the historical range for that structural stage. Cells enclosed in a box indicate those instances where the given percentage is below the historical range. Deviations (whether above or below the HRV range) were noted when the given percentage differed by 2% or more.

Table 61. 1939-1997 Structural Stage Comparisons.

STRUCTURAL STAGE	TOTAL 1939 ACRES	TOTAL 1997 ACRES	% CHANGE IN TOTAL ACRES
OFSS	18,946	800	**-96**
OFMS	15,390	781	**-95**
YFMS	10,909	8,802	**-19**
UR	1,184	6,761	**471**
SECC	12,641	5,195	**-59**
SEOC	72	7,021	**9651**
SI	7,427	35,944	**384**

If one assumes that the 1939 conditions represent a largely unmanaged or unmodified situation (at least with respect to a lack of timber harvest), then the reference condition HRV analysis might indicate that the historical ranges used are reasonably accurate. If that wasn't the case, then one would have expected more deviations in current percentages (above or below the historical ranges) than actually occurred. Since few human-caused changes had affected forest conditions by the late 1930s, the apparent accuracy of the historical ranges would indicate that they adequately reflect the natural disturbance regime of the analysis area.

Figure 35. Structural Stage comparisons, 1939-1997.

Landscape Patches
"Fragmentation" as used in this analysis refers to changes in the size, distribution, and/or connectivity of similar "patches" of forest vegetation. Fragmentation of primary natural forest has been a recent concern, as the shrinking and/or outright loss of viable patches of old forest continues (Noss and Cooperrider 1994).

Table 62 contrasts patch characteristics by cover type between 1939 and 1997. While the overall numbers of patches has remained almost unchanged over that period (331 vs 334), patch characteristics for some forest cover types and structural stages have changed substantially. Lodgepole pine had a larger mean patch size in 1939 (434 acres) than in 1997 (189 acres). Subalpine fir, Douglas-fir, and western larch on the other hand experienced patch size decreases between 1939 and 1997. Mean patch size for Engelmann spruce, ponderosa pine, grand fir, and mixed conifer increased between 1939 and 1997.

Table 62. Patch Characteristic Comparisons, 1939-1997.

COVER TYPE	PREDOMINANT TREE SPECIES	1939 # OF PATCHES	1997 # OF PATCHES	% CHANGE IN # PATCHES	1939 AVE. PATCH SIZE	1997 AVE. PATCH SIZE	% CHANGE IN PATCH SIZE
CA	Subalpine fir	23	28	22	348	192	-45
CD	Douglas-fir	85	63	-26	152	130	-14
CE	Engelmann spruce	10	15	50	48	194	304
CL	Lodgepole pine	59	77	31	434	189	-57
CP	Ponderosa pine	35	24	-31	103	162	57
CT	Western larch	22	41	86	68	36	-47
CW	Grand fir	80	66	-18	150	401	167
CX	Mixed	20	15	-25	119	128	8
CB	Whitebark pine	0	1	NA	0	117	NA
CJ	Western juniper	0	1	NA	0	21	NA
TOTAL		334	331		NA	NA	NA

Table 63 provides a comparison of patch size by structural stage. Patch size appears to have *increased* significantly for some structural stages (e.g. SI patch size), and thus are now certainly more connected and more continuous than in 1939. Conversely, both maximum and average patch size for the old forest structural stages are significantly smaller than in 1939. The SECC and YFMS stages also had larger mean patch sizes in 1939 than in 1997.

Table 63. Summary of Patch Analysis for Structural Stages, 1939 and 1997.

STRUCTURAL STAGE	1939 # PATCHES	1997 # PATCHES	CHANGE IN NUMBER OF PATCHES	1939 AVERAGE PATCH SIZE (ACRES)	1997 AVERAGE PATCH SIZE (ACRES)	% CHANGE IN AVERAGE PATCH SIZE
OFMS	72	14	-58	214	56	-74%
OFSS	85	22	-63	223	36	-84%
SECC	69	49	-20	183	106	-42%
SEOC	3	100	+97	24	70	192%
SI	117	75	-42	63	476	656%
UR	12	35	+23	98	193	97%
YFMS	73	60	-13	149	146	-2%

Forest Disturbances

"Healthy" forests are able to tolerate periodic disturbances and may even depend on them for renewal. Such forests maintain their integrity, resiliency and productive capacity over time. Forest integrity involves sustaining a wide range of ecological processes whereby plants, animals, microorganisms, soil, water and air are constantly interacting. These processes form soils, recycle nutrients, store carbon, clean water, and fulfill other functions essential to life. Significant changes in the level or pattern of natural disturbances may be an indicator of impaired forest health.

The effects of forest disturbances were more apparent in 1997 than in 1939 (Table 64). In particular, the effects of anthropogenic disturbances (primarily timber harvest) were more obvious in 1997 than in 1939. The impacts of recent wildfires (Bull and Summit) were readily observed on the 1995-1997 aerial photography. No similarly recent burned areas were visible on the historical photographs, however, patterns from older fires were apparent. It is believed that the lack of obvious disturbance indicates that the late 1930s and early 1940s were a particularly quiescent period in the Desolation watershed, although significant changes were on the way in the form of bark-beetle and spruce budworm outbreaks that would begin in 1944 or 1945 (see Table 14 in Upland Forest Vegetation Analysis, in Appendices).

Table 64. Forest Disturbances, 1939 and 1997.

	1939		1997	
Overstory Mortality Description	**Acres**	**%**	**Acres**	**%**
Low; 10 dead TPA	66,569	96	47,653	69
Moderate; 11-20 dead TPA	0	0	12,356	18
High; 21-60 dead TPA	0	0	2,315	3
Very high; 60 dead TPA	0	0	2,980	6

Insects and Diseases

The last 20 years have been a period of rapid change in the forests of the Desolation watershed. Substantial portions of the analysis area were affected by a mountain pine beetle outbreak in the late 1970s and early 1980s, western spruce budworm outbreaks in 1944-1958 and 1980-1992, and outbreaks of Douglas-fir beetle and fir engraver during the late 1980s and early 1990s (Gast and others 1991). A prolonged dry period in the late 1980s and early 1990s exacerbated those problems by reducing tree vigor and lowering stand resistance to insect damage.

A computerized model was used to estimate current risk (susceptibility) for 14 insects and diseases present in the analysis area. Risk ratings were calculated for both the 1939 and 1997 vegetative conditions, thereby facilitating a side-by-side comparison of risk trends. The results of that analysis are provided in Table 60. When comparing risk only, the table shows increased susceptibility to several insects and diseases Assessment of Forest Sustainability between 1939 and 1997.

Table 65. Insect and Disease Risk Rating Comparisons, 1939-1997.

Insect or Disease	Risk Rating	1997 (Acres)	1939 (Acres)	Change (Acres)
Douglas-fir Beetle	High	27,812	10,296	17,516
	Moderate	1,505	18,494	-16,989
	Low	37,022	34,569	2,453
Douglas-fir Dwarf Mistletoe	High	15,727	9,030	6,697
	Moderate	7,088	17,733	-10,645
	Low	43,524	36,524	7,000
Fir Engraver	High	19,220	41,680	-22,460
	Moderate	1,100	317	783
	Low	46,019	21,362	24,657
Indian Paint Fungus	High	8,937	1,774	7,163
	Moderate	32,727	22,909	9,818
	Low	24,657	38,359	-13,684
Mountain Pine Beetle (Lodgepole Pine)	High	2,892	3,845	-953
	Moderate	1,736	16,232	-14,496
	Low	61,711	43,282	18,429
Mountain Pine Beetle (Ponderosa Pine)	High	736	532	204
	Moderate	691	1,302	-611
	Low	64,912	61,525	3,387
Ponderosa Pine Dwarf Mistletoe	High	7,811	3,679	4,132
	Moderate	4,400	3,718	682
	Low	54,128	55,645	-1,517
Mixed Conifer Root Diseases	High	28,614	30,980	-2,366
	Moderate	37,359	31,191	6,168
	Low	366	747	-381
Schweinitzii Root and Butt Rot	High	38,836	22,179	16,657
	Moderate	26,779	38,483	-11,704
	Low	724	2,380	-1,656
Spruce Beetle	High	0	0	0
	Moderate	0	0	0
	Low	56,499	61,370	-4,871
Western Spruce Budworm	High	49,206	40,569	8,637
	Moderate	12,768	17,988	-5,220
	Low	2,828	3,941	-1,113
Tomentosus Root and Butt Rot	High	3,109	2,387	722
	Moderate	143	546	-403
	Low	63,087	60,109	2,978
Douglas-fir Tussock Moth	High	0	0	0
	Moderate	52,176	20,218	31,958
	Low	14,163	43,141	-28,978
Western Larch Dwarf Mistletoe	High	16,226	7,996	8,230
	Moderate	14,005	15,971	-1,966
	Low	36,108	39,075	-2,967

Sources/Notes: From the UPEST risk calculator (Ager 1998). "Change" column uses 1939 as the base year.

Fire/Fuels

Low Severity Natural Fire Regime Areas

Because of the frequent fire return interval naturally inherent to the dry forests of the ponderosa and warm/dry potential vegetation groups, these stands have been impacted most by seral transition since the advent of fire suppression. With an average fire return interval of approximately 10 years, it is likely that these stands have missed 5-8 fire return events that would have modified the vegetation composition of the forest as well as modifying the vertical continuity of the fuels. This would be the result from frequent low intensity fires as the less fire resistant tree species such as grand fir and Douglas-fir were killed while in the seedling and sapling stages. So lower stand densities were maintained and, more specifically, fewer trees were present in the lower levels of the forest canopy to provide ladder fuels to the crowns of the dominant trees.

Mixed Severity Natural Fire Regime Areas

Management practices such as total fire suppression, without an offsetting prescribed fire program, and harvest practices that favor shade tolerant species such as grand fir, have created a landscape continuity of densely stocked stands highly susceptible to insects, disease, and stand replacing fire. In many cases, fire intensities and the potential extent of these fires are increased due to insects and/or disease mortality, which increases the amount of available fuel.

High Severity Natural Fire Regime Areas

The impacts of management have been limited here, but continuing to suppress all fires without some other means to create new “large” scale patterns of varying age classes and seral stages will likely result in stand replacing fires becoming more extensive than in a historic fire regime. The Umatilla National Forest portion of the 1996 Summit Fire was largely confined within this fire regime area, and resulted in a large portion of this area being left with a mosaic of stand structures.

Understory and Non-Forest Botanical Resources

Culturally Significant Plants

Changes in land management have altered the plant communities that were present prior to Euro-American settlement, which has altered the availability of culturally significant plants. During pre-settlement and very early settlement times, light grazing pressure and frequent fire allowed berry bushes, especially huckleberry (*Vaccinium* spp.), serviceberry (*Amelanchier alnifolia*), chokecherry (*Prunus virginiana*), bitter cherry (*Prunus emarginata*), and elderberry (*Sambucus cerulea*) to be widespread, large, and highly productive, making up a significant portion of Native Americans’ food source (see Kay, 1994 for a more complete discussion and further references).

Most of the shrubs present in the watershed are highly fire adapted, and sprout readily when the plants are fairly young and/or after a cool fire (which is one of the reasons that Native Americans burned frequently—to rejuvenate the berry grounds). However, after years of fire suppression, and weakness caused by age and competition from later seral species, most shrubs are killed by the hot fires that usually occur in the present time.

The grass steppes and root grounds ("scab flats") have changed with changes in land management practices. While these areas look "barren" to the untrained eye, in a "pristine" state they can actually be some of the most diverse communities, are relatively fragile, and can take centuries to recover from impacts. Extensive domestic grazing has turned what were once dry grassy meadows into dry rocky scabflats with little topsoil left. Over the years, trampling has broken up the cryptobiotic crusts and stream banks, causing extensive soil erosion in many places and loss of wet meadow habitats besides streams. Plant populations, and suitable habitat for species such as camas (*Camassia quamash*) and biscuitroot (*Lomatium* spp.) have been reduced.

Noxious Weeds

Unfortunately, noxious weeds are probably here to stay. These species have the potential to alter the plant communities and ecological processes as profoundly as the excessive grazing of the late 1800's or the exclusion of fire in the 1900's. They are noxious because of their ability to colonize disturbed areas, invade relatively undisturbed areas, outcompete other vegetation. Most of them propagate readily, and/or have long-lived seed that is easily transported long distances. There are large areas at the Forest boundary that are almost solid yellow star thistle. A conversion of a native plant community to a virtual monoculture of noxious weeds removes food and cover for the entire food chain, from small insects to large game animals and predators. They can make rangelands unfit for any ungulates, native or domestic.

Most noxious weeds found on the Umatilla are taprooted and are very poor at holding soil in place, leading to erosion, loss of topsoil and sedimentation of streams. Only 6 of the 14 tracked noxious weed sites (as of spring, 1998) in the Desolation watershed have been cleared through the NEPA process in the Noxious Weed Environmental Assessment. The other 8 known sites, and any new sites, can only be treated manually until the updated noxious weed Environmental Impact Statement is finished. Every year that this is delayed gives these weeds another year to establish a bigger root system and add to the seedbank, making it more difficult to eradicate them.

Sensitive Species

The biology of *Botrychium* spp. is just beginning to be researched, and almost nothing is known about the results of management activities on these plants. Research to date shows them to be strongly mycorrhizal. This trait allows plants to sustain themselves without emerging from the ground every year to photosynthesize. One species almost never emerges from beneath the duff. This can make surveying for them difficult. The seeming absence of plants during any single survey in potential habitat does not necessarily mean that the plants are not present.

Fish and Aquatic Habitat

The Interior Columbia Basin Ecosystem Management Project (ICBEMP) Draft Environmental Impact Statement (DEIS) (1997) classifies all four sub-basins in the John Day Basin as Category 2 (moderate integrity). In that context, ratings from the ICBEMP databases (AQINTEG5, CRBFISH6, CRBFISH5, CRBFISH4) show Desolation Creek aquatic habitat integrity as high or medium *compared to the remainder of the John Day River Basin* (Figure 15).

Subwatersheds 36H and 36F have experienced the largest acreages of timber harvest (Table 66) but because of recovery since some of the earlier harvests and differences in harvest prescriptions over the years, when timber harvest is presented in equivalent clearcut acres as a percentage of the subwatershed, 36F (Battle) and 36C (Kelsay) show the greatest *present equivalent* harvest (Table 13).

Table 66. Desolation Creek Watershed - Total Acres of Timber Harvest, 1971 – 1993.

YEAR	36A	36B	36C	36D	36E	36F	36G	36H	36I
1971		25	73						
1972								157	
1973							390	4571	124
1974									
1975									
1976								88	
1977	131	713	2	5	2617	1309	10		
1978	228	341				135			
1979				242		336			
1980		2		179					
1981			215	379	11	449			
1982		88	241	170	10	293			
1983				510	38	279	20		
1984		23	40		40	34	135		
1985		39	20	16	74	236			
1986	19	165	57	102		232			
1987		42	29	83		41			
1988			126	197		27	35	76	
1989		220	652	327	295	21			
1990								607	
1991					26				
1992	36			34	45	868	90		
1993			3						
Total harvest acres, 1971-93	414	1658	1458	2244	3156	4260	680	5499	124
1998 Equivalent Clearcut Acres	7.8	135.6	395.3	485.1	191.7	813.3	116.0	349.7	0.0
ECA as % of Forested Acres	0.2	1.7	6.4	5.1	5.4	8.4	1.9	4.8	0.0

Water Temperature

Over the period of record, none of the streams in the Desolation watershed met the Oregon Department of Environmental Quality (DEQ) standards for bull trout streams or for chinook spawning streams. No stream met Pacfish standards for all years of record (some met the standard in some years). Junkens Creek and South Fork Desolation are probably the coolest in this watershed, but overall, streams here are too warm to meet the needs of chinook salmon and bull trout. In the Desolation watershed, water temperature is probably the most limiting habitat factor for native salmonids.

Pre-fire water temperatures in South Fork Desolation Creek, and current conditions in Junkens Creek could be used to represent temperature potentials for Desolation Creek tributaries. The two subwatersheds are “minimally” disturbed and exhibit relatively good water quality. Water temperatures in these two tributaries do not meet state standards for bull trout, yet are nominally affected by management activities. This fact suggests that there is low potential for maximum summer water temperatures to achieve the 50 degree F standard. An achievable target maximum standard for tributaries should be in the 55 to 60 degree F range.

Pool Frequencies

As averaged over entire subwatersheds, or over the entire length of Desolation Creek, pool frequencies range from more than double to less than half the 50th percentile for *unmanaged* reaches in ERU 6. South Fork Desolation (36I) and Howard (36G) subwatersheds had the highest pool frequencies in recent USFS surveys. Junkens-Beeman (36E), Kelsay (36C) and North Fork Desolation (36H) had the lowest pool frequencies. Although differences in data formats do not permit direct numerical comparisons between recent USFS survey data and data from ODFW's 1963-64 surveys, it may be significant that North Fork Desolation went from having the highest pool frequency in the 1963-64 ODFW reports, to among the lowest in 1992-93 USFS surveys.

Available resources do not presently permit comparisons to possible management changes over that period, but this might be a fruitful area for future study. North Fork Desolation presently has the second hightest road density in the watershed, and also a relatively high road/stream crossing density (Figure 38), and highest total timber harvest acreage (Table 66).

Pool frequencies throughout the Desolation watershed are not comparable to Pacfish standards, because Pacfish specifies pool frequencies in low gradient (<= 1%), C-type channels. With the possible exception of a few very short sections, streams in the Desolation watershed do not fit this criteria.

Riffle Depth/Width Ratios

When depth/width ratios of Desolation tributaries are averaged over entire subwatersheds, all save one rank above the 50th percentile for ERU 6 (Figure 29). That single case comes from South Fork Desolation Creek, downstream of the roadless area.. Ratios for mainstem Desolation Creek, on the other hand, compare unfavorably to the ERU 6 50th percentile. Although this condition may be related to past management, it may also be at least partly an artifact of the mainstem's larger size. Width/depth ratios throughout the Desolation watershed are not comparable to Pacfish standards, because Pacfish specifies width/depth measurements in low gradient (<= 1%), C-type channels. With the possible exception of a few very short sections, streams in the Desolation watershed do not fit this criteria.

Large Wood Frequency

Large wood frequency in Desolation Creek is, in most cases, below the 50th percentile for ERU 6 (Figure 26), although when compared to only the John Day Basin most streams rate better, particularly high gradient streams. Neither do most subwatersheds reach Pacfish standards, two exceptions being South Fork Desolation (36I) and Kelsay (36C) Subwatersheds .

Units for evaluating wood frequency do not take into account one important parameter: the productivity of the site. It would be entirely reasonable to expect more wood in small streams flowing through forest types that are highly productive or potentially highly productive of large wood than for streams flowing through sites that are inherently less productive. This would not hold for streams large enough to move the wood long distances during high streamflows, at least not in the same way. Most of the tributary streams of Desolation Creek probably seldom or never produce enough flow to move wood in the USFS stream survey large (>20" x 35') category. Only a very few would even move wood in the ICBEMP large (>12" x 35") category for long distances. To evaluate wood frequency in this way, two additional information sets would be needed: 1) Riparian zone productivities, and 2) Stream and tributary annual peak flows. This information has not yet been developed for the Desolation Drainage, but it is at least conceptually feasible to derive it from vegetation mapping work in progress and bankfull width and depth measurements from the stream survey records.

Stream Channel Sedimentation

There seems to be no widely accepted standard for evaluating stream channel sedimentation relative to the needs of Northwest salmonids. Nevertheless, research has clearly demonstrated that excessive stream sedimentation degrades both spawning and rearing habitat. Because the dominant or subdominant substrate in some of the tributary streams is of the sand size, sediment is probably a secondary concern in habitat degradation, (after temperature). Note, however, that several of the reaches having fine sediment as the dominant substrate flow through meadows, where fine sediment would be the expected substrate.

Subwatershed Comparisons

Table 58 represents an attempt to compare overall aquatic habitat quality between subwatersheds. A major drawback to such a comparison is that it treats all habitat parameters as if they were of equal importance, which may not be true, since a severe deficiency in one parameter may make habitat nearly useless and, in other cases, a strength in one parameter may partially compensate for weakness of another. Recognizing its limitations, it is an attempt to compare aquatic habitat quality between subwatersheds, and to relate relevant findings to the management history of the watershed. Hopefully some management recommendations can then be derived from those observed relationships.

One condition immediately apparent is that most subwatersheds differ little in their overall score (Table 67). Two exceptions are 36G (Howard) and 36I (South Fork Desolation). It may not be coincidental that these two subwatersheds contain the lowest road density, the lowest road crossings density, and the smallest percentage of the subwatershed in equivalent clearcut acres of any subwatersheds in the Desolation drainage. South Fork Desolation also has the smallest percentage of the subwatershed included in a grazing allotment.

Table 67. Aquatic Habitat Comparisons Between Subwatersheds.*

	PARAMETERS					
SUBWATERSHED	**POOL FREQUENCY**	**LARGE WOOD FREQUENCY**	**DEPTH/WIDTH RATIO**	**SEDIMENT**	**WATER TEMPERATURE**	**AVERAGE SCORE[1]**
36A	no data**	no data**	no data**	no data**	poor (3)	insufficient data
36B	no data*	no data*	no data*	no data*	no data*	no data**
36C	poor (3)	good (1)	good (1)	poor (3)	poor (3)	2.2
36D	no data**	no data**	no data**	no data**	fair (2)	insufficient data
36E	poor (3)	poor (3)	good (1)	poor (3)	good (1)	2.2
36F	poor (3)	poor (3)	good (1)	fair (2)	fair (2)	2.2
36G	good (1)	poor (3)	good (1)	good (1)	fair (2)	1.6
36H	poor (3)	poor (3)	good (1)	fair (2)	fair (2)	2.2
36I	good (1)	fair (2)	good (1)	fair (2)	good (1)	1.4
Mainstem	good (1)	poor (3)	poor (3)	good (1)	poor (3)	2.2

* Values represent relative quality of habitat parameter as compared to other subwatersheds within the Desolation watershed.
** Tributaries were not surveyed in these subwatersheds.
1 The smaller the average score, the better the habitat conditions.

In general, the most efficient approach to maintaining ecosystem process and function is to identify and protect areas least disrupted by human activities, and initiate restoration efforts in areas of greater disruption. The greatest potential for restoration would usually be in areas where substantial portions of the ecosystem remains intact and the knowledge and technology needed for effective restoration are available.

In this context, South Fork of Desolation (36I) and Howard Creek (36G) subwatersheds would seem to merit a "protect and maintain" management strategy, while subwatersheds 36C, E, F, and H might better fit the "restore" strategy for aquatic habitat.

Subwatersheds 36A, B and D are composed largely of private land; little information about past management or aquatic habitat quality in tributary streams is available for this portion of the drainage. It is, therefore, not feasible to develop subwatershed-wide management strategies for these subwatersheds.

There has been some gully and channel erosion with attendant water quality concerns in Desolation Meadows. This may be related to past grazing practices.

Some subwatersheds have lower road - stream crossing density in proportion to their total road density than others (compare Kelsay and North Fork Desolation in **Figure 18**). This is probably best explained by the different locations of roads in different subwatersheds. Subwatersheds with most roads on ridgetops or otherwise well away from streams could be expected to show a lower crossings density than subwatersheds with most roads in canyon bottoms or on lower mid-slopes. Mapping of road - stream crossings (Figure 36) appears to bear this out. To the extent that crossings density indicates road proximity to streams, and other factors (slopes, soils, etc.) being equal, subwatersheds with lower crossings density might be expected to show less degradation of aquatic habitat.

Figure 36. Road Density

Aquatic Habitat Management Strategies

An important part of the aquatic habitat management strategy is the Riparian Habitat Conservation Area (RHCA). RHCAs can serve as an important part of watershed management by supporting at least four important functions or components of aquatic habitat:

1) Instream woody debris

   Instream woody debris is produced within the RHCAs of Class 1, 2 and 3 streams, and is itself a component of several other important habitat parameters. Much of the woody debris for Class 4 streams may come from outside of the Pacfish RHCA. Instream woody debris functions as hiding and escape cover for fish, a food source for some aquatic invertebrates (thus indirectly for fish), provides pool forming structures, helps trap sediment and agrade the stream channel, increases stream roughness and dissipates energy, and in general adds to habitat complexity.

2) Stream Shade

   Living trees within RHCAs provide shade to the stream and thus function importantly in maintaining low water temperatures. They also support insects that 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. It would appear that, in most areas, all important shade over the stream would be 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 Desolation Watershed.

3) 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.

4) Effects to riparian microclimate

   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 community.

Of the four 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 (woody debris and shade) are satisfied by a buffer width of one tree height. Riparian microclimate conditions could be supported by one or two additional tree heights beyond the "true" riparian zone, which may be much more or less than the Pacfish RHCA width. This seems prudent, especially for the more arid, Eastside forest types found in the Blue Mountains. Some forms of forest vegetation management could be appropriate or even important in this outer microclimate buffer.

Clearly, different components of riparian support to aquatic habitat require different buffer widths.

Pacfish specifies RHCA widths as two tree heights or 300 feet, whichever is greater, for fishbearing (Class 1 and 2) streams. One tree height or 150 feet, whichever is greater, is required for non-fishbearing perennial (Class 3) streams. Since average maximum tree heights in Desolation are generally less than 150 feet, the linear distance criteria would apply here.

In most cases the Pacfish RHCAs for Class 1 and 2 streams will be adequate to support all of the above components. However, the same does not hold true for Class 3 streams, since most of the functions given in items one, two, three and four above are just as important in Class 3 streams as in Class 1 or 2 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 3 as in Class 1 or 2 streams. Certainly shade to maintain cool water temperatures is important in reaches upstream of fishbearing portions of streams. It is therefore difficult to understand from an aquatic habitat perspective why RHCAs should be narrower in Class 3 than in Class 1 or 2 streams.

The smaller Pacfish RHCA widths for intermittent (Class 4) 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 woody debris would meet the needs for sediment detention. However, Class 4 streams are be just as vulnerable to sediment introduction as any other class of stream. Once sediment begins moving as channelized flow, it may travel a very long way, well into the Class 3 or 2 or 1 streams. Wherever there is genuine risk of sediment production by management activities, it is difficult to see why Class 4 streams would need less protection than larger streams, regardless of the presence or absence of fish.

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 (minimum buffer width of one tree height). 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 (minimum buffer width of one tree height). Where non-channelized sediment flow is a concern, buffer width sufficient to prevent its reaching the stream channels would be assured (minimum buffer width of 300 feet). Where riparian microclimate is a concern, RHCAs would ensure sufficient vegetation bordering the true riparian to maintain the natural riparian microclimate.

Terrestrial Wildlife

Habitat

Changes in the relative availability of habitats from 1939 to the present are shown in Table 59 and Figures 39-45. In general, old growth forests, riparian hardwood shrub corridors, and aspen stands have declined in both quantity and quality, while stands of young conifers have increased in abundance.

Old Forest Habitat

The increasing rarity, fragmentation and degradation of late/old forest habitats and riparian systems are of concern across the Blue Mountains. In the Desolation drainage, the availability of old forest habitats has declined dramatically in just half a century. Old forest currently occupies 1,581 acres, or approximately 2 percent of the forested acres in the watershed, as compared to 34,335 acres, or 49 percent of the forested acres in 1939 (Table 68).

Table 68. Changes in Old Forest Habitat Availability, 1939-1997, Desolation Watershed.

FOREST PVG	STRUCTURAL STAGE	1939 ACRES	1997 ACRES	% CHANGE FROM 1939
Cold Upland	OFMS	2,892	264	
	OFSS	3,486	632	
	Total	**6,378**	**896**	**-86%**
Dry Upland	OFMS	8,480	300	
	OFSS	6,754	75	
	Total	**15,234**	**375**	**-98%**
Moist Upland	OFMS	4,017	217	
	OFSS	8,706	93	
	Total	**12,723**	**310**	**-98%**
Grand Total		**34,335**	**1581**	**-95%**

Under the Forest Plan C1 Old Growth network, emphasis was on retaining some of the remaining stands of old growth, but without any effective provision for the movement of late/old stands in and out of the forested landscape over time. While areas “capable” of supporting old growth forest were delineated, no site-specific management plans have been implemented to begin to move these areas toward functional old forest structure. Active management within C1 stands was largely precluded in favor of a “preserve” approach. Across the Umatilla NF, many potential old forest “replacement” stands were harvested over the last decade, precluding replacement options. The same is true of the Desolation Analysis Area, where some C1 areas have been informally “re-sited” after the originally-designated area was fragmented or removed in various timber sales.

There have also been significant changes in the size of old forest patches since 1939. Changes in patch size are summarized in Table 69 (see the Vegetation section for complete information).

Table 69. Changes in Forest Patch Size, 1939-1997

STRUCTURAL STAGE	1939		1997	
	AVERAGE	MAXIMUM	AVERAGE	MAXIMUM
OFMS	214	6,271	56	252
OFSS	223	4840	36	129

Dead Standing and Down Wood Habitat

Lacking any quantitative data for 1939, it is difficult to draw direct conclusions as to changes in snag and down wood density, size class distribution or spatial distribution.

Wetland, Riparian, and Aspen Habitat

The composition and condition of meadow and riparian habitats (including springs) in the Blue Mountains have changed substantially from the turn of the century. Vegetative changes are attributed to a combination of factors, including browsing and grazing pressures, timber management, and the disruption of natural fire cycles. The abundance and health of riparian hardwood species such as aspen, black cottonwood, water birch, cherry and willow are of special concern. Stands of aspen, while never as extensive as those found in the Rocky Mountains, were believed to have been more common in the Blues at the turn of the century than today.

Human impacts are apparent at many springs. In particular, Snapp Springs has been heavily used for camping and by livestock for many years. Overgrazing and trampling of wet meadow habitat by cattle and horses and the garbage of generations has severely degraded this area.

"Special" Habitats

Rock outcrops and talus slopes within the drainage (mostly in the South Fork drainage) have changed very little since 1939. What has changed, is the availability of forest cover, and/or the degree of isolation surrounding some of these areas. While cover is probably not an important issue to species like the peregrine, the increased presence of roads and human activities may well have had an impact on several species, including the peregrine and the wolverine.

Species

Species-Specific Habitat Assessments

Table 38 (Current Conditions) summarizes habitat indicators used to model habitat changes in the Desolation drainage. The results of the 1939-1997 comparisons are shown in Table 70 and Figures 37-43.

Management Indicator Species

Pileated Woodpecker, (Table 70, Figure 37a, b), **American Marten** (Table 70, Figure 38 a, b).
In 1939, suitable habitat for the pileated woodpecker and marten was distributed throughout the drainage. Large blocks of reproductive habitat occurred in the upper, middle and lower portions of the watershed. Foraging habitat was plentiful and well-distributed. By 1997, foraging habitat had decreased by 60 percent for pileated woodpeckers and 74 percent for martens. Reproductive habitat has become so rare (93% and 97%, respectively) that the long-term persistence of local populations of these two species is uncertain.

Northern Three-toed Woodpecker (Table 70, Figure 39 a,b).

In 1939, foraging and nesting habitat suitable for three-toed woodpeckers were available throughout the upper two-thirds of the watershed. Reproductive habitat was concentrated primarily in SWSs B, C, D, H and I. Overall, the drainage provided adequate habitat to support several reproducing pairs. In 1997, habitat for northern three-toed woodpeckers was virtually non-existent in the lower two-thirds of the watershed. Almost all remaining habitat is currently limited to the roadless portions of the drainage. In a study of three-toed woodpeckers on the Deschutes NF in central Oregon, Goggans et al. (1988) reported home ranges of 751, 351, and 131 acres. Mature and overmature forest stands were selected for both foraging and nesting, while younger stands and logged areas were avoided. When current availability (1103 acres foraging, 114 acres reproductive) is contrasted with these research results, it is possible that the Desolation drainage may no longer support a successfully reproducing population of northern three-toed woodpeckers.

Table 70. Changes in habitat availability for selected terrestrial vertebrates, Desolation drainage, 1939-1997.

Species	Habitat Component	1939 Acres	1997 Acres	Change: + or – Ac %)
Pileated Woodpecker	F	18,729	7,552	-11,177 (60%)
	R	8,611	608	-8,003 (93%)
	R	8,494	275	-8,219 (97%)
American Marten	F	19,583	5,044	-14, 579 (74%)
	R	8,494	275	-8, 219 (97%)
No. 3-toed Woodpecker	F	16,817	1,103	-15,714 (93%)
	R	3,990	114	-3,876 (97%)
Rocky Mtn Elk	F	27,691	45,647	+17,956 (65%)
	W R	1,723	2,030	+307 (18%)
	M C	15,871	17,208	+1,337 (8%)
	S C	24,252	4,331	-19,921 (82%)
Wolverine	F	52,381	24,758	27,623 (53%)
	R	33	26	-7 (21%)
Lynx	F	11,129	14,551	+ 3,422 (31%)
	R	7,018	275	-6,743 (96%)
No. Goshawk	F	58,565	58,296	-269 (4%)
	R	29,176	1,204	-27,972 (96%)

F = Forage, R = Reproductive, WR = Winter Range, MC = Marginal Cover, SC = Suitable Cover

Rocky Mountain Elk (Table 70, Figures 40 a,b,c,d).

Total acres of available foraging habitat for Rocky Mountain elk increased by 65 percent over the analysis period, due mostly to the combination of timber harvest and stand-replacement fires. Seeding and fertilizing over the last several years may have contributed to the 18 percent increase in winter range.

Cover trends present a mixed bag. While the data in Table 70 show a modest increase in marginal cover, comparison of Figures 40 c. and d. illustrates how that *increase* is countered by a serious *decrease* in suitable cover (down 82%).

Other Species of Concern

Wolverine

In 1939, before roads, timber harvest, livestock grazing, elk hunters and OHVs, much of the Desolation drainage provided foraging habitat for this wide-ranging predator (Table 70, Figures 41 a, b). By 1997, the combined impacts of timber harvest, fire, roading and loss of isolation had led to a decline of 53 percent in foraging habitat.

Denning habitat was historically restricted to rocky outcrops and talus slopes at the very highest elevations in South Fork Desolation subwatershed (although additional reproductive habitat was probably available in adjoining SWSs outside Desolation). While the availability of rock and talus remained unchanged in 1997, what *had changed* was the loss of surrounding forest cover. Thus reproductive cover declined by 21 percent. There is only a very slight chance that wolverine are reproducing in the drainage, but not unlikely that the upper portions of the watershed still contribute to the home range of an individual or pair.

Lynx

Rabbits, especially snowshoe hares, are the primary prey of lynx (Table 70, Figures 42 a, b). An increase of early-successional habitats would benefit rabbit/hare populations in the drainage, accounting for the increase in lynx foraging habitat between 1939 and 1997. On the other hand, reproductive habitat for lynx is limited to old forest types at higher elevations, and the availability of this habitat has declined by 96 percent.

Goshawk

Results of the Paradox analysis indicated that an abundance of suitable foraging and nesting habitat (approx. 29,000 ac.) were available to goshawks in 1939 (Table 70, Figures 43 a, b). Foraging habitat stayed relatively stable over the analysis period, with only a slight decline (4%). However, by 1997 only about 1,200 acres of suitable nesting habitat in 17 remnant patches remained. The largest patch remaining was approximately 252 acres in size, compared to contiguous patches of several hundred to >1000 acres in 1939.

The change in nesting habitat acreage from 1939 to1997 constitutes a drop of nearly 96 percent. Based on the current distribution and extreme fragmentation of suitable nesting habitat, an estimate of 4-5 pairs remaining in the drainage is probably optimistic.

Rangeland Resources

The numbers of grazing cattle have been reduced in the second half of the decade, and condition and trend studies initiated in the late 1950s show that range conditions are improving (Tom Thompson, personal communication). However, complete recovery of shrub and aspen communities has been prevented by the combination of continued grazing and increased browsing from elk and deer populations, whose numbers are vastly higher now than they were when whites first settled the area (Kay 1994). Fire suppression has allowed the once open forest stands to become thick with smaller trees, blocking cattle accessibility, and putting most of the remaining cattle grazing pressure on the meadows and road sides.

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Figure 37a. Potential Available Habitat, Pileated Woodpecker - 1939.

Figure 37b. Potential Available Habitat, Pileated Woodpecker - 1997.

Figure 38a. Potential Available Habitat, American Marten - 1939

Figure 38b. Potential Available Habitat, American Marten - 1997.

Figure 39a. Potential Available Habitat, Northern Three-toed Woodpecker - 1939.

Figure 39b. Potential Available Habitat, Northern Three-toed Woodpecker - 1997.

Figure 40a. Potential Available Foraging Habitat and Winter Range, Rocky Mountain Elk - 1939.

Figure 40b. Potential Available Foraging Habitat and Winter Range, Rocky Mountain Elk - 1997.

Figure 40c. Potential Available Marginal and Suitable Cover, Rocky Mountain Elk - 1939.

Figure 40d. Potential Available Marginal and Suitable Cover, Rocky Mountain Elk - 1997.

Figure 41a. Potential Available Habitat, Wolverine - 1939.

Figure 41b. Potential Available Habitat, Wolverine - 1997.

Figure 42a. Potential Available Habitat, Lynx - 1939.

Figure 42b. Potential Available Habitat, Lynx - 1997.

Figure 43a. Potential Available Nesting Habititat, Northern Goshawk - 1939.

Figure 43b. Potential Available Nesting Habitat, Northern Goshawk - 1997.

VI. RECOMMENDATIONS

Formulation of recommendations is the final step in the six-step process for ecosystem analysis at the watershed scale. The purpose of step six is to bring the results of the previous five steps to conclusion, focusing on management recommendations that are responsive to ecosystem processes identified by the analysis. In some instances, subwatershed-specific recommendations are included.

Monitoring activities, data gaps and analysis limitations are also documented at this point in the process (Regional Ecosystem Office 1995).

This section provides management recommendations that could facilitate either short-term recovery, or long-term restoration within the Desolation watershed. These recommendations do not explicitly consider project feasibility, but rather represent management opportunities. Recommendations are often based on mid-scale analysis and information (such as photo interpreted data). Whether those opportunities can be realized or not will depend on the detailed project planning that will follow this ecosystem analysis.

A. Management Recommendations

General

1. Most soils recommendations are related to roads, mining, harvest activity, and grazing and prescribed fire, with fire having the potential to affect the most acreage. These recommendations are largely incorporated in discussions of vegetation, fire, hydrology, and fisheries concerns. Additional assessment at ground level will be required to determine specific needs that could be associated with silvicultural treatments.

2. As a general rule, concentrate vegetative manipulation, soil amendments, or physical rehabilitation efforts on the more productive areas of deeper soils and gentler slopes for the most cost-efficient and effective results.

3. Maintain/strengthen erosion control efforts aimed at avoiding management activity related soil losses. Examples include control measures on activities such as timber harvest, mining, road use, and restoration activities including road improvements, meadow restoration/enhancement projects, other watershed improvements. Increased surface erosion resulting from the 1996 wildfires should diminish over the next few years as vegetation reestablishes.

4. Apply Best Management Practices for all land-disturbing activities, including administrative actions, operations, and mitigation for short term disturbances. All management plans should include site-specific BMPs for water quality protection.

5. Further refine management indicators for meeting water quality standards and aquatic habitat needs. These indicators should include criteria for water temperature, sediment, bank stability, pools, and large wood. See Clean Water Act discussion which follows. Standard RHCAs may need to be adjusted to achieve specific goals.

6. Develop and implement road system upgrades (“storm-harden”) and decommissioning (“store”) projects as part of project level planning.

7. Increase involvement of private landowners in watershed management activities. Continue to communicate with the NFJD Watershed Council to discuss issues, concerns, and opportunities, to share monitoring data and coordinate management activities.

8. Results from the forest vegetation and fire management analyses include recommending treatments such as salvage, thinning, and prescribed fire that have the potential to improve or degrade watershed conditions depending on project scope and implementation. Over the short term, some salvage and thinning treatments could result in minor affects to water quality. Over the long term, improved vegetation stand conditions could result in improved water quality by lowering risk of high-intensity fire.

9. Federal Consistency with the Clean Water Act - The Forest should complete a Water Quality Restoration Plan (WQRP) to improve water quality in the Desolation watershed. This ecosystem analysis document serves as background for a WQRP. The following elements are contained in the Final Ecosystem Analysis report and in the supporting Watershed Hydrology report:

    Water quality standards that apply in the Desolation watershed include temperature, sediment, turbidity, habitat, and flow. Affected beneficial uses are: public and private domestic water supply, livestock watering, anadromous fish passage, salmonid fish rearing and spawning, resident fish and aquatic life, wildlife and hunting, water contact recreation, and aesthetic quality. Watershed conditions contribute to water temperatures exceeding standards, and are affecting anadromous fish passage, salmonid fish rearing and spawning, and resident fish and aquatic life. Other beneficial uses are not likely to be directly impacted by water temperature.

    The WQRP will include water quality objectives. For example, water temperatures in the South Fork Desolation and Junkens Creek subwatersheds are generally representative of tributary potential (maximum 55-60 degrees F). Mainstem Desolation Creek potential may be in the 60° F to 65° F range. Surrogate objectives should also be considered, for example, bank instability is a factor influencing water temperature. Other factors contributing to water temperature potential, for example, groundwater influences and effective shade, have not been quantified.

<u>How to Know When Progress is Being Made in Water Quality Improvement</u>

Demonstrated improving trends in water temperatures by measured reduced summer maximum temperatures in tributaries and mainstem of Desolation Creek.

Added surrogates for water quality improvements include:

- Properly functioning riparian areas. For example, Kelsay currently “functioning at risk” rating moved to proper functioning condition.
- Reduced sediment delivery to streams from roads and other disturbed sites.
- Overall stream channel processes are not impaired by excess sedimentation, loss of stream bank vegetation and road-stream crossings.

10. Bull and Summit Fire Areas - Differing Management Strategies, resource concerns and fire effects contributed to a unique set of recommendations for the portions of the Bull and Summit burns located within the Desolation drainage.

    While the Bull fire burned primarily in actively managed portions of the drainage (including Management Areas A4, C7, and C2, with a small area of "unmanaged" C1) most of the area burned in the Summit fire (within the drainage) occurred in "unmanaged" areas, primarily the Greenhorn Mountain Roadless Area –Management Area A8.

    Salvage harvest in the Bull wildfire, based on a North Fork District NEPA analysis, is in the final planning stages. Based on results of this Ecosystem Analysis, the following recommendations are made:

    a. Salvage treatments should be designed to address the following concerns:

        1) Emphasize salvage in dry-forest areas (Figures 12a & 12b) that have the capability to support a high proportion of ponderosa pine (Douglas-fir and warm grand fir plant associations). [Sites meeting this criterion would address changes in species composition on warm dry sites.]

        2) Consider salvage where timber volume, tree size, and species characteristics would generate sufficient revenue to fund tree planting and other restoration treatments. [This concern addresses the fact that tree planting is expensive, and that Congress may not fund all of it.]

        3) Consider salvage for sites where the existing density of dead trees is great enough that a future reburn would probably destroy newly-established tree regeneration, especially if it occurred shortly after the dead trees had fallen over and increased fuel continuity.

        4) Consider salvage of live, damaged trees that are unlikely to survive more than a year or two:

            a) Ponderosa pines and western larches that have less than 20 percent green, healthy-appearing crown (by crown volume), regardless of bole scorch, scorch height, or duff consumption.

            b) Douglas-firs having less than 40 percent green, healthy-appearing crown (by volume) AND scorch height greater than 16 feet AND more than 50% of the preburn duff around the base of the tree was consumed by the fire.

            c) Subalpine firs, lodgepole pines, and Engelmann spruces with less than 60 percent green, healthy-appearing crowns (by volume) AND bole scorch on greater than 50% of the tree's circumference AND scorch height greater than 4 feet AND more than 25% of the preburn duff around the base of the tree was consumed by the fire.

            d) Guidelines for Post-fire Restoration Projects were developed as part of the Tower Fire Ecosystem Analysis (1997), addressing snags, dead and down coarse woody debris, soils, and riparian buffers. As stated in the Acting Forest Supervisor's letter of March 17, 1997, if, during NEPA analysis for project level planning, it is found that certain guidelines cannot be implemented (because of new information, etc.), that outcome should be documented in the analysis file.

b. It is recommended that upland plantings in burn areas emphasize early-seral species such as western larch and ponderosa pine to a greater degree than lodgepole pine, where ecologically appropriate, since lodgepole pine is expected to regenerate naturally on all but the highest intensity burns.

   Tree planting in burned areas should occur quickly, to give seedlings a chance to establish before allelopathic plants and other competitors have fully recovered from the fire. Of particular concern is the potential for pinegrass, smooth brome, red top, Kentucky bluegrass, bracken fern, elk sedge, red fescue, snowbrush ceanothus and other competing vegetation to affect the survival of planted or naturally-regenerated tree seedlings. If reforestation does not occur before competing vegetation threatens tree survival, consider treatment of competing vegetation, taking into account concerns relative to water quality, fisheries and wildlife.

11. Tree plantings should emphasize establishment of early-seral conifers on upland sites, where appropriate, based on the ecological potential of the site.

12. Thinning treatments should address the overstocked areas (approximately 3,000 acres) described in Table 56. The tables in the Upland Forest Vegetation Analysis in the Appendices provide tree density recommendations by species and by plant association (or an average for an entire PAG). The tables include a "management zone" in which stand densities are presumed to be ecologically sustainable and resistant to insect and disease problems.

13. Thinnings or understory removals should be considered for warm dry sites that have two or more tree canopy layers and a canopy cover of 40 percent or more, since they would be considered marginally overstocked and currently have a vertical structure that would inhibit reintroduction of landscape-scale fire. Careful interdisciplinary coordination is needed when planning thinning activities in the area, since big game cover is already deficient, and these forest types support large numbers of wintering elk and deer.

14. Understory removal of fir species on warm dry sites are the highest priority for vegetation treatments in the watershed. The treatment is most effective with remnant pine/larch components. Understory removals are appropriate in area supporting multi-storied mixed species stands on the hot and warm dry plant association groups. The intent is to reduce densities and obtaain more open and vigorous stands to ensure future vegetation sustainability and resliency on these sites. Associated recommendations are to retain large trees and follow up with low intensity prescribed fire. Interdisciplinary review of the specific proposals is needed to ensure appropriante retention of habitat for current wildlife. About 4,000 acres of national forest have been identified as potential candidates for understory removal. The proposals are a first approximation and need to be ground verified.

15. Understory removals may be appropriate for removing firs that have encroached on warm dry sites. They may also be effective on other sites with a remnant pine/larch component, especially if thinnings reduce stand densities to more sustainable levels and improve the vigor and survivability of pine and larch. Understory removals may also be appropriate in areas supporting multi-storied, mixed-species stands, especially if they occur on the hot dry or warm dry plant association groups. Watershed specific recommendations regarding potential stand treatments follow.

16. To offset nutrient losses as a result of recent fires, and with the objective of reducing susceptibility to future insect and disease outbreaks, fertilization should be considered as a future treatment for young stands growing on the hot dry or warm dry plant association groups. Fertilization would probably not be needed until 20 to 30 years after plantations have been established, and could then be coordinated with other cultural treatments such as precommercial thinning.

17. Pruning may be appropriate as a future treatment for young stands on the hot dry and warm dry plant association groups. Pruning may not be needed until at least 30 years after plantations have been established, when it could then be coordinated with prescribed burning treatments as a way to lower the risk of pole-sized trees being killed by a fire (torching), and could also play a role in the future management of budworm-susceptible forests by removing food for the survival and growth of budworm larvae. Coordinate pruning proposals with physical and biological resource staff, visual and recreation specialists to minimize potential impacts.

18. After completing salvage harvests, understory removals, thinnings and other treatments recommended in this section, managers should strongly consider implementing a prescribed burning program (see general recommendations for different fire severity regimes, below). Once ponderosa pines and 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 regularly, usually at intervals of 15 to 25 years. Fall burns, which are desirable from an ecological standpoint because they replicate the natural fire regime, result in fewer losses of large ponderosa pines to fire damage or western pine beetle attack (Swezy and Agee 1991).

19. Periodic burning can also be used to manipulate the nutrient capital of a site by maintaining sparse stands of snowbrush ceanothus, lupines, peavines, vetch, buffaloberry, and other nitrogen-fixing plants.

20. See the Upland Forest Vegetation Analysis for precautions in the use of fire on moist sites, droughty sites, and dry areas with coarse or shallow soils and thin forest floors. Prescribed burning will be most effective when used in existing dry-forest types (ponderosa pine and Douglas-fir) that have already undergone understory removal treatment. Prescribed burning should also be considered as a future treatment for plantations established on hot dry and warm dry PAGs. Future prescribed burns would probably not occur until at least 30 years after plantations establishment, and could then be coordinated with pruning treatments to lower the risk of pole-sized trees being killed by a fire (torching) (where understory cover is not lacking).

21. **General Recommendations For The Use Of Prescribed Fire:**

    a. Low Severity Natural Fire Regime Areas (i.e. : Dry Forest PVG):

        1) Manage to maintain stand densities on at least 50 percent of the area to be 100 trees per acre or less by the time stands reach maturity (=>20” DBH), with the remaining 50 percent of the area having a range of stand densities. Stand composition should be dominated (=>80%) by single storied stands of ponderosa pine. Proposals for stand density manipulation should be reviewed by an interdisciplinary team at the District level to assure the most benefits and least impacts to all resources.

        2) Manage for diversity of age class, species composition and patch size across the landscape, with the intent that areas of stand replacement fire will create openings within the historic range of disturbance patterns. To effectively modify the characteristics of wildfire, patches should be several hundred acres in size. Fuels treatments should be implemented in conjunction with other vegetation management practices, with full consideration of all resource concerns at the stand, subwatershed and watershed levels.

        3) Identify a fuels profile (a combination of fuel load by size classes and physical arrangement) that would keep wildfires primarily as surface fires. Natural fuels management should include a program of management-ignited fire on a 15-25 years rotation.

4) Because such a large proportion of this area is in private ownership, cooperative agreements should be pursued to facilitate prescribed fire treatments (underburning) across ownership boundaries. This would result in a more effective and efficient burning program utilizing roads and/or topographic features to define unit's boundaries rather than ownership boundaries.

b. Moderate Severity Natural Fire Regime Areas, i.e. : Moist Forest PVG:

Manage for diversity of age class, species composition and patch size across the landscape, with the intent that areas of stand replacement fire will create openings within the historic range of disturbance patterns. To effectively modify the characteristics of wildfire, patches should be several hundred acres in size. Fuels treatments should be implemented in conjunction with other vegetation management practices (commercial harvest, thinning, etc.).

c. High Severity Natural Fire Regime Areas, i.e. Cold Forest PVG:

Maintain fuel break buffers around improvements (Desolation Lookout, electronic site). Beyond site protection, this type is a low priority for any treatments for several reasons:

1) Much of the high severity type is in wilderness or roadless areas,
2) These stands are of lower commercial value, and
3) Stand-replacement fires in this type are inevitable, and difficult to control either through fuels management or fire breaks

A long-term plan for management ignited fire, and/or mechanical treatments to reduce fuel loading near improvements and private boundaries should be developed.

22. Riparian Areas:

a. Management of fire in riparian areas remains a source of controversy. A suggested approach is to manage some stream reaches as "hardwood-dominated" over the long term (greater than 30 years), where such stands are historically indicated or otherwise ecologically appropriate. The intent of management in these areas would be for the hardwood community to function essentially as a shaded fuel break along the stream.

b. Management of livestock use to reduce the impact on hardwoods during sprouting initiation, and to maintain species composition and stand viability, would be necessary. Thinning and/or the use of prescribed fire in these reaches may be appropriate tools for maintaining conifers as scattered individuals rather than as a continuous canopy capable of supporting a crown fire, as long as serious soil disturbance or compaction does not result (see RHCA guidelines).

<u>Native Understory Plants for Restoration</u> - General Considerations

Successful revegetation projects take into account the physical, biological and management aspects. Restoration situations are varied and complex; physical, biological and management aspects will be unique for each, thus it is inappropriate to put together one "restoration seed mix" for use throughout the entire watershed (or District or Forest) for every possible restoration activity.

Ideally, restoration projects are site specific. On some small projects, there is enough of the native plant community left that the best restoration approach may be to simply allow the natural regeneration process to occur. Site visits and advanced planning can also help maximize effectiveness of the money, materials, and effort expended. It can also allow the use of a plant that is plentiful, well adapted, and easily collected from the vicinity of the project (making it cost-effective).

Existing documentation (such as stream survey data, range allotment notes, etc.) should be reviewed to identify areas that may be degraded. Surveys should be conducted to confirm these areas and identify other areas that are in need of restoration.

Proposed or ongoing projects within the watershed should be reviewed to determine what restoration needs will result, and whether appropriate revegetation plant material is available.

Plants for restoration can be broken down into three broad categories:

- Plants with a very limited "growing niche" (eg. only semi-shaded, semi-moist, serpentine derived soils, etc.), which may be ideal for a particular situation, but will not work outside of that niche. These can be extremely useful in the right circumstances (and in some situations, a "finely tuned" plant to the particular site may be the only thing that <u>will</u> work), but general collection and seed increase (production) isn't cost effective or warranted unless there is a specific project in mind for them.

- Plants having a much broader niche (e.g,. "meadow", "grass steppe", etc.), but inappropriate outside of that broad niche. These can be invaluable within their niche, and would help add biodiversity that wouldn't occur if only one or a few species were used for restoration projects.

- "Workhorse" species - these plants are adapted to a wide range of habitats, establish easily, have desirable characteristics, and can be readily propagated or increased. These plants could (if the genetic guidelines allow) be increased and stockpiled for unforeseen, immediate needs, and for small projects where only a small quantity of seed is needed, and the "workhorse" species would be appropriate.

available for smaller projects. Since restoration planting and propagation with native species is still a relatively new field, not much is known about the genetics and cultural needs of the hundreds of potentially useful plants.

Some "management-caused" habitats were so uncommon historically, that we have no native species that have adapted to perfectly fill these niches. Major road cuts are a good example. The lack of soil and nutrients make plant establishment difficult. The steepness of the resulting banks usually means the few plants that try to establish are often washed out or knocked off the bank. Until the native species program matures, and has a stable program and stockpile of seed, locally adapted native species seed will be expensive and precious, and should be used where it will do the most good.

23. Locally adapted native plants should be used for restoration activities wherever possible, although sometimes the need exceeds the availability, e.g., catastrophic events such as large fires or major landslides. Alternatives include using a native but not locally adapted seed, using carefully selected non-native seed, not planting, or a combination of these options.

24. Shrubs should be used as often as possible where appropriate in restoration plantings to help counteract their decline. Many of our shrubs, having valuable restoration potential for site stabilization and wildlife habitat, are in decline due to browsing.

25. To ensure successful establishment of shrubs, browsing must be controlled until they are large enough to withstand browsing pressure. While cattle can be excluded from an area, it is more difficult to exclude elk and deer. Various fencing or caging methods are currently being used. More work needs to be done to determine the most cost-effective method(s) for protecting shrubs.

26. Potential “workhorse” forb species should be developed to help increase the biodiversity of planting efforts using a general seed mix. The overwhelming numbers of potentially suitable species, and a lack of information has made using forbs for restoration secondary to other growth forms. Until a comprehensive knowledge base of collection, propagation, and planting methods exist, one or a few species could be tried with each revegetation project where appropriate, and the suitability and methodology of each species determined.

27. Many grasses are potentially “workhorse” species. The use of native species such as native blue wild rye (*Elymus glaucus*), instead of introduced orchardgrass (*Dactylis glomerata*), is an improvement from an ecological perspective, but may not result in long term restoration unless it is part of an overall strategy for a given site.

28. Activities planned in rocky "scab flats", meadows, riparian areas, and shrub thickets should be evaluated for both positive and negative impacts to culturally-significant plants, since most grow in such areas. Using culturally significant plants for revegetation and restoration work would help assure that these plants are present and available.

29. During project level planning, consideration should be made of the proximity to known populations of noxious weeds, the potential for introduction or spread of noxious weeds, and the inclusion of measures to prevent infestation/spread, or including the cost of long-term treatment if weeds are introduced or spread. In addition to the noxious weed species currently being tracked, there are additional species that are either in the early stages of infestation or are widespread and constitute a larger hazard than had been previously assumed. See Botany specialist’s report for additional information on noxious weeds.

30. Treating noxious weeds by chemical or manual methods is recommended, knowing that almost none of our native species can out compete noxious weeds. Such treatments could potentially remove intermixed native species. Revegetating noxious weed sites with expensive, locally collected native species makes sense only after the noxious weeds have been completely eliminated, or in an extremely rare instance, where the native happens to be aggressive enough to completely choke out the weed.

31. Because of its apparent abundance and widespread distribution, it has been suggested that the highly variable *Botrychium minganense* be dropped from the Regional Forester's List of Sensitive Plant Species. However, until pending taxonomic work is published, it is recommended that *B. minganense* populations continue to be documented and tracked.

32. *Botrychium fenestratum* and “*B. glaucum* sp. nov” should be treated as sensitive species, pending listing by the Regional Forester or the Oregon Natural Heritage Database. Both have very limited abundance and distribution. Effects from fire, grazing, changes in overstory (if any) composition or changes in the water table are unknown. If new populations of these species are not found, their currently known population numbers are low enough (at least for “*B. glaucum* sp. nov” if it is a new species) to make them possible candidates for Federal listing as Threatened or Endangered

33. While no recommendations are made specific to insects and disease, several previously listed recommendations on salvage, stand density management, understory removals, pruning and prescribed burning, if implemented, could have beneficial effects in reducing or maintaining insects and diseases to more ecologically balanced levels.

34. RHCA implementation in Desolation Watershed could take one of two paths:

   a. Use the Pacfish RHCAs as they stand, or

   b. Design RHCAs specific to the needs of the aquatic and riparian habitat and the contemplated management in each subwatershed.

   In order to implement (b), evaluations of habitat quality as presented in other parts of this document (and from other sources as well) could be used to determine the habitat concerns specific to the stream, stream reach, or subwatershed, including downstream reaches. RHCA widths could then be designed to address concerns. The following fundamental observations ought to be incorporated:

   - Temperature is a concern for all streams in this watershed.
   - Woody debris frequencies are below ICBEMP ERU 6 50th percentiles in most of these streams.
   - 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 (36C and 36E) and some stream reaches are at levels that warrant attention (see Table 30).

   Suggested adjustment of Pacfish RHCAs:

   Redesign RHCAs to have an inner zone of 150 feet (or one tree height) in which all trees would normally be left for aquatic and riparian habitat needs, road construction and livestock grazing would be avoided (or minimized if necessary), and in general, active management would be minimal.

   An outer zone of another 150 feet would be utilized, in which management might occur when it would improve, or at least not degrade, the quality of riparian and aquatic habitat. In general, soil disturbing or compacting activities would be avoided in both zones. Retaining near natural vegetation density for at least two tree heights would help maintain the riparian microclimate.

   For reasons given above, these split RHCAs would be applied to class three as well as class one and two streams (Figure 44).

   Pacfish sized RHCAs for class four streams might be adequate for production of in-channel woody debris, but are probably insufficient for protection from erosion and sedimentation, especially for areas burned at high intensity or on steep slopes or granitic soils. Activities that could expose or compact soil, remove natural obstructions to flow, or initiate channelizing of flow would best be avoided for another 150-200 feet.

   To summarize, the following are recommended for modified RHCAs:

   a) Apply the same size RHCAs to perennial non-fishbearing streams as to fishbearing streams. The widths of these RHCAs should follow Pacfish standards for fishbearing streams except when site specific analysis determines that different widths would be appropriate. Normally their total width should be 300 feet on each side of the stream.

Figure 44. Diagram of Split RHCAs

b) Split the RHCAs for all perennial streams into inner and outer zones to allow for different management objectives (see Figure 19). Each zone should normally be 150 feet wide (or the average of the maximum tree height, reference Northwest Forest Plan 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.

35. Old forest resources are currently well below historic levels, and are not meeting habitat needs of associated terrestrial species. An Old Forest Management strategy for improving the existing and *future* status of old forests within the drainage is proposed in the Appendices.

36. Maintain snag levels in excess of the minimum requirements, particularly in areas vulnerable to windthrow, to help ensure the retention of viable populations of species dependent on standing and down dead wood. Although snag and down wood habitat are currently in good supply in the drainage, salvage logging in burned areas, and future harvest/stand manipulation in green stands have the potential to substantially reduce these resources in some areas.

37. Restore aspen and cottonwood stands. Comprehensive inventories on the North Fork John Day Ranger District have revealed many aspen clones and cottonwood stands to be in decline and at risk of extirpation unless immediate actions are taken to initiate new stem recruitment and protect regeneration from browsing.

    Recommended restoration treatments that mimic natural disturbance and stimulate resprouting include removal of conifer encroachment, underburning, root ripping, and creation of natural refugia with existing slash. Natural regeneration of aspen and cottonwood may be augmented by transplanting root suckers from nearby stands or by outplanting nursery stock. In order to protect regeneration from excessive browsing, planting and/or treatments to induce suckering should coincide with protective measures such as caging or big game exclosures.

    To date, the buck and pole exclosures at Howard Creek and Park Creek are the only treatments that have been applied to aspen stands in the Desolation drainage.

38. Grazing of riparian areas by domestic livestock(and probably to some extent by wild ungulates) can contribute to both the degradation of habitats critical to Neotropical migrant songbirds, and to an increase in invasive species such as cowbirds. Future AMPs, and existing management strategies should take these concerns into consideration.

39. The wet grassland habitats provided by Desolation and Kelsay meadows are extremely uncommon in this area of the Blues, and may support uncommon assemblages of terrestrial vertebrates (especially small mammals and amphibians). Removal of "encroaching" young conifers may be warranted, but should be carefully planned, with specific objectives explicitly stated. Avoid removing any large conifers at the meadows' edge. Pre- and post-treatment inventories of birds, mammals and amphibians should be integral to any restoration prescription.

40. Maintain large green conifers and snags along mainstem Desolation Creek and its larger tributaries for use by wintering bald eagles. Osprey will also benefit from maintenance of large steam-side snags for nesting.

41. Maintain South Fork Desolation Creek in its current roadless state in order to continue to protect the undisturbed nature of existing den habitat for wolverine. Likewise, the small area of rocky outcrops suitable for use by peregrines will be best served by retaining roadless areas.

42. Retain all remaining old forest habitat. Old forest habitats required by Management Indicator Species such as the pileated woodpecker, American marten, and three-toed woodpecker are much reduced from historic levels in the Desolation Watershed. These species will remain as long-term inhabitants of the watershed only if suitable habitat is available.

43. Snag and down wood resources are critical, but are not the only habitat components required by primary cavity nesters. When stand manipulations such as thinning, basal area reduction, etc., are being considered, it is important to review the local area as a whole, to determine how these actions may affect local populations of primary cavity excavators. Salvage logging in burned areas is of special concern, as some species of woodpeckers are closely tied to burned areas.

44. Continue to manage winter range areas for optimal forage conditions on elk/deer winter ranges. Emphasize use of locally-native grass species when seeding is indicated.

45. Conserve and/or restore suitable cover as needed. Subwatersheds most in need of restoration (from a historic perspective) include SWSs 36B, C, D, E, F and G. Include ODFW biologists in discussion of restoration priorities.

46. Potential Recreation Projects - the following list of potential recreation projects, provided by the District, was not reviewed in detail as part of this ecosystem analysis. The watershed team recommends that an integrated recreation plan be developed for the Desolation Watershed, since recreation is such an important component in the watershed.

    Scenic Trails/Trailheads

    Jump-Off Joe Peak #3028 (2.5 miles) - needs assessment work and upgrade - log out, brushing, trail tread improvement and signing .

    Blue Mtn. #6141 (6.1 miles), Lost Lake #3020 (4.6 miles), Squaw Rock #3039 (1.3 miles), S Fork Desolation #3001 (8.0 miles) - backlog maintenance work needed to be done includes trail tread improvement, waterbarring, stream crossing improvements (bridging, hardening), brushing and signing.

    Lost Lake Trailhead (near Desolation Guard Station) - rebuild horse corrals which have fallen into disrepair and harden circular drive-through area with approx. 40 yds. of pit run material to reduce erosion problems. Boulder placement is also recommended to protect adjacent meadow area.

Motorized Trails

Welch Creek #3030 (3.5 miles), Skinner Diggens #3013 (2 miles), Sharps Ridge #3026 (7 miles), Howard Creek #3005 (2.8 miles), Bull Prairie #3003 (2.5 miles), Beeman Junkins #3015 (8.5 miles), Battle Creek #3004 (3.9 miles) - continued maintenance is needed on these trails which includes: waterbarring, trail tread improvements, waterbarring, minor rerouting, bridge construction and repair and signing.

Skinner Diggens Trailhead - harden camping spots (gravel placement), improve fire rings and install a bulletin board.

Skinner Diggens Trails Tie-in with F.S. Road 1010 - To improve loop riding opportunities in the Desolation area, 1/2 mile of new trail designation to connect Skinner Diggens Trail with Rd 1010, which is an open road designated for OHV (Off Highway Vehicle) use also. 1/4 mile of this route would use an existing closed road and 1/4 mile of trail would be new construction. Trail work would include construction of a 20' bridge over Line Creek.

Note: Several trails/trailheads in the Desolation Planning Area are currently in the Trailhead Fee Demonstration Program, which requires trail users to pay set fees for use of these trailheads and trails. These fees will be used for routine and backlog maintenance and other necessary trail improvements. It is anticipated this program will continue into the future which will help ensure adequate, safe facilities for recreational visitors.

Developed and Dispersed Campsites

Tollbridge Campground - 1) vegetative plantings to provide screening between campsites and between campground and F.S. Road 10, 2) gravel parking spurs and replace decaying parking barriers to protect soils and define parking areas.

Four dispersed campsites near Howard Creek Trailhead - widen approach and gravel entrance way with pit run to reduce existing erosion concerns - approx. 20 yds. material needed

Two dispersed sites adjacent to Road 45 gravel pit - harden entrance way to dispersed sites in order to reduce soil erosion (road rutted) - approx. 20 yds. material needed

Three dispersed sites adjacent to Desolation Guard Station - gravel entrance way to reduce soil erosion - approx. 20 yds. material needed

Rock Springs dispersed camp sites (near Olive Lake) - gravel entrance way to reduce soil erosion - approx. 20 yds. material needed

Routine maintenance, planning, and minor improvements will continue at developed and dispersed campsites in the planning area, as funding and safety priorities are considered. This work includes such items as: hazard tree assessments and removal, firering clearing, toilet cleaning, inventories/GPS work, providing visitor information and receiving public input (bulletin boards, personal contacts, registration forms), trash removal and structure repair. The district also actively seeks and obtains partnerships with volunteers and other agencies to help maintain recreational facilities and services.

Cabin Rental Program: While there currently are no plans at this time to include the Desolation and Battle Creek Cabins into the Cabin Rental program, it is foreseeable these cabins could be in the program within the next five years, as funding becomes available to repair cabins for this type of use.

B. Subwatershed Specific Recommendations

The following recommendations are intended to address a number of concerns/problems related to water quality, aquatic habitat, vegetation sustainability, habitat for terrestrial vertebrate populations, and to build an integrated approach to management of the Desolation Watershed.

Many of the forested vegetation recommendations are aimed at accelerating re-establishment of old forest **(OF)** stands to historic, sustainable levels. Details of this strategy are found in the Appendices.

This following process was used in the old forest restoration strategy for Desolation:

1. Stands currently meeting old forest criteria are identified and recommended for protection under a conserve approach (see below), because of the limited amounts of old forest present in the watershed as compared to historical and HRV levels. These stands will form the core for development of larger patches of old forest (Table 62).

2. Stands nearby those in (1), with the potential to quickly move toward old forest structure, are identified for potential treatments. Stands in late-seral structural stages, understory reinitiation **(UR)** and young forest multi strata **(YFMS)**, probably have the greatest potential to move toward old forest structure. Some of these stands are recommended for field review for treatment, if vegetation data indicates they are in a structural stage that may warrant treatment. Other factors, including elk cover needs, or the presence of suitable habitat for MIS were also reviewed before potential treatment was recommended. Stands recommended for field review for potential treatments are found in the " Subwatershed Habitat Characteristics" Appendix.

Please see the Upland Forest Vegetation Analysis for a detailed discussion on data limitations. Many of the following recommendations are based on landscape level information (much of it photo interpreted data), and specific forest stand information represents a first approximation, a place to start in project level planning. Recommendations need to verified through on-the-ground visits. Recommendations for specific stands may not turn out to be feasible; however, it is hoped that other opportunities may arise in the course of site visits, to complement the overall strategy.

As used in the subsequent recommendations, the following terms mean:

> **Restoration -** Actions taken to modify an ecosystem to achieve desired, healthy, and functioning conditions and processes. Generally refers to the process of enabling the system to resume its resiliency to disturbances.
>
> **Conserve -** Management emphasis on protection and maintenance of forest, rangeland , and aquatic conditions, health, and integrity, recognizing that natural processes dominate the landscape and gradual change will occur.
>
> **Evaluate -** Further examination of conclusions; continue current surveys and monitoring, and expand as needed, develop management plans.

Lower Desolation (36A)

Pursue partnerships: coordinate fuels management and road right-of-way (maintenance), with private land owner**.** ***Evaluate*** condition of acquired lands, and potential for restoration (obliterate roads and plant streamside areas).

About 58 percent of Subwatershed 36A is private land, and little information about past management or aquatic habitat quality in tributary streams is available for this portion of the watershed. No specific recommendations are made regarding aquatic habitat.

Stands 2 (53 ac.) 14 (48 ac.) and 26 (248 ac.) comprise the only remaining old forest (OF) in the subwatershed, with stand 26 providing the only suitable reproductive habitat for the pileated woodpecker in the drainage. As presented in the Old Forest Restoration Strategy proposed for the watershed, these stands would be Priority 1 areas, where the objective would be to protect all remaining old forest patches. These areas are currently serving as “refugia’ for old forest species, and will serve as “core” patches for restoration purposes within the 731 acres delineated within the subwatershed (Figure 45, Table 71).

Stand 21, with only 11 acres in National Forest ownership (33 additional acres are privately owned) currently provides the only Satisfactory big game cover in the subwatershed. The stand also provides foraging habitat for pileated woodpeckers (1 of only 3 stands, see above). It is recommended that stand 21 and immediately-adjacent stands 7, 18, and 20, be deferred from silvicultural treatments in the short term, in order to retain and expand this small area of Satisfactory cover.

Adjacent to Stand 26, Stands 35 and 43 (totaling 243 acres), both in the UR structural stage, were identified as candidates for understory removal, since they occur on Warm Dry sites (SWS Habitat Appendix). The location of the stands, adjacent to a large old forest stand, makes them a high priority for possible treatment to speed up movement toward OF structure. However, these stands also provide “marginal” cover (MC) adjacent to big game winter range. Field review by District wildlife staff is needed to determine which resource is most lacking here, “future” old forest, or existing cover resources.

Stand 10 (87 ac., understory removal, warm dry) is recommended for field review for possible treatment to return the stand to a more appropriate open structure, and to accelerate movement towards mature/old forest conditions.

Figure 45. Old Forest Restoration Strategy (Proposed)

Table 71. Structural stage composition of the proposed Old Forest Restoration Strategy for the Desolation Analysis Area.

SUBWATERSHED	STRUCTURAL STAGE			
	OF	YFMS	UR	TOTAL ACRES
Lower Desolation (36A)	353	44	334	731
Wasson (36B)	89	100	1412	1601
Kelsay (36C)	0	675	429	1104
Bruin (36D)	0	1418	777	2195
Junknens-Beeman (36E)	290	1008	0	1298
Battle (36F)	0	1873	311	2184
Howard (36G)	0	1671	25	1696
N.F. Desolation (36H)	165	866	50	1031
S. F. Desolation (36I)	652	724	256	1,632
TOTAL	1,549	8,379	3,594	13,472

Wasson (36B)

Pursue partnerships: coordinate fuels (and other resource) management with private land owner.

About 55 percent of Subwatershed 36B is private land, and little information about past management or aquatic habitat quality in tributary streams is available for this portion of the watershed. No specific recommendations are made regarding aquatic habitat.

Fencing of the spring and the immediately-adjacent wet meadow in Snapp Springs area is recommended. Cleanup of old camp debris and increased law-enforcement are recommended to discourage future dumping. Surrounded by large old growth ponderosa pine, this large spring with its lush meadow provides extremely valuable habitat for mammals, birds, and particularly amphibians. The area immediately surrounding the spring is trampled and muddy, and generations of camps have resulted in unsightly accumulations of junk.

Stands 140 and 129 (totaling 89 acres) the only remaining old forest stands, are currently in C7 Management Area, and should be protected as core area for expanded old forest as it develops over time. Approximately 1601 acres were identified for old forest retention and/or restoration (Table 71, Figure 45).

Stand 158 (45 acres) was identified as a candidate for precommercial thinning, but is currently the only satisfactory elk cover in the subwatershed, and is not recommended for thinning at this time.

Kelsay (36C)

Kelsay Subwatershed has one of the highest road densities, and the highest number of road/stream crossings per square mile, in the Desolation watershed. Finding ways to reduce road densities in riparian areas, especially stream crossing density, is the first consideration for watershed and aquatic habitat restoration. Fortunately, this subwatershed also has high potential for aquatic restoration, with relatively good large wood frequency and depth/width ratios. Evaluation of potential restoration projects should focus on roads and road-related problems within the subwatershed, with the objective of reducing sediment delivery to streams..

Proper Functioning Condition (PFC) assessments indicate the upper reaches of Kelsay Creek are functioning at risk, and are degrading. Grazing, roads, and past harvest were identified as primary impacting factors. Management of livestock to improve riparian function is needed and may include limiting access to riparian areas through fencing or other means. Effectiveness of instream structures needs evaluation - field surveys indicate that some structures need repair.

There is currently no OF habitat in this subwatershed. The single C2 area designated within the drainage appears to be comprised totally of stands in the Stand Initiation structural stage. The area provides no suitable habitat for the target MIS (three-toed woodpecker) at present, nor would it be expected to provide suitable habitat for 75 to 100 years. Given this circumstance, stands in the UR and YFMS stages should be field evaluated for potential replacement of the existing C2 management area.

With no old forest to use as a "core area", stands in the UR and YFMS were identified as high priority for being the base of a new "network". Approximately 1100 acres were included (Table 71, Figure 45).

While foraging habitat for pileated woodpeckers, northern goshawks, marten and wolverine is relatively abundant in the Kelsay subwatershed, the absence of old forest stands precludes the use of this subwatershed for reproduction by any of these species. The northeast and eastern portions of the drainage are especially lacking in older stands, reducing the potential for movement of old-forest dependent species between Desolation and the adjacent watershed. Stand 203 (Understory Reinitiation, warm dry, 185 acres) was identified as a candidate for understory removal. This may be a good stand to nurture toward the OF structural stage, since it could contribute to the expansion of an old forest "core" area (stands 140 and 129 in Wasson Subwatershed). Stand 203 also currently provides marginal cover for elk, so further interdisciplinary assessment is necessary.

Satisfactory Cover for big game species is limited to a single, small stand (stand 141, 25 ac). No silvicultural treatment was identified for this stand (see SWS Habitat Appendix).

Stands 231, 270 and 203 (see above) were identified as candidates for understory removals, while stands 251 and 305 are overstocked and are candidates for precommercial thinning. There appear to be few conflicts with proposed silvicultural treatments in these stands.

<u>Bruin</u> (36D)

Restore subwatershed; reduce road density[1], upgrade (storm-proof) stream crossings .

About 27 percent of this subwatershed is in private ownership, and like Subwatersheds 36A and 36B, aquatic habitat information is lacking. Tributary streams in the Bruin subwatershed have not been surveyed, so correllations to management activities are not possible, but Bruin does have the second highest road - stream crossings density in the watershed. Thus a first approach to restoration here might well be the reduction of streamside road density.

The Desolation vegetation database indicates that no OF structure stands are present in this subwatershed, including C1/C2 management areas. All of the designated areas contain a relatively high percentage of forests that will not provide suitable habitat for another 50 years or more. Analysis for old forest Management Indicator Species shows no suitable reproductive habitat available for pileated woodpecker, marten or goshawk.

Options for developing OF structure stands of large enough patch size to be functional *do* exist; however, restoration will be a long-term proposition. In the short term, retention of connectivity between existing patches of YFMS and UR stands is critical. In the northeast corner of the subwatershed, stands 233, 285, 302, 337, 360, and 459 provide a potential "core" for development of both old forest structure and connectivity with maturing stands in the Kelsay subwatershed to the north, and SWS 36F to the south. A cluster of YFMS stands at the western subwatershed (and watershed) boundary provides similar opportunities for restoring old forest habitats for and enhancing connectivity between subwatersheds 36D and 36C, and the Indian Creek drainage to the southwest.

Forest stands proposed for old forest conservation/restoration total approximately 2195 acres (Table 71, Figure 45). With the exception of stand 508, none were proposed for silvicultural treatments at this time. Stand 508 (67 acres, UR structural stage) is a Warm Dry stand. It currently provides no habitat for pileated woodpecker, marten or other closed-canopy OF species. This may be an appropriate stand for active management, although there are concerns for elk cover.

Cover for elk and deer is patchy. Five stands provide a total of just 287 acres of Satisfactory Cover. Three of these were identified as candidates for understory removals. Given the scarcity of this habitat, these stands are not recommended for thinning at this time.

Stands 465, 474, 508 and 525, also identified as candidates for thinning, form part of a block of cover that provides connectivity to a large stand of Satisfactory Cover in Junkens Subwatershed (36E). Thinning these stands is not recommended at this time.

Stands 465, 483, 508, 541, and 525 were proposed for understory removal. Portions of these stands are adjacent to Desolation Creek. Any proposed treatments need to be consistent with RHCA guidelines.

<u>Junkens - Beeman</u> (36E)

Conserve as an important cold water source for Desolation Creek.

The headwaters portion (approximately the upper one-third) of the Junkens - Beeman subwatershed is roadless and has not been logged. The lower part is fairly densely roaded and has experienced extensive timber harvest. Junkens Creek, along with South Fork Desolation, are among the coolest in the Desolation watershed. It appears that this subwatershed has excellent potential for restoration. Possible avenues include protection of the upper subwatershed and restoration of the lower reaches (including reduction of road density, ensuring regeneration of harvested areas), and close monitoring of livestock grazing with provision of adjustments to grazing management as necessary.

Table 31 identifies four human-caused barriers to fish passage on Junkens Creek, and one on Beeman Creek. These barriers should be reviewed for restoration opportunities.

This subwatershed contains two OF structure stands (820 and 751), totaling 290 acres. Stand 751 (61 acres) supports suitable *reproductive* habitat for the pileated woodpecker, goshawk and marten, and also provides foraging habitat for lynx, wolverine and three-toed woodpeckers. These stands should be protected as the "core" area for old forest habitat conservation in the Junkens-Beeman drainage. Approximately 1,298 acres were identified for potential inclusion in the first priority (short term) strategy for old forest conservation (Table 71, Figure 45).

Satisfactory cover for big game is limited to three stands (573, 638 and 831) totaling 452 acres. These stands also provide foraging habitat for one or more MIS. Stands 573 and 638 were initially identified as overstocked; in light of their importance to big game (and several other species), treatment is not recommended until additional cover in the area reaches “Satisfactory”.

Battle (36F)

Restore subwatershed; reduce road density[1].

Except for its low wood frequency, the situation in the Battle subwatershed is similar to that of Kelsay. For restoration in this subwatershed, consider adding large wood to the stream in addition to reducing road density. Battle SWS has the third highest road-stream crossing density: focusing on reducing road densities in riparian zones should be first priority. Battle also has the highest Equivalent Clearcut Acreage of the subwatersheds for which data is readily available. Ensuring that regeneration of harvested areas is proceeding apace and that any additional harvest not further stress the aquatic environment are important components of an aquatic habitat management strategy for this subwatershed.

No old forest stands remain in the Battle subwatershed, and there are very few short-term restoration opportunities. Stands in the UR and YFMS structural stages are clustered at the east and southwest SWS boundaries. These stands account for the majority of the 2184 acres identified in the old forest strategy for this SWS (Table 71, Figure 45). Stands 459, 551, and 590 are important for their potential role as northeast-southwest “connectors”.

Stand 701 (86 acres) (RHCA concerns) and Stand 519 (54 acres) have potential for understory removal treatments. A total of about 501 acres were identified for potential precommercial thinning, and 3 acres for salvage within the Bull Fire area.

Stands 551, 590, 459, 460, and 626 represent the best opportunities for OF restoration.

Howard (36G)

Evaluate in-stream structure effectiveness in Desolation Creek; maintain Road 10 to reduce ditch erosion.

Judging from surveys of tributary streams, aquatic habitat in the Howard subwatershed is in good condition. Howard has fairly low road density and has had only a small amount of timber harvest. High quality aquatic habitat could probably be maintained in this subwatershed by keeping the road density and equivalent clear-cut acreage low. One barrier to fish passage was identified in stream surveys (Table 31, and should be field reviewed for repair opportunities.

This subwatershed currently has no OF stands, consequently analysis revealed no reproductive habitat availability for old forest-dependent species. However, several large stands in the YFMS stage currently provide foraging habitat for MIS species (except the three-toed woodpecker). Some of the large stands (679, 711, 764, 776 and 824) may represent opportunities to accelerate movement toward OF structure. However, in a subwatershed where old forest resources are no longer available, special attention should focus on the needs of the *current* vertebrate community and habitats.

About 327 acres within the Bull Fire perimeter were identified as having salvage potential.

The Howard Creek drainage supports the largest single patch of Satisfactory Cover (stand 764) within the Desolation watershed. The combination of stands 764 and 776 (directly adjacent to the southeast), provides over 1000 acres of contiguous cover in the subwatershed. No silvicultural priorities were identified for this area.

North Fork Desolation (36H)

Restore subwatershed; reduce road densities[1] and road-stream crossings, plant natives and protect meadows. ***Evaluate*** ditching/drainage impacts on meadow, develop a plan for restoring natural flows.

Habitat conditions in North Fork Desolation Creek are similar to those in Battle, excepting that water temperatures are somewhat lower. Road density is similar, but road - stream crossings density is a little lower. An aquatic habitat management strategy similar to that for Battle, but taking into account its status as eligible for Wild and Scenic River designation, would probably be appropriate.

One barrier to fish passage was identified in stream surveys (Table 31) and should be field reviewed for treatment need.

As discussed in Chapter V, a determination of the cause(s) for the apparent dramatic reduction in pool frequency from 1963-64 to 1992-93 is recommended.

One hundred sixty-five acres of old forest are present along the North Fork of Desolation Creek (Stands 801, 805, 815). Stand 815, at approximately 120 acres, supports potential reproductive habitat for three-toed woodpeckers and goshawks. Stands 801 and 805 are very small (16 and 21 acres, respectively), but might still provide “nest groves” for individual pairs. These three stands form a logical core for old forest restoration in SWS 36H. Moving out from the old forest core, stands 780, 783, 821, 852, 869, 871, may have potential as “future” old forest. These stands are recommended for review for treatment to determine if active management practices might accelerate movement toward OF structure. Approximately 1,031 acres were included in the conservation strategy for the North Fork SWS (Table 71, Figure 45).

Six hundred seventy-seven acres within the subwatershed were identified for salvage in the Bull Fire area; 151 acres of precommercial thinning were designated (see map).

South Fork Desolation (36I)

Conserve cold water source through relocation of trail from riparian areas. ***Evaluate*** potential for shrub planting to accelerate stream bank recovery in fire area (stabilization and shade).

The very good aquatic habitat conditions in South Fork Desolation plus its very low road and road crossings density, its low timber harvest history, its “A8” Forest Plan Management Designation and its eligibility for Wild and Scenic River status would suggest a protect and conserve management strategy, but the recent fire in the subwatershed makes some shrub and tree planting desirable.

Stream survey reports mention several waterfalls downstream (below the meadow in South Fork Desolation). At least one of them, at 13 feet high (between river mile 2.2 and 3.7), is almost certainly a fish passage barrier. This implies:

a) That bull trout in this upstream part of the South Fork are unlikely to cross with the introduced brook trout present downstream in mainstem Desolation and in Howard Creek;

b) The rainbows reported here by USFS stream surveys may actually be native redbands, although they may have crossed with introduced west-slope cutthroat trout; and

c) Should fish in this upstream section of South Fork Desolation be extirpated, natural recolonization might not be possible.

Taken together, these factors suggest a recommendation that South Fork Desolation be accorded special protection for the fisheries values present here.

Special attention to protection of fisheries values in subwatershed 36I (South Fork Desolation) is warranted. The entire subwatershed is presently designated as Management Area A8, Scenic Area. Although the goal for A8 management areas is to "protect or enhance the unique natural characteristics of landscapes noted for their scenic beauty" (Umatilla National Forest, 1990), it appears that the Management Area Standards and Guidelines for A8 are relatively conservative from the perspective of fisheries values protection, and if consistently followed, additional protection may not be necessary. However, cautious implementation of those developments permitted is warranted, particularly ensuring that trails and camping and parking areas are well away from streams and that grazing be indeed maintained at a very light level, and in such a way as to keep livestock from congregating and lingering near streams.

Since much shade and future large woody debris was lost in Subwatershed 36I as a result of the Summit fire, accelerated recovery of streamside vegetation, shade and large wood through conifer and shrub planting is especially important in riparian areas burned at moderate and high intensities.

Once again, all stands currently in OF structure are recommended for protection. No vegetation treatments are recommended within the 1,559 acres identified as part of the conservation strategy.

[1] "Target" road densities, for example "x" miles per square mile, are not suggested because of the many factors controlling road impacts, eg., slope position, soil type, slope steepness.

C. Inventory and Monitoring Needs

1. Bring current the backlog of water data collected at Forest Service gage at Forest Service Road 10 crossing. Maintain core set of monitoring stations; stream temperature, flow, sediment, channel morphology (establish permanent reference reaches on key streams, revisit sites established on NF Desolation and Kelsay Creek).

2. Monitoring of revegetation efforts using native seed is needed to determine in what habitats and conditions the particular native species will establish.

3. Establish permanent monitoring plots of *Botrychium* spp. populations to provide much needed baseline and management effects data.

4. Complete inventory of abandoned mines, identify reclamation needs. Prioritize and request funds for reclamation.

5. Inventory mine shafts, attits, etc., for presence of bats prior to reclamation activities.

6. Complete inventory of trails and dispersed recreation sites. Identify segments and sites for modification. Prioritize and request funds for rehabilitation.

7. Update/validate stream classification databases during stream inventories and project-level planning.

8. Monitor recent wildfire effects; including channel recovery, in Subwatershed 36I (South Fork Desolation).

9. Conduct field inventory for fish passage barrier culvert conditions to verify and update the information reported in the 1992 and 1993 stream survey reports. This will be especially useful for future consultations for listed aquatic species.

10. Conduct bull trout redd inventory on Mainstem, North, and South Forks of Desolation Creek to help quantify the population status and better inform management.

11. Conduct snorkeling survey for presence of large migratory bull trout to help determine the migratory/resident status of the local population.

12. Surveys for sensitive amphibian species are warranted, given the unique complex of wetland and riparian habitats in the drainage.

13. Review/monitor the potential effects of OHV and snowmobile use on Rocky Mountain Elk on the Sharp’s Ridge Trail during fall hunting seasons. ODFW has expressed concern that some road “closures” that permit OHV use are not compatible with the stated intent of wildlife “protection”.

14. Continue to collect data relating to all mining activity and continue to monitor mining activities on the District.

15. It is recommended that whitebark pine surveys be completed as soon as possible, as this species’ occurrence on the Umatilla is limited to Desolation Watershed, and some adjacent areas, and the presence of white pine blister rust is unknown.

16. *Botrychium* species surveys need to be periodically repeated, as numerous factors can make a difference on whether or not a plant is found. Whether "*Botrychium glaucum* sp. nov." is indeed a new species, or a form of *B. pedunculosum,* its currently known worldwide distribution (with one unvouchered exception of 6 plants) is found within one subwatershed of the Desolation watershed.

17. Information on status of local populations of Management Indicator Species is needed. Current evaluations are based only on habitat quality and quantity.

D. Data Management, Analysis Limitations, Research Needs

1. Data from private lands were not available for this assessment which limited the evaluation of watershed condition. Forest databases are not up to date, or are incomplete, for example stream classes and riparian inventories. Overall findings are based on limited data, with interpretation relying on published research and data from other similar watersheds. Further work at the project-level will require field investigation to validate or adjust general recommendations.

2. Review stream survey data in the SMART database and restructure the data to allow separate calculation of values for habitat parameters in the meadow portion of South Fork Desolation Creek.

1. Add missing data to SMART database. (e. g. comments and fish species encountered in South Fork Desolation narrative report, but which is missing from the database.)

2. Conduct genetic testing of bull trout in South Fork Desolation above the waterfall to establish whether they are isolated or genetically distinct populations.

3. Adjust the SMART database for reach five of South Fork Desolation Creek.

4. Reach five of South Fork Desolation includes the meadow plus some very steep channel upstream. The Survey team originally intended to make that part of the stream upstream of the meadow a separate reach, but it turned out to be too short, so they added it to reach 5, the South Fork Desolation Meadow reach. This explains the high gradient (5%) given for the meadow reach. This clearly is not representative of the meadow. It would be helpful to split reach five into a meadow and upstream section. Even if the upstream reach were not long enough to meet SMART database reporting requirements, the meadow portion is, and its characteristics would be reflected more accurately if the data for the much steeper gradient upstream section were not included.

5. Check and correct the GIS stream class database regarding miles of class III and IV streams in Subwatershed 36D.

6. Complete and refine the STR_STREAM tables in the Forests Geographic Information System (GIS). These tables are already set up as part of the Forest's GIS, but have been empty of data untill very recently. An effort, spearheaded by the Pomeroy Ranger District, is presently underway to establish the inital presence/absence records for fish species of especial interest, and to link the GIS Stream Layer to the SMART database.

   This information will be a powerful analysis and management tool, and it is important to follow this project through to completion, and then to refine it beyond simple presence/absence information by following the fish distribution codes in the STR_DATA table (GIS Data Dictionary).

7. While there are some upland "grasslike" species which could be invaluable in the appropriate locations, most of these species are riparian plants. Many of them start readily from seed or vegetatively, and could become the "workhorse" species for riparian areas. There are so many of them that it will take additional work to determine the ecological needs and amplitudes of each species, and which ones would be most appropriate for further development as a "workhorse".

8. While very little work has been done on using bryophytes and lichens for restoration work, they could be extremely useful in some situations. These organisms are primary colonizers of new habitats, are often the first “plants” growing on exposed rock and subsoil after severe fires, and initiate the soil formation process. Some of the lichens shelter blue-green algae that fix a considerable quantity of nitrogen and release it into the otherwise relatively sterile substrate. While methodology and suitable species would have to be worked out, propagation could be by spores or by vegetative pieces. A piece of moss consisting of at least 5 cells will usually start growing as soon as it is moistened and placed in the appropriate conditions, even if it had just spent the previous 100 years in a herbarium packet.

   While they don't have roots and therefore can't hold hillsides in place, they can inhibit or stop surface erosion, and create a moister microsite for establishment of vascular plants. With the appropriate methodology and species, these could become one of the “workhorses” for revegetation of large-scale catastrophic events. If they could be sustainably collected, they could be stored almost indefinitely, would be inexpensive, easily applied, and on some of the harshest sites, may be the only vegetative organisms likely to thrive.

   A separate paper listing potential revegetation species will be developed as time and funding allow.

9. Research is needed the effects of harvesting special forest products, on what levels are critical to given species. Over-harvesting a plant species as a special forest product could affect a seemingly unconnected part of the ecosystem. Currently on the Umatilla, the demand for everything except morel mushrooms is quite low. As markets are developed for special forest products and/or the forests on the west side are exhausted, harvesters may migrate to the Umatilla.

   Please see full discussion of special forest products in the botanical specialist’s report for background, potential species of concern, management implications, and suggestions on policy formulation.

10. Until the effects of the burning on *Botrychium* species can be assessed, fire prescribed for Desolation Meadows should be on an experimental basis, and only a portion of the meadows should be burned. Adequate information is simply not available to be able to assess the implications of management activities on *Botrychium* species.

Umatilla National Forest
North Fork John Day Ranger District
Desolation Watershed Ecosystem Analysis

UPLAND FOREST VEGETATION ANALYSIS

David C. Powell
Forest Silviculturist
October 1998

[Looking into a portion of the Desolation watershed from Desolation Butte Lookout; October 10, 1935.]

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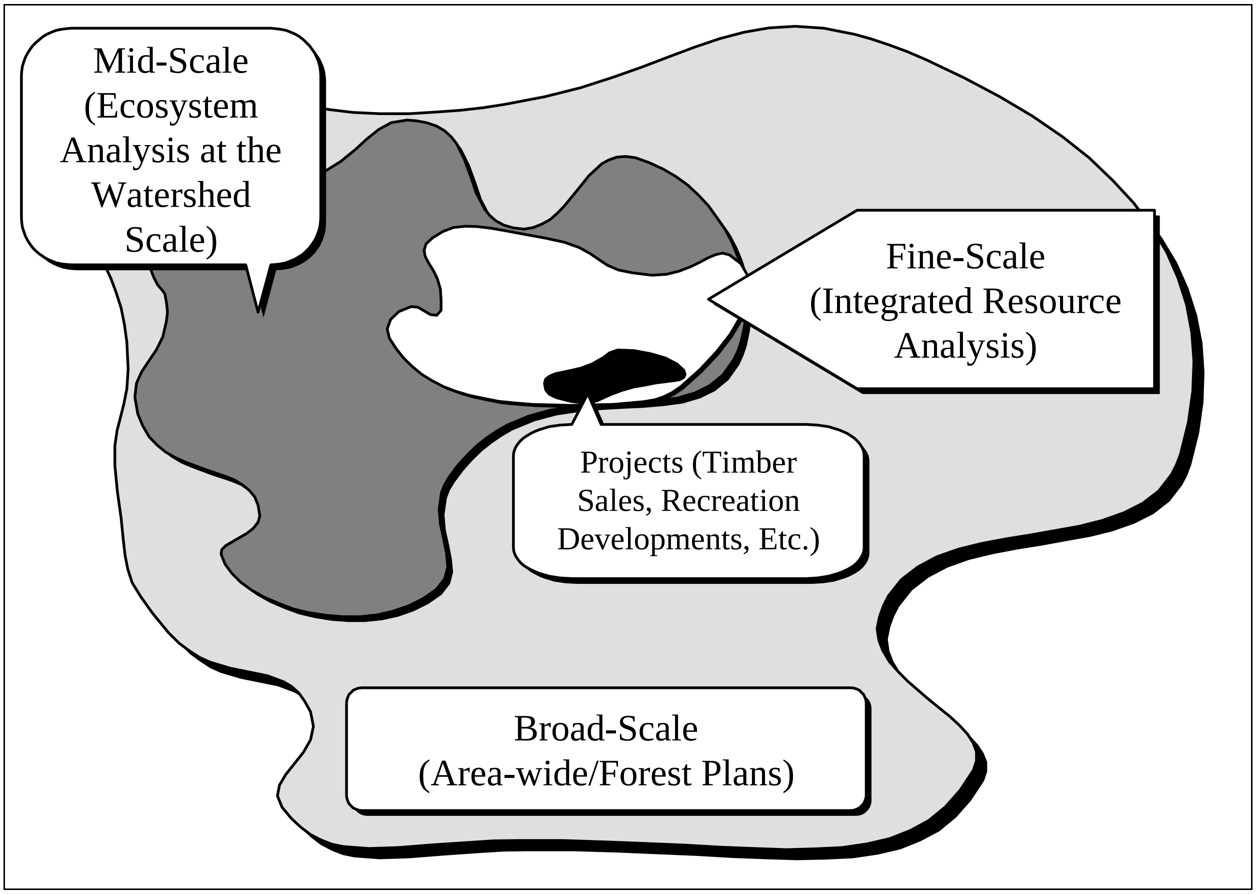
INTRODUCTION

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 agents in a drainage. The understanding gained through such an analysis is critical to sustaining the health and productivity of the natural resources that have been entrusted to our care (Regional Ecosystem Office 1995).

Federal agencies are conducting watershed analyses as a way to shift their focus from individual species and sites to the ecosystems that support them. Hopefully, that change in attitude will result in a better understanding of the consequences of management actions before they are implemented. The watershed scale was selected because a watershed is a well-defined land area with a relatively homogenous set of features and processes, at least from a hydrologic perspective (Regional Ecosystem Office 1995).

Watershed analysis is driven by issues. Rather than attempting to address everything in the ecosystem, analysis teams focus on seven core topics along with 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).

Watershed analysis is not a decision-making process. It is an incremental endeavor, with new information derived from surveys or monitoring incorporated whenever it becomes available. An important function of watershed analysis is to set the stage for subsequent decision-making processes by providing context for fine-scale integrated resource analysis and project planning (Regional Ecosystem Office 1995; Veg Figure 1).



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

This report provides the results of an upland-forest vegetation analysis for the Desolation watershed. It describes the potential natural vegetation, cover types, landscape patches, size classes, structural stages, canopy cover, canopy layers, and disturbances for upland forests of the Desolation ecosystem analysis area. In addition, several other factors pertaining to upland forests were also examined, including the historical range of variation for forest structural stages, an analysis of stand density, an assessment of forest sustainability, and consideration of limited vegetation components. At the end of this report, one appendix describes the vegetation databases that were used to support the analyses; a second appendix provides suggested stocking levels for tree species that occur in the analysis area.

CHARACTERIZATION

Characterization is the first step in a six-step process for ecosystem analysis at the watershed scale (EAWS). It is designed to identify the ecosystem elements (components, structures, and processes) that influence vegetation conditions in the watershed (Regional Ecosystem Office 1995). For this report, the scope of characterization and other ecosystem analyses was limited to upland forest vegetation only.

Forest vegetation reflects the interaction of ecosystem components, structures, and processes. *Components* are the kinds and numbers of organisms that make up an ecosystem (Manley and others 1995). Forest vegetation components include tree species, aggregations of tree species called cover types, or combinations of cover types called life-forms, depending on the scale being considered (Veg Table 1). The existing situation with respect to forest vegetation components of the Desolation watershed is described in the *Current Conditions* section (page 13); the historical situation is described in the *Reference Conditions* section (page 26).

Structures are the arrangement or distribution of ecosystem components (Manley and others 1995). Structures can occur both horizontally (the spatial distribution of structural stages across a landscape) and vertically (trees of varying height growing together in a multi-layered structure). Forest structures consist of size classes, structural stages, or physiognomic types, depending on the scale being considered (Veg Table 1). The existing situation with respect to forest vegetation structures of the Desolation watershed is described in the *Current Conditions* section (page 13); the historical situation is described in the *Reference Conditions* section (page 26).

Processes are the flow or cycling or energy, materials, and nutrients through space and time (Manley and others 1995). Forest processes can include everything from photosynthesis and nutrient cycling to stand-replacing wildfires and insect outbreaks (Veg Table 1). In the Desolation watershed and the Interior Northwest in general, disturbances have influenced vegetation conditions to a greater degree than other ecosystem processes (Clark and Sampson 1995; Oliver and Larson 1996). The existing and historical situation with respect to forest disturbances is discussed in both the *Current Conditions* and *Reference Conditions* sections (pages 13 and 26, respectively).

Veg Table 1: Selected examples of forest ecosystem elements.

ECOSYSTEM ELEMENTS	ECOSYSTEM SCALE (HIERARCHICAL LEVEL) FINE	MID	BROAD
Components	Tree Species	Cover Types	Life-form (forest; shrubland, etc.)
Structures	Tree Size Classes	Structural Stages	Physiognomic Types
Processes	Wind; Senescence	Bark Beetles; Pathogens	Fire; Defoliators

Sources/Notes: Although they are shown individually in this table, it is important to note that forest components, structures, and processes are interrelated – from an ecosystem perspective, they do not operate independently.

Veg Table 1 demonstrates that ecological analysis is highly influenced by scale because ecosystem elements occur in hierarchies (Haynes and others 1996). Some elements are easily identified at one scale but not at another. That doesn't mean an element ceased to exist – it is just not apparent at the resolution of a different hierarchical level. For example, at the fine scale represented by the interior of a forest stand, individual tree species can be readily distinguished. After moving back to the mid-scale, individual species are imperceptible but species groups (cover types) become apparent. At a broad scale, discrete cover types can no longer be discerned although life-forms (forest versus non-forest) are obvious.

Potential Natural Vegetation

Why do some forest components occur only in certain portions of the Desolation watershed (subalpine fir cover type at high elevations, for example)? Why are some forest structures associated more often with one component than another (the *old forest single stratum* structural stage with warm dry sites)? And why do certain disturbance agents act differently depending on which cover type they occur in? Those and other questions are best addressed using a concept called potential natural vegetation (PNV), which is defined and described below.

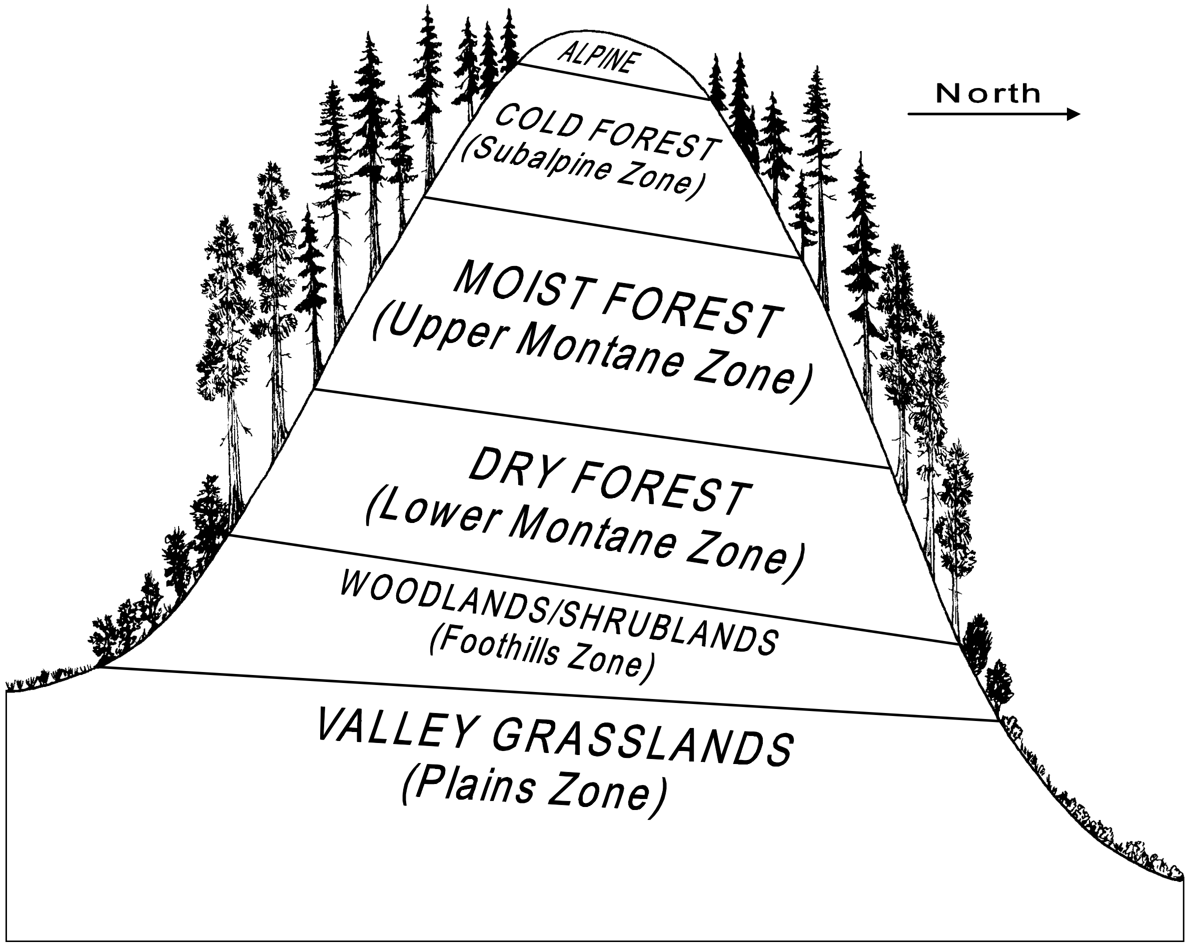
Mountainous areas such as the Desolation watershed have steep environmental gradients, which means that site conditions vary in response to changes in landform, elevation, climate, soils, slope exposure, geology, and a variety of other abiotic factors. Any unique combination of abiotic factors results in a slightly different environment, usually expressed as a change in temperature and moisture conditions. In the Desolation analysis area, temperature and moisture varies somewhat predictably with changes in elevation and aspect (Veg Figure 2).

The climax plant community (e.g., the PNV) associated with a particular set of environmental conditions (temperature and moisture) is called a *plant association*. 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 taxonomy or hierarchy of potential natural vegetation, ranging from plant associations at the lowest level to potential vegetation groups at the highest level (Veg Table 2). Veg Figure 3 shows the location and distribution of upland forest PVGs in the Desolation watershed; Veg Figure 4 provides the same information for PAGs. Veg Table 3 summarizes selected characteristics of the PVGs.

PNV has an important influence on forest components, structures, and processes for the Desolation watershed. 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 influence that fire, insects, pathogens, and other disturbance agents exert on forest structure. Those processes are predictable, at least to some extent, for a reason – they can be related to PNV, and research has consistently shown that sites with the same PNV behave in a similar way.

Because of its predictive power, PNV is valuable for developing management implications. Disturbances and management activities can have widely varying results in different environments. For example, a prescribed fire with a flame length of 2 feet and an intensity of 25 BTU/ft/sec would have relatively benign, nonlethal results when used on warm dry sites where the overstory trees are thick-barked ponderosa pines, Douglas-firs, and western larches. That same treatment could have dramatic results (total tree mortality) on cold dry sites dominated by thin-barked subalpine firs and lodgepole pines.

Recent EAWS efforts have reported management recommendations by subwatershed – a delineation within a hydrologic coding system that represents a group of streams flowing into a watershed (Quigley and Arbelbide 1997). Using subwatersheds during analysis is reasonable in terms of understanding spatial patterns of aquatic ecosystem quality and for addressing aquatic risk (Omernik 1995). However, subwatersheds have limited influence on upland forest processes at a landscape scale. Since ecosystem processes are strongly influenced by PNV, all recommendations pertaining to upland forests are summarized and reported using PNV (either by PAG or by PVG).

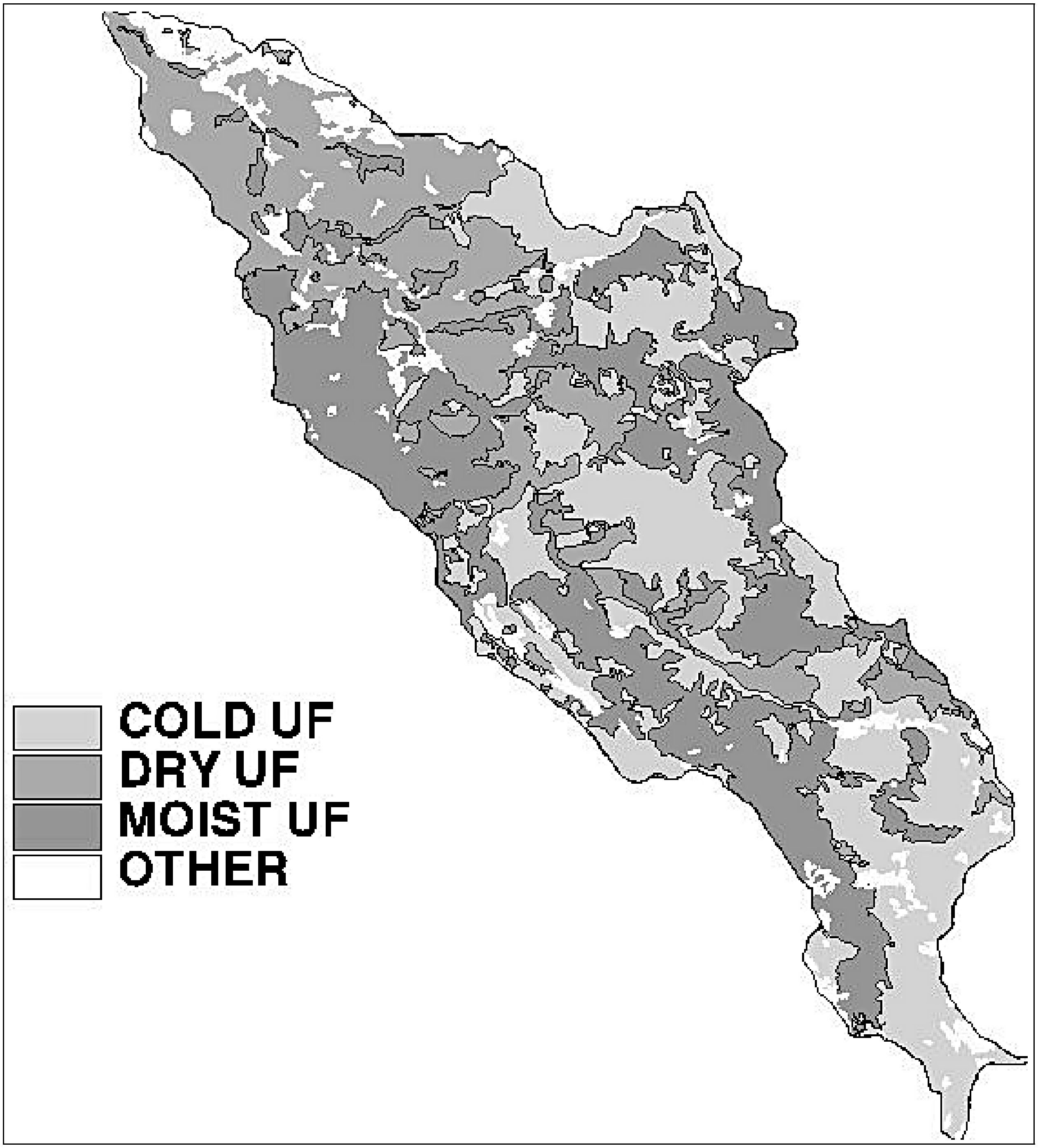


Veg Figure 2 – Vegetation zones of the Blue Mountains (Powell 1998). Vegetation types tend to occur in zones as one moves up or down in elevation. In the Northern Hemisphere, a south-facing slope receives more solar radiation than a flat surface, and a north-facing slope receives less. Thus the same 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 temperature and the lower edge by tolerance to low 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, grand fir, and Engelmann spruce have expanded their range 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 in the central and southern Blue Mountains, although shrublands (serviceberry, hawthorne, chokecherry, etc.) occupy this zone in the northern Blues where a marine climate prevails. **Dry forests** occur on warm dry sites where ponderosa pine, Douglas-fir or grand fir are the climax species. These sites were historically dominated by ponderosa pine because it is well adapted to survive the natural disturbance regime – low-intensity wildfires that occurred every 8 to 20 years. The **moist forest** zone is relatively common, especially in the northern Blue Mountains. It includes cool moist sites where Douglas-fir, grand fir or subalpine fir are the climax species. Lodgepole pine and western larch are common seral species. Western white pine occurs in this forest zone. **Cold forests** occur on harsh sites at high elevations in the subalpine zone. This zone features forests of subalpine fir and Engelmann spruce. Lodgepole pine 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.

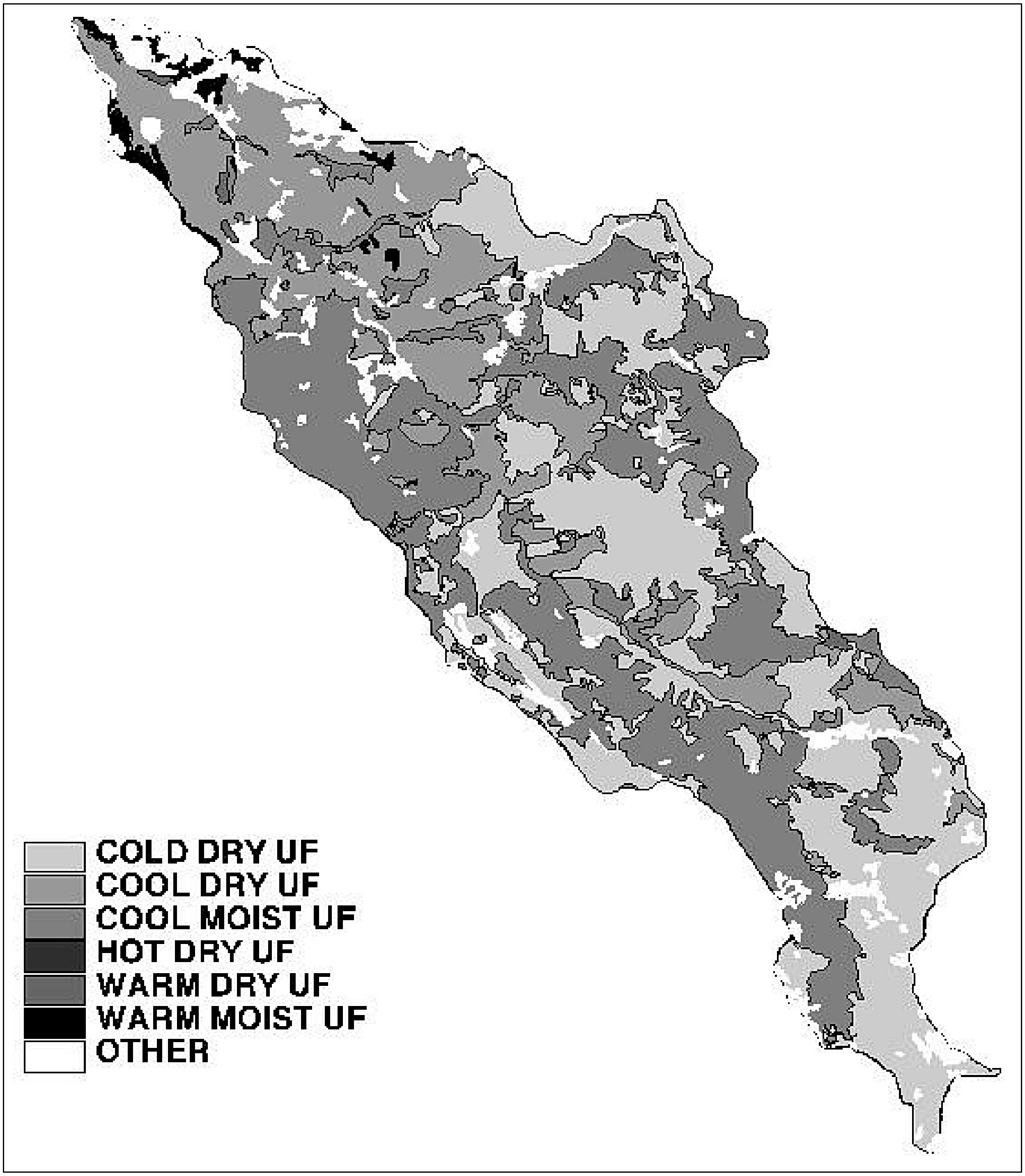
Veg Table 2: PVGs, PAGs, and vegetation types for upland forests/woodlands of the Desolation area.

PVG	PAG	Abbreviation & Common Name of Vegetation Type (Association/Community Type)		Area
Cold Forest	Cold Dry	ABGR/VASC	Grand Fir/Grouse Huckleberry	6,657
		ABLA2/CAGE	Subalpine Fir/Elk Sedge	1,675
		ABLA2 subalpine parks	Subalpine Fir subalpine parklands	641
		ABLA2/VASC	Subalpine Fir/Grouse Huckleberry	10,091
		PICO(ABGR)/VASC/CARU	Lodgepole Pine (Grand Fir)/Grouse Huck./Pinegrass	1,990
		PICO(ABLA2)/VASC	Lodgepole Pine (Subalpine Fir)/Grouse Huckleberry	2,322
		PICO subalpine parks	Lodgepole Pine subalpine parklands	61
	Cool Dry	ABLA2/CARU	Subalpine Fir/Pinegrass	12
Moist Forest	Cool Moist	ABGR/CLUN	Grand Fir/Queen's Cup Beadlily	357
		ABGR/LIBO2	Grand Fir/Twinflower	2,261
		ABGR/VAME	Grand Fir/Big Huckleberry	9,119
		ABGR/VASC-LIBO2	Grand Fir/Grouse Huckleberry-Twinflower	2,168
		ABLA2/CLUN	Subalpine Fir/Queen's Cup Beadlily	102
		ABLA2/LIBO2	Subalpine Fir/Twinflower	1,699
		ABLA2/VAME	Subalpine Fir/Big Huckleberry	7,783
		PICO(ABGR)/VAME	Lodgepole Pine (Grand Fir)/Big Huckleberry	746
		PICO(ABGR)/VAME-LIBO2	Lodgepole Pine (Grand Fir)/Big Huck.-Twinflower	42
		PICO(ABLA2)/VAME	Lodgepole Pine (Subalpine Fir)/Big Huckleberry	216
	Warm Moist	ABGR/BRVU	Grand Fir/Columbia Brome	212
Dry Forest	Warm Dry	ABGR/CAGE	Grand Fir/Elk Sedge	1,669
		ABGR/CARU	Grand Fir/Pinegrass	2,867
		PIPO/CAGE	Ponderosa Pine/Elk Sedge	2,011
		PIPO/CARU	Ponderosa Pine/Pinegrass	1,950
		PIPO/CELE/CAGE	Ponderosa Pine/Mountain-mahogany/Elk Sedge	416
		PIPO/PUTR/CAGE	Ponderosa Pine/Bitterbrush/Elk Sedge	61
		PIPO/SPBE	Ponderosa Pine/Birchleaf Spirea	128
		PIPO/SYAL	Ponderosa Pine/Common Snowberry	1,235
		PSME/CAGE	Douglas-fir/Elk Sedge	1,448
		PSME/CARU	Douglas-fir/Pinegrass	2,769
		PSME/SPBE	Douglas-fir/Birchleaf Spirea	97
		PSME/SYAL	Douglas-fir/Common Snowberry	842
		PSME/VAME	Douglas-fir/Big Huckleberry	413
	Hot Dry	PIPO/AGSP	Ponderosa Pine/Bluebunch Wheatgrass	537
		PIPO/PUTR/FEID-AGSP	Ponderosa Pine/Bitterbrush/Idaho Fescue-Bluebunch Wheatgrass	276
Moist Wood-land	Hot Moist	JUOC/CELE/CAGE	Western Juniper/Mountain-mahogany/Elk Sedge	48
		JUOC/FEID-AGSP	Western Juniper/Idaho Fescue-Bluebunch Wheatgrass	172

Sources/Notes: Adapted from Powell (1998). The “Area” column is the total acreage for the vegetation type in the Desolation area (summarized from the DesoPNV database). Area values will not sum to the analysis area total because non-forest types (grassland, herbland, shrubland) and riparian forests are not included in this summary.



Veg Figure 3 – Potential vegetation groups (PVGs) for upland forests of the Desolation analysis area. Codes are as follows: Cold UF is cold upland forest; Dry UF is dry upland forest; Moist UF is moist upland forest; and Other includes non-forest and riparian forest PVGs. See Veg Table 2 for additional information about the upland-forest PAGs that were aggregated to form these potential vegetation groups.



Veg Figure 4 – Plant association groups (PAGs) for upland forests of the Desolation analysis area. Codes are as follows: Cold Dry UF is cold dry upland forest; Cool Dry UF is cool dry upland forest; Cool Moist UF is cool moist upland forest; Hot Dry UF is hot dry upland forest; Warm Dry UF is warm dry upland forest; Warm Moist UF is warm moist upland forest; and Other includes non-forest and riparian forest PAGs. See Veg Table 2 for additional information about the plant associations that were aggregated to form these plant association groups.

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

PVG	AREA (ACRES)	DISTURBANCES	FIRE REGIME	PATCH SIZE	ELEVATION (FEET)	SLOPE (PERCENT)	TYPICAL ASPECTS
Dry Upland Forest	16,719	Harvest Fire Insects	Low	433 (4-12809)	4508 (2971-6792)	15 (1-57)	Southwest West South
Moist Upland Forest	24,705	Harvest Fire Insects Diseases	Moderate	473 (1-7216)	5424 (2984-7278)	15 (0-52)	North Northeast Northwest Level
Cold Upland Forest	23,449	Wind Insects Fire Diseases	High	655 (1-7888)	6125 (4395-7632)	17 (1-58)	Northeast North Southwest West

Sources/Notes: Areas, elevations, slope percents, and aspects were summarized from the vegetation databases (see appendix 1). Patch size (acres) was calculated using the UTOOLS computer program (Ager 1997). Disturbances, which show the primary agents affecting upland-forest ecosystems, were based on the author's judgment. For patch sizes, elevations, and slope gradients, values are portrayed in the following format: average (minimum-maximum). Fire regime ratings (Agee 1993) have the following interpretation:

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.

ISSUES AND KEY QUESTIONS

Identification of issues and key questions is the second step in a six-step process for ecosystem analysis at the watershed scale. The purpose of step 2 is to focus the analysis on key elements of the ecosystem that are most relevant to the management questions and objectives, human values, or resource conditions within the watershed. Key questions are formulated from indicators commonly used to measure or interpret the key ecosystem elements (Regional Ecosystem Office 1995).

Over the last 10 to 20 years, Blue Mountains forests have experienced increasing levels of damage from wildfire, insects, and diseases. Scientific assessments and studies have documented the high damage levels and speculated about their underlying causes (Caraher and others 1992, Gast and others 1991, Lehmkuhl and others 1994, Powell 1994, Shlisky 1994). Partly in response to the scientific assessments, the Blue Mountains area attained national notoriety for its forest health problems (Boise Cascade Corporation 1992, Joseph and others 1991, Lucas 1992, McLean 1992, Petersen 1992, Phillips 1995).

A recent survey conducted by Oregon State University found that residents of the Blue Mountains perceive their forests to be unhealthy (Shindler and Reed 1996). In response to high levels of concern about forest health, both from the scientific community and the general public, the primary issue used in this analysis was **forest sustainability**.

Forest sustainability was assumed to be somewhat analogous to forest health – sustainable forest ecosystems maintain their complexity while providing for human needs (O'Laughlin and others 1994). This means that sustainable forests contain insects, diseases and other tree-killing agents, but not to the extent that they jeopardize the long-term integrity, resiliency and productive capacity of the forest.

The upland-forest vegetation analysis was designed to respond to these key questions:
1. How do current forest conditions compare to those that existed historically?
2. Are current forest conditions considered to be ecologically sustainable over the long term?
3. If current forest conditions are considered to be unsustainable, how could they be changed in order to create a more sustainable situation?
4. How have disturbance processes shaped existing forest conditions, and what role might we expect them to play in the future?

The key questions were addressed during an analysis of the ecosystem elements. Specific analysis indicators were selected for each ecosystem element and are shown in Veg Table 4. A variety of databases were used for the analysis and are described in appendix 1.

Veg Table 4: Key elements and analysis indicators for forest vegetation.

ECOSYSTEM ELEMENTS	ANALYSIS INDICATORS
Forest Components	Cover Types Forest Density Landscape Patches
Forest Structures	Size Classes Structural Stages Canopy Layers
Forest Processes	Disturbances Insect and Disease Risk Overstory Mortality

Sources/Notes: Ecosystem elements exert a strong influence on forest conditions in the analysis area. Analysis indicators are items commonly used to measure or interpret the ecosystem elements. Also, see Veg Table 1 for more information.

CURRENT CONDITIONS

Description of current conditions is the third step in a six-step process for ecosystem analysis at the watershed scale. The purpose of this step is to develop information (more detailed than was done for characterization in step 1) that is relevant to the issues and key questions identified in step 2. The current range, distribution, and condition of key ecosystem elements are documented in this step (Regional Ecosystem Office 1995).

Forest Cover Types. The *Characterization* section of this report described the potential natural vegetation of the Desolation analysis area, e.g., the plant composition that would be expected to occur if disturbances were prevented from interrupting plant succession. This *Current Conditions* section describes forest cover types as they actually *exist right now*, regardless of whether they represent the potential natural ("climax") community or a seral stage resulting from wildfire, timber harvest, windstorms, or another disturbance.

Veg Table 5 summarizes forest cover types for the Desolation ecosystem analysis area (the data is current as of 1997 and reflects post-fire conditions for the Bull and Summit wildfire areas). It shows that the predominant forest cover type is grand fir (38% of the analysis area), followed by lodgepole pine (21%), Douglas-fir (12%), and subalpine fir (8%). Forests dominated by whitebark pine, western larch or western juniper are rare, occupying less than three percent of the analysis area in aggregate.

Veg Table 5: Forest cover types of the Desolation ecosystem analysis area (1997).

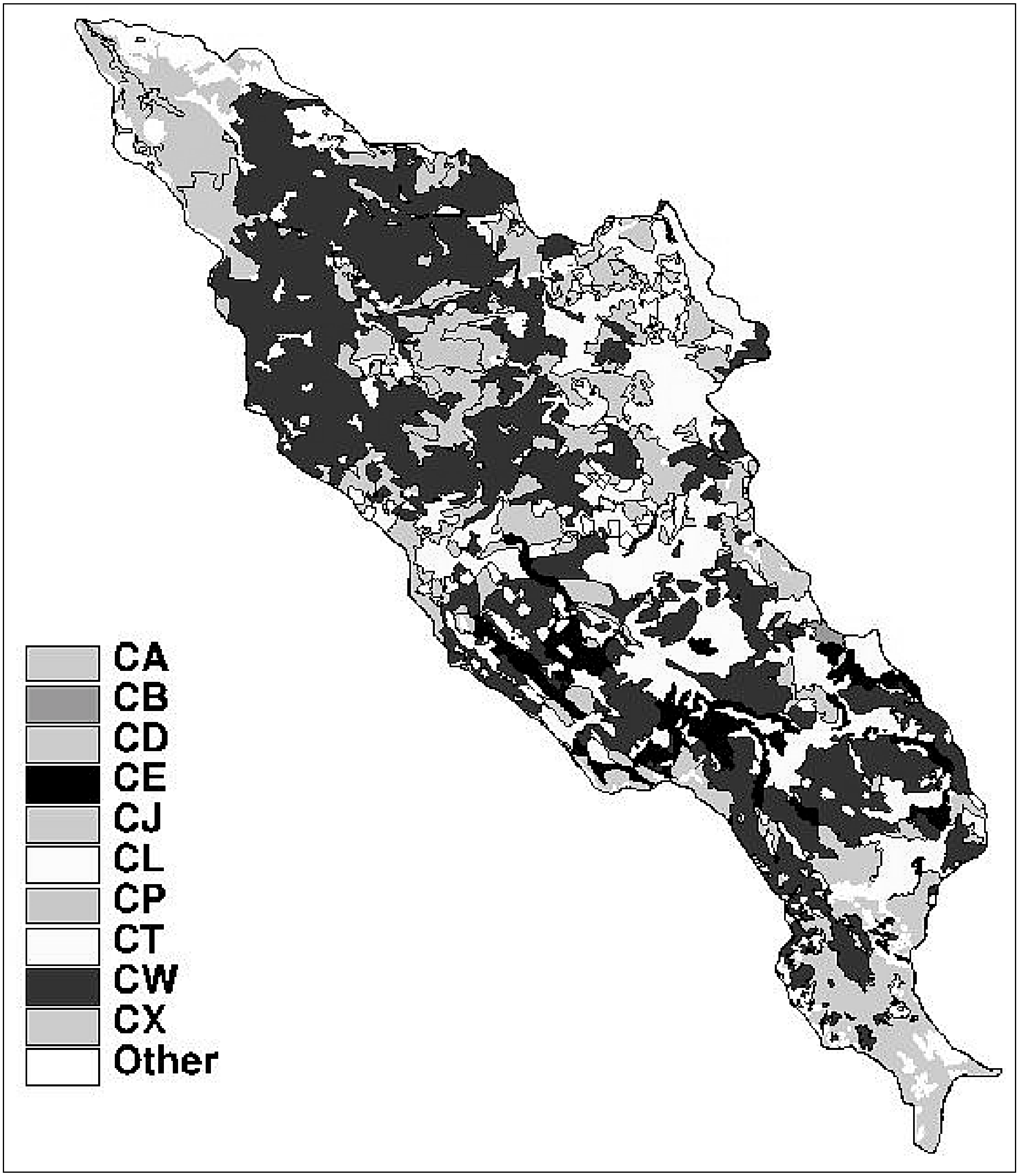
CODE	COVER TYPE DESCRIPTION	ACRES	PERCENT
CA	Forests with a predominance of subalpine fir trees	5,667	8
CB	Forests with a predominance of whitebark pine trees	116	<1
CD	Forests with a predominance of Douglas-fir trees	8,203	12
CE	Forests with a predominance of Engelmann spruce trees	2,916	4
CJ	Forests with a predominance of western juniper trees	21	<1
CL	Forests with a predominance of lodgepole pine trees	14,598	21
CP	Forests with a predominance of ponderosa pine trees	3,902	6
CT	Forests with a predominance of western larch trees	1,501	2
CW	Forests with a predominance of grand fir trees	26,459	38
CX	Forests with a mixed composition; less than 50% of one species	1,921	3
Other	Non-vegetated and non-forested cover types (see appendix 1)	4,232	6

Sources/Notes: Summarized from the 97veg database (see appendix 1). Acreage figures include private land located within the analysis area. Forest cover types are based on a plurality of stocking and are seldom pure – the grand fir type (CW), for example, has a predominance of grand fir trees (50% or more) but can also contain minor proportions of ponderosa pine, Douglas-fir and other species.

The Desolation watershed contains a relatively high proportion of forests dominated by Engelmann spruce and subalpine fir, which is unusual for the Umatilla National Forest. A large acreage of spruce-fir forest reflects the fact that about 20% of the Desolation area occurs above 6,000 feet, and those elevations typically support Engelmann spruce, subalpine fir, whitebark pine, and other species indicative of the subalpine vegetation zone (see Veg Fig. 1). Veg Figure 5 shows forest cover types as of 1997.

Landscape Patches. Ecologists refer to landscapes as large areas comprised of interconnected or repeated patterns of habitats or ecosystems (Forman 1997, Turner and Gardner 1991). The science of landscape ecology studies the biological functions and interactions of vegetation patterns across large areas. A single drainage basin may be considered a landscape if it is large enough to contain a variety of repeating patterns, but often a landscape will include more than one watershed. To be considered a "landscape" an area must contain a variety of components that interact over time and space to perform ecological functions and processes (Forman and Godron 1986, Turner 1998).

The most common element in a landscape is referred to as the "matrix." The matrix in many landscapes of the Pacific Northwest would be a continuous forest cover of conifers. In some landscapes of the northern Blue Mountains, the matrix would consist of grassland. The most important quality of the matrix is that it is the most connected element in the landscape; there are no inherent barriers to movement from one portion of the matrix to another. Like the open space in a pinball machine, energy, animals, or objects can move freely within the matrix area (Diaz and Apostol 1992).



Veg Figure 5 – Forest cover types of the Desolation watershed (1997). Refer to Veg Table 5 for a description of the forest cover type codes.

An area within the landscape that differs from the matrix and is isolated from other similar areas is called a "patch." Like the pins in a pinball machine, patches lack the connectivity of the matrix. A patch may consist of a single opening in a forest, or it could be a remnant stand of mature forest in a landscape dominated by young trees or openings.

Landscape patterns affect how organisms use large land areas. Characteristics of landscape patterns, such as connectivity or the quality and quantity of edges between different landscape elements, can be measured and analyzed to reveal how well different plant and animal species may survive or move through an area. FRAGSTATS, UTOOLS and other computer programs have been developed to aid in the analysis of landscape characteristics (Ager 1997, McGarigal and Marks 1995).

Due to time and computer processing constraints, it was not possible to complete a robust analysis of landscape patterns for the Desolation watershed. However, a rudimentary analysis was completed using the UTOOLS program (Ager 1997), although no attempt was made to differentiate the matrix from patches or to analyze edge characteristics. This means that all landscape elements were treated as patches and analyzed accordingly. For the Desolation analysis, two categories of forest vegetation were included in the landscape analysis: cover types, which represent plant composition at a mid scale, and structural stages, which reflect how that composition is arranged from a vertical perspective.

Veg Table 6 summarizes patch characteristics for forest cover types and structural stages for the Desolation analysis area (the data is current as of 1997 and reflects post-fire conditions for the Bull and Summit wildfires). It shows that lodgepole pine has the most cover type patches in the Desolation landscape, followed by grand fir and then Douglas-fir. The largest patches are those comprised of grand fir, however, since they average 401 acres in size and range up to 15,475 acres. In terms of landscape characterization, grand fir forest would be considered the matrix from a plant composition standpoint.

Veg Table 6 shows that the *stem exclusion open canopy* structural stage has the most patches in the Desolation watershed (excluding the non-forest patches (NF) that were ignored for the structural stage analysis), followed by *stand initiation* and then *young forest multi strata*. The largest patches are those comprised of young, single-layer forest (*stand initiation*), since they average 476 acres in size and range up to 21,544 acres. In terms of landscape characterization, *stand initiation* would be considered the matrix from a structural stage viewpoint.

Forest Size Classes. Historically, forest size classes were defined using economically important criteria that emphasized product or utilization standards (small sawtimber and large sawtimber size classes, for example). Recently, size class definitions have been evolving to incorporate a biological approach based on tree size or physiological maturity. This Desolation analysis used size class definitions that reflect tree size (size was based on tree diameter rather than height).

Veg Table 7 summarizes forest size classes for the Desolation ecosystem analysis area (the data is current as of 1997 and reflects post-fire conditions for the Bull and Summit wildfire areas). It shows that the predominant overstory size class is small trees ranging from 9 to 15 inches in diameter (49% of the analysis area), followed by poles and small trees mixed (21%), and small trees ranging from 15 to 21 inches in diameter (10%). Forest overstories dominated by large or medium trees (those with diameters of 21 inches or more), or saplings (trees from 1 to 5 inches in diameter) are rare; each of those size classes occupies one percent or less of the Desolation area.

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 Veg Table 8). 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).

Veg Table 6: Patch analysis for the Desolation analysis area (1997 conditions).

	PATCH TYPE	NUMBER OF PATCHES	MINIMUM PATCH SIZE	AVERAGE PATCH SIZE	MAXIMUM PATCH SIZE
Cover Types	CA	28	1	192	3,119
	CB	1	21	21	21
	CD	63	3	130	997
	CE	15	21	194	1,015
	CJ	1	117	117	117
	CL	77	1	189	3,792
	CP	24	7	162	2,096
	CT	41	4	36	246
	CW	66	3	401	15,475
	CX	15	23	128	453
	Total	331			
Structural Stages	NF	148	1	29	674
	OFMS	14	1	56	252
	OFSS	22	2	36	129
	SECC	49	1	106	796
	SEOC	100	1	70	1,305
	SI	75	1	476	21,544
	UR	35	2	193	2,344
	YFMS	60	2	146	1,728
	Total	503			

Sources/Notes: Based on information contained in the 97veg database (see appendix 1), including private land located within the analysis area. Refer to Veg Table 5 for a description of the cover type codes; refer to Veg Table 9 for a description of the structural stage codes. Patches were calculated using the UTOOLS program (Ager 1997).

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 size 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.

Veg Table 7: Forest size classes of the Desolation ecosystem analysis area (1997).

CODE	SIZE CLASS DESCRIPTION	ACRES	PERCENT

1	Seedlings; trees less than 1 inch in diameter	1,559	2
2	Seedlings and saplings mixed	1,403	2
3	Saplings; trees from 1 to 4.9 inches in diameter	228	<1
4	Saplings and poles mixed	439	<1
5	Poles; trees from 5 to 8.9 inches in diameter	1,853	3
6	Poles and small trees mixed	14,625	21
77	Small trees; trees from 9 to 14.9 inches in diameter	34,317	49
88	Small trees; trees from 15 to 20.9 inches in diameter	7,035	10
8	Small trees and medium trees mixed	2,805	4
9	Medium trees from 21 to 31.9 inches in diameter	344	<1
10	Medium and large trees mixed	689	1
11	Large trees from 32 to 47.9 inches in diameter	7	<1
Other	Non-vegetated and non-forested cover types (see appendix 1)	4,232	6

Sources/Notes: Summarized from the 97veg database (see appendix 1). Acreage figures include private land located within the analysis area. Forest size classes are based on the predominant situation and are seldom pure – the pole size class (5), for example, has a predominance of pole-sized trees (50% or more) but may also contain minor proportions of other size classes. For multi-layered stands, this information pertains to the overstory layer (tallest stratum) only.

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, their system was expanded to seven stages to include a greater variety of structural conditions and was recently used for the Interior Columbia Basin Ecosystem Management Project (O’Hara and others 1996).

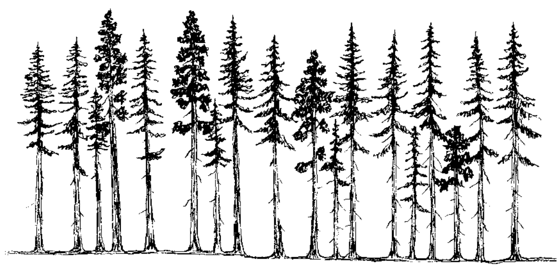
Veg Table 9 summarizes forest structural stages for the Desolation ecosystem analysis area (the data is current as of 1997 and reflects post-fire conditions for the Bull and Summit wildfire areas). It shows that the predominant structural stage is *stand initiation* (52% of the analysis area), followed by *young forest multi strata* (13%), *stem exclusion open canopy* (10%) and *understory reinitiation* (10%). Old forest structures (*old forest multi strata* or *old forest single stratum*) are rare, occupying one percent or less of the analysis area. Veg Figure 6 shows forest structural stages in the Desolation watershed as of 1997.

Forest Canopy Cover. Very little of the Desolation analysis area has been recently examined using field surveys such as stand examinations. For that reason, quantified data suitable for characterizing stand density (such as trees per acre or basal area per acre) was unavailable for this analysis effort. Consequently, canopy cover values resulting from interpretation of aerial photography were used for any analyses that required information about stand density.

Veg Table 10 summarizes existing canopy cover for forests of the Desolation ecosystem analysis area (the data is current as of 1997 and reflects post-fire conditions for the Bull and Summit wildfire areas). It shows that the predominant situation is low-density forest (≤40% canopy cover; 48% of the analysis area), followed by moderate density (41-55% cover; 23%) and high density (56-70%; 19%). Very high density forest (>70% canopy cover) is rare, occupying only three percent of the analysis area.

Veg Table 8: 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 growth from their underground roots or 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 of moisture (**stem exclusion open canopy**).

Understory Reinitiation (UR). As a forest develops, new age classes of trees (cohorts) establish as the overstory trees die or are thinned and no longer fully occupy growing space. Regrowth of understory 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 underneath.

Young Forest Multi Strata (YFMS). In this stage of forest development, three or more tree layers have become established as a result of continued canopy stratification. This stage consists of a broken overstory layer with a mix of sizes present (large trees are absent or 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, old-forest stand of ponderosa pine that evolved from low-intensity underburning (**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).

Veg Table 9: Forest structural stages of the Desolation ecosystem analysis area (1997).

CODE	STRUCTURAL STAGE DESCRIPTION	ACRES	PERCENT

OFMS	Old Forest Multi Strata structural stage	781	1
OFSS	Old Forest Single Stratum structural stage	800	1
SECC	Stem Exclusion Closed Canopy structural stage	5,195	7
SEOC	Stem Exclusion Open Canopy structural stage	7,021	10
SI	Stand Initiation structural stage	35,944	52
UR	Understory Reinitiation structural stage	6,761	10
YFMS	Young Forest Multi Strata structural stage	8,802	13
Other	Non-vegetated and non-forested cover types (see appendix 1)	4,232	6

Sources/Notes: Summarized from the 97veg database (see appendix 1). Acreage figures include private land located within the analysis area. Veg Table 8 describes the forest structural stages.

Veg Table 10: Forest canopy cover classes of the Desolation ecosystem analysis area (1997).

CODE	CANOPY COVER DESCRIPTION	ACRES	PERCENT
≤40	Live canopy (crown) cover of trees is 40 percent or less	33,668	48
41-55	Live canopy cover of trees is between 41 and 55 percent	16,190	23
56-70	Live canopy cover of trees is between 56 and 70 percent	13,142	19
>70	Live canopy cover of trees is greater than 70 percent	2,304	3
Other	Non-vegetated and non-forested cover types (see appendix 1)	4,232	6

Sources/Notes: Summarized from the 97veg database (see appendix 1). Acreage figures include private land located within the analysis area.

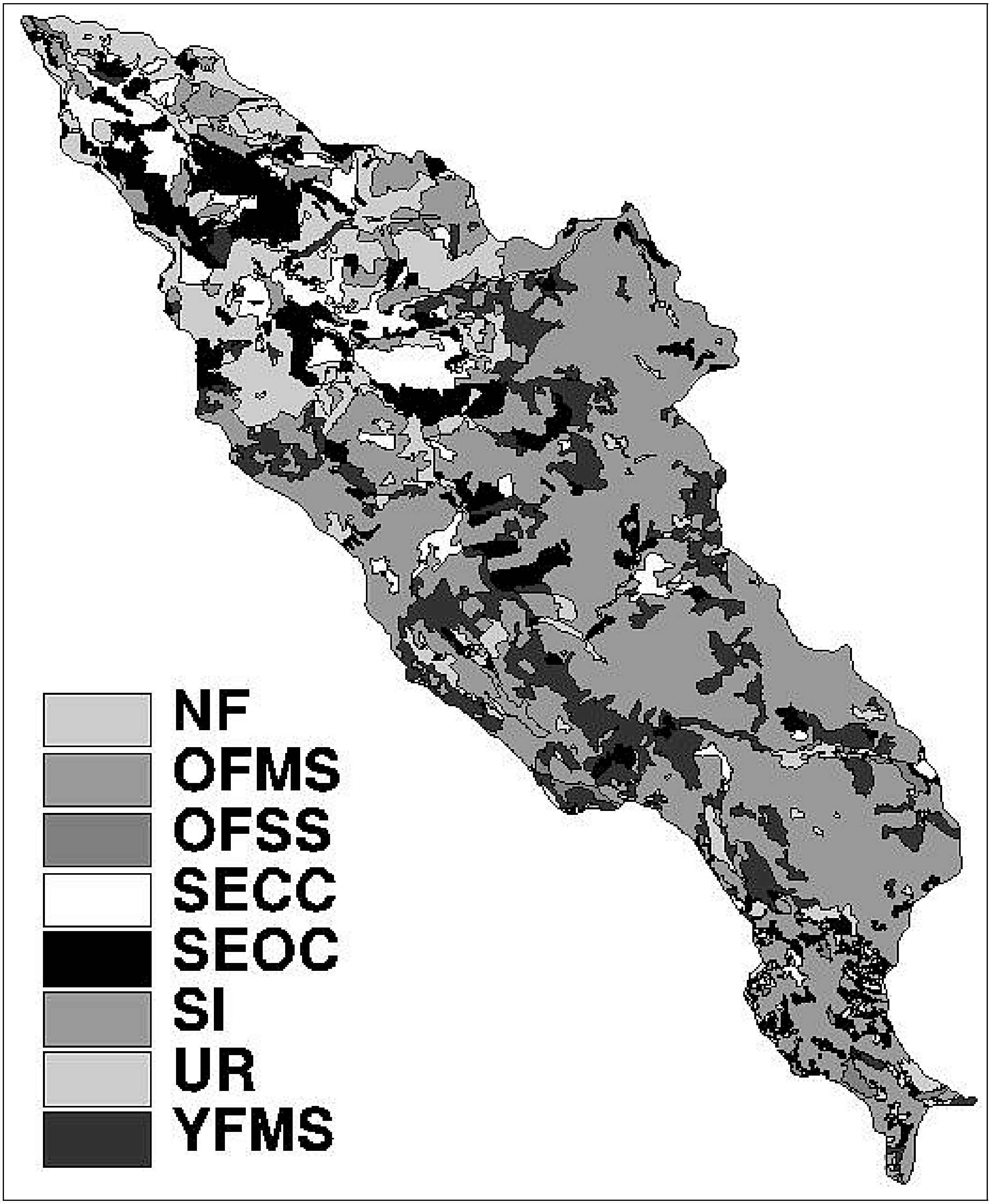
Forest Canopy Layers. The vertical arrangement of tree canopy can affect management objectives in several ways. For example, multi-layered stands with "old-growth" characteristics (e.g., a predominance of grand fir trees, high canopy closure, and the absence of logging) are extensively used by pileated woodpeckers in the Blue Mountains (Bull and Holthausen 1993). Open, single-layered structures may have limited value for water quality, but high desirability for water yields (O'Hara and Oliver 1992).

Veg Table 11 summarizes existing forest canopy layers for the Desolation ecosystem analysis area (the data is current as of 1997 and reflects post-fire conditions for the Bull and Summit wildfire areas). It shows that the predominant situation is a two-layer stand structure (48% of the analysis area), followed by single-layer forest (19%) and a highly-complex layer structure (3 or more layers; 4%).

Veg Table 11: Forest canopy layers of the Desolation ecosystem analysis area (1997).

CODE	CANOPY LAYER DESCRIPTION	ACRES	PERCENT
1	Live canopy (crown) cover of trees occurs in l layer (stratum)	13,467	19
2	Live canopy cover of trees occurs in 2 layers or strata	49,194	71
3	Live canopy cover of trees occurs in 3 or more layers or strata	2,643	4
Other	Non-vegetated and non-forested cover types (see appendix 1)	4,232	6

Sources/Notes: Summarized from the 97veg database (see appendix 1). Acreage figures include private land located within the analysis area.



Veg Figure 6 – Forest structural stages of the Desolation watershed (1997). Refer to Veg Table 9 for a description of the structural stage codes.

Forest Disturbances. The last twenty years saw a period of rapid change for thousands of forested acres in the Desolation area. Some of that change was related to normal forest growth and maturation, but much of it resulted from disturbance processes. Substantial portions of the project area were affected by a mountain pine beetle *(Dendroctonus ponderosae)* outbreak in the late 1970s and early 1980s, western spruce budworm *(Choristoneura occidentalis)* outbreaks in 1944-1958 and 1980-1992, and outbreaks of Douglas-fir beetle *(Dendroctonus pseudotsugae)* and fir engraver *(Scolytus ventralis)* during the late 1980s and early 1990s (Gast and others 1991). A prolonged drought in the late 1980s and early 1990s exacerbated those problems by reducing tree vigor and lowering stand resistance to insect damage.

Veg Table 12 summarizes forest disturbances for the Desolation ecosystem analysis area (the data is current as of 1997 and reflects post-fire conditions for the Bull and Summit wildfire areas). It shows that the predominant disturbances have been associated with multiple-use activities such as timber harvest (Veg Figure 7) – clearcuts (15% of the analysis area), partial cuts (16%, including sanitation/salvage), and thinnings (11%) could all be distinguished on recent aerial photography for the analysis area. Wildfire was also a common disturbance (13% of the analysis area).

Seral vegetation refers to the plant communities that establish after disturbance. In seral communities, the populations of some species are replaced by others as a result of plant succession. On many forest sites in the Desolation analysis area, a seral stage resulting from fire, timber harvest, or another disturbance agent is currently occupying the area. In some areas, the seral stage is a non-forest type such as grassland or shrubland; in others, it is lodgepole pine or another forest type that colonizes disturbed sites.

What impact did disturbances have on tree mortality in the analysis area? Veg Table 13 summarizes overstory mortality for the Desolation area (the data is current as of 1997 and reflects post-fire conditions for the Bull and Summit wildfire areas). It shows that disturbances have resulted in 25% of the analysis area supporting forests with moderate, high, or very high overstory mortality. Sixty-nine percent of the analysis area has forests with low overstory mortality (10 or fewer dead trees per acre).

Although insects and diseases were not specifically noted as a disturbance agent in Veg Table 12, they have been important disturbance agents in the past (Veg Table 14). Often, the timber harvest program was designed to respond to insect or disease problems by removing dead or dying trees (sanitation/salvage harvests).

A computerized model was used to estimate current risk (susceptibility) for 14 insects and diseases present in the analysis area (Ager 1998). Risk ratings were calculated for both the 1939 and 1997 vegetation conditions, thereby facilitating a side-by-side comparison of risk trends. The results of that analysis are provided in Veg Table 15. When comparing high risk only, it shows that susceptibility to Douglas-fir beetle, Douglas-fir dwarf mistletoe, Indian paint fungus, ponderosa pine dwarf mistletoe, Schweinitzii root and butt rot, western spruce budworm, and western larch dwarf mistletoe have all increased between 1939 and 1997.

Veg Table 15 shows that high susceptibility to fir engraver, mountain pine beetle, and mixed-conifer root diseases (laminated root rot, annosus root disease, and armillaria root disease) decreased between 1939 and 1997. It is interesting that Douglas-fir tussock moth susceptibility increased substantially between 1939 and 1997. Each spring, pheromone traps are placed in mixed-conifer stands throughout the Umatilla National Forest as an early-warning system for Douglas-fir tussock moth. Some traps had very high moth counts when they were collected in the fall of 1998, indicating that a tussock-moth outbreak could be imminent for some portions of the Forest.

Veg Table 12: Forest disturbances of the Desolation ecosystem analysis area (1997).

CODE	DISTURBANCE DESCRIPTION	ACRES	PERCENT
CC	Recent clearcut timber harvest	1,943	3
CR	Old clearcut, now regenerated	8,256	12
FI	Evidence of recent fire	8,850	13
PC	Recent partial cutting timber harvest (selection, seed-tree, etc.)	2,283	3
PR	Old partial cut, now regenerated	8,187	12
SS	Evidence of sanitation/salvage timber harvest	848	1
TH	Evidence of a thinning silvicultural treatment	7,442	11
Blank	No discernable evidence of disturbance (on air photos)	27,495	40
Other	Non-vegetated and non-forested cover types (see appendix 1)	4,232	6

Sources/Notes: Summarized from the 97veg database (see appendix 1). Acreage figures include private land located within the analysis area.

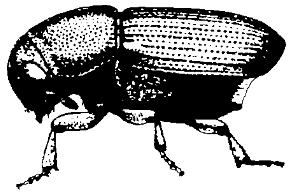
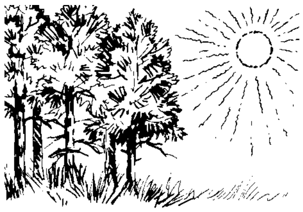
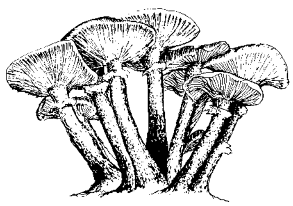
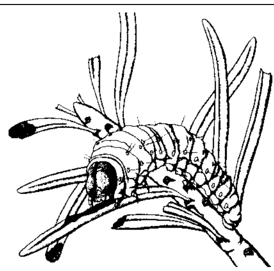
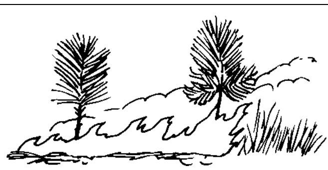
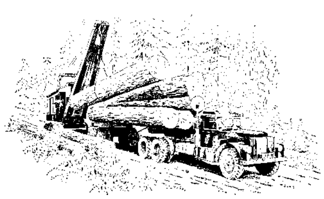
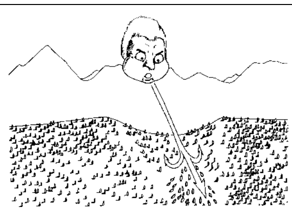
Veg Figure 7 – Multiple use management in Desolation watershed, 1960.

Veg Table 13: Forest overstory mortality of the Desolation ecosystem analysis area (1997).

CODE	OVERSTORY MORTALITY DESCRIPTION	ACRES	PERCENT
L	Low overstory mortality; 10 or fewer dead trees per acre	47,653	69
M	Moderate overstory mortality; 11-20 dead trees per acre	12,356	18
H	High overstory mortality; 21-60 dead trees per acre	2,315	3
V	Very high overstory mortality; greater than 60 dead trees/acre	2,980	4
Other	Non-vegetated and non-forested cover types (see appendix 1)	4,232	6

Sources/Notes: Summarized from the 97veg database (see appendix 1). Acreage figures include private land located within the analysis area.

Veg Table 14: Selected disturbance agents for the Desolation 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 the mortality).
	**Diseases and Pathogens**. Root diseases tend to be localized, but can cause significant tree mortality in affected areas. Armillaria root disease is found in mixed-conifer stands, whereas 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 Desolation 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, 1953 and 1958 (Dolph 1980). In the second outbreak, defoliation peaked by the late 1980s (Sheehan 1996). Douglas-fir tussock moth has periodically defoliated mixed conifer stands in the analysis area.
	**Wildfires**. A very large fire occurred in the analysis area about 1893; portions of the area also burned in 1910, a "bad" fire year throughout the Interior West. More recent fires included Junkens (100 acres), Jumpoff (2,000 acres), Lost Lake (3,200 acres), Saddle Camp (100 acres) and South Fork (350 acres), all in 1986; and the Summit and Bull fires of late summer and fall in 1996.
	**Timber Harvest**. Timber harvesting and other management practices designed to meet some of the needs of a human society have occurred in the lower and middle portions of the analysis area. 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 demands of local farmers and settlers (Weidman 1936).
	**Windstorms**. Windstorms are common throughout the Blue Mountains and elsewhere in the Interior Columbia River Basin (Ferguson no date). 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 Gast and others (1991); annual, aerial insect detection surveys; and unpublished records available at the North Fork John Day Ranger District and the Umatilla National Forest Supervisor's Office.

Veg Table 15: Insect and disease risk ratings for Desolation watershed.

INSECT OR DISEASE	RISK RATING	1997 (ACRES)	1939 (ACRES)	CHANGE (ACRES)
Douglas-fir Beetle	High	27,812	10,296	17,516
	Moderate	1,505	18,494	-16,989
	Low	37,022	34,569	2,453
Douglas-fir Dwarf Mistletoe	High	15,727	9,030	6,697
	Moderate	7,088	17,733	-10,645
	Low	43,524	36,524	7,000
Fir Engraver	High	19,220	41,680	-22,460
	Moderate	1,100	317	783
	Low	46,019	21,362	24,657
Indian Paint Fungus	High	8,937	1,774	7,163
	Moderate	32,727	22,909	9,818
	Low	24,657	38,359	-13,684
Mountain Pine Beetle (Lodgepole Pine)	High	2,892	3,845	-953
	Moderate	1,736	16,232	-14,496
	Low	61,711	43,282	18,429
Mountain Pine Beetle (Ponderosa Pine)	High	736	532	204
	Moderate	691	1,302	-611
	Low	64,912	61,525	3,387
Ponderosa Pine Dwarf Mistletoe	High	7,811	3,679	4,132
	Moderate	4,400	3,718	682
	Low	54,128	55,645	-1,517
Mixed Conifer Root Diseases	High	28,614	30,980	-2,366
	Moderate	37,359	31,191	6,168
	Low	366	747	-381
Schweinitzii Root and Butt Rot	High	38,836	22,179	16,657
	Moderate	26,779	38,483	-11,704
	Low	724	2,380	-1,656
Spruce Beetle	High	0	0	0
	Moderate	0	0	0
	Low	56,499	61,370	-4,871
Western Spruce Budworm	High	49,206	40,569	8,637
	Moderate	12,768	17,988	-5,220
	Low	2,828	3,941	-1,113
Tomentosus Root and Butt Rot	High	3,109	2,387	722
	Moderate	143	546	-403
	Low	63,087	60,109	2,978
Douglas-fir Tussock Moth	High	0	0	0
	Moderate	52,176	20,218	31,958
	Low	14,163	43,141	-28,978
Western Larch Dwarf Mistletoe	High	16,226	7,996	8,230
	Moderate	14,005	15,971	-1,966
	Low	36,108	39,075	-2,967

Sources/Notes: From the UPEST risk calculator (Ager 1998). "Change" column uses 1939 as the base year.

REFERENCE CONDITIONS

Description of reference conditions is the fourth step in a six-step process for ecosystem analysis at the watershed scale. The purpose of step 4 is to explain how ecological conditions have changed over time as a result of human influence and disturbance processes. Reference conditions serve as a benchmark for later comparison with current conditions and with key management plan objectives (Regional Ecosystem Office 1995). Reference conditions help us understand what an ecosystem is capable of, how disturbance processes operate, and how ecosystems recover after a perturbation.

Forest Cover Types. Previous EAWS efforts used historical cover-type maps to characterize reference conditions (USDA Forest Service 1937). Historically, forest cover types were generally named for an economically important species (such as ponderosa pine) that might be present at a fairly low level of abundance, thus ignoring a more abundant but less valuable species. For that reason, aerial photography from the late 1930s and early 1940s was interpreted to derive unbiased information about historical cover types for the Desolation watershed.

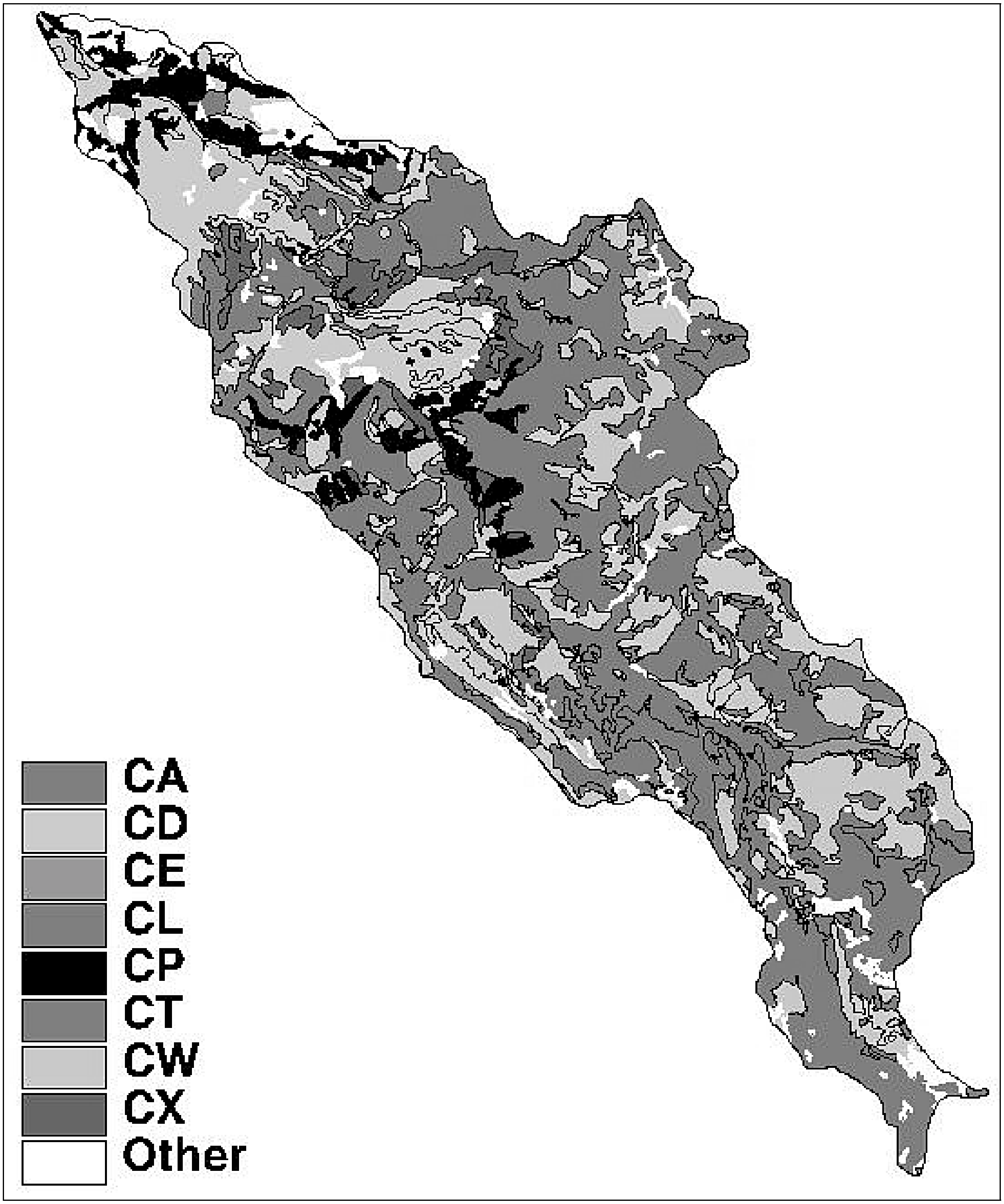
Veg Table 16 summarizes historical forest cover types for the Desolation ecosystem analysis area. It shows that the predominant forest cover type in 1939 was lodgepole pine (37% of the analysis area), followed by Douglas-fir (19%), grand fir (17%) and subalpine fir (11%). Forests dominated by whitebark pine or western juniper were apparently less common in 1939 than in 1997, since neither forest type was identified on the historical aerial photography. Veg Figure 8 shows forest cover types as of 1939.

Veg Table 16: Forest cover types of the Desolation ecosystem analysis area (1939).

CODE	COVER TYPE DESCRIPTION	ACRES	PERCENT
CA	Forests with a predominance of subalpine fir trees	8,003	11
CB	Forests with a predominance of whitebark pine trees	0	0
CD	Forests with a predominance of Douglas-fir trees	12,916	19
CE	Forests with a predominance of Engelmann spruce trees	485	1
CJ	Forests with a predominance of western juniper trees	0	0
CL	Forests with a predominance of lodgepole pine trees	25,624	37
CP	Forests with a predominance of ponderosa pine trees	3,620	5
CT	Forests with a predominance of western larch trees	1,509	2
CW	Forests with a predominance of grand fir trees	12,021	17
CX	Forests with a mixed composition; less than 50% of one species	2,391	3
Other	Non-vegetated and non-forested cover types (see appendix 1)	3,084	4

Sources/Notes: Summarized from the 39veg database (see appendix 1). Acreage figures include private land located within the analysis area. Forest cover types are based on a plurality of stocking and are seldom pure – the grand fir type (CW), for example, has a predominance of grand fir trees (50% or more) but also contains minor proportions of ponderosa pine, Douglas-fir and other species.

Analysis of lake sediments from Lost Lake, which is located in the upper (southeastern) portion of the Desolation watershed, showed that forest composition has been remarkably stable. Fossil and pollen evidence showed that lodgepole pine, western larch, Douglas-fir, grand fir, subalpine fir, and Engelmann spruce were common conifers after the Mount Mazama volcano erupted about 7,600 years ago. White pines, however, were not common in the fossil/pollen record. About 4,000 years ago, a moist climatic regime apparently prevailed and lodgepole pine, spruce, and firs were abundant. Dwarf mistletoe pollen was also present in the Lost Lake sediments; dwarf mistletoe was probably parasitizing lodgepole pines (Mehringer 1997).



Veg Figure 8 – Forest cover types of the Desolation watershed (1939). Refer to Veg Table 16 for a description of the cover type codes.

Landscape Patches. Veg Table 17 summarizes patch characteristics for historical cover types and structural stages for the Desolation analysis area. It shows that Douglas-fir had the most cover type patches in the Desolation landscape, followed by grand fir and then lodgepole pine. The largest patches were those comprised of lodgepole pine, however, since they averaged 434 acres in size and ranged up to 18,126 acres. In terms of landscape characterization, lodgepole pine forest would be considered the matrix from a plant composition standpoint.

Veg Table 17 shows that the *stand initiation* structural stage had the most patches in the Desolation watershed in 1939 (excluding the non-forest patches (NF) that were ignored for the structural stage analysis), followed by *old forest single stratum* and then *young forest multi strata*. The largest patches were those comprised of old forest (*old forest multi strata* and *old forest single stratum*), since they averaged 214-223 acres in size and ranged up to 4,840-6,271 acres. In terms of landscape characterization, *old forest* would be considered the matrix from a structural stage viewpoint.

Veg Table 17: Patch analysis for the Desolation analysis area (1939 conditions).

	PATCH TYPE	NUMBER OF PATCHES	MINIMUM PATCH SIZE	AVERAGE PATCH SIZE	MAXIMUM PATCH SIZE
Cover Types	CA	23	1	348	6,400
	CB	0	0	0	0
	CD	85	3	152	3,087
	CE	10	3	48	273
	CJ	0	0	0	0
	CL	59	1	434	18,126
	CP	35	4	103	1,421
	CT	22	5	68	502
	CW	80	6	150	2,027
	CX	20	12	119	471
	Total	334			
Structural Stages	NF	85	1	36	589
	OFMS	72	9	214	6,271
	OFSS	85	3	223	4,840
	SECC	69	1	183	2,815
	SEOC	3	19	24	31
	SI	117	1	63	838
	UR	12	11	98	423
	YFMS	73	1	149	2,009
	Total	516			

Sources/Notes: Based on information contained in the 39veg database (see appendix 1), including private land located within the analysis area. Refer to Veg Table 16 for a description of the cover type codes; refer to Veg Table 19 for a description of the structural stage codes. Patches were calculated using the UTOOLS program (Ager 1997).

Forest Size Classes. Veg Table 18 summarizes historical forest size classes for the Desolation ecosystem analysis area. It shows that the predominant overstory size class in 1939 was a mixture of small and medium trees ranging from 9 to 32 inches in diameter (50% of the analysis area), followed by medium trees (21 to 32 inches DBH; 20%) and then small trees ranging from 9 to 21 inches in diameter (15%). Forest overstories dominated by seedlings (trees less than 1 inch DBH), saplings (trees from 1 to 5 inches in diameter) or poles (5 to 9 inches in diameter) were rare, occupying less than eight percent of the analysis area in aggregate.

Veg Table 18: Forest size classes of the Desolation ecosystem analysis area (1939).

CODE	SIZE CLASS DESCRIPTION	ACRES	PERCENT
1	Seedlings; trees less than 1 inch in diameter	0	0
2	Seedlings and saplings mixed	30	<1
3	Saplings; trees from 1 to 4.9 inches in diameter	1,722	2
4	Saplings and poles mixed	1,746	2
5	Poles; trees from 5 to 8.9 inches in diameter	2,272	3
6	Poles and small trees mixed	1,356	2
77	Small trees; trees from 9 to 14.9 inches in diameter	5,355	8
88	Small trees; trees from 15 to 20.9 inches in diameter	4,897	7
8	Small trees and medium trees mixed	35,029	50
9	Medium trees from 21 to 31.9 inches in diameter	13,856	20
10	Medium and large trees mixed	307	<1
11	Large trees from 32 to 47.9 inches in diameter	0	0
Other	Non-vegetated and non-forested cover types (see appendix 1)	3,085	4

Sources/Notes: Summarized from the 39veg database (see appendix 1). Acreage figures include private land located within the analysis area. Forest size classes are based on the predominant situation and are seldom pure – the pole size class (5), for example, has a predominance of pole-sized trees (50% or more) but may also contain minor proportions of other size classes. For multi-layered stands, this information pertains to the overstory layer (tallest stratum) only.

Forest Structural Stages. Veg Table 19 summarizes historical forest structural stages for the Desolation watershed. It shows that the predominant structural stage in 1939 was old forest (49% of the analysis area consisted of either of the two old forest structural stages), followed by *stem exclusion closed canopy* (18%), *young forest multi strata* (16%) and then *stand initiation* (16%). The *understory reinitiation* and *stem exclusion open canopy* structural stages were rare, occupying two percent or less of the area. Veg Figure 9 shows forest structural stages for the Desolation watershed as of 1939.

Forest Canopy Cover. Veg Table 20 summarizes historical canopy cover classes for forests of the Desolation watershed. It shows that the predominant situation in 1939 was very high-density forest (>70% canopy cover; 59% of the analysis area), followed by high density (56-70% cover; 23%) and then low-density (≤40% cover; 8%). Moderate-density forest (41-55% canopy cover) was relatively uncommon in 1939, occupying only six percent of the analysis area.

Veg Table 19: Forest structural stages of the Desolation ecosystem analysis area (1939).

CODE	STRUCTURAL STAGE DESCRIPTION	ACRES	PERCENT
OFMS	Old Forest Multi Strata structural stage	15,390	22
OFSS	Old Forest Single Stratum structural stage	18,946	27

SECC	Stem Exclusion Closed Canopy structural stage	12,641	18
SEOC	Stem Exclusion Open Canopy structural stage	72	<1
SI	Stand Initiation structural stage	7,427	11
UR	Understory Reinitiation structural stage	1,184	2
YFMS	Young Forest Multi Strata structural stage	10,909	16
Other	Non-vegetated and non-forested cover types (see appendix 1)	3,085	4

Sources/Notes: Summarized from the 39veg database (see appendix 1). Acreage figures include private land located within the analysis area. See Veg Table 8 for information about structural stages.

Veg Table 20: Forest canopy cover classes of the Desolation ecosystem analysis area (1939).

CODE	CANOPY COVER DESCRIPTION	ACRES	PERCENT
≤40	Live canopy (crown) cover of trees is 40 percent or less	5,284	8
41-55	Live canopy cover of trees is between 41 and 55 percent	4,108	6
56-70	Live canopy cover of trees is between 56 and 70 percent	16,329	23
>70	Live canopy cover of trees is greater than 70 percent	40,848	59
Other	Non-vegetated and non-forested cover types (see appendix 1)	3,085	4

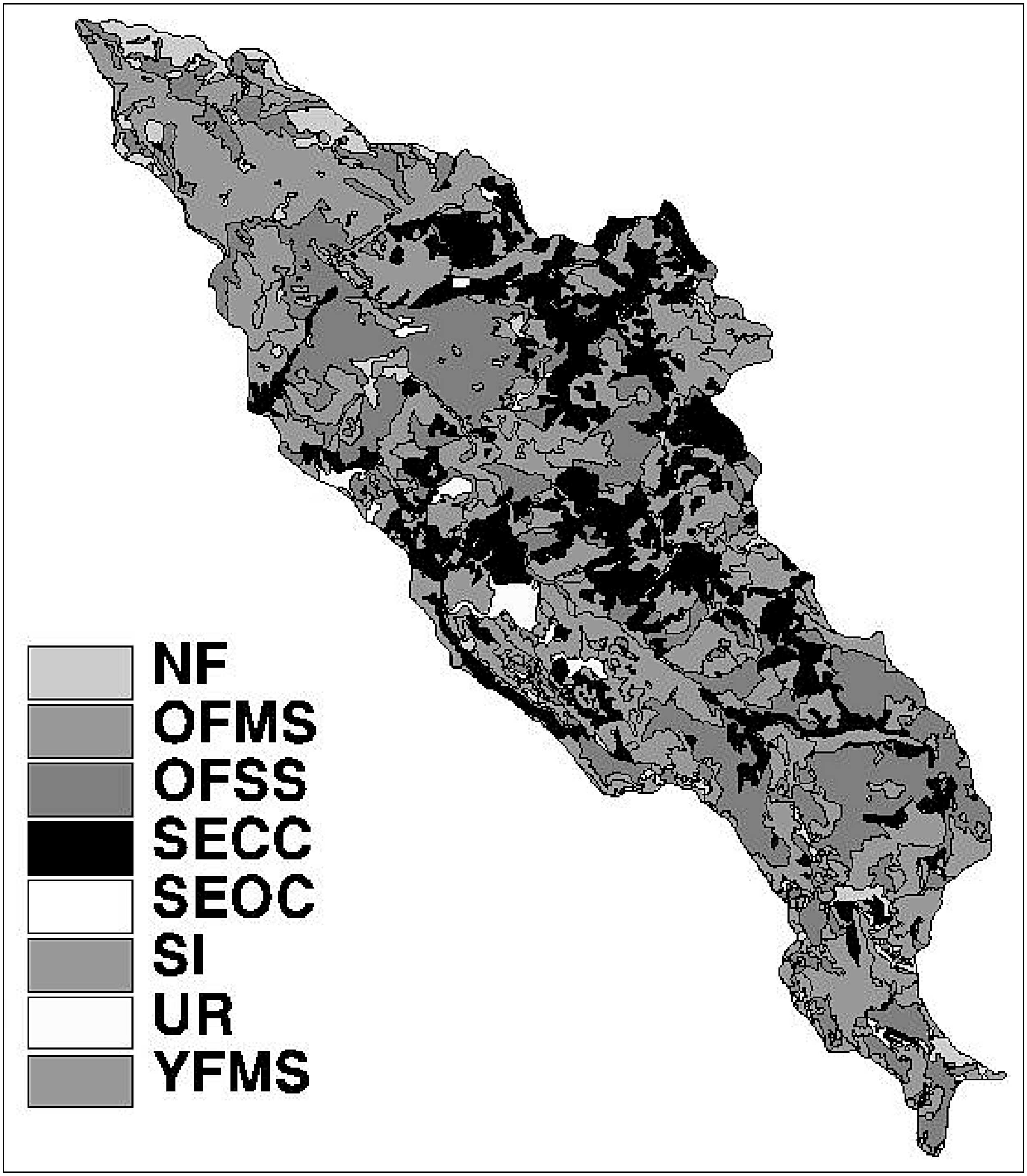
Sources/Notes: Summarized from the 39veg database (see appendix 1). Acreage figures include private land located within the analysis area.

Forest Canopy Layers. Veg Table 21 summarizes historical forest canopy layers for the Desolation watershed. It shows that the predominant situation in 1939 was a two-layer stand structure (64% of the analysis area), followed by single-layer forest (25%). A highly-complex layer structure (3 or more canopy layers) was relatively uncommon, occupying only six percent of the analysis area.

Veg Table 21: Forest canopy layers of the Desolation ecosystem analysis area (1939).

CODE	CANOPY LAYER DESCRIPTION	ACRES	PERCENT
1	Live canopy (crown) cover of trees occurs in l layer (stratum)	17,531	25
2	Live canopy cover of trees occurs in 2 layers or strata	44,830	64
3	Live canopy cover of trees occurs in 3 or more layers or strata	4,208	6
Other	Non-vegetated and non-forested cover types (see appendix 1)	3,085	4

Sources/Notes: Summarized from the 39veg database (see appendix 1). Acreage figures include private land located within the analysis area.



Veg Figure 9 – Forest structural stages of the Desolation watershed (1939). Refer to Veg Table 19 for a description of the structural stage codes.

Forest Disturbances. Veg Table 22 summarizes historical forest disturbances for the Desolation watershed. It shows that the analysis area had little or no evidence of recent disturbance in 1939, or at least none that could be distinguished on the historical aerial photography. Although the effects of long-past wildfire was apparent in the landscape pattern of the watershed (the distribution and configuration of lodgepole pine patches, for instance), there was no recent disturbance other than a minor amount of timber harvest (<1% of the analysis area had been affected by partial cutting). Even though insects and diseases were not specifically noted, they were important disturbance agents historically (Veg Table 14).

Veg Table 22: Forest disturbances of the Desolation ecosystem analysis area (1939).

CODE	DISTURBANCE DESCRIPTION	ACRES	PERCENT
CC	Recent clearcut timber harvest	0	0
CR	Old clearcut, now regenerated	0	0
FI	Evidence of recent fire	0	0
PC	Recent partial cutting timber harvest (selection, seed-tree, etc.)	182	<1
PR	Old partial cut, now regenerated	0	0
SS	Evidence of sanitation/salvage timber harvest	0	0
TH	Evidence of a thinning silvicultural treatment	0	0
Blank	No discernable evidence of disturbance (on aerial photographs)	66,387	95
Other	Non-vegetated and non-forested cover types (see appendix 1)	3,085	4

Sources/Notes: Summarized from the 39veg database (see appendix 1). Acreage figures include private land located within the analysis area.

What impact did disturbances have on tree mortality in the Desolation watershed? Veg Table 23 summarizes overstory mortality for the Desolation area. Not unexpectedly, it shows that disturbances had little or no impact on forest conditions, as least when using overstory tree mortality as a criterion of impact. Ninety-six percent of the analysis area had forests with low overstory mortality (10 or fewer dead trees per acre) in 1936 – which includes all of the forested area since the remaining 4 percent of the Desolation watershed was not forested.

Veg Table 23: Forest overstory mortality of the Desolation ecosystem analysis area (1939).

CODE	OVERSTORY MORTALITY DESCRIPTION	ACRES	PERCENT
L	Low overstory mortality; 10 or fewer dead trees per acre	66,569	96
M	Moderate overstory mortality; 11-20 dead trees per acre	0	0
H	High overstory mortality; 21-60 dead trees per acre	0	0
V	Very high overstory mortality; greater than 60 dead trees/acre	0	0
Other	Non-vegetated and non-forested cover types (see appendix 1)	3,085	4

Sources/Notes: Summarized from the 39veg database (see appendix 1). Acreage figures include private land located within the analysis area.

SYNTHESIS AND INTERPRETATION

Synthesis and interpretation of information is the fifth step in a six-step process for ecosystem analysis at the watershed scale. The purpose of step 5 is to compare current (step 3) and reference (step 4) conditions for key ecosystem elements, to explain significant differences, similarities, or trends, and to examine their causes. The capability of the ecosystem to achieve key management plan objectives is also evaluated in this step (Regional Ecosystem Office 1995).

Forest Cover Types. Stands dominated by lodgepole pine were much more abundant in 1939 than in 1997 (see Veg Tables 5 and 16). The most likely reason for a reduction in the lodgepole pine cover type was a mountain pine beetle outbreak during the late 1970s and early 1980s that killed most of the mature lodgepole pine, not just in the Desolation analysis area but throughout the central Blue Mountains (Gast and others 1991). After bark beetles killed the overstory trees, the new stands were often dominated by shade-tolerant, late-seral species that had regenerated beneath the shade-intolerant, early-seral lodgepole pines. Since grand fir is a shade-tolerant, late-seral species, this scenario could help explain why the grand fir cover type doubled in area between 1939 and 1997.

Although a 43% reduction in the lodgepole pine cover type and a 120% increase in the grand fir cover type represents a substantial amount of change, it is probably within the historical range of variation for species composition. Fluctuations in cover types have always occurred in response to forest disturbances, and is occurring now in response to the Bull and Summit wildfires and other recent disturbance events. For example, one expected consequence of those wildfires in the Desolation watershed is a future reduction in the subalpine fir, Engelmann spruce and grand fir cover types, and an increase in the lodgepole pine, western larch, and subalpine grassland cover types.

A comparison of Veg Tables 5 and 16 would indicate that two new forest cover types became established sometime between 1939 and 1997 – western juniper (CJ) and whitebark pine (CB). Actually, it's possible that one of them (western juniper) did get established during that period, but likely that the other one (whitebark pine) was already present in 1939 and could not be distinguished, or was misidentified, on the historical aerial photography, which was small-scale (1:20,000) and of lower resolution than modern film.

Western juniper trees are not uncommon on hot dry sites at low elevations in the analysis area. Historically, juniper abundance and distribution was largely controlled by fire, since it has low fire resistance (Agee 1993) and seldom survives any but the lowest-intensity burns. One of the consequences of 90 years of fire suppression in the Inland West has been a substantial increase in western juniper, both on grassland sites and in dry ponderosa pine forests (Quigley and Arbelbide 1997). It is possible that the small amount of western juniper cover type identified in 1997 is a direct result of fire suppression.

It is also interesting that the acreage of non-forested cover types (grassland, shrubland, forbland/meadows, etc.) increased between 1939 and 1997 (see Veg Tables 5 and 16). The reasons for that change are many and varied – in some cases, the effect of timber harvest or wildfire resulted in areas with less than 10 percent canopy cover of trees, which caused them to be coded as a non-forest cover type. Eventually, those areas will support trees once again as plant succession progresses. In other instances, the better resolution and larger scale of the 1995-1997 aerial photography allowed more of the "patchy" non-forest vegetation to be delineated as separate polygons (typically ranging from 1 to 3 acres). That level of detail or refinement was seldom possible on the coarser photography used for the 1939 characterization.

Landscape Patches. In some respects, patch characteristics have changed substantially between 1939 and 1997. Lodgepole pine had a significantly larger mean patch size in 1939 (434 acres) than in 1997

(189 acres) (see Veg Tables 6 and 17). Subalpine fir, Douglas-fir, and western larch are other cover types whose mean patch size decreased between 1939 and 1997. Engelmann spruce, ponderosa pine, grand fir, and mixed conifer are the forest cover types whose mean patch size increased between 1939 and 1997. For structural stages, the OFMS, OFSS, SECC, and YFMS stages had a larger mean patch size in 1939 than in 1997. For the SEOC, SI, and UR stages, mean patch sizes in 1997 were greater than in 1939.

Fragmentation of primary natural forest has been a recent concern (Noss and Cooperrider 1994). When considering the Desolation watershed in its entirety, it appears that fragmentation did not occur between 1939 and 1997. In 1939, there were 334 cover type patches and 516 structural stage patches; by 1997, there were 331 cover type patches and 503 structural stage patches. Since there were fewer patches in 1997 than in 1939, it appears that patches became more connected and more contiguous between 1939 and 1997.

When examining individual patch types, however, it does appear that fragmentation may have occurred, at least for certain forest cover types or structural stages (see Veg Tables 6 and 17). A good example is the old forest structural stages – in 1939, their maximum patch sizes were 4,840 and 6,271 acres (for the *old forest single stratum* and the *old forest multi strata* stages, respectively); by 1997, their maximums had declined to only 129 and 252 acres, respectively.

Forest Size Classes. Stands comprised of large-diameter trees were more common in 1939 than in 1997 (see Veg Tables 7 and 18). In 1939, 85% of the analysis area had stands with trees in the small or medium size classes; by 1997, the percentage had declined to only 65% (based on size class 77 and greater). However, the distribution of size classes was more balanced in 1997 since there was a better representation of the small-tree classes (seedlings, saplings, and poles).

The primary reasons for size-class changes were that selective timber harvest removed many of the economically-valuable, large-diameter trees (Powell 1994); that certain bark beetles specifically seeked out and attacked large-diameter trees because the phloem of smaller trees is unsuitable habitat for their broods (Gast and others 1991); and that recent, stand-replacing wildfires initiated new stands that are now dominated by small, seedling-size trees.

Forest Structural Stages. Since structural stages represent different points in the development of a forest, they can serve as a valuable framework for assessing wildlife habitat (Thomas 1979). When analyzing current conditions with respect to structural stages, it is often helpful to put them in an historical context. A technique was recently developed that facilitates a comparison of current and reference conditions – the historical range of variation (HRV).

Historical range of variation for forest structural stages. HRV can serve as a framework for comparing reference and current conditions (Morgan and others 1994). Managers often consider HRV to be an indicator of ecological sustainability – historical conditions are believed to represent sustainable conditions, at least to whatever extent Nature emphasized sustainability. After identifying historical ranges for a particular variable, managers can then infer which ecological processes may have been important for creating and sustaining those conditions. HRV is especially valuable as a reference point or benchmark (Swanson and others 1994).

HRV was recently proposed as one alternative for assessing ecosystem health and integrity. Although "ecosystem health" may not be an appropriate term (Wicklum and Davies 1995), it is valuable for communication – people identify with the concept by drawing an analogy to human health. A key premise of HRV is that native species are adapted to, and have evolved with, the native disturbance regime of an area. For that reason, ecosystem elements occurring within their historical range are believed to represent diverse, resilient, productive, and healthy situations (Swanson and others 1994).

Although HRV can be applied to a wide variety of ecosystem elements, it was decided to use it with structural stages. Structural stages are inclusive – any particular point on a stand's developmental pathway can be assigned to a structural stage. They are also universal – every forest stand eventually passes through a series of structural stages, although not every stand passes through all of the stages or spends an equal amount of time in any particular stage. For those reasons – inclusiveness and universality – structural stages are an ideal framework for comparing current and reference conditions.

An HRV analysis was completed for the Desolation watershed. It was based on two primary factors – forest structural stages and potential natural vegetation (as represented by PVGs). Potential natural vegetation was important for explicitly recognizing that all forest stands will not occupy every structural stage, and that forests with differing ecological potential will not spend an equal amount of time in any particular structural stage.

Results of the HRV analysis are provided in Veg Table 24. It summarizes the current percentage of each structural stage, by PVG, for two groupings of subwatersheds in the Desolation analysis area. Results are also provided for the watershed in its entirety. Subwatershed groupings were developed because it was recommended that an HRV analysis be conducted on land areas of 15,000 to 35,000 acres (USDA Forest Service 1994).

The Desolation watershed has a pronounced elevational gradient spanning almost 5,000 feet (2,971 to 7,632 feet), resulting in a well-balanced mix of upland forest PVGs. Unfortunately, partitioning the watershed into two smaller groups essentially disrupted the good balance. For that reason, the HRV analysis pertaining to the whole watershed (the "Total" section in Veg Tables 24 and 25) is considered to be the most accurate, even though it pertains to an area that exceeds 35,000 acres.

Veg Table 24 also shows the historical range for each of the structural stages. It must be emphasized that the historical ranges vary by PVG, which demonstrates why potential natural vegetation is an integral component of an HRV analysis. The historical ranges were derived from a variety of sources that are described in the "Sources" section of the table.

When considering the entire Desolation watershed, the HRV analysis for current structural stages (Veg Table 24) shows that *old forest* structure is deficient for all PVGs. *Young forest multi strata* is also deficient for the dry forest PVG. The *stand initiation* structural stage exceeds the historical range, often by a considerable amount, for all three of the PVGs. *Stem exclusion* and *understory reinitiation* also exceed the historical range, but only for the dry forest PVG.

In the interest of consistency and also to provide a sensitivity analysis for the historical ranges, an HRV analysis was completed for the reference (1939) structural stages. Results of that analysis are provided in Veg Table 25. It shows that *old forest* structure exceeded the historical range, but only for the dry forest PVG. The *young forest multi strata* structural stage was deficient for the dry forest PVG. The percentage of all other stages occurred within their historical ranges.

If one assumes that the 1939 conditions represent an unmanaged or unmodified situation, at least with respect to anthropogenic changes other than fire suppression, then the reference condition HRV analysis (Veg Table 25) indicates that the historical ranges used in Veg Tables 24 and 25 are reasonably accurate. If that wasn't the case, then one would have expected more deviations in Veg Table 25 than actually occurred (current percentages above or below the historical ranges). Since few human-caused changes had affected forest conditions by the late 1930s, the apparent accuracy of the historical ranges would indicate that they adequately reflect the natural disturbance regime of the analysis area.

Veg Table 24: HRV analysis for structural stages; 1997 forest conditions.

GROUP	PVG		SI	SE	UR	YFMS	OF	ACRES
Lower	Cold UF	H%	5-20	5-35	1-25	10-40	5-40	
		C%	**74**	3	8	13	2	5,062
	Moist UF	H%	1-10	5-25	1-20	20-50	10-60	
		C%	**50**	10	**27**	13	0	10,185
	Dry UF	H%	5-15	5-30	1-10	5-25	5-70	
		C%	16	**60**	**22**	0	3	13,613
Upper	Cold UF	H%	5-20	5-35	1-25	10-40	5-40	
		C%	**75**	8	1	12	4	18,367
	Moist UF	H%	1-10	5-25	1-20	20-50	10-60	
		C%	**61**	3	3	32	2	14,733
	Dry UF	H%	5-15	5-30	1-10	5-25	5-70	
		C%	**65**	31	4	0	0	3,323
Total	Cold UF	H%	5-20	5-35	1-25	10-40	5-40	
		C%	**75**	7	2	12	4	23,429
	Moist UF	H%	1-10	5-25	1-20	20-50	10-60	
		C%	**56**	6	13	24	1	24,918
	Dry UF	H%	5-15	5-30	1-10	5-25	5-70	
		C%	**26**	**54**	**18**	0	2	16,936

Sources/Notes: Summarized from the 97veg database (see appendix 1). Current percentages include private land located within the analysis area. Historical percentages (H%) were derived from Hall (1993), Johnson (1993), and USDA Forest Service (1995a). Potential vegetation group (PVG) is described in Powell (1998) and in Veg Table 2. "Group" is a subwatershed grouping developed specifically for the HRV analyses; see appendix 1 for a description of the subwatersheds in each grouping. The "total" section of the table shows the HRV situation for the Desolation analysis area in its entirety. Structural stage codes are described in appendix 1, with these exceptions: SE is stem exclusion (SEOC and SECC combined); OF is old forest (OFMS and OFSS combined). Shaded cells indicate those instances where the current percentage (C%) is above the historical range for that structural stage. Cells enclosed in a box indicate those instances where the current percentage is below the historical range. Since an HRV analysis is somewhat imprecise, deviations (whether above or below the H% range) were only noted when the current percentage differed by 2 percent or more. Acreage figures (the "Acres" column) include private land located within the analysis area.

Veg Table 25: HRV analysis for structural stages; 1939 forest conditions.

GROUP	PVG		SI	SE	UR	YFMS	OF	ACRES
Lower	Cold UF	H%	5-20	5-35	1-25	10-40	5-40	

		C%	6	**46**	1	7	41	4,019
	Moist UF	H%	1-10	5-25	1-20	20-50	10-60	
		C%	7	10	3	21	59	10,064
	Dry UF	H%	5-15	5-30	1-10	5-25	5-70	
		C%	6	9	1	0	**85**	14,592
Upper	Cold UF	H%	5-20	5-35	1-25	10-40	5-40	
		C%	20	31	1	23	26	18,378
	Moist UF	H%	1-10	5-25	1-20	20-50	10-60	
		C%	9	18	4	26	43	15,742
	Dry UF	H%	5-15	5-30	1-10	5-25	5-70	
		C%	**17**	3	0	4	**77**	3,772
Total	Cold UF	H%	5-20	5-35	1-25	10-40	5-40	
		C%	17	33	1	20	28	22,397
	Moist UF	H%	1-10	5-25	1-20	20-50	10-60	
		C%	8	15	3	24	49	25,806
	Dry UF	H%	5-15	5-30	1-10	5-25	5-70	
		C%	8	7	1	1	**83**	18,364

Sources/Notes: Summarized from the 39veg database (see appendix 1). Current percentages include private land located within the analysis area. Historical percentages (H%) were derived from Hall (1993), Johnson (1993), and USDA Forest Service (1995a). Potential vegetation group (PVG) is described in Powell (1998) and in Veg Table 2. "Group" is a subwatershed grouping developed specifically for the HRV analyses; see appendix 1 for a description of the subwatersheds in each grouping. The "total" section of the table shows the HRV situation for the Desolation analysis area in its entirety. Structural stage codes are described in appendix 1, with these exceptions: SE is stem exclusion (SEOC and SECC combined); OF is old forest (OFMS and OFSS combined). Shaded cells indicate those instances where the current percentage (C%) is above the historical range for that structural stage. Cells enclosed in a box indicate those instances where the current percentage is below the historical range. Since an HRV analysis is somewhat imprecise, deviations (whether above or below the H% range) were only noted when the current percentage differed by 2 percent or more. Acreage figures (the "Acres" column) include private land located within the analysis area.

Forest Canopy Cover. High-density forest (canopy cover greater than 70%) was much more common in 1939 than in 1997 (see Veg Tables 10 and 20). Conversely, low-density forest (canopy cover of 40% or less) is much more abundant currently than it was historically. The primary reason for these changes is that forest disturbances have caused substantial reductions in stand density through time. In some instances, clearcutting, lethal wildfire, or another major disturbance killed an entire stand, with the newly-regenerated, post-disturbance forest often having a lower density (canopy cover) than the original one. In other cases, partial-cutting timber harvests, spruce budworm defoliation, or a similar disturbance killed some trees but not the entire stand, thereby reducing the stand density (canopy cover).

Analysis of stand density. Recently-developed stocking guidelines (Cochran and others 1994) were used to analyze stand density levels and infer whether they were ecologically sustainable. By using the stocking guidelines in conjunction with potential natural vegetation (PAGs) and information about the seral status of forest vegetation, it was possible to determine the acres that would be considered overstocked. The stand density analysis, which was used to help formulate treatment recommendations and opportunities, was completed using the following process.

a. Since canopy cover was the only data item that could serve as a surrogate for stand density, equations were used to convert the SDI information from Cochran and others (1994) into basal areas, and then from basal area into canopy cover (see the tables in appendix 2).

b. Moist sites are capable of supporting higher stand densities than dry sites, so potential natural vegetation (as represented by the PAGs) was used to stratify the watershed into classes with similar ecological capability to support tree stocking.

c. An analysis of stand density is species dependent, but it would be cumbersome to evaluate stocking for every tree species that could occur in each PAG. Therefore, it was decided to assign each of the forest cover types to a seral status (this strategy assumed that a cover type code reflects the predominant tree species for each forested polygon). Since the seral status of a tree species varies depending upon which PAG it occurs in (Hall and others 1995), the assignment of forest cover types to a seral-status category also varied by PAG (Veg Table 26).

d. It was then possible to compare the stand density (canopy cover) information from the vegetation databases with the stocking guidelines that had been converted to canopy cover values. A tree species was first selected to represent each seral-status category (early, mid, late) for each PAG, and the stocking guidelines for that species from appendix 2 were used to determine how many acres of each seral status/PAG combination would be considered overstocked (see Veg Table 27 for the 1997 results, and Veg Table 28 for the 1939 results).

Veg Table 26: Seral status of forest cover types by plant association group.

PLANT ASSOCIATION GROUP	SERAL STATUS EARLY	 MID	 LATE
Cold Dry Upland Forest	CB, CL, CT	CD, CX	CA, CE, CW
Cool Dry Upland Forest		CD	
Cool Moist Upland Forest	CL, CP, CT	CD, CX	CA, CE, CW
Hot Dry Upland Forest			CP
Warm Dry Upland Forest	CL, CP, CT	CX	CD, CW
Warm Moist Upland Forest	CP	CD	

Sources/Notes: The 39veg and 97veg databases were queried to determine which forest cover types were associated with each of the PAGs. The forest vegetation analyst then assigned each cover type to a seral status category, based on his knowledge of the ecological role that the predominant tree species in a cover type would fill in a particular PAG. The cover type/PAG relationships shown in this table were then used to assign a seral status code (ES, MS, or LS) to each forested polygon in both the 39veg and 97veg databases. Refer to Hall and others (1995) for a description of seral status. Note that these are not the only possible combinations of cover type and PAG because some cover types that exist elsewhere on the Forest were not present in the Desolation watershed. However, this table does include every combination that occurred in either of the Desolation databases.

Veg Table 27: Stand density analysis; 1997 forest conditions.

PAG	SS	TREE SPECIES	LMZ COVER	UMZ COVER	TOTAL AREA	OVER-STOCKED
					(Acres)	

Cold Dry Upland Forest	ES	LP	59	66	9,677	1,484
	MS	DF	72	78	2,426	0
	LS	SF	76	83	11,315	63
Cool Dry Upland Forest	MS	DF	72	78	11	0
Cool Moist Upland Forest	ES	LP	58	65	6,304	325
	MS	DF	74	80	4,052	0
	LS	SF	74	81	14,424	366
Hot Dry Upland Forest	LS	PP	26	33	690	308
Warm Dry Upland Forest	ES	PP	43	51	3,402	358
	LS	DF	68	75	12,844	0
Warm Moist Upland Forest	ES	PP	55	62	44	44
	MS	DF	68	75	94	0
TOTAL					65,283	2,948

Sources/Notes: Summarized from the 97veg database (see appendix 1). Acreage figures include private land located within the analysis area. For seral stage (SS), ES refers to early seral; MS refers to mid seral; LS refers to late seral (see Hall and others 1995). Tree species codes, lower management zone (LMZ) values, and upper management zone (UMZ) values are described in appendix 2. The LMZ and UMZ figures are canopy cover values and refer to a "management zone" in which stand densities are considered to be ecologically sustainable (Cochran and others 1994). The "total area" figure shows the acreage of each PVG/SS combination in the analysis area; the "overstocked" value is the acreage with a canopy cover value that exceeds the "UMZ cover" figure and would therefore be considered overstocked.

It is interesting that approximately 57% of the Desolation watershed would be considered overstocked in 1939, as compared to only 4.5% in 1997, and yet the historical overstocking was apparently not reflected in high levels of insect or disease damage (see Veg Tables 22 and 23). The high stocking levels, however, may have been a portent of widespread bark-beetle outbreaks that occurred across the southern Umatilla National Forest in the mid to late 1940s (Buckhorn 1948), and an intense spruce budworm outbreak that began in 1944 and continued until 1958 (Dolph 1980).

Forest Canopy Layers. Stands with two canopy layers were slightly more common in 1997 than in 1939 (see Veg Tables 11 and 21). Single-layer stands were more abundant in 1939 than in 1997, possibly reflecting the influence of a recurring disturbance process called natural underburning. Underburns, which were low-intensity wildfires occurring on a cycle of 8-20 years, resulted in a condition referred to as "park-like ponderosa pine" – large, widely-spaced trees growing above a dense undergrowth of tall grasses (Powell 1998a). Stands with three or more canopy layers have been relatively stable through time, occupying 4 percent of the watershed in 1997 and 6 percent in 1939.

Veg Table 28: Stand density analysis; 1939 forest conditions.

PAG	SS	TREE SPECIES	LMZ COVER	UMZ COVER	TOTAL AREA	OVER-STOCKED
					(Acres)	

Cold Dry Upland Forest	ES	LP	59	66	12,709	11,736
	MS	DF	72	78	2,357	216
	LS	SF	76	83	7,333	1,292
Cool Moist Upland Forest	ES	LP	58	65	11,129	10,565
	MS	DF	74	80	3,636	982
	LS	SF	74	81	11,042	2,556
Hot Dry Upland Forest	LS	PP	26	33	1,059	394
Warm Dry Upland Forest	ES	PP	43	51	5,855	5,242
	MS	DF	68	75	1,072	1,012
	LS	DF	68	75	10,376	3,075
TOTAL					66,568	37,070

Sources/Notes: Summarized from the 39veg database (see appendix 1). Acreage figures include private land located within the analysis area. For seral stage (SS), ES refers to early seral; MS refers to mid seral; LS refers to late seral (see Hall and others 1995). Tree species codes, lower management zone (LMZ) values, and upper management zone (UMZ) values are described in appendix 2. The LMZ and UMZ figures are canopy cover values and refer to a "management zone" in which stand densities are considered to be ecologically sustainable (Cochran and others 1994). The "total area" figure shows the acreage of each PVG/SS combination in the analysis area; the "overstocked" value is the acreage with a canopy cover value that exceeds the "UMZ cover" figure and would therefore be considered overstocked.

Forest Disturbances. The effects of forest disturbances were more apparent in 1997 than in 1939 (see Veg Tables 12 and 22). In particular, the effects of anthropogenic disturbances (primarily timber harvest) were more obvious in 1997 than in 1939. The impacts of recent wildfire were readily observed on the 1995-1997 aerial photography but not on the historical photographs. In fact, it is believed that the lack of obvious disturbance indicates that the late 1930s and early 1940s were a particularly quiescent period in the Desolation watershed, although significant changes were on the way in the form of bark-beetle and spruce budworm outbreaks that would begin in 1944 or 1945 (Buckhorn 1948).

Healthy forests can tolerate periodic disturbances and may even depend on them for renewal. Healthy forests maintain their integrity, resiliency and productive capacity. Forest integrity involves sustaining a wide range of ecological processes whereby plants, animals, microorganisms, soil, water and air are constantly interacting. These processes form soils, recycle nutrients, store carbon, clean water, and fulfill other functions essential to life. Significant changes in the extent or pattern of natural disturbances may be an indicator of impaired forest health. Forest health and sustainability are discussed next.

Assessment of Forest Sustainability. The health and sustainability of forest ecosystems has been a recent issue, not just in the United States but around the World (Heissenbuttel and others No date). As a result of that concern, a protocol was recently established for evaluating forest sustainability at a national or international scale, including a set of criteria and indicators (Montreal Process 1995). In an effort to develop an assessment protocol that could be applied at smaller scales, a landscape-level methodology was recently developed (Amaranthus 1997). It was based on four criteria originally proposed in 1994 (Kolb and others 1994). The four criteria, and an assessment of how the Desolation watershed rates with respect to each of them, are provided below.

1. **The physical environment, biotic resources, and trophic networks to support productive forests**. Over most of the Desolation watershed, the physical, biotic, and trophic networks are intact to support the forest ecosystem. There are some exceptions at the stand level, particularly in the lower or middle thirds of the drainage where there are highly-eroded or steep, raveling hillsides, and recent clearcuts that have not yet regenerated and are out of scale with respect to the natural disturbance regime. Based on this criterion, the forests of the Desolation watershed are probably in a sustainable condition.

2. **Resistance to catastrophic change and the ability to recover on the landscape level**. The major agents of "catastrophic" change include stand-replacing wildfire, defoliating insects, and bark-beetle outbreaks. The watershed has experienced two major budworm outbreaks in the last 50 years (1944-1958 and 1980-1992) but, in general, stands comprised of the late-seral, shade-tolerant species that served as a budworm food source are still largely intact. Although wildfires have recently been active in the drainage, they burned in a mosaic pattern and at a variety of burn intensities, which is what would have been expected for the natural disturbance regime on cold and moist forest sites. Natural rates of fire frequency indicate that much of the lower third of the analysis area has missed two to five fire cycles, but the effects on biomass accumulation and forest sustainability may have been minimal since those areas are generally in private ownership and have been intensively managed (e.g., timber harvest removed the biomass instead of fire). Based on the second criterion, the forests of the Desolation watershed are probably in a sustainable condition, although unsustainable stand densities or species compositions are sometimes present at the stand level.

3. **A functional equilibrium between supply and demand of essential resources.** In some areas dominated by overstocked stands, nutrient cycling and the availability of water and growing space is undoubtedly impaired. In specific areas that sustained high burn intensities, the wildfires may have contributed to future forest health problems because nitrogen, potassium, sulfur and other important nutrients were volatized (lost to the atmosphere) or oxidized. However, the fires burned with a variety of intensities and affected a relatively small percentage of the drainage (13%), so the impacts are not considered to be outside the historical range of variation for that disturbance process. Based on this criterion, the forests of the Desolation watershed are probably in a sustainable condition.

4. **A diversity of seral stages and stand structures that provide habitat for any native species and all essential ecosystem processes**. The Desolation watershed contains a diversity of seral stages and stand structures. Logging and recent wildfires, however, have resulted in an abundance of stands with smaller, younger trees and a simplification of stand structure from what apparently existed in the pre-settlement era. In particular, the representation of old forest structures in the landscape mosaic is substantially reduced from what existed historically. Patch sizes are also reduced from their historical levels for many vegetative elements. Based on this fourth criterion, the forests of the Desolation watershed are either not in a sustainable condition, or are only marginally sustainable. If field reconnaissance verifies that the structural stage information is correct, then thinnings, prescribed burning, fertilization or other management practices should be considered for restoration of old-forest conditions as quickly as possible.

RECOMMENDATIONS

Formulation of recommendations is the sixth step in a six-step process for ecosystem analysis at the watershed scale. The purpose of step six is to bring the results of the previous five steps to conclusion, focusing on management recommendations that are responsive to ecosystem processes identified by the analysis. Monitoring activities are also identified in this step. Data gaps and analysis limitations are documented at this point in the process (Regional Ecosystem Office 1995).

This section provides management recommendations that could facilitate either short-term recovery, or long-term restoration, of upland forest vegetation in the Desolation analysis area. The recommendations did not explicitly consider project feasibility (logging operability, etc.), so they basically represent management opportunities. Whether those opportunities can be realized or not will depend on the detailed project planning that will follow this ecosystem analysis. *It must be emphasized that these recommendations pertain to upland forest sites only (not to Riparian Habitat Conservation Areas)*.

Tree Salvage. Salvage cutting is "the removal of dead trees or trees being damaged or dying due to injurious agents other than competition, to recover value that would otherwise be lost" (Helms 1998). For the wildfire areas in the Desolation watershed, salvage could be considered for three categories of trees:

- dead trees that were killed by the fire;
- live trees that are likely to die in the near future as a result of fire-caused damage;
- live trees that are likely to be killed by insects which attack fire-stressed trees.

Salvage logging can have both positive and negative impacts. 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 sun-loving seral species, and to reduce fuel loadings to the point where wildfire risk is acceptable and a prescribed burning program could be initiated (Powell 1994). Veg Table 29 shows the management areas in which the Umatilla NF Forest Plan allows salvage cutting to occur.

Salvage logging after wildfire has been controversial. Some scientists advocate a passive, custodial approach to post-fire management, maintaining that removal of fire-killed trees makes an unfortunate situation even worse (Beschta and others 1995). Other scientists believe that active management (including salvage logging), in combination with natural processes, is appropriate for restoration of post-fire sustainability. Regardless of which philosophy is considered correct, it is generally accepted that limiting post-fire management to just a single approach (whether passive or active) is inappropriate because each situation is different and should be handled on a case-by-case basis (Everett 1995).

For the Desolation watershed, it may be appropriate to adopt an active management approach with respect to salvage logging of fire-killed trees in the Bull wildfire area. Tree stands in that area often experienced complete mortality as a result of the wildfire (Scott and Schmitt 1996). Even large-diameter western larches – the most fire resistant tree species on the Umatilla National Forest (Agee 1993) – were killed by the fire. Without using salvage logging to remove the heavy fuel loads created by the fire, it will not be possible to reestablish western larch because it requires an open, sunny environment in which to germinate and grow – conditions that are not present in the shade of a dense, dead stand.

Using salvage to remove fuel accumulations would reduce the risk of newly-established plantations being reburned in a subsequent wildfire. In 1986, a major wildfire episode affected the North Fork John Day Ranger District. One of the 14 areas that burned in 1986 was the Long Meadows fire (200 acres), which occurs in the Tower wildfire area just north of the junction of the 52 and 5507 roads. None of the Long Meadows fire was salvage logged, which means that dead trees (mostly lodgepole pines) had fallen over and were lying on and above the ground when the area reburned in 1996.

When the Tower wildfire burned through the 1986 Long Meadows fire, intense combustion of the accumulated fuels resulted in substantial on-site impacts. For example, most of the lodgepole pine seedlings (they averaged 3-4 feet in height) that had regenerated after the 1986 fire were not only killed during the reburn, but were consumed completely down to the ground line. Impacts from the reburn were certainly severe enough that artificially-regenerated plantations, even with seedlings planted at a relatively wide spacing, would not have fared any better than the naturally-regenerated seedlings, *assuming that the same fuel loading was present in both instances*.

Veg Table 29: Management direction summary for the Desolation 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	4.5
A6: Developed Recreation	Yes	No	No♦	<1
A7: Wild and Scenic Rivers	Yes	Yes	Yes	<1
A8: Scenic Area	Yes	No	No♦	19.1
B1: Wilderness	No	No	No♦	1.1
C1: Dedicated Old Growth	Yes*	No	No♦	2.8
C2: Managed Old Growth	Yes	Yes	Yes	1.5
C3: Big Game Winter Range	Yes	Yes	Yes	5.6
C4: Wildlife Habitat	Yes	Yes	Yes	<1
C5: Riparian (Fish and Wildlife)	Yes	Yes	Yes	<1
C7: Special Fish Management Area	Yes	Yes	Yes	46.2
P: Private (non NF) Lands	N.A.	N.A.	N.A.	18.2
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 denuded or understocked lands could be planted using appropriated forest vegetation funds (NFFV); and 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.

I recommend that salvage cutting be considered for approximately 1,000 acres in the Bull wildfire area. It 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.

A salvage program should be designed to address the following vegetation concerns:

1. Emphasize salvage in dry-forest areas (Veg fig. 3) that have the capability to support a high proportion of ponderosa pine (Douglas-fir and warm grand fir plant associations). [Sites meeting this criterion would address changes in species composition on warm dry sites.]
2. Consider salvage where timber volume, tree size, and species characteristics would generate sufficient revenue to fund tree planting and other restoration treatments. [This recommendation recognizes the fact that restoration treatments can be expensive, and that Congress may not fund all of it.]
3. Consider salvage for sites where the existing density of dead trees is great enough that a future reburn would probably destroy newly-established tree regeneration, such as the situation described previously (page 43) for the Long Meadows reburn in the Tower wildfire area.
4. Consider salvage of live, damaged trees that are unlikely to survive more than a year or two:

a. Ponderosa pines and western larches that have less than 20 percent green, healthy-appearing crown (by crown volume), regardless of bole scorch, scorch height, or duff consumption.
b. Douglas-firs having less than 40 percent green, healthy-appearing crown (by volume) AND scorch height greater than 16 feet AND more than 50% of the preburn duff around the base of the tree was consumed by the fire.
c. Subalpine firs, lodgepole pines, and Engelmann spruces with less than 60 percent green, healthy-appearing crowns (by volume) AND bole scorch on greater than 50% of the tree's circumference AND scorch height greater than 4 feet AND more than 25% of the preburn duff around the base of the tree was consumed by the fire.

Even though many portions of the Bull fire were mapped as low burn intensity, they can still be expected to have high fire severity if the pre-fire forests were dominated by subalpine fir, Engelmann spruce, lodgepole pine, grand fir and other thin-barked species. Veg Table 30 shows the relationship between burn intensity and fire severity for all of the forest cover types that occur within the Desolation analysis area.

Veg Table 30: Tree mortality estimates, by fire intensity rating, for forest cover types.

	FIRE INTENSITY RATING		
FOREST COVER TYPE	**HIGH**	**MODERATE**	**LOW**
Douglas-fir (CD)	High Mortality	Moderate Mortality	Low Mortality
Engelmann Spruce (CE)	High Mortality	High Mortality	High/Moderate Mortality
Grand Fir (CW)	High Mortality	High Mortality	Moderate Mortality
Lodgepole Pine (CL)	High Mortality	High Mortality	High/Moderate Mortality
Mixed Conifer (CX)	High Mortality	High Mortality	Moderate Mortality
Ponderosa Pine (CP)	High Mortality	Moderate/Low Mortality	Low Mortality
Subalpine Fir (CA)	High Mortality	High Mortality	High/Moderate Mortality
Western Juniper (CJ)	High Mortality	High Mortality	Moderate Mortality
Western Larch (CT)	High Mortality	Moderate/Low Mortality	Low Mortality
Whitebark Pine (CB)	High Mortality	High Mortality	Moderate Mortality

Sources/Notes: Fire intensity refers to energy release rates; it is a physical descriptor of a fire. Tree mortality is based on fire severity, which refers to the ecological effects of a fire on the dominant organisms (Agee 1997). For the purposes of this table, the dominant organisms were assumed to be large trees. High tree mortality means that 70 percent or more of the large trees would be killed; moderate mortality – 20 to 70 percent; and low mortality – less than 20 percent.

Forest Regeneration. The Bull and Summit fires created conditions that are conducive to regeneration of early seral conifers. Unfortunately, the fires also killed many of the mature trees required for seed production. The probability of obtaining natural regeneration in the fire areas will depend on several factors:

- the availability of surviving trees to serve as a seed source,
- the spatial distribution of seed trees, especially their proximity to severely-burned areas,
- whether the survivors are physiologically capable of producing seed in any abundance,
- whether cone (seed) crops are actually produced, and when.

Forest recovery is expected to be slow in some portions of the Bull and Summit fires, especially for areas that experienced a moderate or high burn intensity and whose pre-fire composition was dominated by tree species with low fire resistance. Initially, severely-burned areas will support herbaceous vegetation (forbs and grasses) and shrubs, with trees beginning to predominate by the end of the third decade after the fire (Koch 1996a).

In the case of lodgepole pine, some natural regeneration will be produced by cones present in the canopy of dead stands, assuming of course that any canopy remained after the fire. In the areas that burned with a low or moderate intensity, most of the lodgepole pines were killed, even though some of their crowns persisted (the "red crown" condition) and served as a seed source if cones were present before the burn. Although lodgepole pine has a low percentage of closed cones (serotiny) in the Blue Mountains (Koch 1996b), it is a prolific seed producer and good seed crops occur frequently (Trappe and Harris 1958). If 1996 was a good seed year for lodgepole pine stands in the Bull and Summit fire areas, we can expect adequate to overly-abundant lodgepole pine regeneration in the future.

Tree planting is an effective way to influence the future composition of a forest. *If forest health and resistance to insect defoliation is an objective, then planting should attempt to establish a future composition with at least 60 percent of the trees being early- and mid-seral species* (Powell 1994).

Whenever possible, tree plantings should emphasize establishment of early-seral conifers on upland sites. Since lodgepole pine is expected to regenerate naturally on all but the highest intensity burns, it is recommended that upland plantings emphasize other early-seral species (western larch and ponderosa pine) to a greater degree than lodgepole pine. Tree planting recommendations (species mixes and densities) are provided in Veg Table 31.

Planting recommendations (species mix, and seedlings per acre) were based on a variety of considerations. Since each tree species can tolerate a particular mix of environmental conditions, it should not be included in a planting mix unless it is well adapted to the sites being planted. As an example, consider ponderosa pine – on hot, dry sites at low elevations, it is typically the only tree species; on warm, dry sites where Douglas-fir or grand fir are climax, it is a dominant seral species; on cool, moist sites where grand fir or subalpine fir are climax, it is a minor or accidental species; and on cold, dry sites at high elevations, ponderosa pine doesn't occur because it cannot survive in those ecological environments.

It must be emphasized that the planting recommendations in Veg Table 31 involve a mixture of species. Even if a mixture was not being planted, a mixed stand would eventually result after natural regeneration got established. A common misconception is that plantations are monocultures – "corn-row" forests devoid of floristic biodiversity. Nothing could be further from the truth, although a monoculture is certainly possible for closely-spaced plantations comprised of a single species, especially if that species is susceptible to stagnation such as lodgepole pine or ponderosa pine.

Veg Table 31: Planting recommendations for Desolation analysis area.

	TREE DENSITY		SPECIES COMPOSITION OF PLANTING MIX							
PAG	**TPA**	**SPACING**	**PP**	**WL**	**LP**	**DF**	**WP**	**GF**	**ES**	**SF**
Cold Dry	222	14 feet		40%	NR	20%		NR	40%	NR
Lodgepole Sites – Cool♦	194	15 feet		30%	NR	30%		NR	40%	NR
Lodgepole Sites – Cold♦	194	15 feet			NR	40%		NR	60%	NR
Cool Moist – Moist♠	222	14 feet		30%	NR	20%	20%	NR	30%	NR
Cool Moist – Mesic•	222	14 feet	NR	40%	NR	40%		NR	20%	
Warm Dry – Mesic♣	151	17 feet	60%	20%		20%		NR		
Warm Dry – Dry♣	151	17 feet	80%			20%				
Hot Dry	151	17 feet	100%							

Sources/Notes: Trees per acre (TPA) and spacing recommendations are based on the author's judgment and Powell (1992). The species composition recommendations are based on the author's judgment, Cole (1993), Kaiser (1992), and Wallowa-Whitman NF (1996). See appendix 2 for a description of the species codes used as column headings in the species composition section of this table (WP is western white pine).

NR = Natural Regeneration. It is expected that these species will occur as natural regeneration. They were not included in the planting mix, but could be used if more desirable species are in short supply.

♦ Cool types are PICO(ABGR)/ARNE, PICO/CARU, PICO(ABGR)/CARU, and PICO(ABGR)/VAME; cold types are PICO(ABLA2)/VASC and PICO/CARU/VASC.

♠ White pine is adapted to these plant associations on the North Fork District, not all of which occur in the Desolation area: ABGR/TABR/LIBO2, ABGR/LIBO2, ABGR/CLUN, and ABGR/ACGL (Urban 1996).

• Includes all cool moist plant associations except ABGR/LIBO2 and ABGR/CLUN.

♣ Mesic plant associations are ABGR/CAGE, ABGR/CARU, PSME/SYAL, and PSME/VAME; all others in the warm dry PAG are considered to be dry.

The tree density recommendations in Veg Table 31 will seem too low to some readers. Relatively low seedling densities were selected for these reasons:

- Silviculturists tend to be conservative and often plant more trees than are really necessary in order to "hedge their bets" for the future (Oliver and Larson 1996).
- Stands with close spacings (high densities) often have poor crown-class differentiation, which could lead to stagnation and arrested or improper development from that point onward.
- High-density stands develop tall, spindly trees often called "wet noodles" because they can't support themselves and fall over if adjacent support trees are removed or die (Oliver and Larson 1996).
- Open stands have low levels of inter-tree competition and are highly vigorous. High-vigor stands are healthier than dense ones and generally experience few insect or disease problems.
- Open stands yield high volumes of usable timber (Sassaman and others 1977). If wood continues to be valuable, then higher yields of usable timber will be a future benefit.
- Wide spacings allow ample opportunity for establishment of natural regeneration, while also minimizing the amount of precommercial thinning that may need to occur in the future.

Competing Vegetation. One of the potential benefits of the Bull and Summit wildfires was that they provided a "site preparation" treatment in terms of tree regeneration. Rhizomatous grasses, shrubs, and other plants that compete with trees for moisture, sunlight, and nutrients have been temporarily "knocked back" by the fire. If planting occurs quickly, trees could get established before allelopathic plants and other competitors have fully recovered from the fire.

Of particular concern is the potential for pinegrass, smooth brome, red top, Kentucky bluegrass, bracken fern, elk sedge, red fescue, snowbrush ceanothus and other competing vegetation to affect the survival of planted or naturally-regenerated tree seedlings. In particular, grasses produce an abundance of surficial roots that rapidly absorb moisture before it can percolate to the deeper roots of woody species. Their rooting habit gives grasses a competitive advantage over trees, particularly on droughty sites (Oliver and Larson 1996).

Stand Density Management. 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). Density management could also be used to shift a site's growth potential to fewer stems so that the large-diameter trees desired as wildlife habitat could be produced more quickly (Cochran and Barrett 1995).

Research conducted in the Blue Mountains of northeastern Oregon has consistently shown that substantial increases in individual tree growth will occur following a low thinning, a stocking-control treatment where small trees are removed to favor those in upper crown classes. This result was obtained in stands of western larch (Seidel 1987), ponderosa pine (Cochran and Barrett 1995) or lodgepole pine (Cochran and Dahms 1998). Research from central Oregon has shown a similar response for thinned stands of Douglas-fir, grand fir, western white pine or Engelmann spruce (Seidel and Cochran 1981).

Thinning treatments should address the overstocked areas shown in Veg Table 27 (approximately 3,000 acres). The tables in appendix 2 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 and resistant to insect and disease problems. In addition, understory thinnings in multi-cohort stands should be considered for warm dry sites that have 2 or more tree layers and a canopy cover of 40 percent or more, since they would be considered marginally overstocked and currently have a vertical structure that would inhibit reintroduction of landscape-scale fire.

Understory Thinnings in Multi-Cohort Stands. 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. Their removal improves overstory vigor by reducing competition and, when the overstory trees are mature ponderosa pines and western larches, this treatment is effective at ensuring their continued survival (Arno and others 1995).

"Encroachment by fir" is a management issue where Douglas-firs and grand firs are growing on sites that historically supported pure, or nearly-pure, stands of ponderosa pine. In those instances, the firs should be viewed as "ecologically offsite" species. Although fir seedlings can obviously get established on many ponderosa pine sites, they would not have survived without human suppression of low-intensity fire. 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 vegetation sustainability.

Understory removals are particularly appropriate for removing firs that have encroached on warm dry sites. They may also be effective on other sites with a remnant pine/larch component, especially if stand densities are reduced to more sustainable levels, thereby improving the vigor and resilience of pine and larch. It is recommended that understory removals be considered for warm dry sites supporting multi-storied, mixed-species stands with canopy cover of 40 percent or more (approximately 4,000 NFS acres).
Prescribed Burning. After completing salvage harvests, understory removals, thinnings and other treatments described in this section, managers should strongly consider implementing a prescribed burning program.

On the areas that have been planted with early-seral tree species, a prescribed burn could be completed once ponderosa pines and larches are 10 to 12 feet tall, 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 regularly, usually at intervals of 15 to 25 years. Fall burns, which are desirable from an ecological standpoint because they replicate the natural fire regime, result in fewer losses of overmature ponderosa pines to western pine beetle (Swezy and Agee 1991) and to Armillaria root disease (Filip and Yang-Erve 1997).

Periodic burning can also be used to increase the nutrient capital of a site by maintaining sparse stands 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 West may have depended more on nitrogen-fixing plants and low-intensity fires to recycle soil nutrients than on microbial decomposition of woody debris (Veg Figure 10).

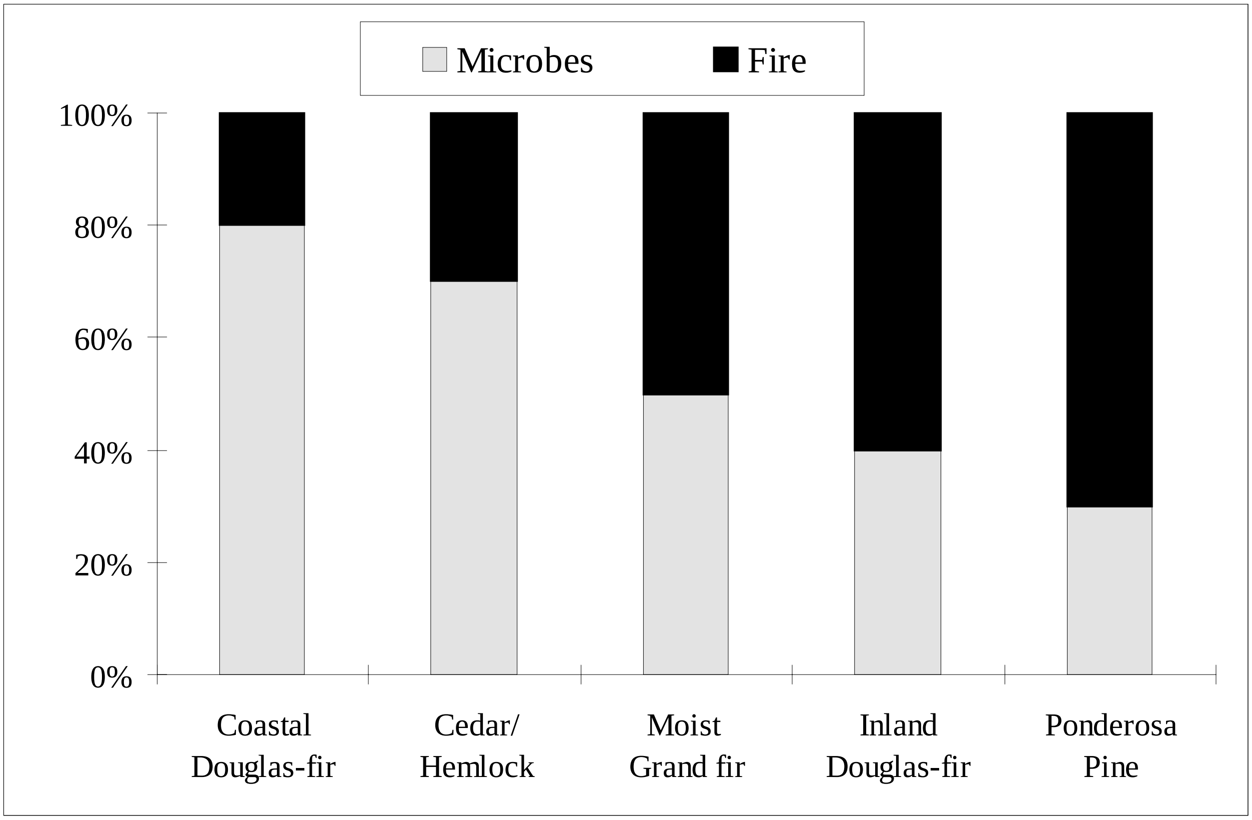
Providing adequate levels of site nutrition is important for maintaining tree resistance to insects and diseases (Mandzak and Moore 1994). In central Oregon, for example, Reaves and others (1984, 1990) found that ash leachates (chemical substances produced when water percolates through the ash remaining 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.

It is recommend that prescribed burning be used in existing dry-forest types (ponderosa pine and Douglas-fir) that have received an understory thinning treatment, and that it be considered as a future treatment for plantations established on hot dry and warm dry PAGs. Future prescribed burns will probably not occur for at least 30 years after plantations have been established, and could then be coordinated with thinning and pruning treatments designed to create stand structures with a low risk of crown fire or other undesirable fire behavior (Agee 1996, Scott 1998).

Cautions About the Use of Fire. Fire may not be beneficial on all mixed-conifer 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).

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 burns, 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 the stand’s life (Brockley and others 1992). In central Oregon, prescribed burning 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).



Veg Figure 10 – Fire as a decomposer. In dry forests of the Inland Northwest, fire was an important ecological process for nutrient cycling. Coastal Douglas-fir forests and other areas with a humid, temperate climate can recycle nutrients using microbial decomposition, but microbes are relatively ineffective in dry ecosystems. After frequent, low-intensity fires were suppressed following Euro-American settlement of the Blue Mountains, microbial decomposition has been unable to keep pace with the organic debris that accumulates beneath forests as they grow and develop (needles, twigs, branches, etc.). Eventually, a disturbance event will "reset" the system by converting the accumulated biomass back to its elemental constituents (carbon, phosphorus, calcium, etc.). Wildfire often serves as the "reset" event in western forests. (Figure adapted from Harvey and others 1994.)

Fertilization. The recent wildfires may contribute to future forest health problems by their impact on nutrients that were present in vegetation, litter, and the upper soil layers. Nutrients can be lost to the atmosphere during combustion (volatilized) or converted by heat to their mineralized or elemental form (oxidized). Oxidized nutrients are retained in the ash and remain on site unless ash is redistributed by wind or water. Mineralized nutrients are eventually returned to the ecosystem as water (snowmelt, rain) leaches them into the soil, where they are available for plant growth unless leaching moves them deeper than roots can reach.

From a forest health perspective, the primary concern is focused on volatilization losses of nitrogen, potassium, and sulfur. Nitrogen is a critical element needed for plant growth, and it is likely that a high proportion of the available nitrogen is now gone in areas that sustained complete stand mortality (i.e., the areas of moderate and high burn intensity). For example, measurements completed after the Entiat fire in 1970 showed that 97% of the nitrogen in the forest floor (litter and duff) was lost, and that 33% of nitrogen in the upper layer of mineral soil (A1 horizon) was also volatilized (Grier 1975). On the dry sites burned by the Entiat fire, those were significant losses – replacement of lost nitrogen from the atmosphere (via precipitation) would require 907 years. Obviously, nitrogen will need to accumulate from other sources – primarily weathering of soil parent material and symbiotic nitrogen fixation associated with the root systems of certain plant species (Grier 1975).

The loss of potassium and sulfur is also important since on-going studies indicate that those nutrients play an important role in forest health. Apparently, forests growing on soils derived from geological parent materials with low potassium concentrations are prone to poor health such as chronic outbreaks of insects and diseases (Moore and others 1993). Fortunately, it appears that mineralized potassium is retained in the upper soil profile (0-8" depth) as ash is leached, thereby making it available for uptake by trees and other plants (Grier 1975).

Fertilization may provide other benefits as related to insect and disease susceptibility. It provides opportunities to modify foliar chemistry and thereby improve a tree's resistance to budworm defoliation (Clancy and others 1993). It may help reduce stem decay for grand firs that have been wounded during logging or by other agents (Filip and others 1992). By changing root chemistry, fertilization with nitrogen and potassium apparently has beneficial effects on a tree's resistance to Armillaria root disease (Moore and others 1993).

It is recommended that fertilization be considered as a future treatment for young stands growing on the hot dry or warm dry plant association groups. Fertilization would probably not be needed until 20 to 30 years after plantations have been established, and could then be coordinated with other cultural treatments such as precommercial thinning.

Pruning. Pruning has historically been used to produce clear, knot-free wood for the lumber trade. But pruning can also play a role in achieving natural resource objectives. For example, the Desolation watershed has experienced two intense outbreaks of western spruce budworm over the last fifty years. In areas where budworm-host trees will continue to be a stand component, pruning could provide several benefits. The first and most obvious benefit is that by removing the lower crown portion of host trees, pruning results in less food for the survival and growth of budworm larvae.

After pruning trees that are large enough to have developed a fire-resistant bark, it would be possible to underburn mixed-species stands without "torching" the leave trees. Trees with short, pruned crowns would be less likely to serve as ladder fuels, thereby minimizing the risk of an underburn turning into a crown fire. Pruning must be carefully coordinated with the onset of an underburning program – if trees were pruned too soon, epicormic "water" sprouts could occur on the stem and increase a tree's risk of torching in an underburn (Oliver and Larson 1996).

Mechanical pruning would produce a stand that can be underburned much more quickly than waiting for natural pruning. For example, Veg Table 32 shows that ponderosa pine can self-prune quickly, but that dead branches often persist and that mechanical pruning would be advisable if a perfectly clean, branch-free bole is desired to minimize the risk of crown scorch or torching.

It is recommended that pruning be considered as a future treatment for young stands on the hot dry and warm dry plant association groups. Pruning may not be needed until at least 30 years after plantations have been established, when it could then be coordinated with prescribed burning treatments as a way to lower the risk of pole-sized trees being killed by a fire (torching).

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, whitebark pine, western white pine or black cottonwood – many of which have a restricted distribution and are indistinguishable at a landscape scale.

Veg Table 32: Natural pruning in ponderosa pine.

AGE	HEIGHT TO BASE OF THE LIVE CROWN (FEET)	BOLE LENGTH WITHOUT ANY DEAD BRANCHES (FEET)
20	3	1
30	18	2
40	28	3
50	36	4
60	45	7
70	50	11
80	56	19
90	61	27
100	65	29

Sources/Notes: From Kotok (1951). This data shows that ponderosa pine "lifts" its live crown very quickly (2nd column), but that dead branches are somewhat persistent and a "clean" branch-free bole requires a long time to develop (3rd column). Note that these figures were derived from dense, wild stands; open, thinned stands would lift their crowns much more slowly than is shown above.

For the Desolation watershed, quaking aspen, black cottonwood, and whitebark pine are three limited components of particular concern. In the case of whitebark pine, Desolation may well be the only watershed on the entire Umatilla National Forest in which it occurs. Unfortunately, it is found in remote situations (on isolated scree slopes, at upper treeline high in the subalpine zone, etc.) and very little is known about its current condition. In other portions of its range, there is high concern about the continued existence of whitebark pine because of mortality caused by an introduced disease – white pine blister rust (Keane and Arno 1993). In the Desolation watershed, it is unknown if whitebark pine is infected with blister rust because planned surveys of whitebark pine have not yet been completed.

It is recommended that whitebark pine surveys be completed as soon as possible, under the direction of the Forest's botany program.

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 other birds 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 used to be more common in the Blue Mountains than it is now – fire suppression activities over the last 90 years have undoubtedly reduced its distribution.

Veg Figure 11 – An aspen enclosure in the Desolation watershed.

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 (Veg Figure 11). Relict aspen clones exist sporadically in the Desolation watershed (Howard Creek, Sponge Creek, Park Creek, etc.). Some of them have already been fenced but others have not, so it is recommended that clones without enclosures be fenced as soon as possible (Veg Figure 11).

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 to curtail or control flooding, however, black cottonwood has declined or disappeared altogether (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 (Kershaw and others 1998). It can also be propagated by sticking a branch cutting into moist soil and letting it form roots (Lanner 1984). Although long-term trend data is unavailable for the Umatilla National Forest, black cottonwood is another species whose distribution is thought to be substantially reduced from historical levels. Grazing by wildlife and livestock, curtailment of frequent spring flooding, and simplification of riverine floodplain areas have combined with other factors to limit cottonwood regeneration.

It is recommended 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.

Restoration of Natural Vegetation Patterns. All landscapes have definable characteristics with respect to their scenic attractiveness. People value highly-scenic landscapes, which research has shown to be those with a natural appearance based on their landform, vegetation patterns, and water characteristics (Lucas 1991, Magill 1992, USDA Forest Service 1995b).

In the Desolation ecosystem analysis area, landscape patterns have been altered by previous timber harvest practices, particularly with respect to the effects of clearcutting. Often, the result of clearcutting was a visual pattern whose texture, form, line, and color were out of scale with "natural" landscapes. [Note that natural landscapes are defined as those whose elements – texture, form, line, color, etc. – were produced by a disturbance regime that did not include timber harvests, fire suppression, or other human-caused activities.] Recent, square-shaped clearcuts resulting from the Junkens timber sale are a good example of a human-induced pattern that is inconsistent with natural landscape patterns.

When considered from a landscape perspective, created openings ranging up to 40 acres in size are out of scale with the natural vegetation patterns associated with a fully functioning disturbance regime (Delong and Tanner 1996). Patch sizes created by anthropogenic disturbances such as clearcutting have been constrained to 40 acres because of limitations imposed by the National Forest Management Act of 1976 and its implementing regulations (36 CFR 219). Veg Table 17 shows that historical average patch sizes for forest cover types ranged from 48 to 434 acres, and from 24 to 223 acres for forest structural stages (see page 28). Clearcuts of 40 acres or less are inappropriately small when considering the historical patch size situation.

It is recommended that future management treatments attempt to rehabilitate the existing visual situation by restoring a natural vegetation pattern. For example, existing clearcut units could eventually be expanded and shaped in such a way as to approximate the pattern, juxtaposition and size of patches created by historical occurrences of stand-replacing wildfire, particularly for areas within the cold and moist forest PVGs. At a minimum, visual rehabilitation efforts should attempt to modify the unnatural, geometrically regular pattern associated with the existing square clearcuts.

Restoration of Old Forest Structure. An analysis of current and reference conditions for structural stages indicates that the existing amount of old forest structure is substantially reduced from historical levels (see Veg Tables 9 and 19). 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 Desolation watershed, old forest structure occurs in two forms, and each form was developed and maintained by a different disturbance regime. In dry forest areas, vegetative 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 Veg Tables 9 and 19).

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 allowed 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 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 Veg Tables 9 and 19).

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, blow-down, 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 late-seral structural stages (specifically, the *understory reinitiation* and *young forest multi strata* stages);
- Although 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 or HRV) 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 Desolation watershed? I believe that the following process would contribute to development of an old forest network:

1. Identify any existing old-forest patches and recommend that they be protected (from anthropogenic disturbances such as timber harvest) as a cornerstone of a future network.
2. Identify late-seral patches (*understory reinitiation* and *young forest multi strata* stands) in close proximity to the existing old forest as potential replacements for them.
3. Examine the 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. 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 (Camp and others 1997).

Data Gaps and Analysis Limitations. One product of the recommendations step in ecosystem analysis at the watershed scale is identification of data gaps and analysis limitations (Regional Ecosystem Office 1995). The following gaps and limitations were identified during analysis of upland forest vegetation for the Desolation watershed:

1. *Future conditions were not considered*. Most of this vegetation analysis focused on reference (historical) and current conditions. There was no explicit consideration of future conditions. Unfortunately, the inter-agency Federal process developed for watershed analysis (Regional Ecosystem Of-

fice 1995) does not require an assessment of future conditions. Perhaps future EAWS efforts would benefit from having the "third leg of the triangle" (i.e., future conditions) take its place alongside reference and current conditions. Analytical tools have recently been developed that would help evaluate future scenarios, such as the Vegetation Dynamics Development Tool (Beukema and Kurz 1996).

2. *A detailed landscape analysis was not completed*. As described previously, time and other constraints allowed nothing more than a cursory analysis of landscape characteristics (see page 16). Although its value could not be fairly judged in this Desolation analysis, it is believed that a robust landscape characterization could have improved our understanding of broad-scale ecosystem processes and their effect on vegetation patterns.
3. *Additional information about limited vegetation components was needed*. Insufficient information was available about the condition and trend of limited vegetation components such as quaking aspen, black cottonwood, whitebark pine and western white pine in the Desolation drainage. The North Fork John Day District has information about some of these components but, in several instances, the information is not readily available or has not yet been synthesized or interpreted. It is recommended that the District continue its on-going efforts to develop a "species of special concern" GIS layer (and associated databases) to monitor the location and status of limited vegetation components.
4. *High-resolution data sources may have improved analysis accuracy*. Inventory information is used to prepare assessments of watersheds, landscapes, entire National Forests, and other mid- or broad-scale land areas. Dating back to the early 1990s, inventory budgets have been steadily declining, quickly resulting in reduced availability of stand examinations and other high-resolution surveys. As high-resolution data sources became scarce, there was increasing reliance on interpretation of aerial photography, satellite imagery, and other remotely-sensed data.

   Ground-based surveys typically provide detailed information about stand density (trees per acre, basal area per acre, etc.), whereas remote-sensing sources do not. Remote-sensing sources, however, do provide canopy cover information that can serve as a surrogate for stand density. Therefore, mathematical formulas developed during an elk thermal cover study (Dealy 1985) were used to calculate canopy cover values for suggested stocking levels of the Blue Mountains (see appendix 2). Once the suggested stocking levels had been converted to their corresponding canopy cover values, a stand density analysis was then possible (see page 38).

   It is important to emphasize that canopy cover is only an approximation of absolute stand density (basal area or trees per acre), and the overstocked area shown in Veg Table 27 (page 39) should be evaluated in the field to determine its actual suitability for thinning or another density management treatment.

   A similar situation exists with regard to structural stage determinations. Previous vegetation analyses have shown that stand examination information could significantly improve the accuracy of structural stage determinations, particularly for old forest. Since stand exams are typically available for only a limited portion of any particular analysis area, it has often been necessary to use low-resolution information derived from satellite imagery or photo interpretation to calculate structural stages. One disadvantage of this situation is that structural stage determinations require detailed information about tree size, and photo interpretation may not provide enough resolution to accurately differentiate certain tree-size categories.

   If accurate information about old forest and other structural stages is important for ecosystem analysis at the watershed scale, then the Umatilla National Forest should evaluate alternative data sources that would provide more resolution than interpretation of aerial photography.

APPENDIX 1: DESCRIPTION OF VEGETATION DATABASES

Vegetation data for the Desolation ecosystem analysis was stored in three different databases. This document serves as a data dictionary for the existing vegetation, historical vegetation, and potential natural vegetation databases, as described below:

- Interpretation of aerial photography acquired in 1995, 1996, and 1997 was used to characterize existing (current) conditions. The 1996 and 1997 photography was obtained after cessation of the Bull and Summit wildfires in order to characterize post-fire conditions. The database name is: **97veg**.
- Interpretation of late-1930s and early-1940s photography was used to characterize historical conditions. The database name is: **39veg**.
- The potential natural vegetation was determined for each polygon in the analysis area (based on the pre-fire polygons). Plant associations were derived from a variety of sources, including field surveys completed by a professional ecologist under contract to the Forest Service (Ayn Shlisky), sensitive plant surveys and personal knowledge of the analysis area by the Forest Botanist (Karl Urban), and historical stand examinations. The database name is: **DesoPNV**.

Note: Although delineation of existing and historical conditions were not made by the same interpreters, both efforts used the same coding scheme and database structure.

Site Number (**Site** is the database field name**)**: Polygons were numbered consecutively, starting at the northwest corner of the analysis area (near Dale work center) and proceeding southerly to the southeast corner by Sunrise Butte. [Note: polygon numbering was not consecutive for the **97veg** database after new polygons for the Summit and Bull fires were merged with existing (pre-fire) polygons.]

Total Area (TotArea): Total acreage within the polygon boundary; calculated using Arc/Info.

Private Area (PvtArea): Acreage within the polygon that is not owned/administered by the Umatilla National Forest; calculated using Arc/Info.

Data Source (Sour): Provides the data source for each record, as described below. [Note: this field was not used with the historical database since all of its data was derived from one source.]

Code	Description
KU	Ecoclass codes assigned by Karl Urban (pertains to plant association database only)
PI	Photo Interpretation
SE	Stand Examination
WT	Walk Through/Field Reconnaissance

Subwatershed (SWS): Provides the predominant subwatershed for each polygon. Derived by overlaying the subwatershed layer with both the historical and existing vegetation polygon layers, and then determining which subwatershed 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 **39veg** and **97veg** databases was assigned to one of two subwatershed groups, as described below:

Code	Description
Low	Subwatersheds occurring in the lower portion of the watershed (36A, 36B, 36C, 36D)
Upp	Subwatersheds occurring in the upper part of the watershed (36E, 36F, 36G, 36H, 36I)

Photo Number (Photo#): Number of the aerial photograph on which the polygon was delineated. Photo number consists of the roll number and the print number, separated by a dash (–) or a space.

Elevation (Elev): Mean elevation of the polygon; calculated by Arc/Info 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 Arc/Info after gridding the polygon into 30-meter square pixels. Value is an average of the pixels within a polygon.

Aspect (Asp): Mean aspect of the polygon; calculated by Arc/Info 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 (degree) value was converted to a compass direction 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°)

Seral Status (Seral): This derived field was based on data in the *plant association group* and *cover type* fields. It was used for the stand density analyses. Each polygon in the **39veg** and **97veg** databases was assigned to one of three seral status categories (see Hall and others 1995), as described below:

Code	**Description**
ES	Early Seral status
MS	Mid Seral status
LS	Late Seral status

Plant Association Group (PAG): Assigned by generating a new thematic map from the **DesoPNV** database, and then overlaying the resulting PAGs with the existing (**97veg**) and historical (**39veg**) polygon layers. 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
Cold Moist US	Cold Moist Upland Shrubland PAG
Cold Wet HSM RF	Cold Wet High Soil Moisture Riparian Forest PAG
Cold Wet HSM RH	Cold Wet High Soil Moisture Riparian Herbland PAG
Cold Wet MSM RF	Cold Wet Moderate Soil Moisture Riparian Forest PAG
Cold Wet MSM RH	Cold Wet Moderate Soil Moisture Riparian Herbland PAG
Cool Dry UF	Cool Dry Upland Forest PAG
Cool Moist UF	Cool Moist Upland Forest PAG
Hot Dry UF	Hot Dry Upland Forest PAG
Hot Dry UG	Hot Dry Upland Grassland PAG
Hot Dry US	Hot Dry Upland Shrubland PAG
Hot Moist UW	Hot Moist Upland Woodland PAG
Rock	Rock (talus, outcrop, etc.) PAG
Warm Dry UF	Warm Dry Upland Forest PAG
Code	**Description**
Warm Moist UF	Warm Moist Upland Forest PAG
Warm Moist UG	Warm Moist Upland Grassland PAG

Warm Wet MSM RH	Warm Wet Moderate Soil Moisture Riparian Herbland PAG
Water Lake	Water (lakes) PAG

Potential Vegetation Group (PVG): Assigned by generating a new thematic map from the **DesoPNV** database, and then overlaying the resulting PVGs with the existing (**97veg**) and historical (**39veg**) polygon layers. Refer to Powell (1998) for a description of how the PAGs were combined into PVGs.

Code	**Description**
Cold UF	Cold Upland Forest PVG
Cold US	Cold Upland Shrubland PVG
Dry UF	Dry Upland Forest PVG
Dry UG	Dry Upland Grassland PVG
Dry US	Dry Upland Shrubland PVG
High SM RH	High Soil Moisture Riparian Herbland PVG
Mod SM RH	Moderate Soil Moisture Riparian Herbland PVG
Moist UF	Moist Upland Forest PVG
Moist UG	Moist Upland Grassland PVG
Moist UW	Moist Upland Woodland PVG
Rock	Rock PVG
Water	Water PVG
Wet RF	Wet Riparian Forest PVG

Plant Association (Ecoclass1, Ecoclass2, Ecoclass3): Since a typical vegetation polygon (20-30 acres) commonly contains more than one plant association, up to three plant associations were recorded for each polygon. The **DesoPNV** database contains the 6-digit Ecoclass codes (Hall 1998) that were used to record the plant association information. There are too many Ecoclass codes to include here; see Powell (1998) or Hall (1998) for a list that relates each Ecoclass code to the plant association it represents.

Plant Community Types (PCT1, PCT2): Up to two plant community types were recorded for each polygon. The **DesoPNV** database contains the 6-digit Ecoclass codes (Hall 1998) that were used to record the plant community type information. There are too many Ecoclass codes to list here; see Powell (1998) or Hall (1998) for a list that relates each Ecoclass code to the plant community type it represents.

Structural Stage (SS): 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 (**97veg**) and historical (**39veg**) databases. Queries differed slightly by PVG. Veg Table 33 shows the structural stage queries. Refer to Oliver and Larson (1996) or O'Hara and others (1996) for definitions and further information about structural stages.

Code	**Description**
NF	Non Forest (no structural stage determined for non-forest 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

Cover Types (CovTyp): These codes describe the predominant cover type (whether vegetated or not) for each polygon. Polygons were considered nonforest when the total canopy cover of trees was less than 10 percent. For forested polygons, the cover type code represents an aggregation of similar stands 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: Not all of the codes were actually used; however, they do reflect what was available to the interpreters.]

Code	**Description**
Non-vegetated Cover Types	
AX	Administrative/Agriculture
NR	Rock Outcrop
NT	Talus/Scree
NS	Sparse/Scabland
NX	Bare Ground/Burned/Other
WL	Water (Lakes)
WR	Water (Running)
Non-forest Cover Types	
FM	Forblands
GB	Bunchgrass Grassland
GS	Subalpine/Alpine Meadow/Grassland
GX	Other Grassland
MD	Dry Meadow
MM	Moist Meadow
MS	Subalpine/Alpine Meadow
MW	Wet Meadow
SD	Dry Shrubland (sagebrush, etc.)
SL	Low Shrubs < 6’
SS	Subalpine/Alpine Shrubland
ST	Tall Shrubs > 6’ (Mtn-Mahogany, etc.)
Forest Cover Types	
CA	Subalpine Fir
CB	Whitebark Pine
CD	Douglas-fir
CE	Engelmann Spruce
CJ	Western Juniper
CL	Lodgepole Pine
CP	Ponderosa Pine
CT	Western Larch/Tamarack
CW	Grand Fir
CX	Mixed; < 50% of any one tree species
HA	Quaking Aspen
HC	Black Cottonwood

Live Canopy Cover (LivCov): Total canopy cover was recorded for polygons with a nonforest or forest cover type code – total tree cover for forest cover types; total shrub cover for shrub types; total herb cover for meadow or grassland types. Total canopy cover refers to the percentage of the ground surface obscured by live plant foliage.

Cover Class (CovCls): This derived field was based on data in the *LivCov* field. It was used for the stand density analyses. Each polygon in the **39veg** and **97veg** databases was assigned to one of four cover classes, as described below:

Code	**Description**
<=40	Live canopy (crown) cover is 40 percent or less
41-55	Live canopy cover is between 41 and 55 percent

56-70	Live canopy cover is between 56 and 70 percent
>70	Live canopy cover is 71 percent or more

Canopy Layers (#Lay): The number of canopy layers was recorded for all polygons with a forest cover type code, 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 *LivCov* field). [Note: the overstory is the tallest tree layer, whereas 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

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

Code	**Description**
BC	Black Cottonwood
DF	Douglas-fir
ES	Engelmann Spruce
GF	Grand Fir
LP	Lodgepole Pine
PP	Ponderosa Pine
SF	Subalpine Fir
Code	**Description**
WB	Whitebark Pine
WJ	Western Juniper
WL	Western Larch

Overstory Mortality (OvMor): For polygons with a forest cover type code, the abundance of dead trees (snags) was recorded for the overstory layer using these codes:

Code	**Description**
L	Low; <10 dead trees per acre
M	Moderate; 11-20 dead trees per acre
H	High; 21-60 dead trees per acre
V	Very High; >60 dead trees per acre

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 total should equal the canopy cover of the polygon as a whole (as coded in the *LivCov* field). [Note: the understory is the shortest tree layer, the overstory 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.

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

Clumpy (Clmp): For polygons with a forest cover type code, the "horizontal patchiness" or intra-stand variation was recorded using the following codes.

Code	**Description**
Blank	Not rated (nonforest polygons)
N	Continuous, non-clumpy distribution
L	Low; widely-scattered clump distribution (<30% of polygon's area)
M	Moderate clump distribution (30–70% of polygon occupied by clumps)
H	High/dense clump distribution (>70% of polygon occupied by clumps)

Disturbance (Dist): For all polygons, evidence of disturbance was recorded using these codes:

Code	**Description**
Blank	No visible evidence of disturbance
CC	Recent clearcut timber harvest
CR	Old clearcut, now regenerating
FI	Evidence of recent fire
PC	Recent partial cutting timber harvest (selection, shelterwood, etc.)
PR	Old partial cut, now regenerating
SS	Evidence of sanitation/salvage timber harvest
TH	Evidence of thinning silvicultural treatment

Veg Table 33: Structural stage methodology used for the Desolation Ecosystem Analysis (for both the historical and existing databases)

Order	PVG	OvCov	OvSiz	UnCov	UnSiz	Stage	Comments
1	Nonforest					NF	All F.., G.., M.., N.., S.., W.. polygons
2	Cold UF	>=30	88, 8, 9, 10, 11	>20		OFMS	Includes smaller size class (88) than ICBEMP (for LP, SF)
3	Cold UF	>=30	88, 8, 9, 10, 11	<=20		OFSS	Includes smaller size class (88) than ICBEMP (for LP, SF)
4	Dry UF	>=15	8, 9, 10, 11	>10		OFMS	Cover values are half of what ICBEMP used
5	Dry UF	>=15	8, 9, 10, 11	<=10		OFSS	Cover values are half of what ICBEMP used
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	Cover values are half of what ICBEMP used
9	Dry UF	<35	4, 5, 6, 77, 88	<10		SEOC	Cover values are half of what ICBEMP used
10		>=70	4, 5, 6, 77, 88	<10		SECC	
11		<=20		>=70	2 – 4	SECC	Stem exclusion under remnant overstory
12		<=20		<70	2 – 4	SI	Seeds/saps under remnant overstory
13			1, 2, 3, 4			SI	Seeds and saps are the overstory layer
14		<30	>=5			SI	Sparse overstory, but no seeds/saps are established yet
15	Dry UF	>=30	>=5	>=10		UR	Cover values are half of what ICBEMP used
16		>=30	>=5	Blank		SEOC	Sparse overstory stocking
17		>=30	>=5	<10		UR	Sparse overstory over sparse understory stocking
18		>=60	>=5	>=10		UR	
19		<60	>=5	>=10		YFMS	
20	?	?	?	?	?	?	Classify remaining polygons by hand (and refine queries)

Sources/Notes: These queries were based on a draft paper entitled “Assessing change in vegetation structure and composition at mid-scale in the Interior Columbia River Basin assessment: analysis plan” by Hessburg and Smith (1996). Order is important because it is assumed that these calculations would occur using the following query statement: “blank, changeto OFMS” (or another structural stage code). Therefore, if a polygon could meet more than one query option, a structural stage code would be assigned by the option with the lowest order number.

APPENDIX 2: 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.

Veg Table 34: 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 1998). 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.

Veg Table 35: 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 1998). 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.

Veg Table 36: Suggested stocking levels for Engelmann spruce (ES).

PLANT ASSOCIATION	FULL STOCKING LEVEL TPA	BA	CC	ES	UPPER MGMT. ZONE TPA	BA	CC	ES	LOWER MGMT. ZONE 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 1998). 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.

Veg Table 37: Suggested stocking levels for lodgepole pine (LP).

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	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 1998). 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.

Veg Table 38: Suggested stocking levels for western larch (WL).

	Full Stocking Level				Upper Mgmt. Zone				Lower Mgmt. Zone			
PLANT ASSOCIATION	**TPA**	**BA**	**CC**	**ES**	**TPA**	**BA**	**CC**	**ES**	**TPA**	**BA**	**CC**	**ES**
ABGR/VASC	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 1998). 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.

Veg Table 39: Suggested stocking levels for Douglas-fir (DF).

	FULL STOCKING LEVEL				UPPER MGMT. ZONE				LOWER MGMT. ZONE			
PLANT ASSOCIATION	**TPA**	**BA**	**CC**	**ES**	**TPA**	**BA**	**CC**	**ES**	**TPA**	**BA**	**CC**	**ES**
ABGR/VASC	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
PSME/HODI	255	139	79	14.0	191	104	74	16.2	128	70	68	19.9
Mean: Warm Moist PAG	266	145	80	13.8	200	109	75	15.9	133	73	68	19.5
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/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	270	147	79	13.9	202	110	75	16.1	135	74	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 1998). 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.

Veg Table 40: 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
PSME/HODI	340	185	70	12.2	278	152	66	13.5	186	102	58	16.4
Mean: Warm Moist PAG	311	169	68	12.8	234	127	62	14.9	156	85	55	18.2
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/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	266	145	65	14.0	131	72	51	20.5	88	48	43	25.0
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 1998). 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.

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