TABLE OF CONTENTS

CHAPTER FOUR - REFERENCE AND CURRENT CONDITION, SYNTHESIS, AND INTERPRETATION 49

CHAPTER FIVE - RECOMMENDATIONS 124

LIST OF FIGURES

LIST OF TABLES

CHAPTER ONE

WATERSHED ANALYSIS OBJECTIVES

Watershed analysis is essentially ecosystem analysis at the watershed scale. Federal agencies are directed to use an ecosystem management approach to manage public lands. The Record of Decision for Amendments to Forest Service and Bureau of Land Management Planning Documents Within the Range of the Northern Spotted Owl (ROD) requires that watershed analysis be conducted within watersheds where management activities are being proposed inside inventoried roadless areas, in order to understand the consequences of management actions *before* implementation. This is the main reason for conducting the Upper Clearwater Watershed analysis.

The objectives of the Upper Clearwater Watershed analysis are to:

- Develop a scientifically based understanding of the dominant physical, biological, and human processes and features and their interactions within the watershed.
- Use this understanding to sustain the productivity of natural resources in order to meet human needs and desires.
- Use this understanding to develop the basis to estimate direct, indirect, and cumulative effects of our management activities.
- Relate these features and processes to those occurring in the river basin or province.
- Guide the general type, location, and timing of management activities within the watershed.
- Identify restoration and rehabilitation opportunities within the watershed.
- Establish a watershed context for evaluating project consistency with ROD standards and guidelines for matrix lands.
- Establish a watershed context for evaluating project consistency with the Aquatic Conservation Strategy objectives.
- Establish a consistent, watershed-wide context for implementing the Endangered Species Act, including conferencing and consulting under Section 7.

- Establish a consistent, watershed-wide context for the protection of beneficial uses identified by the states and tribes in their water quality standards under the Federal Clean Water Act.

Watershed analysis is not a detailed study of everything in the watershed. Instead, it is built upon the most important issues which are discussed and prioritized in Chapter Three of this document. Watershed analysis is not a decision making process. It is not intended to take the place of detailed, site specific project planning and analysis under the National Environmental Policy Act (NEPA).

This watershed analysis report is a dynamic document. Additions or changes to this document may occur as new information becomes available. This is the first iteration of the Upper Clearwater Watershed analysis.

CHAPTER TWO

CHARACTERIZATION

INTRODUCTION

The purpose of this chapter is to:

- Identify the dominant physical, biological, and human processes and features of the watershed that affect ecosystem function or condition.

- Relate these features and processes with those occurring in the river basin or province.

- Provide the watershed context for identifying elements that need to be addressed in the analysis.

- Identify, map, and describe the most important land allocations, plan objectives, and regulatory constraints that influence resource management in the watershed.

GEOGRAPHICAL LOCATION

The Upper Clearwater Watershed analysis area encompasses 38,863 acres (60.7 square miles) north of Mount Bailey, south of Watson Ridge, west of Diamond Lake and Lake Creek, and east of Pig Iron Mountain, Trap Mountain, and Garwood Butte (Figure 1). It is located in all or portions of sections 24-28, 33-36, T26S, R4E; sections 19, 20, 22, 23, 25-30, 31-36, T26S, R5E; sections 1-3, 11-13, T27S, R4E; sections 1-24, 27-34, T27S, R5E; and sections 3-10, 16-18, 20, 21, T28S, R5E, Willamette Meridian, Douglas County, Oregon.

Figure 1 - Vicinity Map

LANDSCAPE OWNERSHIP, ALLOCATIONS, AND MANAGEMENT OBJECTIVES

The entire watershed is public land administered by the USDA Forest Service. All adjacent land is also administered by the USDA Forest Service.

The ROD designates the entire watershed to matrix lands. There are approximately 4,600 acres of riparian reserves and 1,035 acres within owl activity centers inside these matrix lands (Figure 3 and Figure 4). Matrix lands outside of these areas are to be managed primarily for timber production consistent with ROD standards and guidelines and Aquatic Conservation Strategy objectives. The 1990 Umpqua National Forest Land and Resource Management Plan (LRMP) allocates the watershed to Management Areas 1, 3, 10, and 11. Management Area 1 objectives focus upon providing opportunities for unroaded recreation in a semi-primitive environment. Management Area 3 objectives focus upon providing an appropriate area for development of a ski area on Mount Bailey. Management Area 10 objectives focus upon producing timber on a cost efficient, sustainable basis consistent with other resource objectives. Management Area 11 objectives focus upon providing big game winter range habitat and timber production consistent with other resource objectives (Figure 2 and Figure 5).

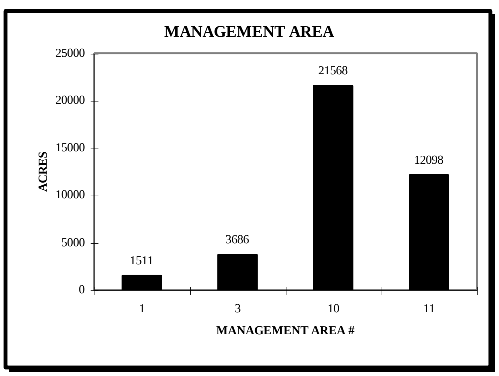


Figure 2 - Management Area distribution

Figure 3 - Map of Riparian Reserves

Figure 4 - Map of Owl Activity Centers

Figure 5 - Map of Management Areas

CORE TOPICS

GEOLOGIC FEATURES AND GEOMORPHIC PROCESSES

Introduction

The Upper Clearwater Watershed is characterized by three distinct geologic assemblages. Sherrod (1986) discussed these in terms of the Western Cascades, High Cascades, and Surficial Deposits (Figure 6). The age and composition of these rock units are based on regional mapping mapping by David Sherrod in support of his doctoral dissertation and suggest the area has a wide wide diversity of geologic features and geomorphic processes. This diversity has resulted in the development of landscapes that are important in the Upper North Umpqua Basin for a variety of resources. This section was reviewed by Dr.Sherrod, U.S.G.S, and incorporates a number of technical and editorial suggestions that were offered.

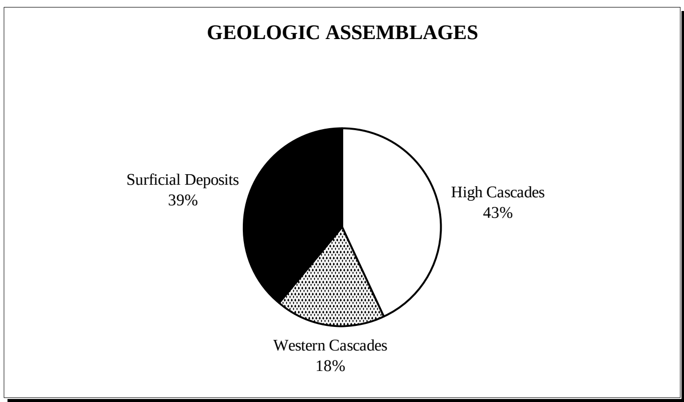


Figure 6 - Geologic assemblage distribution

Western Cascade

There are two distinctly different geologic units that make up the Western Cascade in this area. The andesite rocks (Tla) encompass three percent of the watershed and are associated with the topographic feature known as Watson Ridge. This rock was emplaced between 26 and 20 million years (my) ago based on correlations made by Sherrod. The alteration typical of Western Cascade rock units provides an understanding for the different topographic features and erosional processes evident today. Historically, this type of rock has been one of the primary sources of mineral materials for Forest Service activities, including road aggregate and surfacing material.

Figure 7 - Map of Geologic Assemblages

Approximately 11 percent of the area is underlain by the rock unit Twb, a basalt that was deposited between 9 to 17 my ago. This basalt abuts up against the andesite and extends beyond the analysis area to the north as far as Dread and Terror Ridge. Two areas within the Clearwater are dominated by this rock unit and are similar in drainage density and erosional processes (Figure 7). They are Trap Mountain, west of Bear Creek; and Elephant Mountain near the head of Mowich Creek. This basalt has features that allow for rock resource development in a number of areas. In the past, geologists have had difficulty delineating the fresher or less weathered rocks of this unit from those of the High Cascades, however the correlation work by Barnes (1978) and age dating by Sherrod (1986) leave little doubt on the age and development of this unit.

High Cascade

The rocks associated with the High Cascades in this area can be defined as lava flows with pyroclastic deposits in localized areas. These lava flows are associated with the development of young volcanoes such as Mt. Bailey, as well as older vents like Garwood Butte.

A complex of basaltic andesite that extends along the west slope of Bear Creek is identified as Qtba (three percent) and is about one to two my old. This rock unit originated from a vent complex associated with Garwood Butte and apparently flowed down the ancestral Bear Creek drainage.

The Toketee Basalt (Qbt) encompasses approximately 16 percent of the basin. This rock unit extends far beyond the boundaries of the analysis area and influences the landscape throughout the Upper North Umpqua system. This basalt unit developed as a series of intra-canyon basalt flows with a minor breccia component evident. Although the source of this deposit is now buried beneath the Mazama ash, it appears to be in the vicinity of the headwaters of the Clearwater River and Lava Creek. The large flats associated with Mowich Park comprise a significant portion of this unit, with a smaller exposure identified near Toolbox Meadows.

The Toketee Basalt has characteristics common to intra-canyon basalt, including extensive columnar jointing patterns and the development of large benches and cliffs. Although this rock unit is close to one million years old, it is very resistant to erosion and shows little evidence of stream development. Based on the known exposure, it appears that the ancestral canyon filled by this deposit was over a mile wide in some areas.

Another feature associated with this basalt as well as other lava units in the High Cascade is the storage and recharge capacity that affects runoff rates. These porous and permeable lava flow units act as large reservoirs, capturing snowmelt and systematically releasing water at more uniform rates that extend into the summer season via an extensive network of springs (Ingebritsen et. al. 1994).

A series of vent exposures identified as Qtmv are a small but important component of the geologic record. These are the features that served as the predominant source of the lava flows seen in the basin and were used by native Americans for vision quests. Rodley Butte and

Garwood Butte are two noticeable examples of this rock unit and tend to be steep sided topographic promontories with little soil development.

There is a small basaltic unit identified as Qoba, south of Highway 138 above the Clearwater River crossing, that is distinctly different from the other basalt because it lacks the vesicular texture that predominates most of the younger basalt and andesites. This basalt appears to be older than the surrounding rock units and correlates with the Toketee basalt. The primary difference may be the timing and or depositional environment that resulted in a lack of vesicles. This feature is necessary for a quality aggregate source that requires crushing.

Basaltic Andesites (Qyba) occur on 24 percent of the analysis area and are associated with the development of the north slope of Mount Bailey. These deposits are known to be less than 100,000 years old and could be significantly younger. This highly vesicular rock is the basis for the present day cone of the mountain as well as Rodley Butte and similar vents, which probably developed after the original eruptive period. Little is known about the geologic structure of this bedrock unit due to limited exposures. Although the deposit has a diversity of topographic expressions, there is little evidence of running surface water. The topographic features identified on the maps typically represent local changes in the character of the flow due to mineralogy or cooling patterns. The interconnecting three dimensional joints and fractures allow for horizontal and vertical migration of groundwater through the unit.

A predominant visual feature in the Clearwater watershed is Mount Bailey. Bedrock adjacent to the peak is a young andesite identified as Qya, which is probably some of the youngest volcanic lavas in the area. This rock unit forms the steep sides and summit which is similar to Mt. Theilsen. Unlike Mt. Thielsen, Mt Bailey has been subjected to only minor glaciation that predominated the landscape 25,000 to 12,000 years ago. Recent studies by Sherrod and Smith, 1990, suggest that five to six cubic kilometers (km^3) of material was extruded by Mount Bailey during its eruptive period.

Comment [TS1]:

Surficial Deposits
Much of the analysis area is covered by unconsolidated alluvium and colluvium or slightly indurated glacial till deposits. Some of these deposits accumulate over time and contribute to changes in ecological conditions. Alluvial deposits, colluvium, and landslide deposits are characteristic of the current temperate-humid environment. Other surficial deposits such as glacial drift and outwash correspond to distinct climatic episodes evident in the geologic record. The climax tephra eruption of ancestral Mt. Mazama about 7000 years ago resulted in a significant surficial deposit of pyroclastics, primarily deposited as ash flows down several major drainages. Both of the above mentioned deposits continue to play a role in the ecological processes in the basin.

Approximately 24 percent of the area is underlain by glacial deposits (Qgd), which are predominantly stratified and unstratified glacial tills associated with ground, lateral, and terminal moraines. These deposits are poorly sorted sediments consisting of a fine grained matrix and a large assortment of pebbles and cobbles common to weathering process of volcanic materials.

Occasional deposits of larger boulders are observed, particularly around the lateral moraines parallel to Bear Creek and Lake Creek.

There appears to have been several distinct periods of glaciation within the analysis area (Scott 1977). The glacial drift identified north of Mowich Creek appears to be substantially older than any of the other deposits in the Upper North Umpqua Basin (Sherrod 1986). It has been suggested that this glacial feature overlies the Toketee Basalt and predates most of the High Cascade rocks. The remainder of the glacial deposits appear to be associated with glacial episodes that occurred 25,000 to 12,000 years ago during the Frazier period.

The lateral moraines that lie parallel to Bear Creek are significant features that merit discussion. They form long ridges that serve as the topographic divide between Lost Creek on the east and Trap Creek on the west. These ridges extend for a number of miles in a northerly direction and exceed 300 meters (m) in elevation. Several other glacial deposits are identified that appear to be associated with more recent glacial advances. With the exception of a small amount of glacial drift on the west side of Trap Creek, these deposits overlay High Cascade volcanic rocks. The deposits that extend beyond the east edges of the analysis area serve as the topographic divide between the Clearwater River and Lake Creek. There has been speculation that there may be a shallow subsurface groundwater connection between the west slope of Lake Creek and the Upper Clearwater Watershed (Sherrod 1995, Personal Communication).

The west slope of the analysis area below Trap Mountain shows evidence of localized mountain glaciation in a number of the tributaries to both Trap Creek and Upper Bear Creek. U-shaped valleys, glacial drift and several small impoundment's were identified during the analysis process.

The primary deposits associated with the tephra eruptions of Mt. Mazama (Qaf) encompass 16 percent of the analysis area. This material is primarily unsorted white ash with pumice lapilli and bombs up to 40 cm in size. The pumice was deposited as a pyroclastic ash-flow event associated with the eruption of 40 to 50 km^3 of material (Sherrod and Smith 1990). The analysis area contains two distinct topographic settings that controlled the deposition of the ash flows. Historically, Bear Creek was an incised canyon with a steep gradient, while the Upper Clearwater was probably a broad depositional area. The erosional process affecting the pumice deposits are characteristic of the topographic features that existed prior to the eruption.

The ash flow which traveled over the flank of Mt. Bailey, filling the ancestral Bear Creek canyon, is 30 to 50 meters thick and shows evidence of reworking in several of thicker sections. This is identifiable by the lack of a strong pinkish horizon in deposits where the cooling process was interrupted. The abnormally thick accumulations of this material between Old Man Camp and Forest Service Road 4785 contain sections of stream channel that appear unique to the Forest in terms of channel development and erosional processes.

The pyroclastic flows that blanketed the ancestral Clearwater River are widespread and on average 10 to 20 meters thick. These deposits cover a much larger surface area and tend to influence a much larger landscape than those of Bear Creek. Three significant stream systems have developed along the geologic contact between these deposits and older units: the Clearwater River, Lava Creek, and Lost Creek.

Geologic Structures Significant to the Upper Clearwater River

Bear Creek is associated with the trace of the Rogue River Fault (Barnes 1978) and has been suggested as the boundary between the High Cascade and Western Cascade sub-provinces. Although the fault is buried under younger volcanic rocks and surficial deposits for most of its length, it was identified along Bear Creek and is associated with the bedrock reach below Old Man Camp. Sherrod (1986) identified about 300 meters of displacement in Western Cascades rocks relative to a marker bed of tuffaceous material and dated the fault to be 15 my old. This offset is typical of a down-dropped block (graben) and probably extended for a considerable distance to the east.

While there are no indications of movement along this fault in the past 15 my, it still controls the development of the Bear Creek drainage. The graben was subjected to infilling by several periods of High Cascade volcanism and surficial deposits that are exposed today. Since then, the erosional processes have continued to develop the current drainage system.

Geomorphic Processes

There are two significant geomorphic processes that are important in the Upper Clearwater Watershed as well as the North Umpqua River. The contribution of cold, clear water from the Clearwater River as well other tributaries of the upper North Umpqua has been recognized for years. Little was known about the interactions of the source areas and processes that affected water quality (primarily flow and sediment). This discussion attempts to clarify some causal mechanisms for the area’s water storage capacity and it’s ability to maintain base flows and minimize peak flow response.

By examining the analysis area stratified by sub-provinces and surficial deposits described previously, the importance of the units in terms of base flow source, peak flow response, and sediment production was characterized. The Western Cascade sub-province is characterized by old rock units that have undergone substantial alteration, weathering, and erosion. This is particularly evident in the vicinity of Watson Ridge and Trap Mountain. In these areas the drainage development was significantly older with estimated drainage densities averaging 1.3 miles/mile^2 (Table 1). This number is significantly lower than other areas studied and could be explained by the large amount of overlying surficial deposits in the area.

Table 1- Drainage density by geologic assemblage

GEOLOGIC ASSEMBLAGE	DRAINAGE DENSITY (miles/mile^2)
Western Cascades	1.3
High Cascades	0.7
Surficial Deposits	4

The chemical alteration and weathering processes of these older rocks has affected both porosity and permeability functions that influence water holding capacity. As a result, these older rock units have more ability to transport surface flow in an efficient manner, which allows for an increase in surface runoff in response to climatic events. In addition, the effective erosional forces are increased proportionately and under certain conditions provide for higher erosion rates. This assumes a landscape condition that is unaffected by management activities. Several areas indicate the potential for relatively high sediment production, particularly associated with streams. The weathering processes associated with these rocks provide for an assortment of particle sizes, particularly large boulders as well as high clay proportions in some areas. Although there was little evidence of mass wasting, it has occurred throughout the area and contributes to unsorted deposits of material, occasionally as debris slides and flows. Surface erosion is likely to be the source of fine sediments that could be the source of turbidity in several subwatersheds, particularly Bear Creek and Trap Creek.

The volcanic rocks associated with the High Cascade sub-province have properties that support the storage of large volumes of groundwater and allow for a sustained release throughout the water year (Ingebritsen et al. 1994). There are several geologic features that contribute to this process. The porosity and permeability of the relatively young rock units have not been altered by weathering processes or structural alteration. The uniform mineralogy of the basalt and andesites allow for a large volume of material with similar storage capacity. The common occurrence of joints and fracture patterns in the basalt allow for migration of surface water vertically through the profile. The resistant nature and youthful topography of the lava units contributes to the lack of stream development. Drainage densities were calculated for these rock units and averaged 0.7 miles/mile^2 (Table 1). This density correlates well with other areas of the High Cascades and supports the concept of subsurface flow processes as a primary component in the hydrologic regime. All of these factors serve to minimize the response of surface flow under peak events. As found in other basins, the expected response to a typical rain-on-snow event would be minimal compared to that of a Western Cascade system.

There appears to be an important relationship between the air fall pumice deposits found as part of the soil profile and the potential for peak flows. An assessment of the flow records that incorporate data within the 0.5 meter isopach of the Mazama air fall indicate that there may be a relationship between peak flow discharge and storage capacity of the pumice. In essence a fairly thin deposit of pumice may serve as an efficient buffer to peak flow events by virtue of its ability to absorb a high percentage of moisture prior to reaching a saturated condition.

During the course of the analysis process, we discovered that a stream identified as Lost Creek, which drains the north slope of Mt. Bailey, was in fact a topographic feature associated with the contact between a large volcanic deposit and a glacial moraine. There was no indication of any surface streams in this subwatershed. During field investigations, a significant tributary to the Upper Clearwater River was identified emerging as a series of springs along the contact between the basalt, glacial drift, and ash-flow. Based on limited flow information, we are suggesting that this is the sole outlet for about 9 miles^2 of drainage area. Based on these observations, this poses a question as to what are the controlling features for this spring complex. It is hypothesized that the dip of the basalt unit, trending north to west, allows migration of the groundwater to a point where its confined by the Bear Creek fault and an indurated ashflow deposit parallel to the Clearwater River until it reaches an elevation that allows for surface flow as a spring complex or as accretion flows to Bear Creek.

Under most circumstances, the erosional process associated with this terrain are confined to moderate to steep slopes with developed soil profiles. The Upper Clearwater Watershed has a limited amount of this terrain, primarily associated with localized slopes adjacent to riparian areas and along geologic contacts. In general, the volcanic material in this unit has a tendency to weather from sand to cobble size material and often lacks the fine sediment component that affects turbidity, at least in undisturbed terrain.

The surficial deposits that encompass 39 percent of the Upper Clearwater Watershed include glacial drift as well as Mazama ash. Since these are relatively thin deposits that overlay the older rock units, there is little evidence that these units directly affect the storage capacity of the hydrologic regime, with the exception of surface flow. Drainage density in these deposits increases dramatically to about 4 miles/mile^2 (Table 1). The aquifers that are significant in this area are influenced by the High Cascade rocks and not the surficial deposits that cover them. Under the 1990 L.R.M.P., approximately 9650 acres were identified as aquifer lands. Based on the understanding of the High Cascade rocks and their storage capacity, it is estimated that there are about 20,000 acres of the watershed that are aquifer lands.

There are several erosional processes in this unit that are distinctly different than the older volcanic rocks and merit further discussion. The unconsolidated and poorly sorted glacial drift has a fine textured matrix that is subject to extreme erosion when disturbed. Mass wasting has been identified as an erosional process that occurs in localized areas, typically in association with disturbance on slopes in excess of 50 percent. Surface erosion is the predominant process over much of the area and is controlled by the amount of surface area exposed. Areas where stream systems intercept these glacial deposits are often associated with banks and raveling slopes that are chronic sediment sources. Due to the nature of the deposits, surface erosion can provide a wide array of particle sizes available for transport and delivery to the stream system, with a high percentage of fine sediment.

The pyroclastic ash deposits are subject to erosion whenever water is concentrated on them. In an undisturbed state, they allow rapid permeability and may serve as effective buffer to peak flow events due to the tremendous void space. However, where water is diverted or concentrated, rapid erosion, usually as rill, inter-rill, and gullying occurs. In areas where there is a delivery mechanism that transports these to streams, noticeable impacts on a variety of habitats have been observed.

Stream development in the ash deposits occurred fairly rapidly and appears to have reached base level in most locations (Sherrod, Personal Communication). With the exception of several reaches of Bear Creek, the majority of the streams that are associated with the pumice appear to be affected by sources of moderate sedimentation that is contributed by the adjacent stream banks. Two reaches of Bear Creek exhibit features that are controlled by an inner flood plain that has been established at the base of abnormally high (50 meters) stream banks and a meandering stream channel. Observations during the course of this analysis identified a significant number of bank failures occurring on a regular basis as the stream continues to undercut the steep banks. It was estimated that these sections are contributing an abnormal amount of the entire sediment load to Bear Creek and could be affecting the water quality in the Clearwater River.

While these surficial deposits are not significant in the storage of groundwater, the interface between these deposits and other geologic units is where the headwaters of three major streams emerge as springs to feed the Upper Clearwater River. Lava Creek, the Clearwater River, and Lost Creek are associated with large spring complexes that combine to provide three quarters of the base flow above Stump Lake. These complexes appear to migrate across the landscape, and encompass a much larger area than expressed as surface flow.

SOIL

Soils within the Upper Clearwater Watershed can be divided into three general groups. Each group is closely associated with a geologic subprovince or surficial ashflow deposit.

- Soils of the Western Cascade sub-province are moderately deep and dark colored, fine, and fine-loamy, derived from the residual basalt and clay sediments. Natural bulk densities can be expected to be 0.85 to 0.90 grams per cubic centimeter (g/cc). These soils are easily puddled and compacted when wet, but have relatively high strength when dry. Surface litter layer generally ranges from 5 to 7 cm in depth. On slopes greater than 30 percent, surface erosion hazard is especially significant when vegetation is removed.

- Soils of the High Cascade sub-province are generally coarse, loamy, and shallow to deep, derived from basaltic andesite, glacial till, and outwash. They usually have low soil organic matter content and low plant-available water-holding capacities (8 to 10 cm). The surface litter layer generally ranges from 1 to 5 cm in depth. Soil displacement and erosion represent potential hazards to long-term productivity, particularly on slopes greater than 30 percent. Organic matter, surface soil nutrients, and moisture conservation are likely critical on these soils for maintaining long-term productivity.

- The soils derived from the pumice ashflows are coarse textured, but store relatively high plant-available water (25 cm) (Chappel 1992). The nutrient exchange processes in these soils are dependent on the soil organic matter content which is concentrated within 15 to 25 cm of the surface. Nutrient content therefore declines rapidly with depth. The surface litter layer ranges from 2.5 to 5 cm in depth. Although these soils are relatively resilient and highly productive, conserving organic matter and minimizing soil displacement are critical to maintaining long-term site productivity (Harvey et al. 1987, 1989). The depth of these pumice soils can vary from 30 to 150+cm. In cases where the buried loamy soil is within rooting depth there is an improvement in site quality. Natural bulk densities can very from 0.6 to 0.75 g/cc depending on the nature of the ashflow deposition. These low densities provide for rapid infiltration and good aeration. Recent monitoring suggests these soils may be highly susceptible to compaction with increases in soil moisture. These soils are typically low in calcium and magnesium.

Approximately one percent (290 acres) of the Upper Clearwater Watershed has been mapped as unsuitable for timber management due to reforestation limitations. Overall soil sensitivity to disturbance ranges from moderate to high within the watershed (Figure 8). Overall sensitivity is based on susceptibility and resiliency of Soil Resource Inventory Units (SRI) to erosion, nutrient loss, and compaction. Areas mapped with low sensitivity have resilient soils with the ability to absorb or recover from impacts without significant loss of long-term site productivity. Within the watershed, 15,000 acres (38 percent) recieved a high sensitivity rating. Table 2 shows the distribution of high sensitivity soils for each subwatershed (Figure 31). These are areas with a high probability of having soils with low soil organics, low inherent fertility, and weak soil structure.

Table 2 - Distribution of high overall sensitiviy to soil disturbance

	WATERSHED	**SUB WATER SHED**							
HIGH SENSITIVITY	**TOTAL**	**12D**	**` 12E**	**12F**	**12G**	**12H**	**12I**	**12J**	**12K**
%	38	38	14	54	39	33	39	32	43
ACRES	14,581	1,462	374	1,688	1,484	1,577	1,784	1,798	4,414

Figure 8 -Map of Overall Soil Sensitivity

HYDROLOGY

The Clearwater River is a tributary draining 60 square miles of the North Umpqua River watershed. The North and South Umpqua flow from the crest of the Oregon Cascades to the Pacific Ocean. They drain roughly a quarter and a third of the 4,560 square-mile Umpqua River basin, but the North Umpqua summer flow is ten times that of the South. Flow of 750 cubic feet per second (cfs) of the North Umpqua joins 80 cfs from the South Umpqua below Roseburg, and 970 cfs flow past Elkton through the Coast Range to the ocean (1-day, 2-year low flows).

The North Umpqua is famous for its summer steelhead and spring chinook, and the high summer flow that attracts them. The Clearwater River flows 120 cfs or more in most years, or one-fifth the flow of the North Umpqua where they meet at Toketee reservoir. People recognized long ago that most of the Umpqua River flowed from the High Cascades above Soda Springs, and stream gages were installed in the 1920s. Constant flow provided hydroelectric power, and Pacific Power’s Clearwater, Upper North Umpqua, and Fish Creek diversions were built in the early 1950s. Since then, 95 percent of the Clearwater has flowed through a canal at Stump Lake diversion to a forebay, penstock, and powerhouse at the mouth of Mowich Creek. After canal diversions and storage on each of its three tributaries, water is returned to the North Umpqua Wild and Scenic River below Soda Springs reservoir. Besides hydropower generation, other beneficial uses of the river within the watershed analysis area include recreation at Clearwater and Whitehorse Falls Campgrounds and Stump Lake, habitat for fish and aquatic life, and drinking water at a Pacific Power residence at Clearwater 1 powerhouse.

Almost as much water flows from the Clearwater River as falls on the basin as rain or snow. River flow averages 70 inches per year, and annual precipitation ranges from 47 inches at Toketee Falls to 80 to 90 inches on Mount Bailey.

Nine-tenths of the Clearwater’s summer flow comes from young, fractured basalt in the High Cascade geologic terrain upstream of Bear Creek. Mowich, Trap, and Bear Creeks have flashier peaks in winter and spring, and their channels are wider and shallower. The gentle, constant flow from the headwaters of the Clearwater, Lava, and Lost Creeks changes little from summer to winter.

WATER QUALITY

The Clearwater River is kept cool by groundwater near 40 degrees Fahrenheit (40F). When the North Umpqua below Steamboat is 65F in July and August, and it’s tributaries are 65-75F, the Clearwater might reach a maximum of 50F. Bear Creek and Mowich Creek, with less groundwater flow, are 5 and 10 degrees warmer. The Pacific Power diversion leaves only 5 cfs in the river below Stump Lake, and it quickly warms to 64F. In winter, water temperatures get as low as 34F, then drop to freezing from Stump Lake to Mowich Creek.

Dissolved oxygen, pH, and turbidity in the river usually meet water quality standards (PacifiCorp 1995), except when the canal is shut down for maintenance and flow is suddenly turned back into the channel. That can flush sediment and nutrients from channel banks, and last for several hours. In late summer and fall, the low flow remaining below the diversion sometimes results in low dissolved oxygen during the time brook trout spawn.

Nitrogen and phosphorous are highest in summer and fall, when flow is lowest. These nutrients are used by floating and attached algae, which can cause high and low daily swings of pH and dissolved oxygen downstream. The North Umpqua sometimes exceeds water quality standards for pH. The Clearwater River has the highest phosphorous concentrations measured in the North Umpqua by Pacific Power since 1992, but most observers agree that nitrogen is what limits the growth of algae in this river. While Clearwater River dissolved nitrogen is low, small increases from erosion, timber harvest, fertilizer, or reservoir storage might cause algae growth and water quality changes downstream.

STREAM CHANNEL

Clearwater River

The Clearwater River flows approximately 8.3 miles through the analysis area, from the headwaters in the northeast corner of the analysis area to the site of the Clearwater #2 diversion dam at the analysis area boundary. The portion of the Clearwater River included in the analysis area can be divided into two segments, that occurring upstream from Stump Lake and that occurring downstream from Stump Lake. The Clearwater River segment from the headwaters to Stump Lake is approximately 5 miles in length. Clearwater Falls is located approximately 2 miles downstream from the river headwaters. The reach between Clearwater Falls and Stump Lake is a moderate gradient, heavily riffle dominated system of the Rosgen (1994) "B" channel type. Some woody material is present below Clearwater Falls, but in limited amounts. The portion above Clearwater Falls has not been surveyed. From below Stump Lake to the analysis area boundary at the Clearwater #2 diversion dam, the stream channel is approximately 3.3 miles in length. The channel features of this lower segment are influenced by the North Umpqua Hydroelectric Project. The channel substrate of this lower segment is dominated by cobble and boulder sized material. Very little gravel substrate is present. Trap Creek enters this reach, with the only source of sediment from a tributary. Woody material is present, but in limited amounts. The stream channel type in this segment is predominantly of the Rosgen (1994) "B" type, with some "C" type channel present in the reach immediately downstream from Stump Lake.

The Upper Clearwater above Lava Creek and Lost Creek has only low gradient, intermittent streams which have not scoured discernible channels to the river. Streams sometimes flow during winter or spring runoff, without forming permanent channels. The only apparent channel of Lost Creek is the 0.6 mile spring flow entering the river above the confluence with Bear Creek.

Mowich Creek

Mowich Creek flows approximately 6.9 miles southwest through the analysis area, from the headwaters near the southeastern slopes of Watson Ridge to the creek confluence with the Clearwater River at the site of the Clearwater #2 diversion dam. Mowich Creek can be divided into two different stream segments based on gradient and channel morphology. The upper segment is approximately 4.2 miles in length and flows through Mowich Park, a topographic expression of High Cascade basalts. This upper segment has not been adequately surveyed, but is a lower gradient system and appears to be a Rosgen (1994) “C” channel type. Channel substrates are dominated by gravel and sand. A moderate amount of woody material is believed to be present. The lower segment is approximately 2.7 miles in length and has carved a canyon through Western Cascade rocks. This stream segment is a higher gradient system composed of Rosgen (1994) “A” and “B” channel types. The stream substrate is dominated by small and large boulder sized material. The channel has a stair-step profile with many boulder created dams and plunge pools. The quantity of pools and riffles is very evenly divided, and glides are essentially absent.

Headwater streams flow into Mowich Creek from Watson Ridge within the Western Cascade geologic assemblage. These are steep (15 to 20 percent) Rosgen “A” and “B” channel types that are confined upstream and dominated by gravel and cobble substrate. A tributary to Lower Mowich is controlled by boulders as it descends through High Cascade basalt into the canyon. Valleys are flatter and wider through the surficial deposits near Mowich Creek and stream channels are less stable (see Appendix Hydrology for modified Pfankuch channel stability descriptions). Debris flows in the headwaters contribute to channel instability, despite the more resistant Western Cascade landform.

Lava Creek

Lava Creek originates in the northeastern corner of the analysis area and flows approximately 4.7 miles southwest to the confluence with the Clearwater River, approximately halfway between Clearwater Falls and Stump Lake. The creek mainstem flows through an area of surficial pyroclastic ash deposits originating from Mt. Mazama. Lava Creek is a lower gradient system dominated by the Rosgen (1994) “B” channel type, with some “E” type channel present near the headwaters. The stream substrate is dominated by gravel and sand. Lava Creek is a spring fed system with “glide like” riffles dominating the system. Substrate embeddedness is high throughout the stream. Very little woody material is present. The stream flows through a number of meadows, especially in the upper reach.

One headwater tributary of Lava Creek begins in the Western Cascades below Watson Ridge and Elephant Mountain, and drops at a gradient of five to fifteen percent to Little Bear Lake. The Rosgen “B” channel has gravel substrate increasing to cobble size nearer the mouth, where it is less stable as it crosses surficial deposit terrain. There is no evidence of a channel in the one to three percent slope to the lake and meadow, but water flowed on the surface during rainfall and snowmelt in the winter of 1995-96.

Bear Creek

Bear Creek originates near the southern boundary of the analysis area, flows north for approximately 7.6 miles, and empties into Stump Lake. Most of the mainstem flows through surficial pyroclastic ash deposits, with the mid-section flowing through a gorge controlled by resistant rocks associated with High Cascades and Western Cascades units. Bear Creek begins as a low gradient channel, enters a more confined higher gradient reach through the gorge, and returns to a lower gradient system in the lower reaches. The lowest stream reach flows through a marshy area as the stream enters Stump Lake. The upper stream reach is a Rosgen (1994) “B” type channel, the mid-section is an “A” type channel, and the lower reaches are “C”, “B”, and “E” type channels. Sand and gravel dominate the substrate in all but the higher gradient mid-

section, where cobble sized material dominates. Woody material is present in moderate amounts in the upper half of the stream, and is abundant in the lower half.
The headwater streams in surficial deposits of Bear Creek were the least stable, most actively eroding channels we observed in the watershed analysis area. These are Rosgen “B” and “C” channels, sometimes confined by 60 percent sideslopes to “A” channels, with gradients from zero to 15 percent. Channel bottoms are mostly gravel and sand. One stream adjacent to Bear Creek road begins in an eroding “G” (gully). Channel stability is low in most stream reaches. Through Old Man Camp meadow is a Rosgen “E” channel that has been heavily grazed. The meadow stream has collapsed banks and is forming “C” channel bars. Bear Creek channels through surficial deposits are naturally unstable, and the most sensitive we found to added runoff or sediment.

Trap Creek
Trap Creek originates near the western boundary of the analysis area and flows northwest for approximately 2.5 miles to the Clearwater River. It enters the river between Stump Lake and Whitehorse Falls. The creek mainstem flows through glacial drift surficial deposits. Mainstem gradients are low, and the stream substrate is dominated by sand and gravel. The channel type is predominantly Rosgen (1994) “E” type, with some “C” type channel present near the creek mouth. Very little woody material is present in the channel. Several intermittent tributaries to Trap Creek flow through the Western Cascade geologic assemblage. These channels are deeply incised, high gradient, bedrock controlled “A” channel type systems.

Two tributaries of Trap Creek and the lower Clearwater were surveyed, both originating in Western Cascade geologic assemblage. These were steep, Rosgen “A” and “B” channels dominated by cobble and boulder bottoms. Channel gradients reached 50 percent, except across surficial deposits near Trap Creek and the Clearwater, where streams flattened to less than 15 percent. One tributary disappeared in surficial deposits before reaching the Clearwater at Whitehorse Falls. In the surficial deposits the banks have less rock than in the Western Cascades, and there is more gravel substrate. As was found elsewhere in the analysis area, streams were less stable through the surficial deposits than through the Western Cascade geologic assemblage.

VEGETATION

Natural disturbance, climate, soils, and man's activities have shaped the landscape pattern of plant communities and seral stages in the watershed. These factors are responsible for the high diversity of seral stages, landscape patterns, and plant communities that exist today.

Seven plant series are represented within the watershed. They include the Western Hemlock, Mountain Hemlock, Douglas-fir, White Fir, Pacific Silver Fir, Shasta Red Fir, and Lodgepole Pine Plant Series (Figure 9 and Figure 10). Generally, the Western Hemlock, White Fir, and Douglas-fir Plant Series occur below 4,500 feet in elevation and the Pacific Silver Fir, Shasta Red Fir, Lodgepole Pine, and Mountain Hemlock Plant Series occur above 4,500 feet in elevation.

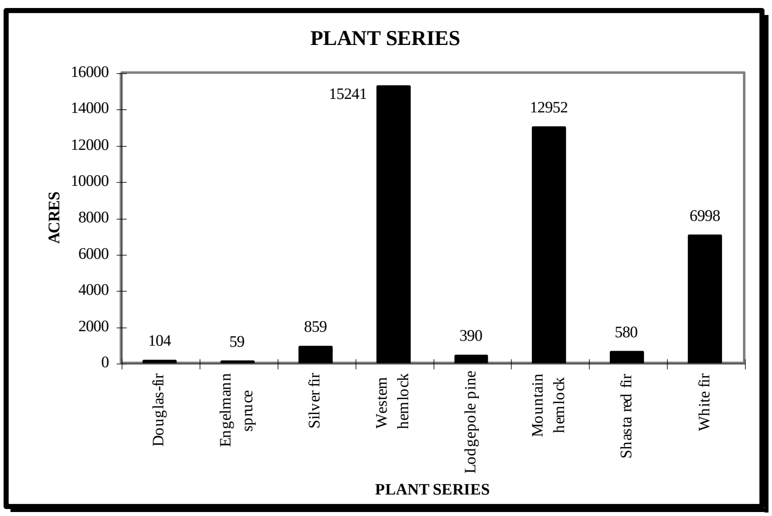


Figure 10 - Map of Plant Series

Table 3- General plant successional patterns

	MAJOR PLANT SPECIES PRESENT			
PLANT SERIES / Association	**0 - 20 YEARS (Early Seral)**	**20 - 50 YEARS (Mid Seral)**	**50 - 80 YEARS (Mid Seral)**	**80 - 200+ YEARS (Late Seral)**
LODGEPOLE PINE	Lodgepole pine, pinemat manzanita, squaw carpet, currants, grasses, lupine	Lodgepole pine, pinemat manzanita, squaw carpet, grasses	Lodgepole pine, grasses	Lodgepole pine, pinemat manzanita, squaw carpet, currants, grasses, lupine
MOUNTAIN HEMLOCK / Subalpine fir	Mountain hemlock, lodgepole pine, sedge, grouse huckleberry	Mountain hemlock, lodgepole pine, subalpine fir, sedge, grouse huckleberry	Mountain hemlock, lodgepole pine, subalpine fir, grouse huckleberry	Mountain hemlock
MOUNTAIN HEMLOCK / Grouse Huckleberry	Mountain hemlock, Shasta red fir, lodgepole pine, western white pine, pinemat manzanita	Mountain hemlock, Shasta red fir, lodgepole pine, western white pine, pinemat manzanita, grouse huckleberry, common prince's pine	Mountain hemlock, Shasta red fir, lodgepole pine, western white pine, grouse huckleberry, common prince's pine	Mountain hemlock, Shasta red fir, common prince's pine
PACIFIC SILVER FIR	Douglas fir, Shasta red fir, lodgepole pine, western white pine, Engelmann spruce, thin-leaved huckleberry	Douglas fir, Shasta red fir, lodgepole pine, western white pine, thin-leaved huckleberry, mountain hemlock, western hemlock, Pacific silver fir, Engelmann spruce, bramble, prince's pine	Douglas fir, Shasta red fir, lodgepole pine, western white pine, thin-leaved huckleberry, mountain hemlock, western hemlock, Pacific silver fir, Engelmann spruce, bramble, prince's pine	Douglas fir, Shasta red fir, thin-leaved huckleberry, mountain hemlock, western hemlock, Pacific silver fir, Engelmann spruce, bramble, prince's pine
SHASTA RED FIR	Douglas fir, Shasta red fir, lodgepole pine, western white pine, thin-leaved huckleberry, boxwood	Douglas fir, Shasta red fir, lodgepole pine, western white pine, white fir, mountain hemlock, thin-leaved huckleberry, boxwood, prince's pine, bramble	Douglas fir, Shasta red fir, lodgepole pine, western white pine, white fir, mountain hemlock, thin-leaved huckleberry, boxwood, prince's pine, bramble	Douglas fir, Shasta red fir, white fir, mountain hemlock, thin-leaved huckleberry, boxwood, prince's pine, bramble
WHITE FIR / Mountain Hemlock, Shasta Red Fir, or Pacific Silver Fir	Douglas fir, Shasta red fir, white fir, western white pine, thin-leaved huckleberry, dwarf Oregongrape	Douglas fir, Shasta red fir, white fir, western white pine, mountain hemlock, Pacific silver fir, Engelmann spruce, thin-leaved huckleberry, dwarf Oregongrape, prince's pine, twinflower	Douglas fir, Shasta red fir, white fir, western white pine, mountain hemlock, Pacific silver fir, Engelmann spruce, thin-leaved huckleberry, dwarf Oregongrape, prince's pine, twinflower	Douglas fir, Shasta red fir, white fir, mountain hemlock, Pacific silver fir, Engelmann spruce, thin-leaved huckleberry, dwarf Oregongrape, prince's pine, twinflower
WHITE FIR / Common Prince's Pine-Pyrola	Douglas fir, white fir, western white pine, western hemlock, ponderosa pine, golden chinquapin, bracken fern, blackberry, boxwood, snowbrush	Douglas fir, white fir, western white pine, western hemlock, ponderosa pine, golden chinquapin, boxwood, dwarf Oregon grape, prince's pine	Douglas fir, white fir, western white pine, western hemlock, ponderosa pine, dwarf Oregon grape, prince's pine	Douglas fir, white fir, western hemlock, ponderosa pine, dwarf Oregon grape, prince's pine
WHITE FIR / Incense-Cedar-Dwarf Oregongrape / Snow Bramble-Vanillaleaf	Douglas fir, white fir, incense cedar, golden chinquapin, braken fern, blackberry, baldhip rose, snowbrush	Douglas fir, white fir, incense cedar, golden chinquapin, baldhip rose, dwarf Oregongrape, prince's pine, snow bramble, creeping snowberry	Douglas fir, white fir, incense cedar, dwarf Oregongrape, western starflower, vanilla leaf, western twinflower, prince's pine, snow bramble, creeping snowberry	Douglas fir, white fir, incense cedar, dwarf Oregongrape, western starflower, vanilla leaf, western twinflower, prince's pine, snow bramble, creeping snowberry
WESTERN HEMLOCK / Dwarf Oregongrape-Western Twinflower	Douglas fir, white fir, western white pine, golden chinquapin, braken fern, blackberry, vine maple, baldhip rose, snowbrush	Douglas fir, white fir, western white pine, western hemlock, golden chinquapin, vine maple, baldhip rose, dwarf Oregon grape, prince's pine	Douglas fir, white fir, western white pine, western hemlock, vine maple, dwarf Oregon grape, prince's pine, vanilla leaf, western twinflower, threeleaf anemone, rattlesnake plantain, white trillium	Douglas fir, white fir, western hemlock, dwarf Oregon grape, prince's pine, vanilla leaf, western twinflower, threeleaf anemone, rattlesnake plantain, white trillium
WESTERN HEMLOCK / Pacific Silver Fir-Thin Leaved Huckleberry	Douglas fir, western white pine, blackberry, bracken fern, thin leaved huckleberry	Douglas fir, western white pine, Pacific silver fir, western hemlock, thin leaved huckleberry, dwarf Oregon grape, prince's pine, vanilla leaf, western twinflower	Douglas fir, western white pine, Pacific silver fir, western hemlock, thin leaved huckleberry, dwarf Oregon grape, prince's pine, vanilla leaf, western	Douglas fir, Pacific silver fir, western hemlock, thin leaved huckleberry, dwarf Oregon grape, prince's pine, vanilla leaf, western twinflower

			twinflower	

Early, mid, and late seral stages occur in different landscape patterns within the watershed (Figure 11). There are two large areas (greater than 4000 acres) of unfragmented late seral stage forest located in the eastern central and southeastern sections of the watershed. The northern and western central sections are heavily fragmented with all seral stages occurring within them.

Riparian associated plant communities vary from the wet meadow complexes of Old Man Camp, Toolbox Meadows, and Stump Lake to the early, mid, and late seral stage forests along the Clearwater River, Bear Creek, Mowich Creek, Trap Creek, Lava Creek, and their tributaries.

The watershed is a transitional zone between a highly developed, fragmented landscape caused by timber harvest and an undeveloped landscape resulting from Congressional set asides which include the Mt. Thielsen Wilderness Area and the Oregon Cascades Recreation Area. It is also a transition zone between the Douglas-fir, Western Hemlock, and White Fir Plant Series and the Lodgepole Pine, Mountain Hemlock, Pacific Silver Fir, and Shasta Red Fir Plant Series.

Figure 11 -Map of Seral Stages

SPECIES AND HABITATS

Resident Fish

The Clearwater River contains a simple fish community as compared to many North Umpqua River tributaries downstream from Soda Springs dam. This is primarily due to the lack of connectivity to the North Umpqua River mainstem, the resultant lack of access by fluvial and anadromous species, and the cold water temperatures of the Clearwater River system. Three species of fish are currently known to inhabit the Clearwater River system. Rainbow trout (*Oncorhynchus mykiss*) and brook trout (*Salvelinus fontinalis*) inhabit the river mainstem and some of the tributaries. Brown trout (*Salmo trutta*) enter the lower river mainstem, outside of the analysis area, from Toketee Lake for spawning during the fall of the year. Of the three species, brown trout and brook trout originate exclusively from introductions (see stocking history in Appendix E). Rainbow trout introductions have also occurred, but a native strain may have been present. The presence of non-game fish has not been documented. Anadromous fish are excluded from the Clearwater River by three barriers on the North Umpqua River mainstem; Soda Springs dam, Toketee Falls, and Toketee dam. The major fish bearing tributaries present in the analysis area are Mowich Creek, Lava Creek, Trap Creek, and Bear Creek.

Fish habitat in the analysis area can be divided into eight primary units, consisting of six stream segments and two lakes; the Clearwater River mainstem below Stump Lake (the Clearwater #1 bypass reach), the Clearwater River mainstem above Stump Lake, the four fish bearing tributaries, the Clearwater #1 forebay, and Stump Lake (Figure 12). The Clearwater #1 bypass reach begins at the Clearwater #1 diversion dam, which creates Stump Lake. Water is diverted at Stump Lake into a canal that provides water to operate the Clearwater #1 powerhouse. The downstream boundary of the analysis area is located at the site of the Clearwater #1 powerhouse and #2 diversion dam on the Clearwater River mainstem, and thus, the entire Clearwater #1 bypass reach is included in the analysis area. The Clearwater River mainstem contains three to five miles of fish habitat above Stump Lake. Mowich Creek flows into the Clearwater River at the site of the Clearwater #1 powerhouse, immediately upstream from the Clearwater #2 diversion dam. Lava Creek is a tributary to the Clearwater River above Stump Lake. Bear Creek flows directly into Stump Lake, and the Trap Creek confluence is located in the Clearwater #1 bypass reach. The Clearwater #1 forebay is located in western Mowich Park, northeast of the Clearwater #1 powerhouse. The Clearwater #1 forebay is fed by the Clearwater #1 canal from Stump Lake.

Fish habitat condition in the Clearwater River system ranges from fair to high quality. The best fish habitat is contained in the Clearwater River mainstem and Stump Lake (created by the hydropower project). Mowich, Lava, and Trap Creeks contain fair to good quality habitat, depending on the location. Habitat in Bear Creek is in fair condition, due primarily to a naturally high fine sediment load. It may be that production throughout much of the system is limited by low water temperatures. Production in some streams may be limited by other factors such as fine sediments, lack of spawning gravels, lack of pools, high stream gradient, and water velocity; or simplified habitat in general.

Rainbow trout and brook trout are primarily resident species in the Clearwater River system, in that they do not migrate, but spawn, rear, and mature in the natal stream. Some adfluvial behavior is believed to be exhibited by brook trout residing in Stump Lake, in that they enter the lower reaches of the Bear Creek and the Clearwater River inlets to spawn. Overall distribution of both species is patchy. This most likely results from both stocking locations, migration barrier locations, and interspecific competition. The Clearwater River system in the analysis area is dominated by brook trout, with a few rainbow trout located in the mainstem below Whitehorse Falls, upstream of Stump Lake, and in some tributaries. Mowich Creek contains both brook and rainbow trout. Brook trout have been found near the mouth of Mowich Creek, and rainbow trout throughout the system. Lava Creek also contains both rainbow and brook trout. Trap Creek contains rainbow trout only, and Bear Creek contains only brook trout. Stump Lake and the Clearwater #1 forebay contain mostly brook trout, with a few rainbow trout present. Brook trout, and a few rainbow trout, are entrained into the Clearwater #1 canal from Stump Lake and either reside in the canal or migrate downstream into the Clearwater #1 forebay (Figure 13).

General life histories of brook and rainbow trout, the species known to currently exist in the Upper Clearwater River analysis area, are discussed below. Other salmonids may have been historically present, and this issue is discussed in some detail in Chapter Four.

Brook Trout

Brook trout are native to northeastern North America. Brook trout have a short life span, rarely reaching four years of age. Brook trout spawn in the fall, usually in October, with declining water temperature and day length. Redds are usually built in gravel, but if ground water upwelling is present, spawning may occur on sandy substrate. Brook trout generally do not migrate far, but some anadromy has been reported. In streams, movement is generally minimal. Young migrate from the redd to shallow water and establish territories, moving into deeper water as they grow. Dominant foods include plankton, terrestrial and aquatic insects, and fish.

Rainbow Trout

Rainbow trout are native to most Pacific northwest rivers and streams, but were not historically as widely distributed as cutthroat trout. Kamloops rainbows are relatively long lived, are piscivorous, grow to a large size, and generally live in lakes. Other non-anadromous strains generally live in streams and feed primarily on terrestrial and aquatic insects their entire lives, and do not grow to a large size. Spawning occurs in the spring, with the timing generally consistent in a given stream, but can vary by a month or more among streams in the same region. Life histories vary from resident, fluvial, adfluvial, to anadromous. Survival in redds is generally directly proportional to the amount of fine sediments present in the gravels.

Figure 12 - Map of Fish Habitat Units

Figure 13 - Map of Fish Distribution

Resident Terrestrial Species

Elk (Cervus elaphus)

Elk in the Upper Clearwater Watershed move between a variety of habitat types from newly harvested logging units to late successional forests, depending on food availability, weather conditions, time of year, and disturbance factors. They may consume grasses, forbs, or browse. They generally favor forest openings to feed when they are not covered by snow. Logging activities in the last four decades have provided a mosaic of habitat types, which has probably enhanced elk herd productivity. For more information about elk habitat needs consult Thomas and Toweill (1982).

The land use patterns within the analysis area are based on transitions. Mowich Park is a major spring-fall staging area with concentrated use during the summer (Figure 42). Winter weather extremes determine elk utilization. As the southern slope meadows and vegetated clearcuts are exposed, elk move in to these areas, primarily along the Watson/Pig Iron ridge. Summer movement, within the analysis area, is up the Bear Creek corridor into the higher meadows of Rodley Butte and Mount Bailey. Because of these transitory movement patterns, this is one of the more popular "road hunting" areas during the bull season, and is probably the most popular area during the "cow hunt".

Northern Spotted Owl (Strix occidentalis caurina)

Spotted owls are generally considered habitat specialists. They inhabit closed-canopy, multi-layered forest sites, usually found in late successional forest stands within the White Fir, Western Hemlock, Shasta Red Fir, and Douglas-fir Plant Series. They depend upon suitable naturally occurring nest sites. They use broken topped trees and cavities, and natural platforms such as abandoned raptor nests and mistletoe brooms in which to nest. Roost sites are typically forest with high canopy closure dominated by large diameter trees. Foraging habitat is characterized by high canopy closure and complex structure, including coarse woody material that serves as habitat for the owl's prey. For more information consult the "Recovery Plan for the Northern Spotted Owl - Draft" (U.S. Department of Interior 1992).

Suitable nesting/roosting/foraging (NRF) habitat in the analysis area is in the northern portion, primarily the Bear Creek corridor and Mowich Park. The increase in fragmentation of suitable spotted owl habitat through the addition of managed stands to the landscape has allowed for the establishment of a single pair of barred owls in the analysis area. The dispersal success of the barred young is not currently known. There are seven, one hundred acre spotted owl core areas within the Upper Clearwater Watershed (Figure 4).

Bald eagle (Haliaeetus leucocephalus)

The bald eagle is primarily a fish-eating bird although it will feed opportunistically on any available carrion. During the breeding season, it is closely associated with lakes, ponds, or large rivers which provide a readily available food source. Their large stick nests are usually located in large trees in the upper reaches of the forest canopy. Non breeding individuals may be seen in many habitats, but still feed primarily near wetland areas. During the winter they are generally found near water bodies with ice-free water, or near frozen water bodies where carrion is common.

Stump Lake is the only habitat identified in the analysis area that has the minimal conditions necessary for pair occupancy. A pair was observed in June 1992, but subsequent surveys by PacifiCorp and Forest Service personnel have not confirmed nesting or additional sitings of other pairs of eagles.

HUMAN USES

Today, humans use the watershed for recreation, commercial and non-commercial forest products, electrical power generation, and as a main travel corridor between eastern and western Oregon. Recreational activities include hiking, biking, fishing, hunting, boating, swimming, snowmobiling, snow skiing, camping, picnicking, bird watching, and wildflower viewing. Commercial forest products that are harvested include timber, firewood, beargrass, hardwood shrubs, Christmas trees and boughs, matsutake mushrooms, princess pine, and yew wood. Non-commercial forest products that are harvested include huckleberries, blackberries, and mushrooms. Pacific Power and Light diverts water from the Clearwater River at Stump Lake through a canal and into Clearwater Forebay #1, where it is then generated into electricity. State Highway 138 is the main east-west access route from Roseburg to Medford and Bend. It is also the route the main western populations use to access Crater Lake National Park and Diamond Lake Resort. Historical human use of the Upper Clearwater Watershed is contained in the Cultural Resource Overview Report in Appendix K (Heritage).

LANDSCAPE ELEMENTS AND FLOWS

The process of identifying landscape elements and flows, as outlined in ecologist Nancy Diaz's "Forest Landscape Analysis and Design" publication, was used to better understand the watershed as an ecological system.

Landscape elements are the structural components of the watershed. In the analysis, landscape elements were divided into three categories: natural forest, patches, and corridors. Natural forest (matrix in Diaz's process) is the dominant landscape pattern or "fabric of the land" and makes up greater than 50 percent of the watershed. It is made up of three vegetative structural stages: transition (late seral), maturation (late seral), and thinning (mid seral) as defined in the ROD. Patches fragment the natural forest and are usually not connected. They include clearcut harvest units in the establishment stage (early seral), open thinning stage (mid seral), and closed thinning stage (mid seral) as defined in the ROD; shelterwood harvest units in the establishment stage (early seral); rocky areas that are rock dominated; rocky areas that are tree dominated; dry and wet meadows; rock pits and parking lots; and lakes, ponds, or forebays. Corridors are relatively linear phenomena within the watershed that move things from one part of the landscape to another. They include roads, riparian reserves, recreational trails, and a Pacific Power and Light canal within the watershed.

Landscape flows are things that move across or through watersheds, whether in the air, over land, or in the soil. Landscape flows identified within the watershed include big game (elk and deer), neotropical birds, humans, surface water, and fire. Table 4 shows how the landscape elements function relative to the landscape flows. Out of this grows an understanding of how the watershed functions as an ecological system.

Table 4 - Interactions between landscape elements and flows

LANDSCAPE ELEMENT	LANDSCAPE FLOW				
	SURFACE WATER	**PEOPLE**	**BIG GAME**	**NEOTROPICAL BIRDS**	**FIRE**
NATURAL FOREST					
Transition Stage (Late Seral)	High water quality; snowpack retention; large woody debris in channel; low erosion potential; low peak flow potential; high snow intercept	Spiritual experience; bear chasing with hounds; commercial forest products; visually forested	Summer and winter optimal thermal cover; high quality hiding cover; abundant winter forage opportunities; travel corridors	Moderate species diversity; nesting; foraging (cones,insects); migratory resting areas	Low intensity due to less fuel on the ground and previous underburning prior to 1910
Maturation Stage (Late Seral)	High water quality; snowpack retention; large woody debris in channel; low erosion potential; low peak flow potential; high snow intercept	Commercial forest products; visually forested; firewood cutting in lodgepole pine stands	Summer and winter thermal cover; limited forage opportunities; travel corridors	Low species diversity; nesting; foraging (cones,insects); migratory resting areas	High intensity due to high fuel load on the ground from self thinning; high resource damage
Thinning Stage (Mid Seral)	Moderate snowpack but lacks retention; moderate erosion potential; channels dominated by hardwoods; high invertebrate diversity; low snow intercept	Christmas tree harvest; firewood in lodgepole stands; visually forested; upland bird hunting	Hiding and escapement cover during hunting season; calving and fawning; limited forage opportunities; travel corridors	High species diversity; nesting; foraging	High intensity; high tree mortality; high resource damage
PATCHES					
Harvest Unit Establishment Stage (Early Seral)	Low water quality; high snowpack but earlier and faster snowmelt; high erosion potential; high peak flow potential; low levels of large wood in channel; channel widening; lower invertebrate diversity; low snow intercept	Beargrass harvest; berry picking; road hunting; visually a created opening; fall color viewing; visually offensive to some	Abundant forage	Low species diversity; seed foragers; low probability of brush species	Low intensity if logging slash treated; high intensity if no logging slash treated
Harvest Unit with Overstory Establishment Stage (Early Seral)	Same as Harvest Unit - Establishment Stage except overstory providing for large woody material recruitment and bank stability in channel	Same as harvest unit - establishment stage except not as visually offensive	Abundant forage with limited hiding cover from overstory trees	Moderate species diversity; overstory providing vertical niche, thus more nesting and territorial opportunity than harvest unit - establishment stage; seed foragers; predators (hawks and owls)	Low intensity if logging slash treated; high intensity if no logging slash treated
Harvest Unit	Low water quality; high snowpack; moderate erosion potential; high peak flow	Berry picking; road	Hiding cover next to		Low intensity if thinning slash treated; high

Open Thinning Stage (Mid Seral)	potential; low levels of large wood in channel; channel widening; hardwoods providing shade; low snow intercept	hunting; visually a created opening; fall color viewing	abundant forage opportunities; calving in areas of surface water; bedding	Low species diversity; seed foragers	intensity if no thinning slash treated; high resource damage
LANDSCAPE ELEMENT	**LANDSCAPE FLOW**				
	SURFACE WATER	**PEOPLE**	**BIG GAME**	**NEOTROPICAL BIRDS**	**FIRE**
Harvest Unit Closed Thinning Stage (Mid Seral)	Moderate water quality; moderate erosion potential; moderate peak flow potential; low levels of large wood in channel; less channel widening; hardwoods providing shade; moderate snow intercept	Commercial Christmas trees and boughs; visually forested; low recreational value	Hiding and escapement cover during hunting season	Low species diversity; nesting; foraging	Low intensity if thinning slash treated; high intensity if no thinning slash treated; high resource damage
Rock (< 10% tree cover)	High snowpack; no snow interception; high water infiltration; low channel density; seeps	Rock shelters; vision quests; long range vistas; native American use; hiking; skiing; snowmobiling	Very low use	Very low use	Fire break
Rock (> 10% tree cover)	High water infiltration; low channel density; moderate snow intercept	Skiing; snowmobiling; hiking	Transitory route	Higher species diversity than rock < 10% tree cover, but less than other elements	Small fires; low rate of spread
Dry Meadow	High snowpack but no channeling; dries out quickly in summer	Dispersed recreation; native American plant foraging; hunting; wildflower viewing	Foraging; resting	Ground based forage species; migratory resting areas; low species diversity; seed foragers	High rate of spread; high quality forage after fire
Wet Meadow	High water table; narrow deep channels; high snowpack but rapid runoff; high invertebrate diversity; sensitive to grazing and browsing; amphibians	Hunting; wildflower viewing; native American plant foraging	Foraging; calving; bedding; breeding; wallowing	High diversity of wetland species	Low occurrence; low rate of spread
Altered (rock pits, parking lots)	High surface runoff; potential of pollutants; channel widening downstream; high erosion potential	Rock sources for roads; staging areas	Rare use; salt licks	Resting; rock wrens; swallows, dusting	Fire break
Aquatic (lakes, ponds, forebays)	Water storage; temperature moderation; high fish populations	Electricity; fishing; boating; swimming	Drinking; cooling; forage along edges	High species diversity; wetland species; ospreys; bald eagles	Fire break; water source
CORRIDORS					
Canal	Channeling and transport; fish traps	Power generation	Travel barrier	Rare use	Fire break; canal maintenance may increase possibility of human caused fires
Roads	High sediment producer; intercept flow and redirect; high erosion potential	Main travel corridors for recreation and business activities; commercial access for wood products; biking; ATV's	Travel hazard; harassment; winter travel corridors	Dusting on native surface roads	Fire break; high possibility of human caused fires; access to fires; reduce attack time

Trails	Low sediment producer; low erosion potential	Hiking; biking; historical significance	Travel to and from forage and water; seasonal migration	Dusting	Fire break; high possibility of human caused fires; access to fires; reduce attack time
Riparian	Surface water transport; water quality; high species diversity; source of large woody material; protection of streambank	High use recreational value; fishing; hiking	Crossing; foraging; calving; drinking	High species diversity; nesting; foraging	High values at risk

CHAPTER THREE

ISSUES AND KEY QUESTIONS

INTRODUCTION

The purpose of this chapter is to:

- Focus the analysis on the key issues that are most relevant to the management questions, human values, or resource conditions within the watershed.

- Prioritize issues to identify those needing investigation in this iteration of ecosystem analysis.

- Formulate key analysis questions for the watershed based on key issues.

- Identify key issue indicators that will be used to answer the key questions.

PUBLIC INVOLVEMENT

Public involvement focused on asking for information about past and current human uses and conditions within the watershed. Press releases were published in Douglas County newspapers. Letters were sent to approximately 60 individuals, businesses, officials, and organizations encompassing timber and environmental interests, tribal representatives, and recreation groups. Three responses were received which provided additional contacts and information. In addition, a search was made of the historical information contained in Douglas County Museum files and two volumes of interviews conducted with Umpqua Valley residents for the Works Progress Administration circa 1938. The Douglas County Water Management Program was also reviewed.

ISSUES AND THEIR PRIORITY

The issues and their priority were based on relevancy to the management questions, human values, or resource conditions within the watershed. They were based on the fact that:

- The entire watershed is allocated to matrix land in the ROD and therefore targeted to supply over half of the probable sale quantity for Diamond Lake Ranger District in 1996.

- Harvest may occur within the Mount Bailey Roadless Area.

- Site productivity may have been affected through past ground skidding harvest activity.
- Natural disturbance regimes and biological diversity may have been affected by years of fire suppression and past management practices.
- The aquatic system, resident fish stocks, water quality, and water flow may have been affected by past management practices.
- The Mowich Park big game winter range, home to a large herd of Roosevelt elk, is located within the watershed.
- Seven spotted owl activity centers exist within the watershed.

- **HIGH PRIORITY ISSUES**

- The following key issues were identified as high priority within the watershed:
- Natural Disturbance
- Timber Supply/Sustained Yield/Site Productivity
- Transportation System
- Aquatic System/Water Quality/Water Flow
- Resident Fish Species and Habitat
- Biological Diversity
- Elk Winter Range
- Mount Bailey Roadless Area
- Threatened, Endangered, or Sensitive Species

MODERATE PRIORITY ISSUES

The following key issues were identified as moderate priority within the watershed:

- Recreation

LOW PRIORITY ISSUES

The following key issues were identified as low priority within the watershed:

- Non-native Species
- Special Forest Products

KEY QUESTIONS

The watershed analysis team formulated the following general key questions that apply to the key issues in order to reduce redundancy. It was felt that these general questions would be enough to spark detailed discussions of each key issue.

- What was the historical range of variability (reference condition)?
- How and why have reference conditions changed over time (current condition and trends)?
- What are the influences and relationships between the issue and other ecosystem processes in the watershed?
- What recommendations could be made to move the watershed towards a range of desired conditions based on reference conditions or management objectives?

ANALYSIS CRITERIA

Table 5 displays the key issue indicators that were used to answer the key questions.

Table 5 - Analysis criteria

KEY ISSUE	INDICATORS
High Priority Issues	
Natural Disturbance	fire regimes, insects, plant pathogens, floods, avalanches
Timber Supply/Sustained Yield/Site Productivity	productivity, growth, land suitability, land allocations, availability, erosion, fertility
Transportation System	road management objectives, road densities, level of use
Aquatic System	down wood, vegetation, physical habitat, biological components
Water Quality	temperature, chemistry, turbidity, sediment
Water Flow	quantity, timing
Resident Fish Species and Habitat	distribution, habitat, productivity
Biological Diversity	species richness, vegetative structure, age class, spatial distribution, communities, abundance
Elk Winter Range	forage, hiding cover, thermal cover, optimum thermal cover, travel corridors
Mount Bailey Roadless Area	roadless character
Threatened, Endangered, and Sensitive Species	habitat, distribution, viability
Moderate Priority Issues	
Recreation	past and future trends, level of use
Low Priority Issues	
Non-native Species	abundance, distribution
Special Forest Products	past and future trends, level of use

CHAPTER FOUR

REFERENCE AND CURRENT CONDITION, SYNTHESIS, AND INTERPRETATION

INTRODUCTION

The purpose of this chapter is to:

- Outline analysis procedures, assumptions, and data gaps.
- Develop a reference for comparison with current conditions and with key management plan objectives.
- Explain how ecological conditions have changed over time as the result of human influence and natural disturbances.
- Develop information relevant to the key issues and questions that is more detailed than information outlined in Chapter Two (Characterization).
- Document the current range, distribution, and condition of the core topics and other relevant ecosystem elements.
- Compare current and reference conditions and explain significant differences, similarities, or trends and their causes.
- Explain influences and relationships to other ecosystem processes based on the key issues.

HIGH PRIORITY ISSUES

NATURAL DISTURBANCE

Fire

Introduction
Fire has played a major role in the development and maintenance of vegetation in the Upper Clearwater area. Evidence of stand replacing and ground fires is visible on the landscape in both the pattern of vegetation and the species composition and structure. Letters and documents of events prior to 1930 describe fires burning for many days or months. In 1889, John Breckenridge

Waldo tells of being forced to camp on the south side of the North Umpqua River near Kelsay Valley because he "found the valley here on fire for miles along the north side". It rained August 30th "which checked and put out a great deal of fire"(Waldo 1889). In Reminiscences of Southern Oregon Pioneers, a personal interview with George Arthur Bonebrake, Mr. Bonebrake tells of a number of fires started by an electrical storm on July 5, 1910 and spread all over the district that were not extinguished until the fall rains in September. Although forest fire suppression began in western Oregon in 1902, effective fire suppression tactics probably did not come to the Upper Clearwater until the early 1930s when access roads were built into the area.

Analysis Procedures, Assumptions, Data Gaps

Analysis of reference fire conditions including fire return intervals, fuel availability, and air quality involved examining anecdotal information and studying vegetation patterns from older aerial photographs and a vegetation map produced in 1949. Photos taken in the 1930s from lookouts with a view of the watershed were also assessed. A fire history study specific to the Upper Clearwater Watershed was conducted. This study was completed using the methods and standards adapted from the Augusta Creek Fire Study (Connelly and Kertis 1991). Average fire return intervals for the Upper Clearwater were determined using fire scar analysis on recently created stumps in fourteen harvest units. The harvest units represented a range of aspect, slope, elevation, and plant series.

The current natural fire regime was determined by using the recent fire occurrence data, descriptions of recent fire effects, current fuel models, and current air quality. Data were gathered from the Umpqua National Forest Fire Atlas for fires occurring in 1932 through 1964. Fire size was recorded by size class, and cause was recorded as human or lightning. Fire data were also retrieved from the National Fire Occurrence Data Library for fires occurring between 1970 and 1994. Fireline intensity was available for some of these fires. A total of 54 years of recent fire data were used in this analysis.

The Umpqua Primary Activities Data Base and the Current Stand Structure Map of the area are the main sources of information for modeling current fuel conditions (Anderson 1982). Fuel Models and assumptions for mapping Fuel Models are described in Appendix A.

Information found in the Umpqua National Forest Annual Fire Report and records in the fire management office were used to describe current air quality.

Reference Condition

Size

The 1949 Stand Structure Map indicates one stand replacement event of approximately 7000 acres in size, located in the center of the watershed running east to west along both sides of Highway 138. In 1949, this entire area was covered by small diameter lodgepole pine. The size and average growth rates for the species on those sites indicates that the stand was probably established in the early 1900s, possibly during a high fire period occurring around 1910. Photos taken during August 1933 from Watson Butte and Elephant Mountain Lookouts show evidence of another stand replacing fire, approximately 200 acres in size, between Watson Butte Lookout and Elephant Mountain, as well as several smaller fire events from this same time period. Historic fire size was quite variable within the watershed.

Frequency and Intensity

According to the fire history study, many fires occurred in the Upper Clearwater area. Sixty-eight fire scars were observed. The earliest fire scar recorded occurred in 1557 and fire scars were observed from both the 17th and 18th centuries. The average fire return interval for the watershed was 43.7 years (sd=21.4), indicative of a moderate fire severity regime (Agee 1990). Due to the difficulties associated with finding information relating to these early fires, the assumption that weather patterns during this time period were wetter and cooler than later years, and then the implementation of fire suppression activities, the reference condition chosen is the period between 1800 and 1932. Two units within the study contained records of scars whose origin was outside the period of interest or outside the bounds of our confidence interval. Aspect and slope, rather than plant series appeared to be a better predictor of fire return interval (Table 6). In general, fires occurred more frequently on flat areas and less frequently in stands located on north slopes.

Table 6 - Average fire return interval

AVERAGE FIRE RETURN INTERVAL (Years)	STANDARD DEVIATION	ASPECT	PLANT SERIES
14	0 (n=1)	Flat	ABCO
18	6	Flat	TSHE
22	4	Flat	TSHE
27	3	Flat	TSHE
36	1	Flat	ABCO
43	0 (n=1)	South	TSHE
45	15	North	TSHE
52	27	Flat	ABCO
55	43	North	TSHE
59	0 (n=1)	North	TSHE
70	2	Flat	TSHE
83	33	North	TSHE

A moderate-severity natural fire regime is characterized by infrequent fires (25 to 100 years) and significant areas of high and low severity resulting in partial stand replacement. Fires typically burn weeks to months, and periods of intense fire behavior are mixed with periods of moderate to low intensity fire behavior. Moderate-severity natural fire regimes produce patchy stands of various sizes mixed with patches of multi-sized stands (Agee 1990).

Fuels are made up of the various live and dead components of vegetation that occur on a site. The type and quantity will depend upon soil, climate, geographic features, and the fire history of the site (Anderson 1982). Fire personnel have classified these vegetation types and structures into broad categories called Fuel Models. These classifications include, for example, general forest stands that have burned in the understory periodically, leaving little fuel on the forest floor (Fuel Model 8), and areas of the forest where fires have not occurred in recent years and large areas of windfall, snow damage, and insect and disease damage are present (Fuel Model 10) (Appendix A). Fuel Models can be used to predict fire behavior and may suggest risk of high intensity fire occurrence.

Fire return interval combined with fire intensity influenced reference conditions in the Upper Clearwater. Modeling showed that prior to fire suppression, more than 90 percent of the Upper Clearwater was in general forest that had been underburned periodically (Fuel Model 8) (Figure 14). Less than 10 percent of the area had experienced stand replacement fires where small shrubs and trees were present (Fuel Model 5) or were meadows without trees or down material (Fuel Model 1). A small percentage of area occurred as forest that had not had any fire for several years (Fuel Model 10).

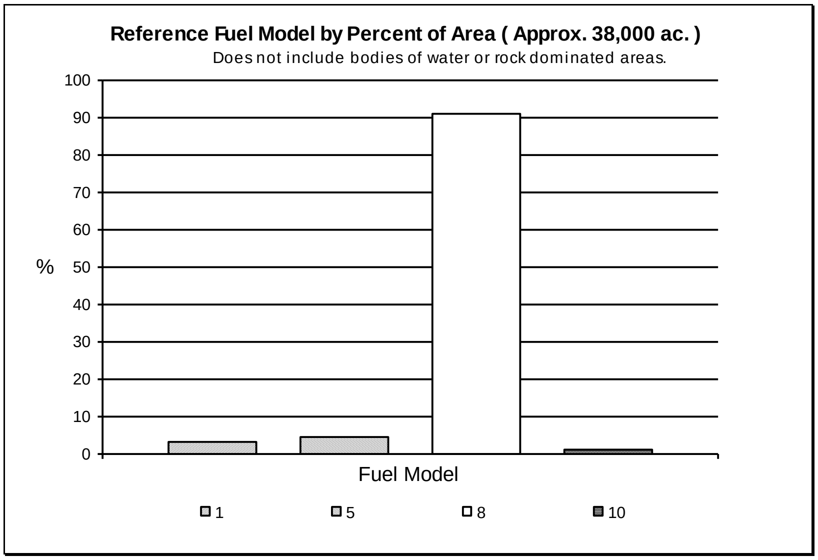


Figure 14 - Reference fuel model distribution

<u>Air Quality</u>
Historic references to air quality in the Pacific Northwest in general, often refer to poor visibility and smoky conditions. In 1889, Judge Waldo describes smoke and haze that made it impossible to photograph Lemolo Falls (Waldo 1889). An interview conducted by employees of the Work Progress Administration mentioned poor air quality in the Diamond Lake area in the summer of 1910, due to fires in the North Umpqua drainage. Based on this and more general information, smoke was probably present at varying densities anytime from June through mid October in the Upper Clearwater, ranging from light haze caused by small fires or distant large fires to a thick layer over the entire drainage.

Current Condition
The current fire regime consists of infrequent, small fires, that have had very little effect on the vegetation. Lightning caused 73 percent of the fires, humans caused the other 27 percent. Between 1932 and 1963 there were nine human caused fires. Since then an average of less than one human caused fire per year has occurred. All were less than one quarter of an acre. They were caused by campfires, smoking, arson, equipment, debris burning, children, and other miscellaneous human-related actions.

Size

The total area burned during the 54 year time period is estimated to be between 40.5 to 88.3 acres. Average fire sizes range between 0.3 to 0.6 acres. Total mean area burned per year on average in the watershed is 0.7 to 1.6 acres. Only 0.17 percent of the analysis area has burned during the current time period.

Frequency and Intensity

Fire starts are spread evenly throughout the geographic area. There have been no stand replacing or stand thinning fires and relatively little ground fuel burning has occurred.

There have been an average of 2.7 fires per year. Of the fires that had fuel model recorded, 52 percent were in Fuel Model 10, 26 percent were in Fuel Model 8, and the remaining 22 percent were distributed in Fuel Models 9 and the slash fuel models. Of the fires that had fire line intensity recorded, all but one had flame lengths of less than 4 feet, exhibiting characteristics of an understory burn, or light thinning fire.

Modeling of current conditions with the assumptions in Appendix A shows that the watershed now has 75 percent Fuel Model 8, 10 percent Fuel Model 10, and approximately 3 percent Fuel Model 11 (Figure 15)

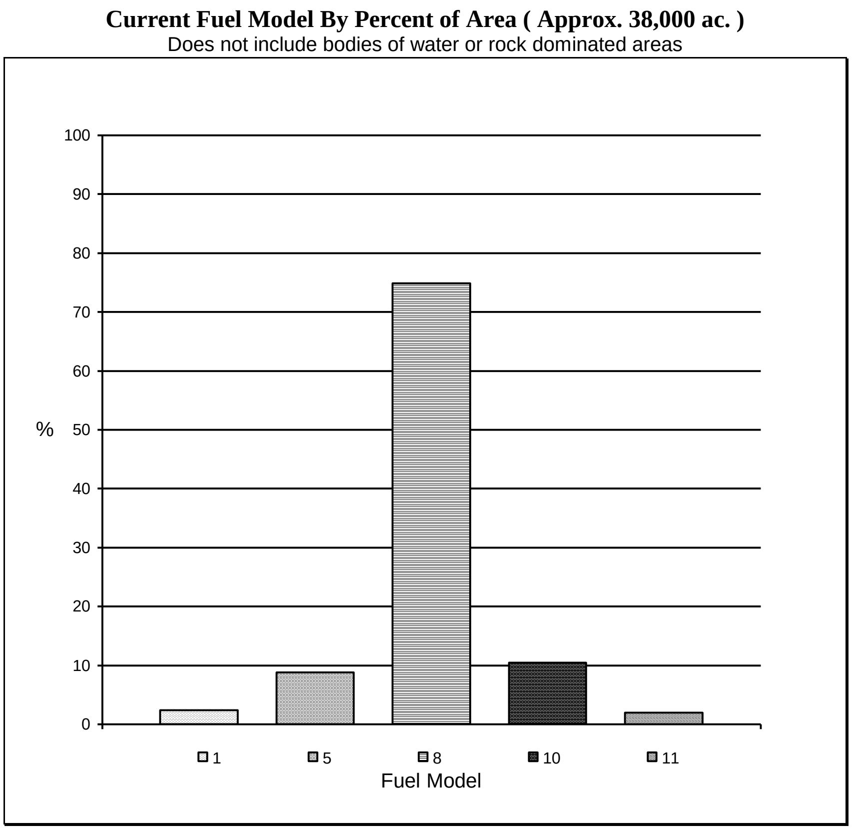


Figure 15 - Current fuel model distribution

Current fuel model area and distribution, fire size information and stand composition indicate that the current fire regime is in a *high-severity regime* (Agee 1990). This regime is characterized by infrequent, usually high intensity, stand replacement fires.

<u>Air Quality</u>

Fire management activities affecting air quality include wildfires and prescribed burning. Currently wildfires are managed with an appropriate suppression response and are usually controlled and mopped up within 24 hours. Visual air quality is negligibly impacted; respiratory air quality is a concern only to the firefighters.

Current prescribed fire activities have included underburning and pile burning. Prescribed fire activities cause greater impacts on the airshed as more particulate matter is released than from current wild fires. All prescribed burns are done in compliance with the Clean Air Act. Air quality standards are administered in cooperation with the Oregon Department of Forestry by following the Oregon Smoke Management Plan. Treatments have been developed and executed to have the least impact on the airshed. Documentation from the Umpqua Annual Fire Report shows a reduction trend in total suspended particulates from forest management activities. Very minor amounts of particulate matter will come from dust as a result of road use, and generally does not have a significant effect.

The closest designated area to the watershed is Roseburg which is approximately 50 miles to the west. The closest Class I Airsheds are the Diamond Peak Wilderness to the northeast, and Crater Lake National Park to the south east. The closest Class II Airsheds are Boulder Creek to the west, Mt. Thielsen to the east, and the Rouge-Umpqua Divide Wilderness to the south. Burning is not done during the restricted period in the Oregon Visibility Protection Plan (July 1 to September 15.)

Differences Between Conditions

- The current fire regime is most like a *high-severity fire regime*; the reference fire regime was a *moderate-severity fire regime*.
- Currently, fires generally burn for a period of less than 24 hours; in reference conditions some fires burned from ignition until the fall rains extinguished them, a period lasting several months.
- Current fires are smaller and affect less overall area than reference conditions.
- Currently, fires are limited to low intensities (if possible); fires burning under reference conditions exhibited a wide range of intensities and effects.
- Currently, the total area of Fuel Model 10 is greater than reference conditions (Figure 16).
- Currently, Fuel Model 10 is more continuous than in reference conditions.
- Currently, Fuel Model 11 or other slash models are present where they were not in reference conditions.
- Currently, the total area of Fuel Model 1 is probably less than reference conditions.
- Currently, there is less smoke and haze and overall less particulate produced than in reference conditions.
- Currently, smoke affects the airshed for less time than in reference conditions.

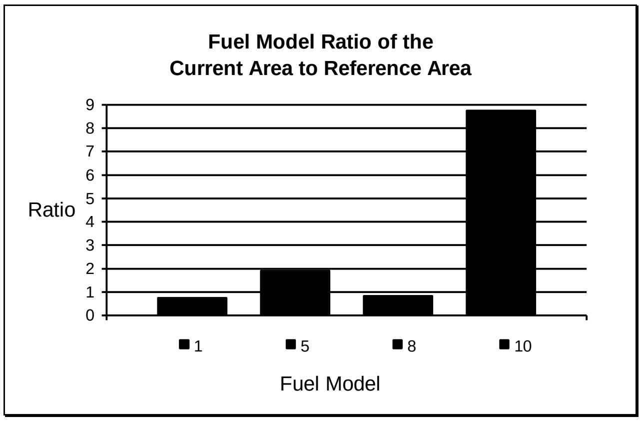


Figure 16 - Fuel model ratio of current to reference condition

Similarities Between Conditions

- Lightning fires occur throughout the watershed.
- Individual areas of Fuel Model 5 are widely dispersed.
- Individual areas of Fuel Model 5 are relatively small.
- Fuel Model 8 makes up the largest portion of the overall area.

Processes or Causal Mechanisms Responsible

The exclusion of fire due to the current fire suppression policy, timber management, and improved access to the Upper Clearwater are responsible for the differences between current and reference conditions. The fire suppression policy was developed as a result of the severe fire season of 1902 when there were large, timber destroying, forest fires in almost every county on the west side of the Cascades in Oregon and Washington. The policy was not very effective until the 1930s when fire detection, access, and fire suppression capabilities improved with the construction of lookouts, roads, and trails and establishment of Civilian Conservation Corps camps.

Future Trends

- Total area of Fuel Model 10 will continue to increase.
- Large areas of Fuel Model 10 will remain relatively unbroken.
- Fuel Model 11 (or other slash models) will continue to be present in very small amounts.
- There will be a reduction in the amount of Fuel Model 1 and Fuel Model 5.
- The probability of a large stand replacing fire continues to increase.

Influence and Relationship to Other Ecosystem Processes

The changes over time from reference conditions to current conditions influence the overall fire regime. Large continuous areas of Fuel Model 10 may lead to larger, more intensely burning, stand replacement fires. This affects the plant species composition. Long periods without fire allows a greater number of thinner bark tree species to grow to maturity and it allows understory vegetation to grow thickly (where not controlled by other factors). It reduces the amount of shade <u>in</u>tolerant species as the shade tolerant ones become established. Fire intolerant species will become more predominant. There is an overall reduction of browse for big game animals (Browse roughly corresponds to Fuel Model 5 and 1).

<u>Insects and Pathogens</u>

Current and Reference Conditions

Insects and pathogens are active in the Upper Clearwater Watershed. Along with fire and timber harvest, insects and diseases cause both large and small-scale disturbances distributed across the landscape. With the exception of white pine blister rust, all of the insects and pathogens influencing the Upper Clearwater are native to the region. They have evolved with their hosts. Single trees or single species may be affected. The insects or pathogens may be operating across the entire watershed or be restricted to local areas by favorable environmental conditions. Host vigor may or may not play a role in susceptibility. The magnitude of insect and disease-related disturbance is greatly influenced by species composition, age class, stand structure, and history of other disturbances on the same site. In turn, insects and pathogens can directly effect vegetative structure, stocking, and species composition over various spatial and temporal scales.

In this analysis, the impacts of insects and pathogens were determined by field reconnaissance, detailed surveys of individual stands, and information collected during routine District Timber Stand Examinations (TSE). (Goheen et al, 1994, Region Six TSE Handbook). Larger scale trends of mortality and associated insect activity for the period 1984 to 1995 were examined using maps created during the Annual Aerial Detection Survey done by the Pacific Northwest Region's Forest Insect and Disease staff group.

White Pine Blister Rust

One of the most important disturbance agents in the Upper Clearwater is white pine blister rust caused by the fungus *Cronartium ribicola*. White pine blister rust is a non-native disease that was introduced to the west coast of North America in 1910. Once established in the West, it spread rapidly, reaching the southern Oregon Cascades in the 1920s. White pine blister rust affects all five-needle pines, including western white pine and whitebark pine. The pathogen girdles and kills infected stems and branches. It causes top and branch death in larger hosts and outright mortality in seedling, sapling, and pole-sized hosts. Infections in larger trees can predispose these trees to bark beetle attack. The white pine blister rust fungus has a complex life-cycle with five spore stages. It requires an alternate host in the genus *Ribes* and needs moist conditions in the summer and fall for intensification on *Ribes* and infection of pines. The disease is much more severe on moist than dry sites and tends to intensify in "wave years" when particularly wet conditions occur.

White pine blister rust is actively killing tops, branches, and whole trees in western white pine regeneration in the Upper Clearwater. In some areas, particularly at higher elevations, 90 to 95 percent of the regeneration was found infected during field reconnaissance. Scattered topkill and branch flagging of overstory white pines also occurs. Mountain pine beetle attacks on mature western white pine frequently occur on these white pine blister rust-infected trees. Within its range, whitebark pine is also affected by white pine blister rust. On the west side of Mt. Bailey near the summit, many trees have dead tops and infected lateral branches.

Root Diseases

Root diseases are major influences on vegetation in the Upper Clearwater. Root diseases affect stand structure, species composition, tree density, and crown closure. They injure trees by decaying and killing roots or by preventing proper root functioning. Damage is expressed as reduced growth rates, butt decay, windthrow, death, and predisposition to bark beetle attack. The root diseases are considered to be diseases of the site; they are able to maintain themselves for decades in stumps and woody root material. Annual rates of spread are slow compared to other disturbance agents, but effects can be large over larger spatial and temporal scales. Root disease can cause scattered mortality of individual trees, preferring a single species or size class or they may cause large openings devoid of mature susceptible hosts. These openings increase or decrease in size depending on the root disease-susceptibility of the vegetation on their margins and that which seeds in after the openings are created.

Laminated root rot, caused by the fungus *Phellinus weirii* is present in stands within the Upper Clearwater. It is the most important root disease in stands within the Mountain Hemlock Plant Series. A significant portion of the later-successional dominated portion of this Series is comprised of laminated root rot mortality pockets. Large circular (sometimes greater than 300 feet in diameter) or sickle-shaped centers are readily visible on aerial photography. The margins of these centers contain dead and downed trees. The area inside the centers regenerates to a mix of both root disease-resistant and susceptible species; large mature susceptible hosts rarely occur. Mountain hemlock is highly susceptible to the fungus; it is readily infected and killed (Thies and Sturrock, 1995). Pacific silver fir, subalpine fir, and Shasta red fir are often infected but rarely killed. Lodgepole pine, whitebark pine, and western white pine are seldom infected and almost never killed. Laminated root rot centers have been present in mountain hemlock stands for hundreds of years or more. The fungus, along with fire, is an important component of the nutrient cycling process. It is responsible for maintaining uneven aged mixed species stands in many areas.

In the laminated root rot pockets within the Mountain Hemlock Plant Series in the Upper Clearwater, western white pine is a primary invader. It is resistant to *P. weirii* and is thus able to survive, grow, and attain a large size, unlike several other species that commonly seed in the pockets. However, due to the active presence of white pine blister rust many of the larger western white pine are currently toppled to the point that reproductive capacity is lost. Much of the regeneration is infected or dead. An important species component of root disease dynamics is being lost to an exotic fungus.

Armillaria root disease caused by the fungus *Armillaria ostoyae* is the most prevalent root disease in the White Fir Plant Series. The pathogen can be both an aggressive tree killer, killing trees across a variety of vigor classes, or it can be an opportunist, affecting weakened trees or colonizing dead material. Spread is slow, usually one to two feet per year. New infections occur when susceptible hosts contact infected root material or fungal rhizomorphs in the soil. Vigorous hosts may be able to resist fungal infection by blocking the penetration of fungal hyphae into the cambium through a variety of chemical and physical responses. In the Upper Clearwater, white fir is highly susceptible; it is readily infected and killed. No clear hierarchy of susceptibility exists for other species. In some areas, western white pine and ponderosa pine are damaged. In others, Douglas-fir and Shasta red fir seem more readily killed. No conifer species completely escapes damage, but all seem more resistant to *A. ostoyae* than white fir. In the past, Armillaria root disease effects were probably greatest in small pockets on suppressed understory trees or larger low vigor individual trees due to drought, injury or the presence of other insects or pathogens.

Dead trees or stumps created by harvest may be quickly colonized by *A. ostoyae*, increasing the amount of available inoculum on a site. In the Upper Clearwater, Armillaria root disease is commonly found in areas where timber harvest has previously occurred. Impacts are greatest along older skid trails or atop landings where soil is compacted. Some Armillaria root disease-caused-mortality is found associated with large ponderosa pine stumps and western white pine snags and stumps. Armillaria-root disease’s prevalence on such sites may be partially the result of white pine blister rust infection, mountain pine beetle infestation, and past salvage activities associated with these organisms.

It is unlikely that stands with major components of large overstory white fir will develop where Armillaria root disease is active in the Upper Clearwater. White fir will continue to be infected and killed by *A. ostoyae*. Harvesting activities that create large stumps or further stress residual trees by compacting soils or wounding stems will also contribute to increased disease activity.

The "S" type of *Heterobasidion annosum,* the cause of annosus root disease, is present in true fir stumps throughout the Upper Clearwater. It is most readily identified in stumps created more than 15 years ago. In several locations the fungus appears to be causing mortality of true firs adjacent to infected stumps. Throughout most of the watershed, however, it is associated with butt decay. In other parts of the West, annosus root disease is found associated with *A. ostoyae* on the roots of dead or dying trees. It's role in such a root disease complex remains unclear for the Upper Clearwater.

Stands where true firs and hemlocks have been harvested have significantly higher levels of annosus root disease than unentered stands. Windborne spores from fruiting bodies colonize recently cut stumps or fresh wounds. The fungus then grows down through the stump or tree into the root system. When roots of susceptible species come into contact with infected root systems the disease is transferred. Low vigor hosts or understory trees are often killed. Repeated entries into stands to harvest susceptible hosts may create higher levels of inoculum, provide additional entrance courts of wounded residual trees and reduce host vigor when entries are made on compactible soils.

Bark beetles

Bark beetles such as the fir engraver beetle (*Scolytus ventralis*) which attacks all true fir species, and Douglas-fir beetle, which attacks Douglas-fir, (*Dendroctonus pseudotsugae*) are commonly associated with root diseases. The beetles are attracted to weakened trees. They maintain their endemic populations by attacking root disease-weakened trees inside and on the perimeter of root disease centers. Build-up in beetle populations occurs when large areas of trees are stressed by environmental conditions such as prolonged drought. Douglas-fir beetle can breed in freshly downed timber and may increase in population after windstorms. Small pockets of both Douglas-fir beetle and fir engraver beetle-caused mortality have been recorded in the Upper Clearwater for several decades. Fir engraver beetle-caused mortality appears to be increasing, most likely in response to increases in host numbers due to fire exclusion and to the recent drought period.

Mountain pine beetle (*Dendroctonus ponderosae*) and western pine beetle (*D. brevicomis*) also attack trees that are stressed by drought or root disease; however, infestations are more strongly correlated with low host vigor resulting from overstocking. In the Upper Clearwater, western pine beetle infests ponderosa pine and mountain pine beetle infests all pine species. Larger trees, greater than 8 inches in diameter, are preferred by the beetles. Single individuals or small pockets of pines in mixed stands may be killed. Large areas of mortality may occur where pine occurs in pure stands. Stand basal areas greater than 120 square feet per acre are considered high

risk for beetles on moderate sites. Higher site quality allows for slightly greater basal areas before trees are at risk. Competition among trees and shrubs of all species, not only pines, contributes to pine susceptibility.
Large bark beetle outbreaks have occurred in the past in areas adjacent to the Upper Clearwater, predominantly in lodgepole pine stands and in western white pine weakened by white pine blister rust. Small pockets of pine mortality have been recorded for several decades with infested area increasing slightly during periods of drought. Currently many stands containing pines are overstocked due to fires exclusion. Stand-level basal areas now range from 100 to 320 square feet per acre. Bark beetle mortality is occurring and appears to be accelerating in some locations. Bark beetles will continue to kill dominant and codominant pines, singly or in small pockets within these stands until stocking reaches levels where individual trees are no longer under stress.

Dwarf Mistletoes
Dwarf mistletoes are parasitic plants that infect conifer species. Small sticky seeds are forcibly discharged from dwarf mistletoe plants and land on conifer needles. They are washed down to the branches where they germinate, invade the tree tissue, and draw water and nutrients from the host plant. Infection is favored by multi-layered canopies of single species. Most dwarf mistletoes are highly host specific, infecting only one or a few tree species. Their effects on the host include growth loss, topkill, distortion, mortality, and predisposition to infection by other agents such as bark beetles or decay fungi. Dwarf mistletoe brooms are often occupied by nesting birds and small mammals.

Dwarf mistletoes are widely distributed throughout forest stands in the Upper Clearwater. They are common on lodgepole pine, mountain hemlock and Douglas-fir. Numbers of dwarf mistletoe infected trees in many areas are higher than they were prior to fire exclusion. Where ground fires were frequent, higher proportions of infected understory trees would have been eliminated. Infected overstory trees with large brooms in the lower portions of their canopies would have been more likely to burn due to the fuel ladder created by the brooms.

Floods

Reference and Current Condition
The Clearwater River floods annually during spring snowmelt, and less often during winter rains. Peak flows from the High Cascade portion of the Clearwater are as little as one tenth the size of floods from shallower soils of the Western Cascades. A stream gage on the Clearwater River has recorded flows from 1929 to the present, and records on other Umpqua rivers go back much farther (USGS, 1995). Floods in 1861 and 1890 affected rivers throughout the basin, although records on the Umpqua near Elkton indicate that these did not match the record flood of 1964. The Clearwater stream gage measures flow from 41.6 square miles above Trap Creek (and below PacifiCorp's Clearwater 1 diversion canal at Stump Lake), or about two-thirds of the Upper Clearwater analysis area above Mowich Creek. All gage flows are corrected to include the canal diversion. Since the gage was installed, the Clearwater had experienced "10-year" floods in January of 1950, 1974, and 1980. Its largest floods occurred in December 1955 (a 25-year flood) and 1964. The record flood of December 23, 1964, was 1020 cfs, larger than a 100-year event (see Figure 17). Winter rains often melted a standing snowpack, and although they caused the

largest floods in the High Cascades, the floods are mild on the Clearwater compared to those in the Western Cascades. The largest flood from spring snowmelt occurred in June 1975, peaking at 402 cfs. This is not quite a 5-year flood, and more typical of the Clearwater's annual snowmelt peak. The period from 1929 to 1950 (before most hydropower facilities and logging activities began), recorded reference condition streamflows. Streamflow recorded from 1950 to 1983 represents the period which led to the current condition.

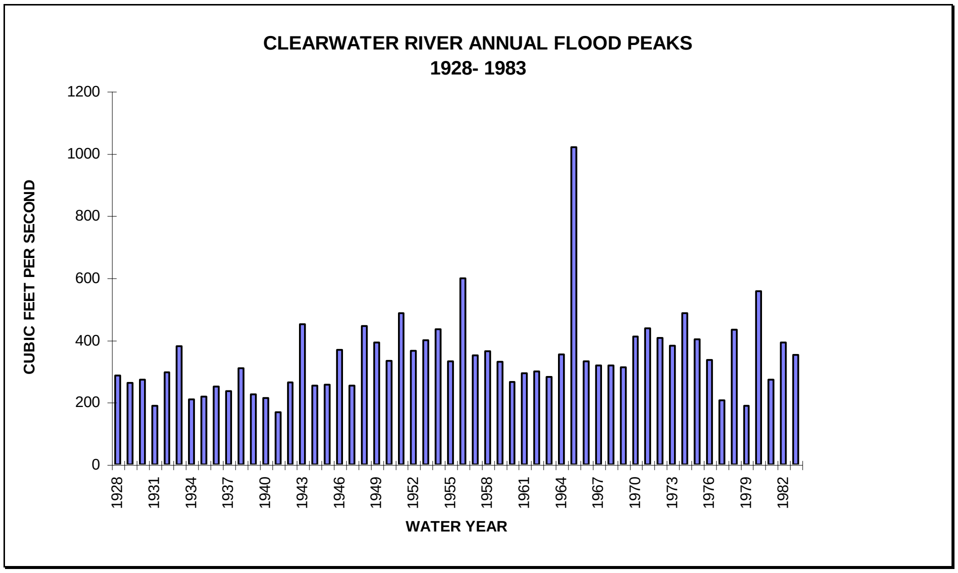


Figure 17 - Annual floods, Clearwater River Gage No. 14314500

Differences or Similarities Between Conditions

Floods on the Clearwater River, Lost Creek, and Lava Creek cause little channel damage when they flood, because they rise slowly and have low flood peaks. Artificial floods occur annually below Stump Lake, when Pacific Power bypasses the diversion canal for maintenance. Returning the historic flow to the Clearwater increases it from about five cfs to more than one hundred cfs. Pacific Power water quality monitoring shows turbidity increases during these events, and other water quality changes. The effect to water quality or any pool and riffle habitat changes is unknown.

The Clearwater #2 canal below Mowich Creek has failed at least 28 times since 1953, sending landslides and the diverted flow down the hillside into the river. Pacific Power (1995) reported no canal breaks or overtopping on the gentler Clearwater #1 canal. The Clearwater #1 forebay has occasionally overflowed, eroding portions of its 3,700 foot unlined spillway into Mowich Creek.

The streamflow record on the Upper Clearwater shows no obvious increase in flood size (see Aquatic Issue-Streamflow).

Processes or Causal Mechanisms Responsible

Annual bankfull floods shape streams by building bars and forming floodplains. The younger surficial deposits are easily eroded, especially where flows are flashy (like upper Bear Creek). Floods have always eroded channels in Bear, Trap, and Mowich Creeks, and it is likely that roads and logging (especially down wood removal from channels) have widened these streams or their tributaries. In Mowich Creek especially, 22 percent of the watershed has been harvested since 1970, and less forest canopy remains to reduce snow accumulation and melt (Jones and Grant, 1994). Bear Creek, with few harvest units, has headwater streams that widen and braid in every bankfull flood. The naturally unstable High Cascade streams in Bear Creek's valley have eroded even more from road runoff and livestock grazing in the upper reaches above Old Man Camp.

Future Trends

In the next 100-year-flood, the Umpqua River will build new floodplains and damage human structures. A 1000 cfs flood similar to the 1964 event would profoundly affect the Clearwater below Mowich Creek. Flood flows would enter this reach from Mowich, Trap, and Bear Creek. Above Bear Creek, a few culverts would overtop (there are more roads today), but Bear, Trap, and Mowich would experience greater channel changes. Culverts would fail, Bear Creek would meander deeper into ashflow cliffs below Old Man Camp, and new bars and floodplains would form. New habitat would be created for fish and other aquatic life, and some would be lost. Except where riparian forests have been lost or landslide rates greatly increased, the changes that would result from a large flood would likely be a net gain. Large trees take longer to grow than the interval between big floods¸ and they will not be there to add the diversity of their roots and boles to a wider, shallower stream.

Drought

Reference and Current Condition

Since 1929, annual low flow in September or October at the Clearwater stream gage ranged from 98 cfs on September 14, 1931 to 192 cfs on October 29, 1972 (Figure 18). In most years, streamflow from the 41.6 square miles above the gage is at least 120 cfs. A comparable watershed in the older, Western Cascade terrain yields about 4 cfs.

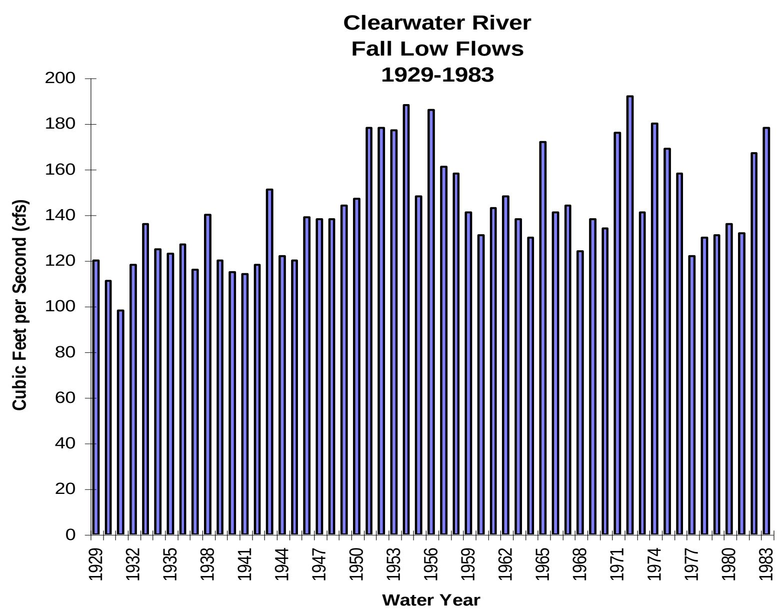


Figure 18 - Annual low flows, Clearwater Gage No. 14314500

In 1995, we measured streamflow when it was lowest in late September and October. While Clearwater and Lava Creek tributaries flowed 113 cfs, Bear Creek had only 13 cfs from a watershed almost as large. Mowich Creek flowed only 0.9 cfs and Trap Creek had 1.7 cfs. Aquatic species and habitats can be affected in these low-flow streams during drought years like 1929 to 1942, 1968, and 1977 (see Appendix D). The streamflow record from 1929 to 1950 represents the reference period before most hydropower and logging activities began, and the 1950 to 1983 record represents the period leading up to the current condition.

Differences or Similarities Between Conditions

The streamflow record on the Upper Clearwater shows no obvious decrease in summer flow (see Aquatic Issue-Streamflow).

Avalanches

Snow avalanches clear trees in their paths, and can leave disturbance patterns of even-aged trees in forests. The scars vary from bare patches with hardwoods and shrubs less than two years after the avalanche, to even-aged stands of mature trees a hundred years old or more (USDA, 1975). Avalanche scars are visible on the north side of Mount Bailey.

TIMBER SUPPLY

Analysis Procedures, Assumptions, and Data Gaps

The Umpqua Project Activities Database (UPAD), Paradox, Geographic Information Systems (GIS), and UTOOLS were used to collect and analyze data for the timber supply issue. The land allocations and standards in the 1978 Umpqua National Forest Land Management Plan (LMP), 1990 LRMP, and the 1994 ROD were used to compute commercial forest land (CFL) acreage. Harvest volume estimates were based on 60 thousand board feet (mbf) per acre. Harvest volumes and acreages were calculated on a decade basis.

Reference and Current Condition

Timber harvest began in 1949 within the Mowich Park area of the watershed. Harvest within the Upper Clearwater increased steadily over time until it peaked in the decade of the 1970s at over 3000 acres and 187 million board feet (mmbf). Since the 1970s it has steadily declined (Figure 19, Figure 20, Figure 21, and Figure 22).

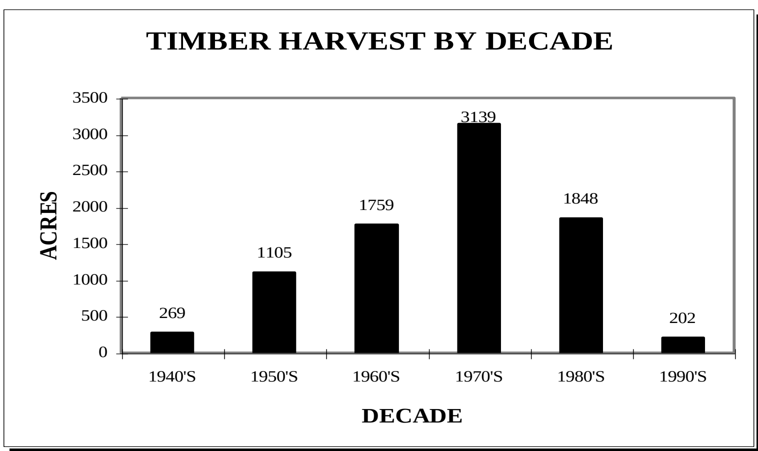


Figure 19 - Timber harvest acreage distribution by decade

Figure 20 - Map of Cumulative Timber Harvest

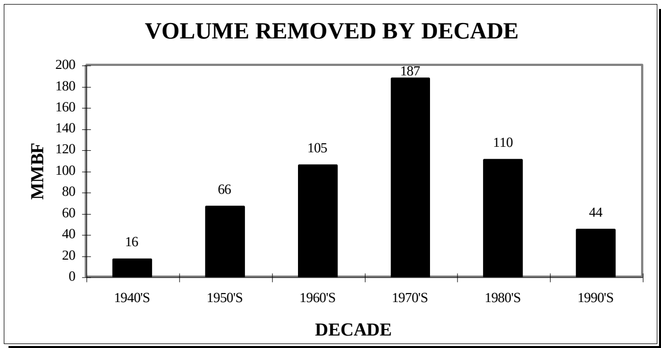


Figure 21 - Timber harvest volume distribution by decade

The commercial forest land base within the watershed has been reduced by 15,550 acres from the 1940s to the present day. The commercial forest land base is defined as land available for harvest based on land allocation and standards contained in forest land management plans. Figure Figure 22 displays acres of commercial forest land based on various land management plans.

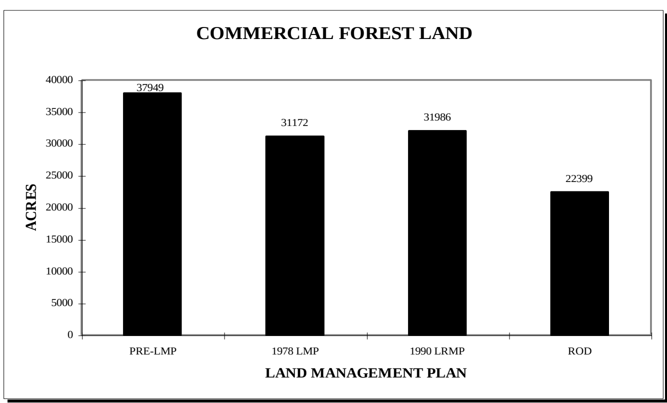


Figure 22 - Commercial forest land distribution over time

Processes or Causal Mechanisms Responsible

There are many biological, economic, and political reasons responsible for the timber harvest trends from 1949 to the present. In general terms, the increase from the 1940s to the 1970s was based on economic supply and demand. The decrease from the 1980s to the present was based on political and biological reasons that dealt with old growth forests, the northern spotted owl, and the decline of anadromous fisheries in the Pacific Northwest.

Future Trends

The Upper Clearwater Watershed will continue to provide timber to local mills because of it's matrix land allocation in the ROD. Two new timber sales, Campwood and Forge, have recently been sold under ROD standard and guidelines. They will harvest 13.4 mmbf from 270 acres. Planning efforts are underway for the Paw and Yogi timber sales within the watershed. These sales are estimated to sell 30 mmbf on 1400 acres in 1996 and 1997. Commercial thinning of managed stands will begin in the next decade as they reach merchantibility.

Influences and Relationships to Other Ecosystem Processes

Influences and relationships to other ecosystem processes are discussed throughout this document under other core topics and key issues. In most cases, past timber harvest has been one of the major causal agents affecting other ecosystem processes.

SITE PRODUCTIVITY/SUSTAINED YIELD

Analysis Procedures, Assumptions, and Data Gaps

The Forest Vegetation Simulator (FVS), formerly known as Prognosis, was used to analyze timber yields for various plant series and management regimes. Information from formal timber stand exams and bare ground projections were used to populate the FVS model. The timber yields that were shown in the LRMP were checked and found that they were essentially identical, indicating that the LRMP yields are reasonable. FVS was also used to estimate the reduction in yield as a result of root rots that are present in the white fir and mountain hemlock plant series. Reconnaissance of the area shows that the mountain hemlock series has 15 percent of the area with active root rot, primarily laminated root rot (*Phellinus wierii*). The white fir series has about 20 percent of the area with active root rot, primarily armillaria (*Armillaria ostoyae*). The reduction in productivity is estimated from FVS runs to be about 12 percent in the white fir series and 18 percent in the mountain hemlock series. The volumes assume precommercial and commercial thinning. The uneven age management regime uses a 30 year re-entry interval.

The extent of ground harvesting disturbance was determined by aerial photography interpretation. The potential for this disturbance to result in loss of site productivity was modeled and prioritized for restoration using the Soil Quality Module developed on the Deschutes National Forest by Karen Bennett. Inherent (reference condition) and existing (current condition) site productivity were compared to each other to determine high priority restoration sites. Inherent site productivity was based on plant series. UTOOLS and Paradox databases were used as analysis tools. Soils information was obtained from the 1976 Soil Resource Inventory for the Umpqua National Forest. Bulk density (g/cc) measurements were obtained from District soils monitoring of ground based harvesting and the National Long Term Site Productivity Study which is being implemented on the Watchdog timber sale on the District.

Reference Condition

Prior to timber harvest, the long term site productivity of the watershed was similar to that of current undisturbed stands. The western hemlock, white fir, and Douglas fir plant series were about twice as productive as the mountain hemlock, silver fir, Shasta red fir, and lodgepole pine plant series. Table 7 displays an estimate of the productivity for each plant series and different management regimes. The estimate of gross productivity shows that the current commercial forest land would have been able to produce 2.2 million cubic feet (11.0 million board feet) per year at the culmination of mean annual increment. This figure takes into consideration the loss from root rots and white pine blister rust. We do not have enough data to determine any minor differences in productivity that might have been caused by differences in climate such as temperatures or rainfall.

Natural bulk densities in the soils derived from pumiceous material and within the High Cascade subprovince ranged from 0.6 to 0.75 g/cc. The surface litter layer of these soils ranged from 2.5 to 5 cm in depth. Natural bulk densities within the Western Cascade subprovince ranged from 0.85 to 0.90 g/cc. The surface litter nutrient layer of these soils ranged from 5 to 7 cm in depth. The amount of large woody material (LWM) followed the general succession and disturbance pattern within the watershed. The highest levels were found in late seral stage forests where there was infrequent fire. Figure 23 shows the inherent site productivity prior to management activities.

Table 7 - Mean annual increment in cubic feet per acre per year

PLANT SERIES	CULMINATION	95% CMAI	300 YEARS	50 YEARS
western hemlock	118	112	65	
white fir	118	112	65	
mountain hemlock	55	52	39	
mountain hemlock, uneven aged	55	52	45	
white fir with root rot	104	99	8	
mountain hemlock with root rot	45	43	29	
mountain hemlock, uneven aged, with root rot	45	43	31	
ponderosa pine				50 (estimated)
lodgepole pine	55	52		50

Figure 23 - Map of Inherent Site Productivity

Current Condition
An estimate of gross productivity shows that the current commercial forest land has the capability to produce 2.0 million cubic feet (10.3 million board feet) per year at the culmination of mean annual increment. This figure takes into consideration the loss from root rots, white pine blister rust, off site species, soil displacement, and soil compaction.

Bulk densities of the soils within the watershed range from 0.7 to 1.2 g/cc. The surface litter nutrient layer ranges from 0 to 7 cm in depth. There is a lack of LWM within managed stands. Figure 24 shows the existing site productivity of the area.

Differences or Similarities Between Conditions
The long term site productivity of commercial forest land has been reduced from the reference condition, especially within the western hemlock, Douglas fir, and white fir plant series. The gross productivity of commercial forest land has been reduced from 2.2 mmcf (11.0 mmbf) to 2.0 mmcf (10.3 mmbf) per year at the culmination of mean annual increment. Bulk densities of the soil have increased from 10 to 70 percent over the reference condition. Surface litter layers have been reduced or no longer exist in some areas of the watershed. Large woody material levels have been reduced from reference condition within managed stands.

Processes or Causal Mechanisms Responsible
Reforesting with off site pondersosa pine and frost resistant species (lodgepole, ponderosa, and white pine), ground based harvesting with skidders and tractors, and tractor slash piling are responsible for the differences between current and reference conditions. Up to 1990, slash piling practices removed most of the large woody material and effective ground cover within regeneration harvested areas. Up to 1985, salvage operations removed large woody material from upland timber stands and riparian zones as part of the timber sale program.

Clearcut harvest areas totaling over 2,391 acres have been reforested with ponderosa and lodgepole pine instead of fir species because pine are resistant to frost damage. There are 757 acres planted to ponderosa pine grown from seed obtained from other than local sources, which do not grow as well as trees which are grown from seed obtained locally. There are 644 acres planted to ponderosa pine from local sources, and 990 acres regenerated to lodgepole pine. With the acres that are currently dominated by ponderosa and lodgepole pine, there is a reduction in production capability of 151 mcf (710 mbf) on commercial forest lands. Ponderosa and lodgepole pines do not have the productivity of most of the species they have replaced, resulting in a loss in growth while those species dominate the sites. The exception to this is where lodgepole is grown on mountain hemlock sites, as the lodgepole will grow as well on those less productive sites as the more tolerant species present. The ponderosa pine is planted on western hemlock and white fir sites, as is most of the lodgepole. About 20 percent (180 acres) of the lodgepole is on mountain hemlock sites. Using FVS, it is estimated that in a 50 year time period, there is a loss of 68 cu. ft./ac/yr. (17 mbf/ac/yr) on the sites planted to local ponderosa pine and lodgepole pine, and a loss of 105 cu. ft./ac./yr. (26 mbf/ac/yr) on the areas planted to off site ponderosa pine.

Figure 24 - Map of Existing Site Productivity

Approximately 6000 acres (16 percent) of the Upper Clearwater Watershed have been even age harvested with ground based systems over a period of 4.5 decades. Tractor-piling and burning has occurred on approximately 4000 acres of this 6000 acres. These management practices are the cause for the increase in soil bulk densities, decrease in large woody material within upland and riparian areas, and the decrease in the depth of surface litter nutrient layers within the watershed.

Future Trends
The long term site productivity of commercial forest land will be improved or maintained through adaptive management techniques in the future (See recommendations in Chapter Five).

Influences and Relationships to Other Ecosystem Processes
The surface litter nutrient layer, LWM, and soil organisms play an important role in nutrient recycling and moderation of extremes in soil temperatures within the watershed. Decomposition and mineralization of forest organic residues are the principle source of nitrogen, sulfur, and to some degree phosphorus available for plant uptake. In undisturbed conditions, roughly 90 percent of the total nitrogen is found in the forest floor, soil, and roots. The rate of decomposition and mineralization is influenced by soil permeability, water holding capacity, and temperature. Oxidation and biologic activity increases the need for organic residue as soil permeability increases. Rates of decomposition are not static across the life of a stand, but tend to peak around crown closure, which coincides with optimal conditions of soil temperature and moisture during summer (Edmonds 1979). Forest cover influences the persistence of frost in soils in cold climates and frost pockets. The forest floor litter layer helps to lower the maximum summer temperature and raise the minimum winter temperature of the surface soil. It also reduces the day-to-day and diurnal changes as well. Litter layer probably has less effect than forest canopy on reducing the maximum soil temperature, but it has a much greater effect than canopy in raising the minimum surface soil temperature during cold weather. Litter also reduces the depth of frost penetration in most instances (Prichett and Fisher 1987).

Humus, rotten wood, and the upper mineral soil are the powerhouses of soil biologic activity (Harvey et al. 1979, 1986). Most woody host plants require soil organisms to facilitate nutrient uptake. Maintenance of long term productivity requires conservation of nutrient capital. Few nutrients leach from the soil when populations of soil organisms are healthy and active (Amaranthus et al. 1990). This is particularly significant for soluble forms of nitrogen. Soil organisms and their interactions affect forest productivity through capture and uptake of nutrients, nitrogen fixation, protecting against pathogens, maintenance of soil structure, and buffering against soil stress.

TRANSPORTATION SYSTEM

Analysis Procedures, Assumptions, and Data Gaps
Several assumptions were incorporated into the discussion of the transportation system for the Clearwater Analysis area. We utilized information from the Umpqua's TMS (Transportation Management System) database to identify road type by surface as well as road management levels. This information was incorporated into a number of GIS retrievals for analysis and

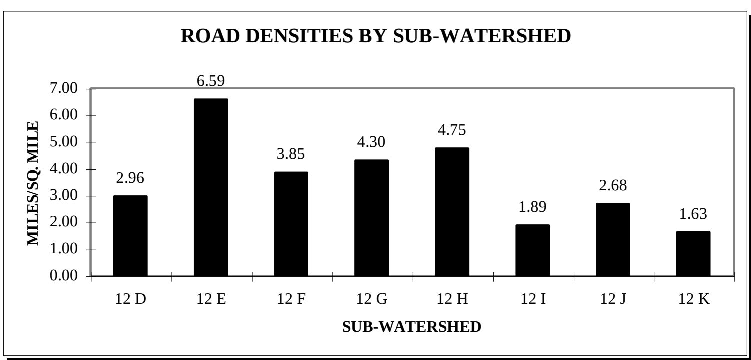
presentation. In addition, GIS was utilized to identify a number of landscape units and develop analysis products.

Two important datagaps were identified during field samples in the area. The actual surfacing of the road system is not consistent with the information contained in TMS and may be significantly higher than shown. In addition, the completeness of the stream network limits the discussion of the role of that roads play relative to the riparian system.

Reference Condition
While transportation to and through this area occurred during historic times, there were no organized and managed routes available for access prior to the first significant entries for timber management activities in the 1940s. Information available suggests that the first road systems developed in the Upper Clearwater were Forest Service logging roads and State Highway 138 to Diamond Lake.

Current Condition
The Upper Clearwater River has a diverse assemblage that comprises the transportation system. It contains a section of the State Highway 138 which is part of the Scenic Byway system, a variety of forest access roads and trails, and a small percentage of roads and canals associated with the North Umpqua Hydropower Project.

There are about 196 miles of road identified as part of the transportation network within the analysis area, which equates to an overall road density of 3.2 miles/mile^2. While the density figures display the cumulative total of the roads within the analysis area, there are dramatic differences in the type as well as the timing of the development of the transportation network. Figure 25 portrays a range of road densities from 1.5 to over 6 miles/mile^2.



Comment [TS2]:

Figure 25- Road densities by subwatershed

Although the overall road density is less than 4 miles/mile^2, there is a significant range throughout the basin in both density as well as the character and history of road development. The initial road development in the area provided the tie through to the Diamond Lake area and allowed the access for timber management as well as construction of the Clearwater section of the North Umpqua Hydropower Project. The majority of the paved roads were initially constructed at this time and by 1950 about 6 percent of the road system had been constructed.

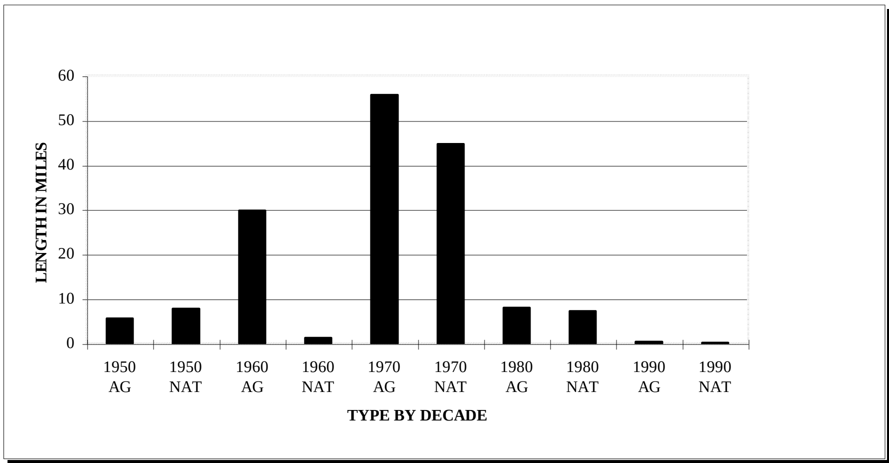


Figure 26 - Road construction miles of aggregate and natural surface type by decade

About 19 percent of the road network was constructed during the 1960s, with an emphasis on accessing subwatersheds F, I and J. The majority of the roads built during this era were subsequently surfaced with aggregate. In some cases as much as two feet of rock has been applied over the past 30 years. The design standards applied during this time period reflected the growing knowledge available for forest access roads and was typical throughout the west. The typical road section incorporated traditional cut and fill construction with ditches and drainage structures at regular intervals. Three subwatersheds were substantially roaded during this time period: Forge (F), Westlake (I), and Paw (J).

During the 1970s the road development increased significantly with about 62 percent of the system constructed during this period. Evaluation of the data suggests that this development was focused in five subwatersheds: E, G, H, J and K. Of these, the La Park (H) area had a high percentage of the total roads developed during this decade. Roads constructed during this time period either accessed new areas or enhanced the existing transportation system. Typically, the arterial roads were designed to a higher level and built to support large volumes of traffic. These roads were constructed by the common drainage and surfacing standards based on use. Approximately 35 percent of the total roads in the Upper Clearwater were built to this standard during the 1970s.

An awareness of the impacts of roads and economics led to the development of an extensive system of roads described as native for analysis purposes. About 27 percent of the roads were developed using this standard during the 1970s and reflect a lower standard of road construction. These roads are predominant in areas where road drainage problems and soil erosion were not anticipated. Roads were typically designed to minimize cut and fill sections and to fit the terrain as much as possible. They frequently were outsloped and designed to disperse runoff rather than concentrate flow. Analysis of the data suggests that these native roads tended to be shorter and minimized the number of stream crossings. There are three subwatersheds (Mich, LaPark, and Paw) that have high concentrations of native roads built during this era.

Road development continued, but at a reduced level during the 1980s, with a focus in the Forge, LaPark, and Paw subwatersheds. Nine percent of the total road miles were constructed during this time period with relatively equal proportions of surface and native roads. Since 1990, less than one mile of road has been constructed in the analysis area.

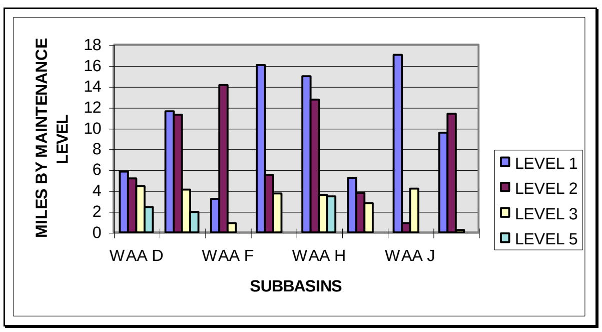


Figure 27 - Summary of roads by maintenance level

The Upper Clearwater contains roads that have maintenance level designations 1, 2, 3, and 5. Figure 27 identifies the proportion of roads by Maintenance Level throughout the watershed.

Differences or Similarities Between Conditions

The development of the transportation system that presently exists has had a pronounced effect on a variety of resources and uses over the past 50 years. A large majority of the landscape is accessible to mechanized travel and resource utilization as a result.

Influences and Relationships to Other Ecosystem Processes

The transportation system is an integral part of a number of ecological processes that often reflect conflicting uses. There are three processes that are directly associated with roads in the analysis area. These are related to the contribution of water, wood, and sediment to the aquatic system as well as the interruption of flow that would typically be absorbed as groundwater.

Recent work by Jones and Grant (1994) and Wemple (1994) suggests that roads could be contributing to the extension of the stream channel network, thereby elevating the peak flows and providing an efficient transport mechanism for water and sediment to riparian areas. Based on this premise, a percentage of the roads were sampled using the protocol described in the Jackson Creek Watershed Analysis, (Umpqua N.F. 1995). This sample supported the premise that even on relatively gentle landscapes there is a strong connection between roads that are surfaced and potential channel extension. The data suggest that 20 percent of the surfaced roads sampled had a direct connection between a road drainage structure (ditch/culvert) and either a stream or a gully. In comparison, the roads identified as native had no connection to a stream or gully. In fact, the native road sample set did not identify a culvert in the 19 miles inventoried.

Roads also interact with the stream network on a more direct basis via stream crossings. A diverse array of stream crossings exist throughout the area ranging from large bridges associated with State Highway 138 to small culverts designed to cross intermittent streams. A GIS retrieval of the road/stream intersect identified 93 apparent stream crossings in the Upper Clearwater basin. A field review of the stream layer resulted in the deletion of stream crossings in the Paw and Westlake subwatersheds because streams identified as Class IVs turned out to be dry swales with no evidence of annual scour. Figure 28 indicates the relative distribution of stream crossing by subwatershed.

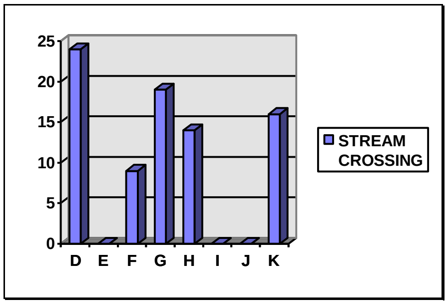


Figure 28 - Number of stream crossings by subwatershed

As described previously, the erosional processes that exist in the analysis area differ depending upon landscape type. Roads associated with the large ashflow deposits and glacial tills are subject to frequent and often severe surface erosion which often ends up in the stream. Even when there is low delivery potential, the fine textured portion is often mobilized by wind during dry periods when there is heavy vehicle traffic. The erosion of the road prism in these areas leads to chronic maintenance problems and the need for replacement aggregate on a routine basis to support traffic.

Although there is a low percentage of the area that experiences mass wasting, there appears to be a relationship between the Western Cascades and the glacial tills where sidecast construction and road drainage interact to initiate failures. The roads in the Bear Creek drainage have been identified as a source of concern during conversations with District Engineering and several localized geotechnical investigations. Based on observations over the past several years, Bear Creek has had a noticeable increase in turbidity during normal winter flows.

The third process that involves roads is the interference with the contribution of large woody material to the aquatic system. The presence of a road in or adjacent to a riparian area limits the availability of trees for LWM recruitment.

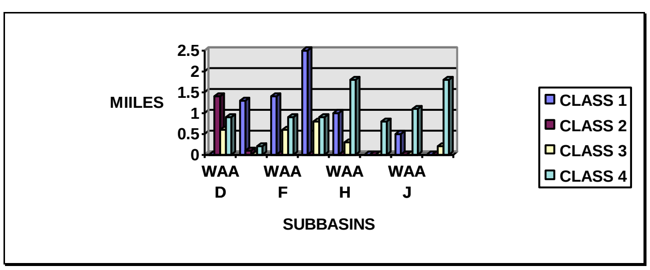


Figure 29 - Miles of road within riparian reserves by subwatershed

Figure 29 portrays the relative frequency of roads within Riparian Reserves. There are 12 miles of road within Riparian Reserves.

A small amount of the transportation system is integral with dispersed recreation areas, particularly the White

Horse Falls and Clearwater Falls developments. A number of resource concerns were identified in association with the Clearwater Falls site. These include visitor safety issues, aquatic habitat degradation, and reduction in site productivity.

Visitor safety issues are centered around the lack of a developed trail system that has resulted in uncontrolled access to the falls and the Clearwater River. The steep area adjacent to the falls has a pattern of historic use resulting in a trail tread that has tenuous footing under dry conditions and extremely hazardous conditions when wet. The spray of the falls on the upper slopes results in a wet trail during most of the year. Another area identified as a potential safety hazard is the stream bank adjacent to the Clearwater River, where the river is flowing immediately below the surface with occasional exposures along root systems. This situation is typical where streams flow in association with fine textured material such as the pumice in this area. The channel development in this area is continuing and should be considered in management of visitor use.

The existing road system and lack of designated trails has resulted in a considerable amount of surface erosion that is noticeable for a considerable distance downstream. At least three primary sources were identified during a preliminary investigation of the area. The access road from Highway 138 provides a direct conduit that effectively serves as a Class IV stream and results in accelerated runoff onto highly erodable pumice slopes directly above the river. The sidecast fills associated with the day use parking area are a chronic source of fine sediment that appears to be a factor in the simplified habitat observed in the reach below. The erosion associated with the historic crossing and the adjacent road has been identified as a source of sediment for a number of years, however opportunities to mitigate this have been limited.

Site productivity in the vicinity of the day use area and both Clearwater Falls campgrounds (old and new) has been affected by the lack of controlled traffic and trail designations. Casual observations of the area identified a number of locations where the only vegetation is large conifers, with no understory or groundcover. Based on experience with compaction in similar areas, it was determined that a large percentage of the area had been severely impacted and would limit vegetative restoration without soil rehabilitation.

Future Trends
Several factors have the potential to affect the management of the transportation system in the Upper Clearwater. Implementation of the R.O.D., specifically Aquatic Conservation Strategy Objectives Two and Five, address the relationship of the transportation system to the ecosystem processes. The implementation of the Matrix Prescription over the majority of this area could continue to influence resources at the landscape level.

The reality of reduced budgets and limited resources will continue to be an important consideration in the development and maintenance of the transportation system. The level of road maintenance support will continue to decline below historic levels and could result in an inability to support elements of the 1990 LRMP, particularly several of the monitoring elements which incorporate the need to evaluate the transportation system based on Maintenance Level. The certainty of reduced maintenance budgets will also result in a proportion of the

transportation system falling into some reduced state that could result in adverse resource consequences.
Another factor that has a potential to affect transportaion system management is the development of a Winter Recreation Area associated with Mt.Bailey. The proposed development surrounding the ski area could dramatically affect the existing transportation system.

AQUATIC SYSTEM/WATER QUALITY AND FLOW

Streams and Channels

Reference and Current Condition

The map (Figure 30) and Table 8 show about 70 miles of streams in the Upper Clearwater Watershed. Subwatersheds are named by the streams they drain to in Table 8. These areas also have planning area names shown elsewhere in the analysis, but watershed numbers are consistent and refer to the same areas. Class I and II streams support resident fish habitat and supply public water systems downstream. Class III streams are perennial (flow year-round). Class IV streams are intermittent and ephemeral (seasonal) streams. In the more dissected Western Cascades, intermittent streams account for about 60 percent of streams, and there are 3 to 5 miles of stream per square mile. In the High Cascades, where high infiltration of rain and snowmelt carves fewer streams, only 45 percent of streams are intermittent. The Upper Clearwater Watershed as a whole averages just over one mi/mi^2 of stream. Trap and Mowich Creeks located in the Western Cascade terrain average 2 mi/mi^2.

Table 8 - Miles of stream by stream class by watershed and subwatershed

SUB-WATERSHED	NO.	GROSS ACRES	TOTAL MILES	CLASS 1	CLASS 2	CLASS 3	CLASS 4
Lower Mowich	12F	3129	7.49	2.40		3.56	1.53
Upper Mowich	12G	3770	11.86	3.98		3.94	3.94
Clearwater N Side	12E	2622	2.28	2.28			0
Trap Creek	12D	3860	16.69	2.18	2.23	4.99	7.29
Bear Creek	12K	10310	13.39		5.78	0.22	7.39
Lost Creek	12J	5708	4.63	0.63			
Upper Clearwater	12I	4543	5.96				5.96
Lava Creek	12H	4718	11.51	4.37		1.33	5.81
Total		38660	69.81	15.84	8.01	14.04	31.92

A few more miles of stream were mapped during stream survey. These do not appear in this analysis. New stream and subwatershed boundary changes are recommended in Chapter 5.

Figure 30 - Map of Streams and Lakes

Figure 31 - Map of Subwatersheds

Differences or Similarities Between Conditions
Stream channels are more stable in the Western Cascades than in surficial deposits of glacial material and pyroclastic flows. There are few channels in the High Cascades, but where they flow through pumice deposits, streams are subject to erosion and migration (see Chapter Two-Geology). Channels were likely always active in the youngest surficial deposits, and all streams have experienced changes since water was diverted from the Clearwater River in the 1950s and roading and logging began. Construction and maintenance of Highway 138 along the Clearwater River also added ditchline runoff and sediment to the river. Fillslopes on the 4785 road, along the south side of the river below Clearwater Falls, have eroded since the 1950s. Road runoff, logging in riparian areas, and channel flushing below the Stump Lake canal have all changed water quality and aquatic habitat in streams (see Water Quality and Resident Fish Habitat issue).

A qualitative rating of channel stability in headwater streams and fish habitat surveys show that streams through surficial deposits and below Stump Lake (regulated flows) have changed the most. Even in the Western and High Cascades, surveys show less wood and more signs of bank erosion in and along streams that were logged.

Future Trends
When high runoff or sediment enters unstable, active channels, they are more likely to get wider and provide less complex (and poorer quality) habitat for aquatic life. The cumulative effect of road runoff and tree canopy removal may have increased the channel erosion we saw in Bear Creek, Trap Creek, and their tributaries. Future activities may cause further changes in these reaches (and the Clearwater below Stump Lake), which are already active. Additional peak flow or sediment may add to the effects of past logging, highway, and hydropower actions.

Streamflow

Reference and Current Condition
A stream gage on the Clearwater River has recorded flows from 1929 to the present (USGS 1995). The Clearwater stream gage measures flow from 41.6 square miles above Trap Creek (and below Pacific Power's Clearwater #1 diversion canal at Stump Lake), or about two-thirds of the Upper Clearwater analysis area above Mowich Creek. All gage flows are corrected to include the canal diversion through 1983.

Pacific Power began constructing dams in 1949 to divert most of the Clearwater River, North Umpqua River, and Fish Creek for hydropower generation. Stump Lake takes the flow of the Clearwater River and Bear Creek through a 2.4 mile canal to a forebay and penstock at Mowich Creek. The powerhouse can generate 15 megawatts of power at Clearwater #1. A minimum flow of five cfs is released to the Clearwater River, and 100 to 230 cfs flow through the canal. Flows greater than 230 cfs spill over the dam at Stump Lake into the river channel, quickly raising the flow from five cfs to flood flows during winter rains and spring snowmelt. A diversion at Mowich Creek sends the river through the Clearwater #2 canal to a forebay and penstock emptying into Toketee Lake on the North Umpqua River. The Clearwater channel emerges at Toketee Lake flowing about 70 cfs, a combination of the five cfs minimum flow release, Watson Creek, and springs that enter the river. All together, 44 miles of canals, three reservoirs, and eight generators have a maximum capability to produce 185 megawatts of power on the North Umpqua River.

Besides hydropower generation, other beneficial uses of the river within the watershed analysis area include recreation at Clearwater and Whitehorse Falls Campgrounds and Stump Lake, habitat for fish and aquatic life, and drinking water at a Pacific Power residence at Clearwater #1 powerhouse.

In fall 1995, we measured streamflow throughout the Clearwater basin when flows were lowest (Figure 32). We used Pacific Power measurements to confirm that only Trap Creek adds flow from Bear Creek to Mowich Creek, and some flow may even be lost. While Clearwater and Lava Creek tributaries flowed 113 cfs, Bear Creek had only 13 cfs from a watershed almost as large. Mowich Creek flowed only 0.9 cfs and Trap Creek had 1.7 cfs (Figure 32). We found that the surface topography does not define the apparent source watersheds of the Clearwater above Bear Creek. Lava Creek, the Upper Clearwater, and an unnamed spring each account for about one-third of the Clearwater River flow above Stump Lake. Lost Creek basin has no channel, but appears to flow toward the Clearwater above Lava Creek. When its area is compared to the flow of the unnamed spring (now labeled Lost Creek on the map in Figure 30), flows from the three streams all average about 4 cfs per square mile. In contrast, Bear Creek and Trap Creek summer flow is about 0.7 cfs per square mile of watershed. Changes in the watershed boundary of subwatershed 12J (Lost Creek) will be made as a result of this watershed analysis (see Chapter 2 - Geologic Features and Geomorphic Processes for an explanation of bedrock properties). Mowich Creek appears to flow less at its mouth than upstream in Mowich Park. Flow may emerge in the Clearwater below Stump Lake, and may flow below the surface in the river channel.

Figure 32 - Map of Streamflow and Water Temperature

These measurements show how different the High Cascades are from the older Western Cascades in the rest of the Umpqua basin. Not only do younger, fractured basalts store and supply more water to streams in the late summer, increased infiltration through very permeable pumice (airfall and pyroclastic volcanic ash soils) reduces flood peaks. A stream gage on Theilsen Creek (a watershed overlain by pumice) is estimated to peak at ten cfs per square mile in a 100-year flood. Existing High Cascade equations for ungaged streams estimate ten times that flow (USGS 1979). See Appendix D for an alternative way to estimate peak flows for crossings on ungaged streams in the High Cascades.

Differences or Similarities Between Conditions

The Clearwater River floods annually during spring snowmelt, and less often during winter rains. Peak flows from the High Cascade geology of the Clearwater are as little as one tenth the size of floods from shallower soils of the Western Cascades. Most of Bear Creek and the northern side of the Mowich Creek subwatershed have higher flood peaks because of Western Cascade rocks. If annual rain and snowmelt did not percolate through ash and glacial soils, seeping into the fractured basalts of the Clearwater above Bear Creek, much less water would remain to sustain summer flows in the Clearwater and North Umpqua Rivers downstream. An important question concerning floods is whether logging with tractors (soil compaction), constructing roads, or diverting flow for hydropower has caused less flow to infiltrate hillslopes or stream channels. Also, removal of forest canopy might increase snowpack accumulation or accelerate melt. If so, the result might be higher floods or lower summer flows.

Jones and Grant (1994), Harr (1981), and Christner (1981) showed that canopy removal and roads can increase peak flow up to 50 percent in the Western Cascades. Table 9 shows that Mowich Creek is the Clearwater subwatershed with the least amount of full (70-100%) canopy cover area. Table 4 in Chapter Two shows the relationships and iteractions between surface flow and landscape elements.

Table 9 - Canopy cover by subwatershed

SUB-WATERSHED	NO.	GROSS ACRES	71-100 (%)	71-100% (acres)
Lower Mowich	12F	3129	46%	1448
Upper Mowich	12G	3770	44%	1672
Clearwater North Side	12E	2622	57%	1495
Trap Creek	12D	3860	68%	2614
Bear Creek	12K	10310	58%	5971
Lost Creek	12J	5708	67%	3806
Upper Clearwater	12I	4543	65%	2939
Lava Creek	12H	4718	50%	2361
Total		38660		22306

Plotting the cumulative sum of annual floods over time shows how the average annual flood changes over time (Figure 33). Spring snowmelt peaks are consistently lower than floods from winter rains (Appendix D). From 1928 to 1942, few winter floods resulted in an average annual flood that was lower than the peaks after 1942 (which included more winter floods). This analysis covers only the area upstream from the gage, especially the Clearwater River and Lava Creek, whose High Cascades flow dominates the streamflow record. Bear, Trap and Mowich Creeks have much higher winter floods for their watershed area and contribute very little summer flow. Only Bear Creek is included in streamflow measured by the gage. The period from 1929 to 1950 (before most hydropower facilities and logging activities began), recorded reference condition streamflows. Streamflow recorded from 1950 to 1983 represents the period which led to the current condition.

This visual look at average floods shows no obvious increase in flood size after 1950, when logging and hydropower diversion began (Figure 33).

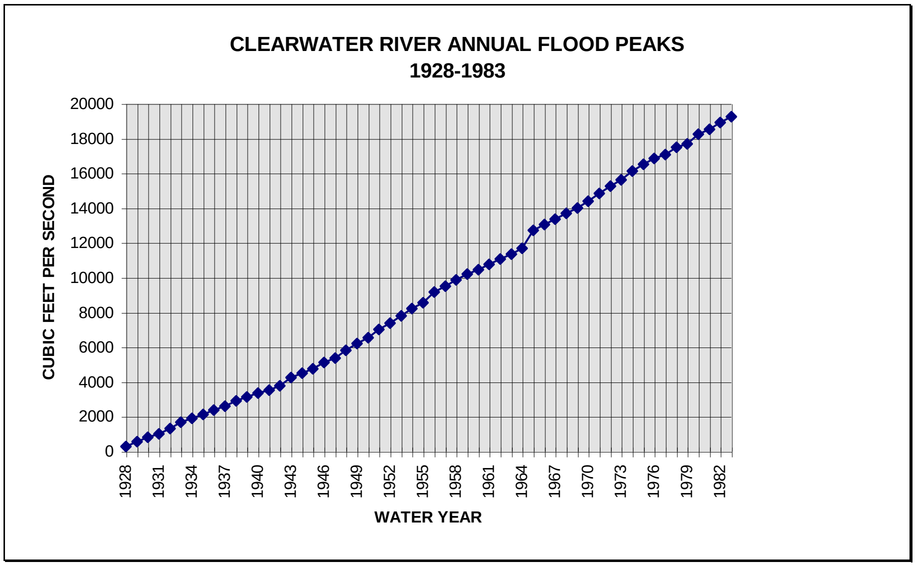


Figure 33 - Accumulated annual flood flows on the Clearwater River from 1928-1983

Just as important as flood increases is whether summer flow has diminished. About 20 percent of the flow in the North Umpqua Wild and Scenic River comes from the Upper Clearwater, providing fish habitat, recreation and water supply all the way to the Pacific Ocean. The North Umpqua River is world-famous for its outstanding summer flow and water quality.

To see if annual rain and snow produces the same summer flow today as it used to, annual precipitation was plotted against the lowest fall streamflow measured each year. Crater Lake precipitation was a good predictor of rain and snow at Toketee Falls, and the record goes back almost as far as the Clearwater stream gage (Appendix D). If logging, roads, or water diversions allowed less snowmelt and rain to infiltrate into hillslopes or channels, less would remain to sustain flow into late summer. The plot of accumulated precipitation and flow shows no obvious decrease in average annual low flow since 1950 when the changes began (Figure 34).

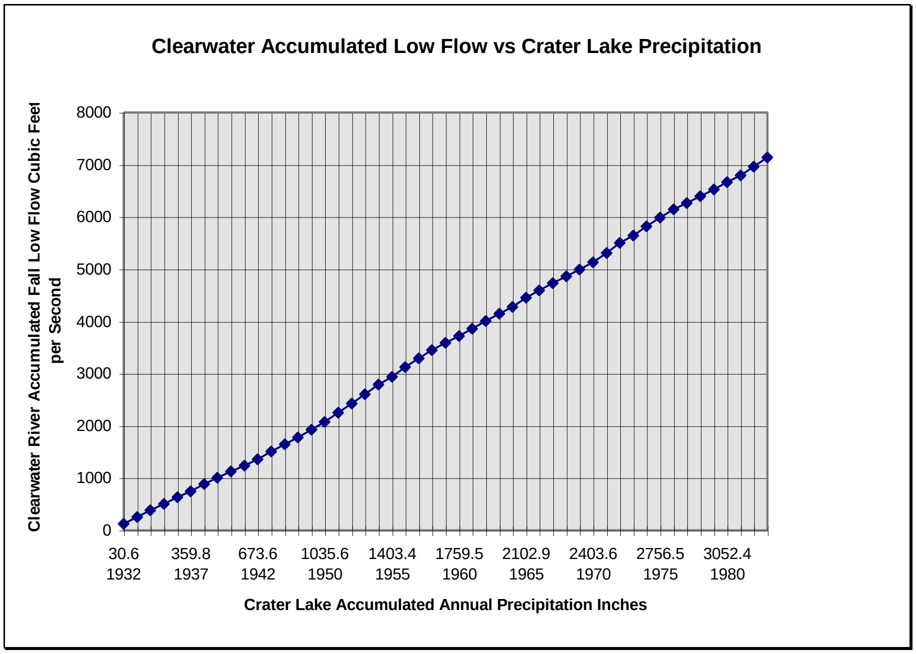


Figure 34 - Relationship between accumulated annual precipitation at Crater Lake and annual low flow in the fall on the Clearwater River from 1932-1983

The streamflow record on the upper two-thirds of the Upper Clearwater shows no obvious increase in flood size, or decrease in summer flow since measurements began around 1930. This means that compaction of soils have not affected the measured flow as it was analyzed. Avoiding further soil compaction and road ditch runoff to streams is still a good idea, but it is unlikely that prevention or mitigation (like soil ripping) will be noticed in flows measured downstream. These measures may be important to individual streams, especially those with unstable channels.

Water Quality

Reference and Current Condition

The Clearwater River is cold and clear year round, unless flooding or erosion muddies Bear, Mowich, or Trap Creeks. Dissolved oxygen, pH, and turbidity in the river usually meet water quality standards in the river below the diversion (PacifiCorp 1995), except when the canal is shut down for maintenance and flow is suddenly turned back into the channel. That can flush sediment and nutrients from channel banks, and last for several hours. In late summer and fall, the low flow remaining below the diversion sometimes results in low dissolved oxygen during the time brook trout spawn. During canal maintenance in July 1993, turbidity increased from 2.5 to 9.5 turbidity units. Turbidity of Bear Creek can be much higher in winter.

The December 1995 proposed Oregon list of streams not meeting water quality standards (303d list Clean Water Act) doesn't include the Clearwater River. PacifiCorp (1995) data indicates that the Clearwater River below Stump Lake does not meet water quality standards for habitat modification, habitat-flow modification, and water temperature at least part of the year. An instream water right filed by the state of Oregon claims 50 cfs from October through April, 40 cfs for May and June, and 30 cfs from July through September at the mouth of the Clearwater River. The priority date for the instream right is 1974. Pacific Power's hydropower license requires an instream flow release of five cfs all year. The power company proposed increasing the instream flow in an application for relicensing (PacifiCorp 1995).

Dissolved oxygen measured by Pacific Power during studies to relicense its project (1992 to 1994), was usually 10 to 11 milligrams per liter (mg/l) but occasionally fell below nine mg/l (less than 90 percent saturation) below Stump Lake in fall. Stream pH was between seven and eight pH units, and specific conductance ranged from 30 to 100 uS/cm (PacifiCorp, 1995).

Nitrogen and phosphorous are highest in summer and fall, when flow is lowest. These nutrients are used by floating and attached algae, which can cause high and low daily swings of pH and dissolved oxygen downstream. The North Umpqua River sometimes exceeds 8.5, the water quality standard for pH. Orthophosphorous (the form most readily used by plants) ranged from 20 to 90 microgram per liter (ug/l). The Clearwater has the highest phosphorous concentrations measured in the North Umpqua by Pacific Power, but most observers agree that nitrogen is what limits the growth of algae in this river. Samples for nitrate (dissolved) nitrogen found less than 50 ug/l, and the highest confirmed level was 20 ug/l in December, 1992. Organic nitrogen (TKN) was measured as high as 400 ug/l during a canal shutdown and flushing. While Clearwater dissolved nitrogen is low, small increases from erosion, timber harvest, fertilizer, or reservoir storage might cause algae growth and water quality changes downstream.

Total dissolved gas (TDG) sometimes exceeds the water quality standard of 110 percent at Whitehorse Falls during spring runoff. High TDG can be harmful to fish, and is caused by waterfalls or high-head penstocks compressing air and supersaturating the water.

The Clearwater River is kept cool by groundwater near 40 degrees Fahrenheit (40F). When the North Umpqua below Steamboat is 65F in July and August, and its tributaries are 65 to 75F, the Clearwater River might reach a maximum of 50F. Bear Creek and Mowich Creek, with less groundwater flow, are 5 and 10 degrees warmer. The Pacific Power diversion leaves only five cfs in the river below Stump Lake, and it quickly warms to 64F. In winter, water temperatures get as low as 34F, then drop to freezing from Stump Lake to Mowich Creek.

Differences or Similarities Between Conditions

Maximum summer water temperatures in the Clearwater River between Stump Lake diversion and Mowich Creek are much warmer than if flow was not diverted. Pacific Power estimated that the river would reach 52F instead of 64F at Mowich Creek if full flow remained in the river in July 1992 (see Appendix D for a profile of the Clearwater stream temperature from Stump Lake to the mouth of the river, with diverted flow "A" and full flow "F"). In winter, the river is 2F colder because of the flow diversion.

Water temperature was as much as 10F lower in summer, and 2F warmer in winter before the hydropower diversion. The reference condition for other measures of water quality is difficult to estimate, but high sediment, lower dissolved oxygen, more algae, and higher pH likely occurs today during floods (sediment) and fall low flows. Water quality standards for habitat, flow, and temperature are not met today, while standards were likely met during the reference period before 1950.

Riparian Condition

Reference and Current Condition

The 1994 ROD established riparian reserves around lakes, streams, wetlands, and unstable areas. The map in Figure 35 shows riparian reserves around the current inventoried lakes and streams and the acres with 70 to 100 percent canopy cover derived from 1988 photography by Pacific Meridian (PMR) interpretation. Since logging took place before the reserves were established in 1994, some open areas (such as along Mowich Creek) show where harvesting occurred. Other openings are natural rock outcrops, water, and meadows (Bear Creek). Non harvest or partial harvest stream buffers were implemented after 1985. Before 1985, down trees across stream channels were removed in salvage operations, stream channels were cleaned out through the yarding of unmerchantible material, and trees were harvested right up to the stream channel. Table 4 in Chapter Two show some of the relationships between harvest, canopy cover, and LWM within channels. The area with full canopy may appear high because of pixel resolution at this small scale (1/2" per mile). Table 10 shows the acres and percent area with full canopy by subwatershed.

Table 10 - Canopy cover within riparian reserves

SUB-WATERSHED	NO.	71-100% (% area)	TOTAL ACRES	71-100% (Acres)
Lower Mowich	12F	48%	497	236
Upper Mowich	12G	44%	727	319
Clearwater North Side	12E	63%	325	205
Trap Creek	12D	69%	968	668
Bear Creek	12K	53%	925	489
Lost Creek	12J	77%	68	52
Upper Clearwater	12I	66%	133	87
Lava Creek	12H	62%	875	546
Total			4518	2602

Figure 35 - Map of Canopy Cover Within Riparian Reserves

Differences or Similarities Between Conditions

Aerial photos from 1946 show little harvest or openings along Mowich Creek and the Clearwater River, but meadows visible along Bear Creek and upper Lava Creek account for some of the openings seen there today.

RESIDENT FISH SPECIES AND HABITAT

Analysis Procedures, Assumptions, and Data Gaps

Fish habitat surveys of Mowich, Lava, Bear, and Trap Creeks were conducted in 1992 by the Forest Service using the Region Six stream survey methodology. Unfortunately, much of the habitat data has been determined to be unreliable due to improper habitat delineation and a lack of data consistency. Fish habitat surveys using the Region Six methodology were conducted by the Forest Service using adequately trained personnel and a more consistent approach to data gathering during the fall of 1995 in Lava and Trap Creeks, and the lower reaches of Mowich and Bear Creeks. The 1995 surveys provided baseline data and allowed the assessment of which portions of the 1992 habitat data could be deemed reliable. The Clearwater River was surveyed from the river mouth to approximately two miles upstream from Stump Lake in 1992 by PacifiCorp as part of the ongoing FERC relicensing process (PacifiCorp 1995). A combination of the Region Six and Oregon Department of Fish and Wildlife (ODFW) methodologies was used.

No thorough, systematic fish population surveys have been conducted in the Clearwater River system by either the Forest Service or the ODFW. The Forest Service has performed electroshocking surveys in some Clearwater River tributaries in association with habitat surveys. Species presence and distribution information is based primarily on the electroshocking surveys performed by the Forest Service and population surveys performed by Pacificorp on the Clearwater River mainstem during 1992 (PacifiCorp 1995).

Data gaps remain on the current condition of fish habitat in upper Mowich and Bear Creeks, the Clearwater River mainstem above Stump Lake, and the short spring fed tributary near Lost Creek. Data gaps also exist on fish population levels and trends in Mowich, Lava, Bear, and Trap Creeks.

Reference Condition

Little information is available from which to describe the reference condition of the resident fish species and their habitat. For purposes of discussion and analysis, it will be convenient to refer to the reference condition as what could have been expected to exist before timber harvest occurred, and roads and the North Umpqua Hydropower Project were constructed in the early 1950s.

<u>Fish Species</u>

It has not yet and may never be determined if any fish species were historically present in the Clearwater River system. It is very possible that native rainbow trout, cutthroat trout, and bull trout were historically present. The following discussion summarizes historic connectivity of the

Clearwater River system to the mainstem Umpqua River and the limited information on historic fisheries.

Under the assumed reference condition, the Clearwater River system may have had fish migration corridors connecting it to the mainstem upper North Umpqua River. However, Toketee Falls, on the North Umpqua River, would still have prevented anadromous fish access. Whitehorse Falls, on the Clearwater River, would have prevented any fluvial fish species from migrating from the upper North Umpqua River to the Lava, Bear, and Trap Creek drainages. If fish were present above Whitehorse Falls, downstream migration could have still occurred. PacifiCorp identified six other barriers to upstream resident fish migration in the Clearwater River mainstem below Whitehorse Falls during their 1992 survey. It is not clear whether these would remain upstream migration barriers at the higher stream flows that would have occurred in the absence of the hydropower development.

The presence of numerous upstream migration barriers on the North Umpqua River and the Clearwater River indicate that any fish species that were historically present in the Upper Clearwater River system would have to have been present before the barriers were constructed by volcanic activity. These fish species would have also had to survive glacial activity and the pyroclastic ash flows originating from Mt. Mazama and flowing down several drainages. This would have been very possible because a few individuals surviving in a small tributary could migrate downstream and repopulate the creek and river mainstems below.

At this time, the only evidence of historical fish presence anywhere in the Clearwater River system is a reference in the 1940 Diamond Lake Ranger District fishery assessment to the presence of a “native” fish species in Bear Creek. Both rainbow trout and “native” fish are documented as being present in Bear Creek in 1940, and “catch records” indicate prior “native” fish presence.

While it is not clear what species that “native” was meant to refer to, it is most likely that “native” was used in reference to cutthroat trout. Rainbow, brown, cutthroat trout, and steelhead are all referred to on the same page of the 1940 document. Cutthroat trout, but not “native” fish were referred to as being present in the North Umpqua River below Toketee Falls, Copeland Creek, and Boulder Creek. There was no reference to either cutthroat trout or “native” fish in the mainstem of the upper North Umpqua River (above Toketee Falls). There are references to “native” fish presence in Fish Creek, Rough Creek, and Bear Creek. Fish Creek is referred to as having rainbow trout and “native” fish present. Since rainbow trout and “native” fish are referred to together (twice) and rainbow trout stockings of that period were typically fry (which it is assumed were not marked), it is unlikely that “native” was meant to refer to native rainbow trout. The presence of cutthroat trout and “native” fish are never referred to as occurring in the same stream. Since a migration corridor connecting Copeland Creek, Boulder Creek, and Fish Creek via the North Umpqua River existed at the time, there is no reason that a species present in Copeland and Boulder Creeks should not have also been present in at least lower Fish Creek. It may be that cutthroat trout present above known upstream migration barriers (resident fish) were referred to as “native”. Also, “native” has been, and still is, used as a colloquial term for resident, and occasionally fluvial, cutthroat trout throughout much of the American west.

Therefore, it is most likely that "native" referred to either the resident form of cutthroat trout, or cutthroat trout in general.

It is possible that native fish, most likely rainbow trout and possibly cutthroat trout, are still present in upper Mowich Creek. Lower Mowich Creek contains a high gradient canyon reach that most likely prevents migration from the Clearwater River into the upper reaches of Mowich Creek. Electroshocking in upper Mowich Creek in 1992 revealed the presence of what appeared to be rainbow trout. Mowich Creek is not mentioned in Forest Service stocking records and ODFW has no record of fish stocking in Mowich Creek. Since there is some evidence of "native" fish presence in Bear Creek and the origin of fish present in upper Mowich Creek is uncertain, the presence of native fish in the Clearwater River system cannot be ruled out.

Fish Habitat

The most obvious differences in habitat quantity and quality would have been due to impacts associated with timber management and the absence of a regulated flow regime and other impacts associated with the North Umpqua Hydropower Project. Specific impacts include straightening of portions of the Clearwater River mainstem below Whitehorse Falls, impacts to riparian areas from timber harvest and road construction, and sediment yield associated with road construction, harvest activities, and the hydropower project. The collective absence of these impacts would have produced much different fish habitat in the Clearwater River mainstem below Stump Lake and upper Mowich Creek, and probably somewhat different habitat in Bear, Lava, and Trap Creeks. The Clearwater #1 forebay and Stump Lake did not exist before development of the watershed.

The Clearwater River mainstem below the location of what is now Stump Lake would have had a much greater quantity and different timing of water flow, and fish habitat would have been quite different. More woody material and gravels would have been present. The presence of large woody material can slow stream flow by dissipating stream energy, provide sediment storage sites, add to habitat complexity, provide nutrient input, and help capture spawning gravels. Thus, the historic condition of the Clearwater #1 bypass reach probably provided higher quality fish habitat than is present today.

The Clearwater River above Stump Lake has not been affected by the hydropower project and has had only minimal riparian harvest. Therefore, the historic condition of the fish habitat would have been very similar to what exists today.

The canyon segment of Mowich Creek would not have been much different than it is today. The lower segment flows through a steep canyon that creates a high energy boulder and bedrock system that has probably been maintained close to historic condition. The riparian areas of the canyon reach have had only minimal harvest, so riparian area function should also be relatively unaltered. The historic condition of the lowest reach of Mowich Creek, that below the canyon segment, may have been quite different from what is present today. The reach has a much lower gradient than the canyon segment and what appears to be a constructed berm is present. The berm may be the result of dredging. The riparian area in upper Mowich Creek has been extensively harvested. Riparian vegetation, sediment and solar inputs, stream channel morphology, and possibly winter water temperatures would have been moderately to very different historically. More large conifers would have been present in the riparian areas, more woody material would have been in the stream channel, more pool habitat would have been present, channel substrate may have had less fine sediment, and winter water temperatures may have been higher.

Fish habitat in Lava Creek would have been somewhat different than it is today. Construction of Forest Service Road 800 dammed Lava Creek and created Little Bear Lake, flooding a historic channel meandering through a meadow. A moderate amount of riparian harvest has occurred along portions of the stream. More woody material was probably present in the historic channel, resulting in more pool habitat and better fine sediment processing. Since a high percentage of Lava Creek is influenced by surficial pumice soils, the stream substrate probably had a substantial fine sediment component historically.

Fish habitat in Bear Creek would have been similar to what it is today, but would have had less fine sediment, and habitat near the headwaters would have been in better condition. Sediment input into Bear Creek would have been less, but the overall percentage and significance of anthropogenic sediment input to fish habitat in the Bear Creek drainage is not clear. It is possible that the historic sediment load of Bear Creek was only slightly lower than it is today. The stream channel near the headwaters, above the canyon reach, would have most likely been of the Rosgen (1994) “E” type. The “E” channel type typically provides good to excellent fish habitat.

Trap Creek probably contained much higher amounts of woody material than is present in the channel today. As with Lava Creek, this would have resulted in more pool habitat and better fine sediment processing. Since the mainstem of Trap Creek flows through surficial deposits, the stream substrate of Trap Creek probably had a large fine sediment component historically.

Current Condition, Differences from Historical Condition, and Responsible Mechanisms
Fish habitat in the Upper Clearwater River system is currently somewhat degraded and altered from the historical condition. The degree of change from historical conditions varies greatly depending on stream and reach. Some stream reaches, such as the Clearwater River mainstem below Stump Lake, have been very significantly altered from the historical condition; whereas other stream reaches, such as the canyon segment of Mowich Creek, have been altered little. Impacts associated with timber harvest, road construction, and hydropower development are the dominant anthropogenic forces responsible for habitat alteration.

The fish community has been drastically altered from the historic condition. While it is not clear if any fish species were present historically, the species currently present and their distribution, with the possible exception of upper Mowich Creek, are the direct result of fish stocking practices. If fish were historically present, fishing pressure would also have been a force altering the population structure and composition. If the Clearwater River system was historically fishless, then the differences between current and historic conditions are clear. The introduction of fish to a previously fishless system would have undoubtedly altered the structure, and possibly the composition, of the aquatic insect and amphibian communities originally present.

Fish Species

If fish were historically present in the Clearwater River system, the stocking of hatchery rainbow trout and brook trout has drastically changed the fish community structure and composition. Any native rainbow, cutthroat, or bull trout that were historically present would have most likely been extirpated from the system through interspecific competition and/or crossbreeding with introduced species. Cutthroat trout do not coexist well with brook trout, and brook trout introductions generally either eliminate or cause a severe decline in cutthroat trout populations (Griffith, 1988). Brook trout and bull trout are closely related chars, and cross breed to produce a sterile hybrid. Due to the production of sterile hybrids, the early sexual maturity of brook trout, and other factors, the introduction of brook trout generally leads to a decline in bull trout populations. Thus, if cutthroat trout and bull trout were historically present, there is a high probability that they would have been eliminated from the system following the introduction of brook trout. Introduced rainbow trout would have crossbred with native rainbow trout, altering the genetic makeup of the native fish.

Historical stocking records are poor, but it is known that both the ODFW and Forest Service were involved in fish stocking in the upper North Umpqua system from early in the 1900s until the 1950s. The ODFW stocked brown trout and brook trout in the upper North Umpqua system in the early 1900's. Brook trout were probably stocked by ODFW in the Clearwater River in the 1920s through the 1930s, and possibly some in the 1940s (Loomis 1996). During the late 1950s, Kamloops rainbow trout eggs and fry were stocked by the ODFW throughout the upper North Umpqua River drainage. It is believed that at least the lower Clearwater River mainstem was stocked with Kamloops eggs and fry by ODFW at this time (Loomis, 1996). Records indicate that the Forest Service first stocked rainbow trout in the Clearwater River mainstem below [the] falls" in 1939. Since road access existed at the time to both Clearwater and Whitehorse Falls, it is not clear which falls are referred to. In 1940 and 1941, rainbow trout were stocked by the Forest Service in the Clearwater River mainstem both "above & below [the] falls". Lava, Bear, and Trap Creeks were also stocked by the Forest Service with rainbow trout in 1940, and Bear and Trap Creeks were stocked with rainbow trout again in 1941.

The current distribution of brook trout and rainbow trout is the net result of stocking locations, interspecific competition, and the location of upstream migration barriers. If no further fish stocking occurs, the current distribution of rainbow and brook trout is likely to either remain stable or experience a further shift to brook trout dominance. However, of the habitat available to brook trout, they overwhelmingly dominate rainbow trout in all but Lava Creek. Pure rainbow trout fisheries are believed to currently exist only in Trap Creek, upper Mowich Creek, and a short reach of the Clearwater River above Stump Lake. This is due to the presence of upstream migration barriers that prevent brook trout invasion. The few rainbow trout that do coexist with brook trout in Stump Lake, the Clearwater #1 forebay, and the Clearwater River downstream from Stump Lake would probably be eliminated from the system through interspecific competition without regular immigration from Trap Creek, upper Mowich Creek, and the Upper Clearwater River. Therefore, the current distribution of brook trout and rainbow trout in the analysis area is most likely to remain stable over time.

Fish Habitat

The Clearwater River stream system has experienced a number of impacts that have altered the historic condition of the streams and resulted in current stream conditions. The North Umpqua Hydroelectric Project created both the Clearwater #1 forebay and Stump Lake impoundments, and reduced streamflow, gravel recruitment, and woody material recruitment in the Clearwater River below Stump Lake. Riparian timber harvest and road construction have reduced woody material recruitment sources in some areas, and instream salvage logging has reduced acting woody material throughout much of the Clearwater River system. The construction of roads throughout the watershed has created new sources of fine sediment and has resulted in higher suspended sediment levels during high water events and increased fine sediment deposition in some areas.

The Clearwater River segment downstream from Stump Lake (Clearwater #1 bypass reach) currently contains less spawning habitat, rearing space, and overall habitat complexity than was historically present. This is due to reduced streamflow, acting woody material, and gravel sized substrate. Suspended sediment levels are probably higher than historic levels. The Clearwater River flow in the bypass reach is currently regulated by the North Umpqua Hydroelectric Project and flow is greatly decreased in the Clearwater #1 bypass reach. Much of the streamflow is diverted at Stump Lake and temporarily returned to the river at the site of the Clearwater #1 powerhouse. The water is again diverted less than 100 feet downstream at the Clearwater #2 diversion dam (at the analysis area boundary). The Clearwater #1 diversion dam at Stump Lake prevents gravel and most large woody material recruitment into the Clearwater River below Stump Lake from Bear Creek and the upper reaches of the Clearwater River. The low gravel recruitment is reflected in the stream survey, which found that only six percent of the substrate in the Clearwater #1 bypass reach is composed of gravel sized material. It was determined that only one percent of the channel area provided spawning habitat. A confounding factor is that no tributary stream large enough to provide gravel input enters the Clearwater #1 bypass reach until Mowich Creek enters at the lower end. Trap Creek enters shortly below Stump Lake, but is too small to efficiently transport large quantities of gravel. Acting woody material has been removed from the stream channel through stream cleaning and salvage logging that occurred before 1985.

The Clearwater River mainstem above Stump Lake is a fundamentally intact system, with some localized impacts. The North Umpqua Hydroelectric project minimally affects only the lower few hundred feet of habitat by slowing water velocity as the Clearwater River enters Stump Lake. Very little riparian timber harvest has occurred and riparian road construction has been limited. Only one timber harvest unit near the downstream end of the reach is partially within designated riparian reserves. Limited timber harvest has occurred within the riparian areas of some tributaries, and may be exerting some downstream effects to the river mainstem. Road 4785 passes within 100 feet of short stretches of the river mainstem in three locations, and Highway 138 crosses the river mainstem near the headwaters. A campsite and picnic area have been developed on both sides of the river at the site of Clearwater Falls. This area is probably the most significant impact to this river segment. Clearwater Falls occurs at a contact zone between High Cascades basalt deposits (downstream) and pyroclastic ash flow surficial deposits (upstream). The river mainstem above the falls flows through ash flow deposits and has a naturally high fine sediment load. The upstream end of Clearwater Falls acts as a check dam and creates a natural slow water reach immediately above the falls. This results in heavy deposition of fine material above the falls and an increase in erosional pressure on the stream banks. An increase in the channel width/depth ratio results. A large, heavily used campsite on the eastern bank of the river immediately above the falls may be aggravating the natural tendency of the channel to widen by decreasing bank strength. The campsite has been present since at least the 1930s, and the streambank vegetation has been removed along portions of the bank. A trail along the western edge of the falls may also be creating some localized impacts.

The upper two thirds of the Mowich Creek subwatershed, in the Mowich Park and Watson Ridge area, has been heavily impacted by timber harvest and road construction activity. Mowich Creek has not been affected by the North Umpqua Hydroelectric Project. A substantial portion of the riparian areas have been cut along the creek mainstem and most tributaries. Approximately 360 acres of harvest within the currently designated riparian reserves (29 percent of the total harvest within riparian reserves in the Upper Clearwater Watershed) has occurred since 1950. Roads have been constructed in riparian areas in a number of locations, and overall road density is high at approximately four mi/mi^2. A stream survey was conducted on upper Mowich Creek in 1992, however, it has been determined that the data is unreliable. Since the 1992 stream survey data was determined to be unreliable, it is not possible to discuss the effects of riparian harvest and road construction on fish habitat in detail. The upper stream segment needs to be re-surveyed in order to clearly assess the current condition. However, stream channels of lower gradient systems, such as Mowich Creek through Mowich Park, tend to be susceptible to both localized impacts and the expression of impacts generated upstream. The canyon segment of the Mowich Creek mainstem has been impacted to a lesser degree, and the current condition is probably very similar to the historic condition.

The Lava Creek subwatershed has received a moderate level of riparian impacts, and the creek has been somewhat degraded from the historical condition. Lava Creek has not been affected by the North Umpqua Hydroelectric Project. Acting woody material levels are very low and fine sediment deposition is high. It is likely that spawning habitat and rearing space have been somewhat reduced from the historical level. The low woody material counts most likely result from a combination of instream salvage, stream cleaning, and a stand replacing fire in portions of the watershed that occurred in 1910. High levels of fine sediment deposition most likely result from a combination of fire history, geologic factors, timber harvest, and road construction. Most of the Lava Creek mainstem flows through surficial pyroclastic ash deposits, making the stream naturally susceptible to a high fine sediment load. A total of 125 acres (15 percent) of the currently designated riparian areas have been harvested since 1960. Road density is high at 4.75 mi/mi^2. Most of the riparian harvest along the Lava Creek mainstem occurs in one large clearcut, approximately 500 acres in size, near the creek headwaters. A section of the stream channel has downcut approximately 1.5 to 2 feet downstream from the clearcut, with the downcut ending when the stream enters a reach containing a number of old and new beaver dams. The stream segment flooded by the creation of Little Bear Lake has been lost.

The Bear Creek subwatershed has received a moderate level of riparian impacts, and the creek has been at least somewhat degraded from the historical condition. The North Umpqua Hydroelectric project affects only the lower few hundred feet of habitat by slowing water velocity as Bear Creek enters Stump Lake. Acting woody material levels are moderate in the upper reaches of the stream and high in the mid and lower reaches, and are likely to be very similar to the historic levels. Fine sediment deposition is high to very high in all but one high gradient stream reach. An increased amount of fine sediment deposition, a consequent decrease in spawning habitat, and an increased suspended sediment load have probably occurred, and may represent the most significant differences between the current and historic habitat conditions. A decrease in pool depth from pool filling and increased width/depth ratio may have also occurred. A moderate amount of riparian harvest has occurred in the Bear Creek subwatershed, with most occurring along the mid-reaches of the creek mainstem. Roads parallel the creek mainstem for most of its length, often on both sides of the creek. The meadow complexes in the upper mainstem, in the vicinity of Old Man Camp, have been used for grazing since at least the late 1800s. The stream channel in the vicinity of Old Man Camp has probably undergone a shift from a highly meandering, low width/depth ratio “E” type channel (Rosgen, 1994) to a less meandering, higher width/depth ratio “C” type channel. The “E” channel type typically provides good to excellent fish habitat and is stable in high water events. The stream channel in the vicinity of Old Man Camp may have been heavily degraded in the past when grazing pressure was higher, and may have recovered somewhat. Most of the Bear Creek mainstem flows through highly erosive surficial deposits, and has a naturally high sediment load. The timber harvest and road construction along the creek mainstem in these sensitive areas is very likely to have increased the stream sediment load. The stream channel may have widened somewhat from the historic condition. The 1940 Diamond Lake Ranger District fishery assessment (Roth, 1940) reported an average width of 15 feet for the lower six miles of Bear Creek. If this is accurate, then the stream channel may have widened somewhat since 1940, as the 1992 stream survey of Bear Creek reported a width of approximately 18 feet. The summer of 1992 was very dry and a narrower, rather than wider, wetter width would be expected.

Stream channels in the Trap Creek subwatershed have been degraded from the historic condition by the extensive harvest of riparian areas, the removal of acting woody material by stream cleaning, and riparian road construction. Trap Creek has not been affected by the North Umpqua Hydroelectric Project. Acting woody material levels are very low, fine sediment deposition is high, and overall habitat complexity is very low. It is very likely that spawning habitat and rearing space have been reduced from the historical level. The original stream channel may have been a Rosgen (1994) “E” type, and converted through impact to a “C” type. The low woody material counts most likely result from a combination of extensive riparian harvest, instream salvage, stream cleaning, and a stand replacing fire in portions of the watershed that occurred in 1910. The Trap Creek mainstem flows through glacial drift and ash flow surficial deposits, and would tend to naturally have a moderate level of fine sediment deposition. However, management impacts occurring adjacent to the stream have probably increased fine sediment deposition significantly. Over 40 percent of the riparian areas of Trap Creek have been harvested and a road parallels over half of the perennial portion of the creek mainstem. At least one stream crossing has failed into Trap Creek and is serving as a chronic sediment source.

Future Trends

Species

The fish species composition and distribution in the analysis area is not likely to change over time. As discussed in the "Current Conditions" section above, brook trout appear to have eliminated rainbow trout and any other fish species that may have been historically present, from areas they have been able to access. In the few areas where rainbow trout are coexisting with brook trout, it appears to be the result of a low level of immigration from upstream areas.

Habitat

An overall upward trend in fish habitat condition may occur over the next several decades even though the entire analysis area is allocated to matrix lands in the ROD. The trend will occur if the Aquatic Conservation Strategy (ACS), as defined in the ROD, is fully implemented. Removal of acting and future woody material and increased fine sediment input are the most common effects pathways in streams in the analysis area that have been impacted by timber harvest and road construction activity. Full recovery of impacted riparian areas is likely to take from one to several centuries. Portions of the Clearwater River system, such the hydropower influenced segments, will never recover to the historic condition, whereas other areas may approach the historic condition over time.

PacifiCorp, the owners of the North Umpqua Hydroelectric Project, have applied to the Federal Energy Regulatory Commission for a 30 year license to continue operation of the project. The granting of the license will assure that impacts to the Clearwater #1 bypass reach allowed under the license will continue for at least another 30 years. However, the implementation of the ACS will allow an increase in quality of some aspects of fish habitat in the bypass reach. The quantity of instream woody material present will increase over time, and will increase the efficiency of gravel capture and storage in the system. Since gravel inputs into the bypass reach are sharply restricted by the presence of the Clearwater #1 diversion dam, increased efficiency of gravel capture will help to increase the availability of spawning habitat and may lead to an increase in fish production. Currently, only one percent of the stream channel provides spawning habitat. In summary, the condition of fish habitat in the Clearwater #1 bypass reach is likely to improve somewhat from the implementation of the ACS, but the potential for improvement will be limited by hydropower impacts.

The condition of fish habitat in the Clearwater River above Stump Lake is likely to remain relatively static overall. The condition of fish habitat in some areas is likely to improve somewhat, and decrease somewhat in localized areas. With the implementation of the ACS, the quantity of instream woody material is likely to increase over time. This river segment is extremely deficient in pool habitat, and an increase in acting woody material will increase the frequency of scour and dam pools. The consequent increase in rearing space is likely to increase the average fish size and possibly increase overall production. The condition of fish habitat in the vicinity of Clearwater Falls may decrease in quality somewhat due to impacts associated with high recreation use.

Fish habitat conditions in Mowich Creek will remain relatively static in the canyon reach, but habitat quality in the upper two thirds of the watershed will increase with the implementation of the ACS and the vegetative recovery of harvested riparian areas. If fish habitat in the upper stream channel is surveyed and restoration projects identified as necessary are implemented, recovery time may be shortened somewhat.

Fish habitat conditions in Lava Creek will improve somewhat over time with the implementation of the ACS and the vegetative recovery of the large clearcut adjacent to the upper creek mainstem. Since fish habitat has not been heavily degraded in this system, the potential for overall improvement in habitat quantity and quality is not high. The amount of instream woody material will increase over time and will improve sediment processing. The recovery of the large clearcut in the upper watershed will decrease fine sediment input somewhat and will reduce the amount of downcutting occurring immediately downstream. The net result will most likely be an increase in pool frequency in the lower reaches, an increase in rearing habitat quality (and possibly quantity), and an increase in the quality of spawning habitat.

Fish habitat conditions in Bear Creek may improve somewhat over time with the implementation of the ACS. The primary change in fish habitat from the historical condition in Bear Creek has largely been the result of increased fine sediment load. The recovery of streamside harvest units and the meadow complexes along the upper stream channel near Old Man Camp will reduce the anthropogenic portion of the sediment yield somewhat. However, streamside roads and stream crossings are likely to remain sediment sources. The natural fine sediment load will remain high. Since the proportion of the fine sediment load due to management impacts is unclear, it is difficult to predict what changes in fish habitat will occur. If implementation of the ACS results in a significant decrease in fine sediment yield, the stream channel width/depth ratio would probably decrease and the quality, and possibly quantity, of spawning habitat may increase.

Fish habitat conditions in Trap Creek are likely to improve significantly over time with the implementation of the ACS. Riparian areas have been extensively harvested and instream woody material is extremely low. Revegetation will increase the supply of woody material and increase stream/upland connectivity. Increased instream woody material will increase pool quality, and spawning and rearing habitat quantity and quality.

Fish habitat conditions in Stump Lake and the Clearwater #1 forebay can be expected to deteriorate over time without maintenance. The quality of the habitat will slowly decrease as both systems slowly fill with sediment. Summer high water temperatures will gradually rise, and winter low water temperatures will gradually drop, as the systems become shallower. This effect will be tempered by the relatively high turnover rate of both systems, and the reduction of habitat space will likely become limiting before summer high temperatures. However, PacifiCorp has proposed dredging the Clearwater #1 forebay. Dredging would probably improve fish habitat in the short term, and delay lake sedimentation.

Influences and Relationships to Other Ecosystem Processes

The influences and relationships of the condition and trends of fish habitat and populations to other ecosystem processes are extremely complex and far beyond the scope of what can be discussed in this document. In general, properly functioning fish habitat, riparian systems, and healthy fish populations provide food, habitat, and microclimates for a variety of terrestrial and aquatic wildlife and plant species, provide critical links in nutrient cycling and upland/stream channel connectivity, control erosion, and many other functions.

BIOLOGICAL DIVERSITY

Vegetation

Analysis Procedures, Assumptions, and Data Gaps

Analysis procedures followed the process described in "Forest Landscape Analysis and Design" by Nancy Diaz. The analysis critieria used to describe vegetative diversity included plant series, structural class (seral stage), and pattern. Information used to map plant series and structural class was obtained from timber stand exams, the GIS size class layer, 1949 aerial photography, 1933 fire lookout photos, and local District knowledge of the watershed. Analysis tools included UTOOLS, EVG, and Paradox databases. Because of the dynamic nature of vegetative structure on the landscape and the lack of information prior to 1933, no analysis of the range of variability was conducted for the watershed. Table 11 defines the structural classes used in the analysis. Definitions were taken from Appendix B of the ROD.

Table 11 - Vegetative structure definitions

STRUCTURAL CLASS	DEFINITION
Establishment	Managed stands following clearcut harvest in the early seral stage, usually 0 to 20 years of age. They exhibit rapid and diverse plant establishment.
Establishment with Overstory	Managed stands following shelterwood harvest in the early seral stage, usually 0 to 15 years of age. They exhibit rapid and diverse plant establishment.
Open Thinning	Managed stands following clearcut harvest in the mid seral stage, usually 20 to 80 years of age characterized by 1 to 5 acre brush or grass openings.
Closed Thinning	Managed stands following clearcut harvest in the mid seral stage, usually 20 to 80 years of age, and characterized by high crown closure and unfavorable growing conditions for most understory species due to low light levels.
Mature	Natural stands in the late seral stage, usually 80 to 140 years of age, and characterized by a slowed rate of height growth and crown expansion, understory development of shade tolerant tree species, and accumulation of down woody material in early decay stages.
Transition	Natural stands in the late seral stage, usually 150 to 300 years of age, and characterized by multiple canopy layers; thick barked, slow growing, open and irregular crowned overstory trees; accumulation of coarse woody debris in later decay stages; and low to moderate intensity disturbances from insects, disease, wind, and fire that create patchy openings and accumulations of standing dead trees.

Reference and Current Condition

The year 1949 was used to characterize reference condition. There was not much diversity in structural class in 1949. The transition (late seral) and mature (late seral) structural classes dominated the landscape pattern (matrix as described in the Diaz process) and provided high amounts of interior forest habitat. The closed thinning (mid seral) structural class, meadows, and rocky areas represented the patches on the landscape. Closed thinning stands were characterized by six to ten inch diameter lodgepole pole pine that pioneered these sites following a 7000 acre stand replacement fire that occurred around 1910 in the eastern central section of the watershed. Based on existing age classes, it is estimated that this reference condition represented the greatest amount of late seral that occurred within the watershed at any point in time. Figure 36 displays the percentage of each structural class in 1949. Figure 38 shows the location of these structural classes in 1949.

Currently, there is great diversity of vegetative structure and pattern within the watershed. All structural classes, ranging from establishment to transition, are represented in various landscape patterns. There are two large areas (> 4000 acres) of unfragmented late seral stage forest made up of the mature and transition structural classes located in the eastern central and southeastern sections of the watershed. These areas are providing interior forest habitat. The northern and western central sections are heavily fragmented with all structural classes and seral stages occurring within them. These areas are providing edge type habitats. This diversity of vegetative structure and pattern is providing a wide range of habitats for wildlife species. Figure 37 displays the percentage of each structural class in 1996. Figure 40 shows the location of these structural classes in 1996.

Plant series and seral stage were overlaid to better understand the vegetative diversity issue. Plant series are used by ecologists to combine various types of vegetation into recognizable groups. Plant series are described by herb, shrub, and tree species on the basis of the likelihood that a particular tree species will become climax given a period of stability free from disturbance. Table 3 in Chapter II described the plant series present in the watershed and their general successional patterns. Plant series are not usually dynamic and are the same for reference and current condition. Figure 39 displays the percentage of seral stage class by plant series in 1949. Figure 41 displays the percentage of seral stage class by plant series in 1996.

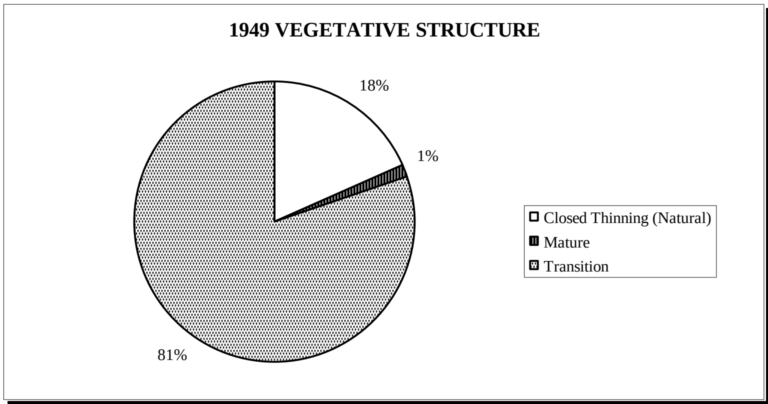


Figure 36 - Percentage of vegetative structure in 1949

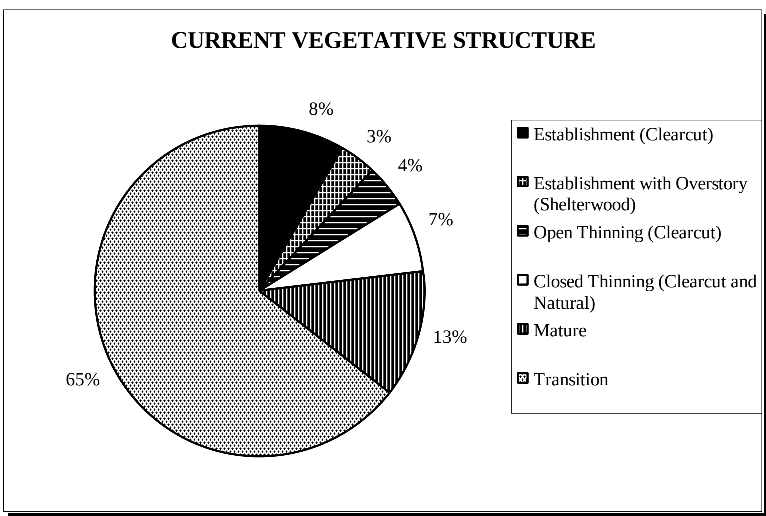


Figure 37 - Percent vegetative structure in 1996

Figure 38 - Map of Vegetative Structure in 1949

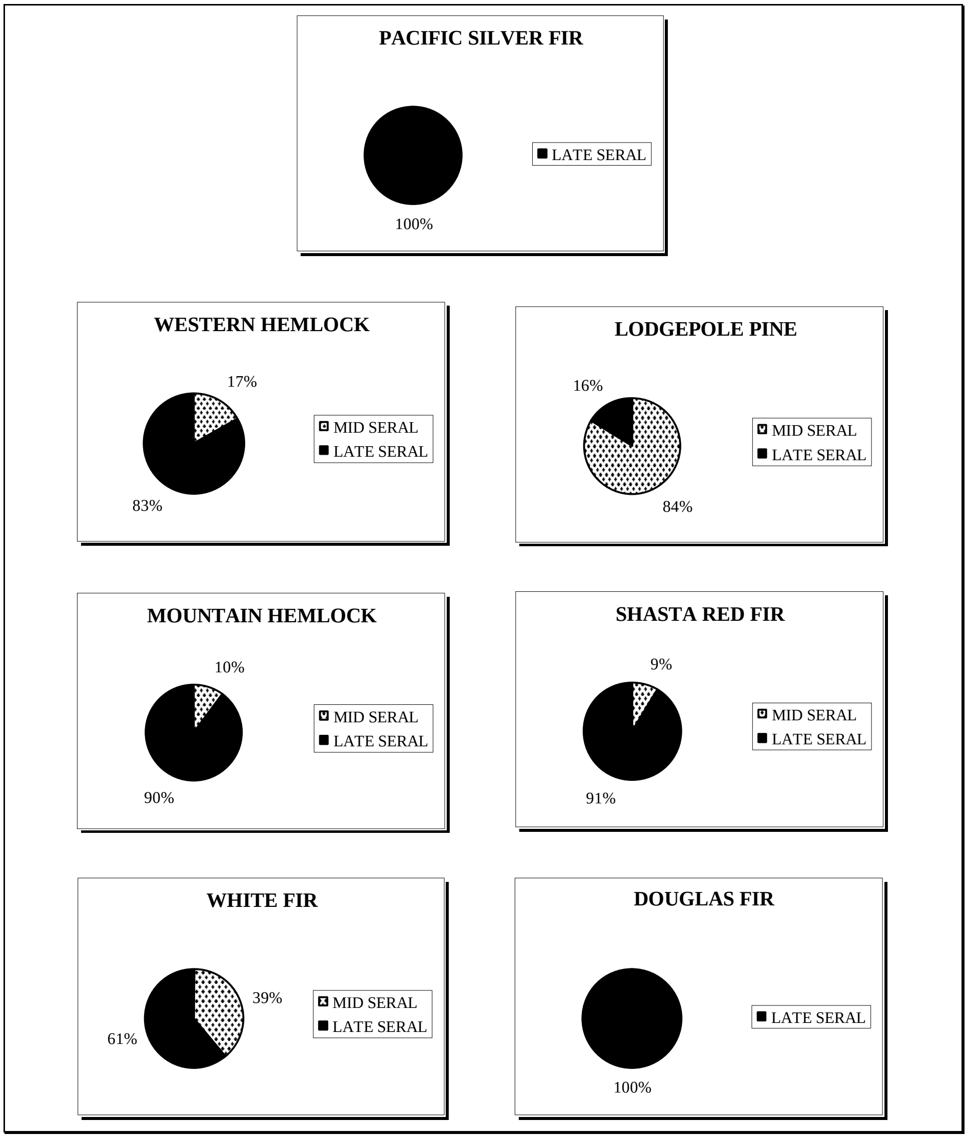


Figure 39 - Percent seral stage by plant series in 1949

Figure 40 - Map of Vegetative Structure in 1996

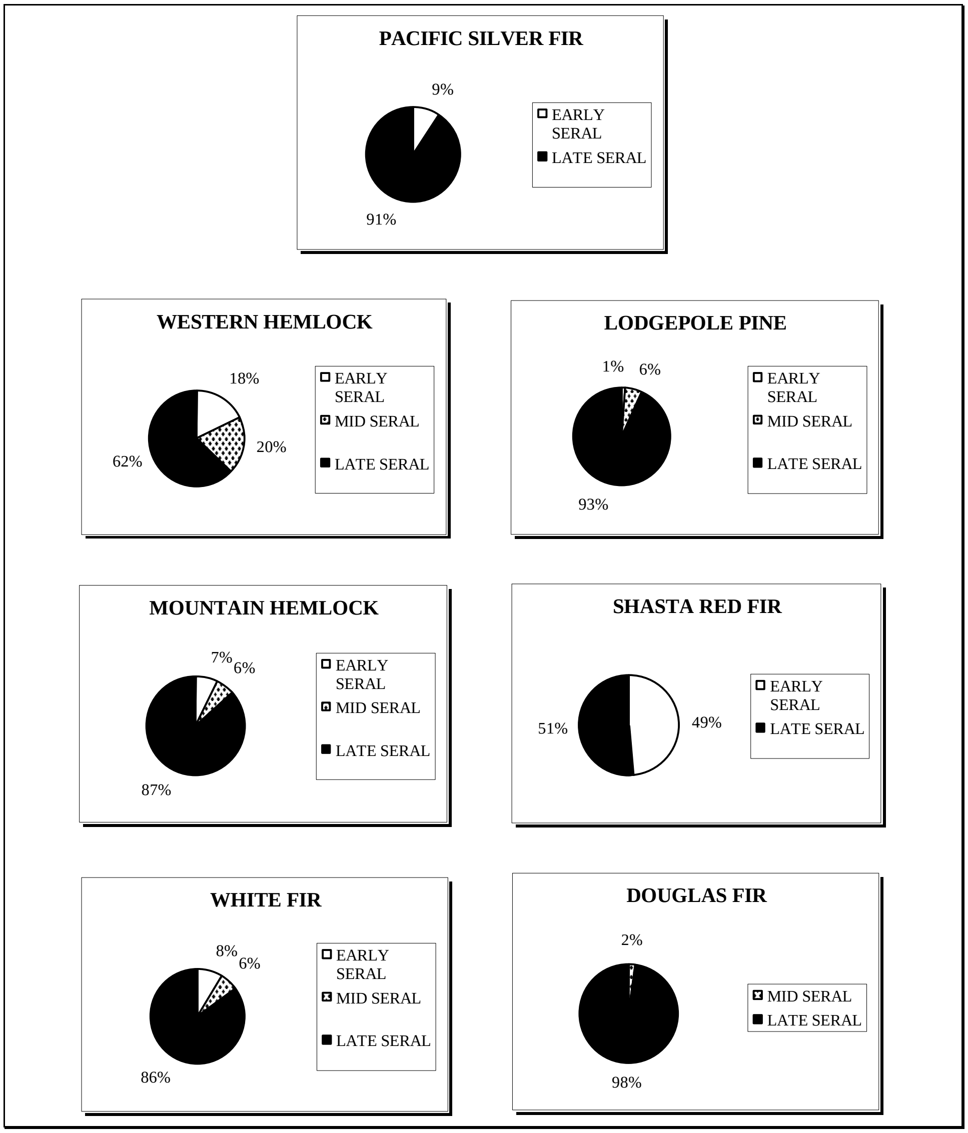


Figure 41 - Percent seral stage by plant series in 1996

Differences or Similarities Between Conditions

There is greater diversity of vegetative structure and pattern within the watershed today than there was in 1949. All seral stages are present today, whereas in 1949 the early seral stage was virtually absent from the landscape except for small scale disturbance microsites caused by root disease, fire, and bugs. The amount of late seral stage forest has declined from 81 percent in 1949 to 65 percent today. Large areas (greater than 4000 acres) of interior forest habitat were present in 1949 and are still present today in the eastern central and southeastern sections of the watershed. Edge habitats are abundant in fragmented areas of the watershed today, whereas they were virtually non-existent in 1949 except around natural meadows and rock outcroppings.

Processes or Causal Mechanisms Responsible

The main causes for the difference between conditions are timber harvest and fire suppression. Timber harvest began in 1949 and shaped vegetative structure and pattern up to the present day. Historically the early seral stage component was achieved through natural disturbance, primarily stand replacing fire. Timber harvest fragmented some areas of the watershed, while a stand replacing fire would concentrate the early seral stage in a more contiguous manner. The Mount Bailey Roadless Area and the Diamond Lake Composite allocation in the 1978 LMP are the reasons a large unfragmented block of interior forest habitat exists today in the southeastern section of the watershed.

Future Trends

Timber harvest will continue to take the place of natural fire and change the structure and pattern of vegetation within the matrix land allocation. The pattern of vegetation will be managed to maintain a diversity of habitats over time (See recommendations for more specifics).

Influences and Relationships to Other Ecosystem Processes

The structure and pattern of vegetation relates to all other ecosytem processes taking place in the watershed. The dynamic nature of this ecosystem component is living proof that ecosystems are not static. Examples throughout this report show how important it is to maintain the diversity of vegetative structure and pattern in order to sustain the physical, biological, and social values within the watershed. Table 4 in Chapter Two shows some of the relationships between landscape flows and vegetative structure (elements).

Wildlife

Analysis Procedures, Assumptions, and Data Gaps

The analysis for this topic was completed by reviewing data from various inventorying/monitoring projects. Little information had been collected on the animal species in the analysis area until the 1980s, when spotted owl surveys began. Dave Fix, a Forest Service employee, started to construct a bird list in the 1980s, but no site specific information is available.

There is discussion on the affect management facilities (roads, canals) may have on genetic linkages across the landscape. Although there is evidence of genetic isolation due to large systems (Columbia River), there is nothing that indicates this to be a critical issue within the watershed. It is considered to be a data gap.

Reference Condition
The reference state of this area was probably one of late seral stage forests with some recent change (past 100 years) in the Mowich Park area due to a stand replacement fire. Species diversity was probably less in the reference state since there were more unbroken tracts of late seral stage forests and less vegetative diversity.

Current Condition
The only information that is available to assess the current condition is general knowledge of the area by Forest Service staff and information collected from a couple of recent projects. A portion of the Demonstration of Ecosystem Options Study (DEMO) involved an inventory of bird species on areas in the Upper Clearwater Watershed. One survey location was near Stump Lake and the other in the Mowich Park Area. Eighty species of birds were counted at these sites during the summer of 1995. A small mammal/amphibian inventory project was conducted using pitfall traps in the Watson Falls and Dog Prairie DEMO sites. Units one and four of the Watson Falls DEMO block are located within the Mowich Creek subwatershed. Sixteen species of mammals and six species of amphibians were collected from October to November 1995. A list of the bird, mammals, and amphibians are listed in Appendix F.

PacifiCorp has been conducting faunal surveys at Stump Lake and the Clearwater #1 forebay as part of the application for a new license for the North Umpqua Hydroelectric Project. They found that Stump Lake supported a diverse mix of wildlife species in the spring and summer. Passerine birds were most common with violet-green swallows, American dippers, and dark-eyed juncos being most frequently observed. Incidental observations of wildlife associated with the Clearwater #1 development during 1992 and 1993 included observations of 337 individuals of 42 species at Stump Lake; 3,123 individuals of 91 species at the forebay; and 121 individuals of 29 species along the waterway (PacifiCorp 1995).

Differences or Similarities Between Conditions
The harvesting of mature timber stands has created a more diverse landscape than during the reference condition, both in structure and species composition. This has probably led to more animal species diversity. Indicators of this change include the nesting of a pair of barred owls in the Upper Clearwater Watershed and an increasing elk population. Both species prefer a mix of open and forested habitats.

Processes or Causal Mechanisms Responsible
Disturbance factors such as forest pests, wind throw, and fire were the driving forces for ecological community changes in the past. The relatively recent addition of logging has probably resulted in more accelerated changes in forest faunal species composition and species diversity due to changes in plant communities.

Future Trends
Since logging is planned in this watershed for the foreseeable future, habitat for early seral stage species will be abundant. Habitat for late seral stage species will be provided through riparian

reserves, owl activity centers, 15 percent green tree retention within harvested areas, and uneven aged management within the mountain hemlock plant series.

Influences and Relationships to Other Ecosystem Processes
Biological diversity is directly affected by ecosystem processes. Disturbances such as stand replacing fires, forest disease outbreaks, and landslides can affect the mix of species.
Table 4 in Chapter Two shows some of the relationships between animal species and vegetative structure (elements).

ELK WINTER RANGE

Analysis Procedures, Assumptions, and Data Gaps
Elk winter range management was identified as a high priority issue due to the increase in elk population and hunting pressure. Historical accounts of western Oregon were researched to ascertain if elk were native to the area. Information on elk stocking efforts and recommended winter range habitat proportions were collected from ODFW. The results from radio-telemetry studies conducted by ODFW in cooperation with the Forest Service were used to analyze elk movements. Mowich Park elk winter range analyses were made based on interpretation of aerial photographs, timber stand exams, and from visits to the area.

One of the data gaps is that there is no accurate estimate of the elk population in this watershed. However, this may not be necessary to properly manage the elk herd. We do not know what the disturbance affect is from people using the Forest where elk tend to congregate. The effect of the transportation network (road density) on elk has not been evaluated.

Reference Condition

<u>History of Elk in the Upper North Umpqua Basin</u>

Populations of elk are not identified in any of the historic accounts of the Upper North Umpqua, above Toketee Falls, until the 1920s, when Jessie Wright in “How High the Bounty” (J.L. Wright 1982) mentions seeing elk tracks for the first time in Kelsay Valley and along the Calapooia Ridge. This corresponds to the release of Rocky Mountain elk into Crater Lake National Park (circa 1920, Oregon Department of Fish and Wildlife (ODFW pers. comm.)). There are anecdotal comments in the ODFW “Ecology and Management of Roosevelt Elk in Oregon” on elk being in the high Cascades in the 1800s. By the late 1880s, few elk remained in Josephine County and the upper Umpqua River country. They were reported as missing from the Crater Lake National Park area and Columbia County.

ODFW attempts at establishing manageable populations of elk are outlined in “Ecology and Management of Roosevelt Elk in Oregon”. This document identifies releases of seven elk in Copeland Creek (Douglas County) in 1948-49 and the establishment of a “huntable population”. Additional releases were in Panther Creek (1967-68), the South Umpqua drainage (1968-69), Beaver Lakes (1969-70), Quartz Mountain (1970-71), and Tallow Butte, South Umpqua (1971-72). In addition, there is reference to a Memorandum of Understanding between the Oregon State Game Commission and the United States Forest Service, dated December 12, 1968, for the release and establishment of manageable elk populations at Black Rock and Lonewoman-Abbot Creeks, Umpqua National Forest.

Current Condition

There is no written evidence to suggest that elk were plentiful in the Upper Clearwater Watershed prior to recent times. Logging during the last four decades has enhanced elk habitat conditions, thus allowing the herd to increase. Clearcutting has provided more forage and a diversity of forest structures. The actual size of the elk population is unknown, but based on various indicators including the number harvested by hunters and observations by ODFW personnel, elk numbers are increasing. ODFW estimates that 2800+ Roosevelt (cascadian) elk live on the Diamond Lake Ranger District (DLRD).

“Cascadian” Elk Habitat Use on the DLRD

The Rocky Mountain elk are migratory, Roosevelt elk are non-migratory, and the “cascadian” elk are anabastic. A cow elk was captured and tagged in the Mowich Park area during a five year radio-telemetry study of elk movement on the DLRD conducted by ODFW from 1983-1987. This animal was subsequently relocated during the study in Big Marsh (headwaters Little Deschutes), Deer Creek (Calapooia Ridge), Sherwood Butte (Rogue River National Forest), and Fish Creek Desert.

The relative flatness allows for easy movements throughout an area contained between township/range 25S/R3E (Boulder Creek Wilderness) to 28S/R3E (Fish Creek Valley, Rogue-Umpqua Divide Wilderness), east to the Cascade crest and eastside meadows, and south to below Crater Lake National Park (Rogue River National Park). There are two primary movement areas south out of the Calapooia divide through Deer Creek: Thorn Prairie (East) and Deer Leap (West). Movement out of Deer Leap is into Boulder Creek and Reynolds Ridge. Movement out of Thorn Prairie has two paths: South through Watson Saddle into Mowich Park or east to Lemolo Lake. Mowich provides access into Fish Creek Desert, Lemolo Lake, and Lost Creek.

Movement out of Fish Creek Desert is three pronged: south up Fish Creek (westerly), south toward Skookum Prairie (easterly), and back east to Mowich Park. Access to Lemolo is through Toolbox Meadows. Bear Creek and Lost Creek are travel corridors through the Stump Lake area. Elk also can access Bear Creek/Lost Creek areas through Skookum Prairie.

Elk movement out of Lemolo is through Kelsay Mountain, Lake Creek, and Lost Creek. Elk also move back into Thorn Prairie along Elephant Mountain and into Mowich Park through Toolbox Meadows.

Elk Winter Range Habitat

Management of elk winter range in the Upper Clearwater Watershed is designed to meet the present and future goals and objectives of the Mowich Park Four Part Winter Range (Figure 42), as designed in the 1990 LRMP. This management emphasizes the maintenance and creation of large block stands providing vertical (snow) and horizontal (wind) intercept, as well as short term forage opportunities. Thermal blocks are identified in areas that provide south slope forage opportunities and travel corridors into “normal” winter range transition areas.

Although many models have been developed to analyze elk winter range, in general they model four different types of cover quality. Optimal cover is a forest stand with at least four layers consisting of overstory canopy, sub-canopy, shrub layer, and a herbaceous ground layer. Canopy closure should be at least 70 percent (Wisdom et al. 1986). These generally occur in transitional or old growth stage forests. This type of habitat provides thermal cover and forage. Thermal cover is a forest stand at least 40 feet in height with tree canopy cover at least 70 percent (Witmer et al. 1985). This is achieved in many closed sapling/pole stands. Hiding cover is any vegetation capable of hiding a standing adult elk at 200 feet or less (Thomas et al. 1985). We have also included a fourth cover type called forage. Forage areas in western Oregon are defined as vegetated areas with less than 60 percent combined closure of trees and tall shrubs. Forage areas include the grass-forb, shrub, and open-sapling pole stand (Wisdom et al. 1986).

Guidelines provided by ODFW call for maintaining 50 percent of the winter range area in thermal cover with at least half of that in optimal cover (ODFW. pers. comm. 1991). This should be well distributed throughout the area. The Mowich Park area has had an adequate mix of these cover types. Optimal cover has decreased since the 1950s from 75 percent to 41 percent (Table 12 and Figure 43). Any further harvesting in this area should be carefully reviewed to ensure that optimal cover is maintained at the 25 percent level recommended by ODFW.

Table 12 - Proportion (%) of elk winter range habitats by decade in Mowich Park

DECADE	OPTIMAL	THERMAL	HIDING	FORAGE
1950 -1959	75	10	2	13
1960 - 1969	69	11	6	14
1970 - 1979	48	11	27	15
1980 - 1989	44	11	13	33
1990 - 1999	43	11	13	33
Future Plans	41	10	13	35

The foraging areas also are well distributed within the optimal habitat (Figure 43). Most of the forage areas in the Mowich Park area are clearcuts or shelterwoods. Forage quantity should not be a problem into the future, based on current projections (Table 12).

Differences or Similarities Between Conditions
There are great differences between the reference and current condition, since elk probably did not inhabit the area during the period of the reference condition.

Processes or Causal Mechanisms Responsible
The increase in logging activity which created a more diverse forest landscape and the stocking of elk have both led to the current condition of an increasing elk herd. Prescribe burning and replanting of the logged areas has also enhanced the quality of the forage available to elk.

Figure 42 - Map of Mowich Park Elk Winter Range

Figure 43 - Map of Elk Winter Range Habitat Over Time

Future Trends
The elk herd will probably remain stable or increase due to the planned logging activities and the active management planned to maintain or enhance the elk winter habitat. Elk are sensitive to human disturbances. Elk productivity could be negatively affected if the numbers of people using the Forest increases in important winter range and calving areas.

Influences and Relationships to Other Ecosystem Processes
Elk require a diversity of habitat types. Therefore they are greatly affected by processes such as fire that leads to increased forage availability. Their numbers would probably decrease if logged areas were allowed to become reforested without new openings. Table 4 in Chapter Two shows some of the relationships between elk and landscape elements.

MOUNT BAILEY ROADLESS AREA

Analysis Procedures, Assumptions, and Data Gaps
The number of acres exhibiting roadless character within the Mount Bailey Roadless Area was used to evaluate this issue. Roadless character was based on the area's natural integrity, natural appearance, opportunity for solitude, and primitive recreation opportunity. Reference condition was based on year 1977, the date when the roadless area was delineated under Roadless Area Review and Evaluation (RARE II). It was assumed that areas between roads that were less than one half mile wide are not exhibiting roadless character.

Reference Condition
In 1977, 20,333 "contiguous" unroaded acres of the Diamond Lake Recreation Management Composite were identified for possible inclusion into a National Wilderness Reservation System. No roads or timber harvest had occurred within the area. All 20,333 acres exhibited roadless character.

Current Condition
Today, 17,070 contiguous unroaded acres exist within the roadless area as identified in Appendix C of the 1990 LRMP. Of these 17,070 acres, 14,830 acres are exhibiting roadless character. The LRMP allocates the Clearwater portion of the roadless area to Management Area 3 (Mt. Bailey Winter Sports Site, LRMP IV-112) and Management Area 10 (timber management providing for dispersed roaded recreation manage opportunities, while providing high visual quality to established viewsheds and meeting wildlife objectives, LRMP IV-128). The ROD allocates the Clearwater portion of the roadless area to matrix lands.

Differences or Similarities Between Conditions
The size of the roadless area has decreased from 20,333 acres to 17,070 acres from reference to current condition. The area exhibiting roadless character has decreased from 20,333 acres to 14,830 acres.

Processes or Causal Mechanisms Responsible
Timber harvest and associated road construction, which began in 1979, has caused the decrease in the size of the roadless area and the number of acres exhibiting roadless character. This is due to allocation of the roadless area to general forest in the 1978 LMP, which allowed development of the area.

Future Trends

Management Area 3

Future development of a winter sports site may increase the theoretical carrying capacity from 500 to 10,000+ recreation visitor days (U.S.D.A. Forest Service 1983 EIS for the Mt. Bailey Winter Sports Site). Auto traffic will increase into the Upper Clearwater Watershed. The risk to water quality issues will increase from increased visitations and increased auto traffic. Unless a tertiary sewage treatment facility is developed, the risk of nitrogen and phosphorus contamination could increase. The risks of erosion and sedimentation into Bear Creek will increase as a result of road reconstruction activities and maintenance, operation of ski facilities, snow removal, and increased runoff from roadways and parking areas.

Management Area 10

Timber harvest will occur on a cost-effective sustained basis consistent with other resource objectives as outlined by the current 1990 LRMP and the 1994 ROD. The area exhibiting roadless character will decrease within Management Area 10. Road construction and reconstruction activities will be necessary to access lands for timber harvest.

Influence and Relationship to Other Ecosystem Processes
A large area of unfragmented late seral stage forest in the mountain hemlock plant series is located within the Mount Bailey Roadless Area. This unfragmented block is providing interior forest habitat and connectivity to surrounding landscapes.

Years of fire suppression have caused overstocking of natural tree regeneration and buildup of natural fuels on the ground. This has increased the threat of catastrophic fire.

THREATENED, ENDANGERED, AND SENSITIVE SPECIES

Analysis Procedures, Assumptions, and Data Gaps
The threatened or endangered species in the watershed analysis area are the northern spotted owl and bald eagle. Although no sensitive species have been documented in the watershed, two red-legged frogs were captured in 1995 in the Dog Prairie and Watson Falls areas, to the west of the watershed (Appendix F). The analysis procedures were to research data from past monitoring projects, review plans for future logging activity, review the district-wide spotted owl distribution, and to analyze timber stand exam data. More information is needed on the status of the spotted owls in the historical activity areas, including a more careful analysis of the forest stand structure within the core areas. More work needs to be done to determine if there are any

bald eagles nesting in this watershed. The bald eagle analysis was based on sitings by USFS and PacifiCorp personnel. No systematic study has been conducted on bald eagles in the area.

Northern Spotted Owls

Reference Condition

There is no estimate of northern spotted owl number or distribution prior to the 1980s. They probably were not found in very high densities in this watershed, because the lodgepole pine, mountain hemlock, and Pacific silver fir plant series cover the southern and eastern parts of the watershed. These plant series are not considered quality owl habitat.

Current Condition

The area supports a lower density of spotted owls than in the western portion of the DLRD due to the relative lack of suitable habitat. The owls are closely aligned with the Douglas-fir, White fir, and Western Hemlock plant series found in the northern and central sites of the Upper Clearwater Watershed. Seven known owl territories have been located within the watershed (Figure 4). The habitat in the owl activity areas conforms to the protection guidelines of maintaining at least 40 percent suitable habitat within 1.2 miles of the owl activity centers (Table 13).

Table 13 - Summary of known Northern Spotted Owl territories

Owl Number	Last Surveyed	Core Area Habitat [a/]	Suitable Habitat (acres) [b/]	Suitable Habitat (%) [c/]
808	1993	10/10	1534	53
809	1989	4/4	1645	57
825	1988	4/5	1873	65
829	1990	3/4	1528	53
832	1990	4/5	1885	65
848	1993	4/4	1305	45
851	1993	7/8	1636	56

a/ This information is based on stand exam information. The denominator is the number of stands in the 100 acre owl activity core area. The numerator is the number of stands in the activity area that were interpreted to have characteristics preferred by owls (old growth characteristics); multiple tree layers with a high proportion of crown closure and preferred tree species.
b/ Number of acres of suitable owl habitat within 1.2 miles of owl activity center.
c/ Proportion (%) of suitable owl habitat within 1.2 miles of owl activity center.

Differences or Similarities Between Conditions

Since there is no historical data on northern spotted owl numbers/distribution in this watershed, condition comparisons can only be postulized. Most likely, the population of owls were never large in this area.

Processes or Causal Mechanisms Responsible
The distribution, tree species composition, and patch size of the forest stands are the main mechanisms that have determined the distribution and numbers of spotted owls in the watershed.

Future Trends
Since most of this watershed is designated as matrix, timber harvesting is planned throughout the area. Much of the analysis area is not suitable owl habitat. Therefore, it is unlikely that the spotted owl population will change significantly in the future.

Bald Eagles

Reference Condition
No information on reference level populations are available, but since bald eagles normally nest and forage near open bodies of water, their numbers were probably never large in the Clearwater watershed.

Current Condition/Future Trends
Bald eagles have been observed within the Clearwater watershed but no nesting has been documented. Eagles have been seen foraging and roosting in the Stump Lake area. PacifiCorp twice spotted eagles in the Clearwater #1 diversion areas and once near the Clearwater #1 forebay during their 1992-93 wildlife observation. It is unlikely that eagles will ever be found in great numbers in this watershed. There are adequate areas for a few eagles to nest.

MODERATE PRIORITY ISSUES

RECREATION

Analysis Procedures, Assumptions, and Data Gaps
Recreation type and intensity data were provided by Diamond Lake Ranger District recreation technician Dee Dee Gleven. Additional information, including specific activities and location of recreation activities, user preferences, forecasts for future recreation demands, and relative demand are found in the North Umpqua Hydroelectric Project Application for New License For Major Modified Project, Volume 6 (Pacificorp 1995). The 1990 LRMP, the publication Oregon Profiles, Number 3 (Oregon State University Extension Service, June 1994) and the North Umpqua River Management Plan (USDA, Forest Service, Umpqua National Forest; USDI , Bureau of Land Management, Roseburg District; and Oregon State Parks and Recreation Department, July 1992) provided additional information.

Reference Condition
Historical accounts of the region, recorded in 1938, and describing conditions from approximately 1850 to 1938, were used as reference condition (Reminiscences of Southern Oregon Pioneers, J. Perkins, 1938). According to these accounts, the Upper Clearwater Watershed was not frequented by humans during this time period. Fishing and hunting were common activities during these years; however, most of this occurred downriver and closer to population centers. A former Forest Service employee, George Arthur Bonebrake, worked in the

North Umpqua area from Little River to Big Camas beginning in 1906. He stated that there were no people in the forests at that time, not even campers, as this was before that activity was common. The very lack of historical information about this area is, in itself, very telling.

Current Condition
At present, there are three developed recreation sites which are within the watershed analysis area: Whitehorse Falls, Clearwater Falls, and Briggs Camp. There are more than twenty established dispersed sites, mostly on Little Bear Lake, Lava Creek, Mowich Creek, Bear Creek, Trap Creek, Lost Creek, and the Clearwater River. Of these, Little Bear Lake, Clearwater #1 Forebay, and Stump Lake are the most significant in terms of use (DeeDee Gleven 1996). Use of the developed recreation sites is about 11,500 recreation visitor days (defined as one person for 12 hours), with a potential of 65,000 recreation-visitor days. Total site-based recreation is about 18 percent of the potential for recreation opportunity. Because quality of experience is affected by numbers of people, 20 to 40 percent usage is considered good or full site usage (Lori Depew, personal communication, Feb. 21, 1996).

Site-based recreation is only one portion of the picture. In the Upper Clearwater Watershed there are approximately 7,500 recreation visitor days of other uses including, but not limited to, snow play, skiing, big-game hunting, photography, fishing, and hiking. Summer trails include the Mt. Bailey trail, Garwood Butte trail, and the Rodley Butte trail. Motorized winter trails are the Dog Prairie, Bear Creek, Mt. Bailey, and Three Lakes trails. In addition, cross-country skiers use Roads 4785, 4790, and 3703 in winter months. Historical trails are also found within the analysis area, and are the Bear Creek, Trap Mountain, Lost Creek, Bear Trap Meadows, and the old Rodley Butte trail.

Total recreation visits along the Clearwater Corridor section of Hwy. 138 are about 550,000 visits, based on traffic counts. This area serves as a destination, as well as a pass-through to Diamond Lake, Crater Lake, and beyond. The North Umpqua River Management Plan notes that most visitors to the North Umpqua River corridor are Oregon residents (78 percent), and that most Oregon residents tend to prefer primitive and natural environmental settings, but also non-wilderness activity for their recreation experiences.

Differences or Similarities Between Conditions
The most dramatic difference in conditions, relative to reference years, is the number of people now visiting the area. The combined population of the eight county area within two to three hours driving distance of the North Umpqua River Corridor is about 780,000 (North Umpqua Hydroelectric Project, FERC Project No. 1927, Pacificorp 1995).

According to a Recreation Regional Demand Assessment Study, FTR for Recreation Resources, activities reported in general order of popularity are camping, sightseeing, picnicking, angling, hiking, and boating. This information was focused on peak season uses, with holiday weekends constituting the highest use. Currently, there are very dramatic differences in the amount of recreation use in the area from peak to non-peak season (peak season generally defined as late April to October).

Processes or Causal Mechanisms Responsible
Increasing populations in Oregon certainly influence the numbers of people now visiting or passing through the Upper Clearwater Watershed. Between 1970 and 1990, Oregon's total population increased by 36 percent (Oregon Profiles, "Oregon's Elderly Population", Karen Seidel and Flaxen Conway, Oregon State University Extension Service, June 1994). Construction of roads has been another factor, as access to sites influences the frequency of use.

Future Trends
The Forest Service has forecast an increase in recreation demand through the year 2030. Projections for demand show that rafting, developed camping, resort use, hiking, sightseeing, cross-country skiing, snowmobiling, and other trail use will increase on the Umpqua National Forest in the future.

Inclusion of the North Umpqua River into the Wild and Scenic River system will continue to draw additional visitors to the area. Because of the remoteness of the area, overnight camping facilities are anticipated to be a future need. The North Umpqua Hydroelectric Project document projects that by the year 2005, campground demand will increase to the point where existing sites will not sustain long-term use. Most of this increase will be in the Diamond Lake area, outside the watershed analysis boundaries, but all developed sites within the area are expected to receive an increase in use that may exceed capacity.

As the total population of Oregon grows, so does that of it's elderly population. The growth rate of Oregon's elderly population (defined as persons 65 years old and over) was double that of the population increase for Oregon during the years of 1970 to 1990. The elderly now make up 14 percent of Oregon's total population (Oregon Profiles, "Oregon's Elderly Population", Karen Seidel and Flaxen Conway, Oregon State Extension Service, June, 1994). The highest proportion of the state's elderly live in southwestern Oregon. This age group tends to have more common health and mobility problems. Recreation planning will need to consider this growing segment of the population.

Influences and Relationships to Other Ecosystem Processes
Table 3 in Chapter Two shows the relationship between people and various landscape elements used for recreation.

LOW PRIORITY ISSUES

NON-NATIVE SPECIES

The only non-native terrestrial species identified in the Upper Clearwater Watershed is the Roosevelt (cascadian) elk (see previous discussion on history of elk in the DLRD). Although there is no concrete evidence available to determine if elk are native to the Upper Clearwater, representatives from ODFW do not believe that they were historically found here. Since they are prized by hunters and for viewing by the general public, management to increase their numbers has been the goal of both the Forest Service and ODFW. There is no evidence that they are impacting native species.

Non-native plant species have been introduced through soil stability activities. These species have not spread across the watershed. Noxious weeds are a potential problem and are introduced along the Highway 138 corridor and local horse camps and "elk" hunting camps. These sites are surveyed yearly for development of noxious weed problems and these surveys indicate that the watershed currently does not have a problem with noxious weeds.

Introduction of non-native trout species has occurred in most of the analysis area. See Chapter Two and Four, "Resident Fish Species and Habitats" for detailed discussion.

SPECIAL FOREST PRODUCTS

Analysis Procedures, Assumptions, and Data Gaps

Special forest products are sold by annual permit. Specific records for permits sold for the Upper Clearwater Watershed were not available. Therefore, the analysis of current and future trends are based on personal communications with administrators and records for the Diamond Lake Ranger District. No reference condition has been established other than these are all forest products which are readily available. Demand for these products, with the exception of Matsutake mushrooms and Pacific yew bark, has been limited by the markets for these products and the remoteness of the Diamond Lake Ranger District.

Current Condition

Four hundred and sixty five special use permits and permits for 388 cords of firewood were issued for the DLRD in 1994 (Table 14). Permit sales for firewood and posts showed a slight increase in 1994. The demand for yew bark has dropped significantly. The demand for mushrooms increases yearly with the largest demand on Matsutake.

Table 14 - Special forest product permit sales

SPECIAL FOREST PRODUCT	NUMBER OF PERMITS
Transport of firewood/posts	7
Cinder/building stone	3
Transplants	6
Boughs	2
Cones	2
Posts/poles	7
Christmas Trees	338
Personal Use Firewood	377
Mushrooms (1995)	11

Future Trends

The overall trend for most special forest products is expected to remain the same. This is because of the remoteness of the Diamond Lake Ranger District. The market for firewood and poles is expected to widen and increase on the District as its availability decreases near community centers. The demand for mushrooms is expected to increase significantly in the future as both foreign and domestic demand increases. The heaviest demands on mushrooms is expected to be placed on Matsutake.

Influences and Relationships to Other Ecosystem Processes

Of special interest is the impact harvesting mycorrhizal mushrooms such as the Matsutake will have on long-term production of these mushrooms, as well as, long-term site productivity to the surrounding ecosystem. The Diamond Lake Ranger District is currently involved with investigating Matsutake and mycorrhyizal management in the National Long-term Site Productivity Study and the Matsutake Harvest Study.

CHAPTER FIVE

RECOMMENDATIONS

INTRODUCTION

The purpose of this chapter is to:

- Outline a desired range of condition based on an understanding of the physical, biological, and human processes and features and their interactions within the watershed.
- Make management recommendations that are responsive to ecosystem processes identified in the analysis.
- Identify monitoring and research activities that are responsive to the key issues and questions.
- Discuss the implications for achieving land management and Aquatic Conservation Strategy objectives.

HIGH PRIORITY ISSUES

NATURAL DISTURBANCE

<u>Fire</u>

Brief Current Condition
The watershed is currently in a high severity fire regime.

Desired Range of Condition
The desired condition is a *moderate-severity fire regime*. This can be quantified by fire return interval, fuel model amounts, and distribution and fire effects. The desired range of these conditions is:

1) Fire return interval for the Upper Clearwater Watershed is 8 to 85 years.
2) Fuel Model 8, between 80 and 90 percent of the watershed.
3) Fuel Model 10, non-continuous and less than 10 percent of the watershed.
4) Fuel Model 5, non-continuous and between 5 and 10 percent of the watershed.

5) Fuel Model 1, between 3 and 5 percent of the watershed.
6) Desired average effect of fire is an underburn or stand thinning result.

Recommendations

1) A *moderate-severity fire regime* should be returned and maintained in the Upper Clearwater Watershed. Fire return interval, fire size, fire effects, and fuel model will have to be modified to more resemble the desired conditions.
2) Use prescribed fire as a tool to meet the objectives of other management prescriptions; such as meadow maintenance or expansion for wildlife, thinning for some silivicultural prescriptions, and forage and browse creation for big game.
3) Where appropriate use prescribed fire to modify areas of Fuel Model 10 to Fuel Model 8.
4) Plan logical sale area boundaries to utilize Knutson Vandenburg money to fund prescribed fire. Develop partnership and cooperative agreements with private groups and other agencies to assist planning and funding prescribed fire within the watershed.
5) Where appropriate continue to use prescribed fire following harvest in order to meet Umpqua National Forest Hazard Reduction Standards and Guidelines.
6) Develop a prescribed fire plan for planned and unplanned ignitions and a decision matrix based on objectives, weather conditions, fire conditions, preparedness level, land use allocation, and values at risk.
7) Utilize the Fire Situation Analysis as described in the Umpqua National Forest Fire Management Action Plan as a resource to determine and document fire response strategies other than immediate control.
8) During the planning process for prescribed fire or the development of individual Fire Situation Analysis, recognize the implications of fire within the mountain hemlock uneven aged managed area.
9) Continue to verify and map fuel models in the watershed. Implement a database in conjunction with the map that identifies vertical arrangement and canopy closure. Specifically identify continuous areas of Fuel Model 10 during the NEPA analysis process.
10) Train and provide practical experience for employees responsible for planning, executing, and monitoring prescribed fire projects.

Monitoring

All prescribed fire activities will be monitored to assure the results meet the objectives of the project and of the Umpqua National Forest Land and Resources Management Plan. Future planning and implementation may be adjusted based on the results of monitoring.

Implications for Achieving Land Management Strategies

Activities in the watershed are managed in accordance with the guidelines from the Umpqua National Forest Land and Resource Management Plan for Management Area 1 (unroaded recreation in a semi primitive setting), Management Area 3 (an area set aside for future development of winter sports on Mount Bailey), Management Area 10 (timber production on a cost efficient basis consistent with other resource objectives), and Management Area 11 (provide for big game winter range habitat and timber production consistent with other resource objectives).

The various prescriptions for these Management Areas require suppression responses of either contain, confine, or control. The choice of response is dependent on the values at risk and cost efficient fire suppression strategies. Values at risk include reproduction, timber, visuals, recreation, and riparian zones.

Some of the prescriptions associated with these Management Areas focus on the use of prescribed burning as a management tool. Prescriptions A1-I, A1-V for Management Area 1 and 3 "prescribed burning of natural fuels permitted to the extent to meet Recreation Opportunity Spectrum (ROS)". The prescriptions E1-I, E1-II, E1-IV, E1-V, for Management Areas 10 and 11 discuss fire's role in hazard reduction associated with activities, and prescriptions C5-1, and C5-3, prescribed burning could possibly be used to promote wildlife and mosaic habitat.

The Final Impact Statement (FEIS) for the plan states " A change from full control policy to the appropriate suppression will be used. Economic and resource benefits in fire management can be gained in using this new suppression policy", (FEIS Chapter IV, page 66). Utilization of contain or confine suppression response would meet forest plan objectives and help return the watershed to a moderate intensity fire regime.

Implications for Achieving Aquatic Conservation Strategies

The 1994 ROD was reviewed to insure that any fire management activities will be in compliance with this plan.

Fire management activities are described on page C-35 and C-36 of the Standards and Guidelines. Fuel treatments and fire suppression activities, and strategies should be designed to meet the Aquatic Conservation Strategy. These should minimize the disturbance of riparian ground cover and vegetation. Strategies should recognize the role of fire in the ecosystem function and identify those instances where fire suppression or fuels management activities could be damaging to long term ecosystem function.

Prescribed burning could help maintain this strategy by reducing the risk of stand replacement fires in or near riparian reserves. Planning prescribed burns in natural or activity fuels when conditions are right to meet resource objectives such as hazard reduction, maintenance of large coarse woody material, and protecting the riparian zone, is a far better alternative than an unplanned ignition during periods of high fire danger.

Insects and Pathogens

Desired Condition

1) Insects and pathogens are present but distribution and damage are closer to reference conditions.
2) White pine components of stands are restored by managing white pine blister rust through employment of resistant stock.

3) Tree vigor is improved or maintained.
4) Armillaria root disease is decreased by improving soil productivity and reducing white fir encroachment in stands.
5) Bark beetle impacts are decreased by decreasing stand densities and root disease levels.
6) Dwarf mistletoes are decreased by allowing fire or harvest to remove infected understories and heavily infected overstory trees.

Recommendations

1) Plant white pine blister rust-resistant strains of western white pine to counterract white pine blister rust and maintain vegetative diversity. Seek opportunities to fund planting resistant stock in allocations where traditional timber management cannot occur, particularly in the Mountain Hemlock Plant Series.
2) Restore soil productivity through subsoiling to alleviate impacts of root disease in the White Fir Plant Series.
3) Plant and manage locally resistant species (species other than white fir) in areas impacted by Armillaria root disease.
4) Manage stand densities to reduce the risk for pine bark beetles. Maintain basal areas below 120-150 square feet per acre around individual pines through thinning or underburning.

TIMBER SUPPLY/SUSTAINED YIELD/SITE PRODUCTIVITY

Precommercial Thinning

Brief Current Condition

Managed stands in the closed and open thinning structural classes and the understories of natural stands in the transition structural class within the Mountain Hemlock Plant Series are overstocked inside the matrix land allocation. Stand exams show that stocking ranges from 300 to 3000 trees per acre.

Desired Range of Condition

These stands should be growing to their fullest potential in order to maximize future timber supply from matrix lands.

Recommendations

Knutson-Vandenberg (KV) funding should be developed through the timber sale planning process to precommercial thin these stands. Present opportunities include the Paw and Yogi timber sales, scheduled to be sold in 1996 and 1997.

Monitoring and Research

Growth and yield of these stands should be monitored through the timber stand exam program.

Timber Harvest Scheduling

Brief Current Condition
Timber harvest has not historically been scheduled on an even flow acreage basis by decade by subwatershed and watershed for different plant series and silvicultural management technique (even age vs. uneven age) within the matrix land allocation.

Desired Range of Condition
There should be a consistent supply of timber each decade from each of the subwatersheds within the Upper Clearwater Watershed.

Recommendations
Timber harvest within matrix land should be scheduled on an even flow acreage basis by decade by subwatershed and watershed, consistent with other 1990 LRMP, 1994 ROD, and ACS objectives. This acreage should be based on rotation. Rotation should be based on the culmination of mean annual increment for different plant series and silvicultural techniques (uneven age or even age).

Monitoring and Research
Timber harvest scheduling will be taken into account during long range timber sale action planning.

Site Restoration and Conservation

Brief Current Condition
Long term site productivity has been reduced by ground based harvest, silvicultural prescriptions, and slash treatment operations in the past.

Desired Range of Condition
The long term site productivity of commercial forest land will be improved or sustained through adaptive management techniques in the future.

Recommendations
Soil restoration will be planned and implemented where feasible using KV funds from future timber sale projects. Restoration sites have been prioritized (Figure 44). A low psi excavator weighing less than 45,000 lbs or a subsoiler will be used to break up the surface to a 44+ cm depth and cover the site with organic residue. These methods appear to be extremely effective in treating compaction and replacing displaced surface organics on slopes less than 30 percent (Orton 1992,1993,1995).

Figure 44 - Map of Soil Restoration Priorities

The following measures will be used to sustain the long term site productivity of commercial forest land:

1) Comply with the large woody material, effective ground cover, and long term site productivity requirements in the ROD and LRMP.

2) Site conversion of pine plantations to mixed conifer will be planned and implemented where feasible using KV funds from future timber sale projects. This will require underplanting mixed conifers while the pines are providing frost protection.

3) Use a tracked loader machine with at least a 40 foot boom for ground based harvest operations in order to minimize soil displacement and compaction. Restrict this equipment to designated loader paths approved by the sale administrator and spaced an average of 100 feet apart. Require the tracks on the loader to operate in a straight line. Require directional felling into designated loader paths.

4) Use a tracked loader that weighs less than 45,000 lbs with a brush attachment for slash piling, only when it is not feasible to broadcast burn.

5) Use partial cut or shelterwood harvest techniques in areas where slopes are less than 20 percent.

Monitoring and Research

The National Long Term Site Productivity Study should continue to be funded and implemented on the District in order to learn more about the effects of compaction on site productivity.

Units that are harvested using the loader logging method should continue to be monitored for compliance with 1994 ROD and 1990 LRMP standards and guidelines.

TRANSPORTATION SYSTEM

Recommendations

1) Utilize a subwatershed approach to identify Road Management Objectives (RMO's) that are in support of the ROD as well as recognize a dramatic shift in the availablity of road maintenance funds.

2) Integrate available information regarding the effect of roads on erosional processes and hydrologic functions relative to Western Cascades, High Cascades, and Surficial Deposits. Use this information to assess the effects of roads and make recommendations to achieve the objectives of the Aquatic Conservation Strategy.

3) Develop a comprehensive plan to address the resource issues associated with the Clearwater Falls Dispersed Recreation Area.

4) Investigate how the erosional and hydrologic processes associated with Highway 138 are affecting the Clearwater River. Explore opportunities to minimize the affects on aquatic conditions.

5) Identify opportunities for the development of additional rock resources for recreation and timber haul needs.

AQUATIC SYSTEM/WATER QUALITY AND FLOW

Recommendations

1) Conduct a watershed improvement needs (WIN) inventory of Bear Creek road to plan road restoration and evaluate design needs if the Mount Bailey ski area proposal is adopted. Evaluate present road location, needs to relocate, and impacts to Bear Creek.

2) Conduct watershed improvement needs survey of roads on Watson Ridge and within the Trap Creek and Bear Creek subwatersheds. This is where culverts could overtop and slides could occur during flood events.

3) Survey roads in flat, High Cascade terrain of Lava Creek (La Park 12H), and Upper Clearwater (West Lake 12I) subwatersheds. Identify road segments that drain to stream channels. Waterbar these road segments in order to interrupt flow and maintain high infiltration of runoff.

4) Change subwatershed boundaries in GIS to show that Lost Creek (Paw 12J) drains to the large spring entering the Clearwater above Bear Creek , and parts of Upper Clearwater (West Lake 12I) drain to Lava Creek and Lake Creek. Change subwatershed names to stream names shown in Chapter Four - Aquatic System issue.

5) Add intermittent streams mapped during watershed analysis to the GIS stream layer. Change stream class to match presence and absence of fish noted in stream surveys. During project planning, identify unmapped streams and fish distribution so that GIS stream layer can be updated.

6) Maintain riparian reserve widths at two site-potential tree height distance from each side of Class I and II streams, and one site-potential tree height from Class III and IV streams, subject to project level layout of boundaries along topographic breaks and identification of additional streams, wetlands, and unstable areas. Delineate the riparian reserve around upper Bear Creek to include wet meadows and unstable areas already identified.

7) Identify the wetland area of Lost Creek spring complex to allow for adequate determination of Riparian Reserve delineations.

8) Use USGS (USGS, 1979) Rogue-Umpqua equations for estimating peak flows at stream crossings in the Western Cascades, and the recommendation in Appendix D for estimating peak flows in portions of the High Cascades.

9) Install crest gages to gather peak flow information on Lava, Upper Clearwater, Bear, Trap, and Mowich Creek culverts to help define peak flow relations in the High Cascades on small watersheds.

10) Install surveyed cross-sections to monitor future changes in Bear Creek (Rosgen 1994), below the proposed ski area on Mount Bailey and any new road construction. At a minimum, three cross sections should be located on the "E" channel near Old Man Camp. Additional cross-sections should be located where Bear Creek meanders through ash deposits above and below Forest Service road 550. At every cross-section, photo points should be used to document changes in vegetation and channel shape. Fish habitat surveys should be used to locate cross-sections and photo points at high quality habitat or reaches vulnerable to changes in streamflow or sediment regimes.

11) Use the results of the snow hydrology studies being conducted for the DEMO Project to improve the present Hydrologic Recovery Model and better understand how partial harvest affects snowmelt within the transient snow zone. Until results are available, use Umpqua National Forest cumulative effects standard and guideline Hydrologic Recovery and Umpqua Sediment Index Analysis (USIA) methods. Use channel stability findings in stream survey results (R6 methodology and modified Pfankuch ratings) to evaluate cumulative effects with these methods (Stream Channels, Chapter Two, Chapter Four, and Appendices).

12) Roads should not be built in riparian reserves, except to cross streams at low risk sites. Design projects to reduce crossing risk in riparian reserves. Remove or improve existing crossings, while constructing fewer low risk crossings. Reducing risk in riparian reserves and meeting the Aquatic Conservation Strategy can be met, in part, by reducing the total number of crossings in subwatersheds of the Upper Clearwater; and reducing the risk of crossing erosion, loss of channel function and interaction with its floodplain, and loss of riparian vegetation at the crossings that remain.

13) Livestock grazing should not take place in the Bear Creek subwatershed. Bear Creek channel has changed from a narrow Rosgen "E" stream to a wider "C" channel above Old Man Camp, and recovery of channel banks is important to maintain aquatic habitat.

14) The Clearwater and North Umpqua rivers exhibit occasional high summer pH, low dissolved oxygen, and very visible aquatic attached algae (periphyton) which can affect water quality. Since algae seems controlled by dissolved nitrogen in runoff, obvious sources of nitrogen in streams should be avoided. Nitrogen fertilizer should not be applied within riparian reserves, or on roads with ditch runoff connected to streams. Isolated eroding sites may be treated with fertilizer when necessary for erosion control if specific measures are used to prevent runoff from reaching streams.

15) Maintain the streamflow and sediment regime of Bear Creek to maintain channel function throughout the channel system. Channel function in surface streams is necessary to maintain habitat necessary for aquatic and riparian-dependent species, populations, and communities. In particular, the meadow stream at Old Man Camp has some vegetated, overhanging banks, and it floods the meadow during bankfull floods. Vegetated banks should be maintained, and the portion of the stream above the camp where banks have eroded should be allowed to revegetate and build again. The large meanders into ash deposits above and below the FS road 550 road have vegetated floodplains and are building bars on the inside bends. Road construction associated with timber harvest or ski area construction should not increase runoff or sediment to surface channels from impermeable surfaces or road ditches.

16) Maintain and restore in-stream flows in the Clearwater River diverted reaches below Stump Lake, sufficient to create and sustain riparian, aquatic, and wetland habitats; and to retain patterns of sediment, nutrient, and wood routing. The timing, magnitude, duration, and spatial distribution of peak, high, and low flows must be protected. Use stream surveys, Pacific Power data, and the streamflow record to recommend how flow is manipulated in the Clearwater bypass reaches, including the timing and ramp rate for maintenance flows, and increases in the current flow releases at Stump Lake and Mowich Creek during relicensing of the North Umpqua Hydropower Project. Increases should correct habitat, channel function, and water quality deficiencies documented in the watershed analysis and other available information.

17) Develop a revised definition of the Aquifer Lands described in the 1990 LRMP as per Soil and Water Standards and Guidelines

18) Where water quality standards are not met on the Clearwater below Stump Lake, recommend to Oregon Department of Environmental Quality to add these reaches to the Section 303 (d) (1) list under the Clean Water Act. Standards not met are habitat modification, habitat-flow modification, and water temperature. Recommend changes in Pacific Power's hydropower license that will meet water quality standards.

RESIDENT FISH SPECIES AND HABITAT

Brief Current Condition and Desired Range of Condition

Species

Resident fish species are dominated by, and may be exclusively composed of, exotic species. It has not been conclusively determined which, if any, fish species were historically present. The only habitat identified that may currently contain native fish is upper Mowich Creek. If native species were historically present in the remainder of the analysis area, they have been either extirpated by interspecific competition with introduced brook trout or have interbred with introduced rainbow trout.

Since the composition of the native fishery has not been determined, it is not possible to base the desired condition of the fishery on historic conditions. Until the composition of the historic fishery can be determined, the current species composition and range should be maintained.

Habitat

Fish habitat in the analysis area is deficient in woody material throughout most of the system, spawning gravel quantity and quality are poor in many areas, fine sediment deposition is high in many areas, and rearing space is low in some stream segments. High summer water temperatures have not been identified as a problem in the Clearwater River system. It is possible, but not yet determined, that low winter water temperatures are limiting fish production.

The Pacific Power hydroelectric project has a profound influence on aquatic habitat downstream of the confluences of Bear and Lava Creeks with the Clearwater River. A project dam creates Stump Lake, a 12 acre impoundment, as well as diverts 95 percent of the Clearwater River flow into a canal to a 16 acre forebay, and eventually through the Clearwater Number One powerhouse. While the hydropower diversion appears to have created two impoundments that provide greater habitat diversity, densities of brook trout, and recreational opportunities than existed prior to the project; the bypass reach of the Clearwater River appears to have been impoverished. Instream Flow Incremental Modeling (IFIM) indicates that the resultant minimum flows are well below those that would provide the most rainbow trout habitat during all seasons of the year (brook trout habitat generally peaks at lower instream flows than rainbow, but even adult brook trout would benefit from substantially higher minimum flows according to the IFIM results). Stream discharges within the bypass reach are manipulated unnaturally, and both LWM and bedload deliveries to downstream Clearwater River reaches are disrupted. The diversion is an effective barrier to both upstream and downstream passage of fish. In addition, neither of the created impoundments will be sustainable over time without dredging.

Desired future condition variables specific to fish habitat in the Clearwater River basin have not been developed, therefore, the desired range of conditions can only be expressed in general terms. Riparian vegetation should be restored to a fully functioning status throughout the area. Fully functioning status would include a range of conditions, from areas of early successional vegetation through mature old growth stands. Many stream segments currently have clearcut harvest units that have been cut down to, and in some cases across, the stream banks. Other harvest units have left stream buffers of inadequate width. General guidelines have been developed by the Umpqua National Forest for the properly functioning condition of stream systems in the High Cascades physiographic region. Briefly, stream systems in the High Cascades region are properly functioning if summer water temperature does not exceed 55^{o} F, pool habitat is greater than 30 percent by area, cobble embeddedness is less than 35 percent, the dominant substrate is gravel or cobble sized material with clear interstitial spaces, less than 10 percent of streambanks are actively eroding, and riparian reserves are intact with greater than 80 percent in late seral condition.

Management, Monitoring, and Research Recommendations

1) Leave riparian reserve widths as currently defined in the ROD.

Very significant water quality issues in the North Umpqua River system remain unresolved, and the populations, habitat conditions, and needs for riparian dependent species other than fish have not been assessed in the analysis area. Riparian reserves that have not been managed should remain unmanaged until water quality issues are better understood and until other riparian dependent species are considered. However, there are specific activities that should be allowed to occur in riparian reserves under certain conditions. Pre-commercial thinning activity in previously harvested units should be site specifically reviewed and proceed where appropriate. Sub-soiling activity in previously harvested units where soil compaction has occurred and is limiting vegetative recovery should be site specifically reviewed and proceed where appropriate. The need for some road crossings at stream channels will be unavoidable in matrix lands. When crossing a stream is unavoidable, the watershed should be reviewed for other roads or road/stream crossings that can be removed as mitigation.

2) Complete Upper Mowich and Bear Creek stream surveys and assess riparian areas and stream channels for restoration needs.

Fish habitat in both Upper Mowich and Bear Creeks has a high probability of having been degraded by management impacts. Both streams should be surveyed to determine the nature and extent of impacts, and what actions may be appropriate for restoration. Survey data would also provide a baseline for future monitoring of restoration project effectiveness.

3) Develop fish habitat objectives by 6th field Hydrologic Unit Code.

Since the Clearwater River watershed encompasses a variety of diverse geologic formations, fish habitat objectives defining the desired future condition should be developed by subwatershed, or 6th field Hydrologic Unit Code (HUC). The Umpqua National Forest is currently in the process of re-delineating 6th field HUC's, or Watershed Analysis Areas (WAA's) as they have been previously referred to, along watershed boundaries. Previous boundaries were based on a combination of watershed divides and timber stand boundaries, and did not accurately reflect subwatershed boundaries.

4) Conduct a genetic study of rainbow trout present in Upper Mowich Creek to determine origin.

Upper Mowich Creek is the only site remaining in the analysis area where native fish might remain. Genetic samples should be taken and tested as appropriate to determine whether rainbow trout found in the upper stream reaches are related to stocks found in areas known to have been stocked with rainbow trout. The upper reaches should also be carefully snorkeled and/or electroshocked to determine whether cutthroat trout are present.

5) Conduct a stream survey, including snorkeling and invertebrate sampling, on “Lost Creek”, a short tributary to the Clearwater River above Stump Lake.

   A short tributary to the Upper Clearwater River identified as “Lost Creek” was determined to be flowing at 37 cfs in the early fall of 1995. This was far beyond what the water yield of the apparent drainage area should be, and it is believed that the system is fed by groundwater from the Lost Creek subwatershed and much of the northern slopes of Mt. Bailey. A large spring fed system of this type may provide unique habitat and species. It is not currently known if fish are present in Lost Creek. Some attempt should also be made at defining the spring complex of Lost Creek, and determining what sort of protection is necessary to avoid damaging the complex.

6) Repeat stream surveys of any tributaries and mainstem reaches that will be affected by future (beyond 1997) timber sales.

   Stream surveys should be conducted for affected stream reaches as part of timber sale planning in the analysis area beyond 1997. This would allow monitoring of stream systems to determine trends in fish species abundance and distribution, and habitat condition. The data would also contribute to the evaluation of riparian reserve effectiveness and possible management needs.

7) Continue to take an active role in relicensing of the North Umpqua Hydroelectric Project.

   Where data gaps exist, suggest additional studies. Continue to investigate whether artificial supplementation of intercepted bedload is desired below Stump Lake and whether other modifications in Pacific Power operations or facilities are necessary to assure that aquatic habitat supporting well-distributed populations of native fish and other aquatic species will be maintained or restored. Develop a comprehensive monitoring plan in association with the new license that documents changes in habitat, operations, and biological indicators through time.

Implications for Achieving Aquatic Conservation Strategy Objectives

The recommendations outlined above are designed to provide a framework for moving streams in the analysis area toward attainment of the ACS objectives as outlined in the ROD. Completion of stream surveys in the analysis area will provide information needed on the current condition of stream channels and fish habitat, and will provide a baseline for monitoring habitat improvement and restoration project effectiveness. The development of fish habitat objectives by subwatershed will provide additional definition on how to achieve ACS objectives in defined areas. Repeating stream surveys at each round of timber sale entries and watershed analysis iteration will provide data for tracking progress toward ACS objectives.

BIOLOGICAL DIVERSITY

Vegetation

Brief Current Condition
There is great diversity of vegetative structure and pattern within the watershed. All structural classes, ranging from establishment to transition, are represented in various landscape patterns.

Desired Range of Condition
The desired range of condition is to maintain the high level of diversity of vegetative structure and pattern within the watershed.

Recommendations
Timber harvest prescriptions over the next five decades within the matrix land allocation will approximate natural disturbance processes and patterns by:

1) Designing and implementing uneven aged silvicultural prescriptions in the Mountain Hemlock Plant Series located within the Management Area 10 land allocation inside the Mt. Bailey Roadless Area. These prescriptions would include precommercial thinning guidelines for overstocked natural stands that were caused by fire suppression over the last 50 years.

2) Minimizing fragmentation within the large block of late seral forest located in the eastern central section of the watershed by designing and implementing commercial thinning and uneven aged prescriptions within this area in the next decade.

3) Designing and implementing even aged prescriptions in already fragmented areas of the watershed except inside the Mowich Park elk winter range.

4) Restoring the diversity of tree species through planting mixes within managed stands.

Monitoring and Research
Future planning efforts for any management activity will monitor vegetative landscape structure and pattern within the watershed.

Upper Bear Creek Headwaters and Meadows

Brief Current Condition
The headwaters and the meadows associated with the headwaters of Bear Creek are providing unique habitat for both terrestrial and aquatic plant and animal species (Figure 45). Soils within this area are very sensitive to mass wasting and surface erosion. Very little timber harvest has occured in this area.

Figure 45 - Map of Bear Creek Mosaic Wildlife Prescription Area

Desired Range of Condition
Natural processes should be allowed to shape the condition of this area.

Recommendations
This area should be classified under the Wildlife-Mosaic Habitats, Protected prescription C5-III outlined in the 1990 LRMP. This information should be entered into the GIS system under the Unique and Mosaic Wildlife Habitat layer.

A management plan based on LRMP and ROD objectives should be formulated for this area.

Animal Diversity

Current and Desired Range/Recommendations/Implications for Achieving Land Management Objectives
The ROD states that one management goal for matrix land is to increase ecological diversity by providing early successional habitats. This will be met in the Upper Clearwater Watershed if the management program for this area proceeds as planned. Timber harvesting is planned to continue well past the year 2000. By continuing to manage for a diverse landscape, the diversity of animal species will be maintained. This benefits early successional species such as the Calliope hummingbird that require open tracts of land which provide them with foraging and nesting sites in shrubs. Elk herds also benefit from this structural diversity. There needs to be a balance so that insular forest species are not lost. Plans should be made that maintain connectivity between late successional areas whenever possible.

Monitoring and Research
The location of future timber sales and their possible effects on forest fragmentation should be assessed. More information needs to be collected on many non-game species such as bats, amphibians, resident and migratory birds, and biodiversity in general.

ELK WINTER RANGE

Current and Desired Conditions/Recommendations
The elk winter range in the Mowich Park area is an important link for elk movements throughout the DLRD. Management activities in this area should maintain a mixture of habitats so that optimal/thermal cover does not fall below current levels (50 percent). This may require an amendment to the Forest Plan since it states that less acreage in optimal/thermal habitat is acceptable. Impact of this management direction must also be reviewed in relation to the timber yields outlined in the ROD.

Monitoring and Research
New research on elk winter range management should be consulted to determine if the three or four part winter range model should be followed or if other methods of determining elk range analysis should be adopted. The effects of road closure on elk disturbance in the Mowich Park

area should be assessed. Road densities throughout the watershed should be reviewed to determine the necessity of individual roads and trails.

MOUNT BAILEY ROADLESS AREA

Brief Current Condition
Three areas located in the northwestern section of the roadless area no longer exhibit roadless character due to past road building and timber harvest. These areas are basically 2000 foot wide peninsulas between existing road systems and are allocated to future timber harvest in the ROD and LRMP.

Desired Range of Condition
Lands not exhibiting roadless character should not be classified as roadless.

Recommendations
The three areas located in the northwestern section of the Mount Bailey Roadless Area that are not exhibiting roadless character should be removed from the Mount Bailey Roadless Area as delineated in Appendix C of the LRMP through a Forest Plan amendment in the near future. Figure 46 shows the location of these three areas within the watershed.

Monitoring and Research
As timber harvest and road building progresses into the matrix and Management Area 10 sections of the roadless area, the Mount Bailey Roadless Area's character should be monitored.

THREATENED, ENDANGERED, AND SENSITIVE SPECIES

<u>Northern Spotted Owl</u>

Current and Future Conditions/Recommendations
The Clearwater Watershed area does not have a large amount of suitable habitat for spotted owls. If the habitat in the known owl territories is managed according to the requirements outlined in the ROD and from consultation direction from the U.S. Fish and Wildlife Service, owl populations should be maintained. Selective thinning may be warranted in some of the heavily stocked areas to perpetuate large diameter trees.

Monitoring and Research
More up-to-date information needs to be collected on historic owl activity areas in planned harvest areas. More stand inventory work should be conducted within the 100 acre owl core areas to ensure that suitable habitat is available.

Figure 46 - Map of Proposed Mount Bailey Roadless Area Annexations

Figure 47 - Map of Proposed Snow Park and Ski Route

MODERATE PRIORITY ISSUES

RECREATION

Brief Current Condition
Winter sports, specifically the sport of cross country skiing, have been gaining popularity in recent years on the Diamond Lake Ranger District. There is an opportunity to provide more primitive cross country ski courses for beginner and intermediate skiers within the Lost Creek subwatershed. The public is currently using the recommended area for cross country skiing.

Desired Range of Condition
Diamond Lake Ranger District should develop a wide spectrum of cross country ski trails for the general public.

Recommendations
A snow park for a cross country ski loop should be designed and built at the intersection of State Highway 138 and Forest Road 4785 using KV funds from the Paw timber sale. The ski route would follow roads 4785-010, 4785-180, and 4785. A short section of trail would need to be constructed from road 4785-010 to 4785-180. Figure 47 shows the location of this proposed cross country ski area.

LOW PRIORITY ISSUES

NON-NATIVE SPECIES

Elk was identified as a non-native species. The goal of many land managers is to eradicate non-native species. However, since management plans call for enhancement and maintenance of elk habitat to encourage population growth and there is no indication of a negative effect on native species from elk, no recommendations to control their populations are warranted.

SPECIAL FOREST PRODUCTS

Matsutake Mushroom

Brief Current Condition
The demand and value of the matsutake mushroom has been on a steady increase over the last ten years. Matsutakes are found within the Mountain Hemlock, Shasta Red Fir, and Lodgepole Pine Plant Series within the watershed. They are a valuable food source for many animal species within the watershed. Habitat for the matsutake and other fungal species has been reduced through clearcut timber management and fire suppression. Very little is known about optimum habitat requirements for the matsutake in the watershed. What we do know is that the matsutake likes large Shasta red fir as it's host. We also know it likes open understories and low ground cover. This condition was present within the Mountain Hemlock and Shasta Red Fir Plant Series

before the age of fire suppression, due to natural underburning cycles caused by lightning. Very little is also known about the effects of human harvest on the matsutake resource.

Desired Range of Condition

The amount of optimum habitat for the matsutake mushroom and other fungal species should be increased within the watershed.

Recommendations

Pre-commercial and commercial thinning strategies should be implemented within areas targeted for timber management within the Mountain Hemlock, Shasta Red Fir, and Lodgepole Plant Series in order to reduce the density of the understory. KV funding should be used to accomplish precommercial thinning. Large diameter Shasta red fir should be left in these areas for host trees.

Monitoring and Research

The existing matsutake harvest technique's study should continue to be implemented in order to better understand the effects of different harvest techniques on matsutake production. Another study should be designed to address the question of optimum habitat requirements for the matsutake and other fungal species. There is an opportunity to help implement the study through planned precommercial thinning activities associated with the proposed Paw timber sale.

CHAPTER SIX

LIST OF PREPARERS

Rick Golden - District Fisheries Biologist
- B.S. Fisheries - Utah State University, 1987.
- M.S. Pharmacy - Oregon State University, 1992.
- Laboratory Technician, Utah Water Research Laboratory, 1985-1986.
- Fishery Biologist, Nez Perce National Forest, 1992-1995.
- Fishery Biologist, Diamond Lake Ranger District, Umpqua National Forest, 1995- present.

Bob Progulske - District Wildlife Biologist
- B.S. Wildlife Management, Univ. of Massachusetts, 1979.
- M.S., Wildlife Ecology, Univ. of Florida, 1982.
- Wildlife Biologist, Florida Game and Fresh Water Fish Commission, 1982-1985.
- Wildlife Biologist, U.S. Air Force, Avon Park, FL, 1985-1995.
- Wildlife Biologist, U.S.D.A. Forest Service, Umpqua NF, 1995-present.

Rick Abbott - Interdisciplinary Team Leader/Forester/District Study Coordinator
- BS Forest Management, Penn State University, 1978
- Forest Engineering Institute, Oregon State University, 1990
- 5 seasons Forest Service presale, fire, and silviculture experience
- 1 year Forest Service presale experience
- 3 years Bureau of Indian Affairs timber sale administration experience
- 6 years Forest Service timber sale planning experience

Keith Graves - District Resource Manager
- BS Vertebrate Ecology, Southern Oregon State College, 1972
- BS Secondary Education, Portland State University, 1984
- 5 years, entomologist, Oregon State University
- 5 years, botanist, Carolina Biological Supply
- 8 years Forest Service wildlife biology experience
- 3 years Forest Service Resource Manager experience

Norm Michaels - Certified District Silviculturist
- BS Forest Management, Oregon State University, 1972
- MFR (Silviculture), University of Washington, 1983
- 21 years Forest Service silvicultural experience
- 21 years Forest Service fire suppression experience

Ellen Goheen - U.S.D.A. Forest Service Pathologist
- BS Forestry, University of Montana, 1979
- BA Secondary Education/Biology, University of Montana, 1979
- MS Plant Pathology, Washington State University, 1983
- Silviculture Institute University of Washington/Oregon State University 1990-1991
- 12 years Forest Service and Bureau of Land Management forest pathology experience

Jill Napper - District Fuels Specialist
- A.S. Forest Technology, Lane Community College, 1985
- A.A.S. Data Processing / Computer Programming, Lane Community College, 1988
- Certificate of Completion of Technical Fire Management, Washington Institute and Colorado State University, 1992
- 11 years of experience in fire management on the Umpqua National Forest

Ken Paul - District Assistant Fire Management Officer
- B.S. Wildlife Management, University of Montana, 1977
- Certificate of Completion of Technical Fire Management, Washington Institute and Colorado State University, 1989
- Certified Prescribed Fire Manager, Complex Burn Boss, Operations Section Chief, and Structure Protection Specialist
- 17 years of fire experience encompassing 20 fire seasons

Gregory S. Orton - Soil Scientist for Diamond Lake and North Umpqua Ranger Districts
- B.S. Agricultural Soil Science from California Polytechnic State University 1990
- A.S. Forest and Park Management from Kings River Community College, 1978
- Soil Scientist U.S.D.A. Forest Service, Umpqua NF, 1990-present.

Paul Uncapher - Umpqua N.F. Geologist
- B.S. Geological Science, C.S.U.Chico, Chico, Ca.
- Geologist, Klamath N.F., Etna, Ca., 1988-1990
- Geologist, B.L.M., Bakersfield, Ca., 1985-1988
- Geologist, Consultant, Sacramento, Ca. 1979-1985
- Geologist, Umpqua National Forest, 1990-present

Michael Jones - Umpqua N.F. Hydrologist
- B.S. Watershed Management, University of Arizona, 1969
- M.S. Forest Hydrology, University of Arizona, 1974
- 20 years of hydrology experience, Shawnee and Umpqua N.F.
- 3 years of hydrology experience, U.S. Peace Corps, Santiago, Chile
- Professional Hydrologist, American Institute of Hydrology

Diane White - Umpqua, Rogue, and Siskyou N.F. Ecologist
- B.S. Biology, University of Nevada, Las Vegas
- M.S. Plant Physiology, University of California, Davis
- PhD Forest Science, Oregon State University
- 8 years of silvicultural/ecology experience, Oregon State University
- 1 year of silviculture experience, BLM state office
- 6 years of ecology experience, Siskiyou N.F.

Sarah Platte - Umpqua N.F. Fisheries Biologist
- B.S. Fisheries and Wildlife, Michigan State University, 1992
- 4 years Forest Service fisheries biology experience

Cindy Lagoudakis - Umpqua N.F. Assistant DEMO Coordinator
- B.S. Forest Management, Oregon State University, 1984
- 1 season recreation technician experience, BLM
- 2 seasons forestry technician experience, Boise Cascade
- 10 years Forest Service silviculture experience

Angie Snyder - District Heritage Manager
- B.A. History, Humbolt State
- 7 years Forest Service cultural resources experience

CHAPTER SEVEN

LIST OF REFERENCES

Amaranthus, M., and D. Perry. 1987. Nitrogen fixation within mycorrhizae of Douglas-fir. *In* Sylvia, D.M., and J.H. Graham. 1980. Proceedings of the North American conference on mycorrhizae. Gainesville, Fla. University of Florida.

Amaranthus, M., and D. Perry. 1989. Interaction effects of vegetation type and pacific madrone soil inocula on survival, growth and mycorrhiza formation of Douglas-fir. Can. Jour. of For. Research 19:550-556. FRL 277.

Amaranthus, M.P., J.M. Trappe, and R.J. Molina. 1990. Long-term forest productivity and living soils. Paper 2265, For. Res. Lab., Oregon State Univ., Corvallis, OR.

Atzet, T. and L.A. McCrimmon. 1990. Preliminary plant associations of the southwestern Cascade mountain province. U.S.D.A. Forest Service, Pacific Northwest Region, Siskiyou National Forest.

Barnes, Calvin. 1978. The geology of the Mount Bailey Area, Oregon. Eugene, Oregon, University of Oregon, M.S. 122p

Christner, Jere. 1981. Changes in Peak Flows From Managed Areas of the Willamette National Forest. U.S.D.A. Forest Service, Eugene, Oregon.

Curran, M.P. and T.M. Ballard. 1990. Some slash burning effects on soil and trees in British Columbia. P. 355-361 In Gessel, S.P., D.S. Lacate, G.F. Weetman, and R.F.Powers, ds.Sustained productivity of forest soils. Proc.7th North American For.Soils Conf.,1988. Faculty of Forestry, Univ. Of British Columbia,Vancouver.

DeBano, L.F., S.M. Salvage, D.A. Hamilton. 1976. The transfer of heat and hydrophobic substances during burning. Soil Science Society Jour. 40:792-782.

Diaz, N., D. Apostol. 1993. Forest Landscape Analysis and Design: A Process for Developing and Implementing Land Management Objectives for Landscape Patterns. USDA Forest Service, Pacific Northwest Region.

Dyk, W.J., Beets, P.N. 1987. Managing for long-term site productivity. New Zealand For. Nov:23-26.

Edmonds, R.L. 1979. Decomposition and nutrient release in Douglas-fir needle litter in relation to stand development. Can. J. For. 9:132-140.

Edmonds, R.L., D. Blinkley, M.C. Feller, P. Sollins, A. Abee, and D.D. Myrold. 1989. Nutrient cycling: effects on productivity of Northwest forests. P. 17-35 In Perry, D.A., R. Meurisse, B. Thomas, R. Miller, J. Boyle, J. Means, C.R. Perry, and R.F. Powers, eds. Maintaining the long-term productivity of Pacific Northwest forest ecosystems. Timber Press, Portland, OR.

Froehlich, H.A., and D.H. McNabb. 1984. Minimizing soil compaction in northwest forests. p. 159-192 *In* E.L. Stone (Ed.). Forest soils and treatment impacts. Proceedings, Sixth N. Amer. For. Soils Conf., June 1983. Univ. of Tenn., Knoxville, TN.

Froehlich, H.A., D.W.R. Miles, and R.W. Robins. 1986. Growth of young Pinus ponderosa and Pinus contorta on compacted soils in central Washington. For. Eco. and Mang. 15:285-294.

Fuller, W.H., S. Shannon, P.S. Burgess. 1955. Effect of burning on certain forest soils of northern Arizona. For. Sci. 1:44-50.

Grier, C.C. 1975. Wildfire effects on nutrient distribution and leaching in a coniferous forest ecosystem. Can. Jour. of For. Res. 5:599-607.

Griffith, J.E. 1988. Review of Competition between Cutthroat Trout and Other Salmonids. *American Fisheries Society Symposium.* 4:134-140.

Haberland, F.P. and S.A. Wilde. 1961. Ecology 42:584-586.

Harr, D. Dennis. 1981. Some Characteristics and Consequences of Snowmelt During Rainfall in Western Oregon, Journal of Hydrology, 53:277-304.

Harvey, A.E., M.J. Larsen, and M.F. Jurgensen. 1979. Comparative distribution of ectomycorrhizae in soils of three western Montana habitat types. For. Sci. 25:350- 358.

Harvey, A.E., M.J. Larsen, and M.F. Jurgensen. 1986. Distribution of active ectomycorrhizae short roots in forest soils of the Inland Northwest: effects of size and distribution. ....

Hatchell, G.E., C.W. Ralston, R.R. Foil. 1970. Soil disturbance in logging. Jour. of For. 68:772-775.

Helms, J.A., C. Hipkin, and E.B. Alexander. 1986. Effects of soil compaction on height growth of a California ponderosa pine plantation. Western Jour. of Applied For.1:104-108.

Hemstrom, M., and J. Cissel. 1991. Evaluating alternative landscape patterns over time an example from the Willamette National Forest in Oregon. S.A.F. proceedings - San Francisco.

Ingebritsen, S.E., Mariner, R.H., Sherrod, D.R., 1994. Hydrothermal Systems of the Cascade Range, North-Central Oregon. U.S. Geological Survey Professional Paper 1044-L. 83p

Jones, J.A. and G.E. Grant. 1994a. Peakflow responses to clearcutting and roads, Western Cascades, Oregon: I. Small Basins. In Press. Corvallis Oregon

Jones, J.A. and G.E. Grant. 1994a. Peakflow responses to clearcutting and roads, Western Cascades, Oregon: II Large Basins. In Press. Corvallis Oregon

Kimmins, J.P., D. Binkely, L. Chararpaul, and J. De Canazaro. 1985. Biogeochemistry of temperate forest ecosystems: literature on inventories and dynamics of biomass and nutrients. Information Report PI-X-47E/F. Chalk River, Ontario: Petawawa Nat. For. Inst., Can. For. Serv.

Leary, R.F., F.W. Allendorf, and K.L. Knudsen. 1983. Consistently high meristic counts in natural hybrids between brook trout and bull trout. *Systematic Zoology.* 32:369-376.

Little River Watershed Analysis. 1995. Umpqua National Forest, North Umpqua Ranger District.

Little, S.N., and G.O. Klock. 1985. The influence of residue removal and prescribed fire on distribution of forest nutrients. Research Paper PNW-338. Portland, OR: Pacific Northwest For. and Range Exp. Sta., USDA-For. Serv.

Little, S.N., and I.L. Ohmann. 1988. Estimating nitrogen lost from forest floor during prescribed fires in Douglas-fir / western hemlock cleatcuts. For. Sci. 34:152-164.

Loomis, D. 1996. Oregon Department of Fish and Wildlife fishery biologist, personal communication January, 1996.

Macadam, A.M. 1987. Effects of broadcast burning slash burning on fuels and soil chemical properties in the sub-boreal spruce zone of central British Columbia. Can. J. For. Res. 17:1577-1584.

Minor, D. 1986. Effects of site preparation on seedling growth: a preliminary comparison of broadcast burning and pile burning. Research Note PNW-RN-452. Portland, OR, Pacific northwest Res. Stat., USDA-For. Serv.

Molina, R., and J.M. Trappe. 1982. Lack of mycorrhizal specificity by the ericaceous hosts *Arbutus menziesii* and *Arctostaphylos uva-usi*. New Phytologist 90:495-509.

Neary, D.G., Morris, L.A., Swindel, B.F. 1984. Site preparation and nutient management in southern pine forests. *In* Stone, E.L., ed. Forest soils conference, 1983 June 19-23, Knoxville, TN, Univer. of Tenn, Dept. of For., Wildlife, and Fisheries: 121- 144.

Neuenschwander (comp.) Proceedings-management and productivity of estern- ontana forest soils: 1990 April 10-12; Boise, ID. Gen. Tech. Rep. INT-80. Ogden, UT: USDA-For. Serv. Intermountain Res. Stat.

Oregon State Parks and Recreation Division. 1988. State-wide comprehensive outdoor recreation plan 1988-1993. Salem, OR.

Orton, G.S. 1992-1995. Soil disturbance monitoring results for loader piling and loader logging on the North Umpqua and Diamond Lake Ranger Districts. Unpublished Reports. USDA-For. Sev. Umpqua NF. Roseburg, OR.

Orton, G.S. 1993-1995. Prescribed broadcast burn monitoring of ground cover, large woody material, and mechanical disturbance for the North Umpqua and Diamond Lake Ranger Districts. Unpublished Reports. USDA-For. Sev. Umpqua NF. Roseburg, OR.

PacifiCorp. 1995. Application for new license for modified project. Vol. 33: Final technical report for terrestrial resources study. PacifiCorp. Portland, Oregon.

PacifiCorp. 1995. Application for New License for Major Modified Project. North Umpqua Hydrorelectric Project, FERC Project No. 1927, Douglas County, Oregon. Vol. 4, 25-28.

Perry, R.F. Powers, eds. Maintaining long-term productivity of Pacific Northwest ecosystems. Portland, OR: Timber Press:3-16.

Piene, H. 1978. Can J. For. Res. 8:398-406.

Powers, R.F. 1980. Mineralizable soil nitrogen as an index of nitrogen availability to forest trees. Soil Sci. Soc. of Amer. Jour. 44:1314-1320.

Powers, R.F. 1989. Maintaining long-term forest productivity in the Pacific Northwest: defining the issues. *In* Perry, D.A., R. Meurisse, B. Thomas, R. Miller, J. Means, C.R.

Powers, R.F. 1991. Are we maintaining the productivity of forest lands? Established guidelines through a network of long-term studies. P. 70-81. *In* Harvey, A.E. and F.

Powers, R.F. 1995. Unpublished meeting notes from Feb. 22, 1995 fertility meeting. Orton, G.S., G. Badura, eds. USDA-For. Serv., Medford, OR.

Powers, R.F., and K. Van Cleve. 1991. Long-term ecological research in temperate and boreal forest ecosystems. Agron. J. 83:11-24.

Powers, R.F., Kani Isik, P.J. Zinke. 1975. Adding phosphorus to forest soils: storage capacity and possible risks. *In* Bulletin of environmental contamination and toxicology. Vol 14, No. 3. Spring-Verg New York Inc.

Powers, R.F., R.L. Edmonds. 1992. Nutrient management of subalpine Abies forests. P. 28-42 *In* Chappel, H.N., G.F. Weetman, and R.E. Miller, eds 1992. Forest fertilization: sustaining and improving nutrient and growth of western forests. Institude of forest resource contrib. 73. Univ. of WA., Seatle.

Powers, R.F., S.R. Webster, P.H. Cochran. 1988. Estimating the response of ponderosa pine forests to fertilization. *In* Schmidt, W.C., comp. Future forests of the Mountain west: a stand culture symposium, 1986 Sept. 29-Oct. 3, Missoula, MT. Gen. Tech. Rep. Stat.:219-225.

Pritchett, W.L., R.F. Fisher. 1979. Physical properties of forest soils. P.120-122. *In* properties and management of forest soils, 2nd ed. John Wiley & Sons, NY, NY.

Ratliff, D.E., and P.J. Howell. 1992. Status of bull trout populations in Oregon. *Proceedings of the Gearhart Mountain bull trout workshop,* p. 10-17. Oregon Chapter of the American Fisheries Society, Corvallis.

Roberge, M.R., G.F. Weetman and R. Knowles. 1970. *In* Tree growth and forest soils. Youngberg, C.T., and C.B. Davey (eds.). p. 73-96. Oregon St. Univ. Press. Corvalis, OR.

Robin, L.E. and Bazilevich, N.I. 1967. Production and mineral cycling in terrestrial vegetation. Oliver and Boyl, Edinburgh.

Rosgen David L. 1994. A classification of natural rivers. In CATENA Vol. 22 No. 3 p. 169-199. Elsevier Science Inc., New York.

Roth, A.H. 1940. Stocking plan for the Diamond Lake Ranger District. Available at Diamond Lake Ranger Station, Umpqua National Forest. Idleyld Park, Oregon.

Sands, R. 1983. Physical changes in sandy soils planted to radiata pine. P. 146-152 *In* R. Ballard and S. P. Gessel (Ed). IUFRO Symposium on Forest Site and contnuous productivity, Nov. 222-28, 1983. USDA-For. Serv. Gen. Tech. Report PNW-163. Pacific Northwest and Range Exp. Stat., Portland, OR.

Scott, William E. 1977. Qauternary glaciation and volcanism, Metolius River area, Oregon, Geologiical Society of America Bulletin, v.88, p.113-124, January 1977

Sherrod, D. R. and Smith, J.G. 1990. Qauternary Extrusion Rates of the Cascade Range, Northwestern United States and Southern British Columbia. Journal of geophysical Research, vol. 95, No. B12, p19,465-19,474, November 10, 1990

Sherrod, David. 1986. Geology, Petrology and Volcanics of a Portion of the Cascade Range between Lattitudes 43°- 44° N, Central Oregon, U.S.A., Dissertation for fulfillment of P.H.D. in Geological Sciences, University of California, 320p

Comment [TS3]:

Switzer, G.L., L.E. Nelson, and L.E. Hinesley. 1981. Effects of utilization on nutrient regimes and site productivity. P. 241-259 *In* Gessel, S.P., R.M. Kenedy, and W.A. Atkinson (Ed.). Proceedings, Forest fertilization conference, contribution No. 40, Inst. of For. Res., College of For. Res., Univ. of WA., Seatle, WA.

Tew, D.T., L.A. Morris, H.L. Allen, and C.G. Wells. 1986. Estamates of nutrient removal, displacement and loss resulting from harvest and site preparation of a Pinus taeda plantation in the Piedmont of North Carolina. For. Eco. and Mang. 15:257-267.

Thomas, J.W. and D.E. Toweill. 1982. Elk of North America. Stackpole Books, Harrisburg, Pennsylvania. 698p.

Thomas, J.W., H. Black, Jr., R.J. Scherzinger, and R.J. Pederson. 1979. Deer and elk. Pages 104-127 in Thomas, J.W. (ed.). Wildlife habitats in managed forests - the Blue Mountains of Oregon and Washington. USDA Agriculture handbook No. 553. 512p.

Trappe, J.M., J.F. Franklin, R.F. Tarrant, and G.M. Hansen (ed). 1968. Biology of alder. Proceedings of a symposium. Northwest Sci. Ass. Portland, OR.: Pacific Northwest For. And Range Exp. Stat., USDA-For. Serv.

U.S. Department of Interior. 1992. Recovery plan for the northern spotted owl - draft. U.S. Government Printing Office: 1991: 691-303. 662p.

U.S. Geological Survey. 1979. Magnitude and Frequency of Floods in Western Oregon. U.S.G.S. Open-file Report 79-553. Portland, Oregon.

U.S. Geological Survey. 1995. Water Resources Data - Oregon - Water Year 1994. USGS Water-Data Report OR-94-1. Portland, Oregon.

U.S.D.A Forest Service. 1994. Final Supplemental Environmental Impact Statement on Management of Habitat for Late-Successional and Old-Growth Forest Related Species Within the Range of the Northern Spotted Owl.

U.S.D.A. Forest Service. 1994. Record of Decision for Amendments to Forest Service and Bureau of Land Management Planning Documents Within the Ranges of the Northern Spotted Owl.

Umpqua National Forest Land and Resource Management Plan. 1990. U.S.D.A. Forest Service, Umpqua National Forest.

Umpqua National Forest Land Management Plan. 1978. U.S.D.A. Forest Service, Umpqua National Forest.

Umpqua National Forest. 1995, Jackson Creek Watershed Analysis, Appendix J

United States Department of Agriculture. 1994. Region 6 Level II Stream Survey Inventory Manual. US Forest Service Region 6, Portland, Oregon.

USDA- Forest Service. 1983. Final environmental narrative for Mt. Bailey winter sports site. USDA-For. Serv., Umpqua Nat'l For., Roseburg, OR.

USDA- Forest Service. 1994. Draft environmental narative for Mt. Bailey winter sports site ski area planning planning special-use permit. USDA-For. Serv., Umpqua Nat'l For., Roseburg, OR.

USDA. 1975. Avalanche Handbook 489. Fort Collins, Colorado.

Vogt, K., C.C. Grier, C.E. Meier,and R.L. Edmonds. 1982. Mycorrhizal role in net primary production and nutrient cycling in *Abies amabilis* ecosystems in western Washington. E cology 63:370-380.

Volt, K.A., Moore, S. Gower, D.Vogt, D.Spugel, and C.Grier. 1989. Productivit of upper slope forests in the Pacific Northwest. P. 137-163 *In* Perry, et al., eds. Maintaining the long-term productivity of Pacific Northwest forest ecosystems. Timber Press, Portland, OR.

Volt, K.A., R.A. Dahlgren, F.Ugolini, D.Zabowski, E.E. Moore, and R.J. Zasoki. 1987. Aluminum, Fe, Ca, Mg, K, Mn, Cu, Zn, and P in above and below ground biomass. II. Pools and circulation in a subalpine Abies amabilis stand. Biogeochemistry 4:295-311.

Wells, C.G., and J.R. Jorgensen. 1975. Nutrient cycling in loblolly pine plantations. P. 137-158. *In* Bernier, B. and C.H. Winget (Eds) Forest soils and forest land management, Proc. 4th N. Amer. For. Soils Conf. Quebec: Laval Univ. Press.

Wisdom, M.J., L.R. Bright, C.G. Carey, W.W. Hines, R.J. Pederson, D.A. Smithey, J.W. Thomas, and G.W. Witmer. 1986. A model to evaluate elk habitat in western Oregon. Publ. R6-F&WL-216-1986. USDA Forest Service, Portland Oregon. 36p.

Wisseman, R. 1990. Sensitive aquatic invertebrates found or suspected to be present on the Umpqua, Rogue, and Siskiyou National Forests, Oregon. Workshop, Roseburg, OR July 24, 1990.

Wisseman, R. 1993. Fall 1992 benthic invertebrate biomonitoring report and bioassessment interpretive manual. Umpqua National Forest, Roseburg, Oregon.

Witmer, G.W., and D.S. deCalesta. 1985. Effects of forest roads on habitat use by Roosevelt elk. Northwest Sci. 59(2):122-125.

Wollum, A.G., II, and C.T. youngberg. 1964. The influence of nitrogen fixation by non-leguminous woody plants on the growth of pine seedlings. Jour. Of For. 62:316-321.

Wright, J.L.. 1982. How high the bounty. Friends of the Douglas County Museum. Roseburg, Oregon. 437p.

CHAPTER EIGHT

ACRONYMS AND ABBREVIATIONS

ABAM	Pacific Silver Fir Plant Series
ABCO	White Fir Plant Series
ABMAS	Shasta Red Fir Plant Series
ACS	Aquatic Conservation Strategy
AG	Aggregate Road
CFL	Commercial Forest Land
cfs	cubic feet per second
cm	centimeter
DEMO	Demonstration of Ecosystem Management Options Study
DLRD	Diamond Lake Ranger District
EIS	Environmental Impact Statement
et al.	and others
F	Fahrenheit
FEIS	Final Environmental Impact Statement
FERC	Federal Energy Regulatory Commission
FS	Forest Service
FVS	Forest Vegetation Simulator
g/cc	grams per cubic centimeter
GIS	Geographic Information System
HUC	Hydrologic Unit Code
KV	Knutson - Vandenberg Act of 1924
LMP	1978 Umpqua National Forest Land Management Plan
LRMP	1990 Umpqua National Forest Land and Resource Management Plan
LWM	Large Woody Material
m	meters
mbf	thousand board feet
MBRA	Mount Bailey Roadless Area
mg/l	milligrams per liter
mmbf	million board feet
my	million years
NAT	Native Surface Road
NEPA	National Environmental Policy Act of 1969
NRF	Nesting, Roosting, Foraging Habitat
ODFW	Oregon Department of Fish and Wildlife
PICO	Lodgepole Pine Plant Series
PMR	Pacific Meridian
PSME	Douglas-fir Plant Series
Qaf	pumice deposits
Qbt	Toketee basalt

Qgd	glacial deposits
Qoba	old basalt
Qtba	basaltic andesite complex
Qtmv	vent exposure
Qya	young andesite
Qyba	young basaltic andesite
R3E	Range 3 East
RARE	Roadless Area Review and Evaluation
ROD	1994 Record of Decision for Amendments to Forest Service and Bureau of Land Management Planning Documents Within the Range of the Northern Spotted Owl
SRI	Soil Resource Inventory
T25S	Township 25 South
TDG	Total Dissolved Gas
TKN	Organic Nitrogen
Tla	andesite
TMS	Transportation Management System
TSE	Timber Stand Exams
TSHE	Western Hemlock Plant Series
TSME	Mountain Hemlock Plant Series
Twb	basalt
ug/l	microgram per liter
UPAD	Umpqua Project Activities Database
USDA	United States Department of Agriculture
USDI	United States Department of Interior
USGS	United States Geological Survey
WIN	Watershed Improvement Needs Survey