ELLIOTT STATE FOREST WATERSHED ANALYSIS

OCTOBER 2003

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Final Report

October 2003

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ABBREVIATIONS AND ACRONYMS

BLM	Bureau of Land Management
CCC	Civilian Conservation Corps
cu. ft.	cubic foot (feet)
cfs	cubic feet per second
DEM	digital elevation model
DEQ	Department of Environmental Quality
DOGAMI	Department of Geology and Mineral Industries
DBH	diameter at breast height
ESA	Endangered Species Act
ft.	foot (feet)
Forest	Elliott State Forest
GIS	Geographic Information System
HCA	Habitat Conservancy Area
HCP	Habitat Conservation Plan
HUC	hydrologic unit code
MMMA	Marbled Murrelet Management Area
m^2	square meter(s)
mg/L	milligrams per liter
MMBF	million board feet
ODFW	Oregon Department of Fish and Wildlife
ODF	Oregon Department of Forestry
ONHP	Oregon Natural Heritage Program
OSCUR	Ownership, Soil-site, Cover, Use, and Rating (state forest inventory system)
OWEB	Oregon Watershed Enhancement Board
PNCERS	Pacific Northwest Coastal Ecosystems Regional Study
RAIS	Riparian Aquatic Interaction Simulator
RM	river mile
sq. mi.	square mile(s)
TLBP	Tenmile Lakes Basin Partnership
TMDL	total maximum daily load
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
USFWS	U.S. Fish and Wildlife Service
WRD	Oregon Water Resources Department
yd.	yard(s)

ELLIOTT STATE FOREST WATERSHED ANALYSIS

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Map Section

Chapter 1. Introduction

The Elliott State Forest (Forest) is a mostly contiguous block of State Land Board and State Board of Forestry lands covering more than 93,000 acres, located south of Reedsport and north of Coos Bay in Oregon. The Oregon Department of Forestry (ODF) manages the Forest from its Coos Bay office. This land supports forests, fish runs, and varied types of wildlife. Once stripped of most of its vegetation by fires in the late nineteenth century, the Forest now contributes to the economic and environmental backdrop of this region.

For this project, the watershed analysis team provides an analysis of the natural resources found in the Forest, with special emphasis on aquatic resources such as fish, other aquatic organisms, and water quality and its use. The approach is first to describe the processes that historically created good habitat for fish and wildlife and provided clean water, and then to evaluate the status of conditions currently within the Forest. Finally, this analysis includes likely future conditions of these resources under current and alternative management scenarios.

PURPOSE AND APPROACH

The purpose of this analysis is to better understand the natural processes that influence fish habitat, wildlife habitat, and water throughout the Elliott State Forest, along with the consequences of human activities on these resources. Using information derived from current inventories of the Forest, or that which can be extrapolated from studies conducted on similar areas, the watershed analysis team provides an analysis that will be useful for several purposes including, but not limited to:

- Development of an updated Management Plan;
- Development of a new Habitat Conservation Plan (HCP) for fish and wildlife;
- Annual operations plans;
- Total maximum daily load (TMDL) studies;
- Restoration activities; and
- Public education and outreach.

This project is not intended to catalog *all* past and current information on processes and natural resources within the Forest. Rather, the analysis team has intentionally streamlined the study to focus on issues most critical for management of the Forest throughout the next several decades. Requirements of the federal Endangered Species Act (ESA) and the Clean Water Act often affect these priorities for the Forest.

Management of the northern spotted owl and marbled murrelet, both federally threatened species, has significantly influenced timber harvest on the Forest since the 1990s. An incidental take permit for the marbled murrelet has expired and a strategy of *take avoidance* is currently being used. An incidental take permit for the spotted owl expires in 2055. The ODF is currently in the process of preparing a new HCP that covers both of these species, along with the federally listed coho salmon and other species currently not listed. For this reason, this analysis does not provide a thorough evaluation of spotted owl and murrelet habitat and its management. Separate documentation for these two species will appear during the processes for updating the *Elliott State Forest Management Plan* (ODF 1993) and preparing the new HCP. Nevertheless, strategies to successfully manage spotted owl and murrelet habitat do overlap with strategies to manage watersheds for fish and water quality.

KEY ISSUES

Time and economic limitations do not allow an in-depth evaluation of all possible natural resource issues associated with the Forest. Early in the study process, the watershed analysis team met with the ODF to identify issues that are likely to be highly important during upcoming planning and public processes. These key issues, in question format, are:

- How do natural processes and human activities influence water temperature throughout the analysis area?
- How do herbicide applications within harvest units or adjacent to roads influence fish, wildlife, and domestic water supplies?
- How do roads and their maintenance alter patterns of sediment supply and transport in streams?
- How does timber harvest alter natural patterns of sediment supply and transport in streams?
- How do past and current management activities influence large wood abundance in streams and related fish and wildlife habitat, both now and in the future?
- How do culverts influence the upstream and downstream movement of fish and amphibians in streams?

Although many other issues are addressed in this document, these key issues receive the greater scrutiny.

GEOGRAPHIC FOCUS

The study area is shown on Map 1.1, located in the map section of this report. State lands managed in the Coos Bay District include a mostly contiguous block covering over 93,000 acres of the Forest, eight scattered tracts of land (about 1,189 acres) located 0.5 to 18 miles from the edge of the main block, and a number of other scattered tracts located much further to the south. These southern tracts are not considered part of the Forest and are not included in this project. Two of the scattered tracts near the main block (about 294 acres) are included in the analysis because they are within several miles of the main block. The other six scattered tracts (about 895 acres) are more distant from the main block and are not included in the analysis of the main block (Table 1-1). The natural resources on these tracts are summarized in Chapter 2, *Watershed Analysis Area Overview*. Five parcels of private forestland totaling about 165 acres also occur within the boundaries of the main block of the Forest.

Table 1-1. Scattered tracts of land associated with the Elliott State Forest.

Tract Name	Acres	Legal Description
Included in the evaluation of the main block of the Elliott State Forest		
Sock Creek*	158	T.23S, R.9W, sec 6
Ash Valley**	136	T.23S, R.10W, sec 24
Total	**294**	
<u>Not</u> included in the evaluation of the main block of the Elliott State Forest		
School Land Bay	91	T.23S, R.12W, sec 16
Folley Creek	156	T.21.S, R.7W, sec 36
Purdy Creek	36	T.22S, R.9W, sec 16
Lighthouse	178	T.22S, R.12W, sec 7 and T.22S, R.13W, sec 12, 13
Tyee 40	42	T.25S, R.7W, sec 16
South Slough (3 parcels)	392	T.26S, R.13W, sec 19, 20, 30 T.26S, R.14W, sec 36
Total	**895**	

* Within analysis basin #1
** Within analysis basin #13

Chapter 2. Watershed Analysis Area Overview

PHYSICAL SETTING

Watersheds and Ecoregions

The streams draining the main block of the Elliott State Forest flow into one of three water bodies. About 47% of the Forest drains southwest into Coos Bay, 30% drains north to the Umpqua River, and 23% drains west to the North and South Tenmile Lakes (Map 2.1 and Table 2-1). Natural processes, current conditions, and management of these three watershed regions (hereafter referred to as the Coos, Umpqua, and Tenmile) differ. The general characteristics of these regions are described below.

Coos region. Currently, the majority of timber harvest occurs in this region. Slopes are somewhat more moderate than elsewhere on the Forest. Roads parallel many of the larger streams. The West Fork Millicoma River dominates this region and is important for producing coho salmon and steelhead. Summer fog is less common in this region.

Umpqua region. Timber harvest has been curtailed in those portions of the region directly upslope of Highway 38 (along the Umpqua River) and Loon Lake Road (along Mill Creek) because of landslide safety concerns and to provide a visual corridor. Land directly upslope of Highway 38 has been designated as scenic conservancy with the provision of no timber harvest. Landslide concerns have extended the no harvest provision to as far as Charlotte Ridge. Many of the basins in this region are designated as "160-240 year-old rotation." Few streams have roads along them. Streams in the eastern portion tend to be steep and short. The eastern portion is warmer and freer of fog than the western portion. The Dean Creek Basin, in the western portion, supports a large elk population.

Tenmile region. Currently, timber harvest is limited because the basins in this region are designated as 160-240 year-old rotation and past harvesting does not allow much additional harvest in the near-term. Most northern spotted owls on the Forest are found in this region. None of the fish-bearing streams have active roads along them. The streams are important for coho salmon because of the high-quality rearing habitat found within them and in downstream waters. Fog can be persistent, especially in mid-summer, leading to moderate temperatures and less moisture stress for vegetation.

Nearly all of the Forest lies within the Mid-coastal Sedimentary Ecoregion (Table 2-1). A small portion (6%) in the far northwest corner is within the Coastal Uplands Ecoregion, which has more marine air influence. This difference is expressed in the species mix of conifer trees. Lower summer soil moisture stress in the Coastal Uplands tends to support a mixed species stand of Douglas-fir, western hemlock, Sitka spruce, and western redcedar, while the Mid-coastal Sedimentary Ecoregion supports forests mainly of Douglas-fir.

Table 2-1. Area of the Elliott State Forest by region and ecoregion.

Region	Acres	Percent of Total
Coos	43,432	47
Umpqua	28,528	30
Tenmile	21,528	23
Combined	**93,488**	**100%**

Ecoregion	Acres	Percent of Total
Mid-coastal Sedimentary	88,152	94
Coastal Uplands	5,171	6
Coastal Lowlands	165	< 1
Combined	**93,488**	**100%**

Analysis Basins

For purposes of this analysis, the Forest was divided into 13 basins based mainly on major drainage areas. The analysis basins are based on hydrologic boundaries (for the most part) and can be aggregated up to fifth-field watersheds. These 13 analysis basins may be used in the future for day-to-day management of the Forest or incorporated into a revised *Forest Management Plan*. The 1995 HCP (ODF 1995) for northern spotted owls is based on the "old" management basins that follow different boundaries.

Four ODF foresters have been assigned a subset of the "old" management basins for which they plan and design timber harvest units. One basin forester covers basins draining into the two Tenmile Lakes plus an eastern portion of the Umpqua region. A second forester covers the western portion of the Umpqua region plus a middle portion of the West Fork Millicoma River drainage. A third forester covers basins in the southwest and south portion of the Forest, including Palouse, Larson, and Marlow Creeks. A fourth forester covers basins in the headwaters of West Fork Millicoma River and Elk Creek plus the eastern fringe of the Forest, which includes Glenn, Mill, and Lake Creeks.

Geology, Landforms and Soils

Gravity and precipitation have combined to erode the relatively weak sedimentary rock underlying the Forest into sharp ridges and slopes dissected by many streams and draws (Maps 2.3 and 2.4). A main north-south ridge separates the West Fork Millicoma drainage to the east from streams that flow directly to the west. Another main ridge, this one going east and west, separates the upper West Fork Millicoma River drainage from those streams that flow north directly to the Umpqua River. The steepest terrain in the Forest occurs off of ridges that branch west and north from the two main ridges. The southeast corner of the Forest has broader ridges and more moderate slopes. Rock outcrops and cliffs occur throughout the Forest but are most common along steep draws.

Although a few large-scale landslide features have been mapped on the Forest, others likely exist that have not been mapped. A landslide located in the northeast corner (230 acres, of which the upper 37 acres are within the Forest) begins at the top of the ridge and extends to Camp Creek. A gently sloping earth flow of 95 acres exists on the downstream end of a tributary to the West Fork Millicoma River near Stulls (Stahls) Falls. Further downstream [near river mile (RM) 13] is an earth flow of about 80 acres that occurs where several small tributaries come together near the West Fork Millicoma River. Field visits indicated that none of the three large-scale landslides are active. A hillslope landslide, probably similar to the one identified above Camp Creek, occurred on Mill Creek many centuries ago and now forms Loon Lake. Mill Creek begins at the 215-acre lake and flows through the northeast corner of the Forest. The dam created by the landslide is impassible for fish.

The mountains on the Forest result from ongoing tectonic activity associated with the Pacific Juan de Fuca plate being forced against the North American continental plate margin (Beaulieu and Hughes 1975). The Oregon coastal margin of the Pacific tectonic plate goes underneath the North American plate resulting in uplift of the overriding North American plate and intermittent thrusts of seafloor sediment against the leading edge of the continent (Goldfinger et al. 1992). Uplift rates of the North American plate in the general area of the Forest are approximately 13 inches per century. Erosive forces more or less counter uplift resulting from tectonic activity (Reneau and Dietrich 1991). As a result, the mountains on the Forest have remained the same height for centuries.

The uplifted strata in the general area of the Forest are primarily marine sedimentary rocks interspersed with some basaltic pillow lava formations (although only sedimentary rock underlies the Forest). These marine sedimentary rocks are part of the Tyee geologic unit, which is notably weak in shear and tensile strength (Ryu et al. 1996). The rock is composed of thick sandstone beds (3-30 feet deep) separated by thin beds of mudstone (2-12 inches deep). The beds dip gently and therefore, the occurrence of landslides is about equal among slope aspects. Since crushed marine basalt rock obtained from nearby pits and river rock mined from the Umpqua River is much stronger than the sedimentary rock underlying the Forest, it is used to surface roads.

Soils tend to be shallow near ridgelines and deeper in valley bottoms and terraces. The downhill accumulation of soil is commonly in the form of soil creep. Soil creep is the gradual plastic flow of the soil mass under gravity. Other natural forms of downhill soil movement include shallow landsliding, deep-seated landsliding, raveling, and soil displacement due to the burrowing of small mammals. Streams often incise soil terraces that develop at the base of valleys. The detachment of particles from the earth's surface under the erosive power of rain is limited, to some extent, by the vegetation and organic material that accumulates at the soil surface. More importantly, soils on the Forest are highly permeable so overland flow rarely occurs and is limited to areas where soils are very shallow or compacted by machinery.

The Forna and Valino soil series overlie three-quarters of the Forest (Map 2.5, Table 2-2). These moderately deep-to-deep soils have surface layers of clay loam with subsoil layers consisting of rock and clay loam. A clay loam is a soil with varying degrees of clay and silt, with clay as the dominant texture. The deeper Valino soils are slightly more productive (Douglas-fir site class II+ to II-) than the shallower Forna soils (site class III+ to III-). The most productive soils (I-) are the Bessee, Noah, and Yoakum soil series but they comprise only 1.4% of the Forest. Site class is an index of the rate of tree height growth, with lower values indicating faster growing trees.

Table 2-2. Description of soils on the Forest.

Code	Soil Series	Area (%)	Drainage	Surface Soil	Subsoil
Bs	Bessee	0.0	imperfectly drained	fine-textured derived from older alluvium	clay with low permeability
Ca	Callahan	2.5	well-drained	stony loam	stony sandy loam
Ct	Cooston	0.1	imperfectly drained	loam	clay loam often with low permeability
FL	Flournoy	1.3	well-drained	clay loam	clay with highly-weathered rock
Fz	Forna	38.8	well-drained	stony loam	stony clay loam
Hk	Hawkins	0.0	well-drained	fine-textured derived from siltstone	clay with soft siltstone rock
Je	Jerden	3.7	well-drained	sandy loam	stony loam
Js	Jolson	0.5	well-drained	stony loam derived from sandstone	stony loam
Mb	Millicoma	3.1	well-drained	clay loam derived from siltstone	clay loam with siltstone rock
Nb	Nabb	0.6	well-drained	med.-textured from sandstone alluvium	sandy loam
Nq	Noah	1.3	well-drained	fine-textured derived from sandstone	clay loam
OK	Ork	1.2	---	---	---
VL	Valino	37.4	well-drained	granular loam	clay loam with sandstone rock
Ws	Wassen	0.0	poorly drained	fine-textured derived from alluvium	clay to clay loam
Yk	Yoakum	0.1	well-drained	fine-textured derived from siltstone	clay loam
Ag	Agriculture	0.4	N/A	N/A	N/A
RS	Rock	0.5	N/A	N/A	N/A
XX	Not mapped	8.4	N/A	N/A	N/A
Sum	**---**	**100.0**	---	---	---

Code	Depth	Douglas-fir Site Class	Position
Bs	deep	I-	along major drainages
Ca	moderately deep	II- to III+	on steep and precipitous slopes
Ct	deep	II+	on toe slopes and benches
FL	shallow	III+	on ridges
Fz	moderately deep	III+ to III-	on steep and precipitous slopes and on ridges
Hk	deep	II+	on smooth upland topography
Je	mod. deep to deep	II-	on colluvial fans and on steep and precipitous slopes
Js	shallow to mod. deep	IV+	on steep and precipitous slopes
Mb	mod. deep to deep	II-	on moderately-sloping and smooth upland surfaces
Nb	deep	II+	along river terraces
Nq	deep	I-	on gently sloping uplands, benches, and toe slopes
OK	---	---	---
VL	mod. deep to deep	II+ to II-	steep and precipitous slopes, highly dissected
Ws	moderately deep	too wet	along river terraces
Yk	deep	I-	on smooth, gently sloping terrain

Climate Patterns

The climate of the Forest is moderate with most precipitation falling from October through May. The temperature is usually mild in the winter, with few days below freezing. Maximum temperatures in the summer can approach 90-100° F on occasion, but marine air often keeps summer temperatures more moderate. Summer fog, especially in mid-summer, often keeps the western fringe of the Forest cooler than inland portions. Since the main ridges of the Forest are only about 1,600 to 1,800 feet in elevation, snow is uncommon.

Average annual precipitation is 70-90 inches, with the highest amounts along high ridges (Map 2.6). A rain shadow caused by the interior high ridges occurs along the eastern boundary of the Forest where precipitation drops to about 60 inches. Short-term, high-intensity rainfall controls the initiation of shallow landslides on steep slopes in this region. High-intensity rainfall in the winters of 1981-1982 and 1996-1997 triggered many shallow landslides throughout the Forest. In November 1996, 6.7 inches of rain fell in 24 hours as measured at North Bend, which resulted in widespread landslides throughout the southern Coast Range.

Streams and Other Water Bodies

The Forest has a high density of streams but few lakes, ponds, and wetlands (Map 2.7). Where they do occur, ponds and wetlands are a part of stream channels and are often a result of beaver activity. These areas tend to be small, and on aerial photographs are often obscured by trees. Almost all ponds have been mapped as water sources for fighting fire. The 215-acre Loon Lake has about 1 mile of Forest ownership along its downstream end.

The ODF has adopted a stream size classification based on the estimated average annual flow of a stream. Average annual flow is estimated by using an empirical equation based on watershed area and average annual precipitation. There are three size classes: (1) large streams have an average annual flow greater than 10 cubic feet per second (cfs); (2) medium streams have an average annual flow between 2-10 cfs; and (3) small streams have an average annual flow less than 2 cfs. Overall, the Forest has similar densities of large and medium streams (0.45 and 0.47 miles per square mile, respectively; Table 2-3). The density of large streams in the Coos region is about twice that found elsewhere in the Forest.

Table 2-3. Length of stream by size class for each watershed region.

Region	Area (sq. mi.)	Stream Length (mi.)			Stream Density (mi./sq. mi.)		
		Large	Medium	Small*	Large	Medium	Small
Coos	67.9	41.1	32.3	277.1	0.61	0.48	4.08
Umpqua	44.1	14.6	22.2	165.4	0.33	0.50	3.75
Tenmile	33.6	9.4	14.6	140.5	0.28	0.43	4.18
Combined	**145.6**	**65.1**	**69.1**	**583.0**	**0.45**	**0.47**	**4.00**

* Stream length for the small size class is dependent on subjective decisions on how far upstream to extend channels and which channels to include during mapping. No obvious criteria dictated the extent or inclusion of small channels when a map was developed for the Forest using the 1996 orthophotos.

The Forest has about 134 miles of large and medium streams, most of which are important for fish, and 583 miles of small streams, many of which also support fish. The mileage of small streams provided in Table 2-3 is not particularly meaningful since it is dependent on how far uphill the original cartographers extended stream lines and which drainages or draws they chose to include a stream line. Such decisions varied among cartographers and the year in which a map was made.

Channel Habitat Types

A system of delineating stream segments with similar channel gradient and geometry is proposed in the *Oregon Watershed Assessment Manual* (OWEB 1999) and this system was used in this project to provide a coarse evaluation of fish habitat and sediment transfer characteristics for the Forest.

For the Forest, stream segments were identified that were fish bearing. Combinations of channel gradient classes (<1%, <2%, 2%-4%, 3%-10%) and channel confinement classes were determined for each segment. For Forest streams, these confinement classes included:

- Large flood plain; broad valley flood plain not confined by hillslopes.
- Moderately confined; flood plain width more than 2 times but less than 4 times the bankfull width.
- Confined; flood plain width less than 2 times the bankfull width

Channel gradient was determined using a digital elevation model of the Forest. Channel confinement was determined using a combination of field observations from Oregon Department of Fish and Wildlife (ODFW) fish habitat surveys and contour maps. This resulted in six distinct channel habitat types for fish-bearing streams on the Forest:

- FP = low gradient (<1%), large flood plain
    - FP1 = large streams
    - FP2 = medium streams
    - FP3 = small streams
- LM = low gradient (<2%), moderately confined
- LC = low gradient (<2%), confined
- MM = moderate gradient (2%-4%), moderately confined
- MC = moderate gradient (2%-4%), confined
- MV = moderately steep (3%-10%), narrow valley

For the Forest, over one-half of fish-bearing stream mileage is moderate gradient, confined channel (MC); this type occurs in each of the 13 analysis basins (Map 2.8, Table 2-4). Moderately steep, narrow valley channels (MV) also are widespread, making up about 19% of the overall stream mileage. The percentage of this type in the Tenmile region is only one-half of that found elsewhere in the Forest. Confined channels, irrespective of gradient, make up nearly three-quarters of the miles of stream that support fish.

The moderate gradient, moderately confined stream type (MM) is found mostly in analysis basins #10 (Marlow Creek) and #9 (lower West Fork Millicoma River drainage) in the Coos region. The low gradient, moderately confined stream type (LM) is relatively rare and occurs mostly in analysis basin #8 (Palouse and Larson Creeks).

Low-gradient channels with a large flood plain occur exclusively in analysis basin #4 (Scholfield Creek) and at the downstream end of larger streams in the Tenmile region. Over one-third of the fish-bearing stream miles in the Tenmile region are of this channel type.

Fish-bearing streams throughout most of the Forest have favorable gradients for salmonids (less than 4%) but are tightly confined by adjacent hillslopes. Although not quantified, some roads constructed parallel to streams have additionally confined stream channels. The energy conveyed by water flowing through narrow and non-meandering channels is considerable at high flows. Consequently, zones of slower water that can be used for refuge by fish during high flows are limited mostly to that provided by large wood in the channel. Unconfined streams common to the Tenmile region provide unique, high-quality habitat for fish not found elsewhere on the Forest. These low-gradient streams are more likely to provide high-quality refuge habitat during high water since the channel can meander freely and create backwater areas.

Table 2-4. Channel habitat types for fish-bearing streams by region and analysis basin.

Region	Gradient	< 1%	< 2%	< 2%	2%-4 %	2%-4 %	3%-10%
	Confinement	**Unconfined**	**Moderately Confined***	**Confined****	**Moderately Confined**	**Confined**	**Confined**
	Code	**FP**	**LM**	**LC**	**MM**	**MC**	**MV**
	Analysis Basin	*Length of fish-bearing stream (miles)*					
Coos	8	---	3.1	---	---	4.7	---
	9	---	0.1	---	9.6	4.8	2.6
	10	---	---	---	3.9	3.4	2.5
	11	---	---	---	---	24.1	7.6
	12	---	---	---	9.1	15.7	6.5
	Combined	**0.0**	**3.2**	**0.0**	**22.6**	**52.7**	**19.2**
Umpqua	1	---	---	5.5	---	2.2	1.2
	2	---	---	---	---	0.7	5.3
	3	---	---	---	---	7.5	---
	4	4.1	0.2	---	---	2.0	1.0
	13	---	---	---	---	3.5	0.7
	Combined	**4.1**	**0.2**	**5.5**	**0.0**	**15.9**	**8.2**
Tenmile	5	7.7	---	---	0.8	3.0	1.5
	6	1.7	0.5	---	---	5.7	1.5
	7	1.8	1.2	---	---	5.8	0.8
	Combined	**11.2**	**1.7**	**0**	**0.8**	**14.5**	**3.8**
Total		**15.3 (9.4%)**	**5.1 (3.1%)**	**5.5 (3.4%)**	**23.4 (14.3%)**	**83.1 (50.8%)**	**31.2 (19.1%)**

* Moderately confined = flood plain width is more than 2 times but less than 4 times the bankfull width.
** Confined = flood plain width is less than 2 times the bankfull width.

BIOLOGICAL FEATURES

Historic Hillslope Vegetation

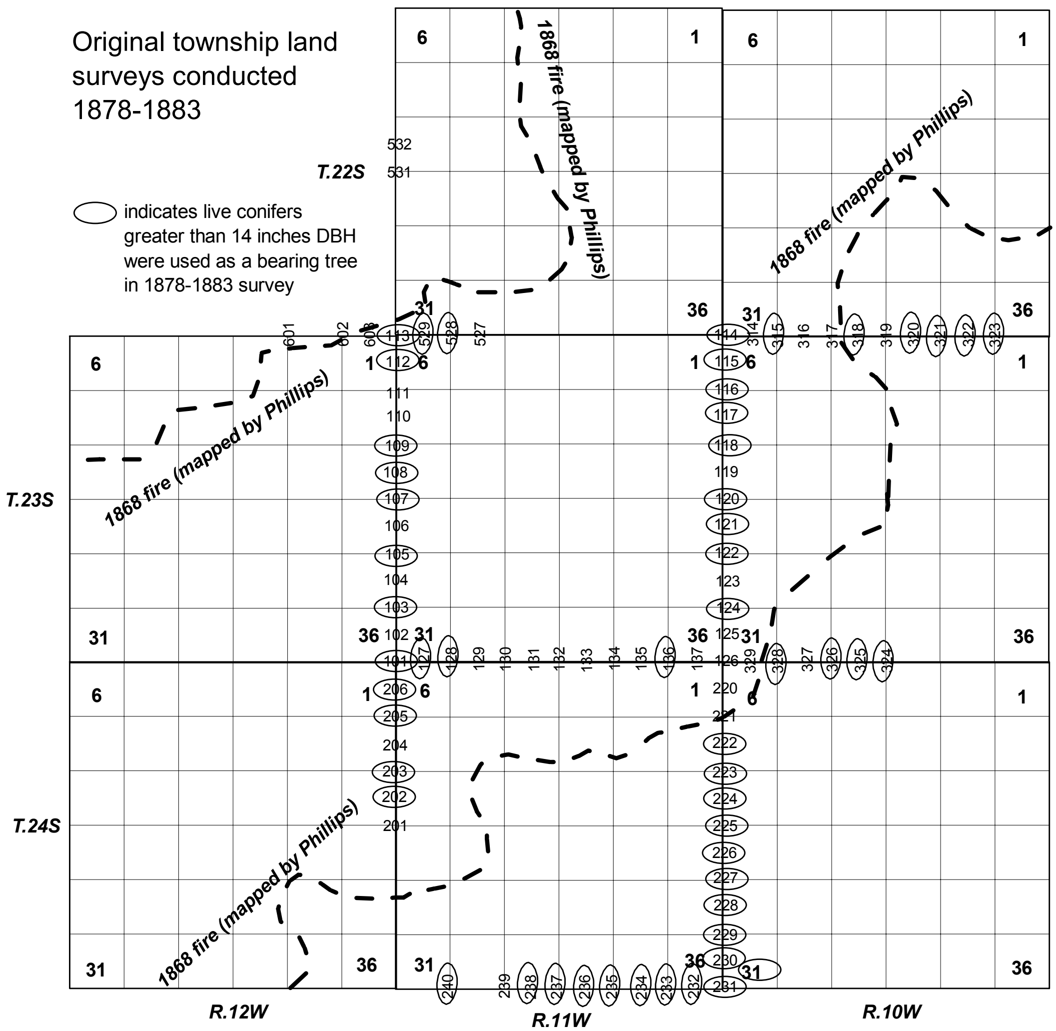
It is commonly believed that much of the vegetation within the boundaries of the Forest was initiated following a single, stand-replacement fire in 1868 (Morris 1934). Mature trees were logged from the Marlow Creek drainage about 50-75 years ago, so early fires appear to have missed this drainage.

To examine this assumption, the General Land Office original land survey notes were obtained for both township lines (surveyed from 1878-1883) and section lines (surveyed around 1893) for the Forest. The analysis team used a typed version of the original notes located at the ODF office in Coos Bay. There were some gaps in notes for the township line coverage; most notable was the line between T.22S and T.23S in R.11W (Figure 2-1). For each township corner indicated in the survey note, the analysis team noted the diameter and species of bearing trees used to mark the corner. Also noted was whether or not bearing trees were living or dead. Any comments about fire-killed timber also were included. Corners were segregated into two groups; those with at least one bearing tree consisting of a live conifer greater than 14 inches in diameter at breast height (DBH) were termed “older stand” and the remainder were “younger stand.” Corners associated with older stands are designated by an oval in Figure 2-1. Added to Figure 2-1 is the boundary of an 1868 wildfire that was mapped by J. Phillips, Coos District Forester from 1952-1989. The Phillips map does not indicate what information was used to define the fire boundary.

For a comparison with current stand conditions, the analysis team calculated average values for quadratic mean diameter of conifers within current stands ranging from 50-331 years old using the state forest inventory system (OSCUR) database. This was compared to the calculated average value of quadratic mean diameter of conifers in older stands noted in the township line surveys.

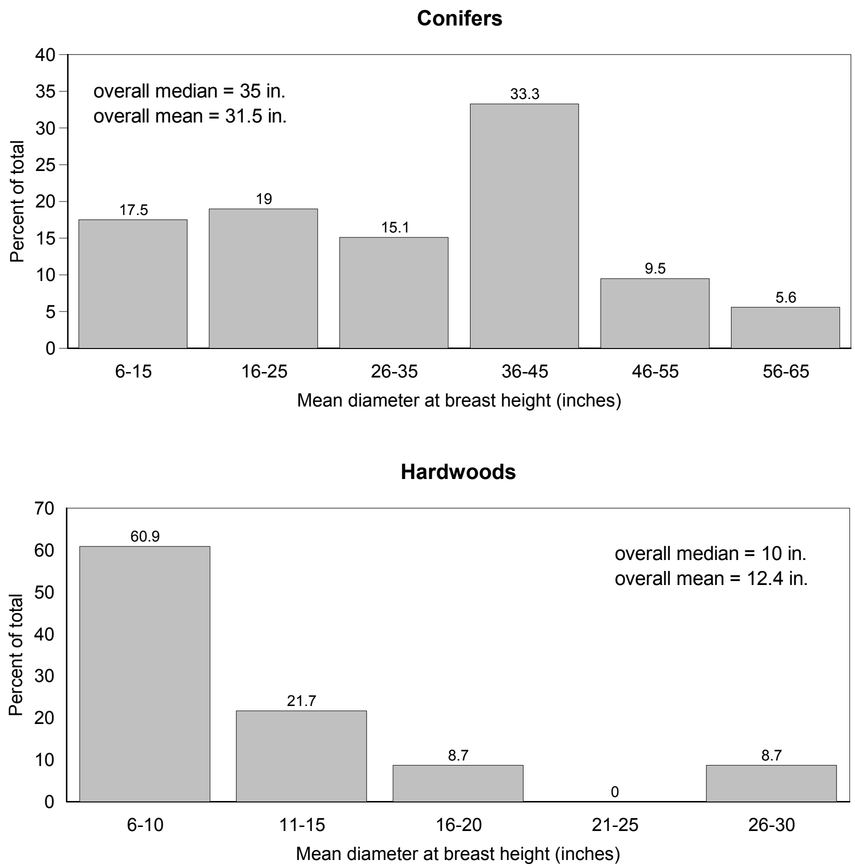
The survey notes indicate that about one-half of the corners in the 1878-1883 township surveys within the boundaries of the Forest and the 1868 fire perimeter had bearing trees that included at least one live conifer greater than 14 inches DBH. This indicates that the 1868 fire had not killed trees at these spots. The remaining corners had young trees or dead conifers as bearing trees corresponding in age to the 1868 fire. This suggests that the 1868 fire was spotty, burning only a portion of the Forest within the boundaries mapped by Phillips. However, by 1893, when corners for the section line surveys were established within the previously surveyed township boundaries, nearly all bearing trees were young trees or fire-killed conifers, indicating either the possibility of a second fire that occurred sometime from 1881-1893, widespread insect infestation and mortality, or widespread windthrow. The analysis team could not find any independent information confirming a second large fire. Reburning of fire-scorched areas has occurred in the Oregon Coast Range. Most notable is the Tillamook State Forest which initially burned in 1933, followed by reburns every 6 years in 1939, 1945, and 1951.

Figure 2-1. Location of township corners and identification numbers created from the General Land Office township survey notes for the Forest and the 1868 fire boundaries as mapped by Phillips.



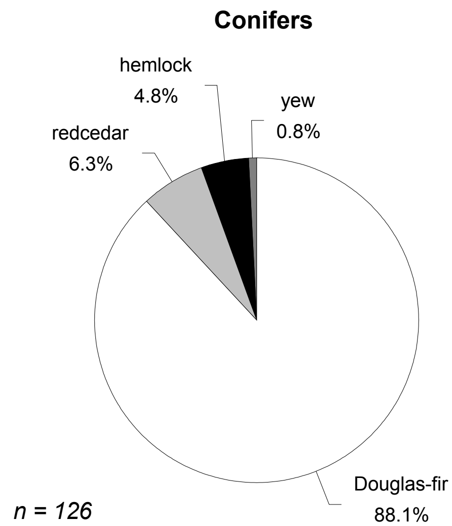
An evaluation of bearing trees associated with the older stand that survived the 1868 fire indicates a forest of mostly conifers dominated by trees in the 36- to 45-inch diameter range (Figure 2-2). Median conifer diameter was 35 inches. No bearing trees were greater than 60 inches DBH. The median diameter for hardwood bearing trees was 10 inches and most trees were in the 6- to 10-inch diameter class. Over 88% of the conifer bearing trees were Douglas-fir (Figure 2-3). Western redcedar (6%), western hemlock (5%), and Pacific yew (1%) made up the remainder. Among hardwoods, most bearing trees were red alder, bigleaf maple, or Oregon myrtle, with some vine maple, “bluewood” (possibly the name used for tanoak), and “greasewood” (possibly the name used for madrona).

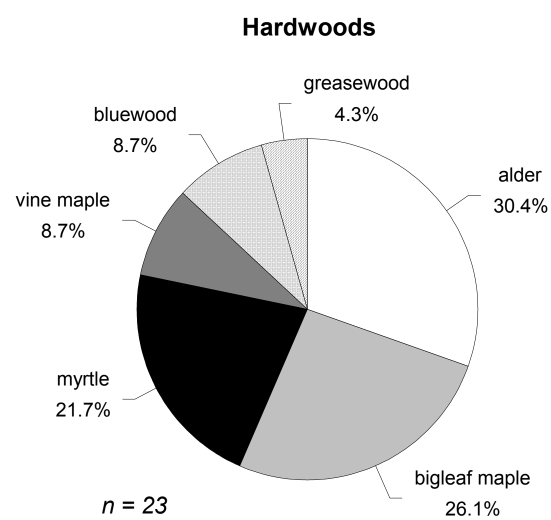
Figure 2-2. Diameter distributions of live-bearing trees that survived the 1868 fire for the original land survey of township lines in the Forest.



Note: Only those bearing trees for corners where at least one tree was a live conifer greater than 14 inches DBH are included.

Figure 2-3. Species distribution of live-bearing trees that survived the 1868 fire noted in the original land survey of township lines in the Forest.



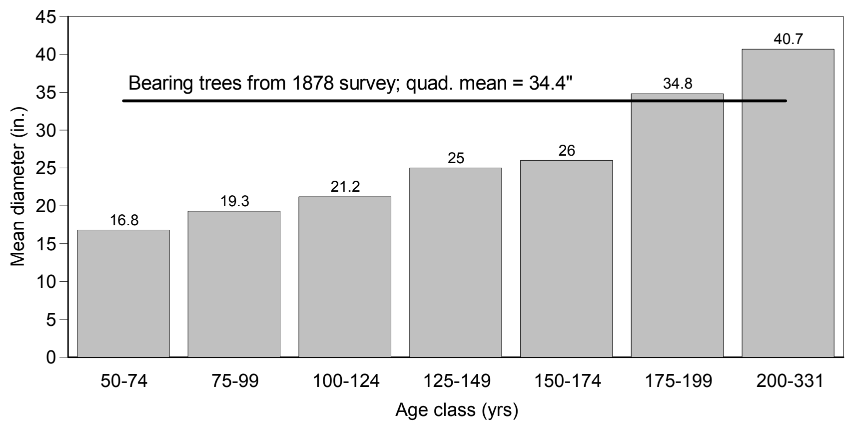


Note: Only those bearing trees for corners where at least one tree was a live conifer greater than 14 inches DBH are included.

The validity of the above analysis is based on the assumption that the original land surveyors selected the *nearest* suitable bearing tree in each quadrant (for section corners) or the nearest suitable tree in each semi-sphere (for quarter corners), as per their instructions.

The quadratic mean diameter of conifers noted in the township line survey was 34.4 inches. This corresponds to the quadratic mean diameter of conifers that are 175-199 years old growing in the Forest today (Figure 2-4). Consequently, the trees consumed by the late nineteenth century fires were about 185 years old. The stands originated about 1693. The species mix of trees noted in the township line survey is about the same as that found in older stands currently growing on the Forest, except that young plantations (<40 years) on the Forest today lack the western redcedar component noted in these earlier stands.

Figure 2-4. Quadratic mean conifer diameter by age class for current stands in Forest and for conifer bearing trees noted in the 1878-1893 land surveys.



The cause of the 1868 fire is unknown. The common use of fire by Native Americans to improve browse for deer and elk, allow easier travel, and promote growth of food plants has been documented for areas in the nearby Umpqua River and Rogue River Basins (LaLande and Pullen 1999). Early settlers also sometimes caused large, long-burning fires that consumed forests indiscriminately (Morris 1934). The U.S. Forest Service began a campaign in 1910 to control settlers burning forests in southwest Oregon (LaLande and Pullen 1999).

Current Hillslope Vegetation

The analysis team used the Forest's coverage of stand characteristics in 2000 to evaluate current vegetation throughout the Forest. Stand ages included in this database are based on aerial photograph interpretation, field measurements of individual trees, and timber harvest unit records (for younger stands).

Trees currently growing on the Forest are predominantly a mixture of fire stands (>100 years old) and younger plantations (<25 years old). Combined, these stands make up about

75% of the Forest. Stands 25-100 years old dominate along the southern and southeastern Forest fringe and reflect a series of land exchanges between the ODF and other landowners (Map 9.4). Trees from 200 and 350 years old account for only 190 acres of the Forest. The 165 acres of private inholdings on the Forest support timber in the 25- to 49-year age class.

The distribution of stand age classes by region and analysis basin in 2000 is provided in Table 2-5. During the last few years, about 425 acres annually of clearcut harvesting has occurred on the Forest (mostly from the 100- to 199-year age class). Map 9.4 and Table 2-5 do not reflect these recent harvests, however. Although not displayed, a number of stands have been thinned over the last several decades.

Table 2-5. Stand age by region and analysis basin, 2000.

Region	Analysis Basin	Acres by Stand Age (percent in parenthesis)						
		0-12 yrs	**13-24 yrs**	**25-49 yrs**	**50-99 yrs**	**100-199 yrs**	**200 + yrs**	**Combined**
Umpqua	1	181	1,229	1,324	185	2,340	92	5,352
	2	416	661	499	627	4,208	0	6,412
	3	537	1,627	1,016	398	3,648	67	7,293
	4	189	1,968	584	265	1,985	0	4,990
	13	153	522	1,184	514	1,728	31	4,132
	Combined	**1,476 (5%)**	**6,007 (21%)**	**4,607 (17%)**	**1,990 (7%)**	**1,3909 (49%)**	**189 (1%)**	**28,178 (100%)**
Tenmile	5	350	2,186	345	909	4,032	0	7,822
	6	529	1,493	450	248	4,606	0	7,326
	7	385	1,374	830	734	2,996	0	6,320
	Combined	**1,263 (6%)**	**5,054 (24%)**	**1,625 (8%)**	**1,892 (9%)**	**1,1634 (54%)**	**0 (0%)**	**21,468 (100%)**
Coos	8	382	1,459	884	921	2,905	0	6,551
	9	461	1,416	2,297	955	3,225	0	8,353
	10	579	961	2,059	2,172	740	0	6,512
	11	993	2,656	1,004	666	5,554	0	10,872
	12	1,475	3,012	1,114	572	5,148	0	11,321
	Combined	**3,890 (9%)**	**9,503 (22%)**	**7,358 (17%)**	**5,286 (12%)**	**17,572 (40%)**	**0 (0%)**	**43,609 (100%)**
Total		**6,630 (7%)**	**20,564 (22%)**	**13,591 (15%)**	**9,167 (10%)**	**43,115 (46%)**	**189 (0.2%)**	**93,255 (100%)**

Analysis basin #6 (Benson Creek and Roberts Creek), and basin #2 (Charlotte Creek and Luder Creek) have the highest percentage of forest in older timber (>100 years old) at 63% and 66%, respectively. Older timber makes up the lowest percentage of the Forest in basin #10 (Marlow Creek and Glenn Creek) at 11% (Table 2-5). On a broader scale, the Coos region has less area in older timber (40%) than the other two regions (both about 50%).

Riparian Vegetation

Streamside stands regenerate and grow differently than upslope stands. Under natural conditions, conifer regeneration along streams tends to be sparse, probably due to competition from riparian brush and the presence of streamside terraces, which can be too moist for conifers. Also, the mortality of young trees caused by beaver, mountain beaver, and elk tends to be greater close to streams. Furthermore, unstable or shallow soils often occur on steep-sided slopes next to streams and may not support a conifer tree once it reaches a certain size. The mortality of conifer trees next to streams seems to be rarely associated with competition among trees since initial tree density is rarely great enough for self-thinning to occur, and snags are scarce (Andrus and Froehlich 1988).

Timber management also can influence riparian vegetation competition. Swaths adjacent to streams that were cleared for the construction of streamside roads have often regenerated to stands of mainly hardwoods. The cut slopes and road surfaces do not normally support tree roots, resulting in a reduced density of trees along streams. Nevertheless, after several decades, trees growing each side of the road often do create a closed tree canopy over a streamside road. The intensity of effort to establish conifers in clearcut areas next to streams has varied over the decades, resulting in variable plantation success in these areas.

In order to characterize current streamside forests on the Forest, the analysis team conducted an inventory of streamside stands along all fish-bearing streams using aerial photographs. Color orthophotos from 1996 incorporated into a Geographic Information System (GIS) layer provided the base map for delineating stands of different age class and conifer dominance. Initial stand demarcations were digitized on the computer screen. High quality color aerial photographs (1:12000 scale) from 2002 were then used to refine stand boundaries and identify general classes of conifer and hardwood mixes and stand age. A GIS layer of general stand age based on hillslope trees was used to help estimate the age class of a streamside stand. The detailed aerial photographs were used to identify the age of stands (using color and texture) where the streamside stand age was visually different than the upslope stand age. Areas without trees also were delineated by type when they appeared through the tree cover. Stand classes included:

Stand age class	< 12 years
	13-24 years
	25-49 years
	50-99 years
	> 100 years
Crown cover class	Hardwood (less than 30% conifer)
	Conifer/hardwood (between 30%-70% conifer)
	Conifer (more than 70% conifer)
Areas without trees	Wide mainline roads
	Wide rivers
	Brush/grass

No attempt was made to distinguish hardwood-dominated stands that were 50-99 years old from those that were greater than 99 years old. Hardwood stands in which the majority of the basal area is composed of trees 100 years old and greater may not actually exist on the Forest. A study of streamside stands in the coastal area of southwest Washington suggests that hardwood stands tend to become multi-aged after about 80 years or revert to brush (Rot 1995, Hibbs and Giordano 1996). As a result, the combined age class for the oldest hardwood trees was labeled as 50-99 years.

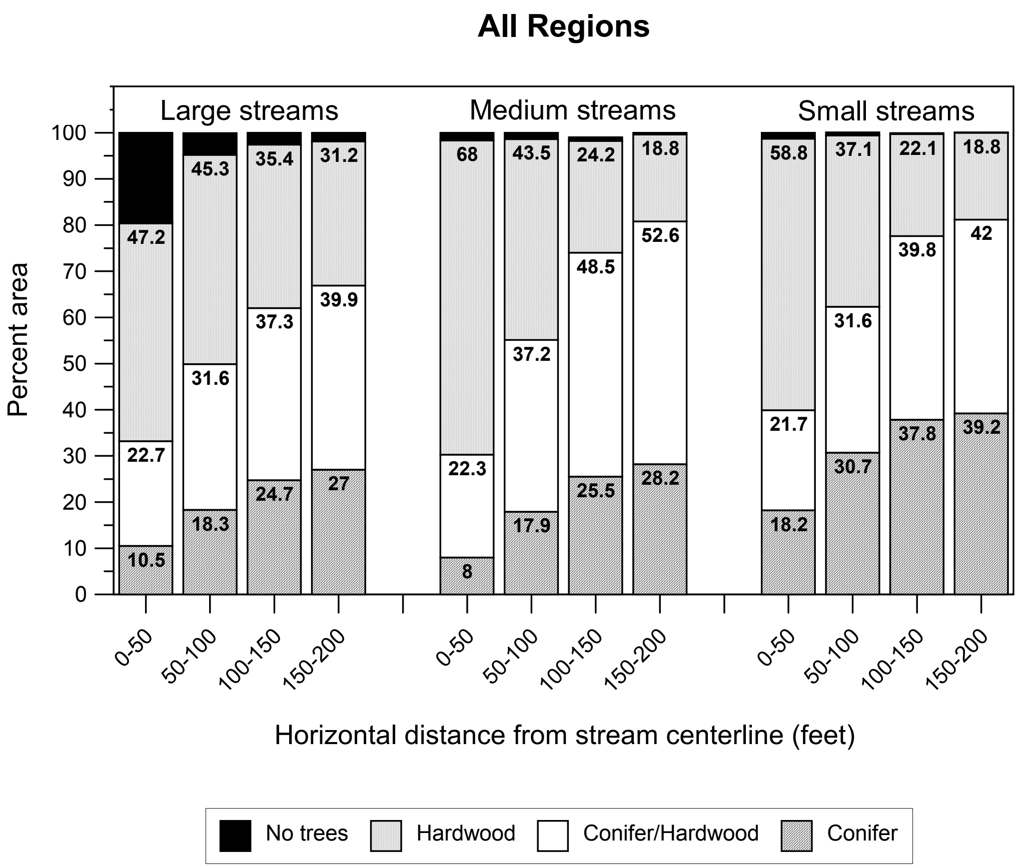
Streamside forest delineations occurred from the centerline of the stream (as shown in the GIS stream layer developed from the 1996 orthophotos) out to a horizontal lateral distance of 200 feet. General results from this analysis are reported in this section. A more detailed discussion is provided in Chapter 7, *Riparian Vegetation and Large Wood*.

The resultant map of streamside vegetation (Map 7.1 shows an example for Scholfield Creek) displays a patchy array of conifer/hardwood dominance classes reflecting the history of harvesting, road building, and debris torrents in the Forest. In addition, young hardwood trees along some of the larger streams, especially in the Tenmile region, are a result of tree invasion into streamside areas that were previously pasture.

Hardwoods are the most dominant stand type found within 100 feet of the stream for all stream size classes (Figure 2-5). Hardwood dominance decreased with increasing distance from the stream but, along large streams, hardwoods still occupy 31% of the land within 150-200 feet from the stream. Conifer/hardwood stands occupied the majority of the area at distances of 100-200 feet from the stream. Conifer-dominated stands made up a minority of the streamside area for all stream size class and distance intervals. Areas with no trees include open water associated with the largest of streams, wide roads, and areas of brush or grass.

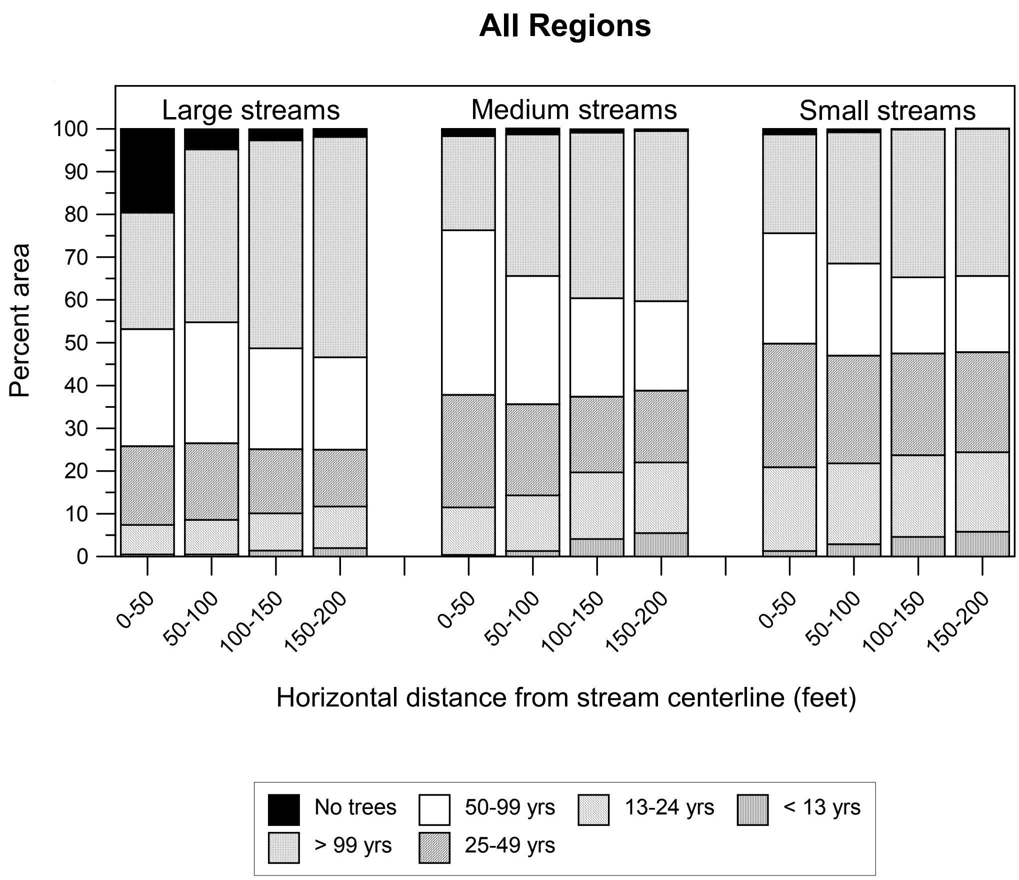
Some of the hardwood dominance along streams is natural; even the old fire stands with no streamside roads or debris torrents usually have a band of hardwoods growing closest to the stream. Among managed stands, hardwood domination of streamside stands seems to be the greatest where a road paralleled the stream, where buffers were retained 7-12 years ago, or where harvest occurred 35-60 years ago, a time when efforts to regenerate conifers near streams were weak. Conifers next to streams in managed stands were most abundant next to recent clearcut harvest units (up to 6 years ago) and harvest units with trees in the 15- to 35-year age class. Trees within units from this latter age class were typically harvested to the edge of streams followed by aggressive site preparation and conifer planting.

Figure 2-5. Percent riparian stand type by stream size for all Forest regions (fish-bearing streams only).



The age-class distribution of riparian stands is equally patchy throughout the Forest, and again corresponds to past management activities. Stands 100 years old or older are the dominant age class, except within 50 feet of medium and small streams (Figure 2-6). The area with trees less than 13 years old is very small, even up to 200 feet from the stream, and reflects the recent practice of retaining wide buffers along fish-bearing streams when timber is harvested and a general pattern of conifer plantation failure in clearcut areas nearest streams. While conifer trees were likely planted to the edge of the retained buffers within harvest units, competition from brush can quickly overwhelm the trees.

Figure 2-6. Percent riparian stand age by stream size for all Forest regions (fish-bearing streams only).



Fish and Wildlife Resources

Four species of salmonids are found on the Forest including coho salmon, chinook salmon, steelhead, and cutthroat trout. Coho salmon are listed as threatened under the federal ESA. All four species are anadromous, although cutthroat trout also are resident. Species of fish found on the Forest are listed in Table 2-6.

Coho salmon are the most dominant anadromous fish on the Forest and are found in most streams with a gradient less than 6% and with sufficient flow to provide cover and living space. Steelhead trout rear throughout the Forest. Some steelhead are reared at a hatchery on the lower reach of the West Fork Millicoma River (on the Forest). Surveys of nearby tributaries by the ODFW (Charleston office) indicate that straying of hatchery fish is limited to only a few streams nearest the hatchery. Steelhead can occupy steeper channels than coho salmon and often segregate into the steeper channels to avoid competition from coho salmon in lower gradient streams.

Table 2-6. Fish species occurring on the Forest.

Common Name	Scientific Name
Coho salmon	*Oncorhynchus kisutch*
Fall chinook salmon	*Oncorhynchus tshawytscha*
Winter steelhead trout	*Oncorhynchus mykiss*
Sea-run cutthroat trout	*Oncorhynchus clarki clarki*
Resident cutthroat trout	*Oncorhynchus clarki clarki*
Dace species (Millicoma and speckled)	*Rinichthys cataractae, R. osculus*
Redside shiner	*Richardsonius balteatus*
Lampreys (Pacific and western brook)	*Lampetra tridentate, L. richardsoni*
Largescale sucker	*Catostomus macrocheilus*
Threespine stickleback	*Gasterosteus aculeatus*
Sculpins (Coast Range and prickly)	*Cottus aleuticus, C. asper*

Chinook salmon spawning and rearing are limited to the lower reaches of the West Fork Millicoma River and Mill Creek. About 100,000 juvenile chinook are reared at the West Fork Millicoma River hatchery.

Although the anadromous form of cutthroat (sea-run) occurs in Forest streams, not much information is known about run sizes or which streams produce more sea-run cutthroat. Chum salmon, now rare in streams of the Coos Bay area, occur in the lower reach of Marlow Creek on private land but not on the Forest. Since chum salmon are naturally limited to low-gradient streams near bays or estuaries, the streams on the Forest were probably never significant producers of chum salmon.

The Forest hosts three species of frogs, seven species of salamanders, and one species of newt (Table 2-7). Those that are aquatic and most influenced by timber harvest include the tailed frog, southern seep salamander, and Dunn’s salamander. Tailed frog tadpoles require very cold water for survival, especially during their first year. The southern seep salamander and Dunn’s salamander are found mainly along small streams in the splash zone of falls and cascades. The Pacific giant salamander (reaching a length of up to 12 inches) is common in the Forest. This species and cutthroat trout prey upon each other’s young in headwater streams. Above the most upstream extent of cutthroat trout use, there is often an increase in the numbers of juvenile Pacific giant salamander.

There are 161 miles of known fish-bearing waters in the Forest (Table 2-8). More miles of fish-bearing streams probably exist but field surveys are incomplete. Field studies done elsewhere in the Coast Range (ODF, Forest Practices, information prepared for the early 1990s review of stream protection rules) indicate that fish typically use nearly all large- and medium-sized streams. However, the database on fish use for the Forest classifies 12.5 miles of medium-sized stream as not fish bearing. About 2.8 miles of these medium-sized streams were examined and did not have fish. For the remaining 9.7 miles, no field examination has been done to confirm whether fish use occurs. Similarly, there are probably a number of miles of small size streams with fish use that have not been identified through field surveys.

Table 2-7. Amphibian species occurring on the Forest.

Species	General Habitat
Tailed frogs, *Ascaphus truei*	Aquatic/Riparian
Red-legged frog, *Rana aurora*	Aquatic/Riparian
Southern seep salamanders (or southern torrent salamander), *Rhyacotriton variegatus*	Aquatic/Riparian
Pacific giant salamander, *Dicamptodon tenebrosus*	Aquatic/Riparian
Dunn's salamander, *Plethodon dunni*	Aquatic/Riparian
Rough-skinned newt, *Taricha granulosa*	Aquatic/Riparian and uplands
Northwestern salamander, *Ambystoma gracile*	Aquatic/Riparian
Clouded salamander, *Aneides ferreus*	Upland
Ensatina salamander, *Ensatina eschscholtzii*	Upland
Foothill yellow-legged frog, *Rana boylii*	Upland
Western red-backed salamander, *Plethodon vehiculum*	Upland

Table 2-8. Mileage and density of known fish-bearing streams.

Region	Area (sq. mi.)	Streams Known to be Fish Bearing (mi.)	Density of Fish-bearing Streams (mi./sq. mi.)
Coos	67.9	95	1.40
Umpqua	44.1	34	0.77
Tenmile	33.6	32	0.95
Total	**145.6**	**161**	**1.11**

For this project, the analysis team did not speculate on which additional streams support fish; the analysis team used fish-bearing miles as identified in the ODF database. It is likely that many streams on the Forest, not yet identified as fish-bearing streams, do support mainly cutthroat trout, and that most stream segments occupied by salmon and steelhead have already been identified.

The density of fish-bearing streams averages 1.4 miles per square mile for the Coos region and only 0.8 miles per square mile for the Umpqua region (Table 2-8). Since the passage of anadromous fish in Mill Creek is blocked by falls at Loon Lake, the lack of salmon and steelhead in upstream waters has probably made fish absence/presence surveys less of a priority in the Umpqua region. Also, since little timber harvest has occurred in tributaries upstream of Loon Lake in the past two decades, there has been reduced impetus to identify fish-bearing streams.

Stream channel gradient is a key factor in determining the extent of fish distribution and use by species and life stage (migration, spawning, and rearing). The range of cutthroat trout generally extends to the higher gradient streams, commonly using streams up to 12% gradient; this species can even sustain isolated populations upstream of waterfalls, as long as the stream has year-round water. They will usually spawn in channels up to an 8% to 10% gradient. Steelhead trout will spawn in channels up to a 6% gradient. Coho salmon prefer spawning in channels of less than 4% gradient.

Salmonid use of streams can be seasonal. Cutthroat trout, in particular, are known to occupy the smallest headwater streams when flows are high in early spring and then migrate downstream as flow diminishes over the summer. It is not uncommon for cutthroat trout and steelhead to spawn in streams that are dry in the summer. Lamprey also have been observed in the Forest using most of the same streams as those used by anadromous salmonids.

SOCIAL CONTEXT

Population and Demographics

Although the population of Oregon as a whole is growing faster than the national population, this is not the case for many coastal areas. Out-migration was high during the recession in the early 1980s, due in part to the decline in the wood products industry. The annual rate of growth for Coos County has been positive since 1987, though less so than the annual rate of growth for Oregon as a whole.

In 2000, the population of the southern Oregon Coast (including Reedsport, Coos Bay/North Bend, Bandon and Gold Beach) was 75,512. By 2006, the population of this area is estimated to decrease slightly to 73,365. The 2000 population was 92.3% Caucasian, 0.3% African American, 2.3% American Indian, 1.0% Asian, and 3.4% Hispanic. For 2006, projections show that Hispanics will experience a 0.5% increase and Asians a 0.1% increase, with a decrease in the Caucasian population (-0.4%).

Coos County has a nearly equal amount of men (48.65%) and women (51.35%), and the median age (43.1 years) is slightly higher than the national average. The average household size is 2.3 people with an average family size of 2.8 people. Coos County is similar to the southern Oregon Coast as a whole in terms of racial demographics.

In 2002, Reedsport had a population of 4,935, a median age of 39.7 years, a median household income of $30,500 and an average household size of 2.3 people. In the same year, Coos Bay had a population of 15,136; however, its median age is a bit younger at 37.2 years, and it has a lower median household income of $28,200 with an equal average household size of 2.3 people. North Bend's population was 9,729 and it has the youngest median age (36.6), the highest median household income ($33,100) and the largest average household size (2.4 people). North Bend has the highest cost of living index at 92, compared to 90 for Reedsport and 87 for Coos Bay. North Bend also has the highest percentage of white-collar workers at 51.8%, with Coos Bay at 48.0% and Reedsport at 40.6%.

Economy

In March 2002, total employment for Coos County was 23,893 with an unemployment rate of 10.1%. The unemployment rate was 1.0% higher in March 2001. Natural resource-based industries such as commercial fishing, agriculture, timber, and tourism continue to be important in Coos County, though timber has declined significantly in recent years (Radtke 1999). Fishing and oyster culture make up about 2.3% of the total personal income of coastal residents in Coos County. Agriculture makes up about 2.5% of personal income, with the largest agricultural sector being cranberries, which generate 33% of total county agricultural personal income. Personal income from timber has declined but still contributes 7.49% of total personal income. Tourism comprises 4% of personal income for county residents and is experiencing steady growth, though this industry is characterized by low wages and seasonal demand fluctuations. There has been a dramatic increase in transfer payments (Social Security, pensions, welfare) as a percent of total county personal income. Currently, transfer payments comprise 28% of personal income. This is partially a function of the increase in retirees collecting Social Security payments (Radtke 1999).

Recreation

According to a report by Anderson and others (2001), "Recreation use of the Elliott State Forest has modest economic effects on Coos County, but these effects measure only part of the total economic contribution of recreational activity." They explain that protecting natural resources contributes to quality of life, increased expenditures by visitors outside Coos County, and the economic value received by the visitors themselves. Availability and access to recreation along the Oregon Coast is important to both local and state economies and includes non-quantitative measures, such as quality of life and environmental conservation and protection (it is interesting to note that the authors of the Anderson study identify non-quantifiable measures as important to stimulating the economy yet ignore the quantifiable multiplier measures that base industries provide).

There is currently little information on the recreational use of the Forest, although surveys performed by the ODF in summer and fall show that some is taking place (Anderson et al. 2001). Recreational use is concentrated within several small areas on the Forest. Hunting is a primary use, occurring mostly during deer and elk hunting season in the fall. Other recreational uses include fishing, off highway vehicle riding, horseback riding, hiking, kayaking, and picnicking. White-water kayaking is most common in the lower West Fork Millicoma River. Most visitors to the Forest come from nearby communities. There are numerous areas for dispersed camping along roads and streams, with the most popular areas being Elk Creek and the West Fork Millicoma River.

Trail use is of one of the fastest growing recreation opportunities in Oregon. Locally, the Coos Regional Trails Partnership has a vision, "…to work in partnership to facilitate the development of outdoor recreation and related tourism in the Coos region and promote it as the premier destination on Oregon's Coast" (Shapiro and Johnson 2000). The Trails Partnership provides opportunities to network and share resources among agencies, trail users, public opinion leaders, and businesses. A high quality hiking opportunity potentially exists in the Forest along Big Creek, which is a tributary to North Tenmile Lake. Much of the lower slopes of Big Creek are older timber and a decommissioned road along the stream provides a level surface for establishing a trail. As its name suggests, Big Creek is one of the larger streams in the Forest, and its size and older timber makes it one of the most scenic. Charlotte Creek, a tributary to the Umpqua River, also offers a high quality hiking opportunity, but noise from Highway 38 may detract from its otherwise scenic qualities, which include older trees and rocky outcrops. The establishment of trailheads adjacent to the Forest is complicated because public roads rarely extend to the edge of the Forest.

Trends in Recreational Activities

A survey of Coos Bay residents was conducted in 2000 by the Pacific Northwest Coastal Ecosystems Regional Study (PNCERS) to help users and managers of coastal resources better understand the effects of human activities and attitudes. The survey had three objectives: (1) assess how residents value specific aspects of their communities and their surrounding natural landscapes; (2) document outdoor recreational activity levels of residents tied to the natural environments of the bays; and (3) identify threats perceived by local residents and their preferred ecosystem management approaches.

Forty percent of survey respondents (518 completed the survey) felt that views and scenery were extremely important community characteristics, which led them to reside in a community near Coos Bay. Almost 30% of survey respondents to this same question noted the importance of recreational opportunities (Table 2-9). When asked what types of outdoor recreational activities they engaged in during the last year, hiking and walking received the highest numbers of responses (Figure 2-7). This was followed by beach combing, fishing, crabbing and boating. About 25% of respondents participated in salmon and steelhead fishing and 16% participated in bird watching.

A majority of survey respondents felt that natural resource management decisions should be equally balanced between environmental and economic factors. Almost 40% felt that existing partnerships between government and citizens were the most influential in making natural resource management decisions in Coos County.

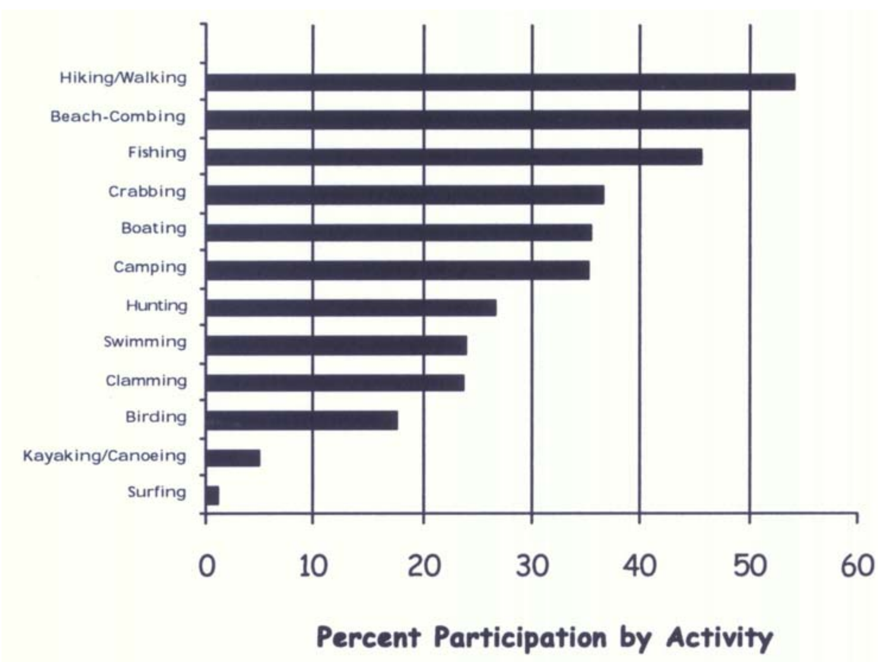
Local environmental quality has emerged as a significant factor in determining where people choose to reside, as well as where they chose to locate businesses. According to Radtke (1999), “During the second half of the twentieth century, changes in the American economy have made residential location choices increasingly important as determinants of the location of economic activity.” Today, both people and businesses are more footloose and changes in the American economy reduced costs relating to distance from economic centers due to improvements in transportation and communication. Also, economic activity is less tied to particular locations because of changes in what our economy is producing. Furthermore, non-employment income, including retirement income, is a greater percentage of personal income.

Table 2-9. Rating of community characteristics related to why people reside in a community near Coos Bay.

Community Characteristic	Percent of Row Totals						Sample Size
	Not Important	Slightly Important	Somewhat Important	Considerably Important	Extremely Important	Not Sure	
Views and scenery	7.6	3.7	15.9	31.4	40.1	1.3	459
Job opportunities	23.0	4.7	19.5	13.9	36.5	2.5	447
Low crime rate	7.8	5.1	22.6	28.0	33.8	2.7	447
Fewer people	11.5	5.3	21.4	27.5	32.8	1.5	454
Near family/friends	28.5	6.1	15.8	16.9	32.5	0.2	456
Near ocean	13.2	7.6	21.3	26.0	31.0	0.9	461
Recreation	9.6	4.4	23.7	31.6	29.4	1.3	456
Good schools	18.3	6.0	17.9	26.6	28.6	2.5	447
Little traffic congestion	7.9	6.4	25.3	31.4	28.4	0.7	455
Health care facilities	10.1	7.0	27.9	25.4	28.3	1.3	445
Clean water in bay	10.6	6.3	25.9	26.1	26.1	5.0	444
Nice people	9.2	6.6	27.5	30.8	24.4	1.5	455
Climate/weather	11.3	6.8	27.7	28.3	24.2	1.7	459
Good public services	12.2	8.4	25.5	28.4	23.9	1.6	451
Low cost of living	18.7	10.8	32.2	20.3	14.6	3.4	444

Source: PNCERS 2000

Figure 2-7. Level of participation in recreational activities.



In deciding where they live, people guide local economies by their choices about what quality of life elements are important. Radtke (1999) states, "A comprehensive study of all 254 non-metropolitan counties in the Mountain West for three time periods, the 1970s, 1980s, and 1990-1995 found that not only was population growth driving employment growth, but that the value of amenities in driving that population growth had been increasing over time." The attractiveness of an area holds a lot of weight in these decisions and can help decide whether an area will be a place of prosperity and economic growth or a depressed economy. Radtke (1999) states, "Economic research has repeatedly demonstrated that areas of high-quality natural environments that are officially protected have been able to attract higher levels of economic activity."

Management choices for the Forest play an important role in providing amenities and environmental benefits. Forest management can have a large influence on job and income creation. According to Radtke (1999), "Measures that improve the attractiveness of an area to current and potential residents will tend to increase the level of local economic activity. Changes that cause deterioration in the local quality of life will tend to discourage the retention and attraction of economic importance." Infrastructure is essential to prevent the need for remediation and to maintain its attractiveness and ease of access for area residents. Even simple measures, such as providing road signs to keep visitors from getting lost, adds amenity value to the Forest.

Land Uses

Agricultural uses on the Forest are negligible because the steep terrain precludes growing agricultural crops. The only possible agricultural use would be Christmas tree farming, which according to the ODF does not seem economically feasible. The only domestic livestock grazing in the Forest is located on 1 acre of grassy area near Palouse Creek being leased to an adjoining rancher. There is no current production of oil, gas or minerals in the Forest. Although oil and gas drilling did occur historically, the Forest is not considered a reliable area for prospectors. As discussed previously, recreational use is concentrated within several small areas. Another potential land use is for special forest products, although no inventory has been done of all the possible products and their locations in the Forest.

The Forest is a consolidated public land holding surrounded mostly by privately owned lands (Map 2.9). The Millicoma Tree Farm, owned by Weyerhaeuser, is located near the east and south borders of the Forest. The Bureau of Land Management (BLM) administers lands with a checkerboard pattern in this region, which includes Loon Lake Recreation Area near the northeast border of the Forest. This recreation area is one of the most popular destination sites near Reedsport, averaging from 70,000 to 80,000 visitors annually. Interpretive programs are conducted each summer at the campground and there is a short hiking trail to a waterfall. Other activities include camping, picnicking, boating, swimming, and fishing. The Dean Creek Elk Viewing Area is a popular wildlife attraction located just outside of Reedsport along Highway 38. Bass fishing competitions are very popular in the Tenmile Lakes.

MANAGEMENT OF THE ELLIOTT STATE FOREST

Elliott State Forest

Management practices on the Forest have changed during the last decade. The most recent change has been the interim adoption by the Forest of stream protection criteria that are currently being implemented by State Forest Districts in northwest Oregon. All timber sales included in the 2003 Coos District *Annual Operations Plan* have been designed to meet these stream protection criteria. The management of streamside areas during the last 6 years does not lend itself to a simple checklist of criteria. Within the framework of the Forest Practices Act and the *Elliott State Forest Management Plan*, the four basin foresters tailor stream protection measures to match the unique conditions within individual timber harvest units. Nevertheless, through conversations with the basin foresters, regeneration foresters, and engineering staff, the following general measures apply (this is not an exhaustive list).

- Surveys for marbled murrelets within proposed harvest units occur each of 2 years prior to finalizing the timber sale.
- All streams within a harvest unit that could be fish-bearing (using criteria outlined in the Forest Practices Rules) are treated as fish-bearing, even if a field survey has not been conducted to confirm the presence of fish.
- All trees growing within 100 feet of a fish-bearing stream are retained. Buffers are expanded to include areas of slope instability, wetlands, and other special features. In-unit trees (green trees and a certain number of snags per acre of clearcut harvest) are often retained as extensions of streamside buffers.
- All trees growing within 50 feet of perennial streams (not considered fish bearing) are retained. These buffers also may be extended laterally to include areas of slope instability, wetlands, and other special features. These buffers are often expanded to satisfy in-unit tree requirements for clearcut harvest units.
- The Southwest Region geotechnical specialist reviews proposed harvest units to determine if unusual slope instability problems exist. If so, higher risk areas may be excluded from the harvest unit or trees may be retained on those portions of the harvest unit where slope instability is high.
- Opportunities to improve fish habitat and slope stability within nearby streams are often incorporated into timber sales. This can include adding large trees from the harvest unit to fish-bearing streams deficient in large wood or decommissioning old roads.

The annual acreage of clearcut harvest has been about 425 acres annually for the last few years. Starting in 2004 and over the next decade, this will increase to 510 acres annually. Thinning of stands, mostly in the 30- to 70-year-old age class also occurs. An average of 535 acres per year was thinned from late 1997 to early 2001.

Under the 1995 HCP for northern spotted owls, the Forest is segregated into short (80-135 years) and long (160-240 years) rotation basins. Most of the Tenmile region (84%) and the Umpqua region (75%) are designated as long rotation. Only the Elk Creek watershed is designated as long rotation in the Coos region. Past timber harvest now curtails additional harvest in the long rotation basins, putting more pressure for near-term future harvest in the

Coos region. Overall, 51,158 acres of the Forest (55%) is designated long rotation, while 45% is designated short rotation.

Surrounding Land Parcels

The two scattered tracts closest to the main block of the Forest (Table 2-10) are managed in a manner similar to the bulk of forestlands. Timber tends to be younger on these tracts and near-term timber harvest will probably occur only on the Ash Valley tract. Only the Sock Creek tract includes a fish-bearing stream.

Some of the remaining scattered tracts considered part of the Forest (Table 2-10) are no longer actively managed for timber production. The timber is older (50-95 years) on these tracts and any future timber harvest may be complicated by the presence of northern spotted owls (such as Tyee 40). Fish-bearing streams only occur on the Folley tract and the north parcel of the South Slough tract. The Lighthouse tract is in a unique setting on a hilltop near the Umpqua River lighthouse. The 47- to 65-year-old Sitka spruce stands on this tract are a noticeable landmark above Winchester Bay.

Federally Listed Species and Clean Water Act Issues

Fish and wildlife species on the Forest that are listed as threatened under the federal ESA include the northern spotted owl, marbled murrelet, and coho salmon. Spotted owls are currently managed according to the 1995 HCP; the incidental take permit under this HCP for murrelets expired in 2001 and a strategy of *take avoidance* is currently being used. The management of coho salmon habitat is currently based on the aquatic strategies incorporated into the Northwest Oregon State Forests Management Plan. These measures are similar to those used during the last 6 years on the Forest, and have a focus on retaining wide buffers along fish-bearing streams and narrower buffers other perennial and intermittent streams.

Application of the Clean Water Act by the Oregon Department of Environmental Quality (DEQ) is currently focused on the TMDL process, whereby impaired streams are addressed in a watershed context and landowners respond to any human-caused degradation of a stream in proportion to their negative influence on the stream. Parameters of concern that could apply to the Forest in any future TMDL process include sediment and nutrients (streams flowing into Tenmile Lake) and water temperature (West Fork Millicoma River Basin).

Table 2-10. Scattered tracts of land associated with the Forest.

Tract Name	Acres	Vegetation	Roads	Legal Description
Tracts included in the evaluation of the main block of the Elliott State Forest:				
Sock Creek	158	30-yr-old DF	Passable	T.23S, R.9W, sec 6
Ash Valley	136	58- to 70-yr-old DF with some alder	Passable	T.23S, R.10W, sec 24
Total	**294**			
Tracts not included in the evaluation of the main block of the Elliott State Forest:				
School Land Bay	91	mostly 22- to 25-yr-old DF with some 120-yr-old DF	Passable	T.23S, R.12W, sec 16
Folley Creek	156	mostly 50- to 60-yr-old DF with some 90-yr-old DF	Passable	T.21.S, R.7W, sec 36
Purdy Creek	36	mostly 80-yr-old hardwood and DF with some brush	No roads	T.22S, R.9W, sec 16
Lighthouse	178	47- to 65-yr-old Sitka spruce; near Umpqua River lighthouse	Impassable	T.22S, R.12W, sec 7 and T.22S, R.13W, sec 12, 13
Tyee 40	42	95-yr-old DF and white fir	Passable road?	T.25S, R.7W, sec 16
South Slough (3 parcels)	392	31- to 60-yr-old mixed conifer (DF, spruce, hemlock, cedar)	Impassable	T.26S, R.13W, sec 19, 20, 30 T.26S, R.14W, sec 36
Total	**895**			

DF = Douglas-fir

Tract Name	Fish	Wildlife
Tracts included in the evaluation of the main block of the Elliott State Forest		
Sock Creek	Includes 0.25 miles of Sock Creek; small fish-bearing stream. A road crosses the stream.	Single spotted owl within ½ mile of tract boundary.
Ash Valley	No fish-bearing streams.	
Tracts not included in the evaluation of the main block of the Elliott State Forest		
School Land Bay	No fish-bearing streams	
Folley Creek	Includes 0.3 miles of Big Tom Folley Creek; large fish-bearing stream. A road parallels the stream.	
Purdy Creek	No fish-bearing streams.	
Lighthouse	No fish-bearing streams.	
Tyee 40	No fish-bearing streams. Very steep slopes above the Umpqua River.	Pair of spotted owls within ½ mile of tract boundary.
South Slough (3 parcels)	North parcel includes 0.3 miles of Elliott Creek; small fish-bearing stream. Middle and south parcel have no fish-bearing streams.	

Chapter 3. Historical Overview

The term “original conditions” is often used to refer to the status of a landscape prior to European settlement. Understanding these conditions is helpful when managing for fish and wildlife resources since these animals have adapted to the original conditions over thousands of years. Wide departures from the original conditions can dislocate or reduce animal populations. Properly understood, original conditions are not a steady-state phenomenon; rather, they include natural cycles of both disturbance and recovery.

The purpose of this chapter is to provide a depiction of major natural disturbance events for the analysis area and to characterize management trends. This chapter will:

- Examine natural disturbance (floods and windstorms) and their impact on the aquatic ecosystem prior to and shortly after European settlement and through recent times.
- Characterize early human disturbance patterns by summarizing settlement patterns, impacts to aquatic habitat from splash dams, and cleaning wood from stream channels.
- Describe the establishment and early management history of the Elliott State Forest.

The descriptions of watershed conditions through time are based on evidence from written and first-hand accounts, reports, land survey records, resource inventories, maps, drawings, and photographs. The other chapters of this analysis cover the current issues and trends that affect the watershed.

NATURAL DISTURBANCES

Over time, natural disturbances have shaped the Forest and its aquatic systems. Chapter 2, *Watershed Analysis Area Overview*, provided a description of patterns of historical fires in the Forest. In this section, an overview of the role of floods and windstorms is provided.

Floods

Floods help shape aquatic habitat by impacting channel morphology, sediment transport and deposition, and adjacent stream vegetation. Habitat quality for fish and other aquatic organisms also is formed by the interaction of these elements. Streams in the Forest generally experience floods generated by high rainfall storm events.

The largest flood of record for western Oregon was the flood of 1861, which appeared to exceed a 100-year event (Taylor and Hatton 1999). In 1890, Oregon Coast Range streams again experienced a large flood, the second largest flood of record for the Rogue River. The floods of December and January 1955-1956 were the next recorded large floods for the streams in the region (Weyerhaeuser 1998). For many streams in the Coast Range, the floods of December 1964 were an extreme event, with record river levels on the Umpqua, Coquille, and Rogue Rivers (Taylor and Hatton 1999).

Windstorms

The Forest is in the direct path of large winter storms from the Pacific Ocean. These storms generate high winds, which in turn shape the region's forests by toppling trees, creating canopy opening, and changing vegetative succession. Extreme windstorms hit the Coast Range in 1880, in 1951 when 3.7 billion board feet of timber blew down, and in 1962 when about 3 billion board feet of timber blew down throughout the Coast Range (Ruth and Yoder 1953). Less severe windstorms also can blow down trees along the edges of clearcuts, including riparian buffer areas, which affect downed wood levels across the landscape and in stream channels. For the Coast Range, windstorms severe enough to cause substantial tree uprooting along clearcut edges have occurred in 1971, 1973, 1981, 1983, and February 2002 (Oregon Climate Service 2003).

Of all major windstorms, the Columbus Day storm of 1962 stands alone in its impact on the management of the Forest. The storm's high winds blew down an estimated 100 million board feet of timber (ODF 1993). Most of the downed trees were on the western half of the Forest where few roads were in place. Many miles of roads were quickly built to salvage the timber before it rotted. Nearly one-third of the 550 miles of forest roads were built to get to the downed timber (Phillips 1996).

HUMAN DISTURBANCE

The Coos Bay region is rich in regional histories that provide a good historic overview of the Forest and surrounding areas. Specifically focused on the Forest is past-District Forester Jerry Phillips' *Caulk Boots and Cheese Sandwiches* (1996), which is a primary source of information for this chapter. Additional sources include Dow Beckham's *Swift Flows the River* (1990); Lionel Youst's *Above the Falls: An Oral and Folk History of Upper Glenn Creek, Coos County, Oregon* (1992); Arthur Smyth's *Millicoma: Biography of a Pacific Northwestern Forest* (2000); and William Robbins' *Hard Times in Paradise: Coos Bay, Oregon, 1850-1986* (1988). A timeline of major historical events is shown in Table 3-1.

Early European Settlement

Early settlers generally sought out farmlands in the lower river valleys on the periphery of the Forest. These farms occurred fairly early in the settlement process as immigrants spread out and up rivers. For example, a potato field in the South Fork Coos River bend just below Dellwood was identified in the first General Land Office survey in 1856. Early farms and settlements were also located in uplands in places with flat terrain and plentiful water. Upper Glenn Creek above Golden Falls was one of these; another was the Ash Valley area south of Loon Lake along Lake Creek.

There were only a few early settlements within the interior of the Forest. The Vaughn Ranch, located along the West Fork Millicoma River (T.24S, R.11W, sec 3 and 4) was an early settlement with a farm and sawmill. Further upstream on the West Fork is the Elkhorn Ranch (T.23S, R.11W, sec 26), originally homesteaded in 1910 and subsequently (with the exception of 5 acres) purchased by the ODF.

Table 3-1. Timeline of major historical events.

Year	Event
1850	Fire burns in the middle Coast Range and perhaps some areas within what was to become the Elliott State Forest.
1856	First public land survey.
1868	Some records indicate that a fire burned some areas within what was to become the Elliott State Forest.
1930	Elliott State Forest, formed by land exchanges with the US Forest Service, is officially dedicated.
1940	Coos County deeded 6,500 acres of tax-delinquent forestland adjacent to the Elliott State Forest to the Board of Forestry.
1960	The state acquired 7,700 acres of public domain lands that were added to the Elliott State Forest.
1962	Columbus Day windstorm blew down an estimated 100 million board feet of timber. A large number of roads were built in to salvage the timber.
1972	Passage of the Oregon Forest Practices Act. The Act has been amended several times since its passage.
1970s to 1980s	7,000 acres of Common School Forest Lands were added to the Elliott State Forest by land exchanges.
1990	Spotted owl listed as threatened under the federal Endangered Species Act.
1992	Marbled murrelet listed as threatened under the federal Endangered Species Act.
1995	Adoption of the Elliott State Forest Habitat Conservation Plan.
1998	Coho salmon listed as threatened under the federal Endangered Species Act.

The Cornell Place, located on Palouse Creek (T.23S, R.12W, sec 10), was purchased and added to the Forest after the 1982 flood deposited large amounts of debris onto its fields from upland lands in state ownership. Some other properties on Palouse Creek were purchased in 1983 for the same reason. Phillips (1996) provides a map and descriptions of these and other additions to the original Forest.

Splash Dams

Compared to many other areas on the south-central Oregon Coast, the Elliott State Forest had relatively little historic splash damming activity.

Methods

Information on splash damming was developed through conversations with Jerry Phillips, by review of *Swift Flows the River* (Beckham 1990), which contains a history of splash damming and logging in the Coos region, and reports by the Division of State Lands as part of their river navigability determinations for Mill Creek, West Fork Millicoma River, Marlow Creek, and the East Fork Millicoma River (Farnell 1979, 1981). Supplementary observations about splash damming were found in notes of stream surveys conducted by William O. Saltzman (Oregon Game Commission stream surveyor) in the Mill Creek – Camp Creek watershed (1960), Lower Umpqua tributaries (1961), and West Fork Millicoma River and Coos Bay tributaries (1959).

Results and Discussion

Although documentary history is sparse, only four splash dam sites in or adjacent to the Forest have been identified. Splash dams were outlawed in 1956, prior to the beginning of extensive timber harvests on the Forest. Although they were generally located outside the Forest, they may have impacted stream conditions within the Forest.

Two areas adjacent to the Forest were intensive sites for splash damming. The first area includes three dams located in the Mill Creek hydrologic unit code (HUC) 5^{th} field watershed upstream from state ownership. One splash dam was on Mill Creek just below its confluence with Camp Creek (RM 6.05; T.22S, R.10W, sec 36), while two others were on Camp Creek (RM 3.11; T.22S, R.9W, sec 31 and RM 4.20; T.23S, R.9W, sec 4). According to William Saltzman, "The physical damage to the stream by this method of log transport appears to have been overcome with the passage of time" (1959, p. 33).

The second area for intensive splash damming was on the East Fork Millicoma River and its tributaries, Glenn and Marlow Creeks. According to the Weyerhaeuser Corporation's *East Fork Millicoma River Watershed Analysis* (1995):

> "At least six splash dams were in operation on the East Fork Millicoma between its confluence with Marlow Creek near Allegany and Milepost 26. Other dams existed on the lower Marlow, lower Glenn, and lower Matson Creeks. Many dams were out of service by 1935, and most were burned or removed by 1957."

In addition, at least two splash dams were located on the West Fork Millicoma River system. One was on a tributary stream entering the West Fork just below Pidgeon Falls (T.24S, R.11W, sec 19) and one was below Stulls (Stahls) Falls (T.24S, R.11W, sec 4) at the Vaughn Ranch. No splash dams are known from the Tenmile and Scholfield Creek drainages. Most of the pre-road log transport in these systems (as well as upper Marlow Creek) was done by logging railroad.

Stream Cleaning

Damage caused to streams and rivers by early logging operations (splash dams, slash disposal in streams, log drives, etc.) often resulted in substantial logjams. In some cases, these jams could be a mile or more in length, and undoubtedly prevented or impeded anadromous fish passage. Largely as a result of these spectacular cases, in the 1930s the Oregon Game Commission began to require loggers to prevent woody debris from entering streams. This effort gained more emphasis and a "scientific" veneer after WW II, which coincided with the time when caterpillar tractors became available for use in logging. There is documentary evidence of stream cleaning in the Forest beginning in 1956, and it probably extended into the mid-1980s before being terminated.

Methods

Three sources of information were used to develop this discussion on stream cleaning and its effects. The first is a set of stream surveys that were conducted under the direction of William Saltzman over the study area from 1958-1963. These early surveys were conducted because Saltzman recognized that the areas would undergo significant changes as logging moved throughout the watershed. A second set of stream surveys covered the entire West Fork Millicoma River watershed, and were conducted by a joint effort of the Oregon Fish Commission and the Oregon Game Commission to collect baseline stream information for a proposed dam located just below the confluence with Trout Creek. The Saltzman surveys and the 1963 West Fork Millicoma survey mapped out stream substrate, identified fish species present, and provided detailed information on the location and extent of "obstructions" to fish passage, generally logjams.

Information from the historic stream surveys was placed into a geo-referenced Access database. Information included survey date, location of any logjams (distance upstream from start of survey), size (length upstream, height and width), type of obstruction, bankfull channel width, and any comments found in the original survey notes. Point locations and gravel bed lengths were transferred from the original survey maps (on onion skin paper) by overlaying onto a computer display and on-screen digitizing. Because the original survey maps were drawn at a four-time enlargement of U.S. Geological Survey (USGS) 1:24,000 quadrangle sheets, the survey maps and the digital raster graph site locations corresponded well. Latitude and longitude coordinates for points and start/end locations were identified from the digital raster graphs and transferred to the Access database.

Also, a third set of surveys was available to identify streams cleaned and relative amounts of material removed. They were the work reporting forms prepared by Bob Guyman of the Oregon Game Commission, Fishery Division and were monthly "Form 237 – Stream Clearance Activities" and "Form 350 – Lake and Stream Improvement Record" reports, as well as annual narrative reports by basins (for example, the West Fork Millicoma River) and by partnership (for example, Cooperative Stream Clearance Project with BLM and Menasha, 1973). Guyman's and reports by others cover the period 1965-1975. Additional information in the form of memos and data forms were obtained from files in the ODFW Charleston and Roseburg offices. This information covers the period from 1957-1975.

Results and Discussion

These early stream surveys provide critical information on the amount of large wood in streams prior to the advent of extensive stream cleaning. Since these surveys were conducted before large-scale timber harvests and road building occurred, they present a pre-management baseline for the Forest. Of particular interest is the relationship between logjams and spawning gravel deposition, and survey notations containing descriptions of landslides and debris torrents, falls, and other stream features. Map 3.1, located in the map section, shows the extent of logjams identified in these surveys.

According to documents in their files, in 1956 the Oregon Game Commission became involved in stream cleaning. A memorandum from James W. Vaughn, Supervisor for Southwest Oregon, dated December 5, 1957, provides the regulatory authority to require the removal of debris in streams from logging operations:

> "I have just received from Roy C. Atchison, Assistant Attorney General, the enclosed copy of ORS 164.820 [this law was repealed in 1971], which I feel that we can use in stream cleanup."

The attached statute says:

> "Any person who willfully, wantonly or negligently cuts, falls, throws, or places in any running stream, irrigation ditch, or draining ditch in this state, any tree, brush, log or drift, without forthwith removing the same, shall be punished upon conviction by a fine not less than $50 or more than $500. This section does not apply to saw logs placed in any stream for driving or rafting. Justices' courts shall have jurisdiction of all offenses committed under this section."

While the early stream surveys often called for clearing debris, its removal was effected in two ways. First, the Oregon Game Commission employed a "stream improvement" crew that drove throughout the region identifying "obstructions" and contacting land managers about their removal. This program lasted for 20 years, from about 1956-1976 according to ODFW files. The second tactic was to include stream cleaning, and specifically logging debris removal, in timber sale contracts. While the watershed analysis team has been unable to determine exactly when this practice was initiated, the first note of stream clearance requirements in some sale contracts was in 1962, and it appears to have continued until at least the mid-1980s.

Both kinds of stream cleaning were often done by running bulldozers up and down the stream (this technique also applied to log yarding from the 1950s into the 1970s). Notations on the Form 370's that the ODFW improvement crew produced often identified the number of Cat D6 or D8 hours required for each job (although this also included winching logs out of streams). Without a doubt, stream cleaning had a widespread impact on aquatic habitat and the effects are still seen today in the amounts and distribution of wood in stream channels. Chapter 7, *Riparian Vegetation and Large Wood*, provides an evaluation of the historical and current wood volumes in streams.

EARLY HISTORY OF THE ELLIOTT STATE FOREST

Phillips (1996) provides the definitive history of the Elliott State Forest. This section is based on his work, supplemented by other information from ODF and ODFW files.

Management through Time

Management of the Forest can be characterized by four phases. The first, from the initial establishment of the Forest in 1929 until World War II, was basically custodial in nature.

The boundaries of the Forest were surveyed and blazed, initial timber inventories were conducted, fire towers were built (and trails or jeep roads to reach them), and the first “truck roads” were constructed by the Civilian Conservation Corps (CCC). The second phase, covering from after World War II (little happened during the war years) until the Columbus Day windstorm in October 1962 saw the rise of forest management on the Forest, including the beginning of its timber sale program and the concomitant rise in road construction. The Columbus Day windstorm initiated the third phase of management, accelerating the timber sale program to salvage blowdown from the storm, and accelerated (and essentially completed) the road-building program to accomplish these sales. The fourth phase began with the listing of the northern spotted owl as a threatened species under the federal ESA in 1990 and the development of the 1995 HCP.

Harvest Programs

The history of harvest programs in the Forest reflects the four management phases described above. The first timber sale was in 1945 in the Ash Valley and Mill Creek areas. Sales during the initial post-World War II period were set up adjacent to existing roads and in proximity to lumber mills. Beginning in 1955, timber sales accelerated when the Oregon Legislature directed that active management of the Forest begin, and the ODF established a local office in Coos Bay. With the beginning of active forest management, the Board of Forestry established a set of priorities for management activities. These priorities were: (1) salvage insect-killed, fire-killed, or blowdown timber; (2) sell over-mature timber generally more than 170 years of age; (3) sell mature stands of between 90-170 years old; and (4) conduct thinnings of immature stands. Accompanying the timber sale prioritization was the requirement that any road building would be done by timber sale purchasers and would be directly related to the sale (see discussion in next section). This policy resulted in a slow increase in timber sales throughout the late 1950s until 1962. Timber harvests (and the Allowable Annual Cut) during this period started at 36 million board feet (MMBF) and were raised to 44.6 MMBF in 1960.

The 1962 Columbus Day windstorm brought with it 100 million feet of blowdown on the Forest. To salvage this blowdown, another 200 million feet of green timber had to be logged. Salvage continued until 1966 and along with the green trees, constituted an annual sale volume of about 100 MMBF. Beginning in 1958, the ODF initiated its first “stand management” or thinning program of partial cuts instead of its usual clearcuts. The objective in these harvests was to remove the slower-growing conifers, defective trees, and any alders in 75- to 125-year-old stands by “thinning from below,” leaving the larger, residual trees for harvest at the end (rather than the beginning) of their rotation age. This program lasted until 1978 and covered 15,000 acres of the Forest. In 1968, the basis for the Annual Allowable Cut was changed from “volume control with an acreage limit” to “acreage control with a volume limit.” The initial annual target was set at 1,300 acres per year, even though the desired rotation age was 100 years (90 years during the late 1950s to accelerate road building). The timber harvest program became more complex in the 1970s and early 1980s as additional scenic restrictions, high landslide risk assessments, and wildlife clearances for northern spotted owls and marbled murrelets were required.

In 1990, the listing of the northern spotted owl as a federally threatened species initiated the current period of forest management. Timber sales dropped from their annual level of 40 to 50 MMBF to the point where *no* sales were held in 1991. The ODF spent the next 4 years developing the 1995 HCP for spotted owls and marbled murrelets that allowed for incidental take of these species (murrelets only until 2001) to occur during forest management operations. In exchange, the Forest was zoned into long-rotation basins of 160 or more years and short-rotation basins of 80+ and 135+ years. In addition, Habitat Conservancy Areas (HCAs) constituting the best northern spotted owl habitat were established, as were Marbled Murrelet Management Areas (MMMAs) to protect this species. The specifics of these management allocations are discussed in more detail in Chapter 9, *Terrestrial Wildlife*. In terms of the timber management program, the effect was to reduce the annual clearcut sales target to 460 acres with an expected volume of 22 to 25 MMBF. The thinning target is 500 acres per year with an expected volume of 3 MMBF.

Road Building

The early road network in the Forest is shown on Map 3.2. Road building in the Forest fits well into the four management phases described earlier in this section. The first, from the initial establishment of the Forest in 1929 until World War II, was basically custodial in nature with the first "truck roads" constructed by the CCC. After World War II, the second phase saw a rise in road construction concomitant with beginning forest management. The 1962 Columbus Day windstorm initiated the third phase by accelerating the road-building program to accomplish timber salvage harvests. The fourth and "modern" phase began in about 1975 after completion of roads to access windstorm salvage and continues in the present. It involves completing roads into areas where salvage was not conducted, extending spur roads to access individual timber harvest sites, and upgrading roads and culverts to improve their performance.

Methods

The primary source used for historical information on road building was Jerry Phillip's *Caulk Boots and Cheese Sandwiches* (1996). Additional information was obtained through discussions with James McIntosh, District Engineer. Forest staff is currently compiling a road atlas that includes the construction year for all Forest roads. This information was not available to incorporate into this analysis.

Results and Discussion

During the custodial period from 1929-1941, the only roads built were ones constructed by the CCC (Map 3.2). The primary one was the Scholfield Ridge (5000) and Umpcoos Road (7000). This road began from the county road that went from Scottsburg over to Glenn Creek and then down to Allegany. In 1933, the CCC began road construction from the vicinity of Lake Creek in Ash Valley (T.23S, R.10W, sec 27). The next year, the CCC camp was moved to Scholfield Creek (Camp Walker) where construction began from that end. The Scholfield/Umpcoos Road was tied together in 1935. Another CCC road, heading south at the junction of the 5000 and 2000 Roads towards Trail Butte, was built in 1935 and extended 5.5 miles along what is now the 2000 Road. The final road built by the CCC was the upper portion of the Elk Ridge Road (1000), extending only about 0.5 miles from that portion of the Umpcoos Road. The primary purpose of these roads was to access fire towers at Dean Mountain, Cougar Pass, Elk Peak, and Trail Butte.

The second phase of road building began after World War II and initially focused on accessing the first timber sales on the eastern edge of the Forest in Ash Valley and along Mill Creek. Small amounts of road building occurred in 1945 along the 1000 Road from Ash Valley to its junction with the 1850 Road, and along the lower part of the 7700 Road up from Mill Creek. As discussed previously, the first large increase in road building occurred in concert with timber sales beginning in 1955. The Unit Forester at the time, Bob Mounteer, determined that the only strategy to road the Forest for management purposes was to have timber purchasers pay for the roads, per Board of Forestry policy. This strategy led to identifying timber sales that would meet the priority scheme, while at the same time extending the existing road network.

As a result, during this period virtually no road building was conducted in the western half of the Forest where stands were about 70 years of age (in 1955). Roads were generally extended from existing ones and accessed old-growth timber. Tie roads also were built in the interest of providing transport to different purchasing areas, such as Reedsport for the Dean Mountain Road, Lakeside for the Benson Ridge Road (built in 1963), and Coos Bay for the Trail Butte Road. The Cougar Pass Road (7700) initially started in 1945 was finally completed in 1956. The Footlog Creek Road (7500) initially started in 1954 as a result of an Indian allotment sale, and then was extended in 1959 for the Footlog Creek No. 1 timber sale. The Elk Ridge Road (1000) was the first joint road development project (with Weyerhaeuser) that started in 1957 and was completed in 1960. The Trout Creek/Beaver Creek Road (2300) was completed in 1961 to tie together the Trail Butte (3000) and Elk Ridge (1000) roads. Finally in 1961, 3 miles of the Elk Creek Road (9000) was started, beginning at the south end junction with the 1000 Road. During the 7-year period from the start of Forest management until the Columbus Day windstorm, about 65 miles of standard (16-foot width) road and 78 miles of lower standard (14-foot width) road were built, with almost 104 miles built from 1960-1962.

The Columbus Day windstorm, and the resulting timber salvage harvesting, accelerated the extent of road building in the Forest and changed its nature as well. An estimated 150 miles of new roads were needed to access the sale areas. These roads were called “wood construction” and generally were below prior standards, with little engineering. Only the center lines and culvert locations were flagged. Construction involved a lot of side-cast, no surfacing or ditches, and a minimal 14-foot width.

In 1966, the policy of only building roads into timber sales was relaxed. This allowed the Forest to begin upgrading some of the roads built earlier, especially during the salvage program. This involved surfacing the road, building ditches, and upgrading bridges from log stringers to concrete. Although the first concrete bridge on the Forest was built over the West Fork Millicoma River for the 2300 Road, since 1966 concrete bridges (or abutments) were used more commonly and included three on the 8000 Road from the mouth of Joe’s Creek to Elk Creek. By 1968, with the surfacing of the upper portion of the West Fork

Millicoma Road (2000), the all-weather road system on the Forest was essentially completed. Although the building of spur roads to reach individual sales continued and existing roads were either upgraded or maintained, the era of new road construction on the Forest essentially ended. The year 1968 also was significant because the Forest began a single road maintenance contract instead of having each purchaser perform maintenance on the Forest roads they used. This system continues to this day.

Other Management and Policy Changes

Beginning in 1963, the first riparian buffer strips were left in timber harvest areas, initially only on one side of the stream. In 1968, buffer strips were left on both sides of the stream, which averaged about 8-10 thousand board feet of commercial sized fir if the stand was 70-80 years of age. The first sale with a 100-foot riparian buffer strip on both sides of a stream was on the Alder Fork of Big Creek, a tributary to North Tenmile Lake. The ODFW requested the 100-foot riparian buffer strip.

A "Land Use Zoning and Classification" system began on the Forest in 1970. Lands were zoned as *scenic* corridors (State Highway 38, Loon Lake, Mill Creek County Road), *limited* production (above domestic water supplies), and *regular* production. Stream classification mapping and testing also began in 1970. This mapping was terminated in a few years when the ODFW determined there were no problems in the Forest's streams (Phillips 1996). By 1984, "high risk" areas with the potential for landslides were being identified in timber sale areas.

Chapter 4. Stream Flow and Water Quantity

STREAMFLOW CHARACTERISTICS

Water Yield and Peak Flows

The influence of timber harvest and roads on the timing and quantity of stream flow has received considerable attention during the last decades. Studies show that clearcut harvesting usually *increases* the summer flow of streams because of the absence of vegetation that had previously transpired water from the soil and intercepted rainfall. For example, a paired-watershed study of small drainages in the central Coast Range showed that annual minimum streamflow increased about 60% following complete clearcut harvest and broadcast burning of a small drainage (Harr and Krygier 1972). Minimum streamflow gradually dropped to pre-harvest levels as trees and brush grew back (about 15 years). Another nearby small watershed, this one 25% clearcut, showed little change in summer streamflow. Similarly, the complete clearcut harvest of one small watershed and the shelterwood harvest of 60% of another small watershed in the northern Cascades resulted in fewer low-flow days after logging (Harr et al. 1982). Further south in the central Cascades, August water yield increased an average of nearly 60% following clearcut harvest and burning of about one-quarter of a small watershed and then returned to normal levels as the watershed revegetated (Hicks et al. 1991). For a watershed in northwest California where 67% of the timber had been removed, the number of low-flow days over the summer decreased an average of 40% (Keppeler and Ziemer 1990).

In some studies, the peak flows of small streams during the rainy season have been shown to increase following complete clearcutting and intensive broadcast burning (Harr et al. 1975). Most other studies on watersheds, where no or less-intensive burning followed clearcutting or where they were in different climates, showed no meaningful increases in peak flows (Harr et al. 1982, Wright et al. 1990, Thomas and Megahan 1998). Where they occur, peak flow increases are associated with lesser recurrence intervals (i.e., less than average annual peak flow) and not for large floods (Beschta et al. 2000). Increases in peak flow for small, headwater basins do not necessarily translate to similar increases in larger streams. This is because peak flow increases in small basins become muted in a downstream direction since not all small streams throughout a watershed peak at once, and rarely are all small basins in a watershed harvested at once (Duncan 1986, Perkins 1997).

The only gauging site within or near the Forest with a record long enough to sufficiently evaluate stream flow characteristics is in the lower West Fork Millicoma River. No gauging information on basins of similar size, which experienced little or no timber harvest during the last 30 years, exists for the central or southern Oregon Coast. Consequently, there was not a control watershed that would allow examination of how flows in the West Fork Millicoma may have changed over several decades of road construction and timber harvest.

The West Fork Millicoma River gauging site was operated by the USGS from 1955-1981 (27 years of record) and was reactivated by the Coos Watershed Association in 2002. Only the 1955-1981 flow records are used in this analysis. Nearly all of the land upstream of the West Fork Millicoma River gauge is within the Forest [46.9 square miles (sq. mi.)] and precipitation in this basin is typical of the Forest. Streams flowing from the western edge of the Forest may have slightly different flow characteristics; summer flows in these streams may not be as low due to their proximity to moist, marine air and diminished solar radiation due to persistent fog. Water withdrawals upstream of the gauging site were either small or non-existent during the period of record. The gauge is located near the boundary between the Forest and private ownership.

Monthly and annual instantaneous peak flow data [reported as cubic feet per second (cfs)] for the West Fork Millicoma River were obtained from the USGS web site. Because the annual peak flow value for water year 1980 seemed erroneously low in the digital record (115 cfs vs. 1,830 cfs for the next highest value), this year was not used in the analysis of peak flows. The log-Pearson Type III distribution of extreme events was used to evaluate peak flows associated with various recurrence intervals. The skew was determined from the flow record rather than using published regional values.

Streams in the Forest experience a period of extended low flow from June through September. The average flow in December, the month with the highest runoff, was 65 times greater than the average flow in August, the month with the lowest runoff (Figure 4-1). The flow in West Fork Millicoma River during August averaged 10 cfs, but during droughty summers (1958, 1966, 1967, 1970, 1972), August monthly flows dipped to nearly 3 cfs (Figure 4-2).

Figure 4-1. Average monthly flows for the West Fork Millicoma River.

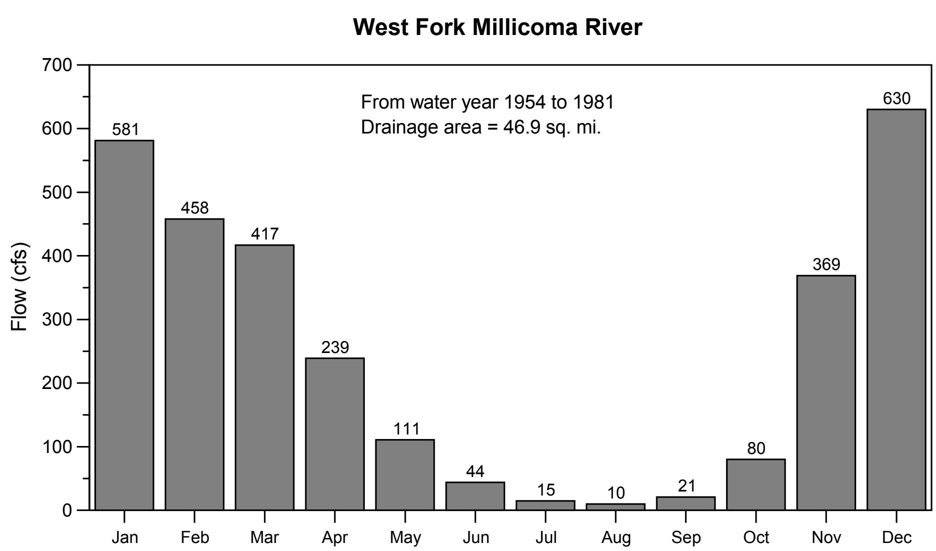
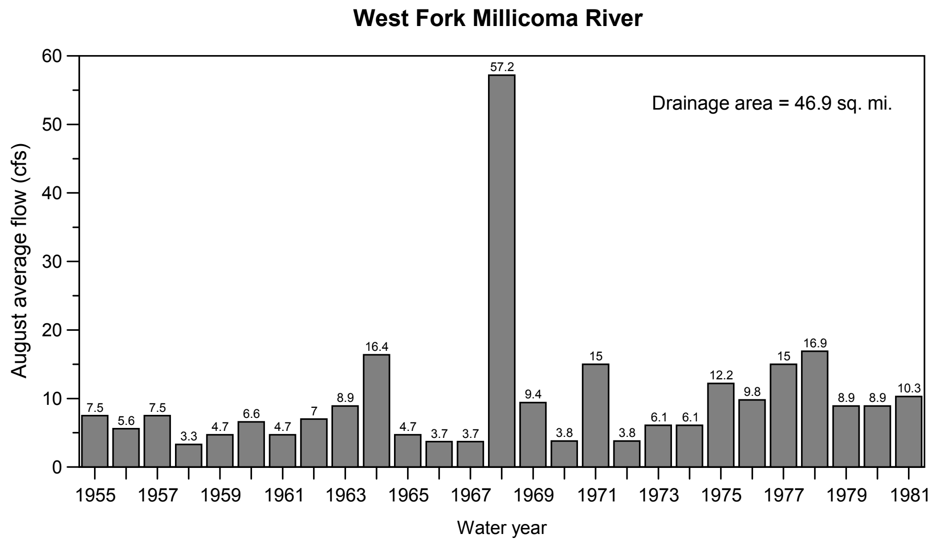
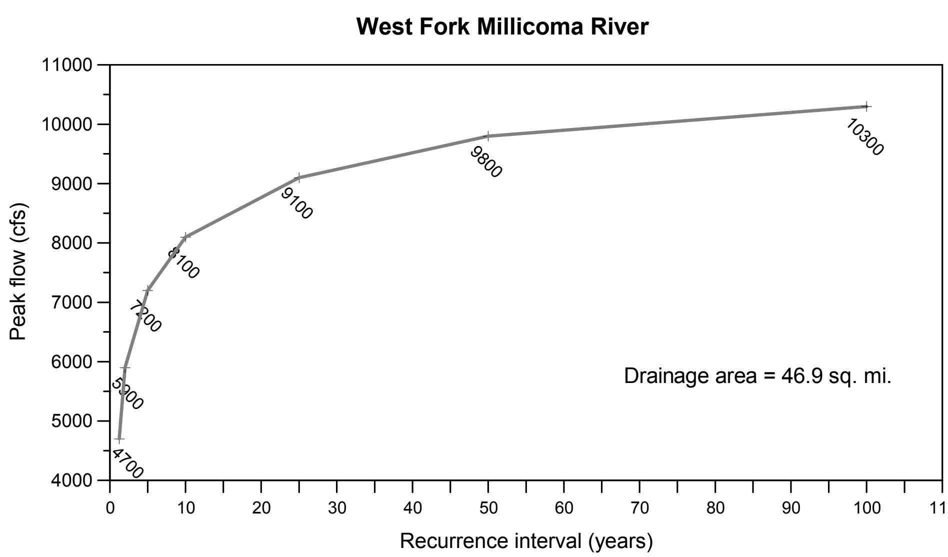


Figure 4-2. Average August flows for the West Fork Millicoma River, 1955-1981.



The peak flow associated with the 50-year recurrence interval was 9,800 cfs or a unit flow of 208 cfs per square mile of drainage area for the West Fork Millicoma River (Figure 4-3). This is typical for lower elevation mountains of the central Coast Range and agrees with the 50-year unit flow map that was prepared in 1994 by the ODF. Map 4.1, located in the map section, shows the 50-year peak flow values for streams in the study area.

Figure 4-3. Relationship between peak flow and recurrence interval, West Fork Millicoma River.



No peak flow events in the West Fork Millicoma River record stand out as unusually high. Even the floods in 1972 and 1965, abnormally high events elsewhere in western Oregon, were not unusually high in the West Fork Millicoma River record. As a result, the curve defining peak flow and recurrence interval is oddly flat at recurrence intervals greater than 10 years. The flow associated with the 100-year recurrence interval is only 13% greater than the flow associated with the 25-year recurrence interval. An analysis of streams with long-term records elsewhere in the Coast Range indicates that the magnitude of the 100-year recurrence interval flow averages 38% greater than the 25-year recurrence interval flow. The stage/rating curve for the West Fork Millicoma River may have been incorrect for the highest of flows.

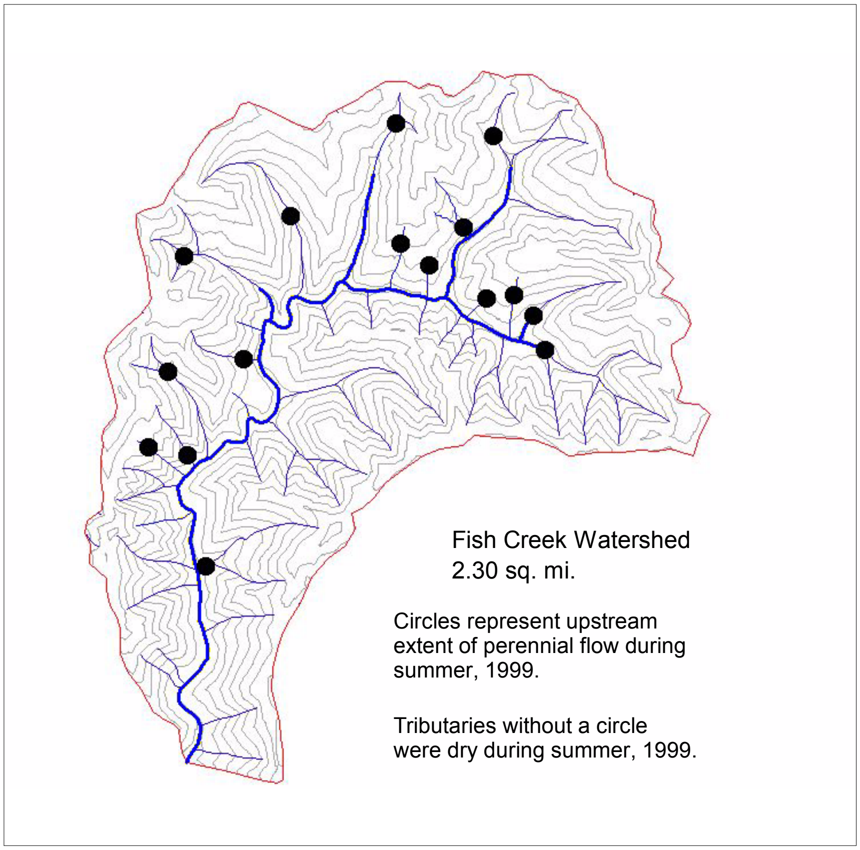
Perennial and Intermittent Flow

The determination of which stream segments have water and which are dry during the summer has had special importance for Forest staff because buffers of large trees have been retained along perennial streams but not seasonal streams. When a timber harvest unit was planned, the absence or presence of summer flow needed to be checked during the summer to determine its status. Large-scale planning of timber harvest units and evaluation of alternative stream protection measures were hampered by the inability to estimate in advance whether or not streams were perennial. This section summarizes the results of a study conducted by Forest staff to determine whether or not perennial streams can be identified by using simple measures such as drainage area, aspect, and distance from the drainage divide.

The Fish Creek watershed was selected for study. It is located in the upper one-half of the West Fork Millicoma River watershed and drains to the south. Fish Creek has a drainage area of 2.3 square miles and its conditions are typical for the Forest. The watershed contains 38 tributaries or draws that feed directly into fish-bearing streams (Figure 4-4). Many of these 38 channels have tributaries to them. Field surveys in July 1999 provided information on where the most upstream extent of perennial flow in the watershed. The watershed area and distance from divide were determined from topographic maps for each tributary at the most upstream extent of perennial flow and for tributaries with no flow.

No association between drainage area and upstream extent of perennial flow was found for the Fish Creek watershed (Figure 4-4). The same was true for the distance from drainage divide. Only one tributary in the southeast one-third of the watershed had perennial flow. The scarcity of summer flow in this part of the watershed may be due to the low elevation and generally west aspect. While much of the upper portion of the basin also faces towards the sun during the hottest part of the day, the high ridge forming the upper basin boundary may be an enhanced source of groundwater. There was no pattern between stand age and where tributaries were perennial.

Figure 4-4. Upstream extent of perennial flow in the Fish Creek watershed, July 1999.



There was perennial flow within some tributaries that had only a few acres of drainage area, as measured from topographic maps. Therefore, groundwater movement in this geology may not necessarily be associated with surface topography. Field observations indicate that water often surfaces at boundaries between sandstone beds where relatively porous siltstone is found. If much of the summer groundwater is carried along these weak layers, even a slight dipping in the strata may transfer flow from one topographic basin to the next.

Results from the Fish Creek study suggest that easy and reliable means do not exist to remotely predict whether or not a tributary has summer flow. The current practice of verifying the presence of water in small streams by field survey is probably the only practical solution.

CONSUMPTIVE WATER USES

Adjacent landowners commonly use water from streams flowing from forestland for irrigation, domestic use, and the filling of ponds. Some landowners may have water rights issued by the Oregon Water Resources Department (WRD) and others may use the water illegally. The enforcement of water use laws in Oregon is mostly complaint driven and illegal uses are rarely discovered until there is a complaint laying claim to the water. In addition to a water use permit, a deed of water conveyance is required wherever the point of diversion is not on the same property as the user. This deed provides proof that an arrangement has been made with any adjacent landowners to convey water across their land from its extraction point to the place of use. Oregon water law also has a provision that for most water rights, the right expires if it is not used for any five consecutive years. Again, enforcement of this provision is complaint-driven and unused water rights may languish for decades without being cancelled. In this section, the analysis team explores the spatial pattern of surface water rights and the location of dwellings adjacent to the Forest, in order to better understand the magnitude of potential conflicts over water quantity and use between the Forest and its neighbors.

All buildings near the Forest boundary were mapped using USGS 7.5 minute topographic maps. Most of the maps covering the Forest were updated in 1985, although the map covering the southwest corner dated to 1971. The mapped buildings were limited to those within a half-mile downstream of the boundary and close enough to a stream channel that extraction of water via gravity was an option. Aerial photographs from 2002 were used to add new buildings constructed since the topographic maps were created, and delete buildings from lands that have come into Forest ownership since that time.

Barns and out-buildings were excluded as much as possible. This was often difficult since trailer houses often can be indistinguishable from out-buildings. In addition, many rural houses are small or disguised by trees. The pattern of driveways and other roads sometimes allowed distinguishing houses from barns and out-buildings in the aerial photographs.

Water right locations and information were obtained from the WRD and points of diversion were plotted. No attempt was made to match individual domestic water use permits with individual houses because this requires looking up detailed records for each permit, and water rights location information is usually incomplete for older rights.

There are 141 dwellings within one-half mile of the Forest boundary that could potentially receive surface water from streams exiting the Forest. Within this same zone, 167 surface water rights exist for purposes of domestic use, irrigation, and pond filling. Most diversion points are outside of the Forest, although the coarseness at which some diversion points are mapped makes it difficult to determine the exact location of many of the rights.

Houses within one-half mile of the Forest are often clumped along terraces in the valley bottoms. The locations of water permits for domestic use and irrigation generally correspond with locations of houses (see Map 4.2). Nevertheless, some individual houses or groups of houses are far from a surface water right extraction point. Some of these houses may have an alternative water source. Houses along the broad terraces of the two large rivers (West Fork Millicoma River, Mill Creek) may be able to get water from wells. Also, many of the houses along the Umpqua River are probably served by a community water system. Houses with no nearby surface water permit and no obvious alternative sources of domestic water occur on the west and east fringes of the Forest.

Because of incomplete information on water rights and individual house locations, it was not possible to make a detailed accounting of where water flowing from the Forest was being used by neighboring landowners. In general, individual water rights were small (usually a maximum use rate of 0.01 cfs or less), with only several larger water rights issued for purposes of irrigation.

The number of households along the Forest fringe that use water from streams and springs is relatively high along the east and west boundaries. These are not areas with much current timber harvest activity since the western slopes are designated as long rotation basins and the timber along the eastern boundary is still relatively young. Nevertheless, there are inherent conflicts with future timber harvest and downstream use of water for domestic purposes. Short-term increases in turbidity following road building or timber harvest can occur and make drinking water unusable or distasteful, especially considering that many rural households have rudimentary or non-existent water treatment systems. Water diversion structures and surface pipes can get crushed when trees are felled in harvest units. In addition, there are real and perceived issues concerning human health when herbicides are applied within drainages that are also used for domestic water.

The Forest is legally allowed to deny use of water from a stream or spring by a neighbor if the diversion point is on Forest property and the neighbor has no deed of conveyance or water right. Nevertheless, the long-term custom of forest landowners in the Coast Range is to avoid unnecessary conflict over water uses. Short of a detailed and comprehensive field study on neighboring residents and their source of domestic water, the Forest likely will need to resolve any potential water use problems on a case-by-case basis.

WATER USE BY THE ELLIOTT STATE FOREST

Water is used on managed forestland for fighting fire and to provide a source for filling herbicide application tanks and dust abatement trucks. Typically, small dams or road fills are constructed to pond water in areas with springs and small tributaries, or water is extracted directly from larger streams. Collectively, these are referred to as pump chances. Water use permits issued by the WRD are required for the storage and use of water for these purposes. Each point of diversion is assigned a maximum storage rate (in acre-feet) or use rate (in cfs), although the actual consumption of water for forest management is invariably small and infrequent.

A recent inventory throughout the Forest indicates that 115 pump chances exist. Only 17 of these pump chances have a water use permit or certificate issued by the WRD (Table 4-1). Filing for permits for the remaining pump chances involves hiring a water rights examiner to map and document the water use. Nearly all streams on the Forest are closed to further water allocation due to instream water rights (see next section); however, since pump chances involve little actual consumption of water, they may be approved by the WRD. Since pump chances are often heavily used by wildlife, especially amphibians, a water use permit application that includes both forest management and wildlife purposes may increase the likelihood of approval.

Table 4-1. Elliott State Forest water rights.

ID#, Priority Date, Use	Name	Maximum Storage or Use	Location
#69165 1/1/1993 Forest Management	Scholfield Ridge Reservoir	0.21 acre-ft	NW1/4 SW1/4 SEC35, T22S, R11W
	Bickford Ridge Reservoir	0.46 acre-ft	SE1/4 SW1/4 SEC22, T23S, R10W
	Footlog Ridge Reservoir	0.18 acre-ft	NE1/4 SW1/4 SEC22, T22S, R10W
	Salander Creek Reservoir	0.97 acre-ft	NW1/4 NE1/4, SEC10, T23S, R10W
#69166 1/1/1993 Forest Management	Big Saddle Reservoir	0.13 acre-ft	SEC6, T24S, R10W
	Beaver Point Reservoir	0.09 acre-ft	SEC2, T24S, R11W
	Trail Buhe Reservoir	0.58 acre-ft	NE1/4 SW1/4, SEC8, T24S, R11W
	Elk Wallow Reservoir	0.57 acre-ft	SW1/4 SW1/4, SEC25, T22S, R11W
	Elk Peak Reservoir	0.06 acre-ft	NW1/4 SE1/4, SEC29, T23S, R10W
	Elkhorn Ridge Reservoir	0.15 acre-ft	NE1/4 SW1/4, SEC24, T23S, R11W
#S53234 6/10/1994 Forest Management	Scholfield Creek	0.7 cfs	NW1/4 SW1/4, SEC35, T22S, R11W
	Mill Creek	0.7 cfs	NE1/4 SW1/4, SEC22, T22S, R10W
	Unnamed trib. to Matson Creek	0.7 cfs	SE1/4 SW1/4, SEC22, T23S, R10W
	Unnamed trib. to Salander Creek	0.7 cfs	NW1/4 NE1/4, SEC10, T23S, R10W
#S53235 6/10/1994 Forest Management*	Unnamed trib. to W. Fk. Millicoma R	0.7 cfs	SEC2, T24S, R11W
	Schumacher Creek	0.7 cfs	NE1/4 SW1/4, SEC8, T24S, R11W
	Elk Creek	0.7 cfs	NE1/4 SW1/4, SEC24, T23S, R11W

* Also recreation and wildlife

INSTREAM WATER RIGHTS

Instream water rights exist on 23 streams that flow partially or completely across the Elliott State Forest (Map 4.3, Table 4-2). Instream water rights are used to retain water within streams to benefit fish and other aquatic life. Most of the larger fish-bearing streams on the Forest have instream water rights. These rights were granted to the ODFW from 1974-1992. As is true for all other types of water rights, instream water rights have priority dates and are superceded by more senior water rights. Since most of the instream water rights were granted in 1990 and 1992, older consumptive water rights usually control the amount of water in streams during the summer. Nevertheless, the existence of instream water rights on these streams has largely prevented any further allocation of water, especially during the summer. However, the WRD can continue to grant domestic water rights (usually less than 0.01 cfs) for streams that are otherwise closed to further allocation.

Table 4-2. Instream water rights for streams partially or completely within the Forest.

Region	Stream	Priority Date	Minimum cfs in Fall	Minimum cfs in Winter	Location of Instream Right
Tenmile	Wilkins	1992	0.2	13.9	from headwaters (NWSW sec 25, T.22S, R.12W) to mouth
Tenmile	Murphy	1992	0.5	17.0	from headwaters (SWSW sec 29, T.22S, R.11W) to mouth
Tenmile	Big	1992	2.1	26.0	from tributary (NWNW sec 4, T.23S, R.11W) to mouth
Tenmile	Noble	1992	0.5	12.0	from headwaters (SWNE sec 8, T.23S, R11W) to mouth
Tenmile	Benson	1992	1.3	60.4	from tributary (NE1/4 sec 16, T.23S, R.11W) to mouth
Tenmile	Roberts*	1992	1.1	17.0	from tributary (NWSW sec 21, T.23S, R.11W) to mouth
Tenmile	Johnson	1992	2.8	17.0	from tributary (SESW sec 31, T.23S, R.11W) to mouth
Tenmile	Robertson	1992	0.1	3.8	from headwaters (NE1/4 sec 35, T.23S, R.12W) to mouth
Tenmile	Adams	1992	0.5	9.0	from tributary (SESE sec 28, T.23S, R.12W) to mouth
Coos	Palouse**	1990	1.5	26.0	from tributary (SWNW sec 10, T.24S, R.12W) to mouth
Coos	Larson	1990	1.5	26.0	from Sullivan Creek to mouth
Coos	Sullivan	1992	0.3	14.0	from headwaters (SE1/4 sec 23, T.24S, R.12W) to mouth
Coos	W.F. Millicoma (upper)	1990	3.1	100.0	from headwaters (sec. 16, T.23S, R.10W) to Deer Cr
Coos	W.F. Millicoma (lower)	1990	7.1	155.0	from Deer Creek to mouth
Coos	Deer	1992	0.5	26.0	from tributary (SE1/4 sec 2, T.23S, R.11W) to mouth
Coos	Knife	1992	0.4	17.0	from tributary (SE1/4 sec 31, T.22S, R.10W to mouth
Coos	Fish	1992	0.3	17.0	from headwaters (NE1/4 sec 5, T.23S, R.10W) to mouth
Coos	Elk	1992	1.0	43.0	from tributary (SE1/4, sec 24, T.23S, R.11W) to mouth
Coos	Marlow	1992	0.7	31.7	from tributary (NW1/4, sec 23, T.24S, R.11W) to mouth
Coos	Glenn	1992	2.1	85.0	from Silver Creek to mouth
Umpqua	Mill	1974	20.0	130.0	from Camp Creek to mouth
Umpqua	Dean	1974	2.0	20.0	from Hakki Creek to mouth
Umpqua	Scholfield	1974	2.0	20.0	from Oar Creek to mouth

*Roberts Creek also has an instream water right with a priority date of 1980; it applies throughout its main channel and tributaries. The amounts are 1 cfs in the fall to 10 cfs in the winter.

**Palouse Creek also has an instream water right with a priority date of 1980; it applies to a point near the mouth at tidewater (sec 25, T.24S, R.13W). The amounts are 2 cfs in the fall to 15 cfs in the winter.

Mill, Dean, and Scholfield Creeks have instream water rights with a priority date of 1974, while instream water rights for Roberts and Palouse Creeks date to 1980. These latter two streams also have 1990 or 1992 instream rights that are only slightly different than the 1980 versions. All other instream water rights date to 1990 or 1992. The permits specify minimum streamflow to be maintained in the stream (after satisfying all other senior rights) and these vary by month, with higher flows in the winter and lower flows in the summer and fall (Table 4-2). Like all other water rights, enforcement of instream water rights is largely complaint driven. The WRD has no program to determine the summer flow of streams on the Forest or ensure that junior water rights do not infringe on the maintenance of instream flows downstream of the Forest.

ANALYSIS

Summer Flow

Research on Pacific Northwest streams indicates that clearcut harvesting increases summer flows rather than decreases flow. Since summer base flows in Pacific Northwest streams are naturally low due to a scarcity of rain from June to September, increases in summer flow due to tree removal can be viewed as a benefit to fish and aquatic amphibians. The extra flow provides more living space for aquatic animals and the greater water depth helps moderate temperature increases. Since the increases in flow are not enough to create measurable increases in water velocity, aquatic animals are not negatively affected. Timber harvesting can have other influences on streams that could counteract the benefits of more water in the stream during summer.

Peak Flow

Research on Pacific Northwest streams indicates that increases in peak flows due to clearcut harvest and road building are minor for lower-elevation terrain and where harvest units do not experience hot broadcast burns. Increases in peak flow, where they do occur, are limited to minor runoff events; the magnitude of large floods is not affected. Any measurable increases in peak flow due to clearcut harvest and road building occur only in very small watersheds. In larger streams, the contributions from smaller subwatersheds, some of which may have increased peak flows and some with intact timber, results in a muted response since the timing of the maximum flow for the various subwatersheds is rarely synchronized for any given storm. Furthermore, any increase in peak flow due to clearcut harvesting is short-lived (less than 15 years) due to regrowth of brush and trees.

Seasonal Flow

The ODF pilot study to remotely identify perennial streams in the Fish Creek watershed indicates that predicting which stream segments have water during the summer is not possible using readily available information such as watershed area, aspect, vegetation, or distance from drainage divide. Sedimentary deposits on the Forest, consisting of thick blocks of non-porous sandstone separated by thin layers of porous siltstone, result in groundwater movement that does not necessarily correspond to topographic features.

Consumptive Water Uses

Water rights for consumptive uses of water are common (167 diversion points) along the fringe of the Forest, as are dwellings (141) located within one-half mile of its boundary. Inaccuracies in the mapping of points of diversion for each water right and uncertainty about which water right corresponds to which dwelling prevents the construction of a water use budget for each stream flowing from the Forest. Nevertheless, water use is generally small and limited to domestic use and the irrigation of scattered parcels of pastureland.

Without a detailed field investigation of individual water rights, it is not possible to determine where water diversions occur on the Forest. However, Map 4.2 suggests that most water diversions occur downstream of the Forest boundary. Although some illegal water diversions probably exist along the Forest fringe, few have been encountered by ODF over the last decades due, in part, to a general lack of timber harvest activity along the fringe.

Water diversions from streams and springs within the Forest boundary, both legal and illegal, create a challenge for Forest staff. The planning of timber harvest units near the Forest boundary is complicated by the need to protect water diversion infrastructure for legal water uses and by public relations challenges encountered when dealing with people who have illegal diversions.

Water Use by the Elliott State Forest

Currently, only 17 of 115 pump chances on the Forest have a water use permit or certificate issued by the WRD. A permit or certificate is required for each pump chance. The process of obtaining permits for the remaining pump chances involves some expense because a water rights examiner must be hired and the fees charged for each application. Also, approval of these applications may be complicated by the existence of instream water rights that may prevent further water allocation on most Forest streams.

Instream Water Rights

Most of the larger fish-bearing streams on the Forest have instream water rights. However, these rights have relatively recent priority dates. This means that actual flow levels in streams are controlled mostly by the more senior rights associated with consumptive uses. Nevertheless, the instream water rights eliminate further allocation of water for the low flow season, except for small domestic uses (0.01 cfs or less). As is true throughout the state, the measurement of summer stream flows and enforcement of instream water rights occurs infrequently, and will probably remain so because of limited staff within the WRD.

Recommended Actions and Monitoring

Summer Flow

The analysis team has no recommended actions or monitoring suggestions on the issue of summer flow increases from timber harvest because such increases in flows are a benefit to fish and aquatic amphibians.

Peak Flow

The analysis team has no recommended actions or monitoring suggestions on the issue of peak flow increases from timber harvest and road construction because: (1) increases are not likely to occur; (2) any increases that do occur are minor considering the climatic conditions on the Forest; and (3) hot broadcast burning does not occur on the Forest.

Seasonal Flow

The analysis team recommends that any further efforts to predict summer flow patterns throughout the Forest be suspended since the pilot study on Fish Creek suggests that little understanding can be gained using readily available parameters such as watershed area, distance from drainage divide, vegetation, and aspect. Instead, the analysis team recommends that the current practice of verifying the presence of water in small streams by field survey be continued. No monitoring is recommended other than documenting the results of summer field investigations of streams within proposed timber harvest units.

Consumptive Water Uses

The analysis team recommends that the current practice of using field investigations to determine the presence of legal and illegal water diversions on proposed harvest units be continued. There does not seem to be a need for a detailed Forest-wide evaluation of water diversions along the Forest fringe.

Forest staff could consider working with the WRD to set up a well-publicized effort to convert any illegal water diversions within the Forest boundary to legal uses. Since most of these diversions are probably for domestic uses and involve only small amounts of water use (less than 0.01 cfs), there would likely be little problem in granting these water rights even though senior water rights exist and often result in an over-appropriation of water. As water uses are discovered on the Forest, staff should insist (as required by Oregon water law) that the user file for a deed of water conveyance with the WRD, if none already exists. Also, Forest staff could consider refusing any new deeds of water conveyance where the point of water occurs on the Forest, and instead encourage those who are requesting a water right to locate the diversion point downstream of the Forest boundary. This would simplify the process of planning for future harvest units along the Forest fringe and relieve the need to protect water diversion infrastructure during timber harvesting.

Pump Chances

The analysis team recommends that the ODF obtain water use permits/certificates from the WRD for the 98 pump chances that do not have a permit/certificate.

Instream Water Rights

The analysis team has no recommended actions or monitoring suggestions on the issue of instream water rights. The measurement of streamflow and enforcement of water use lies with the WRD.

Chapter 5. Water Quality

WATER TEMPERATURE

When groundwater enters into a stream channel, its temperature is immediately influenced by the new surroundings. Solar radiation striking the water surface and heat exchange with the air result in warming. To some extent, this warming is offset by heat lost to the channel substrate, by water evaporating, and by vegetation intercepting the solar radiation. The subsurface component of stream flow, that portion which meanders under the stream substrate, experiences a somewhat different energy exchange. Most notable is the lack of solar radiation input and heat exchange with the air. Consequently, the subsurface component of flow is usually cooler than the surface flow, and where the two intermix (such as in a deep pool), the net result is a cooling of the aboveground component of stream flow. The subsurface component of stream flow does not exist for streams with a bedrock bottom.

Complex interactions driven by local climate, shading, substrate, and channel dimensions result in water temperatures that continually change along the length of a stream. Nevertheless, streams generally warm from their headwaters to mouth. Another generalization is that the maximum temperatures for any given reach of stream vary annually, depending on the timing of maximum air temperature and low flows. Usually, maximum water temperatures in Oregon coastal streams occur from mid-July to mid-August, a time when the sun is high in the sky, flows are relatively low, and air temperature is the highest. However, summer fog in coastal areas can result in extended periods of low air temperature, high humidity, and intercepted solar radiation.

Maximum water temperature is often expressed as the greatest 7-day running average of daily maximum temperatures occurring each summer. Hereafter, this is referred to as the 7-day maximum and is used for expressing maximum water temperature throughout this section. The 7-day maximum, in contrast to the annual daily maximum, better reflects the response of fish to high water temperature. Fish can often endure one day of 75° F water by eating more or moving into zones of cooler water. However, if the water peaks at 75° F for a week, these survival strategies are less effective. The annual maximum water temperature is usually 2-3° F higher than the 7-day maximum for coastal streams. State standards for water temperature also are expressed as the 7-day maximum.

The water temperature standard adopted by the DEQ that applies to Forest streams is 64° F. Most activities that increase the temperature of a stream above 64° F are prohibited. This is not to suggest that all streams are naturally cooler than this standard; Oregon coastal streams with abundant shade commonly exceed 64° F. The goal of the temperature standard is to maximize the time that cold water rearing habitat is available for juvenile salmonids and to minimize warm water stress that can occur when these cold water fish are exposed to elevated temperatures. The Oregon Forest Practices rules, as modified in 1994, were designed to result in the retention of most existing shade along fish-bearing streams and all other streams without fish, except those that are in the small size classification. A specific shade standard is not stated in the rules. Instead, a specified number and basal area of trees is required to be left along streams and is assumed to result in a level of shading that is similar to the original stand. Monitoring by ODF's Forest Practices Division has confirmed that, in most cases, shade loss to streams when timber harvest occurs outside of buffers is minimal under these rules. The Forest is required to meet or exceed the Forest Practices rules.

The state standard for water temperature is not an indicator of what fish can tolerate. Salmonids commonly live in streams that exceed 64° F. However, physiological and behavioral changes often occur in fish when temperatures approach 70° F. Being cold-blooded, fish must consume more food when the water is warmer or they will lose weight. Warm water also can lead to sluggish movement and to fish congregating around zones of cooler water, which further limits their ability to search for food, as well as making them more prone to predation. Since warm temperatures in Forest streams do not correspond to periods of adult holding or spawning by salmon and steelhead, water temperature is not a spawning or egg development issue.

Methods

Suitable water temperature records were available for 14 sites in the West Fork Millicoma Basin and for 7 sites in various streams draining into the Tenmile Lakes. The Forest and DEQ jointly monitored the West Fork Millicoma sites in 1996, 1997, and 1999; the Tenmile Lakes Watershed Council monitored the Tenmile Lakes sites in 2002. Only three of the West Fork Millicoma sites had a temperature record that covered all 3 years of monitoring. Most had at least 2 years of record, and an examination of the 7-day maximum temperatures at these sites indicated that, on average, values for 1996 were 1.027 higher than 1997 values and 1997 values were 1.016 times higher than 1999. Because of the data gaps and temperature differences among summers, temperatures for sites that had missing data for 1-2 years were estimated by multiplying the temperature of known years by these ratios. The average temperature values (actual and estimated) over the 3 years then were calculated.

The Tenmile sites were analyzed separately from the West Fork Millicoma sites because the records were from 2002 and there was no way of determining possible differences in summer conditions between 2002 and the late 1990s. Also, it was suspected that marine air and summer fog would result in a unique spatial pattern of maximum water temperatures in the Tenmile region. Stream flow was unusually low in 2002. Some of the late summer temperatures for the Tenmile gauges appeared to deviate widely from patterns observed earlier in the summer. This may have resulted from the gauges being partially out of the water during later summer as flows receded. Therefore, a warm 7-day period centered on July 11 was used instead of the greatest 7-day maximum for the entire summer. A few gauges with erratic records, even in mid-July, were not used in the analysis.

An indicator of stream shading upstream of each gauging site was obtained from stream surveys conducted by the ODFW in the 1990s or in 2001. This estimate of vegetative cover over the stream, as measured by a clinometer, is not a direct measure of stream shading but a determination of the sun-blocking capability of the top of the tree line or the topography on each side of the stream. Hereafter, it is referred to as "ODFW shade" and was expressed for three distance intervals upstream of the gauging site, 0.5, 1, and 2 miles. Other possible correlates to water temperature were extracted from reach summaries upstream of the sites, including active channel width and the percent of substrate consisting of silt/sand and gravel. Shade derived by DEQ using measurements from aerial photographs and topographic maps, and calculated using the SHADOW model (Forest Service 1993), also was included in this analysis as another indicator of shade. These data were available only for the West Fork Millicoma Basin, and hereafter is referred to as "DEQ shade."

A GIS overlay of contour isopleths, stream channels, and gauge locations provided measures of the distance between the gauge and the basin divide. Distance from divide is the channel distance along the longest possible path extended to the upper basin ridge top. For each of two data sets (West Fork Millicoma and Tenmile Lakes sites), multiple linear regression was used to evaluate variables that may explain temperature variance among sites. Maximum water temperature and related information for Forest streams is shown in Table 5-1.

Table 5-1. Maximum water temperature and related information for Forest streams.

Stream	Max. Temp.	ODFW Shade (%)			DEQ Shade (%)			Divide
		0.5 mi.	1 mi.	2 mi.	0.5 mi.	1 mi.	2 mi.	
Coos Region (1996, 1997, 1999)								
WF Millicoma above Cougar Cr	59.1	98	95	91	80	76	76	2.3
WF Millicoma below Elk Cr	65.5	72	85	88	76	80	80	5.5
WF Millicoma above Knife Cr	67.6	80	81	78	65	65	65	7.0
WF Millicoma at 8000 road bridge	69.8	77	81	75	73	57	59	8.5
WF Millicoma below Stulls Falls	73.3	81	81	78	50	47	56	19.6
WF Millicoma at hatchery	76.1	71	66	60	66	61	54	22.8
WF Millicoma at mouth	74.2*	---	---	---	---	---	---	35.9
Kelly Cr at mouth	64.6	88	88	88	76	83	85	1.9
Panther Cr at mouth	65.3	70	71	75	59	54	69	2.7
Fish Creek at mouth	62.4	93	93	94	83	83	83	3.4
Elk Cr at mouth**	64.7	90	86	87	76	80	80	9.1
Knife Cr at mouth**	63.4	84	87	87	70	69	74	3.5
Deer Cr at mouth	67.6	78	77	73	81	79	64	4.3
Trout Cr at mouth**	62.0	97	98	92	82	82	91	2.5
Tenmile Region (2002)								
Benson, upper	70.2*		74		---	---	---	4.1
Big, lower (dam pool)	68.1*		51		---	---	---	4.9
Big, upper	64.1*		83		---	---	---	3.6
Noble, upper	63.7*		86		---	---	---	2.1
Murphy, upper	61.3*		96		---	---	---	1.9
Big, Alder Fork	60.3*		89		---	---	---	2.6
Johnson, upper forks	59.1*		80		---	---	---	3.8

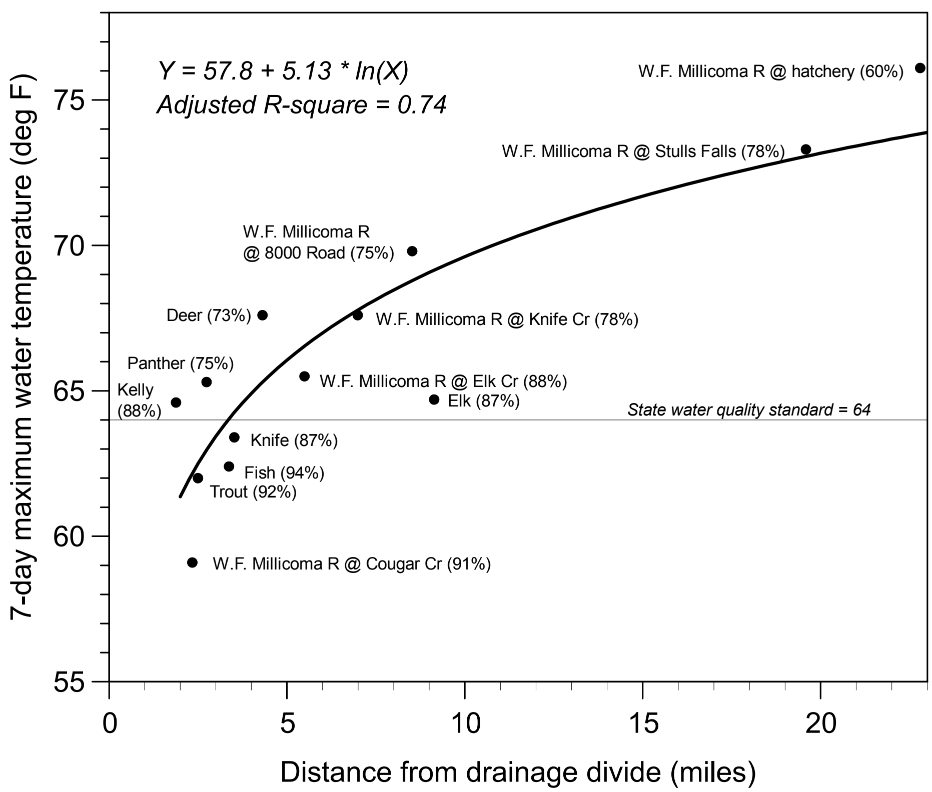
Max. temp. = greatest annual 7-day average of maximum water temperature (°F).
ODFW shade = shading over stream obtained using a clinometer in the field (%).
DEQ shade index = shading over stream obtained from aerial photographs, topographic maps, and simulation using the SHADOW model by DEQ (%).
Divide = distance from gauging station along stream (miles) to the maximum distance to the drainage divide.
* Stream record not used to develop predictive equation.
** Site included a temperature value for each of 3 years; for all other sites temperature values for 1 or 2 years were estimated using common years of record.

Results

West Fork Millicoma Sites

Distance from drainage divide (natural log transformed) explained nearly three-quarters of the temperature variance among sites in the West Fork Millicoma data set (Figure 5-1). The 7-day maximum water temperatures were less than the DEQ water quality standard (64° F) at only 4 of the 13 sites, despite relatively high values of shading at all sites. These four sites were small streams and three of these had the highest ODFW shade values. Sites with more shade tended to plot below the regression line, so shade was added to the regression equation to better quantify sources of variation in water temperature.

Figure 5-1. Variation in maximum water temperature with distance from drainage divide for 13 West Fork Millicoma sites.



Note: Average percent shade values 0-2 miles upstream of the site are shown in parenthesis.

The multiple regression equation is:

$$Temp = 81.0 + 3.17 * \ln(Distance) - 0.243 * Shade$$

where: Temp = 7-day maximum water temperature (°F)
Distance = distance to drainage divide (miles)
Shade = ODFW shade (%)
n = 13

Adjusted squared multiple R = 0.89
P-value for the distance term was 0.002.
P-value for the shade term was 0.003.

No correlation was found when the residuals associated with this equation were plotted against percent substrate consisting of silt/sand or active channel width. The regression equation indicates that most of the water temperature variance among sites (89%) can be explained by a combination of variables that include distance from divide and ODFW shade (integrated 0-2 miles upstream of the gauging site).

Other intervals of shade-averaging upstream of gauging sites were examined to determine whether the predictive equation could be improved. The distance over which shade was averaged was reduced to 1 mile and 0.5 mile. Substitution of these values resulted in a reduction in the R-square values in the regression equation (Table 5-2), thereby showing that the 2 mile distance is more appropriate for explaining variance in water temperature than shorter distances.

The DEQ shade values calculated using the SHADOW model were substituted for the ODFW shade values in the regression equation. The DEQ shade values were not significant at the P=0.05 level, leaving only the independent variable, distance from divide, as a significant term (Table 5-2). Therefore, ODFW shade was better at explaining variance in maximum water temperature for this data set.

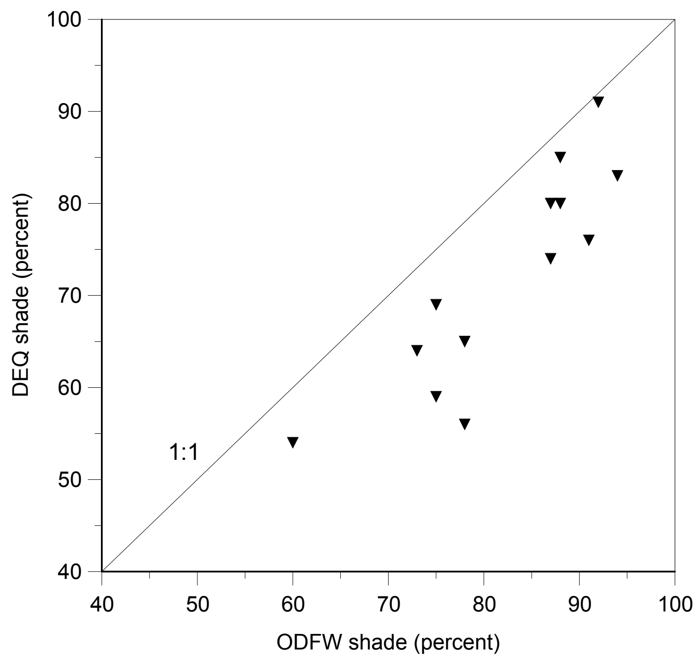
Table 5-2. Significance and fit for a multiple regression equation examining variance in the 7-day maximum water temperature and the independent variables distance from divide (natural-log transformed) and shade.

Shade Measure Method	Shade Averaging distance (mi.)	Adjusted Squared Multiple R	P-term for Distance from Divide	P-term for Shade
ODFW	0 to 0.5	0.82	0.0004*	0.0275*
	0 to 1	0.85	0.0009*	0.0105*
	0 to 2	0.88	0.0019*	0.0028*
DEQ	0 to 0.5	0.75	0.0016*	0.2566
	0 to 1	0.75	0.0019*	0.2137
	0 to 2	0.80	0.0153*	0.0576

* Significant at the 0.05 level.

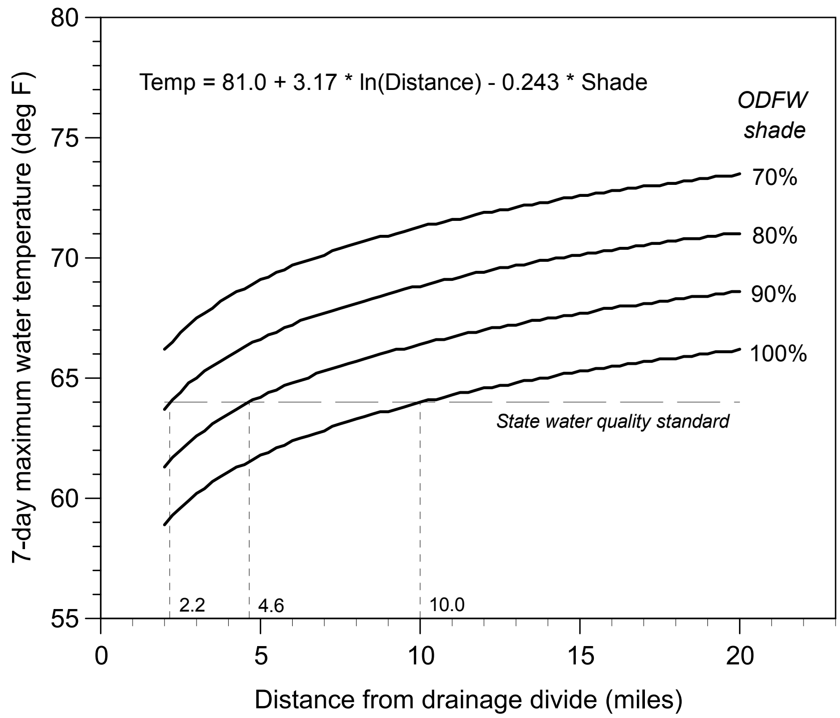
Examining the ODFW and DEQ shade values in more detail, it became apparent that there was only fair correlation between the two methods, and that the ODFW shade values averaged about 10 percentage points higher than the DEQ shade values (Figure 5-2).

Figure 5-2. Comparison of DEQ and ODFW shade integrated 2 miles upstream of the gauge sites.



The predictive equation for the West Fork Millicoma Basin indicates that a 10% loss of shade results in about a 2.4° F increase in water temperature (Figure 5-3). This equation is applicable only for the range of values included in the data set (2-20 miles for distance from drainage divide and 70% to 100% for shade).

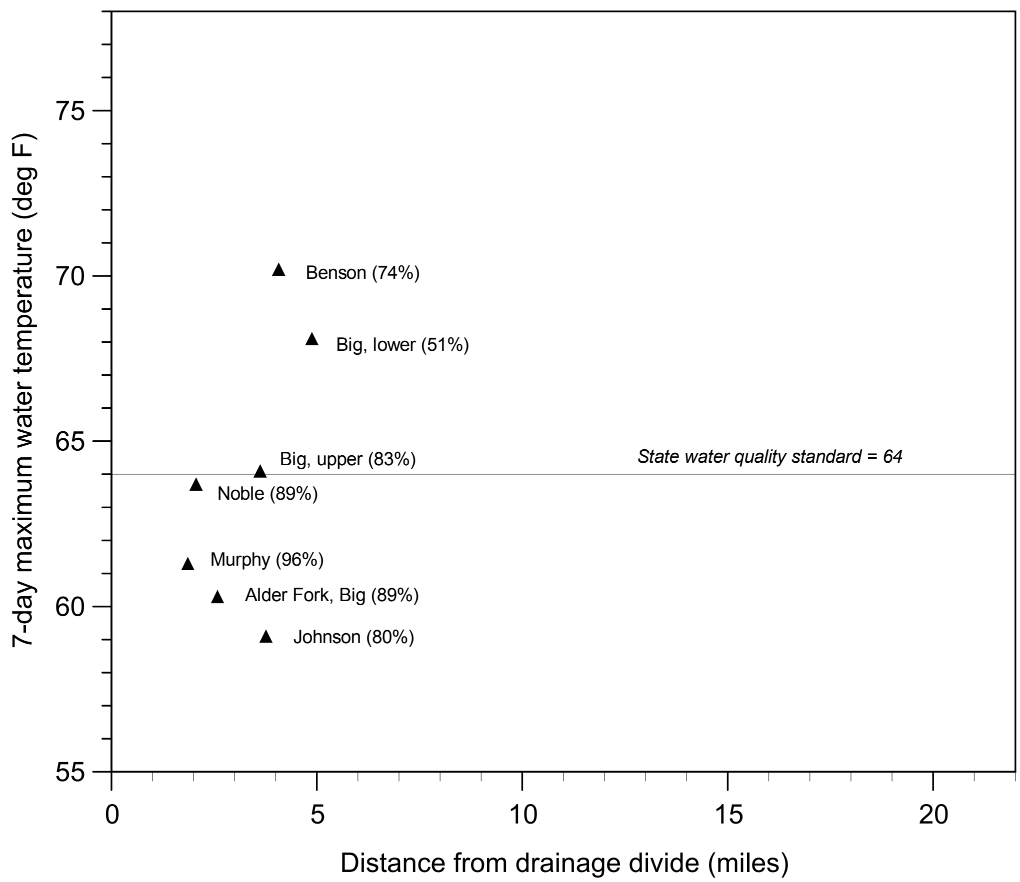
Figure 5-3. Predicted increases in 7-day maximum water temperature for West Fork Millicoma sites.



Tenmile Sites

A similar examination of variance was conducted for the Tenmile sites and no correlation was found between the 7-day maximum water temperature and the independent variables (distance from divide, ODFW shade, percent substrate as silt/sand and gravel, and active channel width). Five of the seven sites (71%) had 7-day maximum temperature values that were equal to or less than the state water quality standard (Figure 5-4). The temperature of Johnson Creek was exceptionally cool (59° F) considering that the gauging site was 3.8 miles from the drainage divide.

Figure 5-4. Variation in maximum water temperature with distance from drainage divide for seven Tenmile sites.



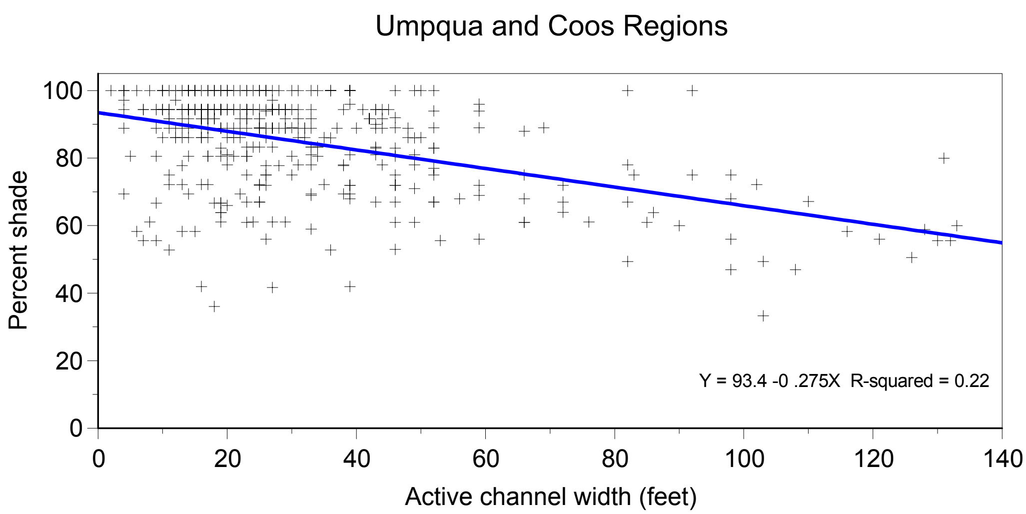
Note: ODFW shade values in parenthesis.

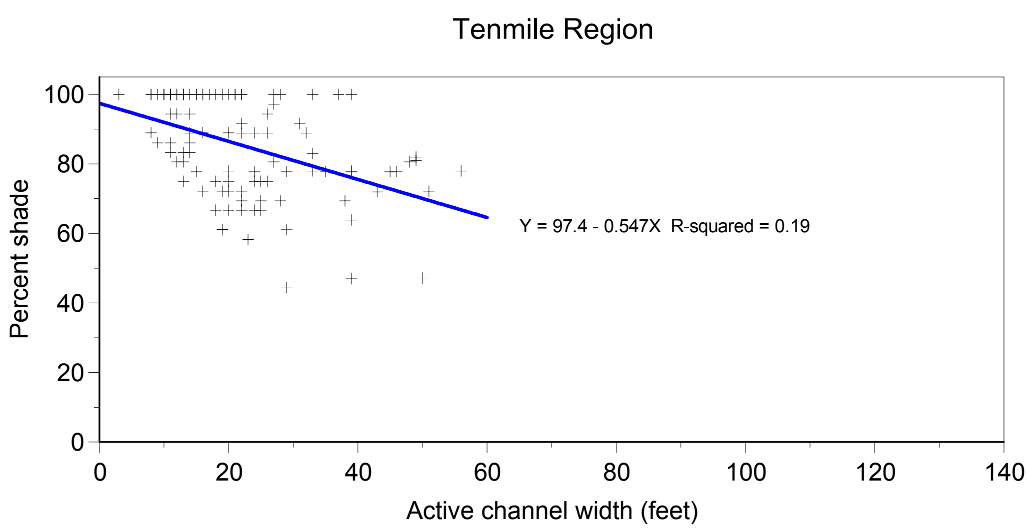
Stream shade values throughout the Forest were obtained from ODFW stream surveys. Nearly 500 points had both active channel width and shade information, and these were used in the following discussion. Shade values did not vary much among regions for streams with the same active channel width (Table 5-3). Correlations between shade and channel width were weak, with only about 20% of the variation around mean shade values explained by width (Figure 5-5).

Table 5-3. Mean ODFW shade values by active channel width by region.

Region	Mean Percent Shade for Active Channel Width Categories (standard deviation in parenthesis)		
	0 - 30 feet	31 - 60 feet	6 - 120 feet
Coos	89 (12)	83 (13)	68 (11)
Umpqua	82 (14)	83 (13)	65 (21)
Tenmile	87 (14)	78 (15)	---

Figure 5-5. Variation in ODFW shade with active channel width along fish-bearing streams.





NUTRIENTS AND DISSOLVED OXYGEN

The abundance of nutrients, the amount of sunlight striking a stream's surface, and the type of channel substrate largely controls the production of aquatic plants (including algae) and insects occupying a stream. Usually, productivity is greatest and species most varied where nutrients and sunlight are abundant and the substrate consists of gravel and cobbles. Nevertheless, the conditions that lead to high productivity can sometimes have side effects. Profuse aquatic plant growth in a stream can lead to elevated pH values that are detrimental to fish. The nighttime decay of plentiful aquatic plants can lead to depressed levels of oxygen in the water. The abundant sunlight, which boosts primary productivity, also may warm the water to the point that a fish's metabolism exceeds its ability to feed itself.

Timber harvest invariably leads to some short-term losses of nutrients from surrounding slopes because the dense root mat dies and roots from the new trees and brush take a few years to reoccupy the site. Although nitrogen is highly mobile in soils, its uptake by roots, bacteria, and other organisms in the soil help keep it on site. The loss of phosphorus after timber harvest is less of a problem since it tightly adheres to soil particles. The main pathway for phosphorus to enter a stream is through erosion of the soil. Even when in the stream, the phosphorus usually remains attached to soil particles, although low dissolved oxygen levels, such as those commonly found in the bottom of lakes, can cause phosphorus in the bottom sediment to come into solution. The following studies done on small (less than 10 square miles) watersheds in Oregon provide some perspective on the amount and timing of nutrient loss following timber harvest.

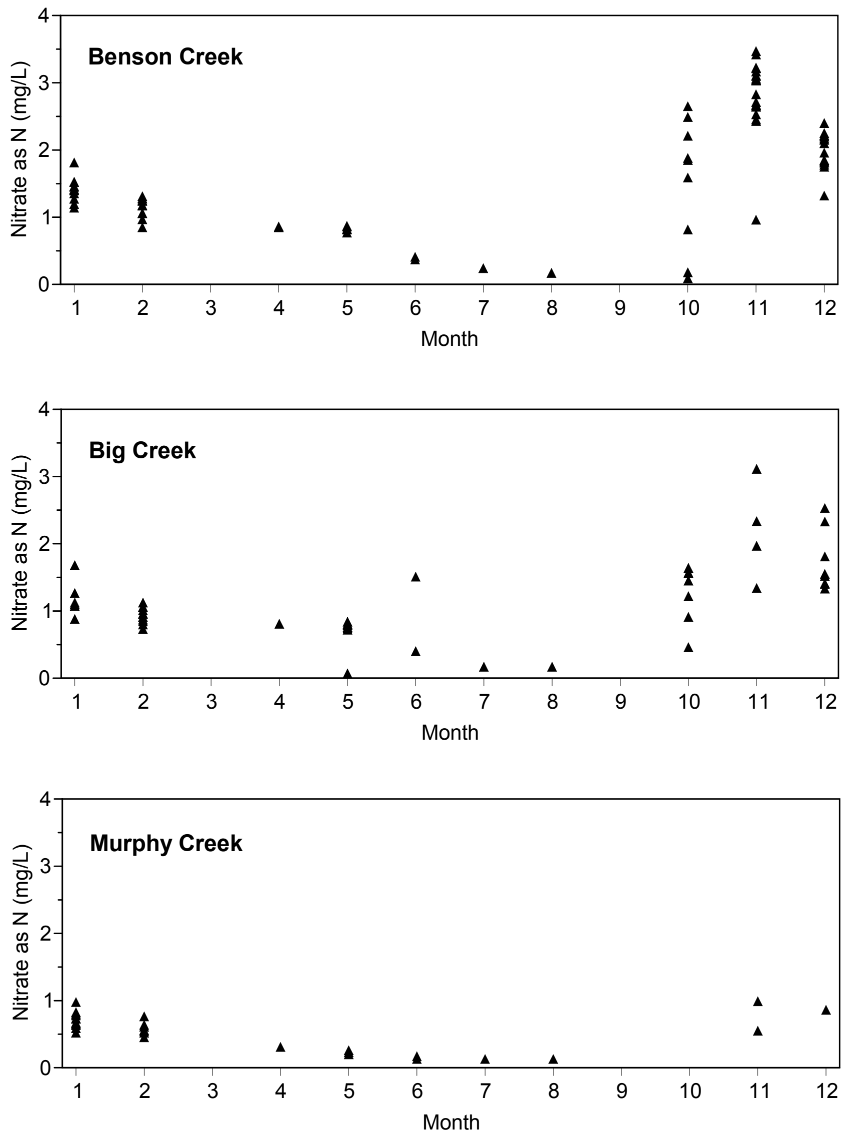
Complete clearcut harvest of a small basin in the South Umpqua River drainage caused nitrate concentrations in the stream to increase for a 5-year period following harvest (Adams and Stack 1989). Pre-harvest concentrations were 0.005 milligrams per liter (mg/L) but increased to 0.120 mg/L by the third year. Nitrate levels returned to normal after the fifth year. An adjacent watershed that had 30% of its area harvested as patch cuts exhibited only small increases in nitrate.

Nitrate concentrations in a small Alsea River tributary, which had been 100% clearcut and then intensely burned increased 4-fold over pre-harvest levels although the increases lasted only 2 years (Brown et al. 1973). Nitrate concentrations did not change for an adjacent small stream, which had 25% of its basin clearcut and lightly burned. Concentrations of phosphorus in the water column were unchanged for both streams.

Nitrate levels in a small stream in the central Oregon Cascades increased from 0.01 mg/L to 0.036 mg/L for the first 3 years after the entire basin was clearcut and lightly burned (Martin and Harr 1989). By the sixth year, nitrate concentrations were back to pre-logging levels. Phosphorus concentrations in the water column did not change.

Accelerated nitrogen leaching from a small basin may not necessarily show up in downstream waters during the summer. Oregon coastal streams are naturally low in nutrients, especially during the summer, and these nutrients are tightly recycled by aquatic life and streamside vegetation. In fall and winter, much of the nitrogen is released back into the water column after the algae and other plants decay (Figure 5-6).

Figure 5-6. Seasonal changes in nitrate concentrations for three streams draining from the Forest to Tenmile Lake.



Note: data from Eilers et al. 2001 and DEQ; samples taken from 1998-2002.

High nitrogen levels in streams during fall and winter are rarely a problem since cool temperatures keep dissolved oxygen concentrations high and the decay of organic material is low. Also, photosynthesis by aquatic plants during winter and spring is low and flows are high, which keeps any high pH conditions from occurring. Dissolved oxygen problems are most likely to occur during fall conditions when dying algae and leaves are abundant and when stream flow is low due to a lack of rain.

Methods

Information on nutrients and related water quality parameters is scarce for Forest streams. Samples have been gathered at only seven sites. Three sites are in the West Fork Millicoma Basin and three are in the Tenmile region. The remaining site is in the headwaters of the West Fork of Lake Creek (Umpqua region). Sampling was done by the U.S. Environmental Protection Agency (USEPA REMAP project), by the DEQ, or by Eilers and others (2001, 2002). Information on recent timber harvest upstream of the sampling sites was not included in the USEPA and DEQ data sets. It can be assumed that an array of stand ages ranging from recent clearcuts to stands older than 100 years exist upstream of most sites.

Variability among sampling periods for sites with multiple records was small so a mean value was calculated and is used in the following discussion. For orthophosphate values that were below the detection limit (0.005 mg/L), a value of one-half the detection limit (0.0025 mg/L) was used in the calculation of a mean value. All nitrogen/nitrite values were at or above the detection limit (0.02 mg/L). Also, results from a study on nutrients within Tenmile Lakes (Eilers et al. 2001, 2002) are included in the discussion of phosphorus.

Results

Summer orthophosphate concentrations were exceedingly low at all stream sites, suggesting that the summer aquatic biota readily extracts most available phosphorus from the water (Table 5-4). Mean orthophosphate concentrations were only 0.003 to 0.012 mg/L. The lowest values occurred in the West Fork Millicoma Basin.

Summer nitrate/nitrite concentrations varied from a low of 0.04 mg/L in upper West Fork Lake Creek to a high of 0.56 mg/L in Big Creek. The average value was 0.24 mg/L among the other sites, which is typical for coastal Oregon streams during the summer. The lack of phosphorous in the water column probably limits further uptake of nitrogen by algae.

Values for pH (average of 7.3) are somewhat higher than would be expected for forest streams in Oregon, which tend to be slightly acidic. Calcium is abundant in the sandstone rock common to the Forest and may be responsible for the somewhat elevated pH values. Values for pH did not vary much among sites.

Consistently high values of dissolved oxygen among samples taken before 10 AM confirm that high pH values are likely a result of geology and not algae productivity. Samples taken prior to 10 AM are least affected by water oxygenation due to photosynthesis by algae. Expressed as percent saturation, oxygen levels ranged from 87% to 100% (morning and afternoon combined) and represent favorable conditions for fish rearing during summer.

However, none of the sampling took place during the fall, the time most critical for fish survival. In fall, dissolved oxygen problems are most likely to occur because leaves are falling into streams, accumulated algae biomass is decaying, and streams often have low flow.

Table 5-4. Selected water quality parameters for streams within or immediately adjacent to the Forest, June through September.

Stream	Date	Time	N	P	pH	DO	DO%
Elk Creek at RM 1.4 (USEPA or DEQ)	9/7/99	1:55 PM	0.16	<0.005	7.2	9.7	96
Elk Creek at RM 3.0 (USEPA or DEQ)	7/26/94	8:00 AM	0.23	0.007	7.3	8.7	87
	8/18/94	9:00 AM	0.17	<0.005	7.6	9.1	92
	9/12/94	10:00 AM	0.14	<0.005	6.9	9.4	86
	8/3/95	9:00 AM	0.22	0.007	7.6	9.6	97
	8/29/95	9:00 AM	0.16	<0.005	8.3	9.6	95
	7/16/96	8:30 AM	0.18	0.006	7.4	8.9	90
	9/10/96	9:20 AM	0.15	<0.005	7.1	9.0	85
	Mean	**---**	**0.18**	**0.004**	**7.5**	**9.2**	**90**
W.F. Millicoma River at RM 22.5 (USEPA or DEQ)	7/27/94	8:00 AM	0.23	<0.005	6.7	9.6	99
	7/18/96	9:38 AM	0.14	---	7.7	9.8	97
	Mean	**---**	**0.19**	**0.003**	**7.2**	**9.7**	**98**
Unnamed tributary of W.F. Lake Creek (USEPA or DEQ)	8/9/94	8:30 AM	0.06	0.015	7.3	9.8	92
	7/8/96	4:00 PM	0.02	0.009	7.7	10.0	95
	Mean	**---**	**0.04**	**0.012**	**7.5**	**9.9**	**94**
Benson Creek at RM 5.0 (USEPA or DEQ)	8/15/95	12:00 PM	0.24	0.009	7.4	9.6	99
	7/17/96	5:00 PM	0.57	0.010	7.5	9.5	93
	Mean	**---**	**0.41**	**0.010**	**7.5**	**9.6**	**96**
Benson Creek (Eilers et al. 2001)	6/13/99	---	0.45	---	7.0	---	---
	6/26/99	---	0.40	---	7.0	---	---
	7/13/99	---	0.14	---	---	---	---
	8/1/99	---	0.13	---	---	---	---
	Mean	**---**	**0.28**	**---**	**7.0**	**---**	**---**
Big Creek 0.5 mi. below Forest (USEPA or DEQ)	9/22/98	12:44 PM	0.19	0.006	7.2	9.1	87
Big Creek (Eilers et al. 2001)	6/13/99	---	1.50	---	7.3	---	---
	6/26/99	---	0.46	---	---	---	---
	7/13/99	---	0.13	---	---	---	---
	8/1/99	---	0.13	---	---	---	---
	Mean	**---**	**0.56**	**---**	**7.3**	---	---
Murphy Creek (Eilers et al. 2001)	6/13/99	---	0.18	---	6.9	---	---
	6/26/99	---	0.13	---	6.9	---	---
	7/13/99	---	0.13	---	---	---	---
	8/1/99	---	0.13	---	---	---	---
	Mean	**---**	**0.14**	**---**	**6.9**	---	---

N = nitrate and nitrite (mg/L as N); P = orthophosphate (mg/L as P); pH = standard units; DO = dissolved oxygen (mg/L); DO% = dissolved oxygen (% of saturation).

A recent study of nutrient dynamics within Tenmile Lakes (Eilers et al. 2001, 2002) was sponsored by the Tenmile Lakes Basin Partnership (TLBP) to better understand processes that influence water quality. The study demonstrated that phosphorus concentrations in the water column control algae growth within Tenmile Lakes, and that the phosphorus is delivered to the lake attached to sediment particles and by leaching from lakeside septic systems. Low dissolved oxygen concentration at the lake bottom during the summer releases some of the phosphorus attached to bottom sediments, thereby making more phosphorus available for additional algae growth.

The authors also examined suspended sediment inputs from streams, including those that primarily drain the Forest. Suspended sediment loads were measured for three streams (Big, Benson, and Murphy Creeks) for 1 year and then modeled using the SWAT model (Arnold et al. 1995). This model was originally developed to estimate sediment production due to rill and gully erosion; it has no mechanism for determining sediment yields due to landslides, which are a major source of sediment delivery into Forest streams. The modeling results indicated that Forest streams have suspended sediment loads that were less than measured sediment loads for three similar coastal watersheds with no previous timber harvest, and were much less than watersheds with various levels of timber harvesting (Table 5-5).

Table 5-5. Annual suspended sediment yield from coastal watersheds and modeled sediment yields for five streams draining into Tenmile Lakes.

Study	Geology	Watershed	Condition	Annual suspended sediment yield (tonnes/sq.km./yr)
Reid 1981, Olympic Mountains, Washington	Steep, sedimentary	Clearwater	Partially clearcut; road landslides	126*
Beschta 1978, Coast Range, Oregon	Steep, sedimentary	Flynn	100% forested.	98*
		Deer	100% forested.	97*
		Deer	100% forested, 25% recent clearcut; road landslides.	136*
		Needle	100% forested.	53*
		Needle	100% clearcut and severely burned.	146*
Eilers et al. 2002, Tenmile Lakes nutrient study; only subbasins with a majority of area in the Forest were included.	Steep, sedimentary	Murphy	90% forested, 7% recent clearcut.	7**
		Big/Noble	92% forested, 5% recent clearcut.	36**
		Benson	92% forested, 3% recent clearcut.	26**
		Johnson	94% forested, 2% recent clearcut.	28**
		Adams	84% forested, 8% recent clearcut	9**

* measured ** modeled using SWAT

HERBICIDES

Herbicides are used on the Forest to remove competing plants in new clearcuts prior to or shortly after planting conifers, and less commonly to release young conifer trees that are in danger of being overtopped by brush and hardwood trees. A third use of herbicides is for eliminating invasive Scotch broom from roadside areas or portions of older clearcuts. No insecticides or fungicides are currently used on the Forest.

Most herbicides are aerially applied during dry weather in September. At this time of year, glyphosate and imazapyr, the most common mix of herbicides used on the Forest, are most effective at killing competing vegetation. Occasionally, an aerial herbicide application will occur during dry weather in July; this has happened only once since 1999. Site preparation applications usually apply glyphosate at a rate of about 0.5 gallons/acre combined with imazapyr applied at a rate of about 0.04 gallons/acre. Common brand names for glyphosate include Roundup and Accord. The common brand name for imazapyr is Arsenal. Both are considered to be of low toxicity to fish. Glyphosate is not mobile in the soil while imazapyr is considered to have high soil mobility (Table 5-6).

Table 5-6. General characteristics of herbicides that have been applied on the Forest since 1999, in order of volume of use.

Compound	Brand Name	Acute Toxicity to Fish (LC50*)	Mobility in Soil
Glyphosate	Roundup, Accord	Low (30)	Low
Imazapyr	Arsenal	Low (>100)	High
2,4-D		Variable**	Moderate
Triclopyr		Low (120)	Moderate
Clopyralid	Transline	Low (110)	High
Sulfometuron	Oust	Slightly (12)	High

* LC50 is the dose (mg/L) that kills 50% of fish after 96 hours of exposure.
** Highly variable depending on formulation.
Toxicity and mobility information from http://infoventures.com/e-hlth.

Since 1999, the herbicide 2,4-D (sometimes combined with imazapyr) has been used on the Forest only for eliminating Scotch broom. Its toxicity to fish is variable depending on the formulation and it is moderately mobile in soils. Three other herbicides, clopyralid, triclopyr, and sulfometuron (in combination with glyphosate) each have been used once since 1999. They have low toxicity to fish except for sulfometuron, which is slightly toxic, and they are moderately or highly mobile in soils (Table 5-6). In addition to aerial or roadside applications of herbicides, red alders on 394 acres were killed with imazapyr by stem injection (hack and squirt) in 1999.

Glyphosate is used on the Forest as a general spray to control a wide array of broadleaf plants, shrubs, and grass. However, since glyphosate is not effective at controlling evergreen huckleberry, rhododendron, or Oregon myrtle, imazapyr is often used in combination. Clopyralid was used one time to control red elderberry. Triclopyr is effective at controlling Scotch broom and evergreen blackberry, and sulfometuron has been used to control Scotch broom. Herbicide applications in the Forest have averaged 550 acres annually over the last 4 years (Table 5-7). Therefore, about 0.6% of the land base is treated each year with herbicides. Imazapyr has been used on 91% of the total area sprayed during the last 4 years, while glyphosate has been used on 80% of the area.

The concentration of a chemical in a stream is usually expressed as mg/L; 1 milligram per liter is the same as 1 part per million. For perspective, adding 1 liter (about 1 quart) of chlorine to an Olympic-size swimming pool (253,000 gallons) results in a chlorine concentration of about 1 part per million.

Since it is commonly used near water, the toxicity of glyphosate on fish has been tested extensively over the last 10 years. One formulation of glyphosate (Rodeo) has federal approval for use in water. Fish have a relatively high tolerance for salt of glyphosate, which is the active ingredient in formulations such as Roundup, Accord, and Rodeo. It is the surfactant used with Roundup that is more toxic to fish. The term commonly used to quantify the toxicity of a compound on fish is LC50. It is the minimum concentration that kills 50% of fish (following 96 hours of exposure) in tank tests. The LC50 for rainbow trout for salt of glyphosate is 140 mg/L (Folmar et al. 1979) but 2-3 mg/L for the surfactant that is included in Roundup (Norris and Dost 1992). The LC50 for salmonids exposed to the combined salt of glyphosate and surfactant ranges from 11-55 mg/L (Table 5-8). A surfactant is used to make the glyphosate stick to vegetation so it can be absorbed through the leaves. It also makes the leaf surface more receptive to the entry of the glyphosate. In the discussions below, references to glyphosate include the formulation of salt of glyphosate plus its surfactant.

The vegetation conditions and the manner in which an herbicide is applied can greatly influence the herbicide concentration to which fish are exposed. When glyphosate was sprayed over streamside areas with no provisions to keep the spray out of the stream, Feng and others (1989) measured peak levels up to 0.16 mg/L in the stream. Following the first rains, concentrations peaked again at 0.11 mg/L. Similarly, Newton and others (1984) measured peak concentrations of 0.27 mg/L when a small forest stream was oversprayed with glyphosate. Thompson and others (1991) found peak concentrations of triclopyr reached 0.23-0.35 mg/L following overspray of a stream in Ontario, Canada. The use of best management practices to avoid direct entry of spray into stream and minimize drift, combined with the presence of streamside buffers of trees and brush that intercept much of the spray, greatly reduces the concentration of herbicides that end up in streams. Rashin and Graber (1993) monitored six clearcuts in Washington that had been sprayed with various herbicides and found glyphosate concentrations never peaked above 0.008 mg/L and imazapyr concentrations stayed below 0.001 mg/L (Table 5-9). Concentrations of 2,4-D were below 0.002 mg/L and below 0.001 mg/L for triclopyr.

Combined with information from Table 5-8, this means that glyphosate concentrations in streams were less than 0.03% of the LC50 acute toxicity concentration for fish when current best management practices were used. For imazapyr and triclopyr, stream concentrations were less than 0.001% of the LC50 values. Although no studies have been conducted on the Forest to monitor the concentrations of herbicides in streams following treatment of clearcut units, the best management practices used are similar to those in Washington.

Table 5-7. Aerial application of herbicides on the Forest, 1999-2002.

Year	Month Applied	Purpose	Acres	Glyphosate *(Roundup, Accord)*		Imazapyr *(Arsenal)*		Clopyralid *(Transline)*		Triclopyr		Sulfometuron *(Oust)*	
				Rate (gal/ac)	Use (gal)	Rate (gal/ac)	Use (gal)	Rate (gal/ac)	Use (gal)	Rate (gal/ac)	Use (gal)	Rate (gal/ac)	Use (gal)
1999	Sept.	Site prep.	143	0.75	107.3	0.034	4.8	---	---	---	---	---	---
1999	Sept.	Site prep.	100	0.50	50.0	0.036	3.6	---	---	---	---	---	---
1999	Sept.	Release	14	0.31	4.4	---	---	---	---	---	---	---	---
1999	Sept.	Release	40	---	---	---	---	0.078	3.1	---	---	---	---
1999	?	Alder stem injection	394	---	---	---	44.0	---	---	---	---	---	---
Total			**691**		**161.6**		**52.4**		**3.1**		**---**		**---**
2000	Sept.	Site prep.	40	0.75	30.0	0.031	1.2	---	---	---	---	---	---
2000	Sept.	Site prep.	392	0.50	196.0	0.038	14.9	---	---	---	---	---	---
Total			**432**		**226.0**		**16.1**		**---**		**---**		**---**
2001	July	Site prep.	278	0.50	139.0	0.047	13.0	---	---	---	---	---	---
2001	Sept.	Site prep.	274	0.37	101.4	0.047	12.9	---	---	---	---	---	---
2001	Sept.	Site prep.	55	0.50	27.5	0.023	1.3	---	---	0.31	17.0		---
Total			**607**		**267.9**		**27.3**		**---**		**17.0**		**---**
2002	Sept.	Site prep.	293	0.37	108.5	0.047	13.8	---	---	---	---	---	---
2002	Sept.	Site prep.	125	0.75	93.8	---	---	---	---	---	---	---	---
2002	Sept.	Site prep.	42	0.25	10.5	0.016	0.6	---	---	---	---	0.023	1.0
2002	Sept.	Release	10	0.31	3.1	---	---	---	---	---	---	---	---
Total			**470**		**215.9**		**14.5**		**---**		**---**		**1.0**

Other projects:
2001: Road application to kill Scotch broom using triclopyr (5.5 gallons) and 2,4-D (3.6 gallons) on about 25 acres.
2002: Aerial application (April or May) to prevent flowering of Scotch broom using 2,4-D (73 gallons) on 146 acres.

Table 5-8. Studies on the toxicity of Roundup and salt of glyphosate on salmonids.

Study	Herbicide	Species	LC50* Toxicity (mg/L)	Comments
Folmar et al. 1979	Roundup Salt of glyphosate only	Rainbow trout Rainbow trout	11 140	No changes in fecundity or gonadosomatic index when exposed to concentrations of Roundup as much as 2 mg/L.
Servizi et al. 1987	Roundup	Juvenile sockeye Rainbow trout Juvenile coho	28 27 42	---
Wan et al. 1989	Roundup	Juvenile coho Juvenile chinook Juvenile rainbow	27 27 15	---
Hildebrand et al. 1982	Roundup	Rainbow trout	55	10-fold and 100-fold increases over recommended aerial application rates (2 lb/ac) resulted in no morality of rainbow trout during field studies.
Holtby and Baillie 1989	Roundup	Juvenile coho	---	Some stress and 3% mortality for caged juvenile coho in a side-channel that had been oversprayed. No stress or mortality for free-swimming coho. No changes in fish mortality, growth, or migration of coho 1-2 years after spraying.
Newton et al. 1984	Roundup	Juvenile coho	---	Following aerial application of Roundup (3lb/ac) on a forest brush patch with a small stream flowing through it, half-life of glyphosate on vegetation was 10-27 days and twice as long in the soil. Glyphosate concentrations in stream peaked at 0.27 mg/L and rapidly declined. No detectable amounts of glyphosate found in juvenile coho salmon that lived in stream.

- LC50 is the dose that kills 50% of fish. In the above studies, exposure was for 96 hours.

Table 5-9. Peak and maximum 24-hour average concentrations of herbicide within streams for treated clearcuts in western Washington.

Site	Herbicide	Peak Concentration (mg/L)	Maximum 24-hour Average Concentration (mg/L)
FH3	Glyphosate	0.0044	0.00029
FH2	Glyphosate Imazapyr	0.0076 0.0011	0.00056 0.00036
FH1	Glyphosate Imazapyr	0.0024 <0.0005	0.00032 <0.0005
SH1	Triclopyr	0.0013	0.0013
SH3	2,4-D Triclopyr	<0.00004 0.00002	<0.00004 <0.00002
SH2	2,4-D	0.0025*	0.00069*

*Rainfall occurred shortly after application of herbicide.
Source: Rashin and Graber 1993.

Herbicide application methods used by the Forest to minimize risks to streams and humans include:

- Use of half-boom techniques when applying herbicides near streamside buffers, where the boom on one side is shut off and the wash of air from the helicopter blade forces the spray downward with little scatter to the side.
- No spraying is done over perennial streams (and all of these streams also are buffered by retained trees), wetlands, seeps, or other wet areas.
- All spray mixing and handling is done on landings away from stream channels.
- Spraying occurs only on calm, dry days in order to avoid drift of spray into adjacent areas or wash-off of spray by rain.
- Nearby landowners are contacted prior to the herbicide application.

The Forest Practice Rules include a number of other restrictions on herbicide use on forestland that further minimize the risk of chemicals entering streams.

WATER QUALITY LIMITED STREAMS AND LAKES

The DEQ oversees a process, as required by the federal Clean Water Act, of listing certain streams and lakes that are deemed to be water quality limited. Data for an individual stream, lake, or estuary can be submitted by agencies or individuals to the 303(d) List. If the data suggests that a water body does not meet water quality standards, the water body is identified on the 303(d) List as water quality limited. A water quality limited stream is not necessarily one impaired by human activity; its designation simply means that a numeric or qualitative water quality standard established by DEQ has been exceeded. The question of whether or not human activities caused the standard to be exceeded is dealt with through a subsequent Total Daily Maximum Load (TMDL) process. The 303(d) List was last updated on March 24, 2003. Since many streams exist throughout Oregon for which information on basic water quality has never been collected, the 303(d) List is not complete.

No segments of stream flowing on the Forest are currently included in the 303(d) List. However, several water bodies to the west of the Forest are on the list (Map 5.1). Larson Slough is listed for both water temperature and bacteria from the confluence of Larson and Sullivan Creeks (1.8 miles downstream of the Forest boundary) to Haynes Inlet, a northern appendage of Coos Bay. The upper portions of Larson and Sullivan Creeks are managed by the Forest and are heavily shaded throughout their lengths. Once Larson Creek exits the Forest, it flows through pasturelands and is exposed to sun through much of its length. A future DEQ assessment of the potential sources of high bacteria counts in lower Larson Creek will address wildlife, cattle grazing, and possible human sources. Portions of the bacterial load from wildlife likely originate on the Forest. These loads are often considered background and are not part of human-caused loads. The downstream end of Scholfield Creek also is listed for bacteria; cattle graze along this stream downstream of the Forest.

Both North Tenmile and South Tenmile Lakes are listed for weeds and algae. Forest streams that flow into these lakes include (from north to south) Wilkins, Murphy, Big, Noble, Benson, Roberts, Johnson, and Adams Creeks. A TMDL of Tenmile Lakes is in progress and Forest staff will be asked to evaluate the contribution of nutrients from Forest streams into the lakes. The ODF has been involved in two previous TMDL processes throughout the state that involved nutrients. One was for the Tualatin River Basin near Beaverton and the other was for Bear Creek near Medford.

ANALYSIS

Water Temperature

The information in this chapter indicates that ODFW shade values of 80% or more typically keep the 7-day maximum water temperature of Forest streams below 70° F, even at distances of 20 miles from the drainage divide. Surveys by ODFW indicate that existing shade along Forest streams currently averages 78% to 89% (depending on region), even for streams up to 60 feet wide. Current management practices on the Forest result in the retention of nearly all existing shade since buffers along fish-bearing streams extend 100 feet or more each side of the channel, and at least to 50 feet on each side of perennial streams without fish. Streams that were exposed to full sunlight decades ago, a time when the harvest of trees extended to the edge of the channel, have since grown back with dense vegetation. Most areas that were once bared to construct streamside roads also have grown back to dense stands of trees.

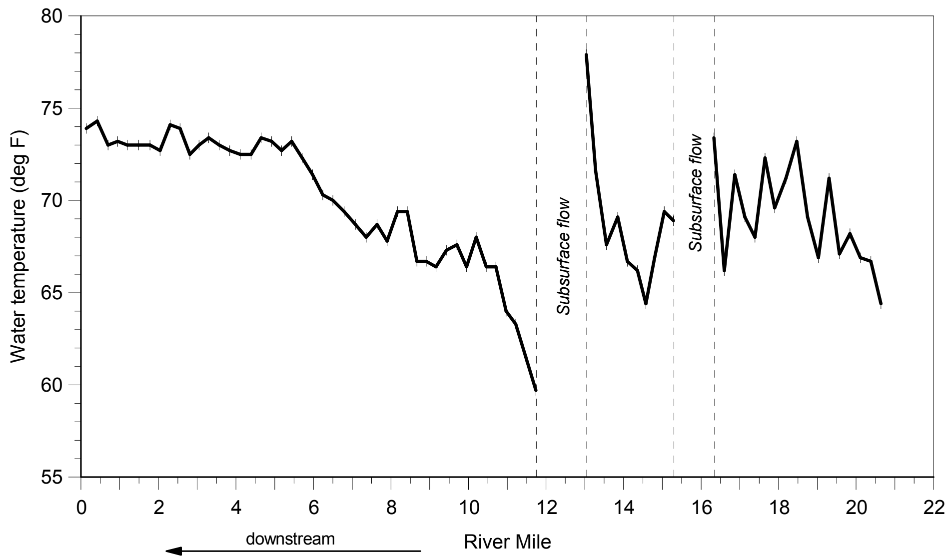
The above information suggests that even with 100% shading, the temperature of a Forest stream is predicted to warm beyond 64° F at distances greater than 10 miles from the drainage divide. The temperature regression equation presented in this chapter provides a more appropriate indicator of natural maximum water temperatures throughout the Forest than does assuming that the state standard of 64° F represents natural conditions. While many smaller streams in the Forest are cooler than the state standard, natural processes warm many larger streams beyond the standard, even with high levels of shading. The ODFW inventories of existing shade along fish-bearing streams show relatively high overall shading throughout the Forest.

While the predictive temperature equation was developed from data gathered in the Coos region, it likely also applies to the Umpqua region because of its similar climate. However, the equation would likely over-predict maximum water temperature for many streams in the Tenmile region, especially those that are influenced by cool marine air or fog during hot spells. Estimating the 7-day maximum temperature of a point along a stream using the predictive equation requires data on distance from divide (obtained from a topographic map) and the shade integrated 0-2 miles upstream of the point (obtained from ODFW surveys).

A limited number of studies on gravel-rich streams (McSwain 1987, Morrice et al. 1997, Poole and Berman 2001) indicate that overall stream temperature can cool considerably when all or some of the stream flow goes subsurface and then resurfaces downstream. The current scarcity of gravel in Forest streams (due in part to the removal of large wood) could be causing streams to be warmer than normal. Figure 5-7 illustrates the magnitude of stream cooling that occurred in Meacham Creek, a northeast Oregon stream, which had two reaches where flow went completely subsurface (data from Jim Webster, Confederated Tribes of the

Umatilla Indian Reservation; reported in the 2003 *Meacham Creek Watershed Analysis and Action Plan*). During the summer, Meacham Creek has about the same flow as the lower West Fork Millicoma River. The analysis team could not find any studies that have been done on streams dominated by bedrock channels where water temperature was evaluated before and after placement of logs and subsequent gravel accumulation in the channel.

Figure 5-7. Downstream trend in water temperature for Meacham Creek, an eastern Oregon stream that has abundant gravel.



Source: 2003 *Meacham Creek Watershed Analysis and Action Plan.*

Nutrients

Limited monitoring of nitrogen and phosphorus during the summer for Forest streams, along with related water quality parameters, indicates that the values are not elevated and fall within the natural range of conditions for Coast Range streams. Since nutrients are naturally scarce in Coast Range streams, the temporary increases of nutrients released when clearcut harvest occurs in small tributary basins are readily assimilated into the aquatic biota in downstream waters. The release of these additional nutrients occurs in the late fall and winter, a time when growth of nuisance algae and low dissolved oxygen levels do not occur.

Tenmile Lakes presents a special situation, in that streams deposit sediment with attached phosphorus into the lakes during the winter, and some of this phosphorus enters the water column during the summer when dissolved oxygen levels at the lake bottom become low. Theoretically, adding more sediment to a lake above background levels can lead to accelerated algae growth since bioavailable phosphorus is the most limiting of the two nutrients needed to support algae. Modeled sediment loads for streams flowing through the

Forest in the Eilers and others (2002) study suggest that sediment loads from Forest streams were not elevated when compared to undisturbed forested streams elsewhere in the Coast Range where sediment loads were actually measured. The SWAT model used in Eilers and others (2002) does not include a process for dealing with landslides, which is a dominant source of sediment within steep terrain underlain by sandstone geology. An appropriate accounting of suspended sediment loads in streams requires direct monitoring over a number of years, in order to account for both dry and wet winters since sediment yields among years can be 10 times higher in wet years than in dry years (Beschta 1978).

HERBICIDES

From 1999-2002, herbicide use on the Forest has averaged about 550 acres annually. Most of these acres have been treated with a combination of glyphosate (about 0.5 gallons/acre) and imazapyr (about 0.04 gallons/acre). No monitoring of these herbicides in streams following spraying of adjacent clearcut harvest units has been done on the Forest. However, monitoring of similar spraying operations in western Washington indicate that glyphosate concentration measured within streams was typically only 0.03% of the LC50 toxicity concentration for salmonids. For imazapyr, the measured concentration was about 0.001% of the LC50 concentration for salmonids. Neither insecticides nor fungicides have been used on the Forest, nor does the Forest staff see any near-term need to use these chemicals.

Under the federal ESA, the USEPA is required to ensure that the pesticide use it authorizes will not jeopardize endangered species. The USEPA is required to register pesticides for use only after a consultation process with affected parties is completed. Federal District Court Judge John Coughenour found the USEPA not in compliance with the ESA with respect to pesticides that pose a threat to salmon because of the lack of the required consultation process. In July 2002, he ordered the USEPA to consult with the NOAA Fisheries (formerly National Marine Fisheries Service) and review 54 pesticides. Although most of these pesticides were insecticides, the list also included 2,4-D and triclopyr, two herbicides that recently have been used on the Forest.

On July 16, 2003, fishing and environmental groups asked the court in the interim to impose no-spray buffer zones of 300 feet wide on each side of stream (for aerial applications) in order to protect salmon until USEPA complies with the order. In a subsequent order, the court found, "…with reasonable scientific certainty, that the requested buffer zones – 20 yards for ground applications, 100 yards for aerial applications – will, unlike the status quo, substantially contribute to the prevention of jeopardy" to salmon. The buffers would remain in place until the USEPA adopts guidelines ensuring that pesticide use does not jeopardize endangered species. The judge heard testimony on August 14, 2003, and told the plaintiffs to develop a recommendation for interim no-spray buffer widths among themselves and other affected parties.

RECOMMENDED ACTIONS AND MONITORING

Water Temperature

The DEQ indicates it will soon propose that the West Fork Millicoma River Basin be added to the 303(d) List, based on temperature measurements that exceeded 64° F in 1996, 1997, and 1999. Once a water body is added to the 303(d) List, a TMDL process may then be initiated. During this process, the DEQ will gather information about natural and human causes of stream warming, determine how much human causes influence temperature and, if human causes exist, develop an energy budget that allocates heat loads to various entities that contribute to water warming. Goals also are set for bringing the water temperature back into compliance. The multiple regression equation developed for the West Fork Millicoma Basin is useful for explaining the variation in stream temperature patterns seen in existing data sets and could be incorporated into the TMDL process as a comparison for any other temperature modeling conducted by DEQ.

One factor that does not normally enter into a temperature TMDL, and may be causing streams to be somewhat warmer than natural, is the role of streambed gravel in keeping water cool. Large wood plays an important role in trapping gravels in Forest streams and, as large wood recovery occurs in the future, a drop in water temperature may occur. The analysis team recommends that Forest staff monitor water temperature when logs are intentionally added to streams to provide habitat for fish, in order to understand the magnitude of such temperature reductions. Monitoring involves the placement of temperature gauges upstream and downstream of the area a few years before and after log placement and gravel trapping, as well as concurrent monitoring of stream temperatures in an upstream control reach.

No Forest streams in the Umpqua region have been monitored for temperature. The climate for most of these streams seems similar to the Coos region, although a gradient of decreasing marine air influence from west (Scholfield Creek) to the east (Mill Creek) probably exists. Monitoring of selected streams in the Umpqua region during a single summer (so that interannual variation can be avoided) would help fill this data gap.

Nutrients

The DEQ has indicated that they will incorporate results of Phase I and Phase II of the Tenmile Lakes study to support an upcoming TMDL of nutrients and nuisance algae in Tenmile Lakes. This will result in some focus on suspended sediment loads within streams that flow from the Forest.

The analysis team does not recommend that Forest staff begin monitoring suspended sediment for streams draining into Tenmile Lakes. An appropriate monitoring effort would require many years of data and involve costly automated measurements of flow and suspended sediment during the wet season. Furthermore, with no information on historic sediment loads from these basins, little could be learned by knowing current sediment loads.

Instead, the analysis team recommends that an update to the 1997-1998 road inventory be conducted in the basins flowing into Tenmile Lakes in order to detect any new discrete sources of accelerated sedimentation.

Herbicides

Studies on herbicide toxicity combined with typical spraying practices used by the Forest indicate a very low risk of harm to fish. Nevertheless, no stream monitoring of herbicides has been conducted on the Forest. Since some members of the public regard the topic of herbicides in streams as very important, the analysis team recommends that Forest staff include stream monitoring as a part of several upcoming herbicide applications. The analysis team also recommends that the methods used by Rashin and Graber (1993) in the western Washington study be adapted by Forest staff in any future herbicide monitoring efforts.

The future use of 2,4-D and triclopyr near Forest streams is uncertain because these two herbicides appear on the list of 54 pesticides under a court-ordered review. An interim ruling may soon restrict the use of these herbicides within 300 feet of streams for aerial applications. The analysis team recommends that brush control plans for the Forest include other herbicides that could be substituted for 2,4-D and triclopyr in case their use becomes further restricted.

Chapter 6. Erosion and Sediment

BACKGROUND

In this chapter, natural and management-influenced processes that affect hillslope-channel interactions are investigated. Management activities evaluated include road construction and maintenance, timber harvest and site preparation. In combination with natural processes, management activities may accelerate natural sedimentation processes and adversely impact stream aquatic systems.

Natural Climate and Precipitation Drivers

The Forest's topography reflects the major influences of climate and precipitation on landform. Climate determines available moisture, which largely governs vegetation types, cover, and plant growth rates. Climate also influences fire weather and fire behavior. The timing and magnitude of sediment pulses through the watershed reflects a strong relationship with climate. Intense rainfall can overcome the surface resistance to erosive forces, generating surface erosion as well as possibly triggering landslides that can contribute sediment to Forest streams.

Cycles of sparse and dense precipitation, stream flow, wildfire intensity, erosion, sedimentation, and salmonid spawning runs are intrinsically linked to these variations in climactic processes (Taylor and Hannan 1999). The North Pacific Interdecadal Oscillation appears to be the significant weather cycle affecting surficial processes on the Forest landscape (Mantua et al. 1997). This climate phenomenon affects precipitation, which in turn affects stream flow regimes and subsequently influences salmonid runs in the Pacific Northwest. It also dictates fire weather and fuel moisture levels, influencing fire periodicity and magnitude. Fire, in turn, affects sediment erosion rates through removal of vegetation that reduces raindrop interception and decreases roots that reinforce shallow soils.

There are several weather cycles that can affect management, none of which management can affect. The most well known is the "El Nino/La Nina" cycle that can cause a particular year to be wetter than normal or drier than normal. The Decadal Oscillation Index shows a cycle of wet and dry trends with a recurrence period of about 20 years. Taylor and Hannan (1999) predict an overall trend of wetter and cooler climate in Oregon until about 2019.

Tectonic Setting

In the Forest, faults and the Mill Creek syncline (or fold) create a large, contiguous block that is topographically isolated from surrounding areas (see Map 2.3). The tectonic history and geology of the Forest also influence its propensity for landslides. In particular, an area at the edge of the Forest northwest of Loon Lake shows evidence of deep-seated slides (see Map 2.4). Loon Lake was created as a result of a deep-seated landslide blocking Mill Creek.

SOURCES OF NATURAL SEDIMENT

Soil is continually produced as under-laying bedrock weathers through bio-geological processes. This action produces rock fragments and soil that may eventually be transported downslope by gravity ("colluvial" processes) and/or by moving surface water ("fluvial" processes). Either of these two transport processes creates sediment. Boulders, gravel, and wood from eroding hillslopes also are transported to channel networks, and then subsequently deposited downstream.

Soil Mantle Production and Transport

The rate of soil production from bedrock weathering is important as a starting point to trace sediment routes through the watershed. Sediment available for transport is fundamentally limited by the rate of soil development. In the Forest, as in most of the Coast Range, soil development is considered limited by the rate of bedrock exfoliation, the "peeling" off of the rock surface (Reneau and Dietrich 1991). The pace of exfoliation and soil production is largely controlled by the spalling and chemical weathering of bedrock. Spalling and weathering create boulders, cobbles, and gravels, as well as smaller soil-sized particles, collectively called the soil mantle. Formation of the soil mantle is a fairly constant process. In contrast, the pace at which the soil mantle is then transported downslope by other processes, such as landslides, is more rapid by many orders of magnitude.

Natural processes that deliver sediment into streams can be placed in one of seven general categories:

1. Biogenic sediment transport occurs as the result of burrowing, hoof action, tree throw, root expansion, and similar events. However, biogenic processes may contribute to downstream movement of soils.
2. Soil creep is the slow downslope transport of soil. Where slopes are low to moderate, soil creep redistributes stored sediment to hollows and channels at lower but pervasive rates as compared to landslides that occur on steeper slopes. Creep processes drive dry ravel and hollow-filling sediment transport.
3. Shallow, rapidly moving landslides include any detached mass of soil, rock or debris that becomes larger as it moves down a slope or stream channel. These slides typically result from the concentration of water through subsurface flow in soils overlaying bedrock on steep slopes. Under semi-saturated or saturating soil conditions, these slides may be triggered on steep (~70% or more) slopes. Under increasingly saturated conditions, they slides become more frequent, often accumulating additional volume, mass, and momentum, and sometimes scour channels into bedrock while moving downslope.
4. Debris flows are small landslides initiated and then sustained by water and debris mass inertia. They may accumulate additional mass and volume as they travel downslope. These flows are capable of abrasive scour into bedrock. They also are capable of dislodging and transporting large boulders and wood down steep slopes.
5. Debris flows become debris torrents when a landslide enters and continues down a channel. Debris torrents significantly affect channel structures and riparian vegetation.

This natural process redistributes both soil and wood sediments downslope between hillslopes and channel systems.

6. Bank erosion occurs on slopes directly adjacent to stream channels or within the channel itself. This is a result of the stream making room for high flows by removing accumulated soil, rock and wood.
7. Deep-seated landslides are slides with deep failure zones.

Fluvial Processes that Detach and Transport Particles

The amount (and rate) of rock and soil moved by gravity and water is determined by their resistance to being detached. The amount of force needed to detach a particle from its resting position is known as its critical shear stress. Different soil types and rock sizes have different shear strengths. Soils on the Forest are generally low in cohesion due to their sandstone-rich parent material and low clay content (see Map 2.5).

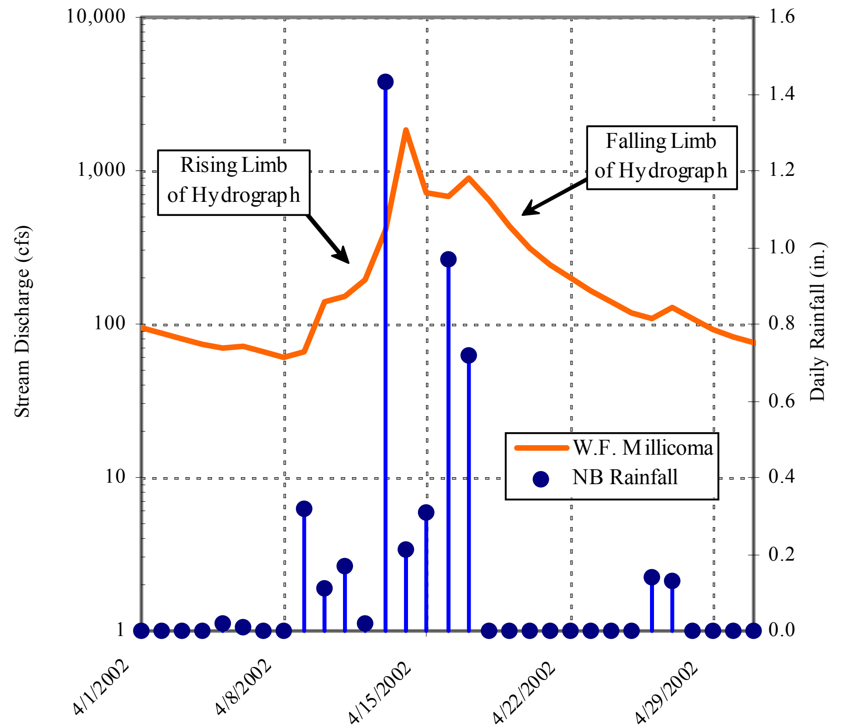
Soils on the Forest also are very transmissive (i.e., permeable) due to their sandy nature. This ability to transmit water limits overland flow that contributes to surface erosion. Water is allowed to travel downslope below the soil surface, sometimes through root pathways or casts. When this water reaches bedrock, the soils above become saturated and increased water pressure induces flows through the soil. This process, on steep slopes, causes a rapid response of streamflow after precipitation.

Figure 6-1 illustrates this streamflow response on the West Fork of the Millicoma River after rains in December 2002. The steep slope of the "rising limb" of the response to rainfall is where most sediment entrainment occurs; sediment deposition is usually associated with receding flows (the "falling limb") following the peak. After about 3 inches of rainfall fell over a 6-day period in December 2002, streamflow sharply increased from about 100 cfs to a peak at 1,100 cfs. This was of sufficient intensity to cause changes in channel location immediately south of the Forest in Hendrickson Creek.

Surfaces with low cohesion can erode especially in channels and slopes with high water concentration or flow. The erosional force from concentrated water flows is expressed as the "stream power" at a specific point. Stream power is a measure of the energy available for moving rock, sediment particles, and woody debris in the stream channel. It is determined by the amount of water above the point and the water surface slope. Resistance to erosional forces is based on a combination of the shear strength of the soil and rock, and the shear and tensile strength of any vegetation cover. Also, vegetation cover acts to reduce the effects of rainfall on soils through canopy interception and evapotranspiration. As a result, places with vegetative cover and intact roots are more resistant to erosion (Roering et al. 2003).

Periods of high surface erosion and mass movement are most closely associated at times when surface critical shear stress is reduced. For example, according to Roering and others (2003), erosion is often accelerated following wildfires when the, "…apparent cohesion due to root re-enforcement" is reduced (Lancaster et al. 2001, Istanbulluoglu et al. 2003). Catastrophic stand-replacing wildfires, while relatively infrequent, may account for the largest portion of the sediment discharged from watersheds over longer time periods (hundreds to thousands of years).

Figure 6-1. Rainfall-runoff relationships in the West Fork Millicoma River.



* NB rainfall is the daily rainfall in North Bend, Oregon, measured at the airport.

GRAVITY-DRIVEN PROCESSES

Soil Creep

Soil creep is a slow, gravity-driven process of downslope movement that is not associated with fluvial (or flowing) water entrainment or suspension. In laboratory settings, soil creep demonstrates a non-linear relationship with landslides (Roering et al. 2003) and can be thought of as a continual downslope micro-adjustment of soil particles. Soil creep rates are difficult to directly measure and have not been extensively investigated (Washington Forest Practices Board 1993). The factors known to influence soil creep rates include soil and rock material, hillslope hydrology, and slope angle. Of factors relevant to creep-driven processes, slope is easiest to estimate, and a simple estimate of soil creep contributions to stream channels can be made.

Methods

Soil creep contributions to streams may be estimated based upon stream lengths adjacent to hillslopes. Assigning creep rates to slope classes allows for this information to be estimated in a GIS using a digital elevation model (DEM). Slope classes were assigned based upon values used in Reneau and Deitrich (1991) and the *South Fork Coos River Watershed Analysis* (Weyerhaeuser 1998). The stream network was overlain on the slope class map and intersected to derive stream length per slope class. A uniform soil depth of 3.280833 feet (1 meter) at the stream bank contact zone was assumed.

The Weyerhaeuser (1993) creep estimates were used to distribute soil creep rates between two slope classes. Slopes less than 30% were assigned an estimated creep rate of 0.0003281 feet per year (0.0001 meters per year). Slopes 30% or greater were assigned a creep rate of 0.0006562 feet per year (0.0002 meters per year). Conservative creep rate estimates were intentionally used because of the lack of field-collected measurements for this extremely slow process.

Results and Discussion

The results of the analysis show that average soil creep sediment yields for the Forest are 4.5 cubic yards per stream mile per year (range 4.4 to 4.9 cu. yd./stream mile/year). On an area basis, soil creep averages about 13.5 cubic yards per square mile per year (range 6.0 to 14.5 cu. yd./sq. mi./year). For the entire Forest, soil creep is estimated to be slightly less than 2,000 cubic yards per year. If this amount is spread evenly across the Forest, it would be less than a sheet of paper in thickness.

This analysis was conducted for the Forest to produce a general estimate of background soil creep sediment contributions into stream channels. As a part of total yield, soil creep represents about 10% of measured sediment in three small, forested Coast Range Basins with similar characteristics (Larson and Sidle 1980). Therefore, it appears that sediment yield attributable to soil creep is relatively small as compared to other sediment-delivery processes such as landslides.

Mass Movement

Landslides are major episodic processes influencing Coast Range topography. This section characterizes the landslide activity in the Forest and similar nearby areas. The spatial pattern of landslides and their influence on fish-bearing streams are examined. Also, human activities that may influence the rate at which landslides occur are discussed. For this discussion, landslides are divided into two types: deep-seated and shallow, rapidly moving. Although deep-seated landslides are less common, their massive, deep-seated flows and slides can contribute large amounts sediments to stream channels. Shallow landslides are common throughout the central Coast Range and are a product of steep slopes, shallow soils, and high-intensity rainfall. Landslides have sculpted the Forest for thousands of years, leaving behind debris fans at the mouths of steep tributaries and V- and U-shaped draws chiseled by successive torrents of soil and rock. The role of vegetation as a control on landslides through surface strength and soil mantle reinforcement is a subject receiving increasing attention (Roering et al. 2003). Also, how fire affects landslide processes through interactions with vegetation and large woody debris was the subject of computerized terrain modeling by Istanbulluoglu and others (2003) and Lancaster and others (2001). The effects of fire will be discussed later in this chapter.

Deep-seated Landslides

Deep-seated landslides have occurred in what is now the Forest. Some of the more massive slides were identified during field geologic mapping efforts (Baldwin and Beaulieu 1973, Niem and Niem 1990) and are shown in Map 2.4. Deep-seated landslides are typically very large and slower moving as compared to more shallow slides, and occur infrequently. Perhaps the last massive deep-seated slide in the Forest region was the slide that blocked Mill Creek and formed Loon Lake.

While usually naturally triggered, these slides may be activated or exacerbated by road and construction activities, especially where traversing steep slopes or cutting through the base of unstable hillslopes and removing buttress supports. Large-scale alteration of stabilizing forest vegetation, such as through extensive wildfire, may alter evapotranspiration and rainfall infiltration rates and trigger earth slumps, flows, or deep-seated mass movements (ODF/DEQ 2002).

Methods

Features associated with deep-seated landslides were identified through combining slope and saturation models in the GIS. Slope and saturation grids were derived from the 10-meter DEM developed for this analysis. This new DEM, using the SINMAP extension to ArcView GIS (Tarboton 1997, Pack et al. 1999) on the original ODF ground control network, provided greater resolution, especially in mid-slope areas. The slope and saturation maps were used as backdrops and overlaid with digitized geologic data on faults, synclines and anticlines (Baldwin and Beaulieu 1973, Beaulieu and Hughes 1975).

Mapped slides by the Department of Geology and Mineral Industries (DOGAMI) and the Loon Lake slide (inferred) were examined for their shape, saturation and slope ranges. Based on this examination, potential areas of deep-seated landslides were identified through a sequence of filters:

1. Regions of low slope not associated with fluvial terraces or floodplains;
2. Regions of features identified in the first criteria that exhibit higher than normal (modeled) saturation levels compared to the surrounding terrain;
3. Those features satisfying the first two criteria that are spatially associated with tectonic features, major mapped faults and folds of the terrain overlays; and
4. In some cases, those areas meeting the previous criteria that are crescent-shaped in plan view provided a crucial factor to screen geomorphic features to detect potential deep-seated landslide deposits.

Results

Map 6.1 shows that the spatial distribution of potential massive deep-seated slides follows a distinct pattern associated with the Mill and Glenn Creek synclines. In all but two areas, the dip angle of bedding planes for the Mill and Glenn Creek areas of interest were greater than 7 degrees (equivalent to 12.3% slope) In this area of the Forest, the eastern and southeastern escarpments of the central highland terrain are populated with the low-slope, crescent-shaped deposits containing adjacent high slope scarps. These are the locations that are highlighted and labeled in Map 6.1 as mass movements.

The DOGAMI data (Baldwin and Beaulieu 1973, Beaulieu and Hughes 1975) also indicates the presence of deep-seated slides not clearly associated with the synclines along the east and southeastern margins of the Forest. These mass movements (Maps 2.4 and 6.1) have occurred in steep terrain elsewhere in the Forest. These slides are found interior to the synclinal margins of the Forest in the West Fork Millicoma River corridor and along the westward Forest boundary with the Coastal and Tenmile Basins. These locations were all steep with high terrain relief.

Discussion

The DOGAMI mapped slides, including the Loon Lake slide, appear to be but a small subset of the potential sites. Because of the limited timeframe, this analysis identifies potential deep-seated landslide deposits through interpretation of GIS data using the criteria and filters described above. To adequately confirm their presence will require field verification. This will likely be more of a theoretical research interest, rather than of management interest, because of the limited ability to either affect the extent or frequency of deep-seated landslides. However, the same processes that generated the deep-seated landslides identified on the maps are still likely to be present.

The low (temporal) frequency of deep-seated slides is implied by the lack of historic record for these large magnitude events. Since the scope and scale of such disturbances would not have gone unnoticed in historical records, these slides are regarded as prehistoric or paleoevents. Baldwin and Beaulieu (1973) estimate the slides near the Mill Creek and Umpqua confluence to be Tertiary in age. Therefore, while these massive slides are significant terrain shaping processes, they are infrequent and not particularly affected by human activities. However, large-scale earth disturbances such as road construction that cuts across the toes of these slide deposits may reactivate slide movement by removing buttressing support along the base of the slide. In addition, earthquakes and canopy removal may play a role in initiating these mass movements.

Shallow, Rapidly Moving Landslides

Shallow, rapidly moving landslides are a dominant natural process in the Tyee geologic basin, and occur on both forested slopes and on slopes where timber harvest has occurred. However, they also can be triggered by road fill failures or the diversion of road runoff water onto unstable areas, especially steep slopes. Shallow, rapid landslides, debris flows, and debris torrents are major contributors to sediment transport between hillslope and channel systems in steep terrain (Benda 1990).

Shallow landslides have been the subject of investigations for over a decade. The Forest has an abundance of geomorphic studies and surveys associated with shallow, rapidly moving landslides. There is an extensive body of literature on shallow landslide processes in the Coast Range that includes geomorphic analysis at Mettmann Ridge near the Forest (Reneau and Dietrich 1991) and investigations specific to the 1996 storm impacts on private, state, and federal forestland (Robison et al. 1999). The study by Robison and others (1999) represents an unprecedented field data collection and analysis effort. Their results support other field-based studies (such as Montgomery and Deitrich 1994) that allow numerical simulation and analyses of landslide initiation triggers, flow behavior, and stream impacts. Additional data exists for a Tenmile Lakes watershed that supplements the Robison results.

The first of the following three sections applies slope stability models by Montgomery and Deitrich (1994) and Tarboton (1997) in the form of ArcView GIS extensions (Deitrich and Montgomery 1998, Pack et al. 1999) to a DEM of the Forest. The second section evaluates a dataset provided by the Tenmile Lakes Basin Partnership (TLBP) of shallow landslides in the Noble Creek watershed. Finally, the third section reviews the findings of the field-based investigations by Robison and others (1999) that include information about landslides in the Elk Creek watershed. Combined, these three approaches represent the full range of investigations of landslides in the Forest.

This analysis should be considered a conceptual model designed to provide an understanding of the relative distribution of unstable terrain across the Forest. Therefore, this general ranking effort will aid in the delineation of subregions of interest for more intensive field survey and analysis.

Methods

An ArcView GIS extension computer model called SINMAP (Pack et al. 1999) was used to evaluate shallow landslide hazards based upon topography. This model relies on terrain slope as a major controlling factor, using a three-dimensional method to determine slopes. A new 10-meter DEM was created by using a statistical interpolation procedure called “kriging” in conjunction with an improved slope algorithm on the point elevation dataset provided by the ODF. The DEM produced through this process is superior to the existing one because it overcomes many of the limitations of evaluating landslides with computer models identified in the Robison and others (1999) study.

As a first approximation, the landslide model assumes a uniform distribution of soil cohesion so that the variable influence of root reinforcement is not included. Even though it is just based on topography, the results provide a useful starting point to evaluate slopes and terrain in the Forest.

Results

The computer model output (Map 6.1) shows regions of the Forest that may have a higher probability of slide initiation. At the larger Forest-wide scale, two areas show a higher likelihood of unstable slopes: the northerly draining watersheds along the Umpqua River and the Tenmile Lakes headwaters. Map 6.1 shows topographically dependant landslide hazards in the northerly draining watersheds along the Umpqua River below the Mill Creek confluence. The excessively steep terrain is unstable when compared to the lower slope interior regions of the Forest. Terrain that is predisposed to rapidly moving shallow landslides also is found along the Mill Creek Basin, interspersed and sometimes superimposed over massive, deep-seated slide deposits. Tributaries with names such as "Slide-out Creek" characterize the southeast margin of the Forest.

The Tenmile Lakes headwaters also are exceptionally steep, second only to the Umpqua tributary watersheds. The landslide scars in the Tenmile Lakes area (TLBP 2003) discussed in the next section provide an indication of this area's propensity to landslide. The interior West Fork Millicoma Basin has less severe slope when compared to the Umpqua or Tenmile regions. Nevertheless, field survey efforts (Robison et al. 1999, Roering et al. 2003) indicate numerous landslides in this area resulting from 1996 precipitation events. The methods and survey intensity in these surveys provides the greatest level of detail in field mapping and description of landslides in the Forest.

The computer model results do not include the influence of soil stability from the presence of roots. While root strength is known to be important an influence on landscape geomorphology (Schmidt et al. 2001, Istanbulluoglu et al. 2003, Roering et al. 2003), it varies at finer scales than are detectable in available Forest datasets. However, more complex landslide models often incorporate stand age as an indicator of root strength contributions to slope stability. Field-mapped landslide initiation point data have been collected for the Elk Creek (Robison et al. 1999) and Tenmile Lakes Basins (TLBP 2003). In combination with stand ages, this data provides an initial point for discussing the effects of overstory vegetation, particularly stand age, on landslide hazard.

Noble Creek Landslide Study (TLBP 2003)

In addition to the computer models, field inventories of landslides in the Forest have occurred in the Elk Creek watershed, in some Mill Creek tributaries (Double Barrel and three small streams draining directly into the Umpqua River above Mill Creek), and in the Tenmile Lakes watershed (Big, Noble, Benson and Johnson Creeks). The Elk Creek and Mill Creek tributary studies were conducted by the ODF (Robison et al. 1999), while the Tenmile Lakes watershed surveys were done by the TLBP as part of their assessment process (TLBP 2003). Road-related landslide information also was compiled during ODF's 1997-1998 Forest-wide road inventory (see Map 6.2).

Methods

Field protocols for the Elk Creek (Robison et al. 1999) and Noble Creek (TLBP 2003) landslide surveys were fairly similar. Most importantly for each of the basins, draws were walked from bottom to top and any slides noted. Although the Noble Creek survey collected fewer specific items than the Elk Creek survey, it did include aspect, slope (%), source of the slide, vegetation type at point of initiation, slide dimensions, and whether sediment from the slide entered a waterway. In addition, field observations for the route of the slide were made, photographs taken, and the path of the slide mapped onto USGS quadrangle sheets.

Results

Landslide density for the Noble Creek Watershed following the 1996 storm events was 0.017 landslides per acre. Landslide run-out paths averaged 802 feet and ranged from 130-5,020 feet in distance traveled. The distribution of average landslide path lengths (in % of total slide length) between differing vegetation environments are presented in Table 6-1.

Table 6-1. Average landslide volumes in Noble Creek based on vegetation class at origin.

Parameter	Noble Creek
Study Area (sq. mi.)	3.9
Landslide Density (#/sq. mi.)	10.88
Landslide Density; entered fish-bearing stream (#/sq. mi.)	7.95
Density of fish-bearing streams (mi./sq. mi.)	1.09
Number of landslides that occurred throughout the study area	42
Number of landslides that entered fish-bearing streams	31
Percentage of landslides that entered fish-bearing streams	73.8%
Average volume of landslide that entered fish-bearing streams (cu. yd.).	2,280

Landslides reaching a channel (31) comprised 74% of the 42 total landslides. Of the landslides reaching the channel, 47.1% originated in a recent clearcut, an additional 10.2% in an old clearcut, and 6.8 % originated in mature vegetation. Overall, landslides traveled a cumulative 6.38 channel miles and impacted 0.55 miles (12.9%) of fish-bearing streams in the Noble Creek watershed. One landslide in Noble Creek is an anomaly due to its extreme length (nearly 1 mile) and may be the result of the combined, near-simultaneous failures in the tributary channel feeding this slide.

Discussion

Landslides that occurred in the Noble Creek watershed during the 1996 floods were surveyed using a structured method that included both air photo interpretation and field-based identification and measurement. This survey produced landslide data that may prove valuable given additional processing and analysis. A cursory examination of the TLBP data indicates that landslides in this basin were not unusually dense, although they were large in average volume. Examination of the field data and digitized maps shows that a large percentage (74%) of the total landslides in the Noble Creek watershed entered fish–bearing streams. These slides averaged over 800 feet in run-out distance, and deposited material along 13% of fish-bearing stream length in the watershed.

No slides that originated in “reprods” (reforested units) reached a stream channel. However, since there was only one sample point for the reprod class, no inference can be made from this statistic concerning significance. The same is true for the “mature” class; due to the low relative proportion of samples in this class, no inference can be made stating the significance of mature vegetation environment and run-out length. Therefore, without additional processing steps and ancillary data, the TLBP dataset is of limited utility and cannot be evaluated on the same basis as the Robison and others (1999) data. These limitations can be overcome by:

1. Compiling and expanding stand age data (circa 1996) from the non-Forest portions of the Tenmile Lakes Basin (a patchwork of ownership) from harvest records and additional air photo analysis.
2. Fully capturing and digitizing the entirety of the TLBP data available in existing field forms into a GIS-compatible format to include survey data and all other attributes (stand volume, valley forms, hillslopes, etc.) from all watersheds in the Tenmile Lakes Basin.

These steps should increase the slide sample numbers and improve the ability to make inferences concerning vegetation effects on slope failure points and landslide run-out distances. This information could then be reliably integrated into a larger dataset of slides for the Forest.

ODF Landslide Study (Robison et al. 1999)

A study was conducted by the ODF in 1997 on landslides following intense rainfall in November and December 1996 (Robison et al. 1999). All landslides were identified and characterized in the field. Results from three study areas that were in steep, sandstone geology in the central Coast Range that were particularly hard-hit by the 1996 storms are reported below. One area was Elk Creek in the upper West Fork Millicoma River on the Forest. Another area, Scottsburg, was along the northeast boundary of the Forest overlooking the Umpqua River and Mill Creek. A third area, Mapleton, was 35 miles to the north in similar terrain and geology. Partial results also were included for a fourth area (Vida). Unlike the other areas, the Vida area is the western Cascade Mountains and is underlain by highly variable volcanic rock and slopes are long with little dissection.

Landslides not related to roads, or in-unit landslides, averaged 11-23 per square mile following the 1996 storms and was highest for the Elk Creek area and lowest for the Mapleton area (Table 6-2). Nearly 70% of the in-unit landslides occurred on hillslopes with the remainder occurring next to or in the channel. The upslope landslides had considerably more volume, on average, than the channel landslides (Table 6-2).

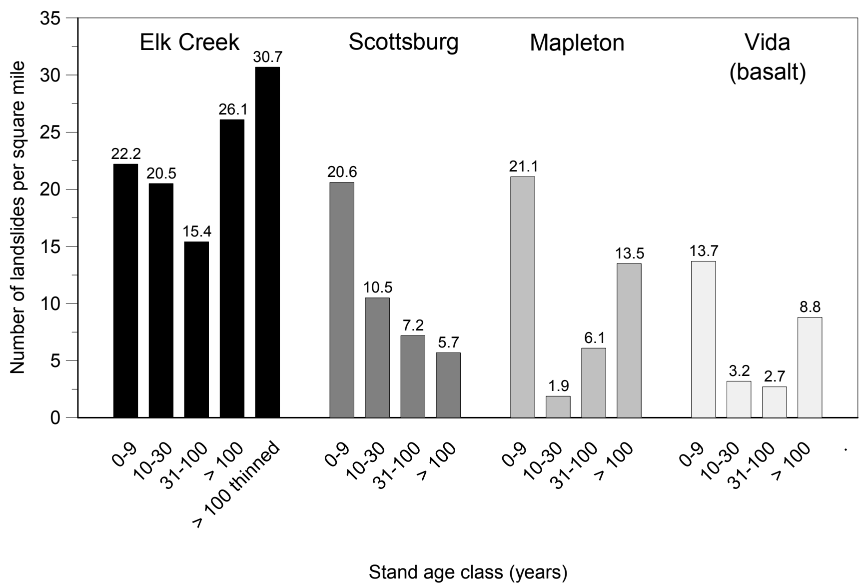
Table 6-2. Landslide characteristics for three study areas in steep sandstone terrain of the central Coast Range following the 1996 storms.

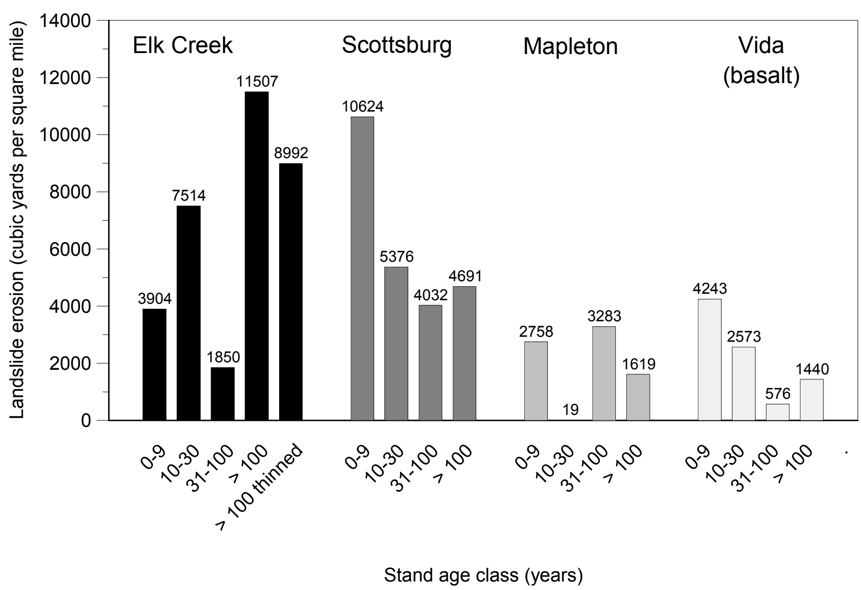
Parameter	Elk Creek	Scottsburg	Mapleton
Storm during which most landslides occurred	Nov. 1996	Nov. 1996	Feb. 1996
Study area (sq. mi.)	6.53	7.10	8.29
Landslide density; all (#/sq. mi.)			
Upslope	15.6	10.8	7.1
Channel	7.5	2.5	4.3
Road	1.2	1.4	1.6
Combined	**24.3**	**14.8**	**13.0**
Landslide density; entered fish-bearing streams (#/sq. mi.)			
Upslope	6.9	7.0	2.4
Channel	2.3	1.8	0.6
Road	0.2	0.6	0.2
Combined	**9.3**	**9.4**	**3.3**
Density of fish-bearing streams (mi./sq. mi.)			
Road along stream	1.5	0.7	0.4
No road along stream	0.2	0.9	1.1
Combined	**1.7**	**1.6**	**1.7**
Number of landslides that occurred throughout the study area	159	105	108
Number of landslides that entered fish-bearing streams	61	67	27
Percentage of landslides that entered fish-bearing streams			
Upslope	44	65	34
Channel	31	72	14
Road	38	40	15
Average volume of landslide material that entered fish-bearing streams (cu. yd.)			
Upslope	521	412	773
Channel	40	27	259
Road	691	181	3492

Landslide density decreased with increasing age of trees growing on the slope for the Scottsburg area, with the density for the 100-year age class only about one-quarter of that for recent clearcuts (0-9 years). The erosion associated with landslides in the 0-9 year age class was about twice that of the other age classes (Figure 6-2).

The Elk Creek area showed opposite results; areas supporting trees older than 100 years had higher landslide density and erosion. The landslide density within intact 100-year-old stands was greater than the density in newer clearcuts (26 versus 22 landslides per sq. mi.) and the erosion rate was over two times higher for the older stands. The higher landslide density in older timber for the Elk Creek area cannot be explained by the terrain being steeper where these stands exist. For both the younger clearcuts and the stands older than 100 years, the percent of land with a slope of 60% gradient or greater was slightly more than 50%. Also, the higher landslide density in older timber cannot be explained by an unusually unstable area within part of the basin. Landslides in this stand age class occurred somewhat uniformly throughout the basin.

Figure 6-2. Landslide density (top) and erosion (bottom), not related to roads, for three areas of sandstone geology in the central Coast Range and one area of basalt geology in the Cascade Mountains following intense rainfall in December and February 1996.





Source: Robison et al. 1999.

Both landslide density and erosion volume in the Mapleton area was 1.6 times higher in newer clearcuts as compared to stands older than 100 years. The landslide density in the basalt Vida area also was 1.6 times higher in newer clearcuts than in areas with stands older than 100 years. In the Vida area, erosion volumes were nearly three times higher for the clearcuts (Figure 6-2).

Three out of four areas showed that landslide density was higher in newer clearcuts than in areas with stands older than 100 years. However, there was not a significant statistical difference in the means between the newer clearcuts and the mature stands when the four study areas were compared using a paired t-test ($P = 0.2$). Similarly, there was not a significant statistical difference for erosion volumes ($P = 0.9$). Consequently, when viewed as a replicated experiment, the data from Robison and others (1999) does not support a conclusion that landslides are denser or cause more erosion in clearcuts than in mature stands. When viewed as a case study, the pooled results for the four study areas indicate that landslide density was 1.5 times greater in the newer clearcuts (0-9 years old) than in mature stands.

In their report, Robison and others (1999) made an adjustment to the landslide density because slope steepness was somewhat less in the newer clearcuts than in the mature stands. With this adjustment, they concluded that the landslide density was two times greater in the newer clearcuts than in mature stands. In contrast to the landslide density, pooled results for erosion volume indicate that erosion was 1.4 times greater in mature stands than in the newer clearcuts. The pooled results for erosion are skewed by the relatively high values for mature stands in the Elk Creek area.

At three of the four areas, landslide density in 31-100-year-old stands was less than either the slopes with new clearcuts or mature stands (Figure 6-2). This 70-year relative lull in landslide activity may be a result of vulnerable areas having already failed during the first 30 years after clearcut logging, followed by a period of high tree density across the slopes and the refilling of hollows with soil and gravel through creep and ravel processes.

The majority of upslope landslides did not directly affect fish-bearing streams, except in the Scottsburg area. About one-third of upslope landslides in the Mapleton area reached fish-bearing streams, while this value was 44% for the Elk Creek area. In contrast, a majority of upslope landslides in the Scottsburg area (65%) reached fish-bearing streams. Most upslope landslides occurred in a western subbasin (Double Barrel Creek) of the Scottsburg area, where nearly every channel experienced a debris torrent and then funneled into Mill Creek, a fish-bearing stream. It is possible that this subbasin received an inordinate amount of rainfall during the November 1996 storm.

The material transported downstream by landslides to fish-bearing streams rarely set up jams of wood, rock, and sediment in the streams (Table 6-3). Only 8% of landslides (all types) could be associated with a debris jam at its junction within a fish-bearing stream or a short distance downstream of the junction. The volume of material in the debris jams averaged 1,277 cubic yards. Overall, the material in debris jams in fish-bearing streams averaged only 216 cubic feet per 100 feet of stream.

Table 6-3. Jams of wood, rock, and sediment transported by landslides into fish-bearing streams.

Parameter	Elk	Mapleton	Scottsburg	Combined
No. of landslides entering fish-bearing streams	64	27	53	144
No. of associated with a nearby debris jam	3	3	6	12
Percent with debris jam	5	11	11	8
Average volume of debris jams (cu. yd.)	830	280	2,000	1,280

Most debris jams were relatively small (less than 200 cu. yd.) but averages were highly influenced by several large debris jams (up to 9450 cu. yd.). At each of the three sites, some landslides ended up in large streams or rivers that were capable of transporting large wood and rock far downstream during high flows. Because the field survey was not conducted during the storm, much of the coarse material could have been washed far downstream by the time observations were made. Only 1 of the 144 landslides that entered fish-bearing streams continued downstream upon encountering a fish-bearing stream. For the single exception, the debris torrent traveled 500 feet down the fish-bearing stream.

The distance upslope from fish-bearing streams where landslides originated averaged from 350-500 feet among the three sandstone study areas (Table 6-4). However, the distribution of distances was spread uniformly from 50-1,000 feet and exhibited no central tendency (Figure 6-3). Slope gradients (measured in the field) at landslide initiation points also varied widely (Table 6-4, Figure 6-3). Nevertheless, for about 90% of the landslides, the slope gradient was 70% or more at the initiation point.

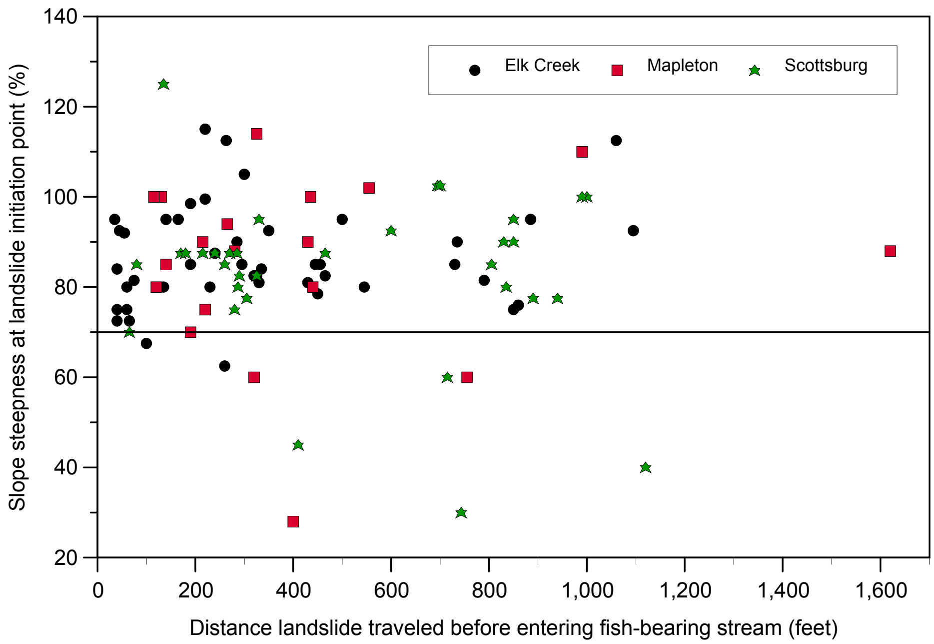
Table 6-4. Distance from initiation point to fish-bearing stream and slope steepness at initiation points for landslides that ended up in a fish-bearing stream.

Parameter	Elk	Mapleton	Scottsburg
Distance from landslide initiation point to fish-bearing stream Average and range	350 feet 40-1,100 feet	390 feet 110-1,620 feet	500 feet 60-1,120 feet
Slope steepness at initiation point Average and range	87% 62%-115%	86% 28%-114%	83% 30%-102%

Discussion

Shallow, rapidly moving landslides are common throughout the Forest when triggered by unusually intense rainfall, such as during the November 1996 (Robison et al. 1999) and 1982 storms (Schroeder and Brown 1984). Landslide frequency during normal winters is much lower. Factors commonly hypothesized to influence the rate and density of shallow landslides include rainfall distribution, duration and intensity, slope, subsurface flow concentration, soil properties and depths, vegetation cover, biomass weight, root strength, root density, and influence of fires.

Figure 6-3. Distribution of slope steepness at landslide initiation point and distance traveled to fish-bearing stream for upslope landslides inventoried after the 1996 storms.



Terrain slope is the most critical factor in the evaluating shallow, rapidly moving landslides. Surface shape also affects the slide initiation, largely due to its influence on directing runoff accumulation and soil saturation. In the Forest and in other coastal State Forest units, the ODF study (Robison et al. 1999) confirmed the findings by Montgomery and Deitrich (1994) concerning the primary control that slope plays on slide and flow processes.

The role that vegetation plays in landslide processes is both controversial and in dispute. An overview of perspectives on the effects of vegetation on landslide processes is discussed below.

Point 1. Vegetation intercepts rainfall, thus reducing infiltration rates. Interception of high-intensity rainfall by the tree canopy and the consequent moderation of the rate at which precipitation hits the ground may be another mechanism by which forest areas generally generate fewer landslides than new clearcuts (Keim and Skaugset 2003). Through modeling of high-intensity precipitation and water infiltration through soils with and without a forest canopy, Keim and Skaugset (2003) noted a distinct moderating influence on peak soil pore pressures when a forest canopy was present.

Point 2. Vegetation roots bind soil and increase resistance to shear forces. Tree roots may play an important role in the timing of landslides in this region (Burroughs and Thomas

1977, Gresswell et al. 1979, Sidle 1987). Surface vegetation mechanically binds soils and augments soil cohesion. Vegetation age, stem distribution and spacing are the primary variables controlling this effect due to their influence on the root tensile strength, rooting depth, and interlocking among roots from different plants. The decay of tree roots following clearcut harvesting could open up a window of landslide vulnerability that persists until roots from the next rotation of trees reoccupy the soil mass.

Results in the Elk Creek and the Mapleton area show renewed susceptibility to slides as stand cohorts reached late maturity. It has been suggested that this occurs in part due to increasing space between trees (and roots) due to progressive tree mortality and other factors affecting the spatial distribution of tree, shrub and groundcover and their root structure and extent (Roering et al. 2003). Robison and others (1999) data suggest that slide susceptible periods peak in the first decade after root death due to fires or harvest activities and then rise again after about one century.

Point 3. There is often little vegetation, especially conifers, at slide locations. Many landslide initiation areas are too wet or unstable to grow conifers, and instead support brush and hardwoods (Robison et al. 1999). Field examinations in steep, sandstone geology north of the Forest by Bransom (1990) indicate that conifer roots rarely penetrated into predicted zones of slope instability or hollows. Instead, root masses within these hollows were mostly of brush and hardwood species, which have lower root strength than do conifers (Skaugset 1997). Roering and others (2003) provide a discussion of this effect in their analysis of the Forest and Mapleton landslide study areas used in the ODF study.

Point 4. Landslides can deposit material in fish-bearing streams. The ODF study (Robison et al. 1999) indicates that almost half (44%) of upslope landslides in Elk Creek, and almost two-thirds (65%) of upslope landslides in the Scottsburg area end up in fish-bearing streams (Table 6-2). The results from the TLBP (2003) survey of Noble Creek showed that 74% of slides there ended up in fish-bearing streams (Table 6-1).

Point 5. There is little field data to support the role that vegetation plays in landsliding. The ODF study (Robison et al. 1999) allows for a comparison of landslide density and related erosion for stands of various ages for terrain similar to that found on the Forest. A field-based study on similar geology conducted further north on the Siuslaw National Forest found that landslide rates were 1.3 times higher in recent clearcuts than in intact older forest (Table 6-5); for the steepest and most unstable soil type, landslides rates density was 3.4 times more frequent in recent clearcuts (Ketcheson and Froehlich 1978).

A similar field-based study also conducted in the 1970s on the Siuslaw National Forest, found that landslide density was actually lower in recent clearcuts than in mature timber over the study area (Table 6-5; Swanson et al. 1981). However, for the steepest and most unstable soil type, landslide frequency density was 1.3 times greater for clearcuts. Erosion volume associated with these landslides was 2-12 times higher in clearcuts than in mature timber for the two studies, depending on soil type.

Table 6-5. Density of shallow, rapidly moving landslides (not related to roads) and associated erosion.

Study	Landslide Density (#/sq. mi.)		Landslide Density; Ratio of Clearcut to Mature Timber	Landslide Erosion; Ratio of Clearcut to Mature timber
	Recent Clearcut	Mature Timber		
Ketcheson and Froehlich (1978)				
All soil types	30	23	1.3	4
Steepest and most unstable soil type	58	17	3.4	12
Swanson et al. (1981)				
All soil types	15	21	0.7	2
Steepest and most unstable soil type	27	21	1.3	4
Robison et al. (1999); all soil types				
Elk Creek area	22	26	0.8	0.3
Scottsburg area	21	6	3.5	2.3
Mapleton area	21	13	1.6	1.7
Vida area	14	9	1.6	3.0
Combined	**19**	**13**	**1.5**	**0.7**

WATERSHED SEDIMENTATION FROM FIRES

Natural Fire Regimes

While not frequent in occurrence, large magnitude, catastrophic fires have preceded periods of accelerated erosion and stream sedimentation. These natural disasters no doubt decimated local aquatic systems, but also played a key part in the cycling of nutrients and stream substrates and channel structure. Aquatic systems, which have co-evolved with the dynamic landform processes and climate, have the ability to recover from these disturbances over longer time frames:

> "…under a natural fire regime … streams in the upper drainage experience large sediment deposits (>1 m thick) infrequently (once every hundreds of years) because sources of mass failure are few and sediment bedload transport rates are low" (Reeves et al. 1995).

Large post-fire sediment pulses occur during accelerated erosion periods following infrequent large fires (Istanbulluoglu et al. 2003). Over time, these fire-weather driven events (including both human- and lightening-caused) may account for a large proportion of sediment discharged from the upper basins to storage in low order fluvial channel environments.

Anthropogenic Fire Regimes

Prescribed fires associated with site preparation are of smaller scale in terms of sediment production due to their low fuel loading, fire weather, and scale. Also, riparian buffers remain intact as filter strips and trap fines generated in prescribed burns. The Forest often exceeds the best management practices for riparian buffer widths. Therefore, the relative contribution of sediment from in-unit burns is expected to be minimal in volume, but perhaps more frequently occurring when compared to the rare but severe stand-replacing wildfire. Broadcast burning associated with in-unit activities is discussed below.

Human-ignition Wildfire

Human-ignition wildfire presents a significant potential hazard for Oregon forests, including the Elliott, and conceivably could increase immediate short term yields of sediment of several magnitudes greater than expected in prescription environments. The presence of fire weather conditions greatly exacerbates risk and is not within human control as are thinning and suppression readiness factors.

Broadcast Burning and Yarding

The baring and displacement of soil during log yarding or skidding has the potential of accelerating sediment loads into streams. The risk is higher on steeper slopes and especially if ground-based logging requires the excavation of skid trails. Intense broadcast burning also can accelerate sedimentation by consuming logs and other organic material; on steep slopes, soil and rock that has built up behind the wood is released (Bennett 1982), and a portion of this buildup may end up in stream channels. This phenomenon is likely of minor consequence for fires of lesser intensity since they leave many larger pieces of wood intact.

Accelerated sedimentation in streams following yarding or skidding of logs and broadcast burning has been evaluated for only a few small watersheds in the Pacific Northwest and some of these studies occurred decades ago, a time when the treatment of soils and streams during logging was occasionally severe. Current practices usually involve much less soil disturbance and less intense burning than what occurred decades ago. In Table 6-6, sediment loads from forested and logged (and some burned) small drainages are presented. These examples are limited this in selection to studies where road-caused landslides were not a major contributor to the overall suspended sediment load.

An extreme case of logging and site preparation intensity occurred in the Needle Branch drainage, located in steep, sandstone terrain of the central Coast Range. The entire basin was clearcut logged using a high lead cable system, intensely burned following harvest, and the stream channels were cleared of most wood. In the lower reaches, stream cleaning was done with the blade of a crawler tractor. These activities produced a three-fold increase in suspended sediment yield that persisted for a number of years and likely represent some of the highest increases in sediment yield possible using practices that have since been replaced with gentler approaches to keeping soil on site.

An equally intensive broadcast burn following logging occurred within Basin #1 of the H.J. Andrews Experimental Forest in the Cascade Mountains. The suspended sediment yield jumped 23 times higher than it was prior to these activities. Sediment yields were significantly less in nearby Basin #6 that had been 100% clearcut and burned, but not intensively. When compared to the sediment yields of two other basins, one forested (#8) and one with half its area partially cut, the sediment differences were small.

Table 6-6. Comparison of the annual suspended sediment yield for forested basins and basins logged and broadcast burned in Oregon.

Study	Average Slope for Basin	Condition	Mean Annual Suspended Sediment Yield (lbs./ac./yr.)
Alsea, Coast Range			
Needle Branch	37%	Forested	473
Needle Branch	37%	Roaded, 100% clearcut, intensely burned, channel clearing	1393
H.J. Andrews, Cascade Mts.			
Basin #1	63%	Forested	71
Basin #1	63%	100% clearcut, intensely burned	1634
H.J. Andrews, Cascade Mts.			
Basin #8	30%	Forested	98
Basin #7	31%	50% partial cut	22
Basin #6	28%	Roaded, 100% clearcut, burned	116
Fox Creek, Cascade Mts.			
Watershed #2	8%	Forested, roaded	18
Watershed #3	8%	Roaded, 25% clearcut	24
Watershed #1	8%	Roaded, 25% clearcut, lightly burned	26

Source: after Larson and Sidle 1980.

Three small watersheds with gentle terrain in the Fox Creek watershed had nearly identical suspended sediment yields even though one was forested, another 25% clearcut, and the other 25% clearcut and lightly burned.

The limited information provided by these studies suggests that intense broadcast burning is a major cause of accelerated soil erosion following clearcut logging on steep terrain, while lighter burns have relatively little influence on suspended sediment loads in streams. Also, there is little to suggest that log yarding alone contributes much sediment to streams.

Current yarding, burning, and riparian buffer practices on the Forest seem well suited for keeping sediment out of streams. Buffers of intact vegetation are retained along all perennial streams and brush is retained (and not sprayed) along intermittent channels. Skyline cable logging systems with carriages are used to provide at least one end suspension of log loads. Ground-based yarding occurs only on the few areas in the Forest where slopes are gentle. There is no use of excavated skid trails on steeper slopes. Broadcast burning is limited to about 15% of the clearcut acreage (about 70 acres per year). Selected areas are burned lightly (only material less than 2 inches in diameter is consumed by the fire) and then planted with forage crops to improve elk forage.

OTHER ANTHROPOGENIC SEDIMENT SOURCES

While the erosion and sediment processes described above are natural and play a major role in forming stream habitat, additional sediment inputs above natural levels may have deleterious effects on a wide range of aquatic species. There are two primary sources for these added sediment inputs: (1) episodic road-related landslides and wash-outs, and (2) the chronic sediment generated from erosion from unvegetated cut banks, ditches, fill slopes (at stream crossings) and the surface of hydrologically connected Forest roads.

Roads

There is a substantial body of knowledge documenting the influence of roads on sediment production and fill failure in steep terrain (Beschta 1978, Reid and Dunne 1984, Bilby 1985, Duncan et al. 1987, Bilby et al. 1989). These studies identified the following key factors for determining sediment production from roads: topographic position; slope/ground slope; age; side-cast extent/fill slides; surface type/levels of use; and drainage feature failure/road wash.

This discussion starts with road-related landslides, since they have been most evident over the years due to their size and extent. However, sediment generated from road surfaces, ditches, crossing fill and cut banks can have even greater effect because it is chronic (generated almost continuously with road use and delivered during wet periods), and the smaller particle sizes from this source have more potential to damage fish, gills of invertebrates, and spawning beds. Surveys of roads on the Forest were used to identify road-related landslides. These include road drainage surveys conducted in 1997-1998 and the study by Robison and others (1999) that focused on landslides in the Elk Creek Basin resulting from the exceptional storm events of 1996. Also, an updated survey of roads in the Elk Creek Basin was conducted as part of this analysis.

Road Position

As mentioned previously, the Forest road system is of sufficient age that many of the potential hazards discussed above have already occurred. Past road failures were repaired using best practices at the time, or in some cases the roads were relocated or decommissioned. Maintenance levels reflect high standards for the road system. Nevertheless, Forest roads traverse steep terrain, cross large numbers of streams, and run adjacent to fish-bearing streams. Continued high levels of investment in the road system will be necessary to avoid adverse impacts during activities for which the Forest was established.

New ODF forest practices guidelines (ODF 2003) identify six critical locations where roads are especially hazardous or sensitive: stream channels; riparian management areas; wetlands; areas conducive to cut-bank failures; toes of past landslide deposits; and steep, dissected slopes not conducive to full bench and end haul construction methods. The analysis in this section focuses on road location as a broad tool to identify and evaluate the relative magnitude of these road position hazards. The analysis is a broad landscape-level look at the roads and highlights areas for additional detailed investigations.

Methods

A GIS was used to determine road segments on the ridgeline, mid-slope, and streamside landscape positions. Information from the slope map (Map 2.4) was combined with road attribute information to create a map of Forest road types and surfaces. Road types were classified into one of four types: ridgeline, mid-slope, streamside, and valley. Streamside roads are those within 100 feet of streams, while valley roads are those located in broad, flat plains outside the 100-foot riparian zone. The ridgeline type includes road segments with less than 1/20th of an acre of upslope drainage. Through a process of elimination, roads were classified as mid-slope if they did not fulfill any of the previous three criteria. Using attribute information in the Forest road layer, roads were further differentiated by surface type: gravel, dirt, or unclassified. The results of this analysis are displayed in Map 6.3. Table 6-7 summarizes the number of miles in each road surface type and landscape location by 5th field HUC.

Table 6-7. Miles of various road types and their landscape location in the Forest by watershed and 5th field HUC.

Basin and 5th field HUC	Road Surface	Road Landscape Position				Totals	Percent
		Riparian	**Valley**	**Mid-slope**	**Ridge**		
Umpqua Region							
Lower Umpqua	Dirt	0.6	0.0	7.0	11.8	19.5	24.8%
	Gravel	2.1	0.8	16.4	39.4	58.7	74.8%
	Unclassified	---	---	0.3	---	0.3	0.3%
	Total	*2.7*	*0.8*	*23.7*	*51.2*	*78.4*	---
	Percent	*3.5%*	*1.0%*	*30.2%*	*65.3%*	---	---
Mill Creek*	Dirt	0.1	2.7	5.4	8.6	16.7	30.4%
	Gravel	2.5	1.6	15.2	18.7	38.1	69.0%
	Paved	---	0.1	---	---	0.1	0.2%
	Unclassified	---	---	0.2	---	0.2	0.3%
	Total	*2.6*	*4.4*	*20.8*	*27.8*	*55.1*	---
	Percent	*4.6%*	*8.0%*	*37.8%*	*50.5%*	---	---
	Region Total	**5.3**	**5.3**	**44.5**	**79.0**	**133.6**	---
	Region Percent	**4.0%**	**3.9%**	**33.3%**	**59.2%**	---	---
Tenmile Lakes Region							
Tenmile Lakes	Dirt	---	1.9	4.3	15.3	21.6	21.8%
	Gravel	---	0.1	24.9	50.8	75.7	76.4%
	Unclassified	---	---	1.0	0.8	1.9	1.9%
	Region Total	**---**	**1.9**	**30.2**	**67.0**	**99.1**	---
	Region Percent	**---**	**2.0%**	**30.5%**	**67.5%**	**---**	---
Coos Bay Region							
Coos Bay	Dirt	---	---	0.6	1.6	2.2	6.5%
	Gravel	1.2	0.3	9.8	21.0	32.2	93.3%
	Unclassified	---	---	---	0.1	0.1	0.3%
	Total	*1.2*	*0.3*	*10.3*	*22.7*	*34.5*	---
	Percent	*3.3%*	*0.8%*	*30.0%*	*65.9%*	---	---
Millicoma River	Bridge	---	---	0.2	---	0.2	0.1%
	Dirt	0.5	2.2	21.8	34.8	59.4	22.1%
	Gravel	16.2	19.2	65.8	97.9	199.1	74.0%
	Unclassified	0.1	0.2	4.5	5.5	10.4	3.8%
	Total	*16.9*	*21.6*	*92.4*	*138.2*	*269.0*	---
	Percent	*6.3%*	*8.0%*	*34.3%*	*51.4%*	---	---
	Region Total	**18.0**	**21.8**	**102.7**	**160.9**	**303.5**	---
	Region Percent	**5.9%**	**7.2%**	**33.8%%**	**53.0%**	---	---
	Grand Total	**23.3**	**29.0**	**177.5**	**306.4**	**536.2**	---
	Grand Total Percent	**4.4%**	**5.4%**	**33.1%**	**57.1%**	---	---

* Includes roads in 211 acres of the Middle Umpqua 5th field HUC.

Results

Map 6.3 illustrates the predominance of ridgeline roads in the Forest. There are no consistent criteria for discriminating between ridgeline and mid-slope road locations. Theoretically, a ridgeline road would have no drainage onto the road surface from adjacent slopes and therefore, no ditches. However, while ridgeline roads on the Forest do follow divides, they also traverse the side slopes of peaks along the ridgeline in order to maintain reasonable grades. Based on discussions with the Forest staff, a small threshold was set for contributing drainage area (1/20th acre) to account for these areas. The resulting ridgeline roads seem to conform well to the ones commonly considered to be in this class.

Based on these criteria, over half of the roads (57%) in the Forest are situated on ridgelines. Close inspection of Map 6.3 and Table 6-7 indicates that mid-slope roads represent about one third of the overall road network. Roads located within 100 feet of stream channels comprise 4.4% of the overall Forest road mileage, with the remainder (5.4%) in valleys.

In the Forest, ridge density in the eastern and northern portions is higher than for other portions. Therefore, it is not surprising that these ridges are heavily utilized as routes because they are the preferred road location. Half of the mid-slope roads (92 miles) are found in the Millicoma portion of the Forest, where landforms are less severe than in the steeper Umpqua and Tenmile regions. Almost three-quarters of the streamside roads in the Forest are located within the basins of the West and East Forks Millicoma River watershed.

Discussion

Road position varies between physiographic regions of the Forest and partially reflects the suitability of terrain to roadway location. Ridgeline and riparian road locations are prevalent in the steeper Tenmile and Umpqua regions, while moderately sloping terrain in the interior of the Forest has a higher proportion of roads in mid-slope position.

Table 6-8 illustrates the influence of the landscape position of the road (ridgeline and mid-slope roads) on the risk of episodic sediment delivery to streams. While the frequency of slides, especially smaller ones, does not vary greatly between ridgeline and mid-slope roads, the volume of landslide debris transported downslope does.

Ridgeline roads are generally good road locations to minimize fill failure hazards and hydrologic connectivity between road drainage the stream channel network. Forest roads located along ridgelines contribute little sediment directly to streams unless drainage feature failures trigger slides by concentrating flow on road fill or onto unstable headwalls and hollows (Montgomery 1994). However, even these ridgeline road segments need to be evaluated for drainage ditch needs where runoff from small hillslopes above the road combines with that from the road surface and is routed into steep, concave valley headwalls. Detailed examination of the GIS results, in concert with input from Forest staff and field review, can identify specific problem locations.

Table 6-8. Percentage of slides by slide volume interval and mean slide volume for ridgeline and mid-slope roads.

Slide Volume Interval (cu. yd.)	Percentage of Slides		Mean Slide Volume	
	Ridgeline	Mid-slope	Ridgeline	Mid-slope
0 - 99	55	53	33	35
100 - 199	18	14	103	135
200 - 399	27	11	271	249
400 - 999	0	16	0	610
1000 - 1999	0	5	0	1,249
> 2000	0	1	0	3,134

Adapted from Sessions et al. 1987.

Mid-slope roads are of management concern because of hazardous road prism fill failures that result in subsequent downslope delivery of sediments to stream channels. Many of these roads have high side slopes and some have a legacy of side-cast construction. Plugged drainage culverts and excessive spacing between culverts on mid-slope roads can erode the roadbed, fill, and ditches (Mills 1997). While mid-slope roads are needed to move traffic from streamside to ridgeline positions, a high level of maintenance is needed to adequately maintain them. Features that reduce potential hazards include increasing the frequency of vertical/linear spacing of drainage features, efficient sizing of ditches and relief culverts, and maintenance (Rashin et al. 1999).

Where roads and drainage features are stacked (positioned above other roadways and crossing identical slopes and channels), there is a potential for hazardous fill failures. A good example of stacked roads is the 7400 Road where it climbs out of Fish Creek (NE1/4 NW1/4 sec 5, T.23S, R.10W). The risk in these situations is that failure of the upper section of roadway may result in debris torrents or concentrated volumes of water to the lower roadway. In some cases, the lower road may catch the flows; however, serial failures can exponentially increase sediment delivery downslope. Hazards resulting from stacked roads can be reduced by insuring continuity of drainage from top to bottom, correct culvert sizing at each crossing, and that each culvert has a appropriately- sized downspout routing drain water to stable slopes.

Streamside roads and stream crossings are of particular concern given their ability to contribute coarse sediments and suspended fine sediments directly to streams. While not prevalent, portions of Forest roads along streams in confined valleys that encroach upon the stream channels create a hazard if the fill slides into or is eroded by the stream. Additionally during grading, small berms of maintenance cast may be created along the edge of the road and has the potential to slide directly into the channel. While minor as episodic events, these sources are chronic sediment contributors especially during the first rains after grading, on heavy haul roads where gravel is broken down, or during wet hauling. Streamside road mileage has been progressively reduced in the Forest through road closures and roadway decommissioning. However, there are still several roads that encroach on streams, especially in the West and East Forks of the Millicoma River watershed. The 1000 Road along Marlow Creek is an example where this situation is most evident.

Road Slope

Road sections with sustained high gradients generally yield greater amounts of sediment than low slope roads (Mills 1997). Road water and sediment discharge may affect the hillslope that a road traverses. Discharge on steep slopes has high stream power and erosive capability. The mean sediment particle size also increases with the road surface slope (Piehl et al. 1988, Bilby et al. 1989). Identification of road segments with higher slopes and categorizing ditch lengths delivering to streams assists in evaluating chronic sediment yield into streams from roads.

Methods

Based on an analysis of the scientific literature previously cited and best management practice guidelines, a road slope sedimentation hazard rating was developed to assess road segments on the Forest. A "high hazard" rating was given to any road segment that contained at least one of the highest slope classes (or both), with the other slope being in at least the second highest category. This classification is shown as shaded in Table 6-9. Road segments within 100 feet of streams also are considered to have a high potential hazard of delivering sediments to streams.

To determine the hazard ratings, road slope values were determined using the DEM developed for this project and the Forest roads layer. Slope values were recoded into the same slope classes used for the Water Erosion Potential Predictive XDRAIN road sediment yield model (Elliot and Hall 1997). Side-slope values were also determined from the DEM. The five side-slope classes are based on parameter values in the XDRAIN model included with Water Erosion Potential Predictive model FSWEPP (USDA 1999). The resulting grid GIS layer (road slope vs. side-slope grid) provides information on locations where the steepest road grades coincide with the steepest side-slope terrain.

Table 6-9. Coding scheme for road slope hazard analysis.

	Slope Ranges*		**Side Slope (%)**				
			0 ≤ x < 4%	**4% ≤ x < 10%**	**10% ≤ x < 25%**	**25% ≤ x < 60%**	**60% +**
Road Slope (%)		Code	1	2	3	4	5
	0 ≤ x < 2%	1	2	3	4	5	6
	2% ≤ x < 4%	2	3	4	5	6	7
	4% ≤ x < 8%	3	4	5	7	7	8
	8% ≤ x < 16%	4	5	6	7	8	**9**
	16% +	5	6	7	8	**9**	**10**

Results

Road slopes and side slopes provide a good starting point to evaluate sediment delivery hazards. Map 6.4 provides the high gradient/high side-slope road segments shown against the hill-shaded background. While it is difficult at the level of detail available in the map to identify specific hazard locations, the results in Table 6-10 show that high gradient/high side-slope road segments are distributed across the entire Forest. Also, it is possible to generally identify specific roadways within the Forest as having numerous areas of high potential hazard due to a combination of steep road gradients and steep side slopes (also see Table 6-20).

No road segments in the Forest have less than a 2% slope according to the GIS analysis. About one fifth of the road miles (17.8%) are in the 2%-4% road slope class, with slightly under a third (31.6%) in the 4%-8% class. A plurality of roads (35.5%) is in the 8%-16% slope class. Slightly over 15% of the road mileage in the Forest has a road gradient of 16% or greater. These latter two classes are places where the condition of roads and ditches becomes important, especially when the road gradient exceeds 13% (Mills 1997).

Road gradient is not the only factor determining how well roads perform with respect to sediment generation and delivery to streams. The slope of hillsides above and below the road provides an important indicator of potential sediment delivery. Steep hillslopes indicate areas where cut banks may ravel and generate sediment, and where small slides may block ditches. Only about 5% of Forest roads pass through generally flat lands (<10% side slope), while about a quarter traverse areas with 10%-25% side slopes. Slightly over half of Forest roads traverse side slopes from 25%-60%. Another 93 miles (17.4%) traverse slopes greater than 60%.

In terms of sediment delivery and fill failure, the highest hazard is for steep roads crossing steep terrain. Approximately 6.9% of Forest roads have segments with a road gradient of 16% or greater traversing slopes of 60% or greater. The Forest-wide average is lowered by the high number of miles of road (235 miles out of 269 miles) in the Millicoma River 5th field HUC that traverse side slopes of less than 60%. However, over half of these miles are on slopes between 25%-60% where potential sediment delivery hazards may exist. In the Umpqua watershed, road segments having 16% or greater road slope and passing through areas with greater than 60% side slope comprise 9.27% of Forest roads in the Lower Umpqua River 5th field HUC and 5.91% in the Mill Creek 5th field HUC. Steep road and hill-slope roads comprise 9.22% of the roads in the Tenmile Lakes 5th field HUC.

Discussion

The utility of the slope analysis is that it can be used as a filter to identify potential road segments where the combination of road gradient, position, and hillslope may result in hazardous conditions. The "steep-on-steep" roadway locations identify road segments perched in inherently precarious positions where additional investigation, enhanced maintenance, and remediation may be needed. The results also identify those steep road segments that are adjacent to, and may be hydrologically connected with, stream channels.

Table 6-10. Miles of Forest roads by road and side-slope class (high hazard areas shaded).

5th Field HUC	Side Slope Class	Road Gradient Class (miles)					Total	Percent
		2	3	4	5	Unident.		
Lower Umpqua River	1	0.5	---	---	---	---	0.5	0.6%
	2	2.3	0.9	---	---	---	3.2	4.1%
	3	5.6	5.1	2.5	0.7	---	13.9	17.9%
	4	7.0	15.5	13.9	**4.8**	---	41.2	53.0%
	5	1.4	3.0	**9.9**	**4.7**	---	19.0	24.4%
	Total	*16.8*	*24.5*	*26.3*	*10.2*	---	*77.8*	---
	Percent	*21.6%*	*31.5%*	*33.8%*	*13.1%*	---	---	---
Mill Creek	1	0.5	---	---	---	---	0.5	0.9%
	2	2.3	0.1	---	---	---	2.4	4.4%
	3	4.3	4.5	3.6	0.3	---	12.7	23.3%
	4	3.3	11.8	10.0	**4.9**	0.1	30.1	55.1%
	5	0.5	2.3	**2.3**	**3.8**		8.9	16.3%
	Total	*10.9*	*18.7*	*15.9*	*9.0*	*0.1*	*54.6*	---
	Percent	20.0%	34.2%	29.1%	16.5%	0.2%	---	---
Tenmile Lakes	1	0.2	0.1	---	---	---	0.3	0.3%
	2	1.0	0.3	1.2	---	---	2.5	2.5%
	3	5.4	5.2	4.8	1.6	---	17.0	17.2%
	4	6.4	13.8	21.9	**11.1**	---	53.2	54.0%
	5	3.1	5.6	**6.8**	**9.8**	---	25.3	25.7%
	Unident.	0.1	0.1	---	---	0.1	0.3	0.3%
	Total	*16.2*	*25.1*	*34.7*	*22.5*	*0.1*	*98.6*	---
	Percent	16.4%	25.5%	35.2%	22.8%	0.1%	---	---
Coos Bay	1	0.2	---	---	---	---	0.2	0.6%
	2	0.7	---	---	---	---	0.7	2.0%
	3	1.3	4.8	1.0	---	---	7.1	20.6%
	4	4.3	4.9	8.8	**2.8**	---	20.8	60.5%
	5	---	1.6	**1.3**	**2.7**	---	5.6	16.3%
	Total	6.5	11.3	11.1	5.5		34.4	---
	Percent	*18.9%*	*32.8%*	*32.3%*	*16.0%*	---	---	---
Millicoma River	1	1.6	5.0	---	---	---	6.6	2.5%
	2	6.4	3.8	0.2	---	---	10.4	3.9%
	3	18.7	33.9	20.3	1.3	---	74.2	27.6%
	4	16.7	41.3	65.4	**19.8**	---	143.2	53.2%
	5	1.6	4.9	**15.7**	**12.2**	---	34.4	12.8%
	Unident.	---	0.3	0.1	---	---	0.4	0.1%
	Total	*45.0*	*89.2*	*101.7*	*33.3*	---	*269.2*	---
	Percent	16.7%	33.1%	37.8%	12.4%	---	---	---
Elliott State Forest Totals	1	3.0	5.1	---	---	---	8.1	1.5%
	2	12.7	5.1	1.4	---	---	19.2	3.6%
	3	35.3	53.5	32.2	3.9	---	124.9	23.4%
	4	37.7	87.3	120.0	**43.4**	0.1	288.5	54.0%
	5	6.6	17.4	**36.0**	**33.2**	---	93.2	17.4%
	Unident.	0.1	0.4	0.1	---	0.1	0.7	0.1%
	Total	*95.4*	*168.8*	*189.7*	*80.5*	*0.2*	*534.6*	---
	Percent	*17.8%*	*31.6%*	*35.5%*	*15.1%*	*0.0%*	---	---

*Includes roads in 211 acres of the Middle Umpqua 5th field HUC.

High-slope hazard locations are not restricted to mid-slope roads. The analysis also found steep grades along ridgeline roads. The results presented in Table 6-10 should not be attributed solely to climbing side-slope roads. This finding stresses the importance of ditch relief along ridges despite their overall landscape position advantage. The objective of this relief would be to prevent road drainage from concentrating on unstable headwalls below the ridgeline saddle axes.

Steep-on-steep roadways adjacent (within ~100 feet) to stream channels are of greatest concern. These roadways can disproportionately contribute fines directly to stream channels. The mid-slope and lower 2 miles of the 7500 Road along Footlog Creek is an example of where this has occurred. The realignment, relocation, or removal of steep, hydrologically connected roadways is one way to reduce these effects. Increasing drainage structure frequency (reducing ditch lengths) may help where adequate buffers exist between outlet and stream. Improving the quality of road surfacing material also is an option for reducing, but not eliminating, the impact potential of streamside roads to stream water quality.

Forest staff, consistent with the Forest Practice Rules, is essentially retrofitting and upgrading the Forest road system. Ditch relief structures are included in these upgrades. However, because all Forest ditch relief structures were not inventoried during the 1997-1998 survey, and many improvements have been made since that survey, the findings in this section point to both the need for a detailed assessment of the status of ditch relief culverts.

Road Age

Chapter 3, *Historical Overview*, discusses the development sequence and age of the Forest road system. Road age has been shown to be an important factor of road-related landslides, particularly due to previous periods when side-cast construction was common. The Forest road system is of sufficient age to have developed roadbed stability, and is subject to fewer slides as compared to roads constructed prior to the 1980s.

For over 20 years, it has been known that side-casting cut bank material (rather than end hauling it) increases the risk of road-related landslides. The higher costs associated with using best management practices, such as end hauling, can be offset by using ridge locations while keeping mid-slope roads to a minimum (Sessions et al. 1987). Nevertheless, best management practices require the constant attention and maintenance of drainage features to reduce or prevent road-related landslides.

Historical narrative and Forest construction/stand sale histories were used to recount the sequence of roads constructed through specific Forest areas. Currently, the Forest is adding initial road construction dates and specifications to the road information database. All timber sales files are being examined; information about roads constructed as a part of timber sales (most were) is being extracted, entered into a database, and mapped in the Forest GIS. When available, this information will allow road age to be incorporated into future road analyses.

Road-related Landslides

Landslides originating from roads due to prism failures or the diversion of water onto downhill terrain are evaluated in this section. This section relies on the results of a study on landslides done following intense rainfall in February and November 1996 (Robison et al. 1999). All landslides were identified and characterized in the field for three study areas located in steep, sandstone geology in the central Coast Range and were particularly hard-hit by the 1996 storms. One area was Elk Creek in the upper West Fork Millicoma River on the Forest. Another area, Scottsburg, was along the northeast boundary of the Forest overlooking the Umpqua River and Mill Creek. A third area, Mapleton, was 35 miles to the north in similar terrain and geology. Additional information on road-related landslides was extracted from the ODF's 1997-1998 Forest-wide road inventory.

Methods

The original data in the Robison and others (1999) study was reworked with the intent of focusing on those landslides that directly influenced fish-bearing streams. Supplemental information on road-related landslides was extracted from the ODF 1997-1998 road inventory. This inventory included locations of past landslides and locations where the surveyor felt that landslides were likely to occur because unstable road prisms existed (impending landslides). A number of these potential landslide spots have since been repaired. For all sites, the surveyor determined whether or not the landslide entered (or would enter) a stream channel.

Results

Only 8% of all landslides surveyed in the three study areas were related to roads, even with a relatively high road density along streams in the Elk Creek area (Table 6-11). The Elk Creek area had a road density of 5.6 miles per square mile, while the Mapleton area had a density of 1.8 miles per square mile. Because half of the Mapleton area was unmanaged and had no roads, the road density for the managed portion was about twice that of the area average. In all three areas, most roads (those with and without landslides) had been constructed 15-30 years ago.

Within the two areas for which information is available (Scottsburg and Mapleton), 47% of landslides resulted from road fill failing and 26% were caused by water discharging to sidecast or other steep slopes below the road. Another 21% were related to cut slopes failing and diverting water across the road and onto sidecast or steep slopes below the road. Because most of the roads had been built prior to the current requirement of end-hauling excavated material, most road fills were unconsolidated material that had been bulldozed to the downhill side of the road.

The percentage of road-related landslides entering fish-bearing streams varied widely among areas, averaging 40% over the three areas (Table 6-11). Although the volume of material originating from road-related landslides entering fish-bearing streams was small to moderate at most sites, the presence of a few large landslides makes the average volume greater than that associated with upslope landslides within two of the three areas (Table 6-11).

Table 6-11. Landslide characteristics for three study areas in steep sandstone terrain of the central Coast Range following the 1996 storms.

Parameter	Elk Creek	Scottsburg	Mapleton
Storm during which most landslides occurred	Nov. 1996	Nov. 1996	Feb. 1996
Study area (sq. mi.)	6.53	7.10	8.29
Landslide density; all (#/sq. mi.)			
Upslope	15.6	10.8	7.1
Channel	7.5	2.5	4.3
Road	1.2	1.4	1.6
Combined	24.3	14.8	13.0
Landslide density; entered fish-bearing streams (#/sq. mi.)			
Upslope	6.9	7.0	2.4
Channel	2.3	1.8	0.6
Road	0.2	0.6	0.2
Combined	9.3	9.4	3.3
Density of fish-bearing streams (mi./sq. mi.)			
Road along stream	1.5	0.7	0.4
No road along stream	0.2	0.9	1.1
Combined	1.7	1.6	1.7
Percentage of landslides that entered fish-bearing streams			
Upslope	44	85	34
Channel	31	87	14
Road	38	67	15
Total # of landslides that occurred within the study area	159	105	108
Number of landslides that would have ended up in fish-bearing streams if not intercepted by a streamside road	15	1	1
Number of landslides that ended up in fish-bearing streams in spite of a streamside road	3	1	2
Average volume of landslide material that entered fish-bearing streams (cu. yd.)			
Upslope	521	412	773
Channel	40	27	259
Road	691	181	3,492

Road-related landslides tallied within the 1997-1998 Forest-wide inventory also were relatively infrequent. The density of past landslides averaged 1.8 per square mile with two-thirds of these reaching a stream channel, but not necessarily a fish-bearing stream (Table 6-12, Map 6.2). The density of impending landslides was only 0.2 per square mile. Of the 26 impending landslides that had potential of reaching a stream channel, 14 have since been treated. Usually this involved pulling back a failing fill slope, removing a failed cut slope from the roadbed, or routing drainage water away from vulnerable portions of the road prism. The remaining impending landslides were evaluated and determined not to pose an imminent threat to downstream waters.

Table 6-12. Road-related landslides included in the 1997-1998 road inventory of the Forest by analysis basin.

Region	Analysis Basin	Area (sq. mi.)	Number of Landslides*				Density of Landslides*			
			Past Landslides		Impending Landslides		Past Landslides		Impending Landslides	
			Delivery	No Delivery	Delivery	No Delivery	Delivery	No Delivery	Delivery	No Delivery
Umpqua	1	8.37	7	12	0	0	0.8	1.4	0.0	0.0
	2	10.03	9	4	0	0	0.9	0.4	0.0	0.0
	3	11.40	12	9	0	0	1.1	0.8	0.0	0.0
	4	7.80	20	12	1	1	2.6	1.5	0.1	0.1
	13*	6.46	3	1	0	0	0.5	0.2	0.0	0.0
	Combined	44.06	51	38	1	1	1.2	0.9	0.0	0.0
Tenmile	5	12.22	43	24	0	1	3.5	2.0	0.0	0.1
	6	11.45	6	12	1	0	0.5	1.0	0.1	0.0
	7	9.88	5	4	5	1	0.5	0.4	0.5	0.1
	Combined	33.55	54	40	6	2	1.6	1.2	0.2	0.1
Coos	8	10.24	16	2	1	0	1.6	0.2	0.1	0.0
	9	13.18	14	1	2	0	1.1	0.1	0.2	0.0
	10	10.18	13	0	0	0	1.3	0.0	0.0	0.0
	11	16.99	20	3	7	0	1.2	0.2	0.4	0.0
	12	17.69	5	3	5	0	0.3	0.2	0.3	0.0
	Combined	111.69	68	9	15	0	0.6	0.1	0.1	0.0
Overall		**145.36**	**174**	**93**	**26**	**4**	**1.2**	**0.6**	**0.2**	**0.0**

*Scattered tracts are not included. For past slides, delivery means that the landslide entered a stream channel when it occurred.
For impending landslides, delivery means that the landslide would probably end up in a stream channel when the landslide occurs.

The densities of road-related landslides in analysis basins in the northwest corner of the Forest that include Scholfield (basin #4, Lower Umpqua 5th field HUC) and Big, Murphy, and Noble Creeks (basin #5, Tenmile Lakes 5th field HUC) were two to three times the Forest average (Table 6-12, Map 6.2). Although the landslides occurred mainly on ridgeline roads, nearly two-thirds of landslides made their way into stream channels.

Despite the term ridgeline road, these roads are usually not restricted to just the center of a ridge. Often segments of road are built across steep slopes between saddles. These road segments on steep slopes are often the headwaters of drainages. Therefore, road failures in these concave headwater locations often have a direct route for moving soil into downstream waters. The landslides in analysis basins #4 and #5 tended to be clustered along a few roads. Roads with unusual numbers of landslides included the 2800, 5240, and 5500 Roads in analysis basin #4 and the 5730, 5420, 4500, and 2580 Roads in analysis basin #5. The oldest clearcuts along these roads are 20-30 years old, which dates road construction back to the 1970s and early 1980s.

Discussion

Road-related landslides tallied in the Forest were relatively infrequent during the 1997-1998 inventory and in the landslide study areas following the 1996 storm (Robison et al. 1999). The aging of the road system, whereby weak sections of road fail and then are repaired, combined with an aggressive road maintenance program by the Forest, probably contribute to the current infrequency of road-related landslides.

The Robison and others (1999) study illustrates to what degree streamside roads intercept loads of gravel and wood contained within landslides as they approach fish-bearing streams. In the Elk Creek area, where roads border nearly 90% of fish-bearing stream miles, the roads along streams kept 20% of landslides from entering fish-bearing streams. The interception of landslides by roads was negligible in the other two study areas, where a majority of fish-bearing stream miles were not bordered by roads. Few other subbasins in the Forest have as many roads along fish-bearing streams as Elk Creek.

Currently, the load of gravel, boulders, and large wood within a landslide that is intercepted by a road prism is typically piled along the upper stream banks and road edges or hauled off-site. An opportunity exists to instead place the boulders and wood directly into the stream channel. However, such a strategy would need approval by federal and state agencies such as the U.S. Army Corps of Engineers and the Oregon Division of State Lands, possibly through the General Permits (federal) and General Authorizations (state) permit process.

Road Surface Type and Level of Use

Another significant determinant of sediment yield from roads is the type of surfacing and the level and type of traffic on the road. Bilby and others (1989) discuss the greater risk posed to streams from differing types of road surfacing material. Specifically, they found that fines production derived from the rapid decomposition of road surfacing materials was greater from submarine basalt sources compared to harder surfacing material such as andesite. Unfortunately, local gravel available for use on the Forest is submarine basalt.

Paved roads produce very little sediment from their surfaces. No paved roads exist on the Forest; in the area, the Douglas County Road up Mill Creek to Loon Lake is paved. However, while reducing turbidity, paving may increase peak discharge in connected stream channels and this should be evaluated in a cost-benefit relationship prior to choosing a surface material.

Table 6-13 shows an order of magnitude increase in sediment produced from high use (wet-haul) versus low use (wet-haul) roads. High use, wet-haul roads can be significant contributors of fine sediment to drainage ditches and subsequently to streams. However, the Reid and Dunne (1984) study evaluated very weak surfacing from submarine basalt, and may show higher sediment yield due to pulling ditch spoils back onto the road surface. Nonetheless, the results presented in Table 6-13 are similar to the findings of Robben and Dent (2002) that form the scientific basis for ODF's current forest practices rules. Strategies to reduce chronic sediment inputs from riparian roads include using high-use and wet-haul roads away from stream sides, closing roads during wet weather, improving rock quality, or paving roads.

Table 6-13. Calculated sediment yield per kilometer of road for various road types and use levels (Pacific Northwest Study).

Road Type	Sediment Yield 1977-1978 (tons/km./yr.)	Average Sediment Yield (tons/km./yr.)
Heavy use	440	500
Temporary non-use	58	66
Moderate use	36	42
Light use	3.4	3.8
Paved	1.9	2.0
Abandoned	0.43	0.51

Excerpted from Reid and Dunne 1984.

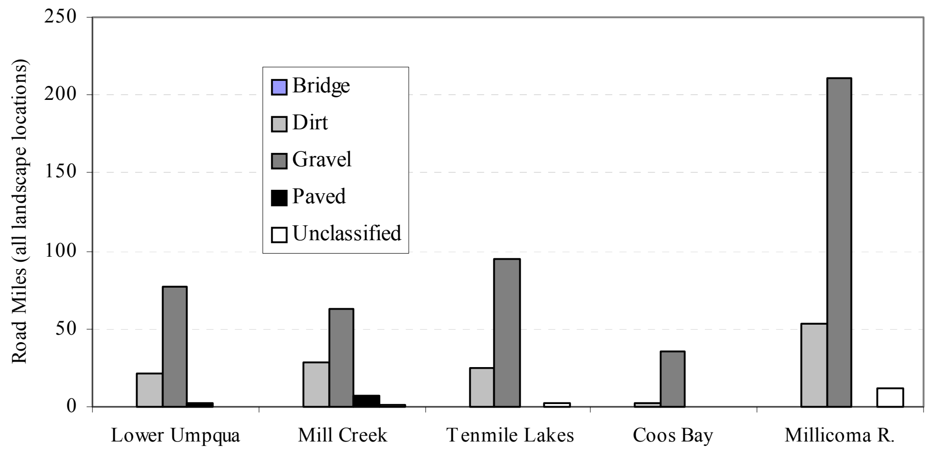
Methods

The road position and surface type information found in Table 6-7 was used for this analysis. It was assumed that all road wash from roads within approximately 100 feet of streams will deliver sediment load to the nearby stream (ODF 2003, Rashin et al. 1999). Admittedly, this criterion may over estimate the extent of hydrological connectivity between roads and streams. However, in the absence of better road survey data, this provides a first approximation of the extent of connectivity between roads and streams.

Results

Most roads on the Forest (75%) are graveled (Figure 6-4). The remaining roads are dirt and only used in dry weather. No Forest roads are currently paved; in the area, the Douglas County Road between Loon Lake and Highway 38 is paved.

Figure 6-4. Road miles by surface type and 5th field HUC.



In the absence of road use intensity information, which is needed to accurately determine sediment yields from Forest roads, the lengths of road within 100 feet of streams (both fish-bearing and non-fish-bearing streams) are shown in Table 6-14.

Table 6-14. Roads within 100 feet of streams.

Road Length >1Mile		Road Length 0.1-1.0 Mile		Road Length <0.1 Mile	
Road #	**Miles**	**Road #**	**Miles**	**Road #**	**Miles**
1000	3.90	400	0.77	2060	0.09
8000	3.80	100	0.70	2310	0.08
9000	3.07	900	0.70	6000	0.08
7400	2.56	7800	0.55	7510	0.08
8100	2.51	200	0.46	3500	0.07
2300	1.74	2000	0.40	2311	0.07
7600	1.67	7630	0.30	9500	0.06
7500	1.27	1100	0.23	9300	0.05
1600	1.12	9380	0.18	7620	0.04
2100	1.10	1822	0.18	9040	0.04
Unident.	7.56	1900	0.18	2110	0.03
		9200	0.15	9360	0.03
		300	0.14	CR 16	0.03
		5100	0.13	1870	0.01
		3300	0.13	9100	0.01
		3595	0.13		
		1820	0.13		
		503	0.12		
		7420	0.12		
		9400	0.10		
			Grand Total	**36.85 miles**	

As shown in Table 6-14, there are 10 roads in the Forest that have over 1 mile of their length within 100 feet of streams. These are the 1000 Road (Marlow Creek), 8000 Road (Joes Creek and the West Fork Millicoma River), 9000 Road (Elk Creek), 7400 Road (Fish Creek), 8100 Road (West Fork Millicoma River), 2300 Road Trout and Beaver Creeks), 7600 Road (Cougar Creek), 7500 Road (Footlog Creek), and the 1600 Road (Elk Creek). In addition, another 7.56 miles of Forest roads are within 100 feet of streams but are not identified by road number in the database.

Discussion

A roadway's surface determines its resistance to erosion. Paved, graveled and dirt types ranked from least to greatest contributors of road wash particulates. Road surfaces typically yield fine-sized sediments that adversely affect the interstitial spaces between streambed gravels used by aquatic organisms and species of concern.

A very limited number of road surface problems were identified in the 1997-1998 road inventory; because little actual site information was collected, the extent of any problems cannot be quantified. In the absence of field measured road-wash sediment yield data and calibrated sediment loads in streams of the Forest, there can be no quantifiable sediment budget developed. Currently, stream turbidity information is being compiled for calibration with rainfall response and suspended sediment discharge volume at the Marlow Creek stream gauging station (immediately above the Forest property boundary). However, this information is not yet suitable for an analysis of road wash yields.

Sediment delivered from the breakdown of road surfacing can have significant detrimental water quality effects, especially during wet hauling periods (ODF 2003). Critical determinants in the amount (and particle size distribution) of road surface-derived sediment delivered to streams is the road slope, spacing of ditch relief culverts, surfacing material quality and the effective buffer distance between the road surface and the receiving stream.

The ODF recently released new Forest Practice Rules concerning the use of durable surfacing for forest roads (ODF 2003). The ODF defines and sets testing criteria/standards for the surface material properties such as penetration and abrasion testing in order to reduce fine sediment production rates from high-traffic roadways. The new Forest Practice Rules provide a basis for evaluating where and how to protect streams from road surface related sediment (ODF 2003). While the guidance in the *Technical Notes* arrived too late to be included in this analysis, the base GIS data layers and initial analyses can be used to identify opportunities for remedial measures.

Road Drainage Features

Hydrologic connectivity occurs when road drainage is discharged directly into channels via culvert outflow or drainage ditch relief near stream channels (assumed to be within 100 feet). Either one of these conditions will potentially increases sediment transport volumes and flood stage elevations downstream. Road surveys were conducted on the Forest for three primary purposes: (1) to identify fish passage impediments at road stream crossings, (2) to determine the degree of road failure risk, and (3) to identify potential locations where hydrologic connectivity of road drainage ditches to fish-bearing stream networks should be examined for stream-sediment abatement.

Methods

The effectiveness of road drainage features was evaluated using the Forest's 1997-1998 road survey. Key fields that describe sediment hazard included road gradient and side slopes, ditch length, proximity to stream channels, and potential delivery volumes. Sites were classified and ranked based on the Water Erosion Prediction Project (WEPP) input protocols (Foltz 1996, Elliot and Hall 1997). Each stream crossing culvert was placed into one of three categories based on its contributing ditch length. Ditches potentially contributing sediments to a stream were considered "short" if ditch lengths were less than 100 feet, "medium" if ditch lengths were between 100-360 feet, and "long" if ditch lengths were greater than 360 feet. Ditch length is only one of three factors, the other two being gradient and soil type (permeability), that determine erosion potential and sediment transport from ditches. Ditch length was the only factor consistently reported in the 1997-1998 road survey.

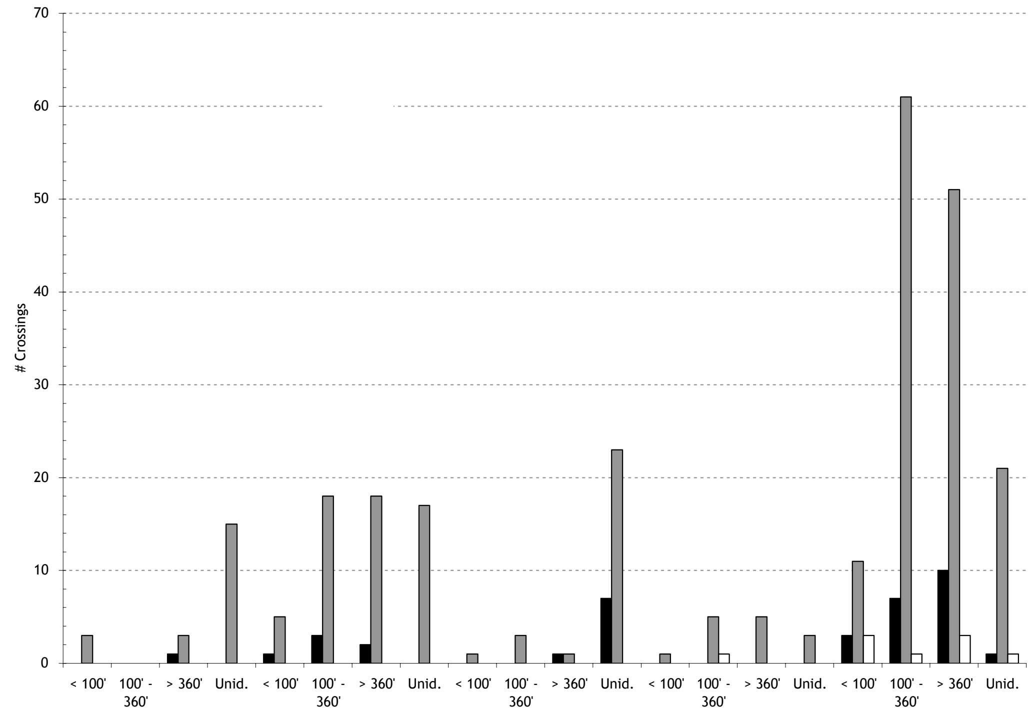
Results

The 1997-1998 road database was searched for stream crossings that were identified as having diversion potential. In these surveys, all stream crossing culverts were evaluated as sites; in addition, ditch relief culverts were included that potentially contributed sediment directly to streams. Three hundred and nine crossings met this criterion and form the basis for the evaluation of the relationship between ditch length and diversion potential (see Map 6.5). Forest road crossings with diversion potential were reported by contributing ditch length class (<100 feet, 100-360 feet, >360 feet) and by stream type (fish-bearing stream, non-fish-bearing stream, unidentified) in Figure 6-5 on a 5th field HUC basis. Table 6-15 provides similar information in numerical form including stream size.

Eighty-five percent of stream crossings in the Forest are located on non-fish-bearing streams (type N). Roads crossing small non-fish-bearing streams represent 75% of all crossings on a Forest-wide basis. Only 12% of the crossings are on fish-bearing streams (type F), divided about 40% on large and 60% on medium classified streams. At 3% of the crossings, the stream classification could not be determined.

Road ditches contributing water (and potentially sediment) into streams evidenced significant sediment. Only 9% of stream crossings had contributing ditch lengths considered "short" (<100 feet), while 32% of the crossings were in the medium (100-360 feet) length class. Thirty-one percent of stream crossings had contributing ditch lengths considered "long." In the remaining 28% of the stream crossings, contributing ditch length could not be determined.

Figure 6-5. Number of Forest road crossings with diversion potential by ditch length class.



Most stream crossings (30 out of 36) in the Tenmile Lakes 5th field HUC do not have ditch length information in the database. A similar situation (15 out of 22 unidentified) exists in the Lower Umpqua 5th field HUC. In the Middle Umpqua and Coos Bay 5th field HUCs, about one third of stream crossing records did not have information on ditch lengths. Only 13% of the sites in the Millicoma 5th field HUC failed to include ditch length information.

Discussion

Sediment resulting from ditch connectivity to streams increases the fine particulate ratios relative to background stream turbidity. The primary source of these fines is breakdown of road surfacing gravel and raveling of cut banks and ditch downcutting. These fine silt and clay particles have low settling rates and will remain in suspension longer than coarser silts and sands. Therefore, the major concern associated with these fine suspensions is not solely oriented toward the interstitial deposition in spawning gravels, but rather in water quality and potential impacts to primary and secondary (invertebrate) stream productivity.

When larger sands and silts are entrained by road ditches and delivered to the stream system, there is risk to the viability of spawning beds. This undesirable condition has led to the development of best management practices that focus on disconnecting road drainage systems from streams. Common practices include decommissioning unneeded roads, densification of cross-drains and reduction of ditch lengths above each connected culvert or outlet, and limiting ditch maintenance frequency to maintain desirable grass cover.

Table 6-15. Contributing ditch lengths to stream crossings on Forest roads.

Watershed	Ditch Length Class	Stream Classification							Grand Total
		LF	MF	SF	LN	MN	SN	Unident.	
Lower Umpqua River 5th field HUC	<100 ft.	---	---	---	---	---	3	---	3
	100-360 ft.	---	---	---	---	---	---	---	---
	>360 ft.	---	1	---	---	---	3	---	4
	Unident.	---	---	---	---	2	13	---	15
	Total	**---**	**1**	**---**	**---**	**2**	**19**	**---**	**22**
Middle Umpqua River 5th field HUC	<100 ft.	---	1	---	---	1	4	---	6
	100-360 ft.	2	1	---	---	1	17	---	21
	>360 ft.	2	---	---	---	1	17	---	20
	Unident.	---	---	---	1	2	14	---	17
	Total	**4**	**2**	**---**	**1**	**5**	**52**	**---**	**64**
Tenmile Lakes 5th field HUC	<100 ft.	---	---	---	---	---	1	---	1
	100-360 ft.	---	---	---	---	---	3	---	3
	>360 ft.	---	1	---	---	---	1	---	2
	Unident.	---	7	---	---	1	22	---	30
	Total	**---**	**8**	**---**	**---**	**1**	**27**	**---**	**36**
Coos Bay 5th field HUC	<100 ft.	---	---	---	---	---	1	---	1
	100-360 ft.	---	---	---	---	---	5	1	6
	>360 ft.	---	---	---	---	---	5	---	5
	Unident.	---		---	---	2	1	---	3
	Total	**---**	**---**	**---**	**---**	**2**	**12**	**1**	**15**
Millicoma River 5th field HUC	<100 ft.	1	2	---	---	1	10	3	17
	100-360 ft.	2	4	1	---	8	53	1	69
	>360 ft.	3	7	---	---	10	41	3	64
	Unident.	---	1	---	---	3	18	1	23
	Total	**6**	**14**	**1**	**---**	**22**	**121**	**8**	**172**
Grand Total		**10**	**25**	**1**	**1**	**32**	**231**	**9**	**309**

LF = large fish-bearing stream; MF = medium fish-bearing stream; SF = small fish-bearing stream.
LN = large non-fish-bearing stream; MN = medium non-fish-bearing stream; SN = small non-fish-bearing stream.

Table 6-16 provides a list of Forest roads with stream crossings that have a potential to contribute sediment from ditches into streams. Roads are listed if they had at least one crossing (site) where ditch lengths were greater than 360 feet. Within this set of sites, roads are listed in declining order according to the number of failed sites on fish-bearing streams, then by number of sites "at risk." As can be seen from Table 6-16, few fish-bearing streams (type F) have long ditch lengths; a total of 10 sites with ditches longer than 360 feet and 7 sites with ditch lengths between 100-360 feet. However, there are greater numbers of sites with long ditches delivering to non-fish-bearing streams. Table 6-16 lists those sites only on roads where at least one site had a ditch length greater than 360 feet. At the time of the 1997-1998 road survey, the 8000 Road had the greatest number of sites, while another 5 roads had more than 10 sites with ditch lengths longer than 100 feet.

Table 6-16. Forest roads with sediment delivery potential from ditch delivery into stream crossing culverts.

Road	Receiving Stream	Ditch Length >360 feet				Ditch Length 100-360 feet				Total #
		Total #	F	N	Unident.	Total #	F	N	Unident.	
7400	Fish Cr.	10	2	8		3	1	2		13
2300	Trout/Beaver Crs.	4	2	2		5	1	4		9
8000	Joe's Cr./WF Millicoma	11	1	10		12	1	11		23
3000	Sullivan Cr.	6		6		3		2	1	9
2000	WF Millicoma/Dean Cr.	6	1	5		8	1	7		14
1000	Marlow Cr.	6	1	4	1	7	1	6		13
7500	Footlog Cr.	5	1	4		4	1	3		9
9000	Elk Cr.	5	1	2	2	4		4		9
7600	Cougar Cr.	4	1	3		7	1	6		11
1600	Upper Elk Cr.	3	1	2		8		7	1	11
1900	Baker/Bickford Crs.	2	1	1						2
6000	Charlotte Ridge	1	1							1
0400	Puckett Cr./Mill Cr.	2		2		5	1	4		7
1850	Glenn/Surprise Crs.	1		1		3	1	2		4
9200	Skunk Cr.	4		4		3		3		7
1840	Cedar Cr.	3		3		1		1		4
3300	Daggett/Totten Crs.	3		3		3		3		6
0320	Mill Cr. Trib.	2		2						2
7800	Salander Cr.	2		2		3		3		5
1100	Marlow Cr.	1		1		2		2		3
1860	Glenn Cr.	1		1						1
5000	Scholfield Ridge	1		1						1
7100	Knife Ridge	1		1						1
7640	Cougar Cr.	1		1						1
8200	Deer Cr. (decomm.)	1		1		1		1		2
9300	Elkhorn Ridge	1		1		1		1		2
9500	Hidden Valley Cr.	1		1						1
	Total	**76**	**10**	**63**	**3**	**76**	**7**	**67**	**2**	**152**

F = fish-bearing stream; N = non-fish-bearing stream.

The difficulty in determining hydrological connectivity (and thus sediment delivery potential) from road ditches into streams is the result of data gaps in existing Forest road surveys. Table 6-17 shows the relative types of information that can be gained from various survey intensities. The initial surveys in 1993-1994 focused on culverts that presented fish passage barriers (see discussion in Chapter 7, *Riparian Vegetation and Large Wood*). The ability to identify and analyze road sediment yield also improves as surveys are structured to collect additional variables such as road surface types, upslope road fill failures, and road use levels. Road surface types are important factors in ranking sediment production from road system elements, especially when used in conjunction with road use level and road landscape position attributes. This information also may be needed for the new ODF road inventory and maintenance database program.

Table 6-17. Road and landing surveys conducted in the Forest.

Survey Type	Culvert Inventory and Size			Road Surface Condition			Cross Drains, Berm Relieved (Ditch-outs)			Road Slides Site Volume		
	Coos	**Tenmile**	**Umpqua**	**Coos**	**Tenmile**	**Umpqua**	**Coos**	**Tenmile**	**Umpqua**	**Coos**	**Tenmile**	**Umpqua**
Fish passage culverts (1993-1994)	C	C	C									
All stream crossing culverts and contributing ditch relief culverts (1997-1998)	C	C	C	P*	P*	P*	P			P	P	P
All ditch relief culverts (1998-2002)	P			P			P					
All road drainage features	P			P			P, I			P		

* Road condition was noted in comments only prior to 2002; damage type and affected road length attributes were added for post-2002 surveys (Elk Creek Basin) only. Codes: C=complete, P = partial, I = Incomplete.

Road Washouts

In this section, the potential risks to streams of various sizes and fish-bearing status from road washouts is evaluated. Road washouts occur at stream crossings when flows exceed culvert capacity and go over (and along) the road. They also occur when culverts are damaged or clogged by debris and sediment, thus reducing the design capacity. Washouts also may occur where steep roads capture road ditch drainage diverted by cut bank collapse. Whatever their cause, these washouts may incise the road and eventually deliver road surface and prism sediments into streams.

Methods

The sediment transport rating used in this section was developed in the field by 1997-1998 road inventory survey personnel based upon protocols from the Pacific Watershed Associates Road Sediment Reduction Survey guidelines (PWA 1997). The database was queried to develop information on stream crossing records attributed with sediment transport capability for analysis. The sediment transport rating is an estimation of the relative capability of the stream to transport sediment (and thereby move sediment and debris down to the culvert inlet). The ranking is expressed in high, medium and low categories.

Results

The sediment transport rating at stream crossing locations was identified in the GIS and cross-referenced to the presence of fish-bearing and non-fish-bearing streams. The results of this analysis are presented in Table 6-18 by region and 5th field HUC, the number of culverts by stream type (fish and non-fish), and size (small, medium, and large) against the sediment transport rating (high, medium, and low) at that stream crossing.

Table 6-18. Distribution of sediment transport capacity at stream crossing culverts.

5th field HUC	Sediment Transport Rating	Fish-bearing Streams			Non-fish-bearing Streams			Unident. Streams	Grand Total
		Large	Medium	Small	Large	Medium	Small		
Lower Umpqua	High	---	---	---	---	---	2	----	2
	Medium	---	2	---	---	4	20	---	26
	Low	---	---	---	---	---	4	---	4
	Unident.	---	---	---	---	---	1	---	1
	Total	**---**	**2**	**---**	**---**	**2**	**27**	**---**	**31**
Mill Creek*	High	6	2	---	2	---	2	---	12
	Medium	2	2	---	---	10	55	---	69
	Low	---	---	---	---	---	37	---	37
	Unident.	---	---	---	---	---	---	---	---
	Total	**8**	**4**	**---**	**2**	**10**	**94**	**---**	**118**
Tenmile Lakes	High	---	6	---	---	---	4	---	10
	Medium	---	10	---	---	2	34	---	46
	Low	---	---	---	---	---	5	---	5
	Unident.	---	---	---	---	---	---	---	---
	Total	**---**	**16**	**----**	**---**	**2**	**43**	**---**	**61**
Coos Bay	High	---	---	----	---	---	---	---	---
	Medium	---	---	---	---	2	2	---	4
	Low	---	---	---	---	1	16	2	19
	Unident.	---	---	---	---	---	1	---	1
	Total	**---**	**---**	**---**	**---**	**3**	**19**	**2**	**24**
Millicoma River	High	6	2	---	---	4	1	2	15
	Medium	4	17	---	---	26	66	8	121
	Low	2	6	2	---	11	174	8	203
	Unident.	---	2	---	---	3	9	---	14
	Total	**12**	**27**	**2**	**---**	**44**	**250**	**18**	**353**
Grand Total		**20**	**49**	**2**	**2**	**61**	**433**	**20**	**587**

*Includes 211 acres of the Forest in the Middle Umpqua 5th field HUC.

Patterns observed in the GIS examination of the spatial distribution of those sites considered as high hazard showed that they tended to be concentrated on certain roads. These roads are listed in Table 6-19.

Discussion

The use of the sediment transport rating in this analysis sought to identify those roads where drainage features were at greater risk of clogging from sedimentation. Culvert failures from clogging (or from under-estimated culvert discharge capacities) may lead to road washouts, a costly and undesirable source of sediment reaching streams.

Table 6-19. Forest roads with High and Moderate Sediment Transport Ratings

Road	Creek	High Washout Hazard				Moderate Washout Hazard			
		# Sites	F	N	Unident.	# Sites	F	N	Unident.
400	Puckett Cr.	1	1	---	---	7	1	6	---
1900	Bickford Cr.	1	1	---	---	---	---	---	---
2100	Johnson Cr.	3	2	1	---	9	1	8	---
2780	(Ridge)	1	---	1	---	---	---	---	---
5100	Big (closed)	4	2	2	---	15	4	11	---
7400	Fish Cr.	4	2	2	---	6	1	5	---
7500	Footlog Cr.	3	2	1	---	9	0	9	---
8100	W.F. Millicoma R.	1	1	---	---	4	0	4	---
9000	Elk Cr.	1	---	---	1	9	1	7	1
9200	Skunk Cr.	1	---	1	---	1	0	1	---

F = fish-bearing stream; N = non-fish-bearing stream.

Confidence in these results is difficult to express due to the subjective and site-specific nature of the rating method. However, when evaluated in context with road position, road gradient, ditch length, stream adjacency and culvert failures, there appears to be merit to this method as presented in the Pacific Watershed Associates report (PWA 1997), as well as in other evaluations of sediment contributions from forest roads (Rashin et al. 1999). The roads (and stream crossing sites) identified in the GIS and listed in Table 6-19 are ones that should be periodically examined and evaluated to determine whether maintenance, upgrade, or replacement is necessary.

Analysis and Recommendations

This chapter focused on sediment production, erosion and mass wasting, and deposition in watersheds of the Forest. Sedimentation is the result of several interlinked processes, including colluvial deep-seated and shallow landsliding and soil creep, as well as fluvial processes such as surface wash and channel bedload. While not fully within human control, large magnitude natural disturbances such as flood events and stand-replacing wildfire have the potential to produce large pulses of sediments to fish-bearing streams and tributaries. These natural processes are modified by management activities including road construction, use intensity, and drainage structure maintenance. The effects of roads on watersheds in the Forest are emphasized since they are usually the largest human-caused source of sediment.

The driving force dominating sedimentation process regimes in the Forest is the cyclic climates of the Oregon Coast Range interacting with the Forest's steep slopes. Cycles of cool and wet years, interspersed with hot, dry years, dictate fire recurrence intervals and vegetation growth. Fire and vegetation work in opposition to control resistance to surface erosion, precipitation infiltration, and mechanical reinforcement of soil.

The tectonic history and geology of the Forest also influence its propensity for landslides. These slides develop natural landforms of the Coastal Range exemplified by the Forest knife-edge ridge and ravine terrain. Massive deep-seated slides, though infrequent, may affect large portions of the landscape. These mass movements are not readily triggered by management activities. Conversely, shallow rapidly moving landslides are more frequent, and can be affected by management activity, including road and landing location and drainage.

Aquatic organisms and ecosystems have adapted to the cycles of sedimentation driven by the variable climate of the Coast Range. Aquatic systems have evolved with the punctuated deliveries of sediment from slides, and are adapted to use the gravels and wood delivered by the slides. However, aquatic systems and populations are dependent on refugia from repeated disturbance, so it important that not all streams and areas are in flux at the same time.

Roads, as compared to in-unit harvest activities (including site preparation burns), harbor the greatest year-to-year risk for the sediment delivery to streams in the Forest. Forest roads are largely a legacy of past practices. This older road system has stabilized through time but is still subject to fill failures due to road location, road drainage malfunctions, and sections of roadways remaining with side-cast construction.

The potential for a catastrophic road fill failure delivering sediment to fish-bearing streams is a major concern for legacy roads that do not substantially meet current forest practice guidelines. Data from studies on the Forest indicate that interior roads were fairly stable during large precipitation events, such as the storms of 1996. Despite this, there were still a number of fill failure related landslides, some even originating along presumably more stable ridgeline roads where side-cast fill existed. These failures delivered significant sediment volumes to streams, including a number of sites in the northwest portion of the Forest.

Much improvement has been made to Forest roads since the 1996 storms and current maintenance practices generally keep roads in good condition. However, using road position, terrain and road slope, ditch length, diversion potential, and sediment transport rating information from the 1997-1998 Forest road inventory, potential road failure hazards were ranked to identify areas where remedial actions may be needed, if not already completed. Table 6-20 provides a listing of these potential road sediment delivery "hotspots" based on concentrations of sites identified in the individual hazard analyses.

Roads which had at least one high or moderate sediment transport hazard site were included on Table 6-20. If a road was included for other criteria, the total number of sediment transport hazard sites also was noted. Culvert and fill failure information in Table 6-20 came from Table 6-18 and associated data tables. Steep slopes (side- and road-slopes) are from data used to prepare Table 6-10. Ditch hazard sites are from Table 6-16. Road position information comes from Table 6-7. Sediment transport hazard data is from Table 6-18 for high and moderate classes on both fish-bearing and non-fish-bearing streams. The mileage of roads within 100 feet of streams is from Table 6-14.

Table 6-20. Cumulative road sediment hazard ratings by Forest road number.

Road No.	Receiving Stream(s)	Ditch Lengths (# Sites)	Culvert Failure (# Sites)	Steep Slopes (mi.)	Road Position (% sideslope & riparian)	High Sediment Transport (# Sites)	Stream Adjacent (mi.)
7400	Fish Cr.	13	10	0.30	75.2%	10	2.56
2300	Trout/Beaver Cr.	9		1.19	82.0%	4	1.74
8000	Joes Cr/W.F. Millicoma	23		0.86	88.4%	7	3.80
2000	W.F. Millicoma/Dean Cr	14		3.67	22.4%	6	0.40
1000	Marlow Cr.	13		1.11	60.9%	5	3.90
7500	Footlog Cr.	9	12	1.05	43.6%	12	1.27
9000	Elk Cr.	9	10	0.30	84.9%	8	3.07
7600	Cougar Cr.	11		0.35	70.9%	4	1.67
1600	Upper Elk Cr.	11		<0.25	90.5%	3	1.12
1900	Baker/Bickford Cr.	2	1	0.51	77.8%	2	0.18
6000	Charlotte Ridge	1		1.35	11.2%	1	0.08
400	Puckett	7	8	0.99	66.4%	8	0.77
5000	Schofield Ridge	1		1.36	30.0%	1	0
7700	Cougar Pass			0.82	66.9%		0
3000	Larson/Sullivan Cr.	9		0.82	33.8%	1	0
3500	Palouse/S.F. Johnson Cr.			0.74	18.5%		0.07
3400	Larson/Palouse			1.01	35.9%		0
7800	Salander Cr.	5		0.72	89.6%		0.55
8100	W.F. Millicoma		5	0.60	83.4%	5	2.51
9200	Skunk Cr.	7	2	<0.25	94.6%	2	0.15
1850	Glenn Cr.				20.3%	3	0

Recommendations Related to Shallow Landsliding

1. The analysis team recommends that Forest staff begin to build a database of shallow landsliding. This database could help the Forest track locations and extent of landslides over the entire Forest. The database could begin with the information from the Robison and others (1999) study and include the TLBP's survey information once additional details are resolved. This database should include in-unit landslides as well as road-related landslides. In-unit landslide information could be collected as a normal course during other management activities; road-related landslide information can be collected as part of a larger road condition inventories. The analysis team recommends that roads identified as having an unusual number of landslides in the 1997-1998 road inventory be periodically examined to see if other impending landslides continue to develop. Roads with unusual numbers of landslides included the 2800, 5240, and 5500 Roads in analysis basin #4 and 5730, 5420, 4500, and 2580 Roads in analysis basin #5.

2. The analysis team recommends that Forest staff explore strategies for providing steep draws with more wood over time so that future landslides are capable of delivering sufficient amounts of large wood, as well as gravel and boulders to fish-bearing streams.

3. The analysis team recommends that Forest staff examine the current practice of piling or removing landslide material ending up on streamside roads, and look for opportunities to place logs, boulders, and gravel in the nearby stream as the road is being cleared.

4. The analysis team recommends that the Forest improve the resolution and quality of digital elevation data. The quality of digital elevation data could be improved by following the recommendations in Robison and others (1999) and Roering and others (2003). LiDAR signals that are suitably processed into high-resolution DEMs can provide this level of information. Despite the lack of this information, the ODF practices as implemented by the Forest and ODF technical staff that provide for detailed site examination and treatment overcome many of the limitations of the existing DEM.

5. The analysis team recommends that the Forest collaborate with other state entities, such as state universities and the State Climatologist Office, to improve precipitation data and maps for the Forest. The PRISM models generated by the Oregon State Climatologist should be integrated into the official 50-year discharge maps to better evaluate runoff for culvert sizing and other hazard evaluations.

Recommendations to Reduce Road-related Sedimentation

The Forest road system is generally stable and well maintained. The ODF has improved conditions in many sites that were identified in past road surveys, but there remains a number of roads and road segments where additional investment in improvements would provide benefits to water quality and fish. These roads were identified in Table 6-20; the following discussion will use the information in Table 6-20, along with more detailed analyses found in this chapter, to identify specific roads and locations where various improvement/mitigation actions may be appropriate. The recommendations that follow were discussed with Forest road staff; however the specifics are the responsibility of the analysis team. The final decision on appropriateness of any recommendation lies with ODF, based not only on watershed benefits but also on cost and operability considerations.

Continue Investing in High Levels of Road Maintenance

The generally good road conditions in the Forest are the result of previous investments in upgrades and maintenance. Continued investments are the most cost-effective way to prevent future problems. Specific maintenance practices that will reduce hazards are:

- ⇒ Maintain and/or improve gravel quality, particularly for top-dressing and along heavily traveled roads adjacent to streams.
- ⇒ Consider "spot-treating" rather than periodic entire road segment ditch pulling to clean out sediments from bank ravel and small slides.
- ⇒ Establish a schedule for periodic re-rocking of major haul routes to insure an adequate, clean, gravel surface based on road use intensity and location.
- ⇒ Insure that outside berms are cleared after grading operations, especially on roads adjacent to streams.

⇒ Reduce the potential for hydrological connectivity by reducing outlet water velocities at drainage culverts.

Roads Where Additional Ditch Relief Culverts Appear Needed

Much road improvement work has been accomplished on the Forest since the 1997-1998 survey was completed. It is difficult without updated information to determine the extent to which ditch relief culverts have remedied problems identified in the 1997-1998 survey. However, based on those survey results, the following roads would most benefit from a program to upgrade ditch relief culverts throughout their length to insure that their diameter, spacing, and discharge points meet current best management practices:

⇒ 1000 Road along Marlow Creek (Millicoma R. 5th field HUC).
⇒ 1600 Upper Elk Creek Road (Millicoma R. 5th field HUC).
⇒ 2300 Road along Trout and Beaver Creeks (Millicoma R. 5th field HUC).
⇒ 5000 Road along Scholfield Ridge (Lower Umpqua R. 5th field HUC).
⇒ 6000 Road along Charlotte Ridge (Lower Umpqua R. 5th field HUC).
⇒ 8000 Road along Joes Creek and W.F. Millicoma (Millicoma R. 5th field HUC).
⇒ 9000 Road along Elk Creek (Millicoma R. 5th field HUC).

The above roads are listed because they combine of high numbers of stream crossings outside best management practices criteria (<100 feet) and a large proportion of “steep-on-steep” terrain with roads predominantly side-slope in their landscape location.

Roads Where Paving may Reduce Sediment Delivery

On roads where wet hauling is infeasible or undesirable, and continued high maintenance costs are incurred for repeated gravelling, paving may become a more cost-effective option for reducing road surface derived fine sediments delivery to streams. Roads where partial or full paving would provide chronic sediment production benefits include:

⇒ 1000 Road along Marlow Creek (Millicoma R. 5th field HUC).
⇒ 8000 Road along the West Fork Millicoma River (Millicoma R. 5th field HUC).
⇒ 9000 Road along Elk Creek (Millicoma R. 5th field HUC).

There are possible places where paving may be the best mechanism to reduce chronic sediment delivery into these high-quality salmon streams. In the case of the Marlow Creek roadway where valley confinement forces road proximity to the stream channel, a strong case could be made for paving. The 8000 and 9000 Roads also are in adverse locations relative to fish-bearing streams and should be of concern to management due primarily to their ditch lengths draining into streams (ODF 2003). For these latter two roads, spot paving along portions adjacent to streams and on approaches to bridges may be a cost-effective solution.

Roads Where Re-engineering may be Needed to Reduce Road-related Sediment Hazards

A few roads in the Forest have a legacy of road-related hazards (see Table 6-20) but are still crucial to the Forest for its transportation network. For these roads, significant investments and re-engineering may be required to bring them up to current best management practice standards. Roads that should be evaluated to this type of upgrade include:

- ⇒ 0400 Road along Puckett Creek (Mill Creek 5th field HUC)
- ⇒ 2000 Road on Allegany side around the 2.0 – 2.5 mile markers
- ⇒ 3000 Road along Sullivan Ridge
- ⇒ 3300 Road along Daggett Creek
- ⇒ 3400 Road along Larson Ridge
- ⇒ 3500 Road above Palouse Creek
- ⇒ 7400 Road along Fish Creek (W.F. Millicoma R. 5^{th} field HUC)
- ⇒ 7500 Road along Footlog Creek (Mill Creek 5th field HUC)

With the exception of the 0400 Road along Puckett Creek and the 7500 Road along Footlog Creek, the remaining roads are all located in the Coos watershed, mostly in the Coos Bay 5^{th} field HUC. The primary concern for these roads is their legacy of side-cast construction that results in periodic slides from fill failure. The 7400 Road along Fish Creek has been upgraded since the 1996 storm, but may still need additional work along its mid-slope portion based on the GIS analysis. The partial closure through relocating access from mainline roads may be preferable for 0400 Road, which has future timber sales scheduled.

The 7500 Road along Footlog Creek has drainage problems along its mid-slope portion and considerable debris between the road and creek along its lower two miles. This road continually showed up as being at risk for most all the hazard criteria; and field inspection verified a number of problem types and locations. Because it is a major hauling route between the Umpcoos Ridge Road and Highway 38, the Footlog Creek Road (7500) would be difficult to replace. However, the Charlotte Ridge (6000) and Dean Mountain (2000) Roads are alternate mainline routes towards Reedsport, while the Cougar Pass (7700) is an alternate connector to Highway 38 towards Scottsburg.

Roads Where Decommissioning may Reduce Road-related Sediment Hazards

A few roads in the Forest have such a concentration of road-related hazards (see Table 6-19) that closure and/or relocation may be the preferable management action. Closure may be desirable for these roads because their location adjacent to streams means that relocation would be expensive while incurring additional environmental impacts. These roads include:

- ⇒ 0100 Road along Charlotte Creek (Lower Umpqua R. 5^{th} field HUC)
- ⇒ 0200 Road along Luder Creek (Lower Umpqua R. 5^{th} field HUC)
- ⇒ 0900 Road along Johanneson Creek (Lower Umpqua R. 5^{th} field HUC)

⇒ 7600 Road along Cougar Creek (W.F. Millicoma R. 5th field HUC)
⇒ 8100 Road along the W.F. Millicoma River (W.F. Millicoma R. 5th field HUC)

The ODF should evaluate whether these roads can be brought up to current standard or whether the amount of work needed exceeds their value. The Cougar Creek Road has a long reach parallel to high quality coho salmon spawning and rearing areas. Alternate roads, such as Kelly Ridge (7650) and Fish Ridge (7300), may provide (or could be improved to provide) adequate haul routes.

The 8100 Road along the West Fork Millicoma River is a special case because it is used more for recreational, rather than forest management, purposes. The ODF has periodically (and largely unsuccessfully) attempted to block access into this area. A case can be made that water quality and fish could benefit from road closure, especially once additional in-stream habitat improvement work is complete.

Past Road Closures to be Evaluated

Five major roads along high-quality fish-bearing streams have been closed by ODF. These include:

⇒ Big Creek Road (Tenmile Lakes 5th field HUC).
⇒ Johnson Creek Road (Tenmile Lakes 5th field HUC).
⇒ Deer Creek Road (Millicoma R. 5th field HUC).
⇒ Knife Creek Road (Millicoma R. 5th field HUC).
⇒ Crane Creek Road (Millicoma R. 5th field HUC).

Inspection of a past closure in Crane Creek showed that the work was incomplete. The closed Crane Creek road needs additional culvert removal, fill pullback, and revegetation to reduce sediment delivery hazards. The status of other closures is not yet fully known; they should be inspected and any needed remedial measures implemented.

Additional Road Surveys Needed

The 1997-1998 Forest-wide road survey emphasized identifying stream crossing culvert sites that posed a catastrophic sediment delivery risk. Subsequent to those surveys, much road improvement work has been completed. However, the 1997-1998 surveys are noticeably lacking on information about chronic sediment yield. As part of this assessment, road surveys in the Elk Creek watershed were updated by the Coos Watershed Association. The results of this partial study indicated that chronic sediment yields could be determined, and management options developed, if roads are re-surveyed using current protocols.

New road surveys and survey protocols need to better assess hydrologic connectivity downslope of all drainage outfalls. It cannot be established through the existing survey data that there is strong connectivity of ridgeline and side-slope roads draining to fluvial channels via debris torrent tracks.

The analysis team recommends that ODF conduct or fund a resurvey of Forest roads beginning with those mainline roads listed in Table 6-20 as having high ditch length, steep road/steep slope and road position hazard levels. Additional priority could be given to those roads identified for improvement through paving and/or the addition of ditch relief culverts. An alternate prioritizing strategy would be to survey high hazard sites based on criteria found in the recent *Forest Practice Technical Notes* (ODF 2003) and identifiable through the GIS process used for this chapter.

Need for Road Use Intensity Information

A more important factor governing sediment wash from road surfaces is the level of use intensity accrued on wet surfaces. This factor and the degree of surface breakdown between precipitation events govern the transport and supply of road fines to fish-bearing streams. High use intensity on wet roads proximal to streams typically produces the least desirable stream water quality. Unfortunately, the use intensity and spatial patterns can be quite irregular and difficult to assess due to lack of data and dynamic nature of the harvest unit access routes.

While road use intensity changes reflecting the pattern of forest management operations use levels is a critical data requirement for understanding the effects of roads on watersheds. The analysis team recommends that ODF consider cost-effective strategies to obtain this information for use in their new road inventory database.

Chapter 7. Riparian Vegetation and Large Wood

RIPARIAN VEGETATION

The streamside forest is usually the most important source of large wood in streams. Landslides originating in steep, tributary channels also can deliver wood to streams. Large wood is particularly important in Forest streams because these streams are typically straight and constrained by steep side slopes, which results in higher flow velocities during high water events.

Large wood in channels obstructs flow, thereby creating zones of lower velocity water, gravel deposits, and pools. These features benefit fish and aquatic amphibians. Jams of wood often will trap gravel and cobbles that would otherwise move downstream unimpeded during high flows. These deposits create a preferred substrate for fish spawning and for the production of aquatic insects on which fish feed. Wood in streams can create zones of slower water that provide refuge for young fish during high flows; without these refuge zones, fish get washed into the lower reaches of stream systems where predation and competition for food is greater. The wood also can create the deep pools important for summer survival when low flows do not otherwise provide fish enough cover to escape predators. The deep pools, especially those with nooks and crannies provided by large wood, are favored areas for feeding. Where this complex habitat is present, competition for food is more equitable among fish of various species and sizes.

The species mix and age of the streamside forest has a pronounced influence on the volume of wood in the stream. Older stands with high basal area contribute more wood volume than young stands with low basal area. Also, conifer stands contribute wood that is larger and more long-lived in the stream than do hardwood stands.

Stands along streams regenerate and grow differently than upslope stands. Under natural conditions, conifer regeneration along streams tends to be sparser due to competition from riparian brush and the presence of low terraces that are too moist for conifers. Also, the mortality of young trees by beaver and elk tends to be greater closer to streams. Furthermore, unstable or shallow soils often occur on steep-sided slopes next to streams and may not support a conifer tree once it reaches a certain size. The mortality of older trees next to streams is rarely associated with competition among trees; initial tree density is rarely great enough for self-thinning to occur. Rather, tree mortality often is more associated with stream undercutting, unstable slopes, windthrow, and beaver. Areas not occupied by conifer trees are usually thick with hardwoods or brush, which results in too much shade for supplemental conifer establishment in the understory. Individual conifers that escape competition from brush or hardwoods often grow rapidly in streamside areas due to a year-round abundance of water.

In this chapter, riparian stands throughout the Forest are characterized according to species, stem density, basal area, and crown cover. The next section evaluates the downed wood that would be expected to accumulate in streams as stands of various types mature.

Riparian Mapping and Field Inventory

Using aerial photographs, the analysis team conducted an inventory of streamside stands along all fish-bearing streams. Color orthophotos from 1996 incorporated into a GIS layer provided the base map for delineating stands of different types. Initial stand demarcations were digitized on the computer screen. High quality color aerial photographs (1:12000 scale) from 2002 were then used to refine stand boundaries and identify general classes of conifer and hardwood mixes and stand age. A GIS layer of general stand age based on hillslope trees was used to help estimate the age class of the adjacent streamside stand. The detailed aerial photographs were used to identify the age of stands (using texture) where the streamside stand age was obviously different than the upslope stand age. Areas without trees also were delineated by type where they were visible through the tree cover. The classification components included:

Stand age class	<13 years 13-24 years 25-49 years 50-99 years >99 years
Crown cover class	Hardwood (less than 30% conifer) Conifer/hardwood (between 30% and 70% conifer) Conifer (more than 70% conifer)
Areas without trees	Wide mainline roads Wide rivers Brush/grass

Because they appeared the same in aerial photographs, no attempt was made to distinguish hardwood-dominated stands that were 50-99 years old from those that were greater than 99 years old. The combined age class for the oldest hardwood trees was labeled as 50-99 years. Streamside forest delineations occurred from the centerline of the stream out to a horizontal lateral distance of 200 feet. Subsequent summaries of streamside stand characteristics were based on 50-foot wide intervals starting from the stream centerline. Summaries were further segregated by stream size (large, medium, small), by region (Coos, Tenmile, Umpqua), and by analysis basin (#1-13).

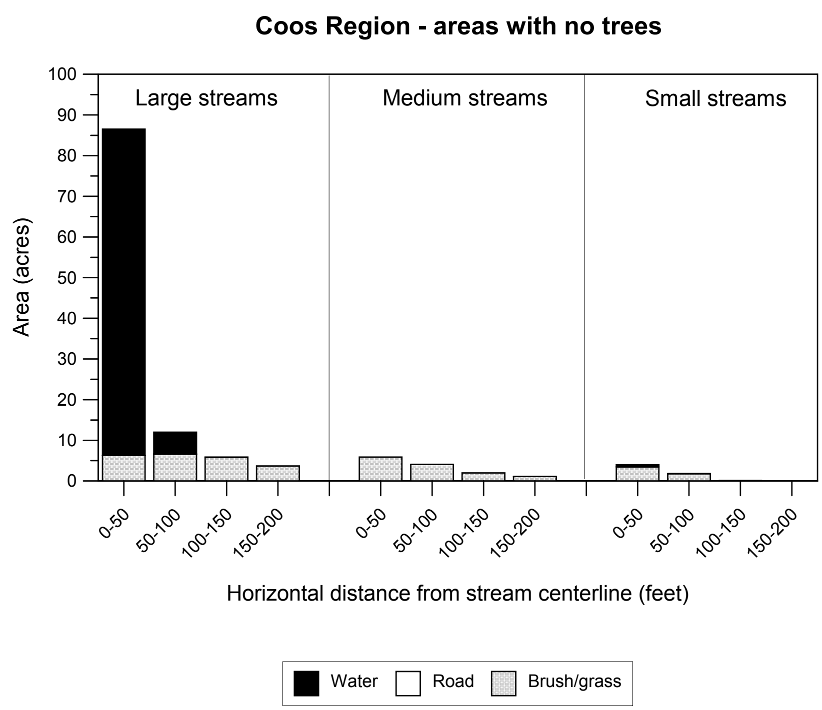
Riparian Vegetation Characteristics

The results of the streamside stand mapping are displayed for Scholfield Creek (Map 7.1) and are generally typical for the Forest. Age classes and conifer/hardwood dominance often vary greatly along a stream and are commonly different between left bank and right bank of a stream. Some of the variation reflects the history of harvesting and road building in the Forest, while some is a result of disturbance by landslides. Young hardwood trees along some of the larger streams, especially in the Tenmile region, are a result of tree invasion into streamside areas that were previously pasture.

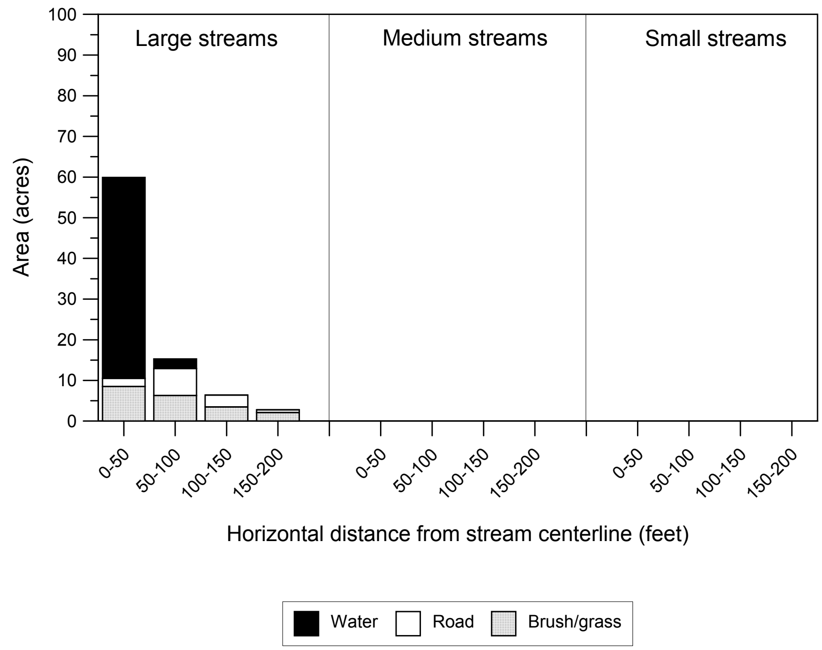
Areas without trees are a sizable component (20% forest-wide) along large streams and within 50 feet of the stream centerline. Within this zone, the percent area without trees is greatest for the Umpqua region (34%) and lowest for the Tenmile region (13%). Open water is the major component of non-forested riparian acreage, followed by areas of brush and grass. However, this varied by region. In the Coos region, most non-forested acreage is due to the open water of the lower West Fork Millicoma River; in the Umpqua region, the major non-forest component is the open water of Mill Creek. In contrast, all non-forested streamside areas in the Tenmile region are brush and grass (Figure 7-1).

Hardwoods are the dominant stand type found within 100 feet of the stream for all stream size classes. Although hardwood dominance decreased with increasing distance from the stream, along large streams hardwoods still occupied 31% of the land 150-200 feet from the stream. Conifer/hardwood stands occupied the majority of the area at distances 100-200 feet from the stream. When summarized by region, conifer-dominated stands never made up a majority of the streamside area for any stream size class or distance interval. Nevertheless, conifer-dominated stands are a majority of the streamside area for some individual subwatersheds.

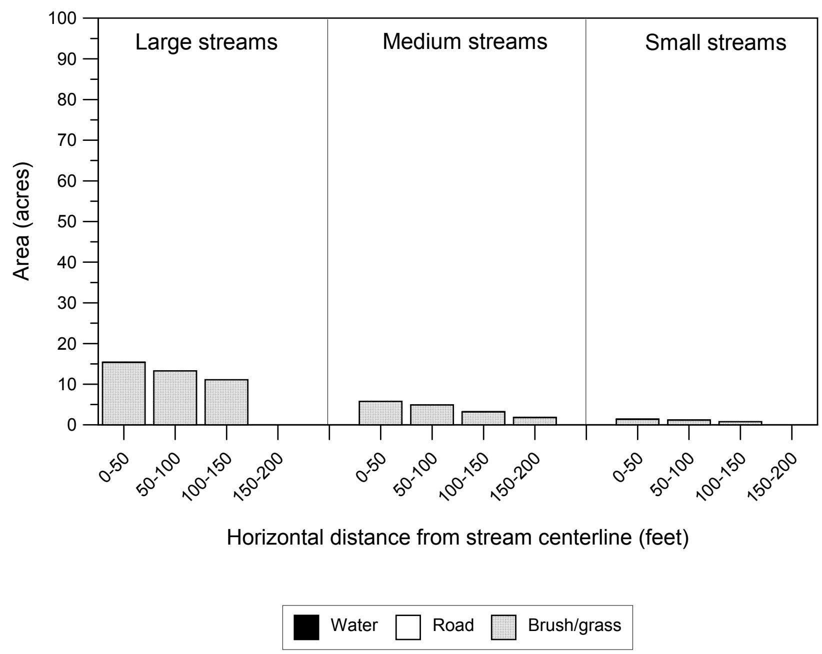
Figure 7-1. The acreage of non-forested areas by type and by stream size for the Coos, Umpqua, and Tenmile regions of the Forest (fish-bearing streams only).



Umpqua Region - areas with no trees



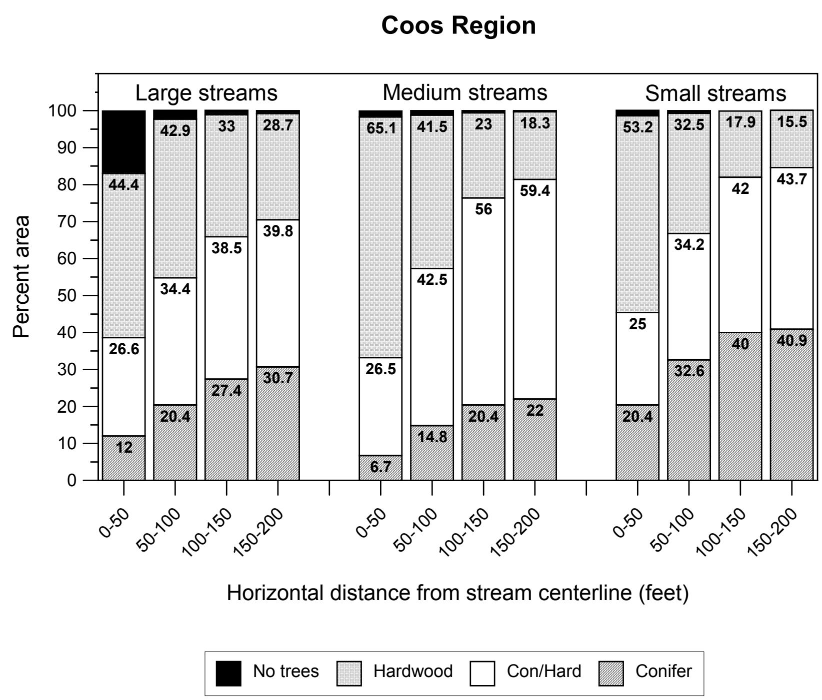
Tenmile Region - areas with no trees

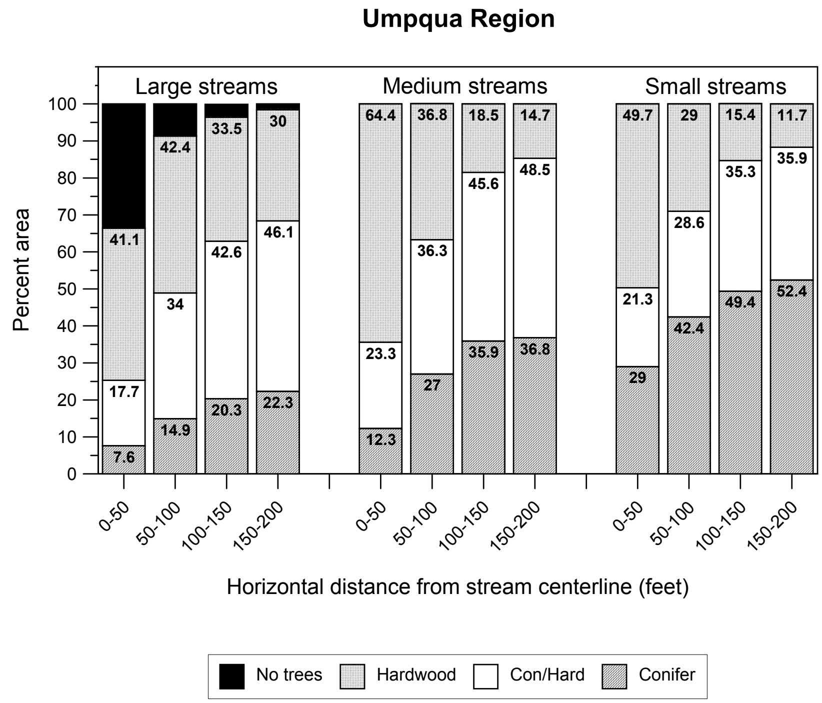


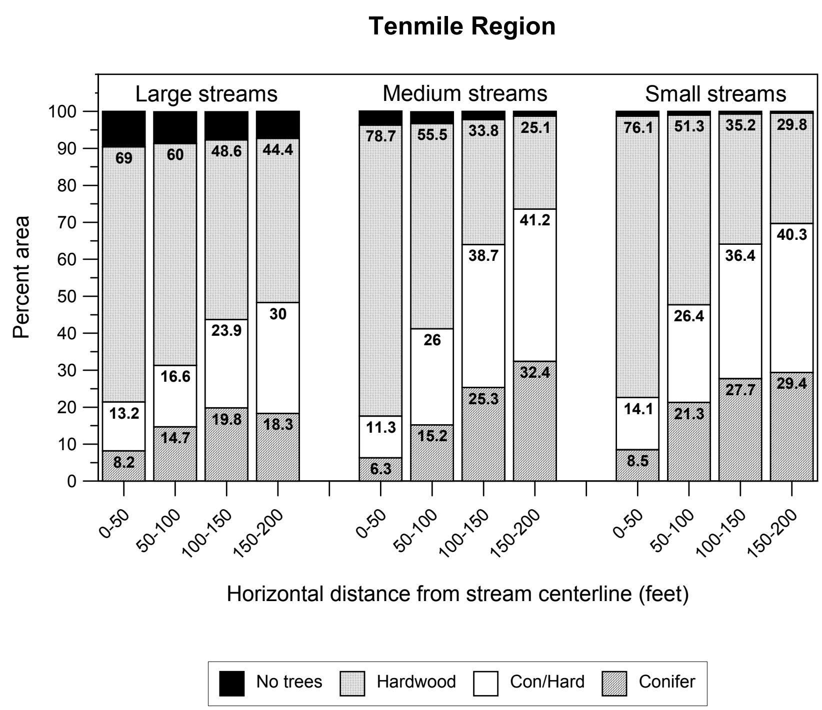
Streamside stand composition in the Coos region is similar to that for the Umpqua region, but with slightly higher conifer dominance along large and small streams (Figure 7-2). In contrast, streamside stands within 100 feet of small and medium streams and out to 200 feet along large streams are much more dominated by hardwoods in the Tenmile region than in the other two regions (Figure 7-2). Among all stream size classes, conifer-dominated stands never made up more than 7% of the trees growing within 50 feet of the stream in the Tenmile region.

Overall, stands 100 years or more old are the most dominant age class along Forest streams, except for the corridor within 50 feet of the stream. This is followed by stands in the 50-99 year and 25-49 year age classes. Young stands along streams are uncommon; where they occur, they are largely a result of debris torrents. Clearcuts between 6-15 years old adjacent to fish-bearing streams usually had a strip of trees retained between the stream and the clearcut. The buffer strips consist mostly of hardwood trees with sparse conifers. Harvest units created in the last 6 years had wider buffers that included more conifer trees with the hardwood trees.

Figure 7-2. The percent riparian stand type by stream size for the Coos, Umpqua, and Tenmile regions of the Forest (fish-bearing streams only).



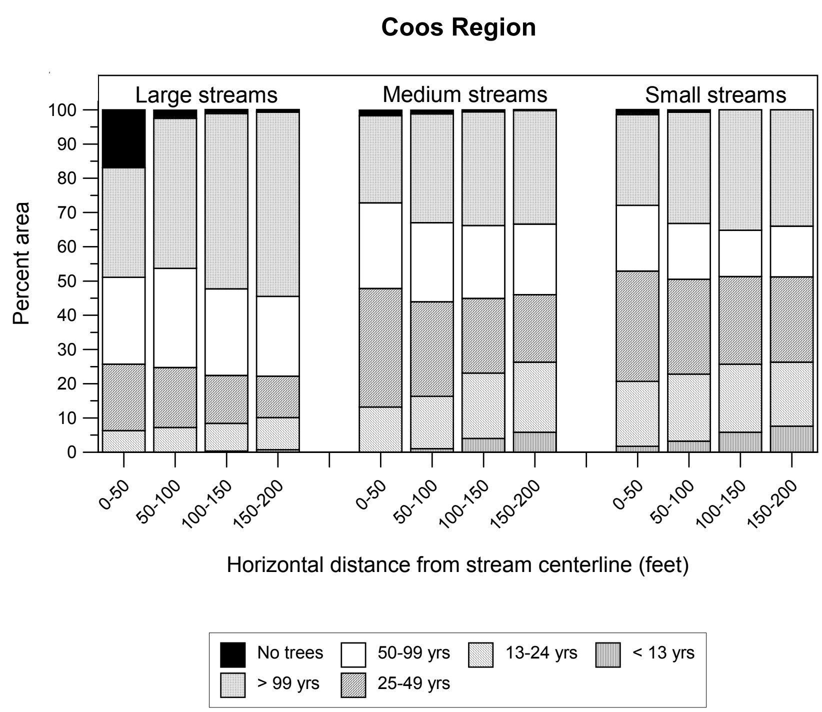

Umpqua Region
Large streams
Medium streams
Small streams
Percent area
0
10
20
30
40
50
60
70
80
90
100
41.1
17.7
7.6
42.4
34
14.9
33.5
42.6
20.3
30
46.1
22.3
64.4
23.3
12.3
36.8
36.3
27
18.5
45.6
35.9
14.7
48.5
36.8
49.7
21.3
29
29
28.6
42.4
15.4
35.3
49.4
11.7
35.9
52.4
0-50
50-100
100-150
150-200
Horizontal distance from stream centerline (feet)
No trees
Hardwood
Con/Hard
Conifer


Tenmile Region
Large streams
Medium streams
Small streams
Percent area
0
10
20
30
40
50
60
70
80
90
100
69
13.2
8.2
60
16.6
14.7
48.6
23.9
19.8
44.4
30
18.3
78.7
11.3
6.3
55.5
26
15.2
33.8
38.7
25.3
25.1
41.2
32.4
76.1
14.1
8.5
51.3
26.4
21.3
35.2
36.4
27.7
29.8
40.3
29.4
0-50
50-100
100-150
150-200
Horizontal distance from stream centerline (feet)
No trees
Hardwood
Con/Hard
Conifer

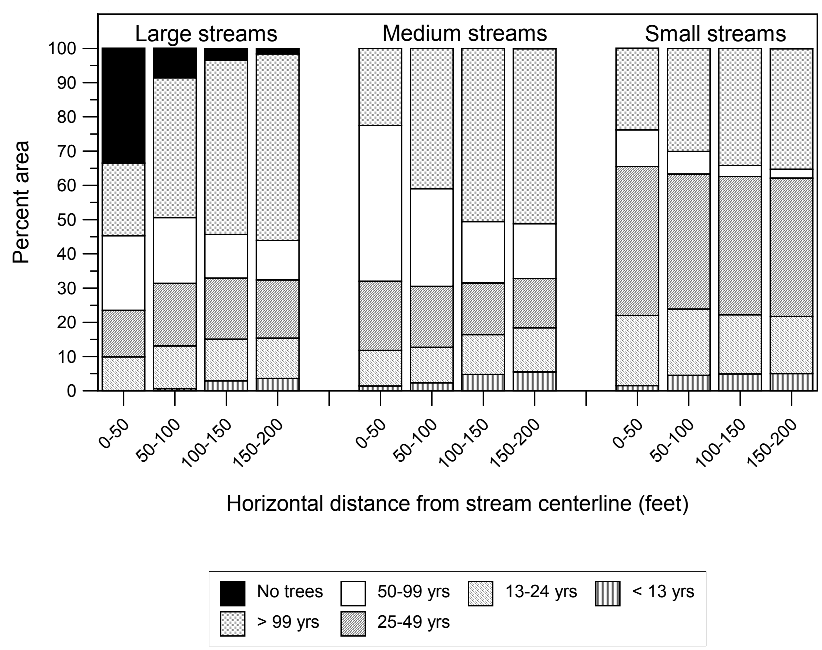
Stands along medium and small streams in the Coos region tend to be younger than same-sized streams in the Umpqua region (Figure 7-3). The acquisition of land by the Forest along the southern edge of the Coos region (i.e., the Marlow Creek drainage), which was harvested in the 1940s and 1950s, accounts some for the skewed age distribution. Streamside areas in the Tenmile region have the lowest percentage of stands older than 99 years (Figure 7-3). Instead, streamside stands age 50-99 years are the most dominant in this region. Appendix A to this report contains complete information on streamside stand composition and age for each of the 13 analysis basins.

Results from a 2001 contracted inventory of selected streamside stands on the Forest (ODF 2001) and nearby streamside stands administered by the BLM (Ursitti 1990) allowed the analysis team to assign stand characteristics (trees per acre, basal area per acre, quadratic mean diameter) to the various combinations of age class and conifer/hardwood ratios incorporated into the overall streamside forest inventory. The Forest study included riparian plots with trees from 20-210 years old and the study on BLM land included riparian plots with trees from 88-408 years old. The minimum tree size counted in the plots was 6 inches DBH. For this analysis, it was assumed that the ratio of conifer to hardwood basal area in field plots was equivalent to the ratio of conifer to hardwood canopy cover, as observed in aerial photographs.

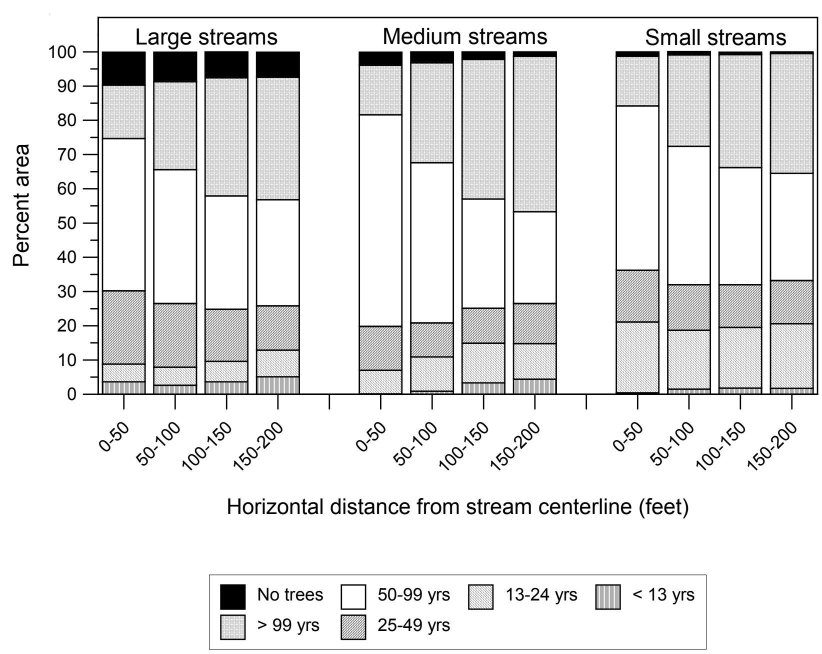
Figure 7-3. The percent riparian stand age by stream size for the Coos, Umpqua, and Tenmile regions of the Forest (fish-bearing streams only).



Umpqua Region



Tenmile Region



For each conifer dominance type (conifer, hardwood/conifer, hardwood), tree density and basal area was plotted against age for both conifers and hardwoods (Figures 7-4 and 7-5). Linear regression was used to determine relationships between stand density and stand basal area with age, often using logarithmic transformations of the independent or dependent variable (or both). The transformation that provided the best fit and made sense when extrapolated to age 400 (no negative numbers) was selected. If the regression equation explained less than 20% of the variance around the mean, then a mean value across all stand ages was used. The equations are shown in Table 7-1. The relationships in Table 7-1 that are later used in the analysis of modeling streamside stands are not particularly refined, nor do they explain a large portion of the variance among plots. Nevertheless, they are appropriate for the coarseness of the streamside stand inventory and the type of management questions addressed in the second part of this chapter.

Table 7-1. Regression equations relating stand density and basin area to stand age for streamside areas.

Parameter		Regression Equation	Adjusted R^2	P value	Sample Size
Stand density (trees per acre)					
Conifer dominated stands	Conifer trees	Y = 183 – 24.7 * ln(Age)	0.35	0.001	26
	Hardwood trees	Average value of 36	---	---	26
Conifer/hardwood stands	Conifer trees	Y = 97 – 15.0 * ln(Age)	0.26	0.007	23
	Hardwood trees	Y = 76 – 0.165 * Age	0.24	0.014	21
Hardwood dominated stands	Conifer trees	Y = 131 * Age $^{-0.683}$	0.27	--	14
	Hardwood trees	Y = 375 * Age $^{-0.354}$	0.29	0.04	14
Stand Basal Area (sq. ft. per acre)					
Conifer dominated stands	Conifer trees	Y = -65.6 + 59.8*ln(Age)	0.27	0.003	26
	Hardwood trees	Average value of 32	---	---	26
Conifer/hardwood stands	Conifer trees	Average value of 77	---	---	24
	Hardwood trees	Y = 20 * Age $^{0.321}$ *for < 90 years*	0.43	0.005	15
		Y = 94.5 – 0.192 * Age *for >= 90 years*	0.31	0.09	8
Hardwood dominated stands	Conifer trees	Average value of 15	---	---	20
	Hardwood trees	Y = 20.2 * Age $^{0.360}$ *For < 120 years*	0.20	0.05	17
		Y = 16309 * Age $^{-1.032}$ *For >= 120 years*	0.94	0.02	4

Figure 7-4. Relationship between stand density and age for conifer-dominated, conifer/hardwood, and hardwood-dominated stands. The regression line for conifers is shown as a solid line and as a dashed line for hardwoods.

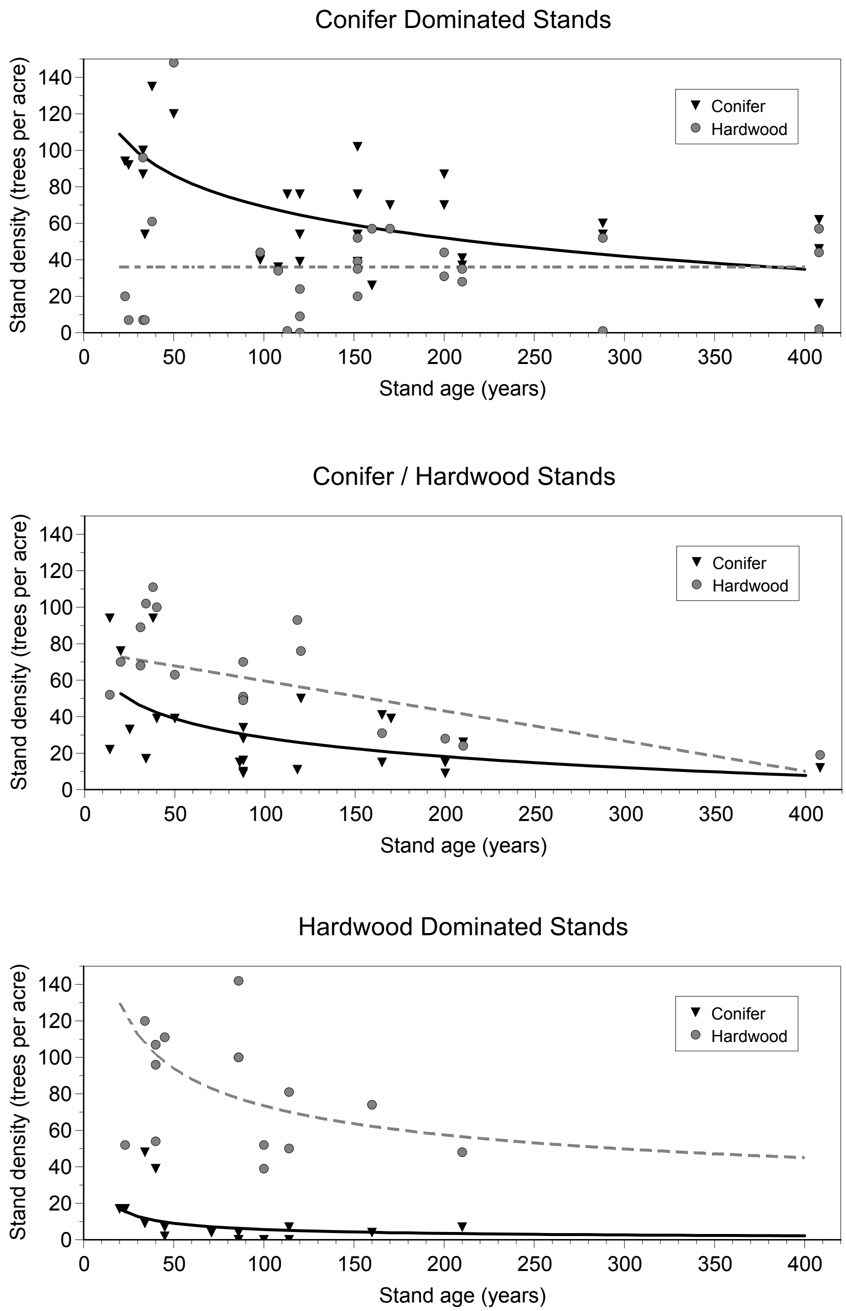
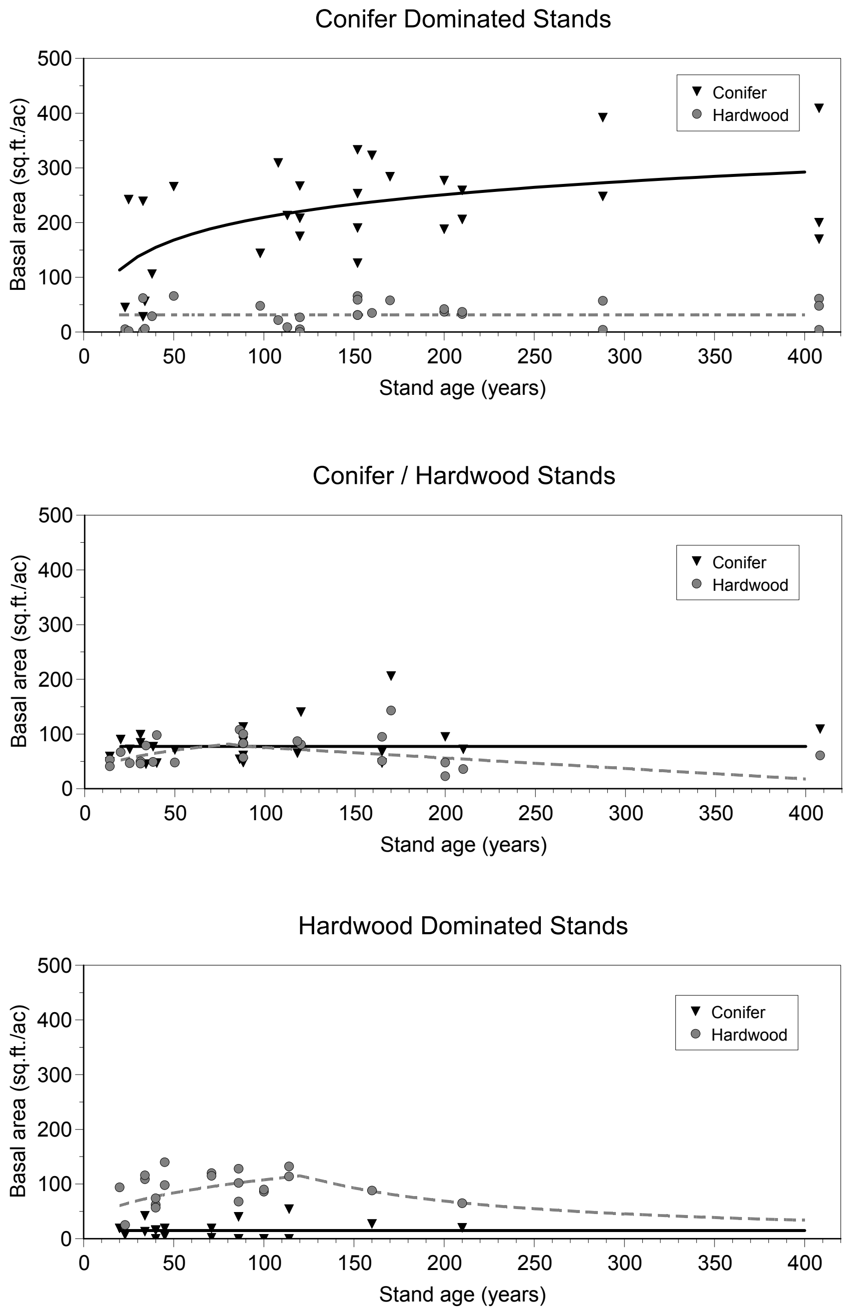
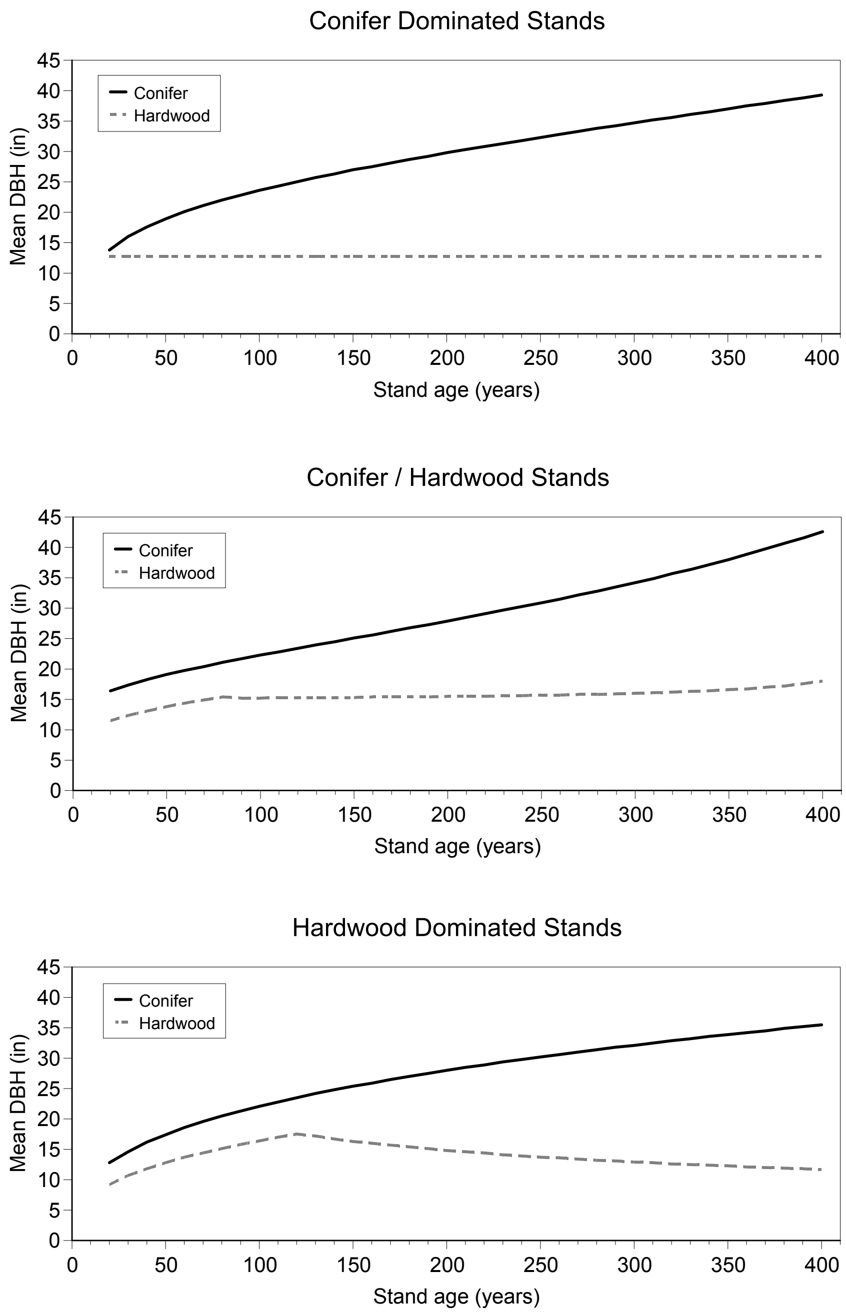


Figure 7-5. Relationship between stand basal area and age for conifer-dominated, conifer/hardwood, and hardwood-dominated stands. The regression line for conifers is shown as a solid line and as a dashed line for hardwoods.



The quadratic mean diameter for both conifer and hardwood trees was calculated by dividing stand basal area by stand density (Figure 7-6).

Figure 7-6. Relationship between mean diameter (DBH) and age for conifer-dominated, conifer/hardwood, and hardwood- dominated stands.



The above equations were used (or mean values if the R-square value was less than 0.20) to estimate values for conifer and hardwood density and basal area for each permutation of stand type and age class, using the midpoint of each age class (Table 7-2).

Table 7-2. Streamside stand characteristics by stand type and age class as summarized from Figures 7-4 to 7-6.

Stand Type	Age Range and Midpoint	Conifer Density (stems/ac)	Hardwood Density (stems/ac)	Conifer Basal Area (sq. ft./ac)	Hardwood Basal Area (sq. ft./ac)	Conifer Diameter (inches)	Hardwood Diameter (inches)
Conifer	13-24 (19)	110	36	110	32	13.6	12.7
	25-49 (37)	94	36	150	32	17.2	12.7
	50-99 (75)	76	36	192	32	21.5	12.7
	99-160 (130)	63	36	225	32	25.7	12.7
Conifer/ Hardwood	13-24 (19)	53	73	77	52	16.3	11.4
	25-49 (37)	43	70	77	64	18.0	12.9
	50-99 (75)	33	64	77	80	20.7	15.2
	99-160 (130)	25	55	77	70	24.0	15.3
Hardwood	13-24 (19)	18	132	15	59	12.5	9.1
	25-49 (37)	11	104	15	75	15.7	11.5
	50-99 (75)	7	81	15	97	20.0	14.8
	99-160 (130)	5	67	15	107	24.2	17.2

Note: The minimum diameter (DBH) of included trees is 6 inches.

Tree height was estimated using relationships derived from information on dominant and codominant trees as measured in streamside plots of various stand ages throughout the Forest (ODF 2001). Since the majority of conifers currently growing along streams are Douglas-fir and most hardwoods are red alder, regression equations for these two species were developed to represent conifers and hardwoods in general:

$$\text{Conifer tree height (feet)} = -189.8 + 114.6 * \ln(DBH) - 1.029 * DBH$$

$$\text{Adjusted } R^2 = 0.91, P = 0.0001, n = 204$$

$$\text{Hardwood tree height (feet)} = -16.9 + 36.5 * \ln(DBH)$$

$$\text{Adjusted } R^2 = 0.34, P = 0.00001, n = 199$$

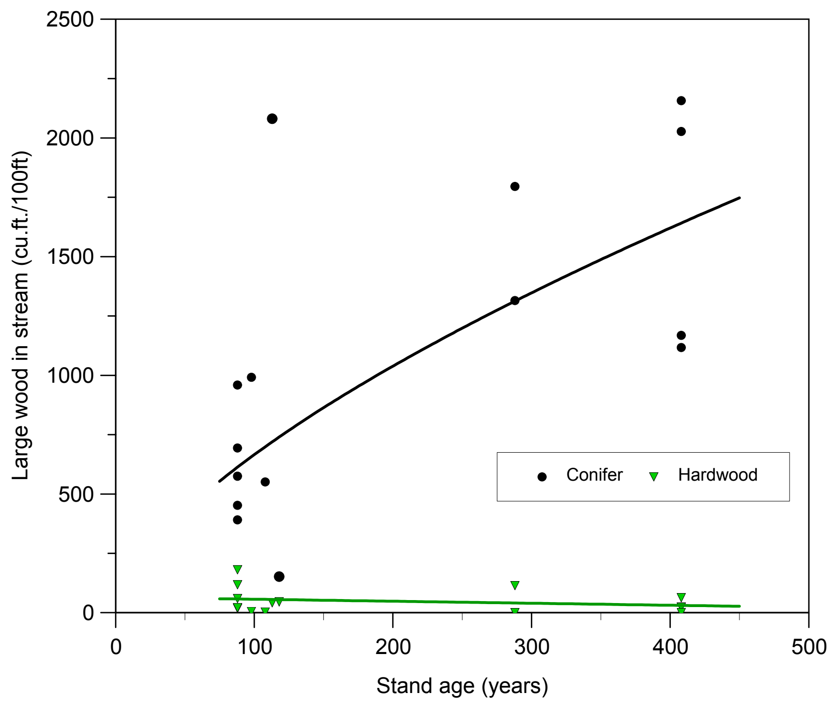
where DBH is in inches and “ln” is the natural logarithm.

The above results illustrate that streamside forests along fish-bearing streams in the Forest are highly heterogeneous both longitudinally and laterally from the stream centerline. Stand characteristics, such as average diameter and tree density, also vary widely among plots, even for a given stand type (conifer/hardwood dominance by age class). This variability results in only fair correlations between stand characteristics and age using the available plot data. Nevertheless, these relationships are preferable to using an upslope stand growth model, such as ORGANON (Hann et al. 1995) to characterize changes in streamside stands over time. Upslope stand growth models assume that self-thinning is the main mechanism for tree mortality, and not unstable slopes or windthrow. In addition, since streamside forests have relatively low initial conifer density, upslope stand growth models invariably under-predict mortality.

LARGE WOOD IN THE AQUATIC SYSTEM

Large wood usually becomes abundant in streams only after the streamside stand reaches an age of several centuries, although localized large accumulations can occur due to windthrow, landslides, or major channel shifts. Large wood in streams bordered by older, undisturbed streamside forests was inventoried on nearby BLM land to the east and south of the Forest (Ursitti 1990), and provides a perspective on natural wood loads. None of the streams had been intentionally cleared of large wood over the last few decades. Results from this study indicate that wood volume was two-fold greater in streams bordered by 300- to 400-year-old stands than those bordered by 100-year-old stands (Figure 7-7). Nearly all instream wood was conifer in spite of an abundance of hardwoods in some of the streamside stands, thereby illustrating the short-lived nature of hardwood in streams. Results from this study were used by the analysis team to provide a benchmark for comparing large wood loading in streams on the Forest.

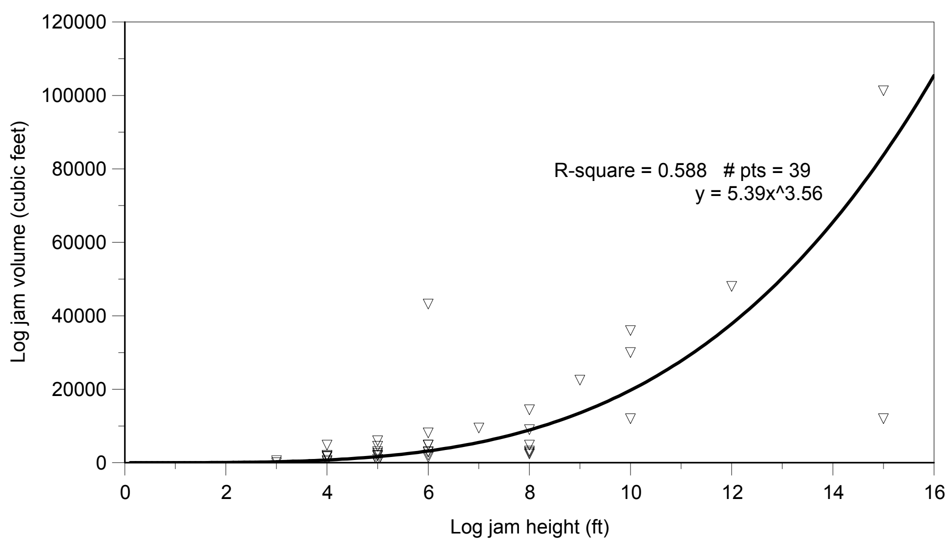
Figure 7-7. Large wood in undisturbed streams bordered by stands 88-408 years old on BLM ownership south and east of the Forest (Ursitti 1990).



Further evidence that large wood was more abundant in streams prior to Forest management was available from 1960s surveys of logjams. Stream surveys of the West Fork Millicoma River watershed were conducted through a joint effort of the Oregon Fish Commission and the Oregon Game Commission to collect baseline stream information for a proposed dam located just below the confluence with Trout Creek. The surveyors mapped stream substrate, identified fish species present, and provided information on the location and extent of possible obstructions to fish passage, which were generally logjams.

Survey information was compiled and entered into a GIS by the Coos Watershed Association. The surveys contain information about the location and character of logjams, and usually an estimate of the jam dimensions (height, length, width). Only for about one-quarter of the jams, the surveyor made a height measurement. Therefore, a correlation relationship was derived between height and volume for those logjams that had complete measurements (Figure 7-8), and then applied to those jams with only a height measurement in order to estimate volume.

Figure 7-8. Relationship between logjam height and logjam volume.



Volumes were multiplied by 0.7 to account for the space between the logs in a jam. This was done so that comparisons could be made between the logjam survey results and results from current large wood surveys, for which the volume of every log is determined. The results from five streams in the West Fork Millicoma River Basin that were relatively undisturbed during the 1960s are shown in Table 7-3. The few jams that were actually beaver dams, piles of brush, logging slash, or a result of logs floated against a bridge abutment are excluded from the summary. All surveys were done in 1963 except for the Elk Creek survey, which was done in 1967.

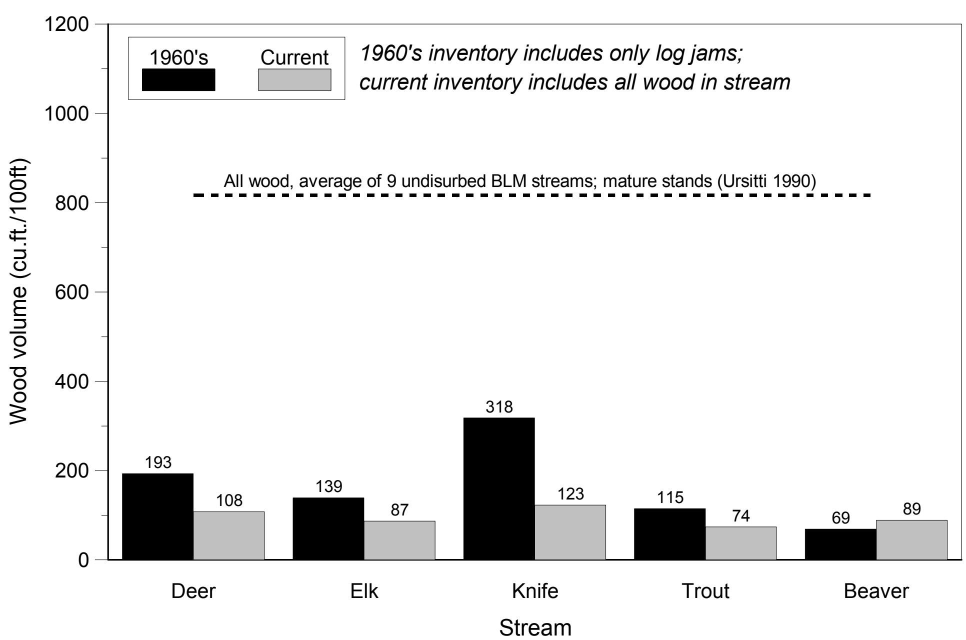
Table 7-3. Volume of wood in logjams during the 1960s for five relatively undisturbed Forest streams.

Stream	Logjam Wood Volume* (cu. ft.)	Distance Surveyed (mi.)	Number of Jams	Unit wood Volume (cu. ft. per100 ft.)
Deer	7,150	0.70	4	193
Elk	59,430	8.10	8	139
Knife	33,110	1.97	9	318
Trout	18,220	3.00	4	115
Beaver	2,922	0.81	2	69
Combined	**120,832**	**14.58**	**27**	**157**

* 30% porosity assumed based on visual observation of existing logjams.

The combined wood volume within logjams for these five streams was 157 cubic feet per 100 feet of stream, ranging from 69 cubic feet of stream for Beaver Creek to 318 cubic feet per 100 feet of stream for Knife Creek. These 1960s values for logjam wood volume averaged 1.7 times higher than the wood volume indicated by current surveys where all wood (not just jams) was measured (Figure 7-9). Obviously, if all wood in streams had been measured during the 1960s surveys, the volume difference would be even greater. The average wood volume in nine nearby, undisturbed BLM streams bordered by mature timber is about five times higher than log jam wood volumes in the West Fork Millicoma River tributaries during the 1960s. This suggests that only a minor portion of all wood volume in a stream is contained within logjams.

Figure 7-9. Wood volume in logjams during 1960s surveys versus total wood volume in streams during current surveys. Also shown is total wood volume in undisturbed streams bordered by mature timber (88-118 years old) for nearby BLM land.



Information from the ODFW stream surveys conducted in the 1990s, 2001, and 2002 (Aquatic Inventory Project, physical habitat surveys) was used to evaluate current levels of large wood in Forest streams. Some streams had multiple surveys; in these cases, the most recent survey was used. Large wood has been intentionally added to some stream segments on the Forest over the last few years (see Chapter 8, *Aquatic Organisms and Their Habitat*). However, in most cases the stream survey took place prior to the wood placement projects.

The ODFW surveys included a majority of the known fish-bearing streams in the Forest. The inventory of large wood in the surveys included all wood pieces that are partially or completely within the active channel width of the stream. It also included wood suspended over the channel. All pieces greater than 10 feet long and greater than 4 inches in diameter were included in the inventory. These specifications also applied to the BLM surveys.

Wood volume (cubic feet per 100 feet of stream) was summarized for each stream reach in the ODFW habitat surveys. The ODFW reaches varied considerably in length, with breaks between reaches often occurring at the confluences of major tributaries. Reaches were about 1 mile long on average. The ODF stream size classification system was assigned to each ODFW reach. Sometimes the ODFW reaches included more than one stream size. In these cases, a combined size class was used. For example, if the downstream end of a survey reach began on a medium size stream and ended where the stream was classified as small, the size class assigned to that reach was medium/small. For this analysis, a *river* size class was added in order to segregate the West Fork Millicoma River downstream of its confluence with Elk Creek and Mill Creek downstream of Loon Lake. In addition to wood volume, the density of key pieces for each reach was calculated. Key pieces are large logs in the stream that are at least 24 inches in diameter and at least 33 feet long. Key piece density provides an indicator of the stability of wood jams in a stream.

Currently, wood volume in Forest streams with an active channel width less than 40 feet averages 28% of the wood volume in nearby reference streams bordered by 88- to 118-year-old timber, and 14% of the wood volume in those reference streams bordered by old-growth timber (Table 7-4). Streams on the Forest that are 40- to 100-feet wide have less than one-half of the wood found in smaller streams. Wood is equally low for all regions of the Forest.

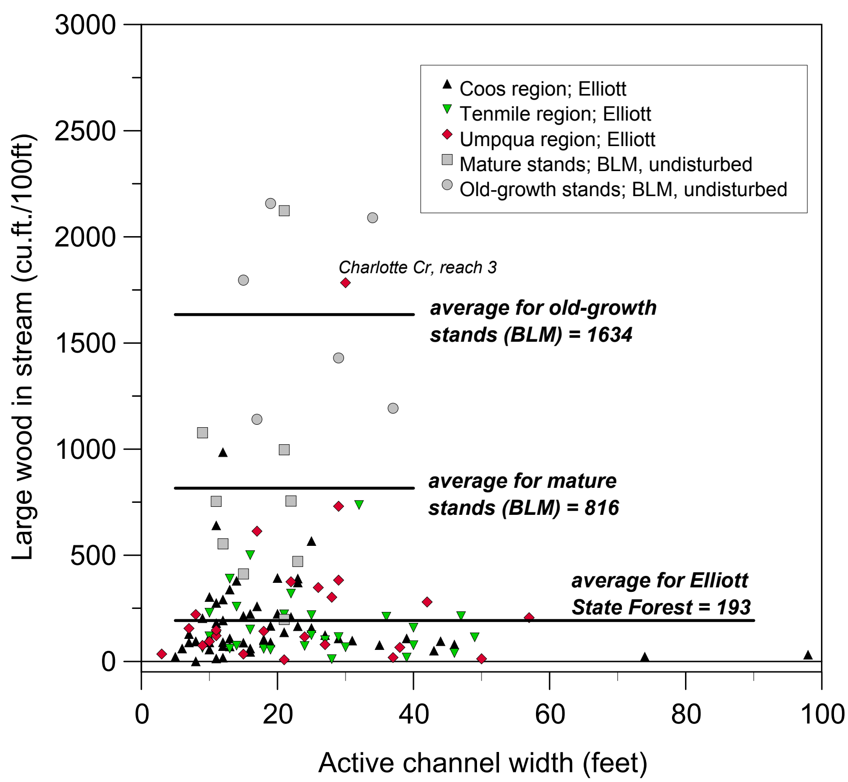
Although the number of key pieces per 100 feet of stream averages about the same for the Coos and Tenmile regions, it is about one-half as much for the Umpqua region (Table 7-4). The density of key pieces in channels greater than 40 feet wide is about one-third that of narrower streams.

Variability in wood abundance among reaches is high for both the Forest fish habitat surveys and the BLM reference streams. Nevertheless, only 2 out of 193 stream reaches on the Forest have wood loadings that exceed the average for the reference reaches (Figure 7-10). For streams less than 40 feet wide, there is no correlation between wood loading and active channel width for either Forest streams or the BLM reference streams.

Table 7-4. Large wood volume in Forest streams, by region, and in BLM reference streams (mean values weighted by reach length).

Location	No. Reaches	Mean Wood Volume (cu. ft. per 100 ft.)	Standard Deviation Wood Volume (cu. ft. per 100 ft.)	Mean Number of Key Pieces (#/100 ft.)
Elliott State Forest				
Active channel width less than 40 feet				
Coos region	51	195	177	0.39
Tenmile region	25	197	170	0.31
Umpqua region	21	166	363	0.17
Combined	97	191	240	0.33
Active channel width 40 to 100 feet	13	65	84	0.10
BLM reference streams				
Active channel width less than 40 feet				
88- to 118-yr-old stands	9	816	564	---
288- to 408-yr-old stands	6	1,634	445	---

Figure 7-10. Large wood volume in Forest streams, by region, as compared to the volume of wood in BLM reference streams.



For stream reaches with an active channel width less than 40 feet, analysis basin #7 (Johnson Creek) has the highest wood loading at 380 cubic feet per 100 feet (Table 7-5). Relatively high amounts of large wood also are found in basin #8 (especially high in Palouse Creek), basin #2 (Charlotte Creek and Luder Creek), Johanneson Creek in basin #3, and Noble Creek in basin #5. Analysis basin #4 (Scholfield Creek) and #1 (Footlog Creek) has the lowest wood abundance at 33 and 95 cubic feet per 100 feet, respectively. These drainages have roads parallel to the stream in their lower reaches and wood may have been removed during road construction. Wood volume and density of key pieces do not vary appreciably with stream size class, except that large streams greater than 40-feet wide and rivers have considerably less wood (Table 7-6).

Table 7-5. Average values for large wood in streams by analysis basin, weighted by reach length.

Region	Basin	Wood Volume in Streams (cu. ft. per 100 ft.)	
		Active channel width <40 ft.	Active channel width >40 ft.
Coos	8	343	---
	9	---	31 (WF Millicoma)
	10	169	---
	11	180	50 (WF Millicoma)
	12	115	38 (Elk, WF Millicoma)
Tenmile	5	177	---
	6	164	---
	7	380	122 (Johnson)
Umpqua	1	95	---
	2	310	206 (Charlotte)
	3	163	12 (Dean)
	4	33	280 (Scholfield)
	13	---	---

Basins with no streams sampled indicated by '---'.

Table 7-6. Large wood in streams by stream size class.

Stream Size Class	Average Wood Volume (cu. ft. per 100 ft.)	No. of Reaches	Average Number of Key Pieces (#/100 ft.)
Small	188	25	0.33
Medium/Small	380	19	0.71
Medium	195	19	0.32
Large/Medium	216	12	0.37
Average of above	*242*		*0.42*
Large ACW* <40 ft.	166	17	0.21
ACW >40 ft.	115	9	0.20
River**	27	2	0.06

* ACW = active channel width
** West Fork Millicoma River downstream of Elk Creek confluence

Many Forest stream reaches were cleared of large wood during timber harvest or road construction. Others were cleared of large wood during the 1960s and 1970s under the mistaken belief that logjams created widespread barriers to the upstream movement of salmon and steelhead. The low wood volume documented in the ODFW inventories reflects these past stream cleaning activities. Reduced wood in Forest streams also resulted from tree removal near or to the edge of streams in older harvest units. Without fresh inputs of wood into channels, the net volume decreases due to decay and downstream movement.

Modeling Streamside Stands and Large Wood

Evaluating the future amount of wood likely to accumulate in streams involves the straightforward calculation of wood additions and subtractions. Wood additions to a stream can include:

- Trees falling into the stream.
- The intentional placement of logs in a stream.
- Log deposition by landslides that reach the stream.

Wood subtractions to a stream can include:
- Log volume loss due to decay and abrasion.
- The intentional removal of logs in a stream.
- Downstream movement of logs during high flows.

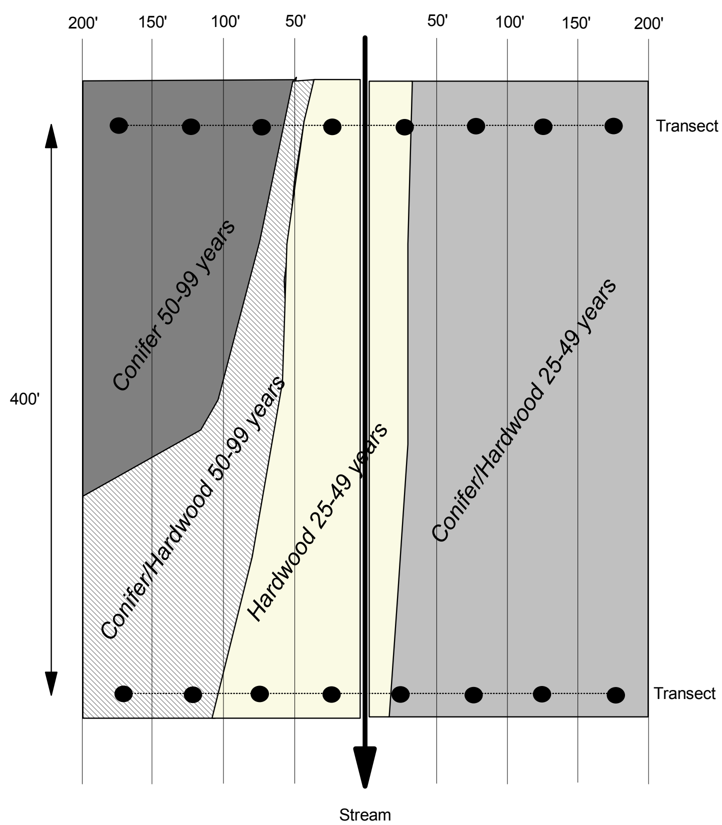
The current difficulty in modeling large wood in streams is a lack of basic information about some of these processes. The long-term addition of wood to streams by landslides is poorly understood since no inventories exist of the amount of wood that accumulates within landslide-prone areas under various management histories. Furthermore, little is known about the portion of wood moved into streams when a landslide occurs. Similarly, little is known about the downstream floating and fate of logs during high flows for streams of various sizes, although casual observation of Forest streams suggests that log movement is limited mostly to streams classified as large. Since the intentional removal of logs from streams is no longer allowed under the Forest Practices Act, this does not need to be included when evaluating the large wood budget of a stream.

In recent years, some progress has been made on techniques for evaluating the input of large wood by streamside stands, and the loss of wood volume in streams over time due to decay (Van Sickle and Gregory 1990, Welty et al. 2002). The analysis team included an application of these methods to fish-bearing streams in the Forest, realizing that other important processes such as wood additions (landslides) and losses (downstream movement) cannot be quantified. Understanding the relationship between the amount and type of trees retained along streams during timber harvest and the future accumulation of wood can lead to better decisions on stream protection practices.

The analysis team adapted methods from the RAIS (Riparian Aquatic Interaction Simulator) model (Welty et al. 2002) to forecast wood inputs from streamside stands and the loss of wood in streams due to decay. However, this model was not used directly because it currently has several software bugs that make critical subroutines unusable. Instead, a spreadsheet version of the model was created and tailored to address various issues pursued in this analysis. The following discussion provides a summary of the subroutines and relationships that went into the spreadsheet version of the model.

The GIS coverage for riparian vegetation and wood loadings from ODFW habitat surveys provided a spatially explicit representation of current stand and stream conditions for fish-bearing streams. An application was developed in ArcInfo to sample a cross section of the riparian vegetation GIS coverage every 400 feet along fish-bearing streams. Since the Forest includes about 161 miles of fish-bearing streams, the total number of transects was 2,125. The vegetation was noted at 4 locations each side of the stream at 50-foot intervals from the stream, beginning 25 feet from stream centerline (Figure 7-11). The large wood model was constructed to track trees that fall from each of these 50-foot bands along the stream.

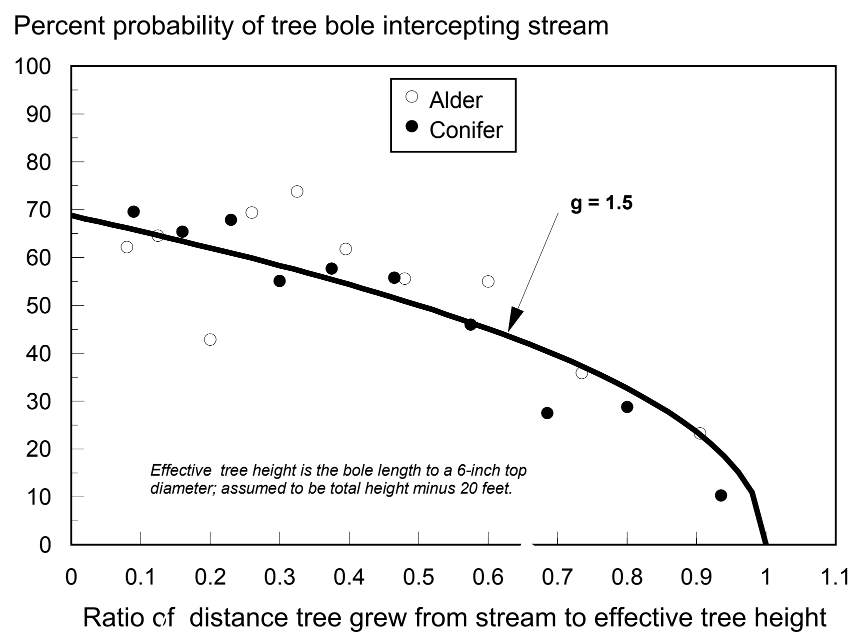
Figure 7-11. An illustration of how streamside stands were characterized using the GIS coverage of fish-bearing streams within the Forest. Filled circles indicate points along transects (spaced 50 feet) with 400-foot-long spacing between transects.



The current wood loading in the channel at each transect was determined from reach averages in the ODFW habitat surveys. For those fish-bearing stream segments with no habitat survey (61 miles Forest-wide), values were assigned based on measured values for nearby streams of similar size (Table 7-5).

The large wood model provides the option of assigning a tree fall bias. A study of windthrown buffer trees in the central and northern Coast Range indicates that, on average, trees are about twice as likely to fall directly towards a stream as they are to fall directly uphill (Andrus and Froehlich 1992). Figure 7-12 provides an empirical probability distribution that shows the likelihood of a tree ending up in a stream depending on its relative distance from the stream. This relationship predicts that a 140-foot tall tree with an effective height of 120 feet would have a 66% chance of hitting the stream upon falling if it grew 10 feet from the stream, and a 30% chance if it grew 100 feet from the stream (downhill bias, g = 1.5).

Figure 7-12. The probability of a tree landing in the stream as a function of its relative distance from the stream for observed fall patterns (Andrus and Froehlich 1992).



Percent probability of tree bole intercepting stream:

P = ((90-z) / 180 * (1 + (g/360 * (90+z))) * 100

where : z = arcsin(Distance / Effective Tree height)

Observed fall pattern based on 405 alder trees and 506 conifer trees. Windthrown trees from streamside buffers in the Oregon coast range (Andrus and Froehlich 1989).

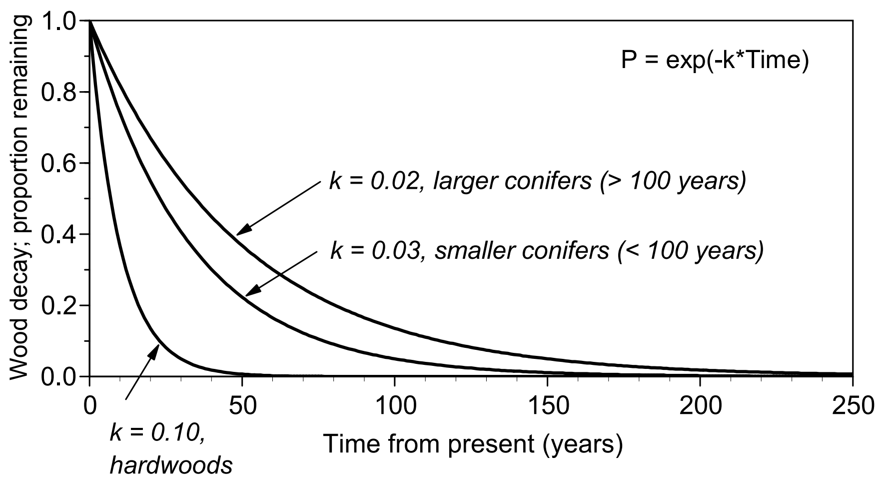
Key information needed for modeling wood losses from streams is the decay rate of logs of various species. Some information on the decay of conifer wood from southeast Alaska streams of various sizes was available from Murphy and Koski (1989). Similar studies on the decay of wood on uplands were conducted by Lambert and others (1980) and Sollins (1982). In these studies, a first-order decay function was used to describe wood volume losses over time. The function is:

$$P = exp(-k * X)$$

where Y is the proportion of wood remaining;
k is the decay rate; and
X is the time from the present in years.

The analysis team used a *k* value of 0.03 for conifers less than 100 years old. A *k* value of 0.02 was used for conifer logs greater than 100 years old; an adjustment based on the ability of large diameter and tight-ringed conifer logs to better resist decay that originates from the outer layers of a log (Harmon et al. 1986). A resurvey of alder logs in Oregon Coast Range streams 12 years after the original survey indicated that a *k* value of 0.10 was appropriate for applying to hardwoods (Heimann 1988). The loss functions using the selected *k* factors are shown in Figure 7-13.

Figure 7-13. Proportion of wood volume remaining as a function of time for conifer and hardwood logs in streams.



The analysis team used the empirical stand relationships in Table 7-1 to model the type (conifer or hardwood), number, diameter, and length of logs provided to streams by the streamside forest for each 10-year time interval, up to a maximum age of 300 years. Fallen trees less than 30 years old were assumed to be of such small size that they would have little influence on the overall volume of wood in streams. The model was run for three stand composition types (conifer-dominated, conifer/hardwood, and hardwood-dominated). Volume results were expressed as cubic feet of wood per 100 feet of stream.

A simple model run was made with the assumption that any preexisting large wood in the stream at year 0 was gone by year 30, and that the streamside stand was of uniform age to the edge of the stream. These assumptions correspond to the timber harvest and stream management practices of 20-50 years ago, when trees were typically harvested to the edge of a stream, merchantable logs were removed from streams, or logs were removed to “clean” the stream.

The amount of wood expected to accumulate in a stream varied greatly by stand composition. Streams bordered by conifer-dominated stands reached a net wood volume of about 770 cubic feet per 100 feet of stream by year 200, while the volume of wood in streams bordered by conifer-hardwood stands was one-half that amount (Figure 7-14). Streams bordered by hardwood-dominated stands had only 10% of the volume of those bordered by conifer-dominated stands.

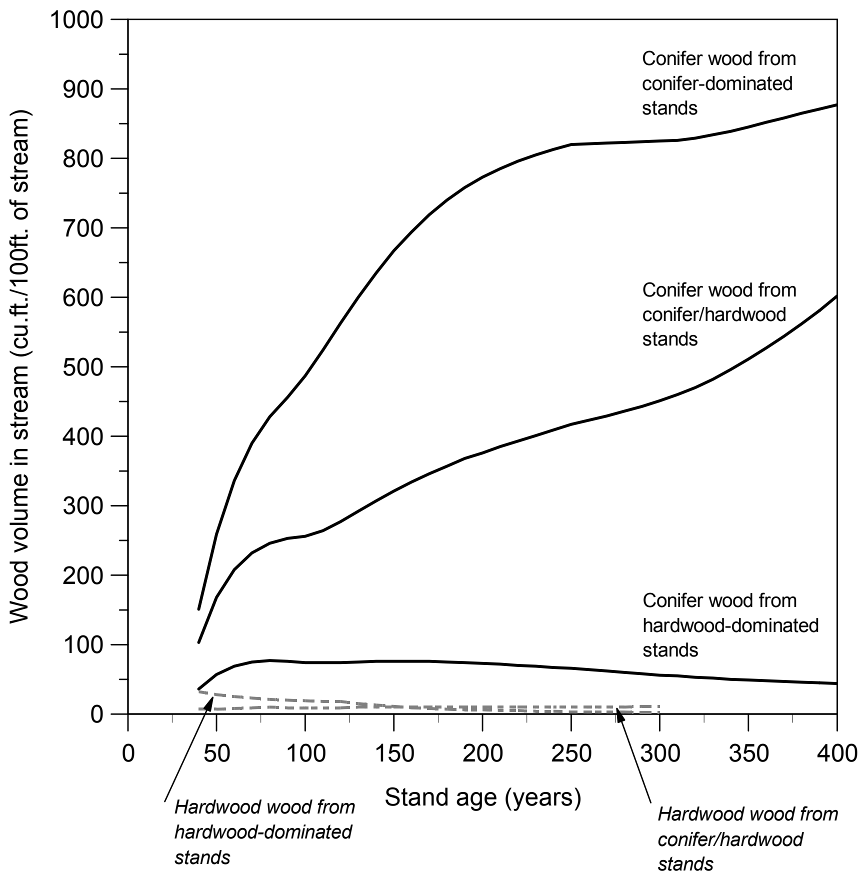
Beyond year 70, nearly all the volume of wood in streams was conifer (Figure 7-14). The volume of hardwood entering streams beyond year 70 is probably underestimated since the model has no mechanism for dealing with the production of hardwood volume for uneven-aged hardwood stands. Nevertheless, hardwood logs decay so quickly that they do little to influence the net volume of wood in the stream.

Wood volume in streams bordered by conifer-dominated streams plateau at about year 200 while streams with hardwood-dominated streams reached their greatest net volume at year 70 (Figure 7-14). The modeled net volume of wood in streams is less than that measured within undisturbed, reference streams on nearby BLM land (Table 7-7). This suggests that, in addition to logs originating from the streamside forest, a considerable amount of large wood in streams originates from landslides where large wood in draws is allowed to accumulate at natural volumes.

Table 7-7. Modeled large wood volume in comparison to measured values for Forest streams (<40 feet wide) and BLM reference streams.

Large Wood Volume	Mean Wood Volume (cu. ft. per 100 ft.)
Modeled wood volume (at year 200)	
Conifer-dominated stands	770
Conifer/hardwood stands	390
Hardwood stands	80
Measured wood volume, Elliott State Forest	
All stand types and ages	190
Measured wood volume, BLM reference streams (most were conifer-dominated stands)	
88 to 118 years old	820
288 to 408 years old	1,630

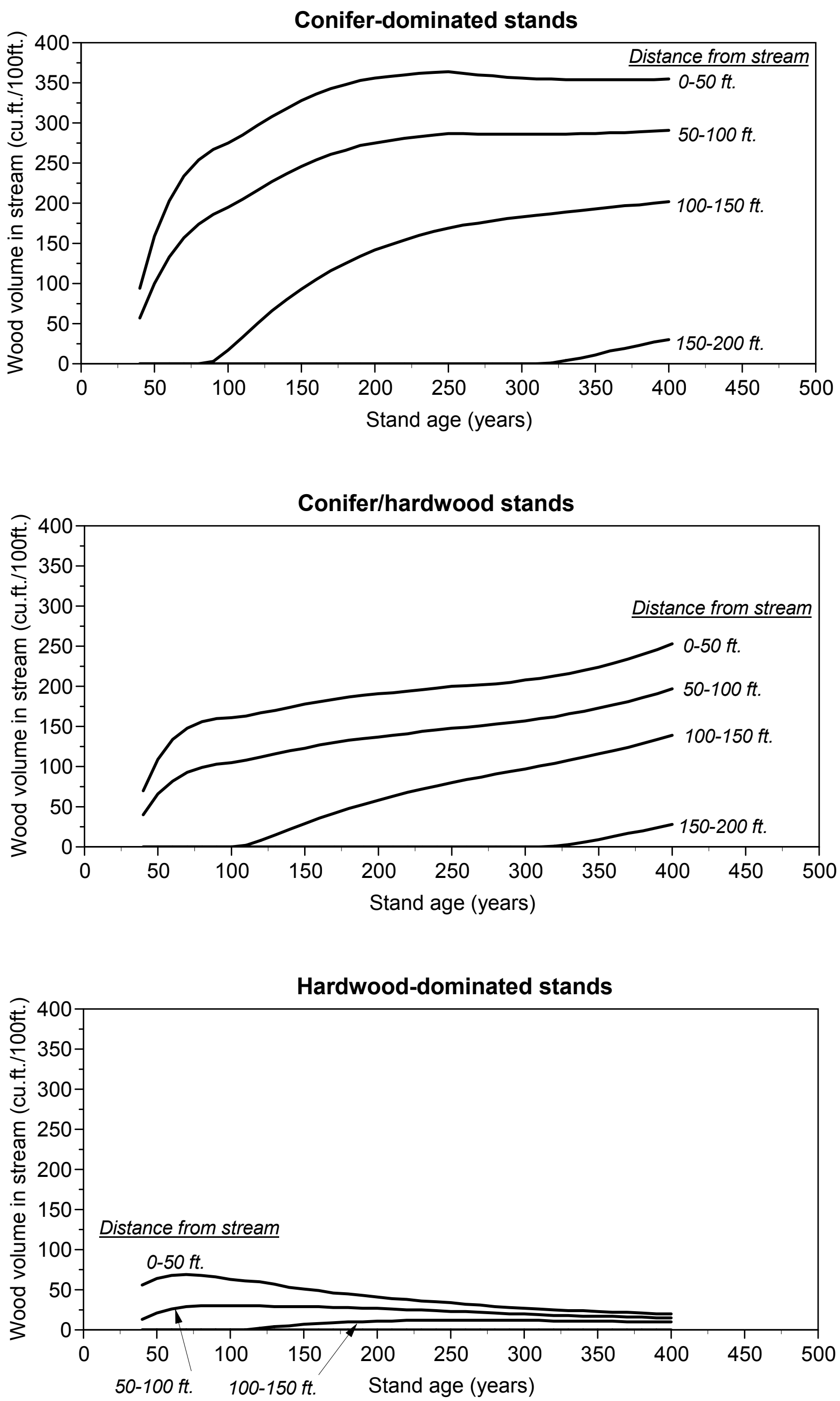
Figure 7-14. Modeled changes in conifer and hardwood wood volume for streams bordered by conifer-dominated, conifer/hardwood, and hardwood-dominated stands (assumes wood from the previous stand does not persist beyond year 30.)



These modeling results indicate that at year 200, most (85%) of the wood that has accumulated in the stream originates from the trees growing within 100 feet of the channel (Figure 7-15). However, the proportion originating from the 100- to 150-foot distance interval increases considerably from year 200 to year 300 for conifer-dominated and conifer/hardwood stands. Very little large wood within the stream originates from the 150- to 200-foot distance since the effective height (total height minus 20 feet) of dominant and codominant conifers exceeds 150 feet only for old stands. For the same reason, nearly all hardwood trees that end up in the stream originate from land within 50 feet of the stream.

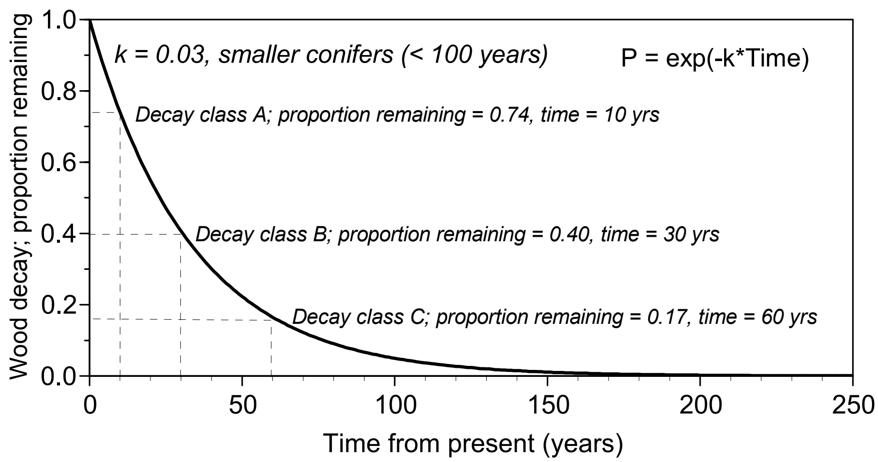
When modeling large wood in streams, the decay of initial wood in the stream (at year 0) needs to be tracked separately from the wood provided by the streamside stand (beyond year 0). Some of this initial wood consists of old logs in advanced stages of decay while some may be relatively sound. As discussed previously, since many Forest streams had in-channel wood intentionally removed over the last four decades, the composition of the current or previous stand provides little insight on the decay status of the wood in the stream.

Figure 7-15. Modeled net volume of large wood in streams and the distance class from which it originated.



The ODFW habitat surveys do not provide information on decay classes for the large wood inventoried in Forest streams in the mid-1990s. Consequently, the analysis team used results of a detailed large wood survey of 63 coastal southwest Washington streams (Bilby and Andrus, unpublished data) to better understand the wood decay classes of large wood currently in streams. The study area was a managed forest landscape that included both plantations and fire stands up to 100 years old. Some stream cleaning also occurred in this area. Focusing only on streams bordered by young plantations with no buffer trees retained during harvest, 34% of the conifer wood had intact bark and sound wood (decay class A), 41% was partially decayed but was still structurally sound (decay class B), and 25% was in advanced stages of decay without much structural integrity (decay class C). An estimate was made of where each decay class fell along a graph of proportion of wood remaining and time, assuming a *k* factor of 0.03 (Figure 7-16).

Figure 7-16. The positions for large wood of various decay classes along a decay curve where the k factor is 0.03 (smaller conifers).



In the model, loss of this initial wood due to decay was calculated by decay class and summed for each time increment. For example, the average value of current wood abundance as measured for Forest streams (193 cu. ft. per 100 ft.) is displayed in Figure 7-17. After 50 years, 17% of the initial volume is still present while only 2% is present after 100 years.

Adding the initial (current) wood volume in streams and projected declines to the logs provided by the maturing streamside stand, a more complete picture of net changes in wood emerges (Figure 7-18). Until the new stand begins yielding functional large wood at age 30, large wood in the stream declines rapidly as the initial wood decays. Large wood abundance increases to initial levels between years 30 and 50 for streams bordered by conifer-dominated and conifer/hardwood stands; streams bordered by hardwood stand never again approach the initial wood volume level.

Figure 7-17. Calculated decline in initial wood volume over time for the average Forest stream, as a composite of three decay classes.

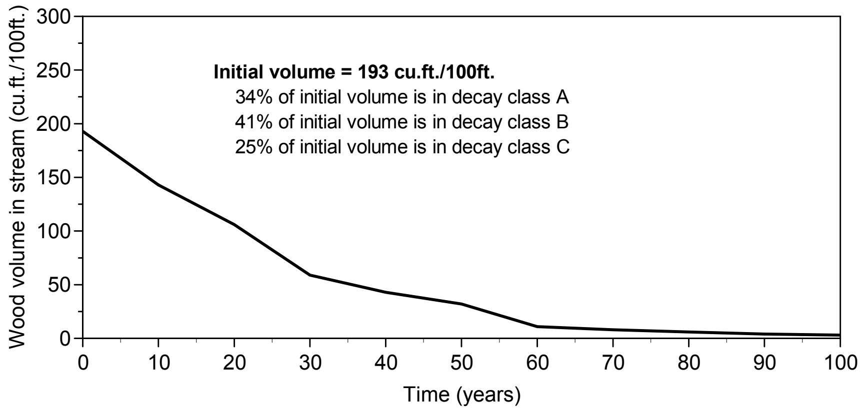
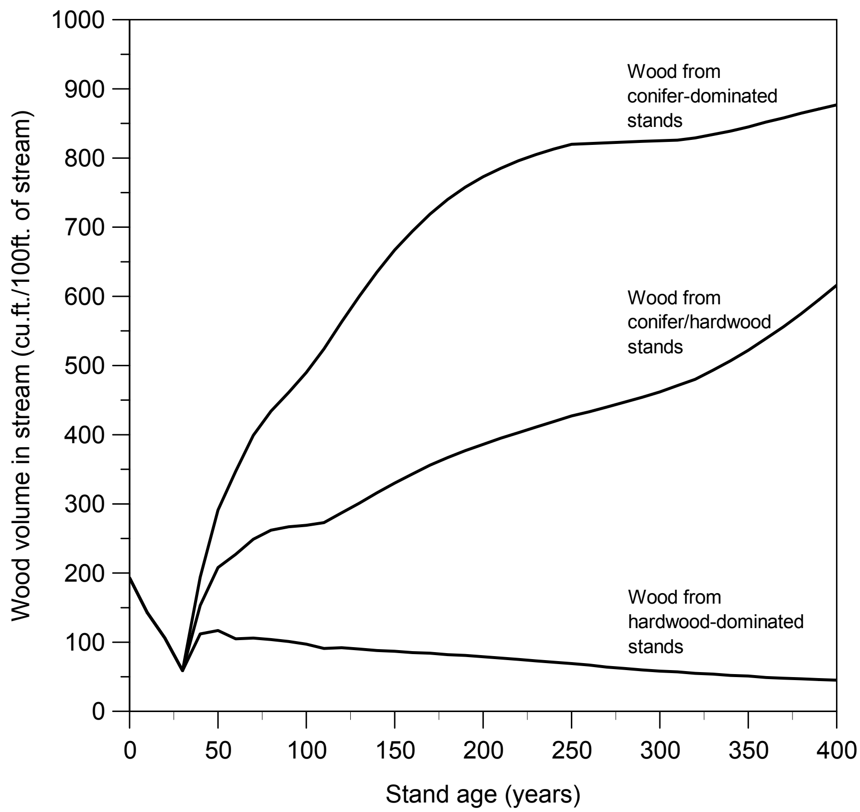


Figure 7-18. Modeled large wood in streams combining the wood initially in the stream at time of stand initiation (assumes a Forest-wide average of 193 cu. ft. per 100 ft.) plus the wood added by the developing streamside stand.



The simplified example shown in Figure 7-18 does not apply to most stream segments on the Forest since stand type and age are rarely the same for each side of the stream and for the entire distance 200 feet out from the stream centerline. In addition, initial wood volume varies widely among stream segments.

The heterogeneous nature of stands typically next to streams is illustrated in Figure 7-19 for Deer Creek, 2,800 feet downstream of the upper extent of fish use. An older conifer/hardwood stand grows on the left bank, a hardwood-dominated stand grows on the right bank out to 100 feet, and the remainder of the right bank is a conifer/hardwood plantation 12-24 years old. The current in-channel wood is 165 cubic feet per 100 feet; within 50 years, most of that will have decayed (Table 7-8). During the first 100 years, much of the wood comes from the left bank where older trees occupy the area within 100 feet of the stream. Within 300 years, the band 100-150 feet from the stream also provides sizable amounts of instream wood. Very little wood comes from beyond 150 feet. The hardwood stand growing on the right bank produces moderately small amounts of wood, with most of this coming from trees growing within 50 feet of the stream. After 50 years, this component becomes minimal. The young conifer/hardwood plantation growing beyond the older hardwood stand on the right bank yields very little wood until 300 years from the present, which originates mostly from trees growing no further than 150 feet from the stream. Adding the wood originating from all distance classes to the initial wood in the stream (or that which remains at any time) indicates that this stream segment will probably experience only modest gains in large wood over the next 100 years. Within 300 years, wood volume increases to about 2.6 times that initially in the stream (Table 7-8).

Figure 7-19. Stand type and age for Deer Creek, 2,800 feet upstream of the mouth.

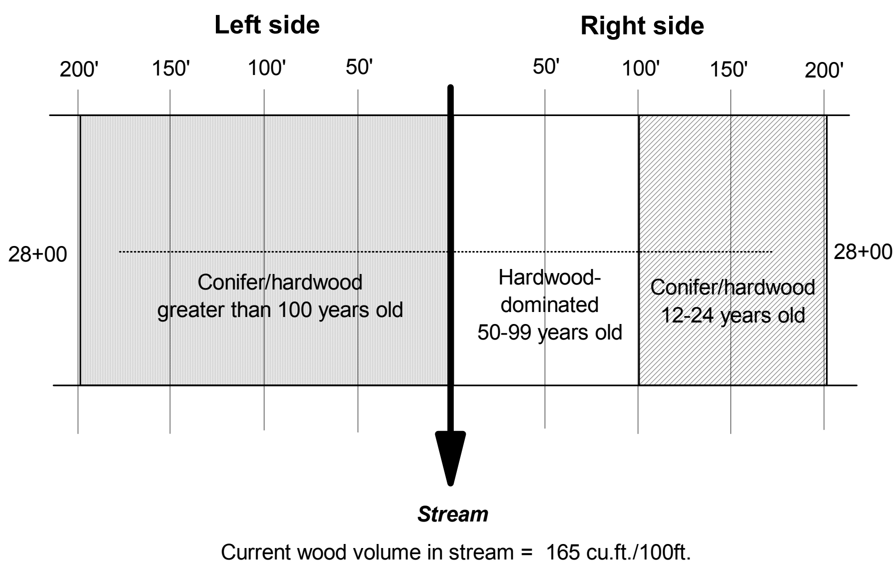


Table 7-8. Modeled large wood in Deer Creek (2,800 feet upstream of the mouth) from the current year to 300 years in the future.

Time from Present	Left Side of Stream (cu. ft. per 100 ft.)				Right Side of Stream (cu. ft. per 100 ft.)				Initial Wood in Stream (cu. ft. per 100 ft.)	Summed Wood in Stream (cu. ft. per 100 ft.)
	Conifer/hardwood >100 yrs				Hardwood-dom. 50-100 yrs		Conifer/hardwood 12-24 yrs			
	200-150'	150-100'	100-50'	50-0'	0-50'	50-100'	100-150'	150-200'		
0	---	---	---	---	---	---	---	---	165	165
50	0	24	66	94	30	15	0	0	32	261
100	0	36	72	98	23	14	4	0	3	250
300	19	79	108	140	13	10	52	1	0	422

The analysis team prepared a database showing current and modeled future large wood volumes for fish-bearing streams at various time intervals up to 300 years from the present. Large wood volume was modeled at intervals of 400 feet along all fish-bearing streams, and incorporated the decay of existing large wood in streams and the wood inputs and decay associated with the existing streamside stand. For purposes of display, results for the 400-foot intervals were averaged over distances of 1 mile or less. Results were reported for each unnamed tributary of a named stream, with tributaries labeled numerically in order from most upstream to most downstream. Unnamed tributaries were less than 1 mile long, except for tributary #1 of Scholfield Creek. Results for named streams were summed by 1-mile increments, starting at the most upstream end of fish use (or the property line in some cases). The most downstream segment was usually less than 1-mile long, stopping at the Forest property line. Appendix B provides a listing of the individual segments, along with their current and modeled future large wood volumes (at years 50, 100, 200, and 300).

Current large wood volume and the volume predicted 200 years from the present are displayed in Map 7.2 in a relative ranking. The 25% of stream segments that currently have the most amount of large wood are displayed as a green along the left side of the stream centerline (facing downstream), while the 25% of stream segments that currently have the least amount are displayed as a red line. Along the right side of the stream centerline are the relative rankings for large wood volume modeled for 200 years in the future. A blue line indicates the stream segment is among the 25% of segments with the greatest wood volume, while a lavender line indicates it is among the 25% of segments with the least wood volume.

The current abundance of wood in a stream segment was generally unrelated to the amount of large wood expected 200 years from now. For example, while wood volume in the lower mile of Footlog Creek is currently one of the lowest on the Forest (34 cu. ft. per 100 ft.), it is projected to be among the 25% of stream segments with the greatest wood volume (417 cu. ft. per 100 ft.) within 200 years (Map 7.2, Appendix B).

The average wood volume currently in fish-bearing streams is about the same for the three regions. However, sizable differences are predicted to develop by 300 years in the future. The Tenmile region has the lowest predicted wood volume at 300 years. Values are predicted to be 2.3 times higher for stream segments in the Umpqua region and 2.7 times higher for the Coos region (Table 7-9).

Up to two-fold differences in large wood volume is predicted to occur among individual analysis basins 300 years in the future (Table 7-9). The volume of large wood within some basins departed sharply from their regional averages (Figure 7-20). Future amounts of large wood were greatest for basins #2, #11, #12, and #13 and lowest for basins #7, #10, and #5.

Table 7-9. Current and projected large wood volume in Forest streams by analysis basin.

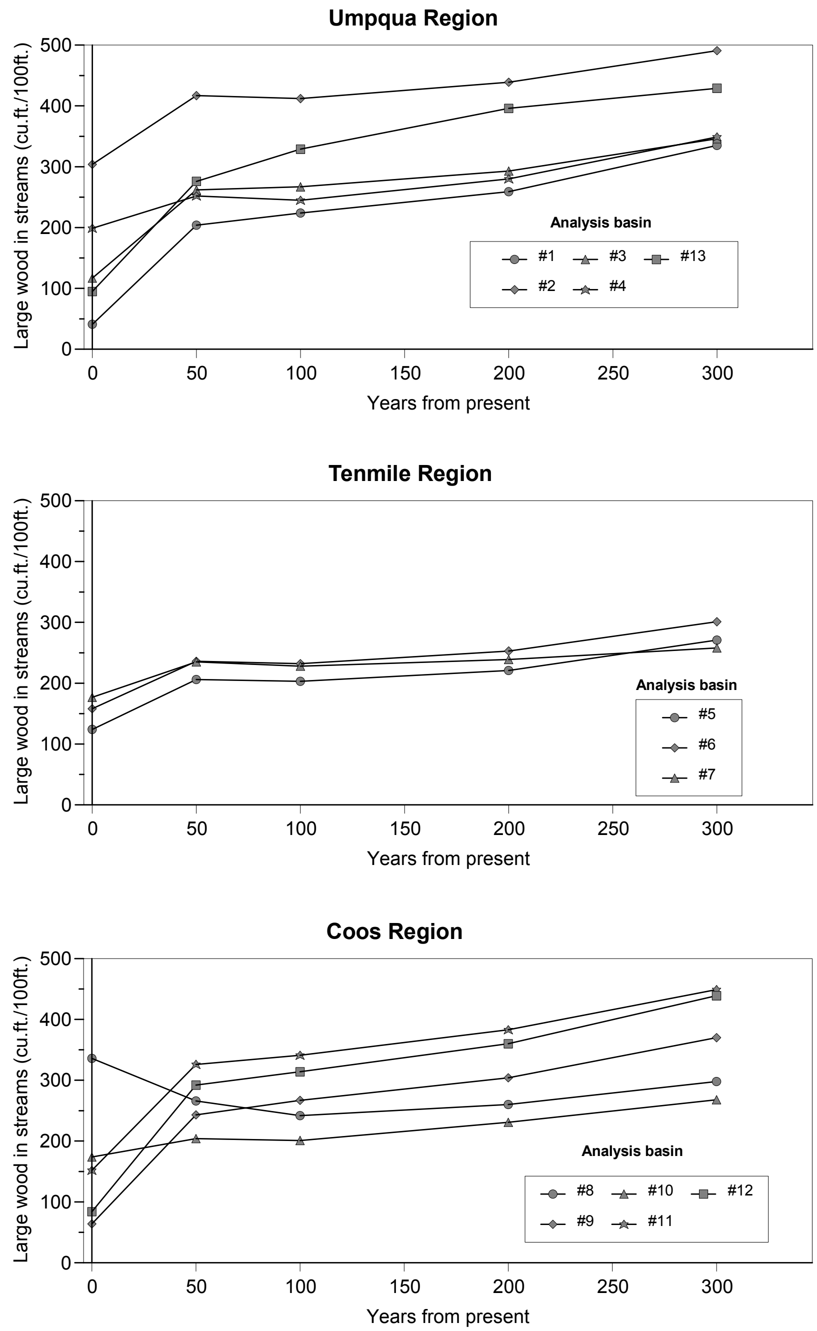
Region	Analysis Basin	Mean Large Wood Volume (cu. ft. per 100 ft. of stream)				
		0 years	50 years	100 years	200 years	300 years
Umpqua	1	41	204	224	259	335
	2	304	417	412	439	491
	3	117	262	267	293	346
	4	199	252	245	280	349
	13	95	276	329	396	429
	Combined	**144**	**272**	**283**	**318**	**378**
Tenmile	5	124	206	203	221	271
	6	158	236	232	253	301
	7	177	235	228	239	258
	Combined	**150**	**224**	**219**	**236**	**276**
Coos	8	336	266	242	260	298
	9	64	243	267	304	370
	10	174	204	201	231	268
	11	152	326	341	383	449
	12	84	292	314	360	439
	Combined	**133**	**283**	**297**	**336**	**401**
	Total	**139**	**270**	**279**	**313**	**372**

EVALUATION OF MANAGEMENT OPTIONS

Evaluating Forest-wide policies on tree retention along streams and creating buffer designs for specific sites can be done using the modeling approach presented above. In this section, the analysis team presents an evaluation of various stream management scenarios that were requested by Forest staff. Three scenarios, presented in question format are:

1. How much would the future volume of large wood in streams increase if buffers were expanded from their current width (about 150 feet each side of a fish-bearing stream) to 200 feet?
2. How much would the future volume of large wood in streams change if hardwood-dominated stands were retained no more than 50 feet from the stream and the next 150 feet clearcut harvested and planted to conifers?
3. How much wood would need to be placed in a stream today to ensure that wood volume in the future does not drop below some desired level?

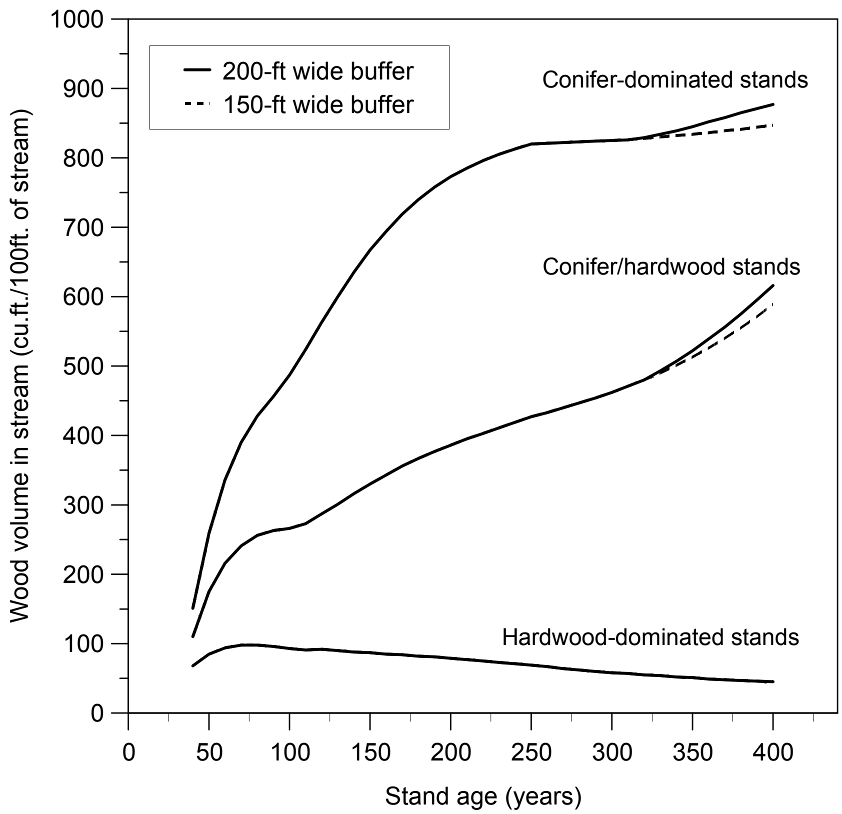
Figure 7-20. Current and projected large wood in Forest streams by analysis basin.



Scenario 1. Increasing buffer width to 200 feet each side of stream. Model results indicate that few trees growing more than 150 feet from the stream end up in the stream. The reason is two-fold. First, the effective height (total height minus 20 feet) of the average conifer tree is less than 150 feet until the trees reach about 230 years old. Secondly, even trees with an effective height greater than 150 have only a small probability of hitting the stream at such distances. For example, a 170-foot tall tree growing 150 feet from the stream has only a 22% probability of landing in the stream when it falls (Figure 7-12).

The numerical differences in stream wood volume between a 150-foot-wide and a 200-foot-wide buffer can be explored by examining the wood that accumulates in streams bordered each side by conifer-dominated, conifer/hardwood, and hardwood-dominated stands. To simplify this analysis, the initial large wood in the channel is assumed to be zero. Differences in wood volume that accumulate in the stream over time are nearly the same for 150-foot-wide and 200-foot-wide buffers (Figure 7-21). Differences show up for conifer-dominated and conifer/hardwood stands only after trees exceed 330 years old.

Figure 7-21. Differences in large wood for streams with 150- and 200-foot-wide buffers.



<u>Scenario 2. Retain hardwood-dominated stands only to 50 feet and establish new plantation beyond 50 feet</u>. About one-half of the land within 100 feet of streams on the Forest currently supports hardwood-dominated stands, while about one-quarter of the land 100-200 feet from streams supports hardwood-dominated stands (Figure 2-5). Some of this area is probably too moist or unstable to support conifer trees, yet conifer stumps are found beneath the current hardwoods in other areas, thereby suggesting that hardwoods are more common along streams now than they were prior to road building and timber harvest on the Forest.

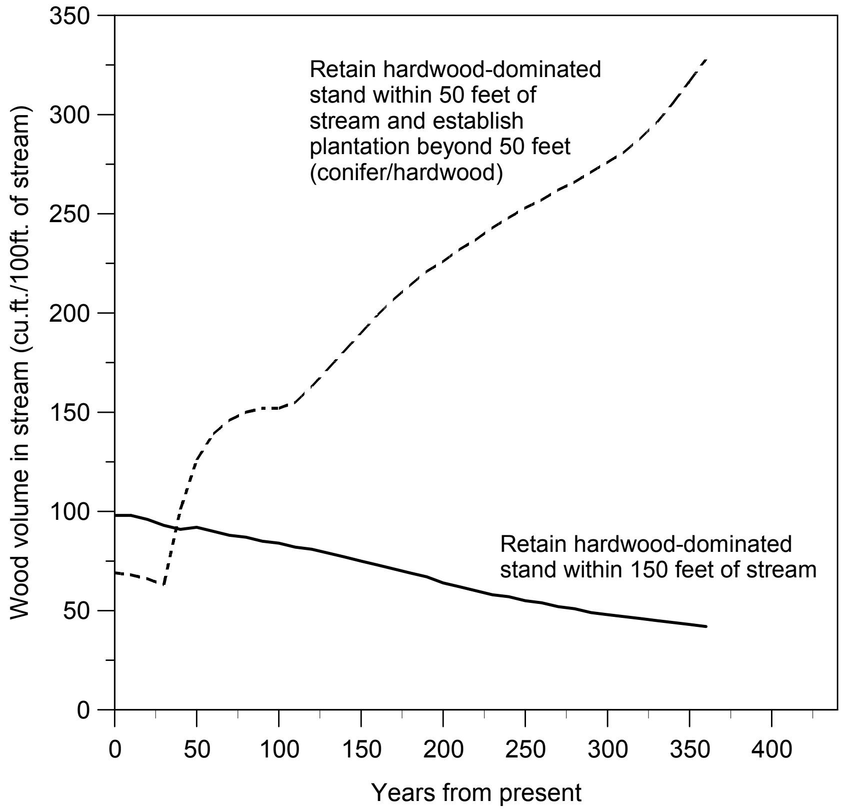
The scenario to retain a relatively narrow buffer of hardwood trees along a stream during adjacent timber harvesting, combined with aggressive conifer regeneration beyond the buffer, has been part of the Forest Practices Act since 1994 as an "alternative plan." The stated goal is to increase the number of conifer trees near streams in the future, realizing some short-term losses in large wood will occur by limiting the hardwood buffer to a narrow width. This option is available to land managers only for sites where regeneration of conifers is physically possible.

The difference in wood volume between these two buffer strategies are modeled and shown in Figure 7-22. Timber harvest was assumed to occur when the hardwood stand was 70 years old. It also was assumed that due to the difficulty of establishing conifers next to streams and buffers, the new plantation beyond 50 feet would be a conifer/hardwood stand rather than a conifer-dominated stand.

During the first 40 years, retaining a 50-foot-wide hardwood buffer resulted in slightly less wood than retaining a 150-foot-wide hardwood buffer (Figure 7-22). Thereafter, the new plantation beyond 50 feet produced wood that quickly outpaced wood produced by the wide hardwood buffer.

Under this model run, it is assumed that a new conifer/hardwood plantation is established up to the edge of the 50-foot-wide hardwood buffer. A number of factors act to frustrate conifer regeneration success next to streamside buffers. First, aerial applications of herbicides are conducted to ensure that no spray gets in the water or damages the buffer. Often this results in inadequate brush control within areas near the buffer and reduced conifer regeneration success. Secondly, logging slash can accumulate at the lower end of steep harvest units near the buffers, thereby reducing available tree planting spots. Furthermore, tree mortality at the lower end of harvest units is often greater due to mountain beaver, which prefer the moist soils near streams.

Figure 7-22. Comparison of retaining hardwood-dominated stand within 150 feet of stream versus retaining only first 50 feet and establishing new plantation beyond 50 feet.



<u>Scenario 3. Placement of logs in streams to maintain a desired wood level over time</u>. The placement of logs in a stream for the purpose of boosting levels of wood to some desired level could occur when adjacent slopes are harvested or it can be a separate activity where there is road access. The amount of wood added depends on how much wood is contributed by the streamside stand and at what interval logs are placed. In evaluating this scenario, the following assumptions have been made:

- Placed logs decay at a relatively slow rate (k=0.02).
- The streamside stand is 70 years old when the first log placement is made; subsequent placements can occur every 70 years thereafter.
- A buffer of trees 150 feet wide each side of the stream is maintained.
- The volume of wood in the stream cannot decline below 386 cubic feet per 100 feet, which is twice the current volume for the average stream in the Forest.

Modeling results indicate that no wood needs to be added to streams bordered by conifer-dominated stands in order to maintain a minimum wood volume of 386 cubic feet per 100 feet (Figure 7-23). Similarly, streams bordered by conifer/hardwood stands only required an addition of 290 cubic feet per 100 feet at time = 0 to maintain this minimum volume for the next 300 years. In contrast, streams bordered by hardwood-dominated stands required the placement of about 850 cubic feet per 100 feet of wood every 70 years in order to maintain the minimum volume. These results indicate the importance of streamside stands in maintaining wood levels in streams. Without adequate wood provided by a streamside stand, the intentional placement of logs needs to occur often and large amounts need to be added.

LARGE WOOD ORIGINATING FROM STEEP DRAWS

Results from the 1996 ODF landslide study (Robison et al. 1999) indicated that only a portion of upslope landslides actually end up in fish-bearing streams, and even fewer result in persistent jams of wood, rock, and coarse sediments. Overall, the material (soil, rock, and logs) in debris jams in fish-bearing streams averaged only 8 cubic yards/100 feet of stream. In the 1996 study, the lack of logjams associated with landslides may have been due to some receiving streams being large enough to transport the material far downstream during the high water. It also may have been due to the removal of logs from contributing draws on slopes that have been clearcut harvested over the last few decades. However, even for draws within mature stands, the wood load seems low. These mature stands are at an age (90-140 years) where trees are healthy and at a density for which little mortality would be expected because of competition.

The analysis team inspected several draws within an old-growth stand (visually estimated to be about 300 years old) in Dry Creek and found wood loading to be very high. Logs were piled about 10 feet deep in the upper sections of headwater channels or draws. Because systematic data has not been collected on large wood abundance within draws surrounded by stands of various ages in the central Coast Range, no conclusions can be made on how draws accumulate wood as stands age.

Ranking the ability of a draw to deliver wood to a stream can be important when determining where to leave trees for benefiting fish within harvest units. Retaining trees along draws that have a high probability of delivering wood to a fish-bearing stream when a landslide occurs would better meet the goals of improving structural habitat for fish, rather than retaining trees along a draw with a small chance of delivering wood to the stream.

There is a coarse method for estimating whether landslides routed down tributary channels are likely to reach a fish-bearing stream. A study of landslides in steep sandstone terrain in the Coast Range (Benda and Cundy 1990) led to a rule-of-thumb about where landslides stop within channel systems. It was concluded that most landslides made their way down through a channel system as long as the angle at channel junctions was less than 70 degrees and the channel slope was more than 6% (Figure 7-24, left panel). This assumes that the landslide remains confined by steep hillslopes. If the gradient of the contributing channel was 20% or more, then the landslide would continue downstream past the confluence, irrespective of confluence angle (Figure 7-24, right panel).

Figure 7-23. Modeled levels of wood in streams where the combination of wood falling from the streamside stand and placed wood is used to maintain a given amount of wood through time.

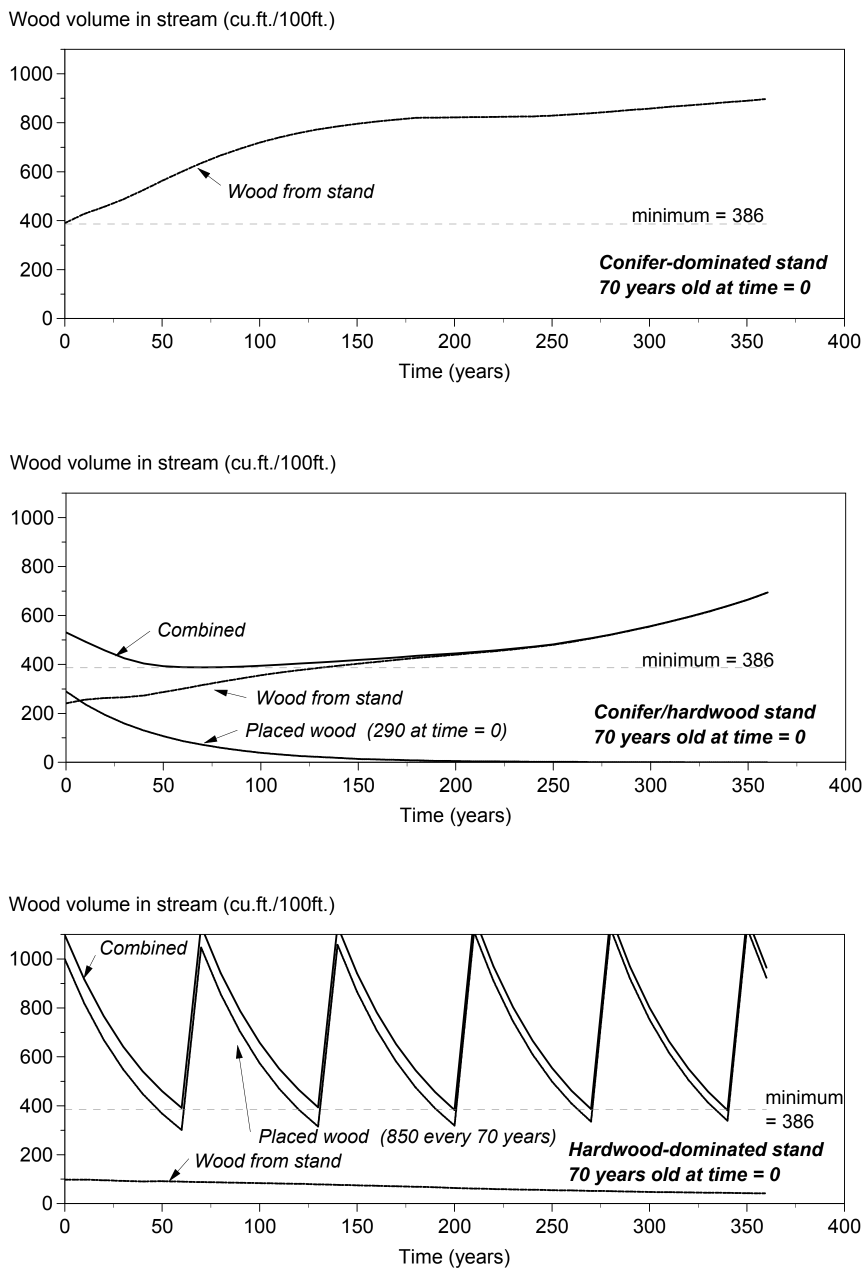
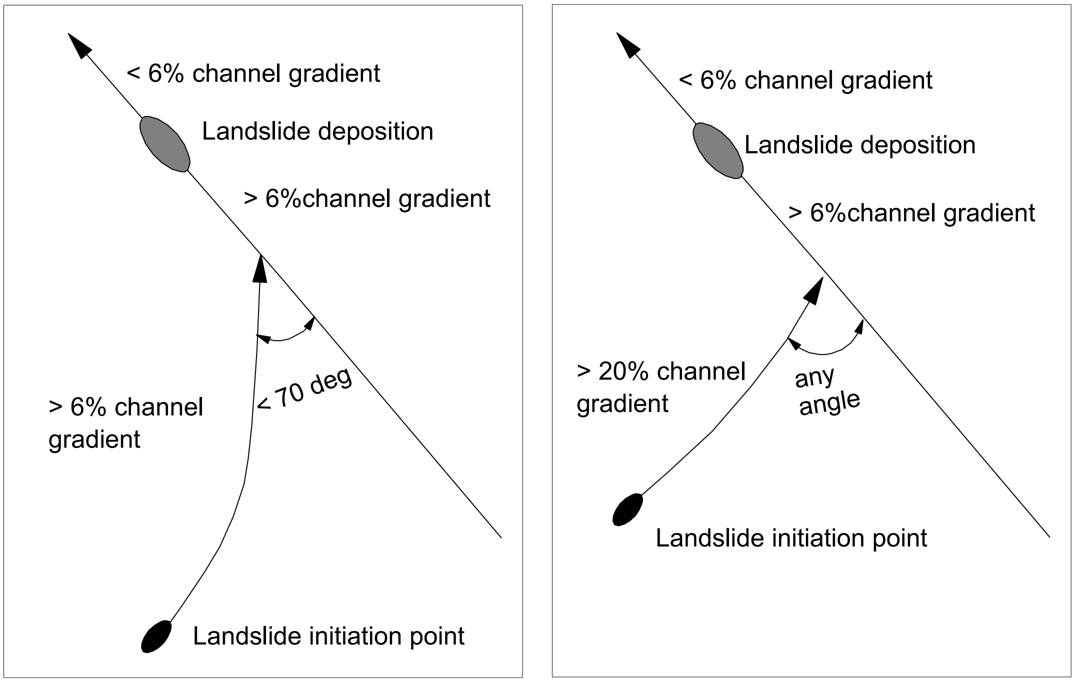


Figure 7-24. Rule-of-thumb proposed by Benda and Cundy (1990) for estimating the downstream extent of landslide travel.



The analysis team tested these findings against results from the 1996 landslide study (Robison et al. 1999) and found that this rule-of-thumb (Benda and Cundy 1990) underestimated the gradient at which landslide deposition occurred; landslides tended to deposit in channels once the gradient dropped to 8%, rather than at 6% as suggested. Therefore, the analysis team adopted the 8% gradient limit. The analysis team then considered the information available to ODF staff for applying this revised rule-of-thumb across the Forest and made the following conclusions:

- The 20-foot contours derived from the orthophotos used by the Forest did a reasonable job of delineating depressions in hillslopes that were the paths of actual landslides. About three-quarters of the landslide paths from the Robison et al. (1999) study coincided with depressions or draws that could be discerned from the 20-foot contours. The remaining one-quarter of landslide paths was shown as uniform slopes by the contours. Consequently, the analysis team used the contour coverage to delineate all draws on the Forest that were not already marked by a stream course line in the stream coverage. A draw was defined as any depression on the hillslope that suggested a channel. The draw was extended upstream until the terrain fanned out to a uniform slope. About 85% of the draws discernable from the contour maps had not been previously included in the existing stream course coverage. Forest-wide, a total of 5,764 draws were added.

- The large number of draws for evaluation (estimated to be about 6,800) presented a problem for conducting a Forest-wide determination of which draws were most likely to supply fish-bearing streams with wood and boulders when a landslide occurred. Although automated calculations of channel gradient using the available DEM were considered, the DEM was too coarse to discern small differences in channel gradient. The inability to discern the difference between a 6% and 8% channel gradient, for example, can result in a one-quarter to one-half mile difference in landslide travel distance for typical Forest streams.
- Because of the lack of automated methods for analysis, the analysis team decided that determining the location of landslide deposits would best be handled for small areas during the planning stages for timber harvest units using manual mapping methods. The steps to accomplish this and an example are provided below.

Steps for prioritizing stream segments according to their likelihood of delivering large wood and boulders to streams when shallow landslides occur are as follows.

1. Number the draws and stream channels without fish into segments, similarly to what is shown in Figure 6-14. A stream segment downstream of the confluence of two other segments gets its own stream segment number.
2. Note which segments flow directly into a fish-bearing stream.
3. Determine which segments have a gradient less than 20% at their downstream ends.
4. At the intersection of two segments, note if the confluence angle is less than 70 degrees.
5. On the map, note where the channel gradient is less than 8%.
6. Using information from items 2-5, indicate which segments are likely to deliver large wood and boulders to fish-bearing waters, based on the following criteria:
   - ⇒ Landslides will deposit their load once the channel gradient becomes less than 8%.
   - ⇒ Irrespective of the confluence angle, landslides traveling through a stream segment will continue downstream as long as the gradient of the contributing channel is greater than 20%.
   - ⇒ If the gradient of the contributing channel is between 8% and 20%, the landslide will continue downstream only if the confluence angle is 70 degrees or less.
7. A further refinement of this method is possible by noting the percentage of segment length bordered by side slopes greater than 70%. Segments bordered by steep slopes have more landslide initiation sites. Furthermore, large wood and boulders are more likely to be produced by steep, unstable side slopes than by gentle side slopes. Therefore, stream segments with a higher frequency of landslides and with abundant accumulations of logs and boulders are more likely to benefit downstream fish-bearing streams.
8. Combining information from items 6 and 7, priority categories can be established to rate the relative importance of stream segments relative to the likelihood of a landslide reaching a fish-bearing stream plus the likely abundance of wood and boulders available for transport by a landslide. The following categories are recommended by the analysis team but other categories could be developed to further refine the process.
   - ⇒ *High.* Landslide expected to reach fish-bearing stream and 70% or more of the segment length is bordered by slopes 70% or greater.
   - ⇒ *Moderately high.* Landslide expected to reach fish-bearing stream and 30% to 70% of the segment length is bordered by slopes 70% or greater.

⇒ *Moderate.* Landslide expected to reach fish-bearing stream and less than 30% of the segment length is bordered by slopes 70% or greater.
⇒ *Low.* Landslide is not expected to reach fish-bearing stream.

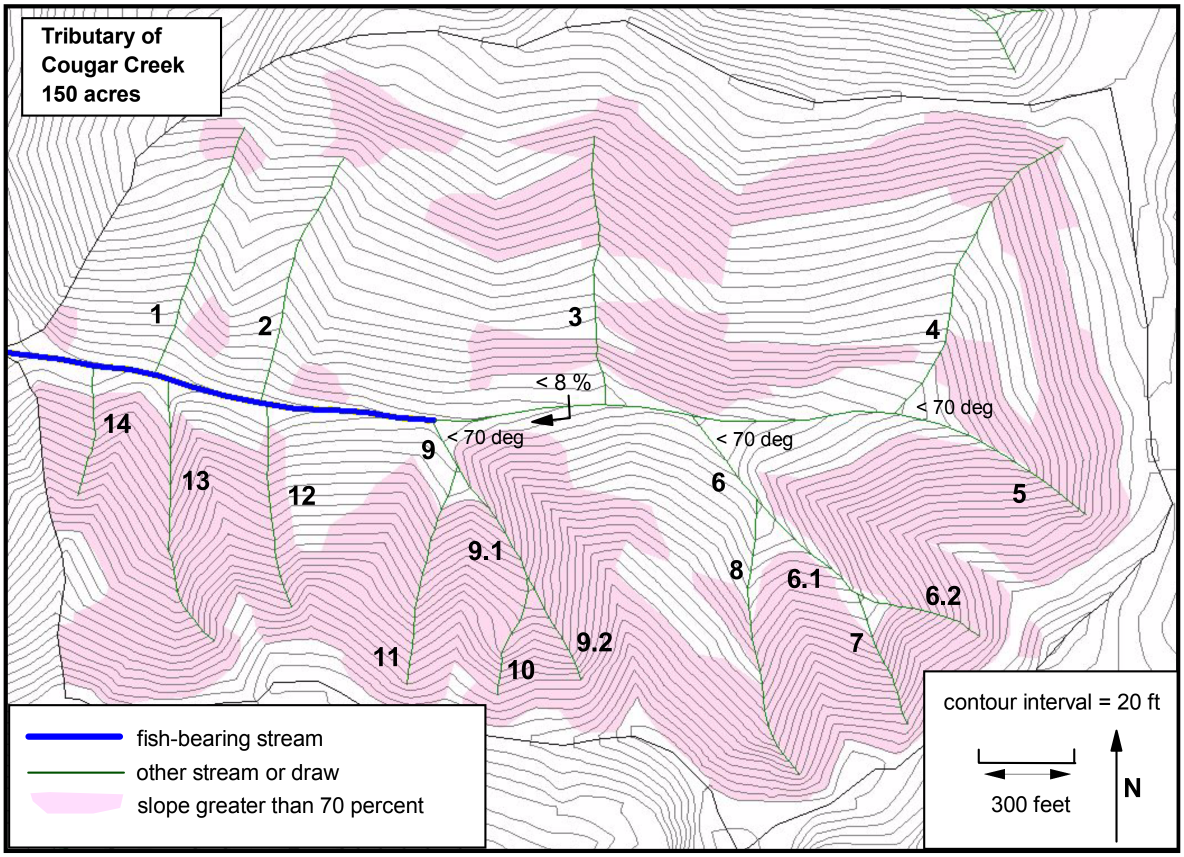
An example of this method is illustrated for a tributary basin of Cougar Creek (Table 7-10, Figure 7-25). Fish use this stream up to the junction with stream segment #9. Because all stream segments but #6 have a gradient at the lower end that is greater than 20%, any landslides would be expected to continue downstream in the receiving channel, even where the confluence angle is greater than 70 degrees. For stream segment #6, since the confluence angle is less than 70 degrees, landslides from this segment also would be expected to continue downstream.

Table 7-10. Information on stream segments within a tributary drainage of Cougar Creek and ranking according to the likelihood that landslides reach fish-bearing streams and expected abundance of large wood and boulders in the contributing stream segment.

A Stream Segment Number	B Empties directly into fish-bearing stream?	C Greater than 20% gradient on downstream end?	D Confluence angle less than 70 degrees?	E Landslide deposit in fish-bearing stream?	F Percent length bordered by slopes greater than 70%?	G Priority for retaining trees for wood delivery to stream*
1	Yes	Yes	No	Yes	10	Mod. high
2	Yes	Yes	No	Yes	0	Mod. high
3	No	Yes	No	No	60	Low
4	No	Yes	Yes	No	40	Low
5	No	Yes	Yes	No	30	Low
6	No	No	Yes	No	0	Low
6.1	No	Yes	N.A.	No	0	Low
6.2	No	Yes	Yes	No	70	Low
7	No	Yes	Yes	No	70	Low
8	No	Yes	Yes	No	60	Low
9	Yes	Yes	Yes	Yes	10	Mod.
9.1	Yes	Yes	N.A.	Yes	100	High
9.2	Yes	Yes	Yes	Yes	100	High
10	Yes	Yes	Yes	Yes	100	High
11	Yes	Yes	Yes	Yes	80	High
12	Yes	Yes	No	Yes	90	High
13	Yes	Yes	No	Yes	90	High
14	Yes	Yes	No	Yes	90	High

N.A. = not applicable.
* Priority rating system (Column G):
High: Column E = Yes and Column F ≥ 70%.
Moderately high: Column E = Yes and Column F between 30% - 70%.
Moderate: Column E = Yes and Column F ≤ 30%.
Low: Column E = No.

Figure 7-25. Stream segments and draws for a tributary of Cougar Creek with information needed to prioritize draws according to the likelihood of landslides reaching fish-bearing stream segments and the relative amount of large wood and boulders likely to accumulate.



The gradient of the main channel increases with increasing upstream distance and reaches 8% about 100 feet downstream of the junction with stream segment 3. This is the point where landslides originating from stream segments #3 through #8 would be expected to stop, which is about 400 feet short of the downstream fish-bearing segment.

Landslides within segments #1-2 and #9-14 would be expected to reach fish-bearing streams in this drainage. The two segments draining from the north (#1-2) would be considered lower priority than those draining from the south (#9-14) because not much of their length is bordered by steep slopes. Segments draining from the south have at least 80% of their lengths bordered by side slopes of 70% or greater, and therefore rated as higher priority.

ANALYSIS

Current and Future Riparian Conditions

Currently, hardwood-dominated stands are common along fish-bearing streams of the Forest and are likely more widespread now than in the past. While hardwood trees growing next to streams provide abundant shade, nitrogen-rich leaf litter to the aquatic environment, and some structure to the stream channel when trees tip over, the ability of these stands to create the volume of large wood sufficient to match historical levels is very limited. The above modeling reveals that within 200 years, a typical hardwood-dominated stand is expected to result in a large wood volume only one-tenth of what a conifer-dominated riparian stand is expected to produce. Furthermore, the large wood volume in streams surrounded by hardwood-dominated stands is predicted to decline to about one-half the current Forest-wide average within 200 years.

Reasons that hardwood trees are currently abundant along Forest streams include: (1) insufficient control of brush and animals to ensure conifer tree survival in the portion of harvest units closest to streams; (2) natural establishment of hardwoods in areas cleared for roads along streams (most built decades ago); and (3) scouring of streamside areas by landslides. Streamside areas most dominated by conifers today are those that were harvested to the edge of the stream 20-35 years ago, followed by intensive control of mountain beaver and brush near streams.

During the last 15 years, buffer strips of trees have been routinely retained along fish-bearing streams in the Forest. More conifers have been retained in recent buffers (0-7 years ago) than in older buffers. Recent buffers commonly extend 100-150 feet on each side of the stream, which is the zone that contributes nearly all wood to streams. Conifer regeneration in clearcut areas at the edge of buffers is usually very sparse since a no-spray zone is usually maintained next to buffers when herbicides are aerially applied. Conifer regeneration within a buffer is rare since the surrounding clearcut area allows side light to penetrate the buffer, which triggers the development of a dense understory. Consequently, only those trees retained in the buffers at time of harvest are a source of wood to streams for the next several centuries.

Currently, wood volume in Forest streams with an active channel width less than 40 feet averages 28% of the wood volume in nearby reference streams bordered by 88- to 118-year-old timber, and 14% of the wood volume in those reference streams bordered by old-growth timber. This severe scarcity of wood can be attributed to intentional removal of wood from streams during the 1960s and 1970s, removal of streamside trees in areas harvested more than 15 years ago, and the regeneration of hardwoods in streamside areas that once supported conifers. The largest streams on the Forest (West Fork Millicoma River and Mill Creek) have only token amounts of large wood, except where it has been intentionally added to improve fish habitat.

Streamside Forest Management and Future Conditions

Modeling results indicate that trees growing more than 150 feet from streams rarely contribute wood to streams. Therefore, widening buffers along streams to distances of 200 feet or beyond does little to increase the large wood budget of streams. Nevertheless, extra conifers retained along the outer edges of buffers are a relatively inexpensive source of wood when logs are intentionally placed in the stream at a later time. This applies mainly to streams along roads when a small cable yarder is used to pull the logs downstream into the channel.

Retaining narrow rather than wide buffers of hardwood-dominated timber along streams, combined with intensive conifer regeneration in cleared areas nearest the stream, is a potential tool for increasing the long-term abundance of wood in Forest streams. Modeling results show that by retaining only a 50-foot-wide buffer of hardwoods along streams and establishing a conifer/hardwood stand in the cleared areas results in a 10-fold increase in large wood 300 years in the future as compared to retaining a wide hardwood-dominated buffer. The one difficulty with this strategy is the cost and diligence involved in establishing conifers near buffers. For adequate conifer regeneration, aerial applications of herbicides would be needed up to the boundary of the buffer or expensive backpack spraying would be needed near buffers. Furthermore, intensive control of mountain beaver (trapping) and elk browsing (planting tall seedlings and using protective tubes) would be needed. Discussions with regeneration foresters working for the Forest indicate that these extra measures could easily cost twice that of establishing conifers elsewhere within harvest units.

The intentional placement of conifer logs within streams during harvest of adjacent areas or placement at later times also is a promising tool for increasing wood in streams, especially for the short-term. Large wood has been placed in a number of streams throughout the Forest during the last decade (see Chapter 8, *Aquatic Organisms and Their Habitat*); with the recent emphasis on placing long logs that are naturally stable in the channel during high flows, most have been successful at creating high quality fish habitat. Modeling results indicate that streams bordered by 70-year-old stands dominated by conifers have the least need for supplemental wood placement and wood volume will steadily increase over time, reaching 800 cubic feet per 100 feet within the next 200 years. Conifer/hardwood stands would need 290 cubic feet per 100 feet of wood added to streams at year 0 in order to maintain a goal of twice the current Forest-wide average over the long term. In order to meet this same goal, streams bordered by hardwood-dominated stands would require a wood addition of 850 cubic feet per 100 feet every 70 years for perpetuity. Obviously without the contributions of large wood from surrounding conifers, supplemented by wood from landslides, intentional wood placement would be a very expensive option for maintaining desired levels of large wood for the 161 miles of fish-bearing stream on the Forest.

Large Wood from Steep Draws

A general lack of information on the amount of wood that accumulates in steep draws, and the mechanisms for wood delivery to streams by landslides, prevented the analysis team from providing much information on this topic. Results from the 1996 ODF landslide study (Robison et al. 1999) indicate that landslides contributed minimal amounts of large wood to streams during the 1996 storms. Whether this was due to a general lack of large wood in the draws studied or the result of much of the wood floating far downstream during the high water (or both) is unknown. More site-specific information on wood loads within draws on the Forest is needed to complete the picture.

The analysis team developed a procedure for isolating those draws within planning areas that are most likely to contribute sizable amounts of large wood to fish-bearing streams when landslides occur. The method requires information on slope steepness, channel gradient, and the angle at which two draws or streams intersect.

RECOMMENDED ACTIONS AND MONITORING

Current and Future Riparian Conditions

The analysis team has no recommended actions on the topic of current and future riparian conditions. The team does recommend that the ODF examine the consistency of the fish habitat condition surveys for the Forest being conducted by the ODFW. The analysis team found large differences in large wood volumes reported within surveys on a number of stream reaches for which two surveys took place within a year or so of each other. Differences in estimating methods among crews are a probable source of error.

Streamside Forest Management and Future Conditions

Forest staff currently does not conduct tree regeneration surveys within harvest units near streams separately from surveys of entire harvest units. Lack of information on conifer regeneration success near streamside buffers, along with the likely success and cost of enhanced conifer regeneration techniques, prevents staff from evaluating scenarios for buffer widths and conifer regeneration in streamside areas now dominated by hardwood trees. Pilot projects on selected harvest units demonstrating the use of alternative conifer regeneration techniques near streams also may be helpful to staff.

Large Wood from Steep Draws

Information is lacking on the abundance of large wood typically found in steep draws surrounded by stands of various ages and management histories. Casual observation of a number of draws by the analysis team suggests that past timber harvest has resulted in a marked reduction in wood. Managing the landscape to provide enough current and future large wood within draws so that future landslides can resupply streams with large wood over time requires some understanding of how wood accumulates in draws over time and of the current wood deficit. In 2001, the ODF contracted with a consultant to create a study plan for acquiring this information through field sampling. The analysis team recommends that the study be conducted so that the information is available for future decision-making on the layout of proposed harvest units and the amount of tree retention along draws.

Chapter 8. Aquatic Organisms and Their Habitat

This chapter evaluates stream habitat and other characteristics that control the populations and distribution of fish and aquatic-dependent amphibians. Natural and management factors are examined that influence fish movement through streams, stream habitat quality, and changes in populations through time. The discussion includes an evaluation of the major downstream influences, including predation, fishing, and cyclic ocean conditions, that control fish runs. Aquatic inventories and other studies by the ODFW are summarized to provide information on aquatic habitat and populations for each watershed region. The chapter concludes with a synthesis of the results from previous chapters and provides a comprehensive analysis of the physical, water quality, and management influences on fish and aquatic amphibian habitat in the Forest. The analysis also identifies current and potential hotspots of productivity and highlights current or future limiting factors to high productivity.

NATURAL FISH PASSAGE BARRIERS

Every stream has a point above which fish use ends due to lack of flow (at least seasonally), steep gradients, and/or impassible natural barriers, such as falls and mass landslides. Debris torrents and logjams can create temporary barriers to fish passage. Fish and other aquatic vertebrates may be isolated or impeded from upstream or downstream migration by these geologic and geomorphic conditions (human-caused barriers and impediments are discussed later). The net result of these barriers and impediments to fish passage is that over time, the species' assemblage (for example, resident versus anadromous; steelhead versus coho salmon) will be determined in an individual stream. For the Forest, fish presence surveys using electroshock, nets, or observations were used to determine the upper extent of fish use and to identify passage barriers.

The Forest has a number of significant natural geologic barriers and impediments to fish passage. Map 8.1 shows the known extent of fish (anadromous and resident) within the Forest and a number of the natural barriers. The distribution of natural barriers is especially important for limiting the upstream spawning and rearing distribution of anadromous fish: coho and chinook salmon, steelhead, sea-run cutthroat trout, and lamprey. Mill Creek has two identified barriers, both probably the result of the Loon Lake landslide. The lower one is a gradient barrier below Mill Creek's confluence with Cold Creek. This gradient barrier likely represents the most downstream extent of the landslide fill. The second barrier is at Loon Lake (site of the BLM campground), which also may be the result of the landslide. According to ODFW fish distribution information, it is the lower gradient barrier that restricts anadromous fish use in Loon Lake and upstream. These two total barriers block significant, low-gradient streams draining the upper Mill Creek drainage on the Forest (Salander and Bickford Creek drainages), the Weyerhaeuser Millicoma Tree Farm (Soup and Lake Creek drainages), and intermixed BLM-managed lands.

On the southeast portion of the analysis area, another pair of permanent, geologic barriers exists at Golden and Silver Falls on Glenn Creek. However, fish passage is blocked approximately 0.5-mile downstream by a cascade that drops 45 feet over a 100-foot section of stream length. This cascade is identified as a total barrier to anadromous fish. Only resident fish (cutthroat trout) inhabit streams in the basin above the falls (West Fork Silver, West Fork Glenn, Howell, and Cedar Creeks).

The West Fork Millicoma Basin historically contained at least seven falls that blocked or impeded anadromous fish passage. The lowest two named ones, Pidgeon Falls (8-foot drop), and Henry's Falls (7-foot drop) impede passage at lower flows for all species (Map 8.1). Fish are able to pass these two sites during freshets and higher flows in the West Fork. The next higher falls in the basin, Stulls (Stahls) Falls (15-foot drop), was a complete passage barrier prior to 1958 when the Oregon Game Commission blasted out steps and jump pools to create fish passage. During the 1960s, the bedrock cascade at Elk Falls on Elk Creek was jackhammered and blasted by the Game Commission to initiate fish passage, but these actions were unsuccessful in obtaining good anadromous passage. As a result, the Game Commission constructed a fish ladder in 1973 to further enhance fish use of the basin above Elk Falls. Three years prior to completion of the fish ladder, Elk Creek was stocked above the falls with up to 400 ripe adult coho salmon to seed the stream.

The remaining impediments and barriers to fish passage shown on Map 8.1 typically occur in higher gradient, lower order streams. In the ODFW database, these are called "Unnamed Falls" or cascades. These are the primary anadromous fish blockages in the Coos Bay, Lakeside, and lower Umpqua 5th field HUC basins.

ROAD CHANGES TO STREAM CHANNELS AND FISH PASSAGE BARRIERS

Stream channels in the Forest have been impacted through the development of the road system. Roads along streams affect stream channels and aquatic habitat by limiting riparian stand development, sediment delivery and water routing, channel movements, and fish passage at road crossings. The delivery of sediment to stream channels from roads was described in Chapter 6, *Erosion and Sediment*. Chapter 7, *Riparian Vegetation and Large Wood*, documented the role that roads play in limiting the area for productive riparian stands and the delivery of wood into stream channels. This section describes the influence of roads at constraining channel movements and creating fish passage barriers.

Methods

Most of the streams throughout the Forest are tightly confined by adjacent hillslopes (see discussion in Chapter 2, *Channel Habitat Types*). Unconfined streams provide unique, high-quality habitat for fish not found elsewhere on the Forest. These low-gradient streams are more likely to provide high-quality refuge habitat during high water since the channel can meander freely, creating tree fall into the channel and backwater areas.

Roads, especially those that parallel streams within 100 feet of the channel, also confine stream channels and reduce recruitment of streamside trees into channels. All roads paralleling streams within a 100-foot band were mapped for the Forest (Map 8.2). To understand the relative distribution of these streamside roads, the length of the segments were summarized by stream size (small, medium, and large; see Chapter 2 for description) and watershed region. It should be noted that not all roads within 100 feet of a stream will constrain the movement of the stream channel. This measure, however, provides a good estimate for the influence of roads on the stream, riparian function, potential delivery of sediment, and the potential to limit the movement of the channel.

Results

Historically, forest roads in most areas of the Coast Range were located along streams because of the relatively easy access up wide valleys. The Forest is unique because most of the roads are on slopes or ridge tops, with very few along streams. There are approximately 551 miles of roads in the Forest, of which only about 49 miles (9%) are within 100 feet of a stream channel (Table 8-1). The Coos region has the largest percentage (12%) of roads along streams, with many of the roads paralleling large streams such as the West Fork Millicoma River (basins #9, #11, and #12) and Marlow Creek (basin #10). In the Umpqua region, 7% of the streams, mostly in the small and medium size class, are constrained by roads within 100 feet of the channel. Basin #1 has the highest percentage of roads in the Umpqua region, with most of the roads paralleling Mill Creek. The Tenmile region, which has the highest proportion of large streams with unconfined channels, has the lowest percentage of roads within 100 feet of the channel.

Table 8-1. Summary of length of roads within 100 feet streams by size class.

Region	Analysis Basin	Total Roads (mi.)	Road Length (mi.) within 100 feet of the Stream			Percent Constrained
			Stream Large	Stream Medium	Stream Small	
Coos	8	34.4	0.1	0.1	0.9	3
	9	49.0	0.6	0.4	2.0	6
	10	54.2	1.9	1.9	4.3	15
	11	93.7	5.4	5.1	5.3	17
	12	78.1	3.9	2.0	3.1	12
Umpqua	1	31.5	1.3	2.2	1.1	15
	2	22.9	0.5	0.1	0.5	5
	3	32.0	0.2	0.4	0.2	3
	4	26.0	0.4	0.5	0.6	6
	13	30.2	0.0	0.4	1.3	5
Tenmile	5	34.3	0.0	0.0	0.3	1
	6	31.4	0.0	0.0	0.5	2
	7	33.1	0.2	0.8	0.9	6
	Combined	**550.8**	**14.5**	**13.9**	**21.0**	**9**

Discussion

There is a relationship between the proximity of forest roads to stream channels and aquatic habitat quality. Streamside roads are associated with reduced riparian trees and less wood in the channel (see Chapter 7, *Riparian Vegetation and Large Wood*), resulting in fewer pools and reduced winter refuge habitat. Fortunately, the length of streamside roads is limited in the Forest. Where there are streamside roads, their impacts should be examined and, where appropriate, impacts mitigated through riparian management and stream channel restoration actions, such as placing large wood in channels or by decommissioning roads.

FISH PASSAGE BARRIERS

Culverts can influence fish by keeping anadromous and resident spawning fish from reaching high-quality spawning habitat. When streams are blocked, fish are often forced to spawn downstream in less desirable areas. This is a special concern in the Forest because stream segments with sorted gravels of favored diameter are rare. Culverts also can block seasonal movement of juvenile salmon and steelhead, as well as resident cutthroat trout. Juvenile fish often are displaced downstream during high flows, and will attempt to move back upstream following high water to reclaim favorable feeding habitat and areas with less competition for food. Also, juvenile fish often will move upstream into cool tributaries during the summer to avoid unfavorable water temperatures in larger streams.

Culverts commonly block fish by creating a drop at the outlet that is higher than some fish species can jump. This is not always a problem for steelhead spawners who can scale obstacles of 5 feet or more, assuming the pool at the base of the jump is deep. Other adult fish have more difficulty jumping obstacles, and even a 2-foot drop can be a barrier for adult cutthroat trout. Since water travels through a culvert more swiftly than in a streambed, excessive velocity in the pipe is another way that culverts block fish. Providing for the upstream movement of juvenile fish and resident trout is even harder than for adult salmon and steelhead. One-foot-high drops at culvert outlets can stop small fish, and they have a reduced ability to swim upstream in fast water. The Oregon Forest Practices rules require that all new culverts be installed such that passage of both adult and juvenile fish is assured. For fish to navigate through culverts, guidelines by the ODFW indicate that the pipes need to be installed at a gradient of no more than 0.5% and have no more than a 6-inch drop at the outlet. Higher gradient installations are allowed for open-bottom culverts and for culverts with baffles installed in the bottom. These criteria create an engineering challenge for streams in the Forest, since fish-bearing streams are typically at a 2% to 4% gradient. Although using an oversized pipe and countersinking the outlet into the channel can work in some cases, it is rarely a solution in steep channels.

Methods

Examining the GIS road and fish-bearing streams coverage for the Forest identified stream crossings and their ability to pass fish. A GIS database compiled by the Forest that utilized field data from 1997 and 1998 was used to check on whether the crossing was a bridge, culvert, ford, or whether a culvert was missing because it had washed out during high flow.

The same database provided information on culvert gradient. The engineering staff at Coos Bay helped refine and update the inventory, and provided information on the drop at culvert outlets and on which culverts had been replaced since 1998.

Results

Culvert sites (where fish-bearing streams pass under roads) are relatively rare throughout the Forest, averaging only 1 for every 4.5 square miles, with the majority of sites located in the Coos region. A total of 32 culverts within fish-bearing streams were identified (Table 8-2). Culverts at over one-third of sites had been replaced in the last few years. Four of these installations were observed in the field and the replacement culverts (usually pipe arches) were well designed and capable of passing fish (Table 8-3). Five culverts had been removed and the roads decommissioned, while two other culverts had washed out during high flows and had not been replaced.

Table 8-2. Status of culverts in fish-bearing streams on the Forest.

Culvert Status	Number of Culverts	Percent of Total
Older culverts that are in place	14	44
Culverts that were recently replaced	11	34
Culverts that were removed and the road decommissioned	5	16
Culvert and fill washed out	2	6
Total	**32**	**100**

Table 8-3. Culverts in fish-bearing streams by region and analysis basin that were removed, washed out, or recently replaced.

Region	Analysis Basin	Site No.	Stream Name	Road No.	Comments
Tenmile	5	5073	Big Creek Trib.	5100	Culvert removed, road decommissioned
Tenmile	5	5072	Big Creek Trib.	5100	Culvert removed, road decommissioned
Tenmile	5	5066	Big Creek Trib.	5100	Culvert removed, road decommissioned
Tenmile	5	5086	Big Creek Trib.	5100	Culvert removed, road decommissioned
Tenmile	7	5010	South Fork Johnson Cr	2100	Culvert removed, road decommissioned
Umpqua	2	5187	Charlotte Cr Trib.	100	Fill was washed out
Coos	12	5319	W.F. Millicoma R Trib.	9360	Fill was washed out
Coos	10	454	Y Creek	1000	Replaced with 95"x67" arch
Coos	11	277	Hidden Valley Cr	9500	Replaced with 96" round pipe
Coos	11	271	Crane Cr	9000	Replaced with 103"x71" arch
Coos	11	263	Skunk Cr	9000	Replaced with 112"x75" arch
Coos	11	239	Elk Cr Trib.	9040	Replaced with 95"x67" arch
Coos	11	240	Elk Cr	9000	Replaced with 142"x91" arch
Coos	11	374	Cougar Cr Trib.	7600	Replaced with 48" round pipe
Coos	11	368	Cougar Cr Trib.	7600	Replaced with 71"x47" arch
Coos	10	432	Marlow Cr Trib.	1100	Replaced with 48" x 140' pipe with baffles
Coos	10	431	Marlow Cr Trib.	1100	
Umpqua	13	5259	Bickford Cr	1900	Culvert to be replaced in 2003

Discussion

Of the 14 older culverts that are currently in place, all have a gradient greater than 0.5% and/or an outlet drop greater than 6 inches. One-half of the 14 culverts have an outlet drop greater than 2 feet and/or a gradient greater than 4% or have an upswept inlet that prevents fish from moving upstream of the culvert inlet (Table 8-4). Based simply on the basis of length of upstream fish-bearing miles upstream of the culvert, sites #569 (Totten Creek), #5179 (Footlog Creek), and #479 (Cedar Creek) would be the highest priority sites for improving fish passage. Anadromous fish use Totten and Footlog Creeks while a natural downstream waterfall excludes anadromous fish from Cedar Creek.

Since not all fish-bearing streams have been identified for the Forest, the number of culverts with fish passage problems is probably larger than shown in Table 8-4. Additional fish-bearing streams, when found, are likely to be in the upper portions of drainage basins, which are steeper. Fish passage problems are usually more difficult to resolve for culverts installed in steeper gradient channels.

HABITAT RESTORATION PROJECTS

The Elliott State Forest, in collaboration with the Coos Watershed Association, Tenmile Lakes Partnership, and the ODFW implements a number of actions that are designed to improve aquatic habitat and watershed processes. There are no aquatic habitat restoration projects on the Forest reported by the Umpqua Basin Watershed Council. The Forest and ODFW have cooperated on several stream restoration projects on Charlotte and Mill Creeks in the Umpqua region and Palouse Creek in the Coos region. Aquatic and riparian habitat restoration actions implemented on the Forest include:

- Replacing culverts to improve fish passage.
- Planting conifers in riparian areas that are dominated by hardwoods.
- Leaving more than the required number of riparian trees along streams.
- Improving road drainage patterns to reduce sediment delivery to stream channels.
- Decommissioning roads to restore natural drainage patterns and vegetation.
- Placing large wood or boulders in channels to increase fish habitat complexity.

Methods

Most watershed restoration projects are reported to the Oregon Watershed Enhancement Board's (OWEB) watershed restoration project database. This database was used to obtain information on the location and type of watershed restoration projects in the Forest. The database includes projects from 1995-2002. Also, additional information was obtained from Forest personnel, the Coos Watershed Association, and the Tenmile Lakes Partnership. The Forest completed additional projects before 1995, which are not reported. These included a number of projects in Palouse Creek focusing on large wood placement, creation of off-channel ponds, and riparian planting.

Table 8-4. Characteristics of older culverts currently in place on the Forest.

Region	Analysis Basin	Site No.	Stream Name	Stream Size	Road No.	Pipe Diameter (in.)	Drop at Outlet (ft.)	Pipe Gradient (%)	Length of Fish-bearing Stream Upstream of Culvert (mi.)	Downstream Barriers to Anadromous Fish?
Coos	10	467	Glenn Cr	Small	1850	56	4	5	0.32 (S*)	Yes**
Coos	10	479	Cedar Cr	Medium	1850	84	0	4	0.67 (M)	Yes**
Coos	10	445	Marlow Cr Trib.	Small	1000	56	4	7	0.40 (S)	No
Coos	10	449	Piledriver Cr	Small	1000	56	2.3	3	0.27 (S)	No
Coos	9	560	Daggett Cr	Small	3300	24	6	4	0.08 (S)	No
Coos	9	569	Totten Cr	Medium	2000	72	0	9	0.32 (M) & 1.19 (S)	No
Coos	9	536	W.F. Milli. Trib.	Small	504	36	0	4	0.24 (S)	No
Coos	12	511	Trout Cr	Medium	2300	96	0	3	0.35 (M)	No
Coos	12	5331	W.F. Milli. Trib.	Small	8100	42	2	3	0.35 (S)	No
Coos	12	419	Joe's Cr	Small	8000	30	0	4	0.36 (S)	No
Coos	11	248	Elk Cr Trib.	Small	9000	42	?	3	0.30 (S)	No
Coos	11	235	Elk Cr Trib.	Small	9000	42	1	3	0.04 (S)	No
Coos	11	339	Fish Cr Trib.	Small	7400	36	1	10	0.11 (S)	No
Umpqua	1	5172	Footlog Cr	Medium	7500	72	0	4***	0.86 (M)	No

* S = small stream, M = medium stream.
** Natural falls.
*** Inlet to culvert is bent upward, creating a velocity barrier to fish movement.

Results

The locations and types of restoration projects are shown on Map 8.3 and are summarized in Appendix C. More than 150 watershed restoration projects were implemented from 1995-2002, with the majority of projects in the Coos region. The projects focused on a variety of instream, riparian, and upslope actions, including fish passage barriers, the placement of large wood in stream channels, voluntary riparian tree retention, and road surface drainage improvements. Table 8-5 summarizes the in-channel habitat (wood or boulder placements, creation of off-channel areas) and fish passage improvement projects by watershed region.

Table 8-5. In-channel habitat and fish passage improvements projects on the Forest, as reported in the OWEB database, 1995-2002.

Region	In-channel Placement of Wood or Other Enhancements*	Fish Passage Improvements**
Coos	27	34
Tenmile	2	1
Umpqua	2	0

* Includes projects where boulders were placed in the stream and off-channel habitat creation.
** Fish passage improvements include culvert replacement with new culvert or bridge, addition of downstream weirs, or removal of the culvert and restoration of natural stream channel.

Note: Projects not reported in the OWEB database include boulder weirs in the W.F. Millicoma River (1998); two sets of boulders weirs below the hatchery at the property line and one set above the hatchery in the W.F. Millicoma River (2002).

Discussion

Many restoration projects focused on fish passage improvements and the placement of wood and other structures (such as boulders) into the stream. Improving aquatic habitat connectivity by addressing fish passage barriers has increased the amount of habitat accessible to anadromous and resident fish. Increasing stream channel complexity through the addition of structure is valuable given the limited in-channel wood (Chapter 7, *Riparian Vegetation and Large Wood*) and the importance of channel structure in the retention of channel sediment, and the creation of deep, complex pools. These active restoration efforts target suitable areas as a stopgap measure until natural wood loading can be reestablished and a "passive" restoration can be reinitiated.

As noted in Table 8-5, not all instream placements are large wood. Large boulders were added to the stream, particularly in channels that were too wide to provide stable wood placements. Other non-wood placements include boulder weirs. Boulders and weirs added to stream reaches with limited channel structure help to retain gravels and capture large wood that is transported into the stream. Boulder placements were favored at locations along the lower reaches of the West Fork of the Millicoma River where log placements were not feasible due to size required for stable logjams and the costs involved. In some cases, the decision to apply boulder placements instead of large wood represents a compromise between the need to enhance stream habitat for salmonid species, while not adversely affecting the streamside habitat of the marbled murrelet. Of particular concern in these cases is the practice of "pulling" streamside trees for large wood placement, which affects the canopy closure and tree platform base relied on by murrelets. Closed canopies are thought to reduce predation on murrelets, while some of the mature tree platforms are favored as nesting habitat.

At this time, there is no comprehensive watershed strategy for the implementation of in-channel habitat and other restoration projects. In practice, most aquatic habitat restoration projects are implemented on an "opportunistic" or project basis, primarily where there are timber sales or nearby streamside roads. Increasingly, the Forest is working cooperatively with watershed councils to implement a variety of habitat restoration projects.

FISH HABITAT PREFERENCES AND POPULATION STATUS

Fish habitats and populations change through time as a result of natural processes and impacts from management. Natural factors such as forest fires and ocean conditions can change the structure of stream habitats and influence survival and returns of anadromous fish. Management of fish runs through hatchery and harvest practices, and forest practices such as road development, also have impacted fish habitat and populations. This section describes fish habitat and population status for key fish species found in the Forest. Tables 8-6 and 8-7 describe the distribution, preferred habitats and legal status (state or federal listings) for salmonids and other fish species. The discussion then evaluates the population status and habitat needs for key anadromous fish: coho salmon, chinook salmon, steelhead trout, sea-run cutthroat trout, and lamprey. Because Forest streams contribute to regionally significant coho salmon populations, the focus of the evaluation is on these stocks.

Table 8-6. Distribution, preferred habitats, and legal status of salmonid species on the Forest.

Species	Distribution and Preferred Habitats by Life History Stage (Croot and Marglolis 1991)	Status (ODFW 1997)
Coho salmon, *Oncorhynchus kisutch*	Anadromous. Migrate through most streams in the Coos, Tenmile, and Umpqua regions, with the exception of high-gradient systems (>6%) and channels with fish passage barriers. Spawning: Returning adults enter streams between Sep-Dec; peak spawning occurs in December in small streams with gradients <5%. Redds located where gravels are the primary substrate. Rearing: Fry emerge between Feb-May. Juvenile coho rear for 1 year in freshwater in streams with gradients <4%, with a preference for pools more than 2-feet deep with logs and other cover and cool water temperatures. Over-wintering habitat preferences include complex habitats that provide refuge from high flows; side channels and pools with abundant wood.	Listed as federal threatened in 1998.* Listed as “critical” on the state sensitive species list.
Fall chinook salmon, *Oncorhynchus tshawytscha*	Anadromous. Chinook migrate and spawn primarily in the mainstem of the West Fork Millicoma River. Spawning: Returning adults enter streams between Aug-Oct, generally holding in deep pools in mainstem Millicoma River; peak spawning in Nov-Dec in areas of concentrated gravel. Rearing: Fry begin to emerge in April and then move rapidly out of the system to rear in the lower river and estuarine areas.	---
Chum salmon, *Oncorhynchus keta*	Anadromous. No viable populations on the Forest; however, there is a population of chum salmon in Marlow Creek downstream of the Forest.	Listed as “critical” on the state sensitive species list.
Winter steelhead trout, *Oncorhynchus mykiss*	Anadromous. Migrate through most streams in the Coos, Tenmile, and Umpqua regions, with the exception of very high-gradient systems (>8%) and channels with fish-passage barriers. Spawning: Returning adults enter streams between Nov-May; spawning occurs between Jan-May in low/moderate gradient streams (up to 8%). Rearing: Juveniles rear as long as 4 years in fresh water; prefer pools with cover, large wood, and cool water temperatures.	Listed as federal candidate species. Listed as “vulnerable” on the state sensitive species list.
Sea-run cutthroat trout, *Oncorhynchus clarki clarki*	Anadromous. Very little information on the distribution of sea-run cutthroat trout; they appear to migrate and rear in most streams in the Coos, Tenmile, and Umpqua regions (ODFW 1993). Both migratory and resident populations usually use smaller and higher gradient streams for spawning/rearing than those used by salmon/steelhead.	Listed as “vulnerable” on the state sensitive species list.
Resident cutthroat trout, *Oncorhynchus clarki clarki*	Resident populations of cutthroat trout are found in numerous streams in Coos, Tenmile, and Umpqua regions, including some isolated populations above fish-passage barriers. Cutthroat trout use stream channels with gradients up to 12% if there is sufficient pool habitat.	Listed as “vulnerable” on the state sensitive species list.

* In 2001, a legal ruling voided the listing decision. Later a stay was granted pending appeal by the Ninth Circuit Court, thereby temporally restoring protections to Oregon coastal coho salmon. In 2002, Trout Unlimited and others filed a petition to list the Oregon Coast coho salmon as threatened under the federal ESA. This petition requests that NOAA Fisheries define the coho population to exclude hatchery fish from the distinct population segment (Trout Unlimited et al. 2002).

Table 8-7. Distribution, preferred habitats, and legal status of non-salmonid species on the Forest.

Species*	Distribution and Preferred Habitats by Life History Stage (Croot and Marglolis 1991)	Status (ODFW 1997)
Millicoma dace, *Rinichthys cataractae*	The Millicoma dace is confined to the Coos River watershed and is morphologically distinct from Umpqua River population; the Millicoma dace has specialized by living among the bedrock cracks and rubble in the swiftest portions of the Coos River (Wagoner et al. 1990).	Listed as "naturally rare" on the state sensitive species list.
Pacific lamprey, *Lampetra tridentate;* Western brook lamprey, *Lampetra richardsoni;* River lamprey, *Lampetra ayresi*	The Pacific and river lamprey are anadromous and brook lamprey is resident. There have been no systematic surveys of lamprey presence in the Coast Range. River and brook lamprey appear to be present throughout coastal streams, with pacific lamprey the most common. ODFW stream survey crews have encountered lampreys in most stream areas they have surveyed in the Coast Range (Kostow 2002). The river lamprey is very rare (Kostow 2002).	Current petition exists to list Pacific, western brook, and other lamprey as threatened under the federal ESA (Klamath-Siskiyou Wildlands Center et al. 2003). Pacific lamprey is listed as "vulnerable" on the state sensitive species list.
Redside shiner, *Richardsonius balteatus*	Common throughout the Forest. Competes for food that is preferred by young salmonids, especially in warmer water. Up to 6 inches long.	---
Largescale sucker, *Catostomus macrocheilus*	Common in larger streams. Scrapes algae off of rocks. Up to 2 feet long.	---
Threespine stickleback, *Gasterosteus aculeatus*	Uncommon. Lives in ponds or backwater areas along streams. Builds nest among reeds and protects vigorously. Up to 4 inches long.	---
Speckled dace, *Rinichthys osculus*	Common except in steep streams. Eats small macroinvertebrates. Up to 4 inches long.	---
Coast Range sculpin, *Cottus aleuticus*	Common except in steep streams. Scrapes algae off of rocks. Up to 3 inches long.	---
Prickly sculpin, *Cottus asper*	Common except in steep streams. Scrapes algae off of rocks. Up to 3 inches long.	---

* In addition to these species, other fish that may be present on the Forest include reticulated sculpin, riffle sculpin, tui chub, and Umpqua dace. Introduced fish species, all present in Loon Lake, include largemouth bass, black crappie, bluegill, and brown bullhead.

Coho Salmon

Population Status and Trends

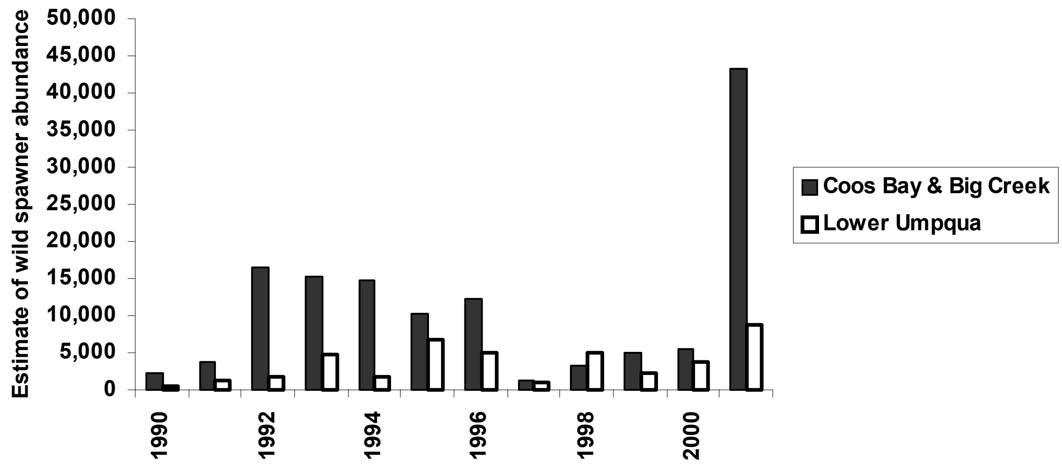
Wild Oregon coastal coho populations have historically oscillated in number. Coho populations fluctuated dramatically in the 1990s and in the early part of this century. The lowest spawner abundance was in 1997 and the highest in 2001 (Jacobs et al. 2002). Prior to the mid-1980s, the number of coho returning to streams was heavily influenced by intense ocean fishery harvest. From 1990-2002, coho spawner abundance was highest in the mid-south coast monitoring area (Sixes River to the Umpqua River, including the Coos and Tenmile regions), ranging from 26,000 adults to a high of 74,000 adults in 2001. The lowest spawner abundance was in the north coast monitoring area (Salmon River north to the Columbia), ranging from a low of 2,200 adults to a high of 34,000 adults.

The most productive coho spawning basins in the mid-south coast area have been the Coos, Tenmile Lakes and Siltcoos Lake Basins (Jacobs et al. 2002). The coho populations in the Tenmile and Siltcoos systems have a very productive lake-rearing juvenile life history. These numbers on coast-wide coho population status point to the regional importance of the Forest in helping to maintain coho populations. The Tenmile Lake and Coos River watersheds are among the most productive areas in the Coast Range. Figure 8-1 illustrates the coho spawner returns over time for the major drainages associated with the Forest (Coos Bay tributaries and Big Creek) in comparison to the lower Umpqua Basin.

Following the trend for streams in the Coast Range, the spawning populations of coho in streams draining from the Forest have fluctuated in numbers over time. Long-term spawning coho salmon counts were collected for Larson and Palouse Creeks, both tributaries to Coos Bay, beginning in the 1950s through 2002 (Figure 8-2). Peak counts of coho spawners within the surveyed section (1 mile) of Larson Creek ranged from a high of 327 fish in 1951 to a low of 6 fish in 1984. Coho spawners within the surveyed section (1 mile) of Palouse Creek ranged from a high of 523 fish in 2002 to a low of 19 fish in 1975. These fluctuations in spawner abundance are partially explained by changes in ocean productivity and associated coho survival and modification in ocean harvests. Since 1984, there have been increasing limitations on the ocean harvest of wild coho salmon.

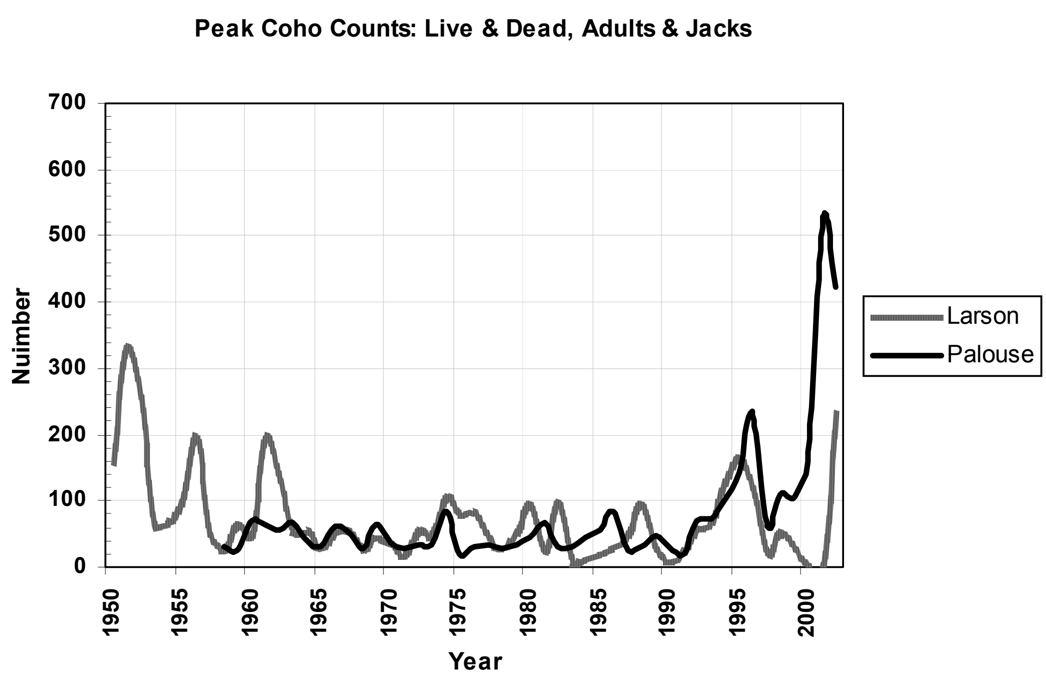
In addition to spawning surveys, assessments of juvenile coho rearing in Forest streams have been conducted. Snorkel counts of juvenile coho numbers were conducted periodically and usually associated with aquatic habitat inventories. For example, beginning in the 1950s, there are records of juvenile coho numbers for Larson Creek. Since 1998, the ODFW has been monitoring juvenile coho numbers for streams in the Coast Range. By providing a consistent methodology and systematic sampling of the same streams over time, these surveys are designed to assess regional (within the monitoring areas) trends in juvenile coho abundance. However, since the monitoring assesses juvenile coho rearing population at regional scales, it is not intended to provide trend information at the finer scale of watersheds. While these data cannot be used to estimate juvenile population numbers for individual watersheds or streams in the Forest, they do provide a consistent method that yields a useful snapshot of rearing population numbers and shifts through time.

Figure 8-1. Annual estimates of wild coho spawner abundance for stream systems within the mid-south coast and lower Umpqua management areas, 1990-2001.



Source: Jacobs et al. 2002

Figure 8-2. Palouse and Larson Creek (Coos Bay tributaries) spawning survey numbers for adult and jack coho salmon, 1950 to 2002.



The Palouse Creek spawning survey data begins in 1958; there are no recorded counts for Larson Creek in 2000 and 2001. Data from Coos Watershed Association 2003.

Table 8-8 and Map 8.4 show juvenile coho densities for selected stream segments in the Forest. To provide consistent comparisons between monitoring areas in the *Oregon Plan for Salmon and Watersheds* (State of Oregon 1999), the metric unit, number of fish per square meter (fish/m^2), is used. Coho densities range from zero to a high of 1.7 fish/m^2 for Johnson Creek in the Tenmile region. For stream reaches with multiple survey years, there can be considerable inter-annual variability in juvenile coho densities. Elk Creek, for example, varied from 0.72 fish/m^2 in 1998 to 0.21 fish/m^2 in 1999. Coho densities of approximately 0.7 fish/m^2 are considered to be adequate "seeding" for pool habitats. A number of other stream reaches exceed this density: Johnson Creek in the Tenmile region (1.7 fish/m^2); Charlotte Creek in the Umpqua region (0.91); and Elk (0.72 and 1.05) and Marlow (0.71) Creeks in the Coos region. Significantly, several sites had no observations of juvenile coho. No juveniles were observed in sampled sites Schumacher Creek in the Coos region (1998 and 2001) and in Dry (2002), Miller (2000) and Scholfield (2001) Creeks in the Umpqua region. The range of juvenile coho densities is an indication of both the productive capacity and the variability of coho numbers for streams on the Forest. These monitoring sites may be revisited, providing a way to track trends in juvenile coho densities over time.

Table 8-8. Coho densities for stream reaches in the Forest, 1998-2002.

Region	Site No.	Year	Stream Name with ODFW Survey Reach	Density (juvenile coho/m^2)
Coos	1153	1999	Cougar – reach 1	0.02
	1031	1998	Elk – reach 1	0.72
	1023	1999	Elk – reach 1	0.21
	1025	2002	Elk – reach 2	1.05
	1396	1998	Marlow – reach 3	0.71
	1403	1998	Schumacher Creek	0.0
	1403	2001	Schumacher Creek	0.0
	2416	1998	W F. Millicoma – reach 2	0.18
Umpqua	995	2000	Charlotte – reach 1	0.91
	1034	2000	Dry Creek	0.16
	1034	2002	Dry Creek	0.0
	1033	2000	Miller – reach 1	0.0
	1026	2001	Scholfield – reach 6	0.0
Tenmile	1149	2002	Johnson – reach 4	1.7

Data were collected as part of the *Oregon Plan for Salmon and Watersheds* (State of Oregon 1999) monitoring program. Data from Steve Rogers, ODFW 2003.

Habitat and Other Factors Limiting Populations

Coho abundance is limited by factors that can influence survival for each life stage for fish: ocean residence, migration (ocean spawning adults and returning juveniles), spawning, and rearing. The return of adults is strongly influenced by ocean productivity and harvest. There is evidence that ocean conditions for coho salmon oscillate with about 20-year cycles, between highly productive conditions and those with limited productivity. Since about 1998, ocean conditions appear to be in a productive phase (Taylor 2003). Until 1946, coho populations in the area were heavily affected by a gillnet fishery, and by splash dams until 1956, especially in the Coos River system (ODFW 1993).

Spawning, rearing, and migration habitat conditions influence coho salmon populations in the Forest. The key limiting factor for migration are human barriers at road crossing culverts and tide gates. As discussed above, culverts are probably not limiting adult migration in the Forest; however, to a limited extent they do impact the movement of juvenile coho. Tide gates, which can limit fish access to streams in the Coos region, are not present in streams on the Forest. The Coos Watershed Association, in collaboration with the county and landowners, is modifying tide gates to improve fish access to estuary streams (personal communication, Jon Souder, Coos Watershed Association 2003). Waterfalls also limit the extent of coho spawning and rearing in the Forest. Improving fish passage at Stulls (Stahls) Falls and in Elk Creek opened up considerable habitat in West Fork Millicoma Basin that historically was inaccessible.

Spawning habitats on the Forest are impacted by the limited amounts of in-channel wood (Chapter 7, *Riparian Vegetation and Large Wood*) that help to retain and sort gravels. Since spawning and rearing usually take place in small, low-gradient (generally <4%) channels, wood in these stream segments is especially important for spawning populations and juvenile survival (Nickelson et al. 1992).

Because juvenile coho rear for at least one year in freshwater, they are sensitive to habitat conditions and are vulnerable to predation. High winter stream flows appear to limit juvenile coho population numbers. Coho require complex pool and off-channel habitats that provide refuge from high flows (Nickelson et al. 1992). These habitat qualities also are applicable for other salmonid species. Numbers of juvenile coho salmon, 1+ steelhead, and cutthroat trout are directly correlated with increasing complexity of pools, as measured by pool depth and amount of wood (Lonzarich and Quinn 1995). Pool complexity can be improved using restoration actions such as the addition of large wood to channels and the creation of off-channel habitats. While most streams in the Forest have confined channels, which limits the opportunities for the development of off-channel habitats, the addition of large wood was observed to increase pool complexity and gravel retention in the Coos Watershed (Coos Watershed Association 2001).

The Tenmile region is characterized by coastal lakes, which provide an ideal habitat for young coho. Historically (and currently), the Tenmile Lakes area was one of the most productive juvenile coho rearing areas in the Coast Range (Jacobs et al. 2002). Most coho salmon probably moved out of the tributaries and reared in the lakes that provided rich food sources and abundant habitat. The introductions of exotic fish into the lake system, perhaps more than the alteration of stream habitat, have affected the productivity of coho in the lakes. Reimers (1989) documented the effect of exotic fish on coho salmon in the Tenmile Lakes. From 1949-1957, the combined number of jacks and adult coho salmon returning to the lakes was estimated to average over 50,000 fish annually. During the following decade, the size of the spawning run declined, averaging less than 30,000 fish annually. It was suspected that competition for food and predation on young salmon fry by exotic fish, such as bluegill and white crappie (introduced in 1987), had increased. In response, the ODFW decided to apply rotenone to the lakes to kill all fish, and then released 930,000 hatchery-reared coho smolts into the lakes. For several years after the rotenone treatment, spawning runs of coho returned to their early 1950s level, peaking in 1970 at 71,000 fish. However, spawning runs declined sharply in the following years, coinciding with the recovery of the exotic fish species in the lakes and the new introduction of largemouth bass.

The introduction of hatchery fish into wild populations also has impacted the genetic diversity of coho salmon populations. For example, hatchery-reared coho salmon were released into the Coos River system beginning in the early 1900s, and non-native stocks were first introduced beginning in 1933. Stocks have been introduced from the Necanicum, Coquille, Klaskanine, and Alsea systems (ODFW 1993). Steelhead trout rear throughout the Forest and are considered wild and relatively unaffected by past hatchery releases. At this time, all hatchery coho broodstock (adult spawners) are native stock derived from adults captured in the Coos River system.

Beginning in 1998, returns of adult coho originating from Oregon coastal hatcheries have been nearly 100% marked with adipose fin clips. This marking has enabled the proportion of wild spawning fish to be estimated during spawning surveys using the recovery figures from the observations of the carcasses of hatchery-reared fish (Jacobs et al. 2002). From 1998-2001, wild fish were the dominant component of all spawning populations, with the exception of the mid-coast monitoring area (Siuslaw River Basin north through the Salmon River Basin). During the last 2 years, there have been few hatchery-reared coho observed among the naturally spawning populations in the monitoring areas encompassing the Forest. In 2000, there were no fin-marked fish observed in the Tenmile and Coos regions, but the lower Umpqua did have 0.4% marked fish. In 2001, the Tenmile and Coos regions had 0.4% marked fish and the lower Umpqua had 2.9% marked fish.

Fall Chinook

Population Status and Trends

In the analysis area, the population of fall chinook was likely significantly affected by ocean harvests, and in the Coos River system by a gillnet fishery until 1946 and splash dams until 1956. Introductions of non-native hatchery stocks also likely impacted fall chinook populations. Since 1900, hatchery-reared chinook have been released into the Coos River system. Introductions of non-native stocks first occurred in 1927 when eggs from Columbia River stocks were raised and released from the Coos River Hatchery (ODFW 1993).

Fall chinook populations remained at very low levels during the 1960s. Since then, populations have recovered somewhat, but probably not to their historical abundance (Nickelson et al. 1992, ODFW 1993). Based on spawning surveys from 1986-2001, fall chinook in the mid-south coast gene conservation area, which includes the Coos and Tenmile regions, have remained stable (Jacobs et al. 2002). In contrast, over the same time period there has been a declining trend in spawner abundance in the watersheds of the Tillamook-Nestucca Basin. Although the north coast and mid-south coast watersheds have very different population dynamics, the stability in the numbers of spawning chinook in the Coos and Tenmile regions is promising.

Habitat and Other Factors Limiting Populations

Because of their comparatively large body size, chinook salmon generally require greater water depths for upstream migration than coho, steelhead or cutthroat. Chinook salmon require holding pools close to spawning areas. Suitable spawning areas include stable gravels and cobbles. On the Forest, chinook salmon are confined primarily to the larger tributaries in the West Fork Millicoma River and the lower portions of Mill Creek. In this system, the key limiting habitats are deep pools and stable spawning gravels. Limited large wood, especially large wood jams in the large channels of the river, limits the creation of deep holding pools and the retention of spawning gravels.

Hatchery fish also have the potential to impact the genetic diversity of wild chinook populations, although this impact is limited since local, native brood stocks are used. A proportion of hatchery-reared fall chinook released from Oregon hatcheries are coded-wire tagged prior to release. Based on the occurrence of the tagged hatchery fish recovered in surveys of wild spawning areas, it appears that few hatchery fish stray into chinook spawning areas. For example, in 2000 a few hatchery fish were found in surveys of Coos River tributaries, with most fish derived from the Coos River stocks (Jacobs et al. 2002). Currently, about 100,000 juvenile chinook, derived from Coos River stocks, are reared and released at the West Fork Millicoma River Hatchery (on the Forest).

Winter Steelhead

Population Status and Trends

Oregon coastal steelhead population trends have traditionally been assessed through a combination of dam passage counts and angler harvest records. Coast steelhead populations have varied in abundance from year to year, largely influenced by ocean conditions and some impacts from harvest and freshwater conditions (Nickelson et al. 1992). From 1970-1990, most coastal steelhead runs, including the Coos River population, were below the long-term average (Nickelson et al. 1992). Since 1992, restrictions in the harvest of wild steelhead have eliminated the usefulness of angler harvest reporting for monitoring the status of coastal winter steelhead stocks (Jacobs et al. 2002). The ODFW developed a survey method for estimating winter steelhead spawning by counting redds, which will be implemented coast-wide in 2003.

Habitat and Other Factors Limiting Populations

Juvenile steelhead spend 1-4 years rearing in fresh water. Using similar fresh water, juvenile-rearing habitats as coho salmon, steelhead also require deep, complex pools and off-channel habitats that provide refuge from high winter stream flows.

Although hatchery stocks have the potential to impact the genetic diversity of wild steelhead populations, currently this impact is limited because local native brood stocks are used. Releases of hatchery-reared steelhead in the Coos River system began in 1925 and continued through 1958 with mostly local stocks reared at the South Coos Hatchery (ODFW 1993). Beginning in 1970, Alsea River stocks were released into the Coos system, including the

West Fork Millicoma River. In 1980, Larson and Palouse Creeks were added to the releases of Alsea stocks. Beginning in 2003, less than 200 steelhead (all native broodstock) will be spawned at the ODFW hatchery on the lower West Fork Millicoma River (on the Forest).

Sea-run and Resident Cutthroat Trout

Population Status and Trends

Resident and anadromous cutthroat trout are native to all of the stream systems in the analysis area. Cutthroat trout are widely distributed in all of the drainages and can occur above natural barriers to migration, where resident populations reside. There is very little information on the population trends or status of resident or sea-run cutthroat trout in the Forest. Although most aquatic habitat inventory and fish survey information include observations of cutthroat, there is little other systematic survey information for the Forest.

Habitat and Other Factors Limiting Populations

Anadromous and resident cutthroat trout populations use smaller streams for spawning and rearing than those used by salmon and steelhead (ODFW 1993). Key habitat limitations for cutthroat include deep pool habitats with wood and cover. The health of the wild population would be improved by increasing habitat quality and connectivity. A key factor would be to address culverts that are fish passage barriers, including barriers for juvenile cutthroat trout.

Lamprey

Population Status and Trends

Pacific and brook lamprey are found on the Forest (river lamprey also may be present). Pacific lamprey is anadromous and brook lamprey is a resident species. Little is known about lamprey population status or trends, but the species appear to be declining. Currently, there is a petition to list Pacific, western brook, and other lamprey as threatened under the federal ESA (Klamath-Siskiyou Wildlands Center et al. 2003). Pacific lamprey is listed as “vulnerable” on Oregon’s sensitive species list (ODFW 1997). Since 1968, the ODFW has counted adult Pacific lamprey at Winchester Dam on the North Umpqua River. These counts show a severe decline in lamprey abundance in the 1970s and very low numbers since that time (Kostow 2002). Although systematic presence/absence surveys targeting lampreys have not been done for Coast Range streams, lampreys appear to be present in most coastal streams (Kostow 2002). The ODFW aquatic habitat inventory and fish presence distribution crews have encountered lamprey in most areas they have surveyed on the Forest (personal communication, Randy Smith, ODF 2003).

Habitat and Other Factors Limiting Populations

Very little is known about the habitat or other issues impacting lamprey populations. Habitat issues that may contribute to the decline in lamprey populations are upstream passage over artificial barriers and through culverts and loss of high quality low-gradient flood plain habitats through channelization and reductions in in-channel large wood.

AMPHIBIANS AND REPTILES: HABITAT PREFERENCES AND POPULATION STATUS

Streams, lakes, wetlands, and riparian areas provide habitat for a number of amphibian and reptile species. Amphibians and reptiles are an important component of the forest fauna and several species are listed on the Oregon's sensitive species list. In headwater streams above the upper extent of fish distribution, amphibians are often the dominant vertebrate predators (Bury 1988). Table 8-9 describes the distribution, preferred habitats and status of aquatic and riparian-dependent amphibians on the Forest.

Reptiles, such as Western pond turtles, are found on the Forest. Pond turtles have been sighted in number of ponds and lakes, including Gould and Loon Lakes, and may be present in some slow water areas of streams (Allbritten 2002). The Western pond turtle is listed as "critical" on the state sensitive species list. Pond turtles require quiet water with rocky or mud bottoms and floating logs or other platforms for resting and basking at the water's surface. These turtles nest on land where there is appropriate substrate and a sunny location within a mile of water. Juvenile pond turtles are especially vulnerable to mortality from aquatic and nest predation and destruction of nesting areas.

Amphibians that occur in headwater stream reaches can be sensitive to disturbance. Increased sediment deposition in the stream channel and changes in water temperature regimes can affect juvenile and adult amphibians. Two headwater amphibian species, tailed frogs and seep salamanders, are especially sensitive to management impacts. Both species require clean substrate and cold waters (Bury et al. 1991). Tailed frogs and seep salamanders can be extirpated from stream systems by forest harvest actions that adversely impact habitat quality and water temperatures; because these species have limited dispersal ability, habitats are not quickly reoccupied (Corn and Bury 1989). Tailed frogs and seep salamanders are listed as "vulnerable" on the state sensitive species list (ODFW 1997).

Methods

There is limited information on the population status of aquatic and riparian-dependent amphibians in the Forest. Allbritten (2002) completed amphibian surveys of pump chances and a limited selection of streams in the Forest; Vesely and Stamp (2001) conducted a survey of amphibians on perennial, non-fish-bearing streams in the Forest.

Table 8-9. Aquatic and riparian-dependent amphibians found on the Forest.

Species	Distribution and Preferred Habitats by Life History Stage (Leonard et al. 1991)	Status (ODFW 1997)
Tailed frog, *Ascaphus truei*	Aquatic. Larvae usually found in cold, rocky streams. Adults prefer areas along the aquatic margins and cool, moist forests in the vicinity of streams. Tadpoles, especially during the first year, do not tolerate warm water. Observed on the Forest (Vesely and Stamp 2001).	Listed as vulnerable on state sensitive species list.
Red-legged frog, *Rana aurora aurora*	Adults are terrestrial and use areas adjacent to streams. Eggs laid in marshes, bogs, swamps, ponds, lakes, and slow moving streams. Observed on the Forest (ODF 1993, Allbritten 2002).	Listed as vulnerable on state sensitive species list.
Foothill yellow-legged frog, *Rana boylii*	Adults found in vicinity of permanent streams; most common in and near streams with rocky, gravely, or sandy bottoms. Eggs are attached to rocks or gravel in pools and stream margins. Observed on the Forest (ODF 1993).	Listed as vulnerable on state sensitive species list.
Pacific tree frog, *Pseudacris regilla*	Very common in the Oregon Coast Range. Requires slow, open water for breeding. Observed on Forest (Allbritten 2002).	---
Southern seep salamander (also called southern torrent salamander), *Rhyacotriton variegates*	Adults live in close proximity to cold streams, splash zones and seeps. Are uncommon. Larvae may be abundant in gravel with water percolating through it. Observed on the Forest (Vesely and Stamp 2001).	Listed as vulnerable on state sensitive species list.
Pacific giant salamander, *Dicamptodon tenebrosus*	Aquatic. Adults range through cool, moist forest areas in the vicinity of cold streams and lakes. Larvae are stream-adapted and common. Salmonids feed heavily on salamander larvae and adult salamander feed on small fish. Observed on the Forest (Vesely and Stamp 2001, Allbritten 2002).	---
Long-toed salamander, *Ambystoma macrodactylum*	Aquatic and terrestrial. Requires quiet water for breeding and feeding. Adults use downed logs or rock for cover and resting. Observed on the Forest (Allbritten 2002).	---
Dunn's salamander, *Plethodon dunni*	Adults usually associated with streams or seeps in the splash zone or under rocks, or occasionally woody debris. Eggs deposited in rocks near stream margin. Observed on the Forest (Vesely and Stamp 2001, Allbritten 2002).	---
Western red-backed salamander, *Plethodon vehiculum*	Adults range throughout forest areas, often found in rocky areas and also under logs and other wood. Observed on the Forest (Vesely and Stamp 2001, Allbritten 2002).	---
Northwestern salamander, *Ambystoma gracile*	During dry months, adults seek refuge in rotting logs and moist crevices. Larvae are adapted to ponds and slow moving streams. Observed on the Forest (Allbritten 2002).	---
Clouded salamander, *Aneides ferreus*	Adults often associated with large decayed logs and stumps, particularly Douglas-fir. Old burns and clearcuts may have large populations. Eggs laid in the cavities in large logs or stumps or in openings deep in rocks.	---
Ensatina salamander, *Ensatina eschscholtzii*	Adults often found in or under large wood, especially conifer logs, on forest floor. Eggs usually laid in cavities of logs and stumps. Observed on the Forest (Allbritten 2002).	---
Rough-skinned newt, *Taricha granulosa*	Aquatic. Adults range throughout forested areas. Eggs are deposited along the vegetated fringes of lakes, beaver ponds, and slow moving streams. Very common. Observed on the Forest (Vesely and Stamp 2001, Allbritten 2002).	---

Vesely and Stamp (2001) surveyed headwater streams for amphibians with the following goals: (1) compare populations of tailed frogs and seep salamanders in streams with riparian harvest buffers and unmanaged streams with older forests; and (2) assess the relative abundance of stream amphibians. In 1995, the Forest began implementing riparian buffers on perennial fish-bearing streams. The intensive portion of the study inventoried amphibians living in or near streams (within about 7 feet of the wetted channel). Nine pairs of streams flowing through recently clearcut units with riparian buffer strips and unharvested late-seral forests (>80 years old) were examined. Before the recent harvest, all of the streams within the clearcuts were in late-seral forest age classes. In addition to the intensive survey sites on buffered and forested stream segments, Vesely and Stamp (2001) sampled 59 transect segments at 44 sampling sites (extensive surveys) near road crossings throughout the Forest. Because of the higher road densities in the Coos region, most of the sampling effort was in this region.

Results

Allbritten (2002) found amphibians within most of the surveyed pump chance ponds. The most common species observed were rough-skinned newts and northwestern salamanders (primarily egg masses; Table 8-10). Based on the frequent sightings of egg masses, it appears that the ponds are important breeding areas for a number of aquatic-dependant amphibians, including long-toed and northwestern salamanders, and red-legged frogs. In addition to the pump chance sightings, there were some observations (not a systematic inventory) of amphibians in streams in the Coos region, with detections of Pacific giant, ensatina, western red-backed, and Dunn’s salamanders.

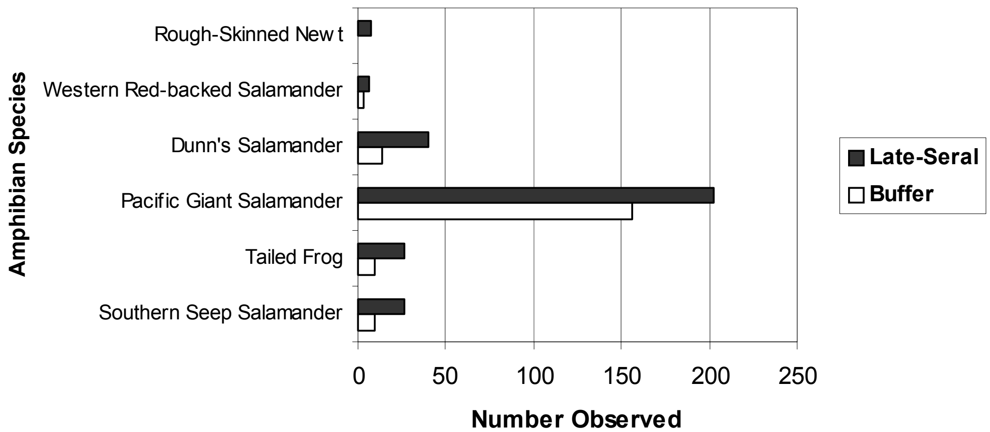
Table 8-10. Amphibians found in fire pump chance ponds on the Forest.

Species	Number of Sightings in Pump Chances	Notes
Long-toed salamander	11	Most sightings were eggs
Northwestern salamander	15	Most sightings were eggs
Pacific tree frog	9	
Red-legged frog	14	Most sightings were eggs
Rough-skinned newt	19	

Data from Marnie Allbritten, ODFW 2002.

The Vesely and Stamp study (2001) did not inventory a large enough sample of streams on the Forest in order to make general conclusions about the population status and possible impact of the non-fish-bearing stream buffers. However, the study does provide a snapshot for one time period for the distribution and numbers of amphibians for a limited number of sites. A total of 499 amphibians of 6 different species were found in streams flowing through buffered areas and late-seral stands. Figure 8-3 shows the distribution of amphibian observations for both the buffered and forested streams.

Figure 8-3. Number and species of amphibians in nine pairs of streams flowing through clearcuts with riparian buffer strips and late-seral forests (>80 years old).



Data from Vesely and Stamp 2001.

Amphibian species and their distributions varied across the study sites. Pacific giant salamanders were the most common species for both the buffered and intact forests. Small numbers of western red-backed and Dunn's salamanders were found in streams in both the buffered and forested sites. Rough skinned newts were the only species found only at the late-seral forest sites. The observations for tailed frogs and seep salamanders were highly variable. The seep salamanders were found at two of the nine riparian buffer sites and four of the nine late-seral forest sites. Tailed frogs were detected at two of the nine riparian buffer sites and seven of the nine late-seral sites. The density of tailed frogs was approximately three times greater, and seep salamander density was four times greater in the late-seral forest streams than in the buffered streams; due to the small sample size, these findings are not statistically significant. Unfortunately, the study did not report on the relationship between amphibian observations related to the distance from the wetted channel.

At the 44 extensive sampling sites, Vesely and Stamp (2001) detected tailed frog larvae at 9 out of 32 sites (28%) in the Coos region; 1 out of 6 sites (17%) in the Tenmile region; and zero out of 6 sites in the Umpqua region (0%). Seep salamanders were observed at 9 out of 32 (28%) sites in the Coos region; 1 out of 6 sites (17%) in the Tenmile region; and 3 out of 6 sites in the Umpqua region (50%).

Discussion

Both the Allbritten (2002) and Vesely and Stamp (2001) findings are consistent with other amphibian population inventories in the Coast Range. Most of the species observed in the pump chance ponds, long-toed and northwestern salamanders and red-legged and Pacific tree frogs, have larvae that are adapted to ponds and slow moving water. In other studies of headwater streams, giant salamanders were noted to be the most abundant amphibians, followed by tailed frogs, with some observations of seep and Dunn's salamanders (Bury et al. 1991). All of these amphibians have aquatic larvae and adults that remain within close proximity to the stream.

There is evidence that forest management actions can affect amphibians residing in high-gradient headwater streams. Amphibian species richness has been found to be highest in uncut forests (Corn and Bury 1989). At the drainage scale, all species except seep salamanders were positively associated with proportion of the stream length with forest bands greater than 140 feet in width (Stoddard 2001). Species richness was highest in uncut forests and in clearcut sites with uncut forest upstream (Corn and Bury 1989). Removing or reducing riparian forest near streams can affect the microclimate and stream temperatures, both of which can impact amphibians (Chan et al. 2003). Some amphibian species have limited dispersal ability after disturbance. There are studies showing that tailed frogs and seep salamander populations in large clearcuts in the Oregon Coast Range had not recovered in 3-5 decades after harvest (Bury and Hyde 2003).

The maximum number of tailed frogs found at one of the buffer sites equals the largest number of frogs found at a late-seral site, with seven observations at each site. Similarly, the maximum number of seep salamanders found at a buffer site (7) was close to the largest number found at a late-seral site (11). The distribution of tailed frogs and seep salamanders found in the study can perhaps be explained by variable habitat qualities in both the buffered and intact forest streams. Both sites with large numbers of tailed frogs had the highest percentages of cobble substrate. There is evidence that tailed frogs prefer cobble substrates and are negatively affected by stream sedimentation (Bury et al. 1991).

To thoroughly examine the impact of riparian-buffer strategies on amphibian populations, future Forest studies should evaluate populations before and after riparian harvest and track trends over time. It is especially important to characterize stream habitat variables and water temperatures. These monitoring efforts should examine a range of stream systems and management impacts, including road sediment delivery to stream channels. In the long term, stream sedimentation may be the most important determinant of the number of amphibians (Bury et al. 1991).

SUMMARY OF STREAM HABITAT AND FISH POPULATION INVENTORIES

In 1993, the ODFW in collaboration with the ODF began inventorying stream habitats in the Forest. Since the start of the program, habitat inventories have been completed for most of the extent of anadromous salmon distribution in the Forest. Many streams have been resurveyed over subsequent years. These surveys measure instream habitat characteristics (pool size and depth, active channel width, amount of wood in the channel, and other attributes), streamside vegetation, and valley attributes (valley width and other factors) up the length of the stream and tributary channels to a point at which it is determined that fish use may cease (these surveys are not used to determine the official end of fish distribution in streams; the upper extent of fish presence is assessed through separate inventories). All streams were divided into individual stream reaches, as determined by channel gradient and valley form. Stream habitat is measured either during summer or winter periods. Summer habitat surveys provide information on low flow conditions, while winter habitat surveys characterize stream habitat during higher flows. Since stream conditions during the winter, particularly in pools and other off-channel habitat features that offer an escape from high flows, are important for juvenile coho survival, the winter habitat surveys can provide a picture of conditions that can limit coho salmon populations.

Methods

For this analysis, the most current summer and winter habitat inventories through 2002 were used. Inventories for many of the surveyed streams began below and continued into the Forest. Information was summarized only for the stream reaches inventoried on the Forest. The aquatic habitat inventory information used in this analysis is summarized in Appendix D. Information on the number of complex pools (pools with more than three pieces of large wood) was not summarized for inventories before 1995.

Results

The aquatic habitat inventories cover more than 120 stream miles in the Forest (Map 8.5). Most of the inventoried miles are in the Coos region, which has the most miles of mapped stream channels (Figure 8-4). The inventories encompass a range of stream channel gradients, from low-gradient areas to steep headwater streams near the end of fish distribution (Table 8-11, Figure 8-5). Throughout the Forest, 64% of the known fish-bearing streams have completed aquatic habitat inventories. The Coos region has the highest percentage of inventoried fish-bearing streams (72%), followed by the Tenmile (62%), and Umpqua (42%) regions. More than 60% of inventoried stream miles are for low-gradient (<4%) channels, which provide good information on the preferred habitats for coho salmon. Based on other stream inventory data, fish presence (usually resident cutthroat) starts to end at higher gradients; usually there are no fish present above 12% gradients.

Figure 8-4. Miles of Forest streams with aquatic habitat inventories.

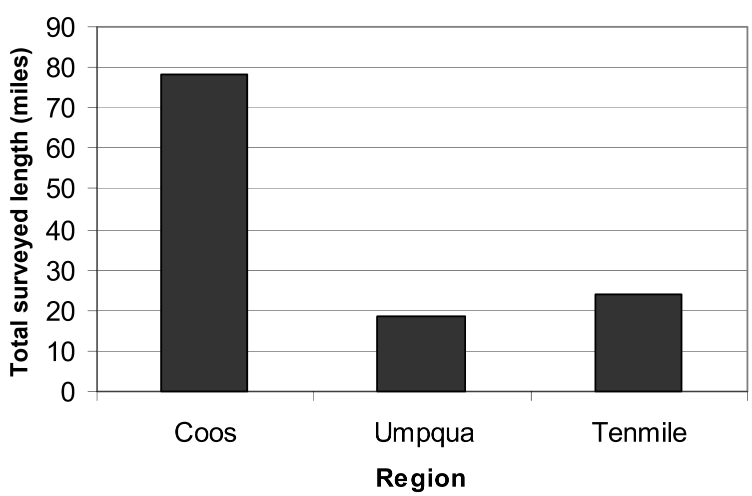
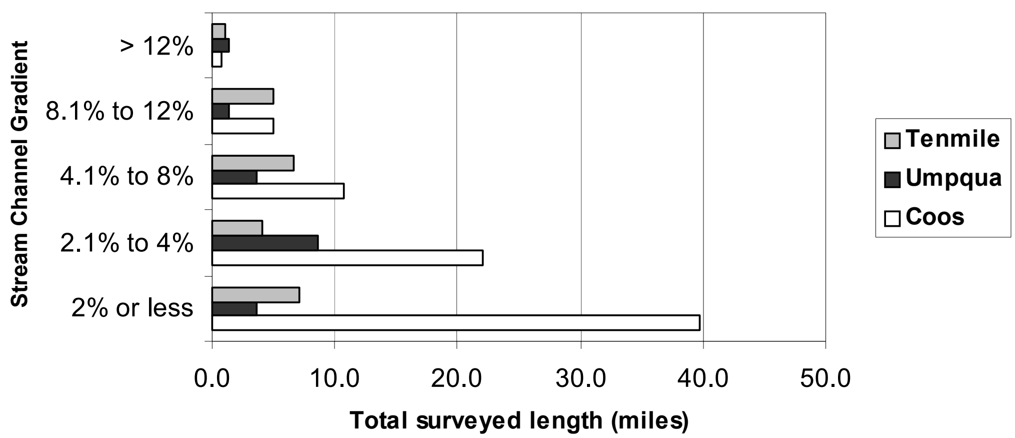


Table 8-11. Miles of streams inventoried by gradient class for each region.

Region	Surveyed Length (mi.) and Percent for Each Gradient Class					Total
	2% or less	2.1% to 4%	4.1% to 8%	8.1% to 12%	> 12%	
Coos	39.8 (50.8%)	22.0 (28.1%)	10.7 (13.7%)	5.0 (6.4%)	0.8 (1.0%)	78.3 (100%)
Umpqua	3.7 (19.8%)	8.6 (46.0%)	3.7 (19.8%)	1.4 (7.5%)	1.3 (7.0%)	18.7 (100%)
Tenmile	7.1 (29.8%)	4.1 (17.2%)	6.6 (27.7%)	5.0 (21.0%)	1.0 (4.2%)	23.8 (100%)

Source: GIS analysis of mapped ODFW aquatic habitat inventory reaches.

Figure 8-5. Miles of streams inventoried by gradient class for each region.



Low-gradient streams can contain the highest quality fish habitat and are responsive to restoration actions such as the placement of large wood. For this reason, aquatic habitat information was evaluated for stream channels with gradients less than 4%. Low-gradient stream channels are distributed in the lower reaches of most inventoried streams (Map 8.6).

Pool habitat is a good indicator of aquatic habitat quality. A pool area of 35% of the total stream area is the aquatic habitat quality benchmark established by the ODFW (Jacobsen and Thom 2001). According to this benchmark, 35% of the stream surface in pools is desirable and less than 10% is undesirable. In addition to percent pool area, an indication of pool depth and complexity provides additional information on habitat quality. According to the aquatic inventory protocol, complex pools must have at least three pieces of wood within the pool. Pools over 3.3-feet deep are summarized to provide information on these important habitats. In general, the Tenmile region has the highest quality pool habitats, measured by percent pool area, depth, and complexity (Table 8-12). It is the only region that exceeds the ODFW's benchmark for percent pools.

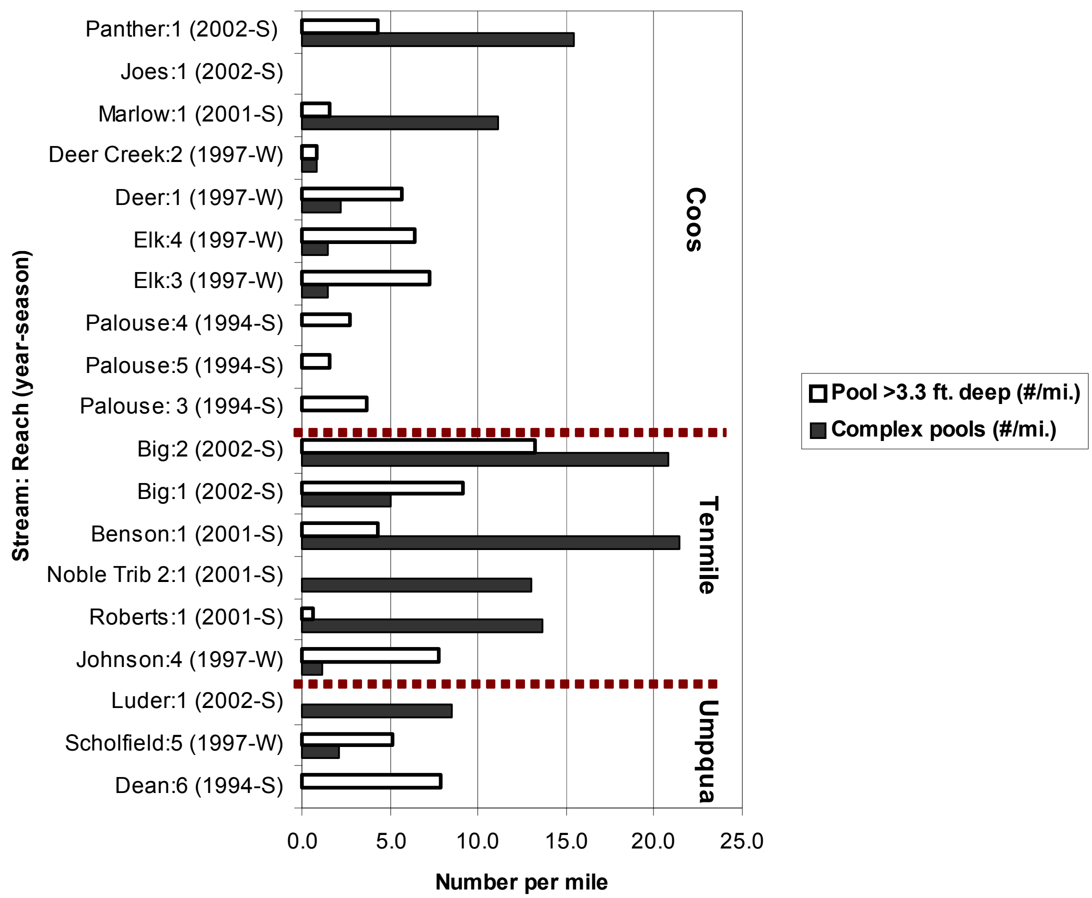
Table 8-12. Average pool characteristics for inventoried streams reaches of less than 4% gradient by region.

Region	No. Reaches	Average Percent Pools	Average No. Pools per Mile > 3.3 feet.	Average No. Complex Pools per Mile
Coos	32	27	2.7	4.7
Tenmile	14	40	3.9	9.7
Umpqua	11	25	4.1	3.2

Individual stream reaches vary in their habitat quality. Figures 8-6 and 8-7 provide summaries for the numbers of pools deeper than 3.3 feet, complex pools, and percent pool area for stream reaches less than 2% gradient and less than 40-foot active channel width. Figures 8-8 and 8-9 provide the same pool characteristics for stream reaches between 2.1% and 4% gradient and less than 40-foot active channel width. Among the streams with an active channel width less than 40 feet, the Tenmile region consistently had the highest pool habitat quality, particularly Big and Benson Creeks. In the Umpqua region, Luder Creek has the highest pool habitat values, and also has high wood loading (Chapter 7, *Riparian Vegetation and Large Wood*). However, most of the stream reaches had pool habitat values below their potential. The limited large wood in the stream channels contributes to the lower pool area and complexity. Stream channels with widths less than 40 feet are ideal candidates for the placement of large wood to increase habitat complexity.

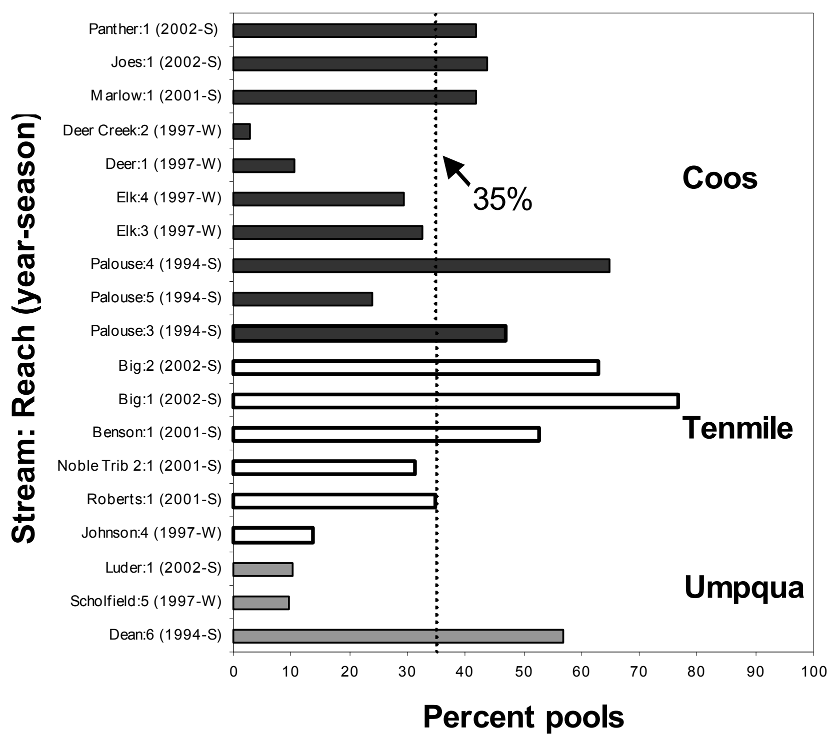
Stream reaches with larger channel widths consistently had poor indicators of habitat quality. Figures 8-10 and 8-11 provide summaries for the numbers of pools deeper than 3.3 feet, complex pools, and percent pool area for stream reaches less than 2% gradient and greater than 40-foot active channel width. Of the inventoried reaches, Dean and Charlotte Creeks in the Umpqua region and Johnson Creek in the Tenmile region had the highest quality pool habitats. The Coos region streams had the overall lowest indicators of pool habitat quality.

Figure 8-6. Pools deeper than 3.3 feet and complex pools for streams less than 2% gradient and active channel width less than 40 feet for streams by region.



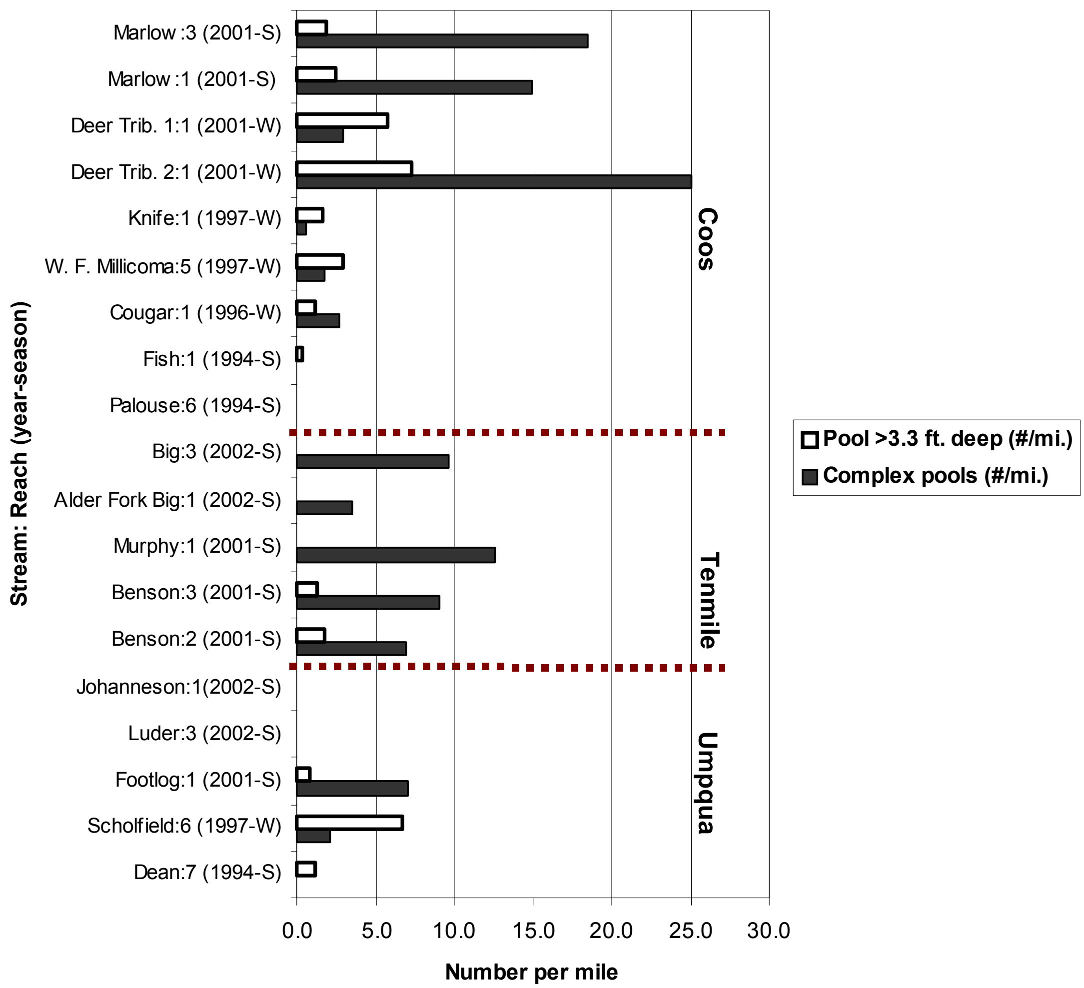
Note: There were no complex pool measurements for Palouse and Dean Creeks (data collected before 1995).

Figure 8-7. Percent pools for streams less than 2% gradient and active channel width less than 40 feet for streams by region.



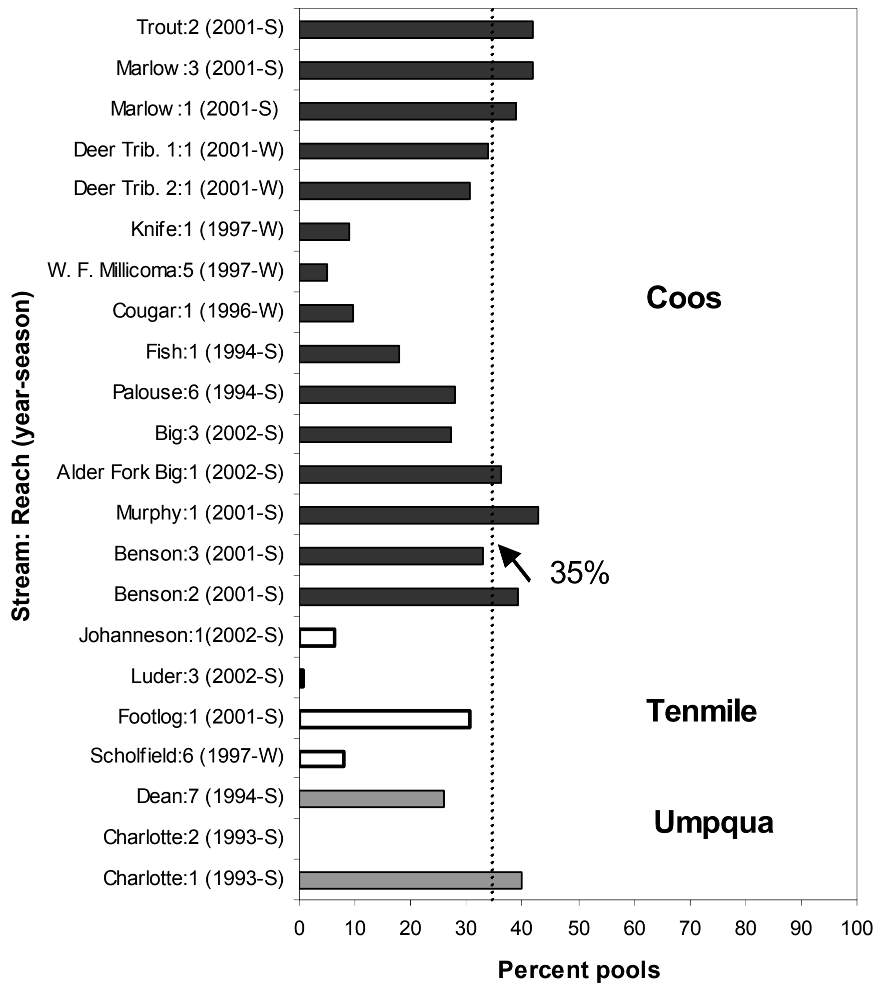
Note: The 35% pool surface area is the habitat quality benchmark established by ODFW.

Figure 8-8. Pools deeper than 3.3 feet and complex pools for streams between 2.1% and 4% gradient and active channel width less than 40 feet by region.



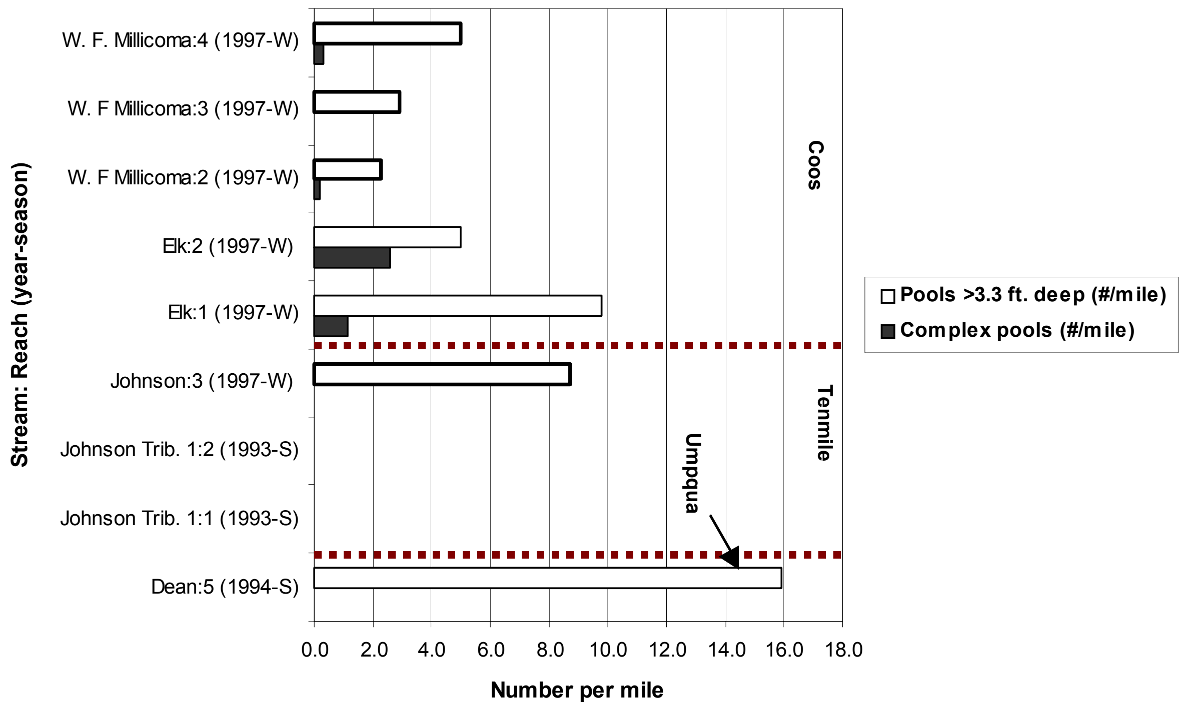
Note: There were no complex pool measurements for Palouse, Fish, and Dean Creeks (data collected before 1995).

Figure 8-9. Percent pools for streams between 2.1% and 4% gradient and active channel width less than 40 feet for streams by region.



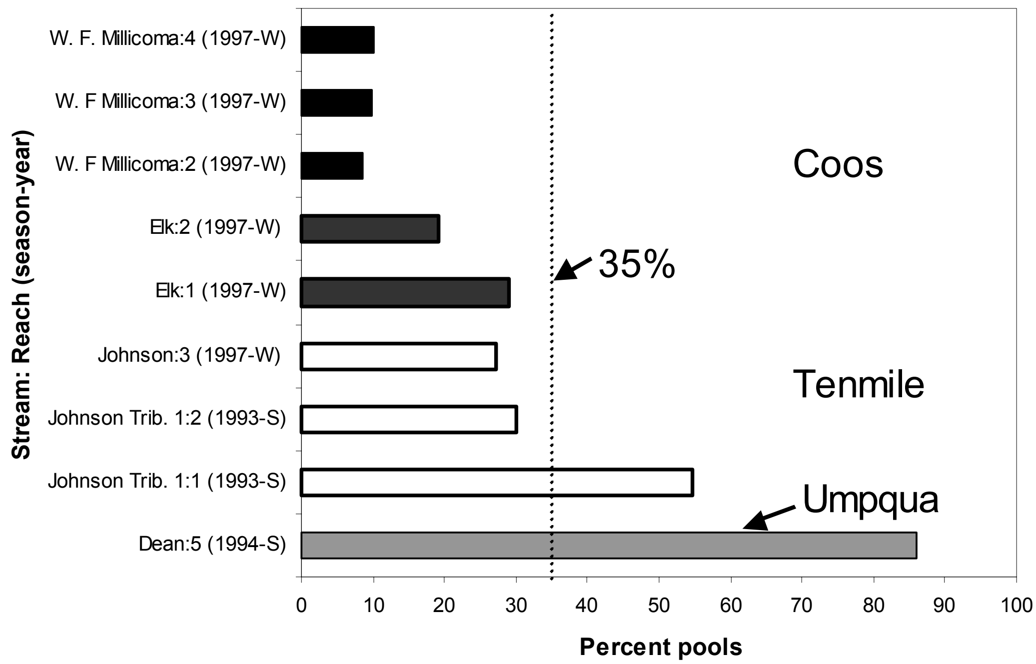
Note: The 35% pool surface area is the habitat quality benchmark established by ODFW.

Figure 8-10. Pools deeper than 3.3 feet and complex pools for streams less than 2% gradient and active channel width more than 40 feet for streams by region.



Note: There were no complex pool measurements for Charlotte, Johnson, and Dean Creeks (data collected before 1995).

Figure 8-11. Percent pools for streams less than 2% gradient and active channel width more than 40 feet for streams by region.



Note: The 35% pool surface area is the habitat quality benchmark established by ODFW.

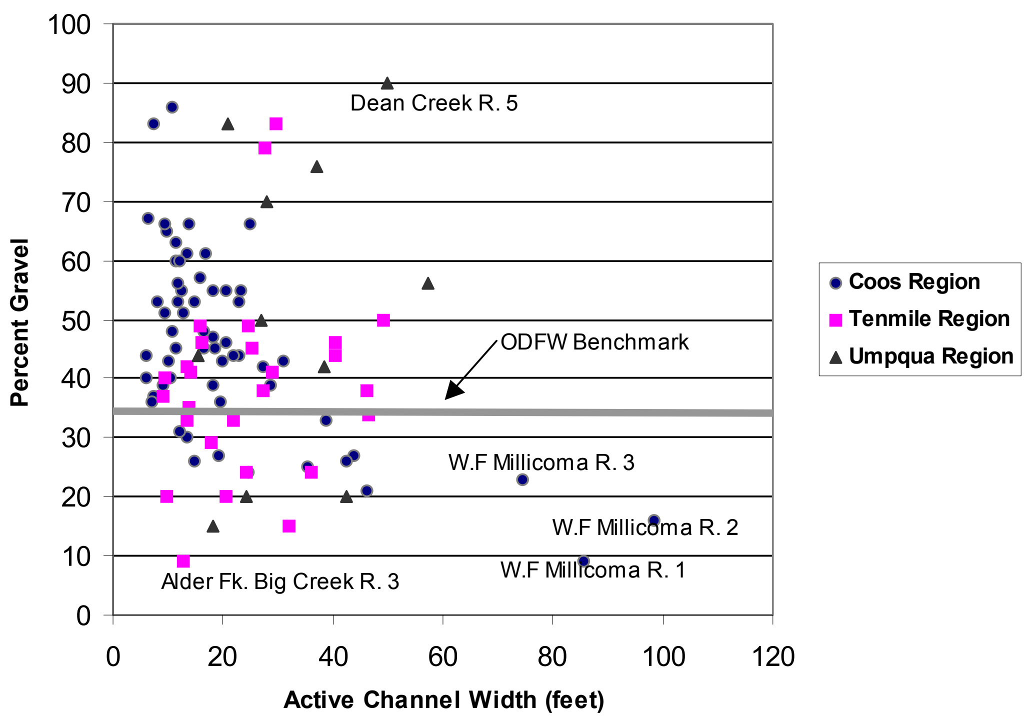
Gravel substrate in stream channels is important for providing spawning habitat and creating scour pools and other high quality habitats. A gravel area of 35% of the total riffle area is the aquatic habitat quality benchmark established by the ODFW (Jacobsen and Thom 2001). According to this benchmark, 35% of the riffle surface in gravels is desirable and less than 15% is undesirable.

Most of the inventoried low-gradient stream reaches in the Coos, Tenmile, and Umpqua regions have average percent gravels in riffle areas near the ODFW habitat benchmark (Table 8-13). However, there is considerable variability in the distribution of riffle gravels, with almost no association between gravel retention and active channel width (Figure 8-12). The wide channels of the West Fork Millicoma River, where there is limited large wood or other structure to capture material, have minimal gravel retention. On the other hand, many streams with active channel widths less than 40 feet have limited riffle gravels, which is usually associated with limited in-channel large wood.

Table 8-13. Average riffle gravel percentages for inventoried stream reaches.

Location	Average Percent Gravel
Active channel less than 40 feet	
Coos Region	49
Tenmile Region	38
Umpqua Region	50
Active channel greater than 40 feet	
Coos Region	20
Tenmile Region	40
Umpqua Region	55

Figure 8-12. Average percent gravels for inventoried reaches by region.



Note: The 35% average gravel for a stream reach is the habitat quality benchmark established by ODFW.

Discussion

There are some high quality stream habitats in the Forest, particularly in the Tenmile region and selected streams in the Coos region, such as Palouse Creek. However, many reaches of stream lack complex pool habitats. Limited wood volume in stream channels, and the interrelated issue of limited gravels in many riffle habitats, contributes to the current aquatic habitat quality. Information on habitat quality for stream reaches provides a framework for identifying opportunities to target stream habitat improvements through the placement of in-channel large wood and other restoration opportunities.

ANALYSIS

Overview

Based on information from aquatic habitat inventories and other studies for the Forest, the primary limiting factor for aquatic productivity for fish and aquatic-dependent amphibians is in-channel and riparian habitat. Other factors having an influence on aquatic habitat quality include: (1) fish passage barriers; (2) road-related sediment delivery to streams; (3) streamside roads constraining channel migration and habitat formation; (4) water quality; and (5) delivery of sediment, gravels, and large wood to channels from landslides. The first of these four factors can be significant *local* constraints on aquatic habitat productivity; at the scale of the entire Forest, however, they are not as significant as in-channel conditions and riparian habitat to current and future aquatic habitat quality. The final factor, landslide-generated material delivered to stream channels, can play a significant long-term role in improving habitat by contributing large wood and gravels to stream channels (see Chapter 6, *Erosion and Sediment*).

Many of the local factors constraining aquatic habitat quality have been addressed through effective management of the Forest. As previously discussed in this chapter, most significant fish passage barriers have been replaced or removed, and the Forest is working cooperatively with watershed councils and other interests to address the remaining passage problems. There are, in comparison to most areas in the Oregon Coast Range, very few streamside roads in the Forest. The restricted length of roads next to streams limits both sediment delivery to channels and the impact on constraining aquatic habitat formation and riparian condition. Many of these road issues on the Forest have been addressed through road decommissions and improvement of drainage patterns using effective placement of relief culverts and other measures. There remain, however, significant opportunities to address roads generating sediment delivery to streams and constraining habitat formation, especially in wide flood plains (see Chapter 6).

The chief water quality concern is elevated water temperature in some stream reaches (see Chapter 5, *Water Quality*). Most of the elevated water temperatures occur within reaches of the larger streams and rivers (e.g., West Fork of the Millicoma River), with most of the smaller tributary streams providing cool water. These cool water tributaries provide important habitat and refuge from the warmer waters for juvenile coho salmon and other fish and amphibians. It is important to continue to maintain cool water tributary streams and explore ways to improve water temperatures where monitoring has identified water temperature issues. Large wood plays an important role in trapping gravels in Forest streams and, as large wood recovery occurs in the future, a drop in water temperature may occur.

Finally, the issue of landslide delivery of material to stream channels requires on-going adaptive management to understand and manage. There is increasing evidence that natural landslides are an important contributor of the large wood and gravels that help shape high quality aquatic habitat. Although episodic events, such as catastrophic windthrow, fire, or severe floods occur infrequently, they can add massive amounts of wood to streams in a short period of time. Landslides and debris torrents can transport large amounts of large wood and gravels from hillslopes and headwater streams into downstream reaches (Bilby and Bisson 1998). While the Forest has addressed many of the road-related landslides (see Chapter 6, *Erosion and Sediment*), there is a need to better understand the role of headwall leave trees in providing large wood that is transported to stream channels through natural landslides.

Aquatic and riparian habitat is the key issue affecting current and future aquatic habitat quality. Compared to historic levels, there appears to be limited wood in stream reaches in the Forest (see Chapter 7, *Riparian Vegetation and Large Wood*). In-channel wood is indisputably important for the creation and maintenance of stream habitat. Large wood is the primary determinant of channel form in small streams, creating pools, cover and other complex habitats (Bilby and Bisson 1998). While wood has less impact on channel form in larger streams, it does play an important role, especially in the formation of large logjams and side-channel areas. Wood in streams is related to the capture and retention of sediments, gravels, and fine organic mater.

Unfortunately, there are no quick fixes for addressing the limited wood in the Forest's streams. The streamside forest is the most important source of large wood. Input of wood, especially large conifer logs from riparian areas, will take decades (see Chapter 7). There is limited riparian habitat in the mature riparian conifer or mixed conifer/hardwood condition, which has implications for current and future large wood delivery and wildlife habitat. Riparian areas with mature conifer forests (stand ages >99 years) are important habitats for amphibians and many wildlife species (see Chapter 9, *Terrestrial Wildlife*).

Aquatic Restoration Opportunities

Low-gradient streams can contain the highest quality fish habitat, especially for spawning and rearing coho salmon, and are responsive to restoration actions such as the placement of large wood. To help identify aquatic habitat restoration opportunities, two key attributes of stream quality, percent pools and in-channel large wood, were assessed for low-gradient stream reaches of less than 4%. Stream reaches were identified with limited volume of in-channel wood (<250 cubic feet per 100 feet of stream) and moderate surface area in pools (<20%; Map 8.7). These values were chosen as very low thresholds based on ODFW aquatic habitat benchmarks and information on the range of natural variability of large wood (see Chapter 7, *Riparian Vegetation and Large Wood*). Two measures, active channel widths of less than 40 feet and greater than 40 feet, were assessed separately to provide guidance on the appropriate type of restoration. It is important to note that because active channel width is an average for the reach, there will be sections of identified reaches with an active channel width of less than 40 feet.

For the Forest, there are more than 40 miles of streams with active channel widths less than 40 feet, which are characterized by limited habitat complexity, as expressed in percent pools and/or large wood in the channel (Table 8-14). Small stream habitats are the most responsive to the addition of large wood. These streams are found in all of the watershed analysis basins, with the largest number in the Coos region, especially basins #11 and #12 (Map 8.7).

Table 8-14. Stream reaches with limited pools and minimal in-channel wood with active channel widths less than 40 feet and gradients less than 4% that provide opportunities for aquatic habitat restoration (Map 8.7).

Region	Analysis Basin	Streams	Length of Stream by Watershed Analysis Basin (mi.)		
			Pools <20% by Reach	Large Wood <250 cu. ft. per 100 ft. of Stream	Pools <20% by Reach and Large Wood <250 cu. ft. per 100 ft. of Stream
Coos	8	Larson, Sullivan	---	1.5	0.23
	10	Marlow	---	3.3	0
	11	Cougar, Elk, Fish, Panther, W.F. Millicoma	---	7.0	8.8
	12	Deer, Joes, Knife, Otter, Trout	---	2.6	7.6
Umpqua	1	Footlog	---	1.1	---
	2	Charlotte, Luder	1.1	---	0.7
	3	Johanneson, Dean	---	2.9	---
	4	Scholfield	---	--	1.1
Tenmile	5	Alder Fork, Big, Murphy	---	4.6	0
	6	Benson, Roberts	---	4.2	0
		Combined	**1.1**	**29.7**	**18.4**

There are more than 32 miles of streams with active channel widths greater than 40 feet with low percent pools and/or large wood in the channel (Table 8-15). While these stream channels are less responsive to the addition of large wood, there are opportunities to add structure though effectively designed logjams, rock weirs, and other habitat structures. These streams are found primarily in the Coos region, particularly the West Fork of the Millicoma River and Elk Creek (Map 8.7).

Monitoring by the Coos Watershed Association on Forest streams and other parts of the Coos watershed demonstrate the habitat benefits of in-channel wood placement (Coos Watershed Association 2001). Hillslopes or roads confine many of the streams in the Forest, even low-gradient channels. However, these confined channels are responsive to the addition of large wood, which creates pools, cover, and captures bedload. While low-gradient streams should be priorities for the addition of large wood, higher gradient streams (4% to 6%) do provide important habitat, especially for steelhead and resident trout. These streams also can benefit from the addition of large wood to the channel. Based on monitoring information, in-channel wood placements are remarkably stable, with very minor downstream movement of logs (Coos Watershed Association 2001).

Table 8-15. Stream reaches with limited pools and minimal in-channel wood with active channel widths greater than 40 feet and gradients less than 4% that provide opportunities for aquatic habitat restoration (Map 8.7).

Region	Analysis Basin	Streams	Length of Stream by Watershed Analysis Basin (mi.)		
			Pools <20% by Reach	Large Wood <250 cu. ft. per 100 ft. of Stream	Pools <20% by Reach and Large Wood <250 cu. ft. per 100 ft. of Stream
Coos	9	W.F. Millicoma	---	---	9.5
	11	Elk, W.F. Millicoma	---	1.7	4.3
	12	W.F. Millicoma	---	---	10.8
Umpqua	2	Charlotte	---	1.2	---
	3	Dean	---	0.8	---
	4	Scholfield	1.6	---	---
Tenmile	7	Johnson, Johnson Trib. 1	---	2.2	0.7
		Combined	**1.6**	**5.9**	**25.3**

High Quality Aquatic and Riparian Habitats

While most of the fish-bearing streams in the Forest will benefit from the addition of in-channel large wood, there are limited areas with high quality stream habitat. In addition, there are limited riparian areas that are in mature conifer conditions. It is important to identify these areas to provide a framework for effective management to maintain and improve these habitat attributes. In addition, these areas serve as models of quality habitat, providing a way to determine changes in key habitat attributes, such as large wood delivery and transport, monitored over time.

To help identify these high quality stream and riparian habitats, in-channel large wood and riparian stand type were assessed for low-gradient stream reaches of less than 4%. Stream reaches were identified when they had relatively large volumes of wood (>500 cubic feet per 100 feet of stream), and riparian stands within 50 feet of the stream were delineated when they had primarily conifers with stand ages older than 99 years (Map 8.8). These values were chosen as thresholds based on the range of natural variability of large wood and the limited area in mature conifer condition for the future delivery of in-channel large wood (see Chapter 7, *Riparian Vegetation and Large Wood*). While wood in stream reaches and riparian stand type are not the only determinants of aquatic habitat quality, they are key components and can be manipulated using habitat restoration actions. In addition, mature riparian conifer stands are important indicators of habitat quality for amphibian and other wildlife species (see Chapter 9, *Terrestrial Wildlife*).

For the Forest, there are very few low-gradient stream reaches (1.3 miles) with the threshold value of large wood or mature riparian stands (Table 8-16; Map 8.8). Only two streams, Palouse Creek in the Coos region and Nobel Creek in the Tenmile region, had wood volumes greater than 500 cubic feet per 100 feet of stream. Both streams are very productive systems for coho. There are less than 13 miles of streams that are bordered by mature conifers. The Coos region has the greatest length of streams with mature riparian stands, with most of the stands along the West Fork Millicoma River and Elk Creek.

Table 8-16. High quality aquatic (in-channel large wood) and mature riparian conifer (stand age older than 99 years) habitat for inventoried stream reaches with gradients less than 4% (all active channel widths, Map 8.7).

Region	Analysis Basin	Streams	Length of Stream by Watershed Analysis Basin (mi.)	
			Large Wood >500 cu. ft. per 100 ft. of Stream	Mature Conifer within 50 ft. of Steam
Coos	8	Palouse	0.8	0.5
	9	W.F. Millicoma	---	3.2
	11	Cougar, Elk, Fish, Panther, W.F. Millicoma	---	3.8
	12	Joes, Knife, Otter, Trout, W.F. Millicoma	---	1.8
Umpqua	1	Footlog	---	0.1
	2	Charlotte, Luder	---	1.6
	3	Dean, Johanneson	---	1.0
	4	Scholfield	---	0.3
Tenmile	5	Big, Murphy, Noble*	0.5	0.1*
	6	Benson	---	0.4
	7	Johnson Trib. 1	---	0.1
		Combined	**1.3**	**12.9**

* 0.1 mile of Noble Creek has mature conifer near the stream and greater than 500 cubic feet of large wood per 100 feet of stream.

RECOMMENDED ACTIONS AND MONITORING

Because there is limited wood in stream channels on the Forest, a significant opportunity exists to restore this important aquatic habitat component. Stream restoration actions could focus primarily on in-channel wood placement within two management opportunity areas: operational and strategic. Operational restoration actions would focus opportunistically on timber sales, while strategic actions would target specific stream reaches. In both cases, where possible, large wood restoration should target achieving post-project volumes within the range of natural variability for the watershed. In most cases, at least 500 cubic feet of wood should be placed per 100 feet of stream. Operational wood placement in stream channels would focus opportunities for restoration involving the planning and administration of timber sales. Key considerations for these operations include:

- Can logs be placed safely?
- Is the stream fish bearing and what fish species are present?
- What is the gradient? The criterion is less than 6%.
- What is the active channel width? The criterion is less than 40 feet.
- Are the necessary log sizes available? The criterion is log length at 2 times the active channel width.

These criteria are general guidelines; there will be opportunities, based on site-specific considerations, to deviate from the criteria. For example, with proper configuration, it is possible to place wood in the channel that is shorter than 2 times the active channel width. In situations related to a timber sale where it is not safe or appropriate to place logs in a channel, the logs can be stockpiled for use at another site.

Strategic stream restoration actions identified in this analysis can focus on stream reaches and other areas, such as roads. There are opportunities to target in-channel wood placement with other coordinated restoration actions such as improving road drainage and fish passage in the vicinity. There have been a number of these integrated projects completed on the Forest, particularly with the Coos Watershed Association (Coos Watershed Association 2001). Many of these actions can be accomplished in cooperation with local watershed councils. Actions identified in this analysis for monitoring within the Forest include:

- Examining the impact of headwater stream riparian buffer strategies on amphibian populations by evaluating populations before and after riparian harvest and tracking trends over time. It is especially important to characterize stream habitat variables and water temperatures. These monitoring efforts could examine a range of stream systems and management impacts, including road sediment delivery to stream channels.
- Assessing and tracking the impact of stream habitat restoration projects on aquatic habitat quality. On a subset of project sites, wood volume and other habitat attributes should be inventoried before and after the completion of the project, and through time.
- Develop a study to assess and track the contribution of in-unit headwall leave tree areas on the contribution of wood through landslides and torrent tracks to downstream reaches. Monitor the movement of wood through stream channels through time.
- While there are no identified fish passage barriers downstream of the Forest, there may be barriers on some small streams. For this reason, private landowners and watershed councils should be encouraged to inventory fish passage barriers downstream of the Forest.
- In stream reaches where elevated water temperatures have been identified, increasing stream gravel retention through in-channel restoration actions may help cool water temperatures. In these areas, gravel deposition and water temperatures should be monitored within stream reaches where large wood has been placed.

Chapter 9. Terrestrial Wildlife

This chapter summarizes the terrestrial wildlife studies that have been carried out on the Forest. The chapter then focuses on three specific wildlife resources whose management has the potential to influence watershed processes. These three resources are riparian birds in general, spotted owl management, and marbled murrelet management. These latter two species, managed under provisions of the federal ESA through the Forest's Habitat Conservation Plan (HCP; ODF 1995), have affected present and future land management activities through determination of rotation ages for management basins, Habitat Conservancy Areas (HCA) for the spotted owl, and Marbled Murrelet Management Areas (MMMA). Each of these determinations, and variations being considered in the new HCP, will have effects on both upslope and riparian management into the foreseeable future.

Summary of Wildlife Studies

This summary of terrestrial wildlife studies for the Forest is based on discussions with John Toman, ODFW District Wildlife Biologist in Charleston; Marcia Humes, ODF Wildlife Biologist in Salem; and Randy Smith, ODF Southern Oregon Area Wildlife Biologist in Coos Bay. In addition, the studies identified below were reviewed, as was the 1995 HCP.

Few wildlife studies have been conducted specific to the Forest with the exception of those dealing with endangered species. While the ODFW conducts an annual elk census and has a long-term study of bears using tetracycline-laced bait as a marker, the results of neither study can be disaggregated specifically to the Forest (personal communication, John Toman, ODFW 2003). The largest non-endangered species, terrestrial wildlife study is, *A Report on Avian Surveys Conducted on the Elliott State Forest*, May-July 2001, by Jennifer Weikel and David Vesely. The results of this study are discussed in the next section.

Endangered species concerns arose on the Forest subsequent to the 1990 listing of the northern spotted owl as a threatened species. The initial effect of the listing was the designation of 1.5-mile buffers ("owl circles") around each nest tree. The significant coverage of these circles on the Forest and effects on forest management were immediately apparent, and in 1992 led the State Land Board to initiate development of an HCP as an alternative to owl-circle-based management (Rice and Souder 1998). When completed in 1995, the Forest's HCP provided 6 years of coverage for marbled murrelets in addition to the 60-year coverage for spotted owls. During development and subsequent implementation, the HCP required monitoring and research studies for both spotted owls and marbled murrelets. Northern spotted owl density surveys done on the Forest in 1996 and most recently in 2003 by Kingfisher Ecological. These surveys provide valuable insight into owl numbers over time on the Forest. In 2000, the principal investigators associated with the Oregon Cooperative Fish and Wildlife Unit and the College of Forestry at Oregon State University summarized the results of spotted owl studies conducted since 1993 in the Forest (Glenn et al. 2000).

The 1995 HCP provided the ODF with a 6-year incidental take permit for marbled murrelets. Under the permit, the ODF was required to survey proposed timber sale areas and rate them for murrelet suitability using six habitat characteristics: multi-storied canopies, remnant trees, deformed trees with greater than 5 inch limbs, number of potential nesting platforms, live crown ratios, and gaps in the stand (Appendix K, ODF 1995). From these line transects a stand's habitat suitability for marbled murrelet was rated in one of three classes: low, medium, or high. During the 6 years of the HCP, timber harvest was to occur first in stands classified as having a low murrelet suitability rating, then in medium, and finally in high suitability areas.

The murrelet incidental take permit required ODF to conduct a study to test and validate whether the suitability rating accurately predicted murrelet use of a particular forest stand. Thomas Hamer of Hamer Environmental (Meekins and Hamer 1996) conducted this analysis, determining that the HCP procedure poorly predicted low and medium quality habitat (although 91% for high-rated habitat). A revised procedure that used only the number of platforms 5 inches in diameter and ground slope was adopted to replace the approach in the 1995 HCP. This "Hamer Model" was used until the 6-year permit expired and the ODF went back to a "take avoidance" strategy of protocol surveys and MMMAs.

A commitment of $500,000 in funding towards a study of marbled murrelet reproductive success in Oregon coastal forests also was required as part of the 1995 HCP. This study, done by S. Kim Nelson and Amanda Wilson (2002), looked at murrelet habitat requirements on all State Forests in western Oregon, including the Elliott. The result showed that high-value marbled murrelet habitat on the Elliott State Forest was characterized by trees with large platforms having substrate and cover, the number of substrate-covered trees in a stand, and high densities of platform-covered trees (Nelson and Wilson 2002). In addition to these two studies, the ODF annually provides summaries of marbled murrelet surveys at the District level (ODF 2002; undated).

BIRDS UTILIZING RIPARIAN AREAS

In a study of birds on the Elliott State Forest, Weikel and Vesely (2001) established 25 point count stations placed randomly on roads in each of the 17 management basins. Stations were sited on non-major roads and surveyed early in the morning to lessen the effects of road traffic. Each site was surveyed only once. After a 2 minute waiting period after arrival, the surveyor listened for and observed birds for 10 minutes at each station. On any given day, counting started 15 minutes before sunrise and ended by 10 AM to correspond to the primary activity period for birds. Data were collected for birds observed within 50 meters (about 55 yards) of the point location, birds beyond the point location, and birds flying over but within 50 meters of the station.

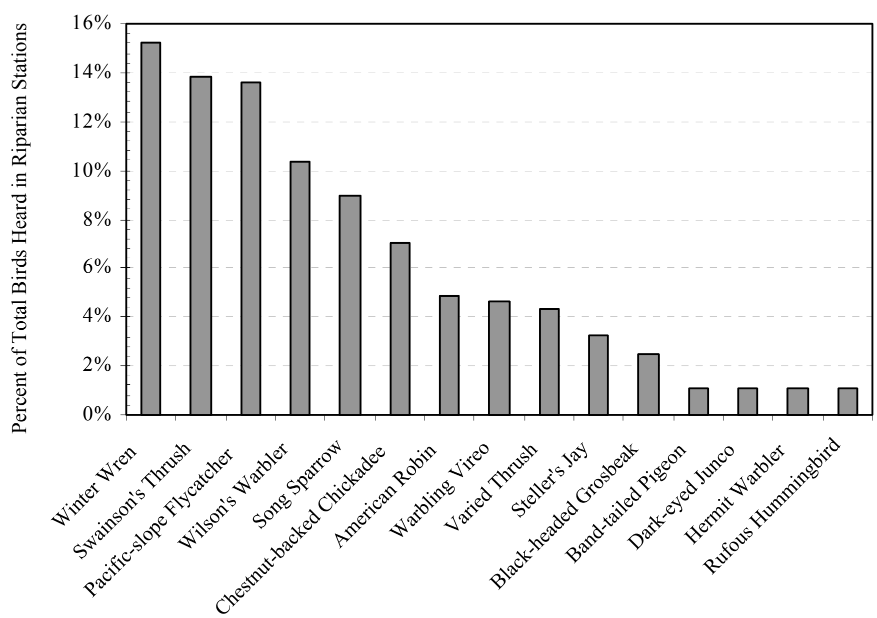
Methods

For this analysis, the bird count station locations located within mapped riparian corridors along fish-bearing streams were identified (see Map 7.1). Data on bird species and numbers were extracted from the bird count file for those stations within mapped riparian corridors for birds observed within 50 meters of the station center.

Results

The data was aggregated by management basin and the resulting information is shown in Table 9-1. In addition, a chart was created showing each species' contribution (if greater than 1%) of birds found in riparian areas in the Forest (Figure 9-1).

Figure 9-1. Most common (>1%) bird species observed from riparian areas.



Source: Weikel and Vesely 2001

Because of the way that the avian surveys were conducted, the results, even for those stations located in riparian areas, do not necessarily suggest a strong correlation or habitat dependency. Taking surveys along roads, which commonly form the boundary between riparian and upland communities, resulted in more "edge" species and probably a proportion of forest-associated species, rather than riparian-associated species. Only two specifically aquatic-obligate species, belted kingfishers and American dipper, were observed during the surveys.

Table 9-1. Number of Individual birds observed at survey stations located in riparian areas of the Forest by management basin.

Bird Species	Management Basin*							Totals
	8	9	10	12	14	15	16	
American Dipper					1			1
American Robin	2	4	1	4	3	4		18
Belted Kingfisher					3			3
Black-headed Grosbeak				4	4	1		9
Brown Creeper				1	2			3
Band-tailed Pigeon		1		3				4
Black-throated Gray Warbler						1		1
Chestnut-backed Chickadee	1	4	3	1	13	3	1	26
Dark-eyed Junco				1	2		1	4
Evening Grosbeak					1			1
Golden-crowned Kinglet					2			2
Hairy Woodpecker					3			3
Hermit Warbler					3	1		4
Hutton's Vireo					2			2
Least Flycatcher					1			1
Pileated Woodpecker							1	1
Pacific-slope Flycatcher		3	3	6	29	6	3	50
Purple Finch	1			1				2
Rufous Hummingbird	1		1	1	1			4
Song Sparrow	1	3	3	11	12	3		33
Spotted Towhee				1				1
Steller's Jay		3	2	2	4	1		12
Swainson's Thrush		4	2	13	26	5	1	51
Varied Thrush				3	11	2		16
Warbling Vireo		3		5	5	2	2	17
Western Tanager				1	1	1		3
Western Wood-pewee				2				2
Wilson's Warbler	2	3	1	11	20		1	38
Winter Wren		2	3	13	27	9	2	56
Total Birds by Basin	**8**	**30**	**19**	**84**	**176**	**39**	**12**	**368**
Total # Species by Basin	**6**	**10**	**9**	**19**	**22**	**13**	**8**	**29**
Number of Riparian Stations	**1**	**3**	**6**	**10**	**19**	**5**	**2**	**46**

* Not all management basins contained listening stations in riparian areas.
Data from Weikel and Vesely 2001.

Northern Spotted Owl Management

With the 1995 HCP, the ODF moved from an owl-circle-based approach to a late-successional habitat-based approach in management of the Forest for spotted owls. This latter approach took two forms: first, approximately 43% of the Forest was designated as long-rotation basins (rotations between 160-240 years) intended to provide nesting, roosting, and foraging habitat; and second, HCAs were established as late-successional reserves intended to protect sensitive wildlife habitat areas within each management unit by providing permanent protection for threatened and endangered species, as well as by contributing to the overall biodiversity (ODF 1995). In addition, a buffer area of 70 acres of suitable habitat was required around spotted owl nests for the first 5 years, in the remaining 57% of the forest that is designated as shorter-rotation basins (80 years). All basins, both long- and short-rotation, must maintain the 50-11-40 rule for spotted owl dispersal habitat (50% of the area having trees averaging 11 inches in diameter with 40% canopy cover).

While the long-rotation basins are not *de facto* reserves, in the near term only "stand improvement cuts," such as thinning from below, are expected in these areas. On the other hand, the HCAs are intended to be reserves and their layout in the Forest has the potential to affect watershed processes. Management of the long-rotation basins and HCAs with less frequent and less intensive forestry operations will affect watershed processes differently than intensively managed areas, as discussed in Chapter 6, *Erosion and Sediment*. The spatial patterns resulting from these land management objectives may affect both the frequency of landslides and their potential for delivery of large wood to streams.

Methods

Using the union routine, the analysis team combined Arc-View Shape files delineating rotation ages, HCAs, and 5th field HUCs to create a map and Excel file. Map 9.1 shows the arrangement of long-rotation basins and HCAs on the Forest. Table 9-2 shows the area and proportion of these land designations in the Forest.

Results

As shown in Table 9-2 and on Map 9.1, long-rotation basins are not equally distributed across the Forest. Almost all (84%) of the Forest in the Tenmile region is in long rotations (160+ years), with over 75% of the Umpqua region also in this category. In contrast, while 47% of the Coos region is in the Forest, only 19% of this area (consisting of the Elk Creek Basin and that portion of basin #8 in the Palouse Creek drainage) is designated for long rotations. While Palouse Creek has some of the highest coho salmon populations on the Oregon Coast, the upper West Fork Millicoma (with the exception of Elk Creek) and Marlow Creek, two strong fish streams, are in short (80 year) harvest rotations. In contrast to the long rotation basins, HCAs are more evenly distributed among the three regions (Table 9-3), representing 6.6% of the Forest in the Coos region, 2.4% in the Tenmile region, and 7.1% in the Umpqua region.

Table 9-2. Land allocation for spotted owl habitat protection in the Forest.

Watershed by 5th field HUC	Elliott State Forest		Long-rotation Basins		HCAs	
	Acres	%	Acres	%	Acres	%
Umpqua Region						
Umpqua/Scottsburg	211	0.2	0	0	0	0
Mill Creek	9,237	9.9	2,826	30.6	682	7.4
Lower Umpqua	18,760	20.1	18,723	99.8	1,327	7.1
Subtotal	28,208	30.2	21,549	76.4	2,009	7.1
Tenmile Region	21,559	23.1	18,085	83.9	1,487	6.9
Coos Region						
Millicoma River	37,116	39.7	4,443	12.0	1,976	5.3
Coos Bay	6,564	7.0	3,800	57.9	893	13.6
Subtotal	43,680	46.7	8,243	18.9	2,869	6.6
Grand Total	**93,448**	**---**	**47,877**	**51.2**	**6,365**	**6.8**

Marbled Murrelet Management

Marbled murrelets were listed as a threatened species under the federal ESA in 1992. Critical habitat for the species was finalized on May 24, 1996. According to the U.S. Fish and Wildlife Service (USFWS), "…the Elliott State Forest was originally proposed for designation as critical habitat. The State of Oregon has since completed the Elliott State Forest HCP that includes provisions for the marbled murrelet and received an incidental take permit. This permit describes how the area will be managed for murrelets. Therefore, the USFWS has removed this area from the final designation" (USFWS 1996). The initial murrelet incidental take permit expired in 2001; the ODF is currently revising the 1995 HCP with the intent to obtain a new permit. Since the incidental take permit has expired, the Forest is currently operating under 'take avoidance' where suitable habitat around proposed timber sales is surveyed according to standard protocols. The ODF designated MMMAs as part of their initial 6-year incidental take permit for marbled murrelets. No timber harvesting is done in the MMMAs, although some thinning has been allowed to improve stand structure. Seasonal activity restrictions are placed on areas within 0.25 miles of MMMAs.

Methods

Similar to the spotted owl management methods discussed in the previous section, the analysis team combined, using the union routine, the 5th field HUC layer with the ODF layers containing MMMAs.

Results

Table 9-3 shows the acreage of MMMAs by region, and Map 9.2 shows their spatial extent across the Forest. These MMMAs cover 2.4% of the Tenmile region, 7.4% of the Umpqua region, and 12.1% of the Coos region. Significant detections during timber sale surveys result in new MMMAs (ODF 2002; undated).

Table 9-3. Percentage of the Forest in Marbled Murrelet Management Areas.

Watershed by 5th field HUC	**Elliott State Forest**		**MMMAs**	
	Acres	**%**	**Acres**	**%**
Umpqua Region				
Umpqua/Scottsburg	211	0.2	61	28.8
Mill Creek	9,237	9.9	1,115	12.1
Lower Umpqua	18,760	20.1	837	4.5
Subtotal	**28,208**	**30.2**	**2,013**	**7.1**
Tenmile Region	21,559	23.1	515	2.4
Coos Region				
Millicoma River	37,116	39.7	5,081	13.7
Coos Bay	6,564	7.0	199	3.0
Subtotal	**43,680**	**46.7**	**5,280**	**12.1**
Grand Total	**93,448**	**---**	**7,807**	**8.4**

Reserves Resulting from Management for Spotted Owls and Marbled Murrelets

Under the 1995 HCP, the HCAs for the spotted owl and the MMMAs can be considered reserves since no harvest (except thinning) is allowed once they are older than 40 years. These reserve areas are more likely to have large trees than more intensively managed parts of the Forest. The watershed effects of larger trees are discussed in Chapter 6, *Erosion and Sediment* and Chapter 7, *Riparian Vegetation and Large Wood*. Map 9.3 shows how these reserves are arrayed across the Forest landscape. Table 9-4 shows data on the extent (area and proportion) of reserves by region and type (HCA, MMMA or both).

Table 9-4. Land allocations for spotted owl habitat protection.

Watershed by 5th field HUC	**Elliott State Forest**		**Reserves**					
			HCAs		**MMMAs**		**Total***	
	Acres	**%**	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**
Umpqua Region								
Umpqua/Scottsburg	211	0.2	0	0.0	61	28.8	61	28.8
Mill Creek	9,237	9.9	682	7.4	1,115	12.1	1,534	16.6
Lower Umpqua	18,760	20.1	1,327	7.1	837	4.5	2,068	11.0
Subtotal	**28,208**	**30.2**	**2,009**	**7.1**	**2,013**	**7.1**	**3,663**	**13.0**
Tenmile Region	21,559	23.1	1,487	6.9	515	2.4	1,660	7.7
Coos Region								
Millicoma River	37,116	39.7	1,976	5.3	5,081	13.7	5,882	15.8
Coos Bay	6,564	7.0	893	13.6	199	3.0	1,092	16.6
Subtotal	**43,680**	**46.7**	**2,869**	**6.6**	**5,280**	**12.1**	**6,973**	**16.0**
Grand Total	**93,448**	**---**	**6,365**	**6.8**	**7,807**	**8.4**	**12,296**	**13.2**

* Takes into account the overlap between HCAs and MMMAs shown in Map 9.3.

From a watershed perspective, these reserves have two principal effects. First, because few forest management operations will take place in them, few anthropogenic sources of impacts to streams will occur. However, because of their status, certain types of watershed restoration activities within these areas will be constrained either in type (no tree pulling), extent (number of trees available for use as large wood in streams), or season (permitted period of work activity).

SUMMARY

The commonality among the previous discussions in this chapter is the effect that different stand structures and management regimes have on wildlife (both aquatic and terrestrial). In addition, watershed processes (such as landslide frequency, aquatic habitat formation, sediment delivery and nutrient cycling, rainfall to streamflow relationships) are all affected by upslope management.

Management under the 1995 HCP (ODF 1995) and the *Elliott State Forest Management Plan* (ODF 1993) delineate the Forest into longer (160+ years), and shorter (80-160 year) harvest rotations. If continued over time, this strategy will result in those shorter rotation basins having more frequent cycles of weak root strength (increasing slide potential), as discussed in Chapter 6, *Erosion and Sediment*.

From a wildlife perspective, creating and retaining habitat structure will be a goal of any future forest management strategy. Structural retention refers to any practice that retains significant elements from a harvested stand for incorporation into a new stand. These elements include snags, fallen logs, and live (green) trees (Rose et al. 2001). Each of these three structural components benefits the ecosystem (both aquatic and terrestrial) in different ways depending upon their density and extent.

FRAMEWORK OF APPROACHES

Focus group discussions with the ODF and ODFW staff during review of the draft analysis identified a number of relevant wildlife-related concerns. The two primary ones were how to evaluate the effects of retaining large dead wood (standing snags and downed trees) and green trees during clearcut harvests; and how management of, and wildlife concerns in, stands adjacent to fish-bearing streams affects potential restoration opportunities.

Based on these focus group concerns and subsequent inputs by Marnie Allbritten (ODFW) and Marcia Humes (ODF), additional effort was undertaken in an attempt to link wildlife-related concerns to the watershed analysis, principally through review of the database provided in *Wildlife-habitat Relationships in Oregon and Washington* (Johnson and O'Neil 2001). However, it became apparent that the effort required to adequately link wildlife habitat effects in upland management to watershed processes exceeded the contract scope of work. While this linkage would be useful and appropriate, a more realistic place for this work is in the new HCP, once silvicultural strategies are identified with a greater degree of certainty. Nevertheless, it is possible to make some general recommendations, as discussed below.

1. Manage dead large wood and green tree retention to meet multiple objectives. According to Rose and others (2001), "Effective management of decaying wood must do more than simply provide for inputs of dead trees....management should strive to provide for diversity of trees species and size classes, in various stages of decay and in different locations and orientation within the stand and landscape." Adequate information is available in the scientific literature on the functions of structural legacies, and how they can meet multiple objectives. Specifically:

   A. Location and distribution. Discussion of location and distribution is generally focused on clumped versus dispersed patterns of distribution. According to Rose and others (2001), snags and downed wood may follow a naturally clumped distribution, and thus, management should take advantage of site-specific occurrences without having to match a particular spatial distribution pattern. It is probably beneficial to vary local densities of snags and down wood across the ground, within and among stands, in order to provide a higher level of habitat structural diversity.

   B. Trends over time. Snags and logs decay and change over time; live trees either live and get bigger or die and become snags and down logs. These structures function differently or at least for different species, as stands develop over time. Thus, the temporal dimension to decaying wood needs to be considered to ensure that sufficient snags and down wood densities are provided through time. Because snags and down logs function differently in terms of their wildlife value depending on their species, diameter, height (length), decay class, decay trajectory, and whether or not they are hollow (Rose et al. 2001), temporal considerations also should include recruiting wood with a wide range of characteristics.

   C. Consider upslope versus riparian location for retained wood. One potential difference to keep in mind between the "upslope" and "riparian" areas is that the riparian areas that are buffered are providing a different type of habitat (forested with edges) than the upslope (primarily nonforested), so structural retention is likely playing a different role in these areas.

2. Identify the benefits and trade-offs of various large wood and green tree retention strategies. There was a request on the part of ODF Elliott staff to have information on the tradeoffs and benefits from a wildlife perspective related to the spatial location and distribution of retained green trees. While requiring more effort than possible in this project, a cursory look at the benefits of green tree retention shows that green trees:

   - Function as biodiversity refugia.
   - Provide future recruitment for snags and down wood.
   - Can be used to grow very large trees in subsequent rotations.
   - Green tree retention can be implemented to favor species that produce larger and more persistent wood (such as Douglas-fir and redcedar) and/or species that are shade-tolerant to add tree species diversity (such as hemlock and redcedar).

- As discussed in Chapter 6, *Erosion and Sediment*, green trees may reduce landslide hazards via maintenance of root strength. While additional literature review, research, and modeling are needed, the spatial distribution and density of retained green trees can play an important watershed process function.
- Retained green trees (and snags and downed wood) provide improved habitat structural functions for late-successional wildlife species earlier in the life of a stand.

The second area of wildlife-related recommendations relates to opportunities to improve watershed conditions and stream habitat through collaborative efforts among ODF, ODFW, and watershed councils. The Forest has benefited in the past through these collaborative efforts, and significant future opportunities have been identified in this analysis. In the past, however, some instream restoration efforts, such as pulling trees into streams, have been constrained by concerns over management of federally listed species, specifically the marbled murrelet. Criteria to determine the specific trees or stands suitable for use in stream complexity restoration work have been developed and are currently being applied in a project on the upper West Fork Millicoma River. The criteria differ slightly depending upon whether the proposed pull sites have been surveyed for marbled murrelets according to accepted protocols, as discussed below (*Regional General Permit For Large Wood and Boulder Placement*, Permit #2000-001, dated June 30, 2000).

For surveyed stands where no significant detections (i.e. occupancy) have been found:

- Projects … must not remove trees from known occupied or unsurveyed suitable habitat within 50 miles of the Pacific Coast.
- For projects located within 0.25 miles of a known occupied murrelet site: (1) no work will occur from April 1 to August 5, and (2) work activities from August 6 to September 15 shall not begin until 2 hours after sunrise and conclude no later than 2 hours before sunset.

Additional requirements for unsurveyed pull tree source stands are:

- Within 50 miles of the Pacific Coast, no standing trees exhibiting structural characteristics suitable for marbled murrelet nesting shall be removed or in any way used for large wood placement. In general, these trees are large (greater than 32 inches DBH) with large branches, deformations, or moss cover creating a platform of at least 6 inches upon which a murrelet may lay an egg.
- All noise-producing activities (including the use of all mechanized equipment such as chainsaws, heavy machinery, etc.) within 50 miles of the Pacific Coast and within 0.25 miles of potential murrelet habitat [forest stands containing the structure described in section 8(a) above] and implemented between April 1 and September 15 (as permitted below) shall not begin until 2 hours after sunrise and conclude no later than 2 hours before sunset. These daily restrictions minimize potential disturbance effects to murrelets during known peak activity times in the forested environment.

The need for additional instream habitat structures leads to the following recommendation:

<u>Extend marbled murrelet surveys</u>. Where possible as part of normal operations, the ODF should consider extending marbled murrelet protocol surveys to include coverage for riparian and near-stream stands that could be potential sources of pulled trees. Potential stream areas that could benefit from additions of large wood are identified in Chapter 8, *Aquatic Organisms and Their Habitat*, and potential project areas and source stands could be identified through coordination with ODFW and watershed councils.

RECOMMENDATIONS

This project illuminated further needs. Some of these needs will be at least partially addressed in the HCP and Forest Management Plan revision process, while others can be addressed as separate projects.

- Explore the impact on watershed processes of arrangement and scale of reserves.
- Explore the impact on watershed processes of the kinds of habitat in reserves.
- Examine how long-rotation basins, short rotation basins and dispersal habitat requirements affect watershed processes.
- Create a tool that can be used as a guide to describe benefits and risks when designing green tree retention areas. For example, the guide could cover: (1) The expected benefits for the watershed if green trees are left in particular locations; and (2) Information on “correct” sizes and amounts of material to load up a channel for future delivery to desired target locations.

Chapter 10. Rare and Exotic Plants and Tree Diseases

Non-forest plants and pathogens affect the Forest landscape in various ways. Tree diseases, through growth loss or mortality, may impact forest structure, susceptibility to fire and windthrow, species composition, and the direction of vegetative succession. Rare plants are usually found on microsites, such as serpentine soils and debris paths, or in other uncommon habitats, such as wet meadows. These plants are affected by watershed- and local-scale processes (e.g., landslides and sediment deposition), and also may indicate the past geomorphological history of a specific area. Similarly, introduced species (invasive species or noxious weeds) also are indicative of land use and history.

RARE PLANTS

Norma Kline, ODF Forester, has compiled information on the occurrence of rare plants on the Forest for use in the new HCP. The information here is a paraphrase of her work. In addition to this summary, individual timber sales are surveyed prior to sale for the occurrence of rare plants.

The ODF has four criteria for determining if a plant is considered “rare” for management purposes: (1) listed as threatened or endangered by federal statute; (2) listed as threatened or endangered by state statute; (3) identified as a candidate for the state threatened and endangered list by the Oregon Department of Agriculture; and (4) identified under policy by ODF as a special concern plant. To determine if any plants meeting these criteria occurred on the Forest, the Oregon Natural Heritage Program database (ONHP 2001) was queried for plant species in Coos and Douglas Counties that fit one or more of the above criteria. The results were then compared to the habitat characteristics of the plants to identify their possible occurrence on the Forest. Of the 25 species that matched one of the four criteria, only the 3 species discussed below live in habitats found on the Forest. Currently, there are no records of these three plant species ever occurring on the Forest.

Bensonia (*Bensoniella oregona*), state-listed candidate species. This plant occurs in wet meadows and moist streamside sites in pre-cretaceous meta-sedimentary rock at elevations above 2,500 feet. Possibly found on the Forest, but no known sites exist. Signal Tree, above Camas Valley, is the furthest northern and lowest elevation location.

Tall bugbane (*Cimicifuga elata*), state-listed candidate species. This plant occurs in Douglas-fir forests with maple and sword ferns. Possibly present in the Forest, but no confirmed site locations.

Howell’s montia (*Montia howellii*), state-listed candidate species. This plant occurs in moist lowland areas, vernally wet sites, often on compacted soils less than 1,300 feet in elevation. Could be present in the Forest but no locations have been confirmed.

INTRODUCED PLANT SPECIES

Introduced plant species (many of which are known as noxious weeds) have significant effects on vegetative diversity and watershed management objectives. These plants are generally invasive (rapidly colonize areas), are pernicious (difficult to remove), and typically form monocultures. Information on introduced plant species was obtained from Roger Johnson, Reforestation Unit Leader for the Elliott State Forest. At present, the ODF does not have a “weed” policy at either the state or the district level. Personnel of the Reforestation Unit carry out weed monitoring and eradication with the assistance of inmate crews from the Shutter Creek Correctional Institution. Weed surveys have been conducted during flowering seasons for two species (gorse and Scotch broom), with sites located by Global Positioning System and entered into an ArcView database. Map 10.1, located in the map section, shows the distribution of introduced plants on the Forest. While the database is somewhat dated (last updated in October 2001), it does allow for an assessment of patterns of introduced plant species of concern. The three introduced species of most concern on the Forest are Himalaya blackberry, Scotch broom, and gorse.

Himalaya blackberry (*Rubus armeniacus*) is an introduced species of blackberry (genus *Rubus*) with a weak stem. It may grow erect, but more frequently clambers and spreads over other plants, crushing and smothering them (Taylor 1990). It spreads laterally largely through tillering and is transmitted at greater distances from the source plant by birds, bears, and other animals eating the berries and excreting the seeds. The extent and distribution of this species has not been surveyed or mapped by Forest staff. Himalaya blackberry generally occurs in areas that were previously homesteaded and subsequently incorporated into the Forest. From these source areas, it has spread up ridgelines. It has become a regeneration problem in some plantation areas by smothering newly planted trees. There is limited control of Himalaya blackberry on the Forest, with most efforts occurring in harvest units where it is controlled until trees are free to grow.

Scotch broom (*Cytisus scoparius*) is a member of the pea (legume) family. Scotch broom was introduced into California from Europe as an ornamental in the nineteenth century, subsequently escaped cultivation, and moved northward (Taylor 1990). It is an extremely aggressive weed that invades non-wooded areas (Taylor 1990). While most Scotch broom surveys have been conducted by road during the flowering season (see Map 10.1), its import and spread throughout the Forest is considered to have resulted from roads in two ways. First, vehicular traffic spreads seeds that are attached to mud or other parts of the vehicle. Secondly, and perhaps more perniciously, Scotch broom seeds may be incorporated into gravel when plants are adjacent to quarries. This gravel is then carried into and distributed throughout the Forest during road construction and maintenance. The seeds of these roadside plants spread by wind to adjacent areas. Scotch broom is considered the major weed species of concern by Forest staff, and is controlled chemically as time and funding are available. The most common control measure is spraying roadside plants with the herbicide Garlon. The most effective, but labor-intensive, control method is painting stems using a combination of Garlon with tree oil as a binder.

Another member of the broom family, gorse (*Ulex europaeus*) is a European transplant with vicious spines that otherwise resembles Scotch broom. At present, it is known in only three locations on the Forest (see Map 10.1). When found, it is aggressively controlled by physical and chemical means.

TREE DISEASES

Staff from the ODF provided information on the occurrence of tree diseases on the Elliott State Forest. This discussion focuses on the most common tree diseases observed on the Forest. In comparison to other state forestlands in the Coast Range, the Forest generally has low levels of tree diseases (personal communication, Alan Kanaskie, ODF pathologist).

<u>Swiss needle cast (*Phaeocrytopus gaeumannii*)</u>. There is severe damage from Swiss needle cast in scattered plantations and natural stands along the Oregon and Washington coasts. The disease mostly affects Douglas-fir plantations, with most growth impacts occurring to younger stands. Over the last decade, there has been an increase in both the total land area impacted and the severity of the disease in Oregon (Filip 2002). Most stands with severe needle discoloration occur within about 18 miles of the Oregon Coast in the fog belt or spruce/hemlock zone. The Tillamook State Forest in the northern Coast Range has extensive areas impacted by the disease.

On the Forest, Swiss needle cast mostly affects young plantations (with ages less than 30 years) on the west side of the Forest and some scattered stands in other areas. Recent inventories indicate that extent of the disease is increasing on the Forest, but it does not appear to have impacted stands with the same severity or extent as locations in the northern Coast Range (personal communication, Alan Kanaskie, ODF). More needle loss occurs on stands on southern or western slopes or ridge tops, which are exposed to winds or have more moisture stress. Increased moisture levels, sheltering from winds, and the diverse mix of species in riparian areas appears to contribute to less extensive disease damage in streamside forests (personal communication, Alan Kanaskie, ODF).

Silvicultural methods are used to manage the stands impacted by Swiss needle cast on the Forest. In areas where the disease is causing needle discoloration, the emphasis is on shifting the stand composition away from Douglas-fir to other tree species (personal communication, Alan Kanaskie, ODF). Plantations in susceptible areas are now planted with a mix of tree species.

Swiss needle cast also can affect stand management activities such as thinning. Pre-commercial thinning allows an opportunity to shift stand species composition away from Douglas-fir toward increased diversity and resilience to Swiss needle cast and other diseases (personal communication, Alan Kanaskie, ODF). Commercial thinning severely damaged stands does not make the disease worse, but response to thinning in these stands may be poor because of the disease. The ODF participates in the Swiss Needle Cast Cooperative and funds specific projects to understand the interaction between Swiss needle cast and thinning.

Laminated root rot (*Phellinus weirii*). Laminated root rot is widespread in the Coast Range. The disease can occur in almost all commercially important conifers in coastal stands (Thies and Goheen 2002). Laminated rot root occurs at very low levels on the Forest and is very rare in riparian areas where resistant species such as red cedar are more common (personal communication, Alan Kanaskie, ODF).

Black stain root disease (*Leptographium wageneri)*. In coastal forests, Douglas-fir is the most common host of black stain root disease. The disease appears in 10- to 25-year-old Douglas-fir plantations or in younger, dense natural stands (Thies and Goheen 2002). The disease occurs at low levels on the Forest, mostly confined to young trees experiencing stressful growing conditions along roads (personal communication, Alan Kanaskie, ODF).

Stem decays (various heart-rot fungi, including *Phellinus pini*). Although stem decay, particularly heart rots, can cause considerable loss of merchantable timber volume, it also provides important substrate for cavity nesting animals. Occurrence of heart rots varies considerably across the forest, but few data exist to describe its frequency and distribution. Decay tends to increase with tree age and the amount of wounding (personal communication, Alan Kanaskie, ODF). Decay can be artificially introduced to living trees to created suitable substrate for cavity nesters.

RECOMMENDED ACTIONS AND MONITORING

Recommended actions and monitoring:

- Rare plants: Continue current practices.
- Introduced plant species: Continue current practices and develop a strategy for weed control.
- Tree diseases: Continue current practices and continue to support ongoing research.

Chapter 11. Synthesis

This chapter summarizes the findings of the watershed analysis and outlines key recommendations. The detailed analysis and recommendations for each of the topics can be found in the individual chapters. This synthesis provides an overview of how natural features interact with management activities to influence fish and wildlife productivity within the Elliott State Forest. The Forest is set in a landscape with dynamic watershed processes and biological productivity. This setting includes natural disturbances such as floods and landslides; the delivery and transport of water, wood, sediment and other components through streams; and the movement of fish and wildlife populations through changing habitat conditions. These natural watershed conditions interact with the Forest's ongoing management practices – roads, timber harvest and other activities – to shape and constrain fish and wildlife habitat and populations.

NATURAL CHARACTERISTICS THAT INFLUENCE FISH AND WILDLIFE PRODUCTIVITY

A number of natural characteristics promote high fish and wildlife productivity on the Elliott State Forest. The Forest's streams empty into nearby lakes and estuaries, which provide high quality habitat for fish that move into these areas after spawning and rearing in the Forest. Landslides on the Forest's steep slopes ensure periodic pulses of gravel and large wood into fish-bearing streams. The relatively well-drained slopes next to fish-bearing streams can support conifer trees that also provide a long-lived source of large wood to streams. This wood creates pools and traps gravel, which benefits both fish and amphibians.

The proximity of the Forest to the ocean and shade from dense streamside vegetation helps keep streams cool. Rapid revegetation following disturbances also helps maintain shade along streams. Douglas-fir stands naturally dominate upslope areas and, when mature, provide potential habitat for the threatened marbled murrelet and northern spotted owl. The mosaic of conifers, hardwoods, brush, and open water along streams helps support a diversity of other bird species.

Some natural features of the Forest diminish fish and wildlife productivity. The sandstone geology underlying the area yields relatively little water during the summer, forcing fish and amphibians to congregate into a condensed stream network where there is more competition for food. Also, the shallow water increases the risk of predation. Much of the landscape has sharply confined valleys. This natural confinement does not allow streams to meander much, thereby limiting the creation of areas with slower water such as side channels (see Chapter 2, *Watershed Analysis Area Overview* and Chapter 8, *Aquatic Organisms and Their Environment*). During winter storms, water moves swiftly through these straight and constrained waterways, thereby causing, in some cases, downstream displacement of fish and amphibians.

The cobbles and gravels within stream channels consist of sandstone which quickly breaks down into sand, silt, and clay. Where stream channels lack large wood and boulders, they can scour to bedrock. Water flowing through a bedrock channel is particularly swift during floods and provides little refuge for fish (see Chapter 8, *Aquatic Organisms and Their Environment*). Fish habitat is further constrained in this terrain by the presence of a number of rock ledges in the channel that keep juvenile fish from moving upstream into some headwater streams during portions of the year. Nonetheless, the exclusion of fish from some headwater streams benefits amphibians in these portions of the watershed since fish will feed upon juvenile amphibians.

Despite these natural constraints, the Forest contains some stream reaches with high quality habitats particularly in the Tenmile region and selected streams in the Coos region, such as Palouse Creek. Many of these streams are productive spawning and rearing areas for anadromous coho salmon and steelhead trout. There are, however, many streams that currently lack complex pools and other high quality habitat, which limits aquatic productivity (for individual stream habitat characteristics, see Chapter 8, *Aquatic Organisms and Their Environment*).

MANAGEMENT FACTORS THAT INFLUENCE FISH AND WILDLIFE PRODUCTIVITY

Overall, the Forest is being managed effectively to address key issues affecting fish, wildlife, and water quality. The Forest has a well-designed and maintained road system, and most human-caused barriers to fish passage have been removed. The Department of Forestry, with assistance from the Oregon Department of Fish and Wildlife and nearby watershed councils, has an ongoing program to improve aquatic habitat, such as adding logs to streams. Where timber harvest occurs, trees are being generously retained along perennial streams and other sensitive areas. Sizable areas of the Forest are managed for the growing of old trees to benefit wildlife and fish. Some of these areas are completely off limits to future timber harvest. Some past practices have negatively affected fish, wildlife, and water quality. Information from this analysis provides a framework for understanding the positive and negative aspects of current management on the Forest. This information also helps identify opportunities to protect and improve stream, riparian, and upslope habitats.

Roads

Most road building occurred decades ago, a time when road-building standards were lower and the relationships between road location and fish habitat were poorly understood (see Chapter 3, *Historical Overview*). Historically, the first roads built in the Coast Range were located along streams because of the relatively easy access up valleys. The Forest is unique in that most of the roads are on slopes or ridge tops, with very few along streams. There are approximately 551 miles of roads in the Forest, of which only about 49 miles (9%) are within 100 feet of a stream channel, where they have the potential to affect stream habitat by restricting riparian tree growth, confining channel movement, and delivering sediment directly to the channel (see Chapter 8, *Aquatic Organisms and Their Environment*). The majority of these streamside roads are in the Coos region.

The historical practice of side-cast road construction on steep slopes with relatively few cross-drain culverts left a number of road sections vulnerable to washouts during high-intensity rainstorms (see Chapter 6, *Erosion and Sediment*). Many of these weak sections have since failed (and were then rebuilt) or were later modified to avoid a washout. Currently, along with the Forest's progressive maintenance program during the past several decades, the road network is relatively stable. The low occurrence of road-related landslides in parts of the Forest surveyed after the November 1996 flood, in addition to a Forest-wide inventory in 1997-1998, attests to the stability of the current road system. In addition, few new roads will be needed for future timber harvest on the Forest. However, some road segments were identified as having unusually large numbers of landslides in the past. The Forest should consider reexamining these areas to avoid future landslide problems.

> **Recommendation:**
>
> To further minimize road-related landslides, the Forest should examine roads identified as having a large number of landslides in the 1997-1998 Forest-wide inventory. This information will help determine if impending landslides continue to develop. Roads with unusually high numbers of landslides include the 2800, 5240 and 5500 Roads in analysis basin #4 (Umpqua region) and the 5730, 5420, 4500 and 2580 Roads in analysis basin #5 (Tenmile region).

Other aspects of the Forest road system are more problematic. Based on field observations and limited road inventory data, it appears that cross-drain culverts (designed to transfer water from the road ditch to the outside edge of the road) are relatively sparse. Some of these feed directly into stream channels with intermittent or perennial flow, along with their load of fine sediments derived from the road surface and road ditch (see Chapter 6, *Erosion and Sediment*). This connection between road ditches and streams is common for roads among all land ownerships in the Pacific Northwest. It can lead to chronic water turbidity during the wet season in downstream fish-bearing waters, thereby reducing the ability of fish to feed. The sediment can be detrimental to aquatic insects, and the sand- and silt-sized component can fill in the gaps between gravels where fish eggs incubate, thereby reducing the amount of oxygen around the developing eggs. Forest staff is addressing this problem on some sections of road by installing additional cross-drain culverts so that ditch water and its sediment are filtered through the soil on stable slopes. However, the backlog of road segments to modify is large. Furthermore, this

> **Recommendation:**
>
> To reduce the amount of fine sediments entrained in road ditch water from entering streams, the Forest should increase the frequency of cross-drain culverts. Where roads are located parallel to streams, consider alternative techniques such as using higher-quality surface rock, paving, clearing road ditches, or decommissioning redundant roads.

solution does not work when roads closely parallel streams, since there are few opportunities to filter the sediment-laden water through soils prior to it entering the stream. Other options such as surfacing roads with higher quality rock (and keeping it regularly graded), frequently clearing road ditches of accumulated ravel, or paving road surfaces can help in these situations. These options have not yet been pursued aggressively throughout the Forest because the costs are high. Mainline roads used during the wet season and located next to streams would be logical first candidates for such treatments. An alternative solution for problem roads located near streams is to decommission the road and instead use alternative ridge routes for log hauling. An example of road decommissioning on the Forest is the road along Big Creek (analysis basin #5) in the Tenmile region. Fills and culverts were removed where the road crossed streams and the road surface was outsloped and vegetated in order to create a stable road prism that needs no further maintenance.

Landslides Not Related to Roads

Another human-related source of fine and course sediment in streams is that derived from landslides within recent clearcuts. Field studies in the Oregon Coast Range indicate that the frequency of shallow landslides on very steep slopes is about 1.5 to 2.0 times greater in recent clearcuts than in mature stands (see Chapter 6, *Erosion and Sediment*). Nevertheless, this research also suggests that this initial increase in landslides is followed by a reduced landslide rate as plantations reach full canopy closure, followed then by an increase as the stands becomes mature. The negative aspects of an increase in fine sediments caused by a short-term increase in landslides from clearcut units are offset, to some extent, by the benefits to fish because landslides transport gravel and large wood into fish-bearing streams (see Chapter 6, *Erosion and Sediment* and Chapter 7, *Riparian Vegetation and Large Wood*). However, in many places streamside roads intercept the landslide material thereby preventing delivery of beneficial gravels and wood into stream channels.

The Oregon Department of Forestry occasionally faces legal and safety challenges concerning landslides and the public. Over 140 dwellings are located within a half-mile of the Forest boundary and many of these were constructed in landslide torrent paths. Furthermore, a major state highway skirts the steep, northern border and landslides originating on the Forest occasionally reach the highway. A number of measures have been used by Forest staff to minimize landslide problems. Much of the area above the state highway and a county road along Mill Creek has been taken out of the harvest land base and will never be logged. Elsewhere, slopes are not harvested where downhill houses are in the path of a future landslide.

Past timber harvest practices, whereby logs were removed from steep draws and trees growing near the draws were harvested, have left a reduced amount of large wood for landslides to move into fish-bearing streams. The analysis team was not able to quantify this reduction, although anecdotal information suggests that as stands approach 200 years old, steep draws fill with sizable amounts of large wood. On the Forest, draws within young plantations had very little wood. Over time, these practices have contributed to a reduction in the amount large wood in the Forest's streams.

> **Recommendation:**
> To increase the amount of course material in streams, the Forest should reexamine the current practice of piling or removing landslide deposits from the site and instead, look for opportunities to place logs, boulders, and gravel in the nearby stream as the road is being cleared.

It is common practice to remove landslide deposits that are intercepted by roads by piling the material to the side or removing it from the site. Much of this landslide material could benefit streams if it were instead placed in the stream downstream of the road. Current state and federal rules prohibit such activities, even if done during the time of year when there are no fish eggs in the stream. An evaluation of the current practices, in consultation with state and federal officials, may lead to a conclusion that a greater benefit would be obtained by placing the material in the stream.

Riparian Stands and Large Wood in Streams

Currently, wood volume in Forest streams averages much less than similar undisturbed streams located on nearby land. Forest streams average 28% of the wood volume of nearby undisturbed streams bordered by 90- to 120-year-old timber, and 14% of the wood volume of undisturbed streams bordered by old-growth timber (see Chapter 7, *Riparian Vegetation and Large Wood*). The interaction of historical and current management actions has contributed to the low amounts of large wood in the Forest's streams. In addition to the reduced delivery of wood by landslides, the intentional removal of wood in streams and harvest of streamside trees in the past also has contributed to a reduction of large wood within fish-bearing streams. Another factor contributing to the lack of persistent wood in streams is the inadvertent conversion of streamside areas from conifer or conifer/hardwood to stands dominated by hardwoods. Hardwood trees provide less volume of wood to streams over the long-term and the wood decays rapidly. Hardwoods are the dominant stand type currently found within 100 feet of fish-bearing streams on the Forest. Although hardwood dominance decreases with increasing distance from the stream, along large streams hardwoods still occupy over 30% of the land 150-200 feet from the stream. Streams draining the west side of the Forest in the Tenmile region have the highest percentage of streamside area dominated by hardwoods.

> **Recommendation:**
> The Forest should conduct a study of large wood in steep draws with stands of various ages and management histories. This would provide Forest managers with tools to understand current and future large wood within draws and how wood levels in fish-bearing streams are influenced by landslides delivering this wood to streams over time.

A model used by the analysis team to predict the amount of large wood in streams over time demonstrates the consequences of perpetuating hardwood stands along fish-bearing streams (see Chapter 7, *Riparian Vegetation and Large Wood*). The volume of wood in streams bordered by hardwood-dominated stands is predicted in 200 years to be only 10% of those streams bordered by conifer-dominated stands or 21% of those streams bordered by a mixed conifer/hardwood stand. The volume of large wood in streams bordered by hardwood-dominated stands is expected to decline by one-half over the next two centuries, while wood volume in streams bordered by other stand types is expected to increase considerably over current levels.

There are several options for increasing the amount of large wood in fish-bearing streams. One option examined in this analysis increased the buffer width on streams. The modeling showed that increasing the buffer width to 200 feet from the current standard of about 150 feet would result in only small increases in instream wood over the next three centuries.

Another option for accelerating the rate of wood accumulation in streams is to place logs in the stream when nearby timber harvest operations occur, or as a separate activity. Over the last decade, logs and boulders have been placed in fish-bearing streams at 31 locations on the Forest, most of which were in analysis basins #9, #11 and #12 in the West Fork Millicoma River Basin (see Chapter 8, *Aquatic Organisms and Their Habitat*). Nevertheless, with over 161 miles of fish-bearing stream on the Forest, and most of those miles currently low in large wood, it is a large and expensive task to supplement streams in this manner, and may not be feasible for many locations where access to the stream is difficult. Pulling over or yarding some streamside trees directly into the channel can reduce the cost of adding logs to streams. Preferably, candidate trees are those growing within 200 feet of the stream but have a low probability of ending up in the stream if they were to eventually tip over on their own. Implementing this approach requires coordination because of concerns with threatened and endangered species, particularly marbled murrelets.

Recommendation:

To address the near-term shortage of instream wood, the Forest should continue to add large wood to streams currently deficient. The Forest could focus on stream segments that have few conifers in the streamside forest to supplement future instream wood and where the costs of placing logs are low (near a road). Consider focusing first on streams with a bankfull width of less than 40 feet and increase effectiveness by using logs with attached rootwads or logs with lengths at least twice the bankfull width. Actions could concentrate on stream segments with year-round flow that are less confined by steep hillslopes or adjacent roads.

Conceivably, retaining more large wood in steep draws and trees growing around draws also would increase the volume of wood in fish-bearing streams, although the efficiency of this strategy compared to the direct placement of instream wood is unknown. The probability of a draw experiencing a landslide of sufficient size to transport wood into a fish-bearing stream is relatively low for any given decade. Nevertheless, the analysis team has provided a method to identify those draws most likely to deliver large wood and boulders to fish-bearing streams should a landslide occur, using information on channel gradient and the angle at which two channels converge (see Chapter 7, *Riparian Vegetation and Large Wood*).

Unfortunately, there are no quick fixes for addressing the limited wood in the Forest's streams. The streamside forest is the most important source of large wood. Input of wood, especially large conifer logs from riparian areas, will take decades (see Chapter 7, *Riparian Vegetation and Large Wood*). There is limited riparian habitat in the mature riparian conifer or mixed conifer/hardwood condition, which has implications for current and future large wood delivery and wildlife habitat. Riparian areas with mature conifer forests are important habitats for amphibians and many wildlife species (see Chapter 8*, Aquatic Organisms and Their Habitat* and Chapter 9, *Terrestrial Wildlife*).

In the longer term, the volume of wood in streams can be increased by several methods. One of the approaches is restricting the width of hardwood buffers (e.g., to less than 50 feet), harvesting hardwoods beyond the buffer, and establishing conifers in the harvested areas. Modeling results indicate only small near-term reductions in instream large wood with this strategy, followed by considerable gains in large wood over the next several centuries. There are some challenges to reestablishing conifers in streamside areas. First, the current practice of retaining buffers of trees and brush along streams has no counterpart in nature. Historically, large fires and landslides occurring every other century or so provided the bare ground near streams that would allow Douglas-firs to regenerate and get a head start over the brush and hardwood trees. Without this disturbance, regenerating conifers near streams will be difficult and may require new perspectives for managing streamside areas. Such techniques could include the intentional creation of small clearings along streams (not associated with timber harvest units) that now support brush and hardwoods, followed by aggressive conifer regeneration.

Recommendation:
To evaluate options for buffer widths and conifer regeneration in streamside areas now dominated by hardwood trees, the Forest should gather information on conifer regeneration success near streamside buffers, along with the likely success and cost of enhanced conifer regeneration techniques. A pilot project could be conducted on selected harvest units to demonstrate the use of alternative conifer regeneration techniques near streams and buffers.

Secondly, current herbicide spraying practices often result in a swath of land of up to 100 feet beyond the edge of the buffer that is not sprayed following clearcut harvest. While effective at keeping spray from damaging streamside buffers or entering streams, another consequence is patchy and sparse conifer regeneration near buffers due to rapid growth of competing brush. This is a critical area to have conifers growing since conifers beyond this distance have little chance of entering the stream once they fall over. Backpack spraying of brush near buffers, combined with mountain beaver trapping, seedling tubing, and the planting of tall seedlings can help improve conifer regeneration, although the added effort is costly.

It is those areas on the Forest that were harvested to the edge of streams followed by intensive site preparation and herbicide applications (typical of practices 20-35 years ago) that are best positioned for providing future wood to streams. In these areas, conifer tree density near streams is currently high.

Water Temperature

Naturally high levels of brush and trees along streams, followed by rapid regrowth of vegetation where human activities have exposed streams to sunlight in the past, have resulted in Forest streams that are relatively cool throughout their length, despite the naturally low streamflow levels throughout the summer (see Chapter 4, *Stream*

Recommendation:
In order to have a Forest-wide understanding of water temperature in streams, the Forest should monitor temperature in selected streams of the Umpqua region so that data are available for all three regions of the Forest.

Flow and Water Quantity and Chapter 5, *Water Quality*). Maximum water temperatures in various tributaries and the main channel of the West Fork Millicoma River were found to correlate well with distance from drainage divide and shade. In this area, streams warmed in a downstream direction and were warmest in stream segments where shade was less dense. Forest-wide shade measurements conducted during Oregon Department of Fish and Wildlife stream surveys indicate relatively high levels of shade over fish-bearing streams throughout the Forest, except for the widest streams. For wide streams, such as Mill Creek (analysis basin #1) and the lower West Fork Millicoma River (analysis basin #9), the tallest of streamside conifers are not capable of providing much shade to the channel.

Water temperature patterns for streams flowing into the Tenmile Lakes were different from streams in the Coos region. Streams in the Tenmile region tended to be cooler than those to the east, and there were no correlations with distance from drainage divide and shade. These streams may be cooler because they are closer to the ocean. Their natural coolness presents more opportunities to experiment with alternative techniques for establishing conifers in streamside areas that are currently dominated by hardwoods and brush. Here, the consequences of short-term decreases in stream shading and localized and small increases in stream temperature would be less stressful for fish. The Tenmile region also is the region most lacking conifers near streams (see Chapter 7, *Riparian Vegetation and Large Wood*).

Although poorly understood, the scarcity of gravel in streams Forest-wide, exacerbated by the low amounts of wood in the streams which functions to retain gravels in the channel, could be causing streams to be somewhat warmer than normal. As wood levels in streams increases and traps more gravel, there could be a cooling in streams as more of the stream flows subsurface through gravel deposits.

Recommendation:

To understand whether there could be water temperature reductions because of large wood trapping gravel and initiating subsurface flow paths, the Forest should monitor temperature at a few sites where logs are intentionally added to streams to improve fish habitat.

Fish Movement

A survival strategy for fish in the Coast Range is to migrate into cool and smaller tributaries during the hottest part of the summer to escape warmer water in larger streams (see Chapter 8, *Aquatic Organisms and Their Environment*). Upstream fish migrations take place at other times of the year also. Juvenile fish will often head back upstream following downstream displacement during high flows. During the spawning season, adult fish also move upstream. The natural ledges and waterfalls common to this steep sandstone terrain can make these migrations a challenge for fish. Fortunately, the current road system on the Forest does not create substantially more fish passage problems.

Recommendation:

To better understand the extent of culvert-related obstacles, the Forest should increase efforts to identify all streams used by fish. Consider focusing first on those unexamined streams falling into the medium size class.

Culverts in fish-bearing streams average only 1 per 4.5 square miles of the Forest. Forest-wide, only 14 of these culverts have characteristics that could impede upstream fish movement (a high drop at the outlet or steep pipe gradient). Nearly all are located in the Coos region. During the last few years, Forest staff have removed or replaced 15 problem culverts. Removal or replacement of the final 14 culverts that impede passage would allow fish to migrate freely into an additional 6 miles of stream. These remaining culverts are located in smaller and steeper streams. It is often expensive, and sometimes impossible, to provide fish passage through culverts in steep streams.

> **Recommendation:**
> To complete the elimination of culvert-related fish obstacles, the Forest should continue to remove, replace, or modify the few remaining culverts blocking fish migration. Consider focusing first on sites where the culvert blocks the greatest length of potential fish habitat. (See Chapter 8, *Aquatic Organisms and Their Habitat).*

Other human activities in the basin have contributed to the expansion of fish migration throughout the Forest. Blasting of pools and a channel (in 1958) around the previously impassable Stulls Falls, located on the lower West Fork Millicoma River, currently allows fish access into this highly productive basin (see Chapter 3, *Historical Overview*). Also, a fish ladder constructed near the mouth of Elk Creek allows migratory fish to access this large tributary of the West Fork Millicoma River.

Water Characteristics

In addition to water temperature, the water characteristics of Forest streams are generally favorable for fish (see Chapter 5, *Water Quality*). Dissolved oxygen levels are high and any leaching of nitrogen into streams during the critical summer months from newly-clearcut areas is quickly absorbed by downstream aquatic plants. Phosphorous in the water column during summer is nearly non-existent, pointing towards an algae community that is held in check by the availability of additional phosphorus and not nitrogen. Similarly, nuisance algae growth in Tenmile Lakes is controlled largely by the availability of phosphorus. Some of this phosphorus comes from sediment deposited by streams into the lakes during the wet season and some likely comes from lakeside septic systems. Also, the lakes now have large populations of introduced fish that consume zooplankton. These small organisms, in turn, are major consumers of algae and their depressed numbers may be adding to the algae problem in the lakes.

> **Recommendation:**
> For the upcoming TMDL process for Tenmile Lakes, the Forest should update the 1997-1998 road inventory in basins draining into the lakes, in order to detect any new, discrete sources of accelerated sedimentation.

There is no indication that streams flowing from the Forest into the lakes currently carry sediment loads that are any greater than natural rates. Timber harvesting on Forest land in these basins has nearly stopped in recent years since they have been designated long-rotation basins. Sediment cores taken from the lake bottom suggest that accelerated erosion

> **Recommendation:**
> In anticipation of possible restrictions on the use of 2,4-D and triclopyr, the Forest should modify brush control plans to include substitute herbicides as ordered under the review of pesticides by USEPA.

from these and surrounding lands probably occurred in the past, a time when roads were constructed and some slopes logged using practices that are not acceptable today.

Many of the 140 residences located immediately downstream from the Forest boundary obtain water from streams flowing from the Forest (see Chapter 4, *Stream Flow and Water Quantity*). Sediment from roads and from landslides in timber harvest units has the potential of increasing stream turbidity and requiring greater treatment of water before use. Also, herbicide concentrations in streams may be of potential concern, although monitoring in other parts of the Pacific Northwest shows that the amount of herbicides in streams from aerial application techniques adopted by the Forest is extremely small.

Recommendation:

To better understand whether herbicide application methods are effective, the Forest should monitor herbicide concentrations in streams during and after some spray operations.

Recommendation:

To make timber harvest planning more efficient and ensure compliance with state water laws, the Forest should continue using field investigations to determine the presence of legal and illegal water diversions within proposed harvest units. There does not seem to be a need for a detailed Forest-wide evaluation of water diversions along the Forest fringe. Users that divert water from Forest streams could be encouraged to obtain a water use permit and deed of conveyance. Also consider encouraging users to move points of diversion outside the Forest boundary.

Also, the Forest should consider obtaining in water use permits/certificates from the Water Resources Department for the 98 pump chances that currently do not have a permit/certificate.

It is highly likely that some users of water from Forest streams have not obtained a water certificate from the Water Resources Department or arranged a deed of water conveyance where the water diversion point is not located on their land. This may make it difficult for Forest staff to plan timber sales near the Forest boundary and work with these landowners to keep water systems from being crushed during timber falling and yarding.

While summer stream flows are naturally low for the sandstone terrain of the Forest, timber harvest does not often dry up streams (see Chapter 4, *Stream Flow and Water Quantity*). Research on Pacific Northwest streams indicates that clearcut harvesting increases summer flows, which can have benefits to fish and aquatic amphibians. The extra flow can provide more living space for aquatic animals and the greater water depth helps moderate temperature increases.

Research on Pacific Northwest streams indicates that increases in peak flows due to clearcut harvest and road building are minor for lower-elevation terrain and where harvest units do not experience hot broadcast burns. Increases in peak flow, where they do occur, are limited to minor runoff events; the magnitude of large floods is not affected. Any measurable increases in peak flow due to clearcut harvest and road building occur only in very small watersheds. In larger streams, the contributions from smaller subwatersheds, some of which may have increased peak flows and some with intact timber, results in a muted response since the timing of the maximum flow for the various subwatersheds is rarely synchronized for any given storm. Furthermore, any increase in peak flow due to clearcut harvesting is short-lived (less than 15 years) due to regrowth of brush and trees.

Timber Harvest

The annual timber harvest on the Forest includes about 515 acres of clearcuts and 535 acres of thinning. The age distribution of timber on the Forest is highly skewed towards plantations less than 25 years old (29%) and stands older than 100 years (48%; see Chapter 2, *Watershed Analysis Area Overview*). Clearcut harvest occurs mostly in timber that is older than 100 years, which also are the stands most preferred by the marbled murrelet and northern spotted owl. Strategies to provide long-term habitat for these two species has lead to a partitioning of the Forest into short-rotation basins (80 years) and long-rotation basins (160-240 years). Over 50% of the Forest has been designated as long-rotation basins. This includes most of the watersheds draining north into the Umpqua River (Umpqua region) and west into Tenmile Lakes (Tenmile region). Consequently, most clearcut timber harvest now occurs in the Coos region. Habitat Conservation Areas cover about 7% of the Forest and are scattered about in both short-rotation and long-rotation basins. The purpose of these areas is to provide for a permanent reserve of intact, older timber that provides connectivity to unique habitat for amphibians, fish, marbled murrelets, and northern spotted owls (see Chapter 9, *Terrestrial Wildlife*).

The Forest is developing an updated *Management Plan*, which will include the aquatic strategies described in the *Northwest Oregon State Forests Management Plan*. To test the operational feasibility of these strategies, fiscal year 2004 timber sales will incorporate these strategies. A major change over current practices is the maintenance of a buffer of trees along seasonal streams.

CONCLUSION

Most current management strategies on the Forest effectively address the aquatic, water quality, hydrologic, and public safety concerns inherent to this challenging terrain. The factors that currently depress aquatic productivity are mostly natural in origin or are related to management practices from past decades. Forest staff has successively initiated a number of measures to compensate for past practices, including the placement of logs in fish-bearing streams, replacing culverts that do not pass fish, and repairing roads before weak sections fail. Other topics, such as reducing fine sediments that originate from roads and providing for long-term sources of large conifer wood in steep draws and in hardwood-dominated streamside areas, have received lesser attention. The scarcity of tested methods for improving conditions, limited monitoring information for some of the problems, and the high expense of solutions has slowed progress on these topics.

The Forest's current landscape-level strategies directed at supporting fish and wildlife species that are sensitive to timber harvest are more rigorous than required by the Forest Practices Act. Areas off limits to future timber harvest or assigned to the growing and harvest of old trees make up a significant portion of the Forest. Since they include both slopes and valley bottoms, these special management areas provide habitat for both wildlife and fish.

Interactions with state and federal agencies, along with the general public, will be common in the near future as the Forest staff updates the *Management Plan* and develops a new *Habitat Conservation Plan* for marbled murrelets, spotted owls, and coho salmon. In addition, Forest staff will need to be involved in upcoming Total Daily Maximum Load processes for the West Fork Millicoma River watershed (water temperature issues) and the watersheds that flow into Tenmile Lakes (sediment issues). Because of the Forest's isolation from high population centers, scrutiny of management practices on the Elliott State Forest have been less than for other State Forests in northwest Oregon. Future public review processes highlight the need for continued documentation and review of management practices. Information on topics, such as herbicide concentrations in streams following aerial application of herbicides and water temperature of streams flowing into the Umpqua River, can be important when engaged in public processes and reviewing current practices.

The information currently available for the Forest points to activities that would fill important information gaps and address current habitat deficiencies. The highest priority recommendations from the analysis team include:

1. To resolve the current lack of large wood in streams, the Forest should increase large wood volume by direct placement of logs in fish-bearing streams and the reestablishment of conifer trees in streamside areas that once grew conifers but now support mostly hardwoods. In-channel wood placement could concentrate on two management opportunity areas: Operational and strategic. Operational restoration actions would focus opportunistically on stream reaches within or nearby timber sales; strategic actions would target specific low gradient stream reaches that have the potential for high quality habitat but limited in-channel wood.

2. To prepare for the upcoming Total Maximum Daily Load study of sediment and nutrients in Tenmile Lakes by the Department of Environmental Quality, the Forest should conduct an inventory of remaining discrete sources of sediment along roads within the watersheds that drain into the lakes.

3. To confirm that application methods are effective at keeping herbicides out of streams, the Forest should monitor herbicide concentrations for several spray operations.

4. To reduce the amount of fine sediments entering stream channels from roads, the Forest should examine cost-effective means for diverting ditch water onto stable locations and continue to disconnect ditches from stream channels. The highest priority should be considered for roads that are heavily used during the wet season.

References

Adams, P.W. and W.R. Stack. 1989. Streamwater quality after logging in southwest Oregon. Project completion report PNW 87-400 to the USDA Forest Service, Pacific Northwest Research Station, Portland OR.

Allbritten, M. 2002. Amphibian and western pond turtle surveys within the Elliott State Forest. Excel spread sheet files. Oregon Department of Fish and Wildlife, Charleston.

Anderson, J., D. Baek, J. Barnes, C. Carter, R. Johnson, G. Lettman, C. Pileggi, T. Potiowsky, H. Radtke, B. Rooney, and K. Vaidya. 2001. Elliott State Forest management plan revision: connection to state and local economies. Oregon Department of Forestry.

Andrus, C.W. 1997. Projecting future wood abundance within streams for managed forestlands in coastal Washington and Oregon. Report from Mantech International to the EPA Research Laboratory, Corvallis OR.

Andrus, C.W. and H.A. Froehlich. 1988. Riparian forest development after logging or fire in the Oregon Coast Range: wildlife habitat and timber value. Pages 139-152 *in* Streamside Management: Riparian Wildlife and Forestry Interactions, K.J. Raedeke, ed. Institute of Forest Resources, University of Washington, Seattle.

Andrus, C.W. and H.A. Froehlich. 1992. Wind damage within streamside buffers and accelerated sedimentation. *COPE Report* 5(1&2):7-9.

Arnold, J.G., J.R. Willimas, R. Srinivasan, and K.W. King. 1995. SWAT: Soil water assessment tool. Texas A&M University, Texas Agricultural Experimental Station, Blackland Research Center, 808 East Blackland Road, Temple.

Baldwin, E.M. and J.D. Beaulieu. 1973. Geology and mineral resources of Coos County, Oregon. Bulletin 80. Department of Geology and Mineral Industries, Salem OR.

Beaulieu, J.D. and P.W. Hughes. 1975. Environmental geology of western Coos and Douglas Counties, Oregon. Bulletin 87. Oregon Department of Geology and Mineral Industries, Salem.

Beckham, D. 1990. Swift flows the river. Arago Books, Coos Bay OR.

Benda L. 1990. The influence of debris flows on channels and valley floors in the Oregon Coast Range, U.S.A. *Earth Surfaces Processes and Landform* 15:457-466.

Benda, L. and T. Cundy. 1990. Predicting deposition of debris flows in mountain channels. *Canadian Geotechnical Journal* 27(4):409-417.

Bennett, K.A. 1982. Effects of slash burning on surface soil erosion rates in the Oregon Coast Range. MS thesis, Oregon State University, Corvallis.

Beschta, R.L. 1978. Long-term patterns of sediment production following road construction and logging in the Oregon Coast Range. *Water Resources Research* 14(6):1011-1016.

Beschta, R.L., M.R. Pyles, A.E. Skaugset, and C.G. Surfleet. 2000. Peakflow response to forest practices in the western Cascades of Oregon, USA. *Journal of Hydrology* 233:102-120.

Bilby, R.E. 1985. Contributions of road surface sediment to a western Washington stream. *Forest Science* 31(4):827-838.

Bilby, R.E. and P.A. Bisson. 1998. Function and distribution of large woody debris. *In* River Ecology and Management: Lessons from the Pacific Coastal Ecoregion, R.J. Naiman and R.E. Bilby, eds. Spring-Verlag NY.

Bilby, R.E., K. Sullivan, and S.H. Duncan. 1989. The generation and fate of road surface sediment in forested watersheds in southwestern Washington. *Forestry Sciences* 35:453-468.

Bransom, M. 1990. Soil engineering properties and vegetative characteristics for headwall slope stability analysis in the Oregon Coast Range. MS thesis, Oregon State University, Corvallis.

Brown, G.W. and A.R. Gahler, and R.B. Marston. 1973. Nutrient losses after clearcut logging and slash burning in the Oregon Coast Range. *Water Resources Research* 9(5):1450-1453.

Burroughs, E.R. and B.R. Thomas. 1977. Declining root strength in Douglas-fir after felling as a factor in slope stability. USDA Forest Service Research Paper INT-190.

Bury, R.B. 1988. Habitat relationships and ecological importance of amphibians and reptiles. *In* Streamside Management: Riparian, Wildlife and Forestry Interactions, K.J. Raedeke, ed. Institute of Forest Resources, University of Washington, Seattle.

Bury, R.B. and E.J. Hyde. 2003. Headwater amphibians in forests subjected to timber harvest and wildfire. Poster Presented at the Headwater Stream Ecology Research Forum, January 16, 2003. Corvallis OR.

Bury, R.B., S.C. Corn, and K.B. Aubry. 1991. Regional patterns of terrestrial amphibian communities in Oregon and Washington. *In* Wildlife and vegetation of unmanaged Douglas-fir forests. Technical Report PNW-GTR-285. USDA Forest Service, Pacific Northwest Research Station, Portland OR.

Bush, G., C. McConnell, C. Cloyd, K Musser, B. Metzger, and H. Plumley. 1997. Assessment of the effects of the 1996 flood on the Siuslaw National Forest. USDA Forest Service, Siuslaw National Forest, Corvallis OR.

Chan, S.C., R. Danehy, and M. Reiter. 2003. Studies on the influence of commercial thinning and regeneration on microclimate and microsite of headwater forests in western Oregon. Poster Presented at the Headwater Stream Ecology Research Forum, January 16, 2003. Corvallis OR.

Coos Watershed Association. 2001. Effectiveness monitoring of large wood, boulder weirs, and culvert replacement projects in selected streams of the Coos watershed. Coos Watershed Association, Charleston OR.

Corn, P.S. and R.B. Bury. 1989. Logging in western Oregon: responses of headwater habitats and stream amphibians. *Forest Ecology and Management* 29:39-57.

Croot, C. and L. Margolis. 1991. Pacific salmon life histories. University of British Columbia Press, Vancouver BC.

Dietrich, W.E. and D.R. Montgomery. 1998. SHALSTAB: A digital terrain model for mapping shallow landslide potential. National Council for Air and Stream Improvement, NCASI Technical Report, February 1, 1998 (http://Socrates.Berkeley.edu/~geomorph/shalstab.html).

Duncan, S.H. 1986. Peak discharge during thirty years of sustained yield timber management in two fifth-order watersheds in Washington State. *Northwest Science* 60(4):258-264.

Duncan, S.H., R.E. Bilby, J.W. Ward, and J.T. Heffner. 1987. Transport of road-surface sediment through ephemeral stream channels. *Water Resources Bulletin* 23(1):113-119.

Ecosystems Northwest. 1996. Mercer/Berry watershed analysis. Final report prepared for the Siuslaw National Forest.

Eilers, J.M., K. Vache, and K. Moser. 2001. Tenmile Lake nutrient study – phase I report. Prepared by E&S Environmental Chemistry, Inc. for the Tenmile Lakes Basin Partnership.

Eilers, J.M., K. Vache, and J. Kann. 2002. Tenmile Lakes nutrient study – phase II report. Prepared by E&S Environmental Chemistry, Inc. for the Tenmile Lakes Basin Partnership.

Elliot, W.J. and D.E. Hall. 1997. Water erosion prediction project (WEPP) forest applications. General Technical Report INT-GTR-365. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ogden UT.

Farnell, J.E. 1979. Coos and Coquille Rivers navigability studies. Division of State Lands, Salem OR.

Farnell, J.E. 1981. Smith River and Umpqua tributaries navigability report. Division of State Lands, Salem OR.

Feng, J.C., D.G. Thompson, and P.E. Reynolds. 1989. Fate of glyphosate in a forest stream ecosystem. Pages 45-64 *in* Proceedings of the Carnation Creek Herbicide Workshop, P.E. Reynolds, ed. Forest Pest Management Institute, Forestry Canada, Sault Ste. Marie, Ontario.

Filip, G. 2002. Swiss needle cast cooperative annual report. Oregon State University, College of Forestry, Corvallis.

Folmar, L.C., H.O. Sanders, and A.M. Julin. 1979. Toxicity of the herbicide glyphosate and several of its formulations to fish and aquatic invertebrates. *Archives of Environmental Contamination and Toxicology* 8:269-278.

Foltz, R.B. 1996. Traffic and no-traffic on an aggregate surfaced road: sediment production differences. Proceedings of the Seminar on Environmentally Sound Forest Road and Wood Transport, June 1996, Sinaia, Romania. United Nations Food and Agriculture Organization, Rome, Italy.

Forest Service. 1993. SHADOW, Stream temperature management program user's manual. Available at the USDA Forest Service, Pacific Northwest Region, Portland OR.

Glenn, E., R. Anthony, A. Ellingson, J. Tappeiner, and T. Nierenberg. 2000. Summary of northern spotted owl research on Oregon Department of Forestry lands in the Coast Range. Oregon Cooperative Fish and Wildlife Research Unit and Oregon State University College of Forestry, Corvallis.

Goldfinger, C., L.D. Kulm and R.S. Yates, C. Mitchell, R. Weldon II, C. Peterson, M. Darienzo, W. Grant, and G. Priest, 1992. Neotectonic map of the Oregon continental margin and adjacent abyssal plain. Open File Report 0-92-4. Oregon Department of Geology and Mineral Industries.

Gresswell, S., D. Heller, and D.N. Swanston. 1979. Mass movement response to forest management in the central Oregon Coast Range. Resource Bulletin PNW-84, Pacific Northwest Forest and Range Experiment Station, Portland OR.

Hann, D.W., A.S. Hester, and C.L. Olsen. 1995. ORGANON user's manual: ver. 5.0. Department of Forest Resources, Oregon State University, Corvallis.

Harmon, M.E., J.F. Franklin, F.J. Swanson, P. Sollins, S.V. Gregory, J.D. Lattin, N.H. Anderson, S.P. Cline, N.G. Aumen, J.R. Sedell, G.W. Lienkaemper, L. Cromack Jr., K.W. Cummins. 1986. Ecology of coarse woody debris in temperate ecosystems. *Advances in Ecological Research* 15:133-302.

Harr, R.D. and J.T. Krygier. 1972. Clearcut logging and low flows in Oregon coastal watersheds. Research Note No. 54, Paper 839.

Harr, R.D., W.C. Harper, J.T. Krygier, and F.S. Hsieh. 1975. Changes in storm hydrographs after road building and clearcutting in the Oregon Coast Range. *Water Resources Research* 11(3):436-444.

Harr, R.D., A. Levno, and R. Mersereau. 1982. Streamflow changes after logging in 130-year-old Douglas-fir in two small watersheds. *Water Resources Research* 18(3):637-644.

Heimann, D.C. 1988. Recruitment trends and physical characteristics of coarse woody debris in Oregon Coast Range streams. MS thesis, Oregon State University, Corvallis.

Hibbs, D.E. and P.A. Giordano. 1996. Vegetation characteristics of alder-dominated riparian buffer strips in the Oregon Coast Range. *Northwest Science* 70(3):213-222.

Hicks, B.J., R.L. Beschta, and R.D. Harr. 1991. Long-term changes in streamflow following logging in Western Oregon and associated fisheries implications. *Water Resources Bulletin* 27(2):217-226.

Hildebrand, L.D., D.S. Sullivan, and T.P. Sullivan. 1982. Experimental studies of rainbow trout populations exposed to field applications of Roundup herbicide. *Archives of Environmental Contamination and Toxicology* 11:93-98.

Holtby, L.B. and S.J. Baillie. 1989. Effects of the herbicide Roundup on coho salmon fingerling in an over-sprayed tributary of Carnation Creek, British Columbia. Pages 273-285 *in* Proceedings of the Carnation Creek Herbicide Workshop, P.E. Reynolds, ed. Forest Pest Management Institute, Forestry Canada. Sault Ste. Marie, Ontario.

Istanbulluoglu, E., D.G. Tarboton, R.T. Pack and C.H. Luce. 2003. Modeling of the interactions between forest vegetation, disturbances and sediment yields. Submitted to the *Journal of Geophysical Research-Earth Surface*, April 2003.

Jacobs, S., J. Firman, G. Susac, D. Stewart, and J. Weybright. 2002. Status of Oregon coastal stocks of anadromous salmonids, 2000-2001 and 2001-2002. Oregon Plan for Salmon and Watersheds, Monitoring Program Report, No. OPS-ODFW-2002-3. Oregon Department of Fish and Wildlife, Portland.

Jacobsen, P. and B. Thom. 2001. 1998-2000 habitat restoration effectiveness monitoring for the western Oregon stream project. Monitoring Program Report Number OPSW-ODFW-2001-07. Oregon Department of Fish and Wildlife, Portland.

Johnson, D.H. and T.A. O'Neil (eds.). 2001. Wildlife-habitat relationships in Oregon and Washington. Oregon State University Press, Corvallis.

Keppeler, E.T. and R.R. Ziemer. 1990. Logging effects of streamflow: water yield and summer low flows at Caspar Creek in northwestern California. *Water Resources Research* 26(7):1669-1679.

Ketcheson, G. and H.A. Froehlich. 1978. Factors and environmental impacts of mass soil movements in the Oregon Coast Range. Water Resources Research Institute Bulletin 56, Oregon State University, Corvallis.

Keim, R.F. and A.E. Skaugset. 2003. Modeling effects of forest canopies on slope stability. *Hydrologic Processes* 17(7).

Klamath-Siskiyou Wildlands Center and others. 2003. A petition for rules to list: Pacific lamprey, river lamprey, western brook lamprey, kern brook lamprey as threatened or endangered under the Endangered Species Act. Klamath-Siskiyou Wildlands Center, Ashland OR.

Kostow, K. 2002. Oregon lampreys: natural history status and analysis of management issues. Oregon Department of Fish and Wildlife, Corvallis.

LaLande, J. and R. Pullen. 1999. Burning for a "fine and beautiful open country": native uses of fire in southwestern Oregon. Pages 255-276 *in* Indians, Fire and the Land in the Pacific Northwest, R. Boyd ed. Oregon State University Press, Corvallis.

Lambert R.K., G.E. Land, and W.A. Reiners. 1980. Loss of mass and chemical change in decaying boles of a subalpine balsam fir forest. *Ecology* 61:1460-1473.

Lancaster, S.T., S. Hayes, and G.E. Grant. 2001. Modeling sediment and wood storage and dynamics in small mountainous watersheds: geomorphic processes and riverine habitat. *Water Science and Application* 4:85-102.

Larson, K.R. and R.C. Sidle. 1980. Erosion and sedimentation data catalog of the Pacific Northwest. R6-WM-050-1981. USDA Forest Service, Pacific Northwest Region, Portland OR.

Leonard, W.P., H.A. Brown, L.L.C. Jones, K.R. McAllister, and R.M. Storm. 1991. Amphibians of Washington and Oregon. Seattle Audubon Society, Seattle WA.

Lonzarich, D.G. and T.P. Quinn. 1995. Experimental evidence for the effect of depth and structure on the distribution, growth, and survival of stream fishes. *Canadian Journal of Zoology* 73:2223-2230.

Mantua, N.J., S.R. Hare, Y. Zhang, J.M. Wallace, and R.C. Francis. 1997. A Pacific interdecadal climate oscillation with impacts on salmon production. *Bulletin of the American Meteorological Society* 78 (June):1069-1079.

Martin, C.W. and R.D. Harr. 1989. Logging of mature Douglas-fir in western Oregon has little effect on nutrient output budgets. *Canadian Journal of Forest Research* 19:35-43.

McHugh, M.H. 1987. Landslide occurrence in the Elk and Sixes River basins, Southwest Oregon. MS thesis, Oregon State University, Corvallis.

McSwain, M.D. 1987. Summer stream temperatures and channel characteristics of a southwest Oregon coastal stream. MS thesis, Oregon State University, Corvallis.

Meekins, D. and T.E. Hamer. 1996. A habitat suitability model for the marbled murrelet and implementation plan for the Elliot State Forest habitat conservation plan. Prepared for the Oregon Department of Forestry, Salem.

Mills, K. 1997. Forest roads, drainage, and sediment delivery in the Kilchis River watershed. Prepared for Tillamook Bay National Estuary Project. Oregon Department of Forestry, Salem.

Montgomery, D.R. 1994. Road surface drainage, channel Initiation, and slope stability. *Water Resources Research* 30:1925-1932.

Montgomery, D.R. and W.E. Deitrich. 1994. A physically-based model for the topographic control on shallow landsliding. *Water Resources Research* 30(4):1153-1171.

Montgomery, D.R., T. Dunne, and W.E. Dietrich. 1993. Geomorphological watershed analysis project. Biennial report for the period from 10/1/91 to 6/30/93, TFW-SH10-93-001. Washington State Department of Ecology, Olympia.

Morrice, J.A., H.M. Valett, C.N. Dahm, and M.E. Campana. 1997. Alluvial characteristics, groundwater surface water exchange and hydrological retention in headwater streams. *Hydrological Processes* 11:253-267.

Morris, W.G. 1934. Forest fires in western Oregon and western Washington. *Oregon Historical Quarterly* 35:313-319.

Murphy, M.L. and K.V. Koski. 1989. Input and depletion of woody debris in Alaska streams and implications for streamside management. *North American Journal of Fisheries Management* 9:427-436.

Nelson, S.K. and A.K. Wilson. 2002. Marbled murrelet habitat characteristics on state lands in western Oregon. Final Report, Oregon Cooperative Fish and Wildlife Research Unit, Oregon State University, Corvallis.

Newton, M., K.M. Howard, B.R. Kelpsas, R.Danhaus, C.M. Lottman, and S. Dubelman. 1984. Fate of glyphosate in an Oregon forest ecosystem. *Journal of Agricultural and Food Chemistry* 32(5):1144-1151.

Nickelson, T.E, J.W. Nicholas, A.M. McGie, R.B. Lindsay, and D.L. Bottom. 1992. Status of anadromous salmonids in Oregon coastal basins. Oregon Department of Fish and Wildlife.

Niem, A.R. and W.A. Niem. 1990. Geology and oil, gas, and coal resources, S. Tyee Basin, Oregon. Plates 1 and 2. Open file report O-89-03. Department of Geology and Mineral Industries, Salem

Norris, L.A. and F. Dost. 1992. Proposed surface water quality criteria for selected pesticides used for forest management and management of forest tree seedling nurseries and Christmas tree plantations in Oregon and Washington. Oregon State University, Corvallis.

Oregon Climate Service. 2003. Weather data from the web site: http://www.ocs.orst.edu.

Oregon Department of Fish and Wildlife (ODFW). 1993. Review of threatened and endangered, sensitive and stocks of concern. Southwest Regional Fish Management Meeting, Charleston.

Oregon Department of Fish and Wildlife (ODFW). 1997. Oregon Department of Fish and Wildlife sensitive species list. Portland.

Oregon Department of Forestry (ODF). 1993. Elliott State Forest management plan. Coos Bay.

Oregon Department of Forestry (ODF). 1995. Elliott State Forest habitat conservation plan. Final May 1995. Salem.

Oregon Department of Forestry (ODF). 2001. Summary of streamside stand measurements on the Elliott State Forest. Report prepared by C.W. Andrus.

Oregon Department of Forestry (ODF). 2002. 2001 Marbled murrelet surveys: district summaries. Salem.

Oregon Department of Forestry (ODF). undated. 2002 Marbled murrelet surveys: district summaries. Salem.

Oregon Department of Forestry (ODF). 2003. Avoiding roads in critical locations, Forest Practices Technical Note 7; Installation and maintenance of cross drainage systems on forest roads, Forest Practices Technical Note 8; Wet weather road use, Forest Practices Technical Note 9. Salem.

Oregon Department of Forestry and Department of Environmental Quality (ODF/DEQ). 2002. Oregon Department of Forestry and Department of Environmental Quality sufficiency analysis: a statewide evaluation of FPA effectiveness in protecting water quality. Salem.

Oregon Natural Heritage Program (ONHP). 2001. Rare, threatened and endangered plants and animals of Oregon. Portland.

Oregon Watershed Enhancement Board (OWEB). 1999. Oregon watershed assessment manual. Prepared by Watershed Professionals Network.

Pacific Northwest Coastal Ecosystems Regional Study (PNCERS). 2000. Coastal resident survey basic summary of responses, Coos Bay, Coos County, Oregon (Draft).

Pacific Watershed Associates (PWA). 1997. Field training in watershed/road sediment source assessments and erosion prevention. June 16-20, 1997, Coos Bay OR. Pacific Watershed Associates, Arcata CA.

Pack, R.T., D.G. Tarboton, and C.N. Goodwin. 1999. GIS-based landslide susceptibility mapping with SINMAP. Pages 219-231 *in* Proceedings of the 34th Symposium on Engineering Geology and Geotechnical Engineering, J.A. Bay, ed. Volume 34.

Perkins, R.M. 1997. Climatic and physiographic controls on peakflow generation in the Western Cascades, Oregon. PhD dissertation, Oregon State University, Corvallis.

Phillips, J. 1996. Caulk boots and cheese sandwiches. Butler's Pronto Print, Coos Bay OR.

Piehl, B.T., R.L. Beshta, and M.R. Pyles. 1988. Ditch-relief culverts and low-volume forest roads in the Oregon Coast Range. *Northwest Science* 62(3):91-98.

Poole, G.C. and C.H. Berman. 2001. An ecological perspective on in-stream temperature: natural heat dynamics and mechanisms of human-caused thermal degradation. *Environmental Management* 27:787-802.

Radtke, H.D. and D.W. Shannon. 1999. Economic description of selected coastal Oregon and Washington counties. Pacific Northwest Coastal Ecosystems Regional Study. The Research Group, Corvallis OR.

Rashin, E. and C. Graber. 1993. Effectiveness of best management practices for aerial application of forest pesticides. TFW-WQ1-93-001. Prepared by the Washington State Department of Ecology for the Timber/Fish/Wildlife Cooperative Monitoring, Evaluation, and Research Committee.

Rashin, Ed., C. Clishe, A. Loch, and J. Bell. 1999. Effectiveness of road and timber harvest best management practices with respect to sediment-related water quality impacts. TFW-WQ6-99-001. Washington State Department of Ecology, Olympia.

Reeves, G.H., L.E. Benda, K. Burnett, P.A. Bisson, and J.R. Sedell. 1995. A disturbance-based ecosystem approach to maintaining and restoring freshwater habitats of evolutionarily significant units of anadromous salmonids in the Pacific Northwest. *American Fisheries Society Symposium* 17:334-349.

Reid, L.M. 1981. Sediment production from gravel-surfaced forest roads, Clearwater Basin, Washington. Masters thesis, University of Washington, Seattle.

Reid, L.M. and T. Dunne. 1984. Sediment production from forest road surfaces. *Water Resources Research* 20(11):1753-1761.

Reimers, P.E. 1989. Management of wild and hatchery coho salmon in Tenmile Lakes system. Information Reports, No. 89-5, Oregon Department of Fish and Wildlife, Portland.

Reneau, S.L. and W.E. Dietrich. 1991. Erosion rates in the southern Oregon Coast Range: evidence for an equilibrium between hillslope erosion and sediment yield. *Earth Surfaces Processes and Landform* 16:307-322.

Rice, T. and J. Souder. 1998. Pulp friction and the management of Oregon's state forests. 13 *Journal of Environmental Law and Litigation* 209-273 (1998).

Robben, J. and L. Dent. 2002. Best management practices compliance monitoring project. Final Report. Oregon Department of Forestry, Salem.

Robbins, W.G. 1988. Hard times in paradise: Coos Bay, Oregon, 1850-1986. University of Washington Press, Seattle.

Robison E.G., K. Mills, J. Paul, L. Dent, and A. Skauget. 1999. Storm impacts and landslides of 1996. Forest Practices Technical Report #4, Forest Practices Monitoring Program. Oregon Department of Forestry, Salem.

Roderiguez-Iturbe, I. and A. Rinaldo. 1997. Fractal river basins: chance and self-organization. Cambridge University Press, Cambridge UK.

Rose, C.L., B.G. Marcot, T.K. Mellen, J.L. Ohmann, K.L. Waddell, D.L. Lindley, and B. Schreiber. 2001. Decaying wood in Pacific Northwest forests: Concepts and tools for habitat management. Pages 580-622 *in* Wildlife-habitat Relationships in Oregon and Washington, D.H. Johnson and T.A. O'Neil, eds. Oregon State University Press, Corvallis.

Rot, B. 1995. The interaction of valley constraint, riparian landform, and riparian plant community size and age upon channel configuration of small streams of Western Cascade Mountains, Washington. MS thesis, University of Washington, Seattle.

Ruth, R.H. and R.A. Yoder. 1953. Reducing wind damage in the forests of the Oregon Coast Range. Research Paper 7. USDA Pacific Northwest Forest and Range Experiment Station.

Ryu, I.C., A.R. Niem, and W.A. Niem. 1996. Oil and gas potential of the southern Tyee basin, southern Oregon Coast Range. Oregon Department of Geology and Mineral Industries, Salem.

Saltzman, W.O. 1959. Stream surveys of the Coos and Millicoma River watersheds. Oregon Game Commission, Salem OR.

Saltzman, W.O. 1960. Stream surveys of the Mill Creek – Camp Creek watersheds. Oregon Game Commission, Salem OR.

Saltzman, W.O. 1961. Stream surveys of the Lower Umpqua tributaries and Elk Creek tributaries. Oregon Game Commission, Salem OR.

Schmidt, K.M., J.J. Roering, J.D. Stock, W.E. Dietrich, D.R. Montgomery, and T. Schaub. 2001. The variability of root cohesion as an influence on shallow landslide susceptibility in the Oregon Coast Range. *Canadian Geotechnical Journal* 38(5):995-1024.

Schroeder, W.L. and G.W. Brown. 1984. Debris torrents, precipitation and roads in two coastal Oregon watersheds. Pages 117-122 *in* Symposium on Effects of Forest Land Use on Erosion and Slope Stability, Oregon State University, Corvallis.

Servizi, J.A., R.W. Gordon, and D.W. Martens. 1987. Acute toxicity of Garlon 4 and Roundup herbicides to salmon, daphnia, and trout. *Bulletin of Environmental Contamination and Toxicology* 39:15-22.

Sessions J., J.C. Balcom, and K. Boston. 1987. Road location and construction practices: effects of landslide frequency and size in the Oregon Coast Range. *Western Journal of Applied Forestry* 2(4):119-124.

Shapiro, M. and L. Johnson. 2000. Coos regional trails plan. Coos Regional Trails Partnership, Coos Bay OR.

Sidle, R.C. 1987. A dynamic model of slope stability in zero-order basins. pp. 101-110 *In* Erosion and Sedimentation in the Pacific Rim. IAHS Publication No. 165.

Skaugset, A.R. 1997. Modeling root reinforcement in shallow forest soils. PhD dissertation, Oregon State University, Corvallis.

Smyth, A. 2000. Millicoma: Biography of a Pacific northwestern forest. Forest Historical Society.

Sollins, P. 1982. Input and decay of coarse woody debris in coniferous stands in western Oregon and Washington. *Canadian Journal of Forest Research* 12:18-28.

State of Oregon. 1999. The Oregon plan for salmon and watersheds. Office of the Governor, Salem. Updated annually. Available at http://www.oregon-plan.org.

Stoddard, M.A. 2001. The influence of forest management on headwater stream amphibians at multiple spatial scales. MS thesis, Oregon State University, Corvallis.

Swanson F.J., M.M. Swanson, and C. Woods. 1981. Analysis of debris-avalanche erosion in steep forested lands: an example from Mapleton, Oregon, USA. Pages 67-75 *in* Erosion and Sediment Transport in Pacific Rim Steeplands. IAHS Publication 132. Christchurch, New Zealand.

Tarboton, D.G. 1997. A new method for the determinations of flow direction and upslope areas in grid digital elevation models. *Water Resources Research* 33(2):309-319.

Taylor, G.H. 2003. Long-term climate trends and salmon population. Oregon Climate Service Report. Corvallis OR. http://www.ocs.orst.edu/reports/climate_fish.html.

Taylor, G.H. and C. Hannan. 1999. The climate of Oregon; from rain forest to desert. Oregon State University Press, Corvallis.

Taylor, G.H. and R.R. Hatton. 1999. The Oregon weather book: A state of extremes. Oregon State University Press, Corvallis.

Taylor, R.J. 1990. Northwest weeds. The Mountain Press, Missoula MT.

Tenmile Lakes Basin Partnership (TLBP). 2003. Unpublished GIS digital landslide data.

Thies, W.G. and E.M. Goheen. 2002. Major forest diseases of the Oregon Coast Range and their management. *In* Forest and stream management in the Oregon Coast Range, S.D. Hobbs and others, eds. Oregon State University Press, Corvallis.

Thomas R.B. and W.F. Megahan. 1998. Peak flow responses to clearcutting and roads in small and large basin, western Cascades: a second opinion. *Water Resources Research* 34(12):3393-3403.

Thompson, D.G., B. Staznik, D.D. Fontaine, T. Mackay, G.R. Oliver, and J. Troth. 1991. Fate of triclopyr ester (Release) in a boreal forest stream. *Environmental Toxicology and Chemistry* 10:619-632.

Trout Unlimited and others. 2002. Petition to list the Oregon Coast coho salmon (*Onchorhyncus kisutch*) as a threatened species under the federal Endangered Species Act. Trout Unlimited, Washington DC.

Ursitti, V.L. 1990. Riparian vegetation and abundance of woody debris in streams of southwest Oregon. MS thesis, Oregon State University, Corvallis.

U.S. Department of Agriculture (USDA). 1999. FS WEPP; Forest Service interfaces for the water erosion prediction project computer model. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station and San Dimas Technology and Development Center.

U.S. Fish and Wildlife Service (USFWS). 1996. Endangered and threatened wildlife and plants; final designation of critical habitat for the marbled murrelet; final rule. *Federal Register* 61(102):26255-26280.

Van Sickle, J. and S.V. Gregory. 1990. Modeling inputs of large woody debris in streams from falling trees. *Canadian Journal of Forest Research* 20:1593-1601.

Vesely, D.G. and J. Stamp. 2001. Report on surveys for stream-dwelling amphibians conducted on the Elliott State Forest, June-September, 2001. Report prepared for the Oregon Department of Forestry. Pacific Wildlife Research, Corvallis OR.

Wagoner, L.J. and others. 1990. Coos River fish management plan. Oregon Department of Fish and Wildlife, Charleston OR.

Wan, M.T., R.G. Watts, and D.J. Moul. 1989. Effects of different dilution water types on the acute toxicity to juvenile Pacific salmon and rainbow trout of glyphosate and its formulation products. *Bulletin of Environmental Contamination and Toxicology* 43(3):378-385.

Washington Forest Practices Board. 1993. Standard methodology for conducting watershed analysis. Version 2.0. Washington Department of Natural Resources, Olympia.

Weikel, J. and D. Vesely. 2001. A report on avian surveys conducted on the Elliott State Forest, May-July, 2001. Pacific Wildlife Research Inc., Corvallis OR.

Welty, J.J., T. Beechie, K. Sullivan, D.M. Hyink, R.E. Bilby, C.W. Andrus, and G. Pess. 2002. Riparian aquatic interaction simulator (RAIS): a model of riparian forest dynamics for the generation of large woody debris and shade. *Forest Ecology and Management* 162:299-318.

Weyerhaeuser. 1995. East Fork Millicoma River watershed analysis. Weyerhaeuser Corporation.

Weyerhaeuser. 1998. South Fork Coos River watershed analysis. Weyerhaeuser Corporation, Coos Bay OR.

Wright K.A., K.H. Sendek, R.M. Rice, and R.B. Thomas. 1990. Logging effects on streamflow: storm runoff at Caspar Creek in northwestern California. *Water Resources Research* 26(7):1657-1667.

Youst, L. 1992. Above the falls: An oral and folk history of Upper Glenn Creek, Coos County, Oregon.

Appendix A
Streamside Vegetation or Land-type Area by Stream Size and Distance from Stream for Fish-bearing Streams

Basin #1

Basin	Stream Size Class, Length	Type	Age Class (yrs)	Distance from Stream Centerline (feet) 0-50 ft. (acres)	51-100 ft. (acres)	101-150 ft. (acres)	151-200 ft. (acres)
Basin #1 -- Mill Cr, Cold Cr, Double Barrel Cr, Puckett Cr, Footlog Cr	Large; 6.82 miles	Brush	---	0.2	0.4	0.0	0.0
		Conifer	≤12	0.0	0.0	0.0	0.0
			13-24	0.0	0.0	0.0	0.0
			25-49	0.3	0.1	0.0	0.0
			50-99	0.0	0.0	0.0	0.0
			≥100	3.5	8.5	11.8	13.4
		Conifer/ Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	0.8	1.8	1.9	2.4
			25-49	1.8	4.9	5.1	5.0
			50-99	0.0	0.0	0.0	0.0
			≥100	12.1	27.3	34.4	38.4
		Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	1.7	5.1	4.0	2.4
			25-49	6.0	14.7	14.2	13.0
			≥50	5.5	11.8	9.2	7.6
		Road	---	1.9	6.4	2.8	0.6
		Stream	---	49.4	2.5	0.0	0.0
	Medium; 2.10 miles	Brush	---	0.0	0.0	0.0	0.0
		Conifer	≤12	0.0	0.1	0.7	1.1
			13-24	0.0	0.0	0.0	0.0
			25-49	0.0	0.0	0.0	0.0
			50-99	0.0	0.0	0.0	0.0
			≥100	1.2	3.0	3.7	3.7
		Conifer/ Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	0.0	0.0	0.0	0.0
			25-49	0.3	1.2	2.0	2.4
			50-99	0.5	1.1	1.1	1.1
			≥100	9.0	10.2	11.8	11.9
		Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	0.0	0.0	0.1	0.1
			25-49	7.3	6.4	4.3	3.8
			≥50	6.7	2.9	1.2	0.8
		Road	---	0.0	0.0	0.0	0.0
		Stream	---	0.0	0.0	0.0	0.0
	Small; 0.00 miles	Brush	---	0.0	0.0	0.0	0.0
		Conifer	≤12	0.0	0.0	0.0	0.0
			13-24	0.0	0.0	0.0	0.0
			25-49	0.0	0.0	0.0	0.0
			50-99	0.0	0.0	0.0	0.0
			≥100	0.0	0.0	0.0	0.0
		Conifer/ Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	0.0	0.0	0.0	0.0
			25-49	0.0	0.0	0.0	0.0
			50-99	0.0	0.0	0.0	0.0
			≥100	0.0	0.0	0.0	0.0
		Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	0.0	0.0	0.0	0.0
			25-49	0.0	0.0	0.0	0.0
			≥50	0.0	0.0	0.0	0.0
		Road	---	0.0	0.0	0.0	0.0
		Stream	---	0.0	0.0	0.0	0.0

Basin #2

Basin	Stream Size Class, Length	Type	Age Class (yrs)	Distance from Stream Centerline (feet) 0-50 ft. (acres)	51-100 ft. (acres)	101-150 ft. (acres)	151-200 ft. (acres)
Basin #2 -- Luder Cr, Charlotte Cr	Large; 2.75 miles	Brush	---	0.0	0.0	0.0	0.0
Basin #2 -- Luder Cr, Charlotte Cr	Large; 2.75 miles	Conifer	≤12	0.0	0.0	0.0	0.0
Basin #2 -- Luder Cr, Charlotte Cr	Large; 2.75 miles	Conifer	13-24	0.0	0.0	0.0	0.0
Basin #2 -- Luder Cr, Charlotte Cr	Large; 2.75 miles	Conifer	25-49	0.0	0.0	0.0	0.0
Basin #2 -- Luder Cr, Charlotte Cr	Large; 2.75 miles	Conifer	50-99	0.8	0.3	0.0	0.0
Basin #2 -- Luder Cr, Charlotte Cr	Large; 2.75 miles	Conifer	≥100	6.8	12.3	15.6	16.4
Basin #2 -- Luder Cr, Charlotte Cr	Large; 2.75 miles	Conifer/ Hardwood	≤12	0.0	0.5	3.1	3.7
Basin #2 -- Luder Cr, Charlotte Cr	Large; 2.75 miles	Conifer/ Hardwood	13-24	0.1	0.2	0.5	0.5
Basin #2 -- Luder Cr, Charlotte Cr	Large; 2.75 miles	Conifer/ Hardwood	25-49	0.0	0.0	0.0	0.0
Basin #2 -- Luder Cr, Charlotte Cr	Large; 2.75 miles	Conifer/ Hardwood	50-99	0.1	0.3	0.3	0.3
Basin #2 -- Luder Cr, Charlotte Cr	Large; 2.75 miles	Conifer/ Hardwood	≥100	6.2	6.0	3.6	2.9
Basin #2 -- Luder Cr, Charlotte Cr	Large; 2.75 miles	Hardwood	≤12	0.0	0.0	0.0	0.0
Basin #2 -- Luder Cr, Charlotte Cr	Large; 2.75 miles	Hardwood	13-24	6.5	5.8	5.4	5.1
Basin #2 -- Luder Cr, Charlotte Cr	Large; 2.75 miles	Hardwood	25-49	2.4	1.1	0.7	0.5
Basin #2 -- Luder Cr, Charlotte Cr	Large; 2.75 miles	Hardwood	≥50	11.0	6.8	3.6	2.6
Basin #2 -- Luder Cr, Charlotte Cr	Large; 2.75 miles	Road	---	0.1	0.2	0.1	0.1
Basin #2 -- Luder Cr, Charlotte Cr	Large; 2.75 miles	Stream	---	0.0	0.0	0.0	0.0
Basin #2 -- Luder Cr, Charlotte Cr	Medium; 3.04 miles	Brush	---	0.0	0.0	0.0	0.0
Basin #2 -- Luder Cr, Charlotte Cr	Medium; 3.04 miles	Conifer	≤12	0.0	0.0	0.0	0.0
Basin #2 -- Luder Cr, Charlotte Cr	Medium; 3.04 miles	Conifer	13-24	0.0	0.0	0.0	0.0
Basin #2 -- Luder Cr, Charlotte Cr	Medium; 3.04 miles	Conifer	25-49	0.0	0.0	0.0	0.0
Basin #2 -- Luder Cr, Charlotte Cr	Medium; 3.04 miles	Conifer	50-99	7.3	8.5	9.4	9.3
Basin #2 -- Luder Cr, Charlotte Cr	Medium; 3.04 miles	Conifer	≥100	6.3	12.9	13.4	12.9
Basin #2 -- Luder Cr, Charlotte Cr	Medium; 3.04 miles	Conifer/ Hardwood	≤12	0.0	0.9	2.5	2.7
Basin #2 -- Luder Cr, Charlotte Cr	Medium; 3.04 miles	Conifer/ Hardwood	13-24	0.4	1.3	4.1	5.8
Basin #2 -- Luder Cr, Charlotte Cr	Medium; 3.04 miles	Conifer/ Hardwood	25-49	0.0	0.0	0.0	0.0
Basin #2 -- Luder Cr, Charlotte Cr	Medium; 3.04 miles	Conifer/ Hardwood	50-99	0.0	0.0	0.0	0.0
Basin #2 -- Luder Cr, Charlotte Cr	Medium; 3.04 miles	Conifer/ Hardwood	≥100	2.9	2.9	2.0	1.8
Basin #2 -- Luder Cr, Charlotte Cr	Medium; 3.04 miles	Hardwood	≤12	0.0	0.0	0.0	0.0
Basin #2 -- Luder Cr, Charlotte Cr	Medium; 3.04 miles	Hardwood	13-24	4.1	3.5	1.9	0.7
Basin #2 -- Luder Cr, Charlotte Cr	Medium; 3.04 miles	Hardwood	25-49	4.3	1.7	1.0	1.0
Basin #2 -- Luder Cr, Charlotte Cr	Medium; 3.04 miles	Hardwood	≥50	10.3	3.5	0.8	0.7
Basin #2 -- Luder Cr, Charlotte Cr	Medium; 3.04 miles	Road	---	0.0	0.0	0.0	0.0
Basin #2 -- Luder Cr, Charlotte Cr	Medium; 3.04 miles	Stream	---	0.0	0.0	0.0	0.0
Basin #2 -- Luder Cr, Charlotte Cr	Small; 0.24 miles	Brush	---	0.0	0.0	0.0	0.0
Basin #2 -- Luder Cr, Charlotte Cr	Small; 0.24 miles	Conifer	≤12	0.0	0.0	0.0	0.0
Basin #2 -- Luder Cr, Charlotte Cr	Small; 0.24 miles	Conifer	13-24	0.0	0.0	0.0	0.0
Basin #2 -- Luder Cr, Charlotte Cr	Small; 0.24 miles	Conifer	25-49	0.0	0.0	0.0	0.0
Basin #2 -- Luder Cr, Charlotte Cr	Small; 0.24 miles	Conifer	50-99	0.0	0.4	0.5	0.5
Basin #2 -- Luder Cr, Charlotte Cr	Small; 0.24 miles	Conifer	≥100	0.1	0.5	0.6	0.6
Basin #2 -- Luder Cr, Charlotte Cr	Small; 0.24 miles	Conifer/ Hardwood	≤12	0.0	0.0	0.0	0.0
Basin #2 -- Luder Cr, Charlotte Cr	Small; 0.24 miles	Conifer/ Hardwood	13-24	0.0	0.0	0.0	0.0
Basin #2 -- Luder Cr, Charlotte Cr	Small; 0.24 miles	Conifer/ Hardwood	25-49	0.0	0.0	0.0	0.0
Basin #2 -- Luder Cr, Charlotte Cr	Small; 0.24 miles	Conifer/ Hardwood	50-99	0.0	0.0	0.0	0.0
Basin #2 -- Luder Cr, Charlotte Cr	Small; 0.24 miles	Conifer/ Hardwood	≥100	0.0	0.0	0.0	0.0
Basin #2 -- Luder Cr, Charlotte Cr	Small; 0.24 miles	Hardwood	≤12	0.0	0.0	0.0	0.0
Basin #2 -- Luder Cr, Charlotte Cr	Small; 0.24 miles	Hardwood	13-24	0.0	0.0	0.0	0.0
Basin #2 -- Luder Cr, Charlotte Cr	Small; 0.24 miles	Hardwood	25-49	0.0	0.0	0.0	0.0
Basin #2 -- Luder Cr, Charlotte Cr	Small; 0.24 miles	Hardwood	≥50	0.0	0.0	0.0	0.0
Basin #2 -- Luder Cr, Charlotte Cr	Small; 0.24 miles	Road	---	0.0	0.0	0.0	0.0
Basin #2 -- Luder Cr, Charlotte Cr	Small; 0.24 miles	Stream	---	0.0	0.0	0.0	0.0

Basin #3

Basin	Stream Size Class, Length	Type	Age Class (yrs)	Distance from Stream Centerline (feet) 0-50 ft. (acres)	51-100 ft. (acres)	101-150 ft. (acres)	151-200 ft. (acres)
Basin #3 -- Dean Cr, Johannson Cr, Hakki Cr	Large; 2.34 miles	Brush	---	7.7	5.6	3.4	2.1
		Conifer	≤12	0.0	0.0	0.0	0.0
			13-24	0.0	0.0	0.0	0.0
			25-49	0.0	0.0	0.0	0.0
			50-99	0.0	0.0	0.0	0.0
			≥100	1.5	2.8	5.0	5.8
		Conifer/ Hardwood	≤12	0.0	0.1	0.6	0.8
			13-24	0.0	0.0	0.0	0.1
			25-49	0.0	0.0	0.0	0.0
			50-99	0.8	0.6	0.7	1.0
			≥100	3.2	6.7	8.1	7.4
		Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	1.7	1.6	1.3	1.6
			25-49	3.9	3.8	3.8	4.0
			≥50	10.2	6.5	4.0	3.8
		Road	---	0.0	0.0	0.0	0.0
		Stream	---	0.0	0.0	0.0	0.0
	Medium; 4.12 miles	Brush	---	0.0	0.0	0.0	0.0
		Conifer	≤12	0.0	0.3	0.9	1.0
			13-24	0.0	0.0	0.0	0.0
			25-49	0.0	0.0	0.0	0.0
			50-99	0.0	0.0	0.0	0.0
			≥100	3.9	12.7	20.4	21.4
		Conifer/ Hardwood	≤12	2.3	2.5	4.2	5.0
			13-24	2.0	4.0	6.1	7.3
			25-49	0.0	0.0	0.0	0.0
			50-99	2.0	2.6	3.8	4.5
			≥100	2.1	4.6	5.2	4.5
		Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	6.0	3.6	1.7	1.0
			25-49	1.8	1.4	1.2	1.2
			≥50	28.5	16.7	4.9	2.2
		Road	---	0.0	0.0	0.0	0.0
		Stream	---	0.0	0.0	0.0	0.0
	Small; 1.06 miles	Brush	---	0.0	0.0	0.0	0.0
		Conifer	≤12	0.0	0.0	0.0	0.0
			13-24	0.0	0.0	0.0	0.0
			25-49	0.0	0.0	0.0	0.0
			50-99	0.0	0.0	0.0	0.0
			≥100	1.8	5.3	7.0	7.1
		Conifer/ Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	0.0	0.0	0.0	0.0
			25-49	0.4	1.4	1.5	1.4
			50-99	0.0	0.0	0.0	0.0
			≥100	2.2	2.3	2.1	2.1
		Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	0.0	0.0	0.0	0.0
			25-49	3.0	0.2	0.0	0.0
			≥50	5.0	2.7	1.0	0.7
		Road	---	0.0	0.0	0.0	0.0
		Stream	---	0.0	0.0	0.0	0.0

Basin #4

Basin	Stream Size Class, Length	Type	Age Class (yrs)	Distance from Stream Centerline (feet)			
				0-50 ft. (acres)	51-100 ft. (acres)	101-150 ft. (acres)	151-200 ft. (acres)
Basin #4 -- Schofield Cr, Miler Cr, Dry Cr, Alder Cr	Large; 2.54 miles	Brush	---	0.6	0.3	0.0	0.0
		Conifer	≤12	0.0	0.0	0.0	0.0
			13-24	0.0	0.0	0.0	0.0
			25-49	0.1	0.5	0.9	0.8
			50-99	0.0	0.0	0.0	0.0
			≥100	0.5	2.0	2.8	2.9
		Conifer/ Hardwood	≤12	0.0	0.5	1.5	1.8
			13-24	2.4	4.5	6.1	6.5
			25-49	0.0	0.1	0.2	0.1
			50-99	0.0	0.0	0.0	0.0
			≥100	4.0	6.9	8.9	9.0
		Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	4.4	3.2	2.4	2.3
			25-49	9.7	7.2	6.3	6.2
			≥50	9.2	5.7	1.7	0.8
		Road	---	0.0	0.0	0.0	0.0
		Stream	---	0.0	0.0	0.0	0.0
	Medium; 3.52 miles	Brush	---	0.0	0.0	0.0	0.0
		Conifer	≤12	0.0	0.0	0.0	0.0
			13-24	0.0	0.0	0.2	0.3
			25-49	0.4	1.3	1.4	0.9
			50-99	0.0	0.0	0.0	0.0
			≥100	0.9	3.1	3.5	3.3
		Conifer/ Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	1.0	4.4	6.4	7.0
			25-49	0.0	0.6	1.2	1.2
			50-99	1.1	3.4	3.8	3.9
			≥100	8.6	13.2	14.4	13.8
		Hardwood	≤12	0.0	0.2	0.5	0.4
			13-24	3.7	1.0	0.6	1.6
			25-49	9.6	8.6	7.6	7.6
			≥50	16.6	6.4	2.3	1.2
		Road	---	0.0	0.0	0.0	0.0
		Stream	---	0.0	0.0	0.0	0.0
	Small; 1.32 miles	Brush	---	0.0	0.0	0.0	0.0
		Conifer	≤12	0.0	0.0	0.0	0.0
			13-24	0.1	0.6	1.4	2.3
			25-49	0.0	0.0	0.0	0.0
			50-99	0.0	0.0	0.0	0.0
			≥100	0.0	0.0	0.0	0.0
		Conifer/ Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	0.1	2.0	4.0	4.1
			25-49	0.0	0.0	0.0	0.0
			50-99	0.0	0.0	0.0	0.0
			≥100	7.1	6.0	6.3	6.4
		Hardwood	≤12	0.7	2.1	2.3	2.3
			13-24	8.1	5.3	1.9	0.7
			25-49	0.0	0.0	0.1	0.1
			≥50	0.0	0.0	0.0	0.0
		Road	---	0.0	0.0	0.0	0.0
		Stream	---	0.0	0.0	0.0	0.0

Basin #5

Basin	Stream Size Class, Length	Type	Age Class (yrs)	Distance from Stream Centerline (feet) 0-50 ft. (acres)	51-100 ft. (acres)	101-150 ft. (acres)	151-200 ft. (acres)
Basin #5 -- Big Cr, Alder Fork Big Cr, Murphy Cr, Nobel Cr, Alder Gulch	Large; 3.16 miles	Brush	---	9.4	9.6	8.6	7.4
		Conifer	≤12	0.0	0.0	0.0	0.0
			13-24	0.0	0.0	0.0	0.0
			25-49	0.0	0.0	0.0	0.0
			50-99	0.0	0.0	0.0	0.0
			≥100	0.2	0.3	0.8	1.4
		Conifer/ Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	0.0	0.0	0.0	0.0
			25-49	0.0	0.0	0.0	0.0
			50-99	0.0	0.1	0.8	1.2
			≥100	9.3	8.2	8.8	9.3
		Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	0.7	0.8	0.8	0.9
			25-49	0.0	0.0	0.0	0.0
			≥50	20.7	19.7	16.8	14.2
		Road	---	0.0	0.0	0.0	0.0
		Stream	---	0.0	0.0	0.0	0.0
	Medium; 5.55 miles	Brush	---	4.7	4.0	2.9	1.7
		Conifer	≤12	0.0	0.0	0.0	0.0
			13-24	0.0	0.0	0.0	0.0
			25-49	0.0	0.0	0.0	0.0
			50-99	0.0	0.1	0.2	0.3
			≥100	1.7	5.9	10.7	13.0
		Conifer/ Hardwood	≤12	0.0	0.4	2.1	2.4
			13-24	1.2	2.3	5.2	5.7
			25-49	0.0	0.0	0.0	0.0
			50-99	1.8	3.5	4.3	4.6
			≥100	7.6	15.4	20.6	21.1
		Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	0.2	0.1	0.0	0.0
			25-49	0.0	0.0	0.0	0.0
			≥50	50.5	34.0	18.6	14.6
		Road	---	0.0	0.0	0.0	0.0
		Stream	---	0.0	0.0	0.0	0.0
	Small; 4.18 miles	Brush	---	1.0	0.8	0.7	0.5
		Conifer	≤12	0.0	0.0	0.0	0.0
			13-24	0.3	1.3	2.1	2.3
			25-49	0.0	0.0	0.0	0.0
			50-99	0.0	0.6	0.8	0.9
			≥100	3.4	6.7	7.3	7.2
		Conifer/ Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	0.6	3.2	6.3	7.1
			25-49	0.0	0.0	0.0	0.0
			50-99	2.2	2.9	3.2	3.2
			≥100	4.3	8.0	10.7	11.6
		Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	10.1	5.0	1.5	0.7
			25-49	0.0	0.0	0.0	0.0
			≥50	24.7	17.9	13.5	12.0
		Road	---	0.0	0.0	0.0	0.0
		Stream	---	0.0	0.0	0.0	0.0

Basin #6

Basin	Stream Size Class, Length	Type	Age Class (yrs)	Distance from Stream Centerline (feet) 0-50 ft. (acres)	51-100 ft. (acres)	101-150 ft. (acres)	151-200 ft. (acres)
Basin #6 -- Benson Cr, Roberts Cr	Large; 2.74 miles	Brush	---	1.8	0.6	0.1	0.2
		Conifer	≤12	0.0	0.0	0.2	0.4
			13-24	0.0	0.0	0.0	0.0
			25-49	0.0	0.0	0.0	0.0
			50-99	0.0	0.0	0.0	0.0
			≥100	1.3	8.0	10.2	3.6
		Conifer/ Hardwood	≤12	0.0	0.1	1.0	1.4
			13-24	0.0	0.4	0.9	1.2
			25-49	0.0	0.0	0.0	0.0
			50-99	0.0	0.0	0.0	0.0
			≥100	3.6	7.7	10.2	11.1
		Hardwood	≤12	0.0	0.0	0.5	1.0
			13-24	4.8	3.4	2.4	2.6
			25-49	0.0	0.0	0.0	0.0
			≥50	21.9	17.6	10.8	6.7
		Road	---	0.0	0.0	0.0	0.0
		Stream	---	0.0	0.0	0.0	0.0
	Medium; 4.25 miles	Brush	---	0.0	0.0	0.0	0.0
		Conifer	≤12	0.0	0.0	0.0	0.0
			13-24	0.5	1.4	2.8	4.1
			25-49	0.0	0.3	2.2	5.1
			50-99	0.0	0.0	0.0	0.0
			≥100	3.7	6.6	8.8	8.9
		Conifer/ Hardwood	≤12	0.0	0.1	0.2	0.5
			13-24	0.2	5.3	5.7	2.4
			25-49	0.0	0.0	0.6	1.6
			50-99	0.0	0.0	0.0	0.0
			≥100	6.5	10.0	12.0	12.3
		Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	3.2	2.8	1.9	0.8
			25-49	3.6	2.8	2.1	1.3
			≥50	35.7	25.3	13.6	7.5
		Road	---	0.0	0.0	0.0	0.0
		Stream	---	0.0	0.0	0.0	0.0
	Small; 2.46 miles	Brush	---	0.3	0.3	0.1	0.0
		Conifer	≤12	0.0	0.0	0.0	0.0
			13-24	0.0	0.0	0.1	0.4
			25-49	0.8	3.7	4.5	4.3
			50-99	0.0	0.0	0.0	0.0
			≥100	0.8	2.8	3.6	3.6
		Conifer/ Hardwood	≤12	0.3	0.4	0.4	0.4
			13-24	0.0	0.4	1.2	1.7
			25-49	0.0	0.0	0.1	0.3
			50-99	0.0	0.0	0.0	0.0
			≥100	5.4	6.5	6.4	6.6
		Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	6.6	3.6	1.9	1.2
			25-49	5.6	2.3	1.3	1.2
			≥50	7.0	6.7	7.1	6.8
		Road	---	0.0	0.0	0.0	0.0
		Stream	---	0.0	0.0	0.0	0.0

Basin #7

Basin	Stream Size Class, Length	Type	Age Class (yrs)	Distance from Stream Centerline (feet)			
				0-50 ft. (acres)	51-100 ft. (acres)	101-150 ft. (acres)	151-200 ft. (acres)
Basin #7 -- Johnson Cr, South Fork Johnson Cr, Hatchery Cr, Robertson Cr, Adams Cr	Large; 3.48 miles	Brush	---	0.0	0.0	0.0	0.0
		Conifer	≤12	4.2	3.0	2.4	2.5
			13-24	0.1	0.2	0.2	0.1
			25-49	0.0	0.0	0.0	0.0
			50-99	0.0	0.0	0.0	0.0
			≥100	3.7	5.9	8.9	10.9
		Conifer/ Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	0.3	1.1	1.9	2.3
			25-49	0.0	0.3	1.7	2.3
			50-99	2.1	1.5	1.5	1.4
			≥100	0.0	0.2	0.6	0.8
		Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	0.1	0.4	0.7	1.0
			25-49	24.9	21.7	15.7	11.0
			≥50	7.0	7.3	8.0	8.6
		Road	---	0.0	0.0	0.0	0.0
		Stream	---	0.0	0.0	0.0	0.0
	Medium; 2.75 miles	Brush	---	1.1	0.9	0.3	0.1
		Conifer	≤12	0.2	0.8	2.5	3.1
			13-24	0.0	0.0	0.0	0.0
			25-49	0.1	0.2	0.4	0.5
			50-99	0.6	1.4	2.0	2.4
			≥100	2.9	6.5	7.3	7.3
		Conifer/ Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	0.0	0.1	0.7	1.1
			25-49	0.0	1.3	2.2	2.2
			50-99	0.1	1.2	2.7	2.9
			≥100	0.0	0.0	0.0	0.0
		Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	5.4	3.3	0.6	0.3
			25-49	16.1	10.5	7.3	5.4
			≥50	6.6	5.8	5.1	4.7
		Road	---	0.0	0.0	0.0	0.0
		Stream	---	0.0	0.0	0.0	0.0
	Small; 3.39 miles	Brush	---	0.2	0.0	0.0	0.0
		Conifer	≤12	0.0	0.0	0.0	0.0
			13-24	0.1	1.7	2.8	3.1
			25-49	0.0	0.0	0.0	0.0
			50-99	2.1	3.5	4.2	4.5
			≥100	2.1	3.6	5.5	6.2
		Conifer/ Hardwood	≤12	0.2	1.3	1.6	1.5
			13-24	0.4	1.4	3.4	4.0
			25-49	0.0	0.4	1.0	1.5
			50-99	2.2	2.8	3.0	3.2
			≥100	0.4	2.4	3.4	3.4
		Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	5.4	2.7	0.5	0.4
			25-49	10.7	8.5	7.1	6.6
			≥50	16.2	11.0	6.4	4.0
		Road	---	0.0	0.0	0.0	0.0
		Stream	---	0.0	0.0	0.0	0.0

Basin #8

Basin	Stream Size Class, Length	Type	Age Class (yrs)	Distance from Stream Centerline (feet) 0-50 ft. (acres)	51-100 ft. (acres)	101-150 ft. (acres)	151-200 ft. (acres)
Basin #8 -- Palouse Cr, Larson Cr, Sullivan Cr, Kentuck Cr	Large; 3.07 miles	Brush	---	4.0	4.3	3.7	2.8
		Conifer	≤12	0.0	0.0	0.0	0.0
		Conifer	13-24	0.0	0.0	0.0	0.0
		Conifer	25-49	0.7	0.6	0.4	0.2
		Conifer	50-99	1.8	5.2	6.8	6.8
		Conifer	≥100	1.0	3.4	4.2	4.8
		Conifer/ Hardwood	≤12	0.0	0.0	0.0	0.0
		Conifer/ Hardwood	13-24	0.0	0.0	0.0	0.0
		Conifer/ Hardwood	25-49	0.9	1.0	1.3	2.0
		Conifer/ Hardwood	50-99	4.9	3.7	2.9	2.8
		Conifer/ Hardwood	≥100	1.0	1.6	1.2	0.9
		Hardwood	≤12	0.0	0.0	0.0	0.0
		Hardwood	13-24	0.6	0.6	0.8	0.9
		Hardwood	25-49	9.3	5.3	4.5	4.0
		Hardwood	≥50	13.2	11.8	10.8	10.1
		Road	---	0.0	0.0	0.0	0.0
		Stream	---	0.0	0.0	0.0	0.0
	Medium; 3.30 miles	Brush	---	0.0	0.0	0.0	0.0
		Conifer	≤12	0.0	0.0	0.0	0.0
		Conifer	13-24	0.0	0.0	0.1	0.4
		Conifer	25-49	0.0	0.0	0.0	0.0
		Conifer	50-99	0.0	0.4	0.9	1.2
		Conifer	≥100	0.7	4.7	6.8	7.8
		Conifer/ Hardwood	≤12	0.0	0.0	0.0	0.0
		Conifer/ Hardwood	13-24	0.1	0.8	1.8	2.1
		Conifer/ Hardwood	25-49	0.0	0.0	0.0	0.0
		Conifer/ Hardwood	50-99	3.5	7.0	9.3	9.9
		Conifer/ Hardwood	≥100	0.9	3.8	5.3	5.3
		Hardwood	≤12	0.0	0.0	0.0	0.0
		Hardwood	13-24	1.5	0.4	0.3	0.2
		Hardwood	25-49	9.7	2.6	0.2	0.1
		Hardwood	≥50	23.7	20.1	15.1	12.8
		Road	---	0.0	0.0	0.0	0.0
		Stream	---	0.0	0.0	0.0	0.0
	Small; 1.39 miles	Brush	---	0.0	0.0	0.0	0.0
		Conifer	≤12	0.0	0.0	0.0	0.0
		Conifer	13-24	0.1	1.9	2.2	2.1
		Conifer	25-49	0.0	0.0	0.0	0.1
		Conifer	50-99	1.3	2.4	2.4	2.7
		Conifer	≥100	2.2	4.0	4.9	5.1
		Conifer/ Hardwood	≤12	0.0	0.0	0.0	0.0
		Conifer/ Hardwood	13-24	0.3	2.3	4.0	4.0
		Conifer/ Hardwood	25-49	0.0	0.0	0.0	0.0
		Conifer/ Hardwood	50-99	0.0	0.0	0.0	0.0
		Conifer/ Hardwood	≥100	2.0	2.3	2.3	2.2
		Hardwood	≤12	0.0	0.0	0.0	0.0
		Hardwood	13-24	5.9	2.3	0.5	0.2
		Hardwood	25-49	0.4	0.5	0.0	0.0
		Hardwood	≥50	4.6	1.0	0.2	0.2
		Road	---	0.0	0.0	0.0	0.0
		Stream	---	0.0	0.0	0.0	0.0

Basin #9

Basin	Stream Size Class, Length	Type	Age Class (yrs)	Distance from Stream Centerline (feet)			
				0-50 ft. (acres)	51-100 ft. (acres)	101-150 ft. (acres)	151-200 ft. (acres)
Basin #9 -- Lower West Fork Millicoma R, Daggett Cr, Totten Cr, Schumacher Cr	Large; 9.61 miles	Brush	---	0.0	0.6	0.5	0.0
		Conifer	≤12	0.0	0.0	0.0	0.0
			13-24	0.0	0.1	1.2	1.6
			25-49	0.0	0.0	0.0	0.0
			50-99	2.5	5.1	4.5	4.2
			≥100	8.0	24.3	31.4	33.4
		Conifer/ Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	0.0	0.0	0.6	1.5
			25-49	0.0	0.0	0.0	0.0
			50-99	2.7	7.0	8.0	8.3
			≥100	13.0	32.8	32.9	31.3
		Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	0.7	1.5	1.8	2.3
			25-49	3.9	7.2	6.9	6.7
			≥50	11.4	21.7	16.5	13.2
		Road	---	0.0	0.0	0.0	0.0
		Stream	---	64.2	4.9	0.0	0.0
	Medium; 2.50 miles	Brush	---	1.0	0.8	0.5	0.4
		Conifer	≤12	0.0	0.0	0.0	0.0
			13-24	0.0	0.3	1.2	1.4
			25-49	0.0	0.3	0.6	0.7
			50-99	0.2	0.8	1.6	1.7
			≥100	1.5	2.6	2.9	2.9
		Conifer/ Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	0.0	0.4	0.6	0.7
			25-49	0.7	3.3	4.7	4.6
			50-99	1.3	1.3	1.5	1.6
			≥100	4.4	3.4	3.1	3.1
		Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	0.0	0.1	0.3	0.4
			25-49	14.6	10.1	6.4	5.8
			≥50	4.2	4.6	5.2	5.5
		Road	---	0.0	0.0	0.0	0.0
		Stream	---	0.0	0.0	0.0	0.0
	Small; 4.53 miles	Brush	---	0.5	0.1	0.0	0.0
		Conifer	≤12	0.0	0.0	0.0	0.0
			13-24	0.2	0.9	2.4	3.5
			25-49	0.4	1.0	2.1	2.3
			50-99	0.2	0.4	0.6	0.7
			≥100	0.9	3.1	3.4	3.4
		Conifer/ Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	1.0	3.5	4.5	4.2
			25-49	4.5	7.6	12.0	13.5
			50-99	0.2	0.6	1.4	1.4
			≥100	9.9	11.8	13.2	13.1
		Hardwood	≤12	0.0	0.2	0.2	0.2
			13-24	4.6	3.9	2.3	1.7
			25-49	21.0	13.4	7.1	5.1
			≥50	9.4	7.1	4.2	3.6
		Road	---	0.0	0.0	0.0	0.0
		Stream	---	0.5	0.0	0.0	0.0

Basin #10

Basin	Stream Size Class, Length	Type	Age Class (yrs)	Distance from Stream Centerline (feet)			
				0-50 ft. (acres)	51-100 ft. (acres)	101-150 ft. (acres)	151-200 ft. (acres)
Basin #10 -- Marlow Cr, Silver Cr, Glemn Cr, Howell Cr	Large; 2.38 miles	Brush	---	0.0	0.0	0.0	0.0
		Conifer	≤12	0.0	0.0	0.0	0.0
			13-24	0.0	0.0	0.0	0.0
			25-49	0.0	0.0	0.0	0.0
			50-99	2.7	4.6	7.3	8.0
			≥100	0.0	0.0	0.0	0.0
		Conifer/ Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	0.0	0.0	0.0	0.0
			25-49	0.3	0.7	1.9	2.8
			50-99	0.5	1.5	3.9	4.3
			≥100	0.0	0.0	0.0	0.0
		Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	0.0	0.0	0.0	0.0
			25-49	1.5	1.2	0.8	0.4
			≥50	24.7	21.0	14.2	11.7
		Road	---	0.0	0.0	0.0	0.0
		Stream	---	0.0	0.0	0.0	0.0
	Medium; 4.67 miles	Brush	---	0.0	0.0	0.0	0.0
		Conifer	≤12	0.0	0.0	0.0	0.0
			13-24	0.0	1.5	1.7	1.7
			25-49	0.0	0.0	0.1	0.1
			50-99	0.1	1.0	1.7	1.8
			≥100	0.0	0.0	0.0	0.0
		Conifer/ Hardwood	≤12	0.1	2.4	5.9	6.5
			13-24	1.1	5.8	11.1	11.6
			25-49	1.5	4.2	7.3	8.5
			50-99	0.1	2.3	5.9	6.5
			≥100	9.0	8.0	5.4	4.8
		Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	12.5	7.2	2.2	1.6
			25-49	12.6	7.7	3.1	1.8
			≥50	20.5	16.8	11.8	10.2
		Road	---	0.0	0.0	0.0	0.0
		Stream	---	0.0	0.0	0.0	0.0
	Small; 2.91 miles	Brush	---	0.0	0.0	0.0	0.0
		Conifer	≤12	0.6	2.0	2.5	2.6
			13-24	0.3	0.7	0.7	0.7
			25-49	0.1	0.2	0.5	0.6
			50-99	0.3	1.8	3.1	3.6
			≥100	1.1	1.2	1.9	2.4
		Conifer/ Hardwood	≤12	0.2	1.1	2.8	4.0
			13-24	0.0	0.0	0.0	0.0
			25-49	0.7	2.3	5.0	6.4
			50-99	2.5	4.0	3.8	4.0
			≥100	2.2	2.0	1.2	0.1
		Hardwood	≤12	2.1	0.6	0.0	0.0
			13-24	0.3	0.2	0.2	0.2
			25-49	14.7	9.7	4.3	2.7
			≥50	6.8	5.6	5.1	5.0
		Road	---	0.0	0.0	0.0	0.0
		Stream	---	0.0	0.0	0.0	0.0

Basin #11

Basin	Stream Size Class, Length	Type	Age Class (yrs)	Distance from Stream Centerline (feet) 0-50 ft. (acres)	51-100 ft. (acres)	101-150 ft. (acres)	151-200 ft. (acres)
Basin #11 -- Upper West Fork Millicoma R, Elk Cr, Fish Cr, Kelly Cr, Panther Cr, Cougar Cr	Large; 12.77 miles	Brush	---	2.3	1.7	1.5	0.9
		Conifer	≤12	0.0	0.0	0.0	0.0
			13-24	0.0	0.7	1.7	2.0
			25-49	1.4	1.7	2.1	2.8
			50-99	0.0	0.0	0.0	0.0
			≥100	22.5	31.4	45.4	52.3
		Conifer/ Hardwood	≤12	0.0	0.0	0.5	1.6
			13-24	1.4	2.8	6.1	7.0
			25-49	2.3	3.4	2.8	2.8
			50-99	0.0	0.0	0.0	0.0
			≥100	44.2	44.0	45.0	42.4
		Hardwood	≤12	0.0	0.0	0.1	0.3
			13-24	12.7	11.6	8.7	9.1
			25-49	57.1	46.1	31.0	20.0
			≥50	14.3	11.0	5.7	2.6
		Road	---	0.0	0.0	0.0	0.0
		Stream	---	0.0	0.0	0.0	0.0
	Medium; 10.44 miles	Brush	---	4.8	3.4	1.6	0.7
		Conifer	≤12	0.0	0.0	0.0	0.0
			13-24	0.4	4.6	10.3	12.0
			25-49	0.1	3.9	6.6	7.2
			50-99	1.2	3.5	4.1	3.6
			≥100	16.8	21.3	22.4	21.1
		Conifer/ Hardwood	≤12	0.0	1.2	6.2	9.0
			13-24	4.6	8.7	13.3	15.1
			25-49	3.8	9.6	11.8	10.7
			50-99	1.2	3.3	4.7	4.6
			≥100	21.7	24.6	23.3	21.5
		Hardwood	≤12	0.0	0.0	0.1	0.3
			13-24	10.8	8.8	6.1	4.0
			25-49	51.9	26.7	8.2	4.2
			≥50	11.6	5.6	2.3	1.4
		Road	---	0.0	0.0	0.0	0.0
		Stream	---	0.0	0.0	0.0	0.0
	Small; 7.88 miles	Brush	---	1.2	0.9	0.1	0.0
		Conifer	≤12	0.6	2.3	3.6	4.3
			13-24	1.3	5.0	7.1	7.3
			25-49	3.4	8.1	10.0	10.4
			50-99	7.3	6.6	6.4	6.5
			≥100	11.8	14.8	17.8	18.7
		Conifer/ Hardwood	≤12	0.6	0.8	1.3	2.3
			13-24	1.3	3.0	3.8	4.0
			25-49	4.1	5.2	6.1	6.3
			50-99	0.4	0.7	0.7	0.8
			≥100	11.8	15.0	16.4	14.9
		Hardwood	≤12	0.4	1.4	1.8	1.9
			13-24	14.3	5.9	2.0	1.0
			25-49	22.0	13.0	7.7	6.5
			≥50	5.4	2.8	0.2	0.0
		Road	---	0.0	0.0	0.0	0.0
		Stream	---	0.0	0.0	0.0	0.0

Basin #12

Basin	Stream Size Class, Length	Type	Age Class (yrs)	Distance from Stream Centerline (feet)			
				0-50 ft. (acres)	**51-100 ft. (acres)**	**101-150 ft. (acres)**	**151-200 ft. (acres)**
Basin #12 -- Middle West Fork Millicoma R, Trout Cr, Beaver Cr, Shake Cr, Buck Cr, Joe's Cr, Otter Cr, Deer Cr, Knife Cr	Large; 14.45 miles	Brush	---	0.0	0.0	0.0	0.0
		Conifer	≤12	0.0	0.0	0.0	0.0
			13-24	0.0	0.1	0.5	0.5
			25-49	0.5	1.2	0.3	0.2
			50-99	0.0	0.0	0.0	0.0
			≥100	20.3	23.6	28.4	28.8
		Conifer/ Hardwood	≤12	0.0	0.1	1.1	1.5
			13-24	7.1	9.3	11.2	11.1
			25-49	3.3	4.0	4.8	4.9
			50-99	1.1	1.8	2.1	2.3
			≥100	53.4	58.4	62.3	60.8
		Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	9.5	9.4	6.9	8.3
			25-49	17.8	15.4	11.7	10.3
			≥50	50.0	50.9	41.2	36.1
		Road	---	0.0	0.0	0.0	0.0
		Stream	---	16.0	0.6	0.0	0.0
	Medium; 8.97 miles	Brush	---	0.0	0.0	0.0	0.0
		Conifer	≤12	0.0	0.0	0.2	0.7
			13-24	0.0	0.0	0.0	0.0
			25-49	0.7	4.4	6.4	6.6
			50-99	0.0	0.0	0.0	0.0
			≥100	2.5	2.8	3.0	3.3
		Conifer/ Hardwood	≤12	0.0	0.0	1.3	2.9
			13-24	2.2	7.1	13.1	14.4
			25-49	4.3	9.2	11.7	11.1
			50-99	0.7	2.6	3.7	3.8
			≥100	34.2	41.1	42.9	42.0
		Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	14.1	8.4	3.9	3.5
			25-49	24.6	15.4	8.5	5.1
			≥50	21.7	12.1	6.0	4.7
		Road	---	0.0	0.0	0.0	0.0
		Stream	---	0.0	0.0	0.0	0.0
	Small; 7.32 miles	Brush	---	1.9	0.9	0.0	0.0
		Conifer	≤12	0.0	0.0	0.0	0.0
			13-24	9.9	13.1	13.9	11.7
			25-49	0.6	2.6	4.3	4.6
			50-99	0.0	0.0	0.0	0.0
			≥100	12.5	15.7	17.4	17.7
		Conifer/ Hardwood	≤12	0.0	0.3	3.2	5.4
			13-24	3.2	4.0	5.6	7.2
			25-49	5.2	7.3	8.1	8.4
			50-99	0.1	0.7	1.3	1.6
			≥100	17.3	17.7	15.8	14.8
		Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	8.6	6.1	4.2	3.0
			25-49	9.9	3.8	1.2	0.6
			≥50	13.4	10.1	6.7	10.1
		Road	---	0.0	0.0	0.0	0.0
		Stream	---	0.0	0.0	0.0	0.0

Basin #13

Basin	Stream Size Class, Length	Type	Age Class (yrs)	Distance from Stream Centerline (feet) 0-50 ft. (acres)	51-100 ft. (acres)	101-150 ft. (acres)	151-200 ft. (acres)
Basin #13. Lake Cr, Surprise Cr, Bickford Cr, Baker Cr, Salander Cr	Large; 0.09 miles	Brush	---	0.0	0.0	0.0	0.0
		Conifer	≤12	0.0	0.0	0.0	0.0
			13-24	0.0	0.0	0.0	0.0
			25-49	0.0	0.0	0.0	0.0
			50-99	0.0	0.0	0.0	0.0
			≥100	0.0	0.0	0.0	0.0
		Conifer/ Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	0.0	0.0	0.0	0.0
			25-49	0.0	0.0	0.0	0.0
			50-99	0.0	0.1	0.7	1.4
			≥100	0.0	0.0	0.0	0.0
		Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	0.0	0.0	0.0	0.0
			25-49	0.0	0.1	0.4	0.4
			≥50	1.2	2.1	2.5	2.7
		Road	---	0.0	0.0	0.0	0.0
		Stream	---	0.0	0.0	0.0	0.0
	Medium; 2.22 miles	Brush	---	0.0	0.0	0.0	0.0
		Conifer	≤12	0.0	0.0	0.0	0.0
			13-24	0.0	0.0	0.0	0.0
			25-49	0.0	0.1	1.5	2.2
			50-99	0.0	0.2	0.8	1.0
			≥100	0.1	2.7	6.1	6.7
		Conifer/ Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	0.0	0.0	0.0	0.0
			25-49	3.6	3.7	3.4	3.0
			50-99	2.3	3.3	4.4	4.7
			≥100	0.0	0.5	2.3	3.5
		Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	0.0	0.0	0.0	0.0
			25-49	6.2	5.3	3.9	3.2
			≥50	0.0	0.0	0.0	0.0
		Road	---	0.0	0.0	0.0	0.0
		Stream	---	0.0	0.0	0.0	0.0
	Small; 1.56 miles	Brush	---	0.0	0.0	0.0	0.0
		Conifer	≤12	0.0	0.0	0.0	0.0
			13-24	0.0	0.0	0.0	0.0
			25-49	11.6	13.1	13.6	13.6
			50-99	0.0	0.0	0.0	0.0
			≥100	0.0	0.0	0.0	0.0
		Conifer/ Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	0.0	0.0	0.0	0.0
			25-49	0.2	1.7	2.6	2.5
			50-99	0.0	0.0	0.0	0.0
			≥100	0.0	0.0	0.0	0.0
		Hardwood	≤12	0.0	0.0	0.0	0.0
			13-24	1.3	1.2	0.8	0.6
			25-49	5.2	2.1	1.1	1.0
			≥50	0.0	0.0	0.0	0.0
		Road	---	0.0	0.0	0.0	0.0
		Stream	---	0.0	0.0	0.0	0.0

Appendix B
Current and Modeled Future Large Wood Volume for Fish-bearing Streams

Note: This list includes current and modeled large wood volume for fish-bearing streams at various time intervals up to 300 years from the present. Named stream segments are labeled sequentially in a downstream direction (M1, M2, etc) and are summed by 1-mile increments, starting at the most upstream end of fish use (or the property line in some cases). The most downstream segment is usually less than 1-mile long, stopping at the Forest property line. Unnamed tributaries are labeled sequentially (T1, T2, etc) in order of most upstream to most downstream, and are less than 1-mile long, except for tributary #1 of Scholfield Creek.

Stream	Segment	Large Wood Volume in Stream Segment (cubic feet per 100 feet of stream)				
		0 years	50 years	100 years	200 years	300 years
Adams	M1	230	383	375	385	426
Alder	M1	150	149	140	168	185
Alder Fork	M1	143	242	241	276	368
Alder Fork	M2	79	153	145	142	167
Alder Fork	T1	120	158	144	149	189
Alder Gulch	M1	120	291	311	356	462
Barn Gulch	M1	120	273	281	327	443
Beaver	M1	153	244	261	324	356
Beaver	M2	89	281	294	336	456
Benson	M1	124	177	172	181	214
Benson	M2	89	254	257	273	322
Benson	M3	73	202	204	224	281
Benson	M4	211	198	178	190	248
Benson	T1	119	156	181	212	214
Benson	T2	119	274	372	484	510
Benson	T3	119	237	239	267	349
Benson	T4	119	223	222	255	334
Benson	T5	119	303	304	296	311
Bickford	M1	95	262	315	395	450
Bickford	M2	95	154	168	198	215
Bickford	T1	95	470	633	808	836
Bickford	T2	95	139	145	152	154
Big	M1	158	216	203	222	274
Big	M2	136	242	240	271	359
Big	M3	80	118	101	87	88
Big	M4	15	57	53	47	47
Big	M5	11	187	202	231	313
Big	T1	120	373	382	393	444
Big	T2	390	379	358	388	454
Big	T3	120	555	582	597	644
Big	T4	120	110	84	63	53
Big	T5	120	229	251	318	405
Big	T6	120	117	110	137	156
Big	T7	120	161	155	209	244
Buck	M1	115	510	550	610	730
Buck	T1	115	578	626	684	730
Cedar	M1	169	330	340	418	554

Stream	Segment	Large Wood Volume in Stream Segment (cubic feet per 100 feet of stream)				
		0 years	50 years	100 years	200 years	300 years
Charlotte	M1	658	692	677	707	749
Charlotte	M2	206	281	268	278	323
Charlotte	T1	206	307	299	346	383
Cougar	M1	157	389	419	465	505
Cougar	M2	157	258	289	348	399
Cougar	M3	157	258	303	368	396
Cougar	T1	157	697	776	828	881
Cougar	T2	157	652	756	826	872
Cougar	T3	157	195	210	260	293
Cougar	T4	157	582	678	761	800
Cougar	T5	157	456	502	571	612
Cougar	T6	157	175	202	249	301
Cougar	T7	157	628	688	767	819
Crane	M1	379	571	565	597	663
Daggett	M1	115	194	208	275	319
Dean	M1	79	212	220	257	314
Dean	M2	37	265	280	304	378
Dean	M3	13	78	84	89	100
Dean	T1	79	281	299	335	378
Dean	T2	79	312	337	379	440
Dean	T3	79	334	350	375	426
Dean	T4	79	230	242	275	341
Dean	T5	79	300	311	321	363
Dean	T6	79	154	152	173	196
Deer	M1	165	328	332	381	467
Deer	M2	134	213	212	253	307
Deer	M3	108	183	177	199	246
Deer	M4	108	221	221	247	327
Deer	T1	70	288	324	404	512
Deer	T2	259	357	357	428	580
Deer	T3	192	243	234	276	357
Eleven	M1	115	169	171	211	252
Elk	M1	98	270	284	307	347
Elk	M2	98	314	335	381	433
Elk	M3	98	290	300	330	428
Elk	M4	98	256	266	299	394
Elk	M5	79	181	180	194	224
Elk	M6	83	336	356	397	507
Elk	M7	91	210	204	202	224
Elk	M8	79	397	416	430	466
Elk	M9	79	409	429	437	469
Elk	T1	98	262	318	417	481
Elk	T2	98	298	366	453	525
Elk	T3	76	220	227	257	328
Elk	T4	76	253	288	404	480
Fish	M1	223	199	184	219	267
Fish	M2	223	307	306	340	399
Fish	M3	223	356	352	373	419
Fish	T1	223	366	390	428	458
Fish	T2	223	302	320	420	506

Stream	Segment	Large Wood Volume in Stream Segment (cubic feet per 100 feet of stream)				
		0 years	50 years	100 years	200 years	300 years
Footlog	M1	121	237	238	264	329
Footlog	M2	34	332	364	417	544
Glenn	M1	169	278	282	333	402
Glenn	M2	169	125	101	102	106
Hatchery	M1	230	126	89	79	75
Hatchery	T1	230	171	164	223	243
Hidden Valley	M1	338	369	348	395	493
Howell	M1	169	168	152	184	225
Howell	T1	169	190	186	241	276
Joe's	M1	54	302	348	413	486
Joe's	M2	29	308	351	426	560
Joe's	T2	60	272	295	370	490
Johanneson	M1	395	431	408	437	509
Johanneson	M2	142	282	285	298	338
Johanneson	T1	613	615	582	636	783
Johnson	M1	77	328	346	350	375
Johnson	M2	90	259	259	255	269
Johnson	M3	104	145	133	132	138
Johnson	M4	40	70	61	51	46
Johnson	M5	40	9	6	6	5
Johnson	T1	77	257	294	341	371
Johnson	T2	230	143	127	165	189
Kelly	M1	291	343	324	359	432
Kelly	M2	291	330	334	409	451
Knife	M1	123	230	243	300	382
Knife	M2	123	343	361	424	584
Knife	M3	123	335	344	371	456
Larson	M1	95	149	145	147	166
Larson	M2	87	182	190	211	256
Luder	M1	128	440	475	500	542
Luder	M2	310	418	401	430	500
Luder	T1	147	374	392	411	446
Luder	T2	383	295	257	306	390
Marlow	M1	224	161	141	145	170
Marlow	M2	204	154	131	122	123
Marlow	M3	108	194	207	226	251
Marlow	M4	108	213	228	237	248
Marlow	T1	224	193	175	170	167
Marlow	T2	224	228	229	253	291
Marlow	T3	108	212	225	250	300
Mill	M1	31	152	172	211	270
Mill	M2	31	83	83	88	90
Mill	M3	31	190	209	232	293
Mill	M4	31	261	291	332	429
Mill	M5	31	149	168	196	262
Mill	M6	31	167	190	243	320
Mill	M7	31	191	208	232	299
Mill	M8	31	222	247	282	357
Mill	M9	31	102	120	152	229
Miller	M1	8	145	166	190	193

Stream	**Segment**	**Large Wood Volume in Stream Segment (cubic feet per 100 feet of stream)**				
		0 years	**50 years**	**100 years**	**200 years**	**300 years**
Murphy	M1	73	238	248	277	355
Murphy	M2	75	128	126	130	148
Murphy	T1	64	244	256	272	303
Murphy	T2	64	136	137	145	173
Noble	M1	501	362	311	334	424
Otter	M1	105	210	211	249	311
Palouse	M1	390	325	301	335	394
Palouse	M2	390	290	247	254	289
Palouse	M3	374	291	268	279	308
Palouse	M4	476	283	249	270	310
Palouse	M5	423	151	101	105	107
Palouse	T1	392	381	350	366	433
Panther	M1	213	338	358	425	538
Panther	M2	184	278	274	319	417
Panther	M3	137	316	351	428	526
Panther	T1	213	402	416	494	692
Panther	T2	213	350	358	452	594
Piledriver	M1	224	201	205	243	276
Roberts	M1	327	262	233	256	280
Roberts	M2	210	298	292	318	370
Roberts	M3	115	217	210	214	254
Roberts	T1	230	363	333	350	425
Roberts	T2	230	169	141	188	218
Roberts	T3	367	319	303	297	312
Roberts	T4	230	150	120	114	135
S Frk Johnson	M1	217	204	194	215	234
S Frk Johnson	M2	164	167	157	162	191
S Frk Johnson	T1	737	575	506	517	566
S Frk Johnson	T2	230	264	270	285	302
S Frk Johnson	T3	230	161	129	118	144
Salander	M1	95	245	251	262	303
Salander	M2	95	106	84	64	61
Salmon Gulch	M1	120	89	66	50	37
Scholfield	M1	280	316	305	359	499
Scholfield	M2	280	297	280	317	400
Scholfield	M3	165	234	227	255	315
Scholfield	M4	66	137	131	143	147
Scholfield	T1.1	280	335	323	376	504
Scholfield	T1.2	280	326	315	348	420
Schumacher	M1	115	302	311	341	420
Schumacher	M2	115	464	493	550	688
Shake	M1	115	213	208	225	293
Skunk	M1	379	294	257	281	378
Sullivan	M1	111	274	308	361	421
Totten	M1	115	169	171	191	220
Totten	M2	115	241	254	272	293
Totten	T1	115	188	193	211	228
Trout	M1	99	214	243	299	352
Trout	M2	74	216	248	297	336
Trout	T1	103	216	236	308	371

Stream	Segment	Large Wood Volume in Stream Segment (cubic feet per 100 feet of stream)				
		0 years	50 years	100 years	200 years	300 years
W Frk Glenn	M1	169	215	222	287	346
W Frk Millicoma	M1	167	288	292	315	345
W Frk Millicoma	M2	167	335	349	397	504
W Frk Millicoma	M3	68	216	220	222	248
W Frk Millicoma	M4	50	380	416	481	640
W Frk Millicoma	M5	50	369	392	418	476
W Frk Millicoma	M6	28	526	568	599	678
W Frk Millicoma	M7	22	300	331	390	522
W Frk Millicoma	M8	22	292	319	369	432
W Frk Millicoma	M9	22	371	398	423	494
W Frk Millicoma	M10	22	285	310	344	410
W Frk Millicoma	M11	22	179	185	198	251
W Frk Millicoma	M12	22	472	515	564	686
W Frk Millicoma	M13	22	399	435	478	588
W Frk Millicoma	M14	22	185	202	228	269
W Frk Millicoma	M15	22	89	97	107	140
W Frk Millicoma	M16	22	187	208	239	311
W Frk Millicoma	M17	31	238	263	288	351
W Frk Millicoma	M18	31	353	393	433	519
W Frk Millicoma	M19	31	235	271	305	364
W Frk Millicoma	M20	31	168	190	220	279
W Frk Millicoma	M21	31	263	290	325	405
W Frk Millicoma	M22	31	155	176	212	278
W Frk Millicoma	M23	31	203	237	293	390
W Frk Millicoma	M24	31	278	329	382	464
W Frk Millicoma	M25	31	396	440	477	549
W Frk Millicoma	M26	31	164	179	213	280
W Frk Millicoma	T1	167	214	248	294	297
W Frk Millicoma	T2	115	381	418	445	483
W Frk Millicoma	T3	115	338	350	434	586
W Frk Millicoma	T4	115	195	204	232	294
W Frk Millicoma	T5	115	343	362	387	427
W Frk Millicoma	T6	115	524	614	731	798
W Frk Millicoma	T7	115	526	646	809	855
W Frk Millicoma	T8	115	263	305	396	461
W Frk Millicoma	T9	115	316	345	418	540
W Frk Millicoma	T10	157	747	793	815	870
W Frk Millicoma	T11	125	312	320	352	448
W Frk Millicoma	T12	115	160	152	153	166
W Frk Millicoma	T13	115	219	229	265	353
W Frk Millicoma	T14	115	292	358	460	510
W Frk Millicoma	T15	115	386	414	494	692
W Frk Millicoma	T16	115	165	172	211	244
W Frk Millicoma	T17	115	243	246	275	369
Wilkins	M1	150	240	226	217	222
Y	M1	224	168	147	150	156
Y	T1	224	213	248	350	371

Appendix C
Aquatic Habitat Restoration Projects, 1995-2002
(Map Numbers refer to Map 8.4)

Coos Region

Map No.	Watershed Region	Stream Name	Project No.	Year	Project Description
1	Coos	Palouse Cr.	431	1996	Instream habitat enhancement: off-channel ponds (3 ponds each 350 cu yds), riparian tree planting, riparian fencing
2	Coos	Palouse Cr.	1012	1997	Instream large wood placement, rootwad placement
3	Coos	Cougar Cr.	1013	1997	Instream large wood placement
4	Coos	Fish Cr.	1014	1997	Instream large wood placement
5	Coos	Y Cr.	1027	1997	Instream habitat enhancement: repair of existing rock weirs
6	Coos	Marlow Cr., U tribs of	1028	1997	Fish passage improvements: 1 culvert w/ rock weirs installed below outlet
7	Tenmile Lakes	Big Cr.	1229	1996	Off-channel habitat; riparian tree planting, riparian fencing
8	Tenmile Lakes	Big Cr.	1230	1996	Hardwood conversion; upland erosion control; road survey
9	Coos	Deer Cr.	980026	1998	Instream large wood placement; road survey, road vacated, peak flow passage improvements
10	Coos	Knife Cr.	980027	1998	Instream large wood placement; road survey
11	Coos	Fish Cr.	980028	1998	Instream large wood placement
12	Coos	Cougar Cr.	980029	1998	Instream large wood placement, fish passage improve: 1 culvert replaced
13	Coos	Elk Cr.	980030	1998	Instream large wood placement
14	Coos	Elk Cr.	980031	1998	Road closure; fish passage improvements: 2 culverts removed
15	Coos	Kelly Cr.	980032	1998	Instream large wood placement
16	Coos	Panther Cr.	980033	1998	Instream large wood placement
17	Coos	West Fork Millicoma R.	980034	1998	Instream large wood placement
18	Coos	Marlow Cr.	980035	1998	Fish passage improvements: reconnected historic creek oxbow w/2 new culverts adding 600 feet of stream habitat
19	Coos	Palouse Cr., trib of	980037	1998	Instream habitat enhancement: rootwad placement
20	Coos	Palouse Cr., trib of	980038	1998	Fish passage improvements: 1 culvert replaced
21	Coos	Fish Cr., trib of	980106	1997	Voluntary riparian tree retention
22	Coos	Old Mill Cr., trib of	980107	1997	Voluntary riparian tree retention
23	Coos	Knife Cr., tribs of	980108	1997	Voluntary riparian tree retention
24	Coos	Knife Cr., tribs of	980109	1997	Voluntary riparian tree retention

Map No.	Watershed Region	Stream Name	Project No.	Year	Project Description
25	Coos	Deer Cr., trib of	980110	1997	Voluntary riparian tree retention
26	Coos	Deer Cr., trib of	980111	1997	Voluntary riparian tree retention
27	Coos	Panther Cr., trib of	980112	1997	Voluntary riparian tree retention
28	Coos	West Fork Millicoma R., headwater channel of	980113	1996	Voluntary riparian tree retention
29	Coos	Elk Cr., trib of	980114	1996	Voluntary riparian tree retention
30	Coos	Trout Cr., trib of	980115	1996	Voluntary riparian tree retention
31	Coos	Beaver Cr., tribs A & B of	980116	1996	Voluntary riparian tree retention
32	Coos	Cedar Cr.	980117	1996	Voluntary riparian tree retention
33	Tenmile Lakes	Benson Cr., trib of	980118	1996	Voluntary riparian tree retention
34	Tenmile Lakes	Benson Cr., trib of	980119	1995	Voluntary riparian tree retention
35	Tenmile Lakes	Benson Cr., tribs A & B of	980120	1996	Voluntary riparian tree retention
36	Coos	Old Mill Pond Cr	980217	1997	Fish passage improvements: 1 culvert replaced
37	Coos	West Fork Millicoma R, trib of	980220	1997	Peak flow passage improvements
38	Coos	Marlow Cr.	990030	1999	Instream habitat enhancement: weirs
39	Coos	Kelly Cr.	990032	1999	Instream large wood placement
40	Coos	West Fork Millicoma R.	990033	1999	Instream habitat enhancement: anchored structures, deflectors, 'V' structure, boulder placement
41	Coos	Deer Cr.	990034	1999	Instream habitat enhancement: anchored structures, deflectors, boulder placement
42	Coos	Elk Cr.	990035	1999	Instream habitat enhancement: boulder placement
43	Coos	Y Cr.	990036	1999	Fish passage improve: culvert replaced and weir installed below outlet
44	Coos	Crane Cr.	990037	1999	Fish passage improve: culvert replaced and weir installed below outlet
45	Coos	Elk Cr., trib of	990038	1999	Fish passage improve: culvert replaced and weir installed below outlet
46	Coos	Cougar Cr., trib of	990039	1999	Fish passage improve: culvert replaced and weir installed below outlet
47	Coos	Cougar Cr.	990040	1999	Instream large wood placement, natural boulder placement, boulder deflector
48	Coos	West Fork Millicoma R	990041	1999	Instream large wood placement, weirs, deflectors
49	Coos	West Fork Millicoma R, trib of	990051	1998	Voluntary Riparian tree retention
50	Coos	Park Cr.	990053	1998	Voluntary Riparian tree retention; surface drainage improvements
51	Coos	Park Cr.	990054	1999	Voluntary Riparian tree retention; surface drainage improvements
52	Coos	Trout Cr.	990055	1998	Voluntary Riparian tree retention; surface drainage improvements
53	Coos	Buck Cr.	990056	1998	Voluntary Riparian tree retention; surface drainage improvements, road closed, road relocated

Map No.	Watershed Region	Stream Name	Project No.	Year	Project Description
54	Coos	West Fork Millicoma R, trib of	990057	1999	Voluntary Riparian tree retention; surface drainage improvements
55	Coos	Kelly Cr.	990058	1999	Voluntary Riparian tree retention; surface drainage improve, road closed
56	Coos	Howell Cr. and W Fk Glenn Cr.	990059	1999	Voluntary Riparian tree retention
57	Coos	Skunk Cr. and Elk Cr.	990061	1999	Voluntary Riparian tree retention
58	Umpqua	Miller Cr.	990162	1999	Instream large wood placement
59	Coos	East Cougar Cr./Cougar Cr.	990486	1998	Voluntary Riparian tree retention
60	Coos	Marlow Cr/Y Cr.	990487	1999	Voluntary Riparian tree retention
61	Coos	West Cougar Cr.	990488	1998	Voluntary Riparian tree retention
62	Coos	Cedar Cr.	990489	1998	Voluntary Riparian tree retention
63	Coos	Kelly Cr.	990490	1999	Voluntary Riparian tree retention; surface drainage improvements
64	Coos	Daggett Cr., trib of	990491	1999	Voluntary Riparian tree retention
65	Coos	West Fork Millicoma R, trib of	990492	1999	Voluntary Riparian tree retention
66	Coos	West Fork Millicoma R, trib of	990493	1999	Voluntary Riparian tree retention
67	Umpqua	Cold Cr.	990630	1999	Voluntary Riparian tree retention
68	Coos	Beaver Cr.	991052	2000	Voluntary Riparian tree retention
69	Tenmile Lakes	House Gulch Cr.	20000001	2000	Fish passage improvements: 1 culvert replaced with bridge
70	Tenmile Lakes	Johnson Cr.	20000005	2000	Road vacated
71	Tenmile Lakes	Johnson Cr.	20000006	2000	Riparian tree planting
72	Coos	Elk Cr.	20000009	2000	Fish passage improvements: 1 culvert replaced with weir/baffle culvert, 1 culvert with weirs installed below outlet
73	Coos	Skunk Cr.	20000010	2000	Fish passage improvements: 1 culvert replaced with weir/baffle culvert, 1 culvert with weirs installed below outlet
74	Coos	Elk Cr., trib of	20000011	2000	Fish passage improvements: 1 culvert replaced with weir/baffle culvert, 1 culvert with weirs installed below outlet
75	Coos	Elk Cr.	20000012	2000	Fish passage improvements: 1 diversion modified
76	Coos	Deer Cr.	20000025	2000	Instream large wood placement; Voluntary Riparian tree retention; surface drainage improvements
77	Coos	Otter Cr.	20000026	2000	Instream large wood placement; Voluntary Riparian tree retention; surface drainage improvements
78	Coos	Cougar Cr., trib of	20000027	1999	Voluntary riparian tree retention
79	Umpqua	Salander Cr.	20000028	1999	Voluntary riparian tree retention
80	Coos	Shake Cr.	20000029	2000	Voluntary riparian tree retention; surface drainage improvements
81	Coos	Shake Cr., trib of	20000030	2000	Voluntary riparian tree retention; surface drainage improvements
82	Coos	Knife Cr.	20000031	2000	Voluntary riparian tree retention; road closure

Map No.	Watershed Region	Stream Name	Project No.	Year	Project Description
83	Coos	Panther Cr.	20000032	2000	Voluntary riparian tree retention
84	Coos	West Fork Millicoma R, trib of	20000033	2000	Voluntary riparian tree retention; surface drainage improvements
85	Coos	Beaver Cr.	20000034	2000	Voluntary riparian tree retention; surface drainage improvements
86	Coos	West Fork Millicoma R.	20000035	1999	Voluntary riparian tree retention
87	Coos	Panther Cr.	20000036	1999	Voluntary riparian tree retention
88	Coos	West Fork Millicoma R., trib of	20000037	2000	Voluntary riparian tree retention
89	Coos	West Fork Millicoma R., trib of	20000038	2000	Voluntary riparian tree retention
90	Umpqua	Bickford and Baker Cr.	20000039	2000	Voluntary riparian tree retention
91	Coos	Deer Cr., trib of	20000040	2000	Voluntary riparian tree retention
92	Coos	Joes Cr. and trib	20000041	2000	Instream large wood placement; Voluntary Riparian tree retention; surface drainage improvements, road closure
93	Umpqua	Charlotte Cr.	20000105	2000	Instream large wood placement
94	Coos	Fish Cr., trib of	20011075	2001	Fish passage improvements: 1 culvert replaced
95	Coos	Hidden Cr.	20011076	2001	Fish passage improvements: 1 culvert replaced
96	Coos	Hidden Cr.	20011077	2001	Instream large wood placement
97	Coos	Fish Cr.	20011078	2001	Instream large wood placement
98	Coos	Knife Cr.	20020046	2002	Instream large wood placement
99	Coos	Palouse Cr., tribs of	20020047	2002	Fish passage improvements: 2 culverts removed and not replaced
100	Tenmile Lakes	Johnson Cr.	20020435	2001	Riparian tree planting
101	Tenmile Lakes	Big Cr.	20020448	2001	Fiparian tree planting
102	Coos	Elk Cr.	20020568	2001	Fish passage improvements: 1 fish ladder improved
103	Coos				Weir and boulder placements
104	Coos				Weir and boulder placements
105	Coos				Large woody debris placement
106	Coos				Large woody debris placement
107	Coos				Large woody debris placement
108	Coos				Large woody debris placement
109	Coos				Large woody debris placement
110	Coos				Road decommission

Data from the Oregon Watershed Enhancement Board's Watershed Restoration Database and the Coos Watershed Association.

Appendix D
Aquatic Habitat Inventory Summaries

Coos Region

Name	Reach	Stream Size	Major Reach Fish Bearing	Year of Survey	Season of Survey	Total Length (mi.)	ACW	Avg. Gradient	Complex Pools (#/mi.)
Beaver Creek	1	M	Yes	2001	S	0.94	19	6.4	10.9
Beaver Creek	2	M	Yes	2001	S	0.59	11	5.6	12.1
Beaver Creek	3	S	No	2001	S	0.62	8	8.9	8.9
Cougar Creek	1	M/S	Yes	1996	W	2.38	25	2.7	2.7
Crane Creek	1	M/S	Yes	1994	S	1.05	14	4.2	
Deer Creek	1	L	Yes	1997	W	2.09	39	1.2	2.3
Deer Creek	2	M	Yes	1997	W	1.13	23	2	0.8
Deer Creek	3	S	Yes	1997	W	0.49	13	6.3	0.0
Deer Creek Trib. 1	1	S	Yes	2001	W	1.03	12	3.5	2.9
Deer Creek Trib. 2	1	M	Yes	2001	W	0.54	17	3.2	25.1
Deer Creek Trib. 2	2	S	No	2001	W	0.36	12	5	0.0
Elk Creek	1	L	Yes	1997	W	1.70	46	1.6	1.1
Elk Creek	2	L	Yes	1997	W	1.16	44	1.8	2.6
Elk Creek	3	L	Yes	1997	W	1.34	35	1.2	1.4
Elk Creek	4	L/M	Yes	1997	W	4.52	31	1.7	1.4
Fish Creek	1	L/M	Yes	1994	S	2.80	16	3.7	
Hidden Valley Creek	1	M/S	Yes	1994	S	1.21	13	6.9	
Joes Creek	1	M	Yes	2002	S	0.36	12	1.2	0
Joes Creek	2	M	Yes	2002	S	0.33	16	4.9	5.8
Joes Creek	3	M/S	Yes	2002	S	0.31	10	2.1	0
Joes Creek	4	S	Yes	2002	S	0.30	11	3	3.1
Joes Creek	5	S	Yes	2002	S	0.49	7	8.1	0
Kelly Creek	1	M/S	Yes	1994	S	1.35	12	6.4	

Name	Reach	Stream Size	Major Reach Fish Bearing	Year of Survey	Season of Survey	Total Length (mi.)	ACW	Avg. Gradient	Complex Pools (#/mi.)
Knife Creek	1	L/M	Yes	1997	W	2.22	27	3.1	0.6
Larson Creek	1	M	Yes	2001	S	0.73	18	2.8	6.3
Larson Creek	2	M/S	No	2001	S	1.40	13	8.7	4.5
Marlow Creek	1	L	Yes	2001	S	1.51	29	2.3	15.0
Marlow Creek	2	L/M	Yes	2001	S	0.59	22	1.1	11.1
Marlow Creek	3	M	Yes	2001	S	1.30	20	2.9	18.5
Otter Creek	1	M	Yes	2002	S	0.5	15	2.8	0
Otter Creek	2	S	Yes	2002	S	0.25	9	3.7	3.5
Otter Creek	3	S	Yes	2002	S	0.25	6	5.3	0
Otter Creek	4	S	Yes	2002	S	0.19	5	9.3	0
Palouse	4	L	Yes	1994	S	0.90	25	0.5	
Palouse	5	L	Yes	1994	S	0.60	23	1.7	
Palouse	6	L/M	Yes	1994	S	2.63	23	2.4	
Palouse Trib. A	1	M/S	Yes	1994	S	0.36	11	6.2	
Palouse Trib. A	2	S	No	1994	S	0.65	12	11.6	
Palouse Trib. B	1	S	No	1994	S	0.64	11	6.7	
Palouse Trib. C	1	S	No	1994	S	0.25	8	8.5	
Palouse Trib. D	1	S	No	1994	S	0.18	8	9.6	
Palouse Trib. E	1	S	No	1994	S	0.47	10	10.6	
Palouse Trib.F	1	M/S	Yes	1994	S	1.22	20	6.6	
Panther	1	L	Yes	2002	S	0.85	21	1.8	15.5
Panther	2	M/S	Yes	2002	S	1.48	15	3.9	4.4
Panther Creek #2	1	L	Yes	2001	W	0.81	25	2	11.4
Panther Creek #2	2	M/S	Yes	2001	W	1.46	13	4.5	5.6
Panther Creek Trib.	1	M/S	Yes	2001	W	1.03	18	7.7	10.1
Sullivan Creek	1	M	Yes	2002	S	0.14	10	6.8	0
Sullivan Creek	2	M/S	Yes	2002	S	0.43	12	3.7	0
Sullivan Creek	3	S	Yes	2002	S	0.52	7	3.5	9.3

Name	Reach	Stream Size	Major Reach Fish Bearing	Year of Survey	Season of Survey	Total Length (mi.)	ACW	Avg. Gradient	Complex Pools (#/mi.)
Trout Creek	1	M	Yes	2001	S	0.33	16	6.2	2.9
Trout Creek	2	M	Yes	2001	S	1.10	18	3.5	2.9
Trout Creek	3	M/S	No	2001	S	0.68	10	18.1	5.2
W. Fork Millicoma	2	River	Yes	1997	W	8.03	98	1.4	0.2
W. Fork Millicoma	3	River	Yes	1997	W	9.98	74	0.5	0.0
W. Fork Millicoma	4	L	Yes	1997	W	2.69	43	1.3	0.3
W. Fork Millicoma	5	L/M	Yes	1997	W	1.67	19	3.1	1.8
W. Fork Millicoma	6	S	No	1993	S	0.25	10	13.6	

Umpqua Region

Name	Reach	Stream Size	Major Reach Fish Bearing	Year of Survey	Season of Survey	Total Length (mi.)	ACW	Avg. Gradient	Complex Pools (#/mi.)
Charlotte	1	L	Yes	1993	S	1.35	57	2.3	
Charlotte	2	L/M	Yes	1993	S	0.51	26	3.5	
Charlotte	3	M/S	No	1993	S	0.21	30	13.7	
Charlotte	4	S	No	1993	S	0.15	8	13.6	
Dean Creek	5	L	Yes	1994	S	1.01	50	0.5	
Dean Creek	6	L	Yes	1994	S	0.95	37	0.6	
Dean Creek	7	L/M	Yes	1994	S	1.71	27		
Footlog Creek	1	L	Yes	2001	S	1.09	15	3.8	7.1
Footlog Creek	2	M	Yes	2001	S	1.55	11	7.1	0.0
Footlog Creek	3	S	No	2001	S	0.41	7	14.9	0.0
Johanneson Creek	1	M	Yes	2002	S	1.01	18	3.6	0.0
Johanneson Creek	2	M	Yes	2002	S	0.20	22	4.6	0.0
Johanneson Creek	3	M	Yes	2002	S	0.18	29	4.8	0.0
Johanneson Creek	4	S	Yes	2002	S	0.40	17	10.9	2.4
Johanneson Creek	5	S	No	2002	S	0.37	10	10.1	0.0
Luder Creek	1	L	Yes	2002	S	0.53	28	0.8	8.5

Name	Reach	Stream Size	Major Reach Fish Bearing	Year of Survey	Season of Survey	Total Length (mi.)	ACW	Avg. Gradient	Complex Pools (#/mi.)
Luder Creek	2	L	Yes	2002	S	0.42	29	4.2	0.0
Luder Creek	3	L/M	Yes	2002	S	0.69	24	3.6	0.0
Luder Creek	4	M/S	Yes	2002	S	0.65	11	10.7	0.0
Luder Creek	5	S	No	2002	S	0.20	9	16.2	0.0
Luder Creek	6	S	No	2002	S	0.19	3	32.6	0.0
Miller Creek	1	M	Yes	1994	S	1.14	21	4.3	
Scholfield Creek	5	L	Yes	1997	W	0.91	38	1.3	2.1
Scholfield Creek	6	L	Yes	1997	W	1.44	42	3.9	2.1

Tenmile Region

Name	Reach	Stream Size	Major Reach Fish Bearing	Year of Survey	Season of Survey	Total Length (mi.)	ACW	Avg. Gradient	Complex Pools (#/mi.)
Alder Fork Big Creek	1	M	Yes	2002	S	0.52	18	3.1	3.5
Alder Fork Big Creek	2	M	Yes	2002	S	1.00	16	8.4	1.0
Alder Fork Big Creek	3	S	Yes	2002	S	0.23	13	7.7	0.0
Benson Creek	1	L	Yes	2001	S	0.68	36	0.6	21.4
Benson Creek	2	L/M	Yes	2001	S	1.55	24	2.1	6.9
Benson Creek	3	M	Yes	2001	S	0.76	25	3.4	9.0
Benson Creek Trib.	1	M/S	Yes	2001	S	0.94	10	9.7	2.9
Big Creek	1	L	Yes	2002	S	1.30	28	0.3	5.0
Big Creek	2	L	Yes	2002	S	0.51	30	0.4	20.8
Big Creek	3	L	Yes	2002	S	0.96	27	4	9.7
Big Creek	4	L	Yes	2002	S	0.82	25	4.9	9.7
Big Creek	5	L	Yes	2002	S	0.29	19	4.2	0

Name	Reach	Stream Size	Major Reach Fish Bearing	Year of Survey	Season of Survey	Total Length (mi.)	ACW	Avg. Gradient	Complex Pools (#/mi.)
Big Creek	6	M	Yes	2002	S	0.27	11	7.3	3.4
Big Creek	7	M/S	No	2001	W	0.75	11	9.4	3.2
Big Creek	8	S	No	2001	W	0.16	8	22.4	0.0
Big Creek Trib.	1	M/S	Yes	2002	S	1.75	13	9.1	1.1
Johnson Creek	3	L	Yes	1997	W	0.62	46	1	0.0
Johnson Creek	4	L	Yes	1997	W	0.90	40	1.5	1.1
Johnson Creek	5	L/M	Yes	1997	W	1.36	40	4.2	0.6
Johnson Trib. 1	1	L	Yes	1993	S	0.32	49	0.7	
Johnson Trib. 1	2	M	Yes	1993	S	0.93	47	1.6	
Johnson Trib. 1	3	M/S	Yes	1993	S	0.44	10	7.6	
Johnson Trib. 2	1	M/S	Yes	1993	S	0.81	32	8.1	
Johnson Trib. 2	2	S	No	1993	S	0.29	39	24.8	
Johnson Trib. 3	1	S	No	1993	S	0.74	21	14.4	
Murphy Creek	1	M	Yes	2001	S	0.96	14.4	2.7	12.6
Murphy Creek	2	M	Yes	2001	S	0.54	9	11.8	3.1
Noble Creek #2	1	M	Yes	2001	S	0.59	16	1.4	13.0
Noble Creek #2	2	M/S	No	2001	S	0.92	14	7	9.3
Roberts Creek	1	L	Yes	2001	S	1.26	29	1.9	13.7
Roberts Creek	2	L/M	Yes	2001	S	1.37	22	4.3	6.3
Roberts Creek	3	M	Yes	2001	S	0.16	13	4.7	21.1