CALAPOOIA RIVER

WATERSHED ANALYSIS

PART I - RESOURCE ASSESSMENT REPORT

Weyerhaeuser

August 1998

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INTRODUCTION

This *Watershed Analysis Synthesis* brings together important points from each of the assessment reports contained in this document (Appendices A-G). These reports detail mass wasting (landslides), hillslope and road erosion, hydrology, riparian conditions, channel processes, water quality, fish resources and fish habitat in the Calapooia River Watershed Administrative Unit (WAU). Following this synthesis are *Causal Mechanism Reports*, which link forest management activities to potentially deleterious effects on fish habitat and water quality. Causal mechanism reports describe locations and specific triggering mechanisms, which may require tailored prescriptions.

Watershed Analysis Methods

The critical questions, guiding assumptions, and methods used in the assessment reports are detailed in the Standard Methodology for Conducting Watershed Analysis, Version 4.0 (Washington Forest Practices Board, 1997). In a few cases, methods were modified by the assessment team members to more appropriately address specific resource and assessment issues relevant to this watershed as well as to employ methods more recently developed. The Calapooia River WAU team members are listed in Table 1.

Table 1 The Calapooia River WAU watershed team.

Team member	Title	Responsibility
Karin Baitis	Geomorphologist	Stream Channel (E)
Jeffrey Clark	Washington Watershed Analysis Team Leader	Editor
John Heffner	Research Technician	Field support
Lillian Herger	Fish Biologist	Fish Habitat (F) and Water Quality (G)
Susan Madsen	Fluvial Geomorphologist	Surface Erosion (B)
Maryanne Reiter	Hydrologist and Riparian Specialist	Hydrology module (C), Riparian Function (D) and Water Quality (G)
Ted Turner	Geologist	Mass Wasting (A)
Jim Stark	Watershed Analysis Project Team Leader	Coordinator
Robin Lindly	Administrative Assistant	Administrative support

WATERSHED OVERVIEW

All watersheds have unique natural characteristics and land use histories, which provide a framework for interpreting the watershed's current condition and function. This overview is intended to provide the reader with a general understanding of those natural components and known human interactions that have affected the aquatic resources in the watershed.

Location and Ownership

The Calapooia River Watershed Administrative Unit (WAU) is located in the west-central Cascades mountain range of Oregon approximately 24 miles northeast of Springfield, Oregon (**Map 1**). Weyerhaeuser ownership accounts for 68.1 percent of the total watershed acreage. The remaining acreage is in federal and private ownership (**Map 2**, Table 2).

Table 2 Ownership distribution in the Calapooia River WAU.

Ownership	Acreage	Percentage of total
Weyerhaeuser	37,126	68.1
Willamette National Forest	5,900	10.8
Bureau of Land Management	1,633	3.0
Other private	9,822	18.0
Total	54,481	

Geology and Slope Stability

Regionally, the watershed lies at the western margin of the Western Cascades physiographic province (Orr et al., 1992). This province is primarily situated between the younger, snow covered peaks of the High Cascade range on its eastern flanks and the Willamette Valley on the west. The assessment area is underlain by volcanic rocks including basalt and andesite flows and volcaniclastics (primarily tuff which is volcanic ash that has been compressed into rock) that are roughly 10 to 30 million years old (**Map 3**). Basalt and andesite flows cap many of the ridges in the assessment area and form many of the steeper slopes. The underlying volcaniclastic unit, where it does not contain basalt flows or hard breccia, is weaker and underlies the gentler, lower elevation slopes over much of the assessment area. In this area are also found large, ancient landslides which probably occurred hundreds to thousands of years ago during major disturbance events (e.g., seismic activity).

The geomorphology of the WAU consists of the narrow alluvial and bedrock controlled valley of the upper Calapooia River (with associated terraces only where the valley widens); moderate to steep slopes of the Calapooia River tributaries; and occasional broad ridges of the northern and southern watershed boundaries which delineate the tops of geologically recent basalt and andesite flows (see **Map 3a**). Additionally, there are scattered igneous intrusions, which form portions of the ridges and peaks within the WAU.

Landslides

Approximately 600 landslides were inventoried from low elevation aerial photographs at roughly 10-year increments between 1949 and 1997. The highest occurrence of observed landslides were from the 1967 and 1996/1997 air photos (Figure 1). These periods coincided with major storms as well as intensified management activities in the WAU. The majority of the landslides are from steep, concave slopes, followed by steep planar slopes and bench edges (Figure 2). When these landslides become channelized, the steep and confined tributaries facilitate high debris flow occurrence as well as long debris flow runouts.

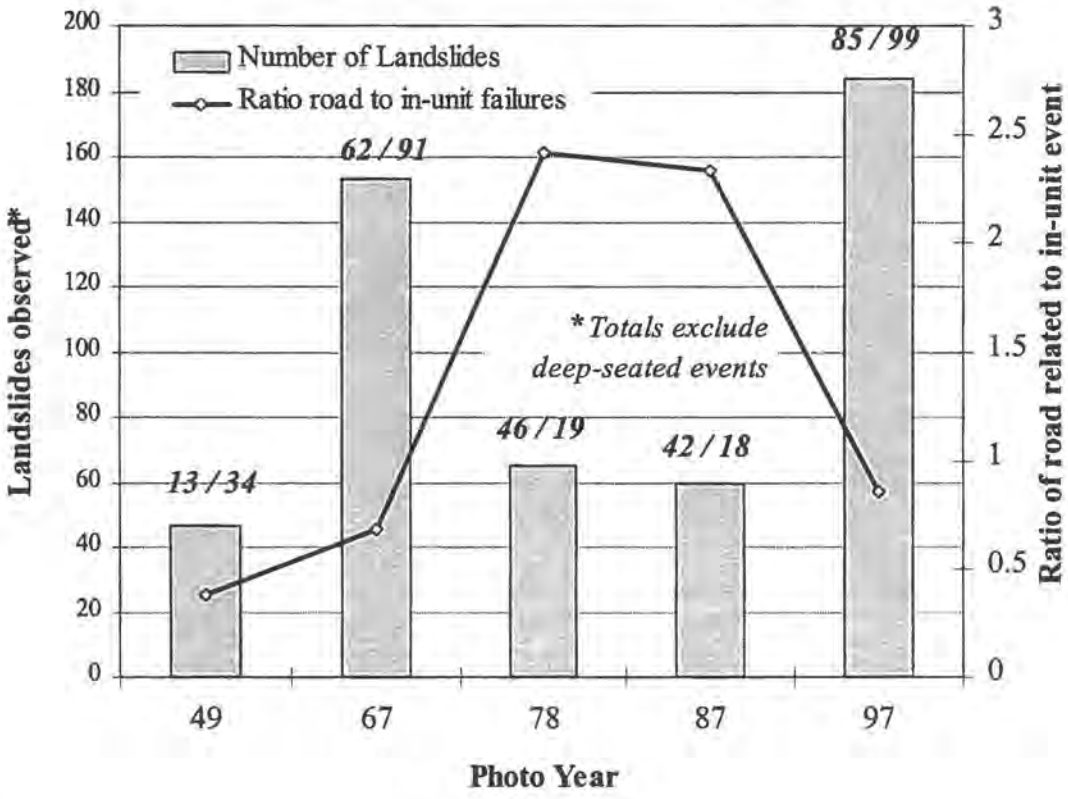


Figure 1 Landslide occurrence by photo year and land use association (road/non-road related ratio) in the Calapooia River WAU, 1949–1997

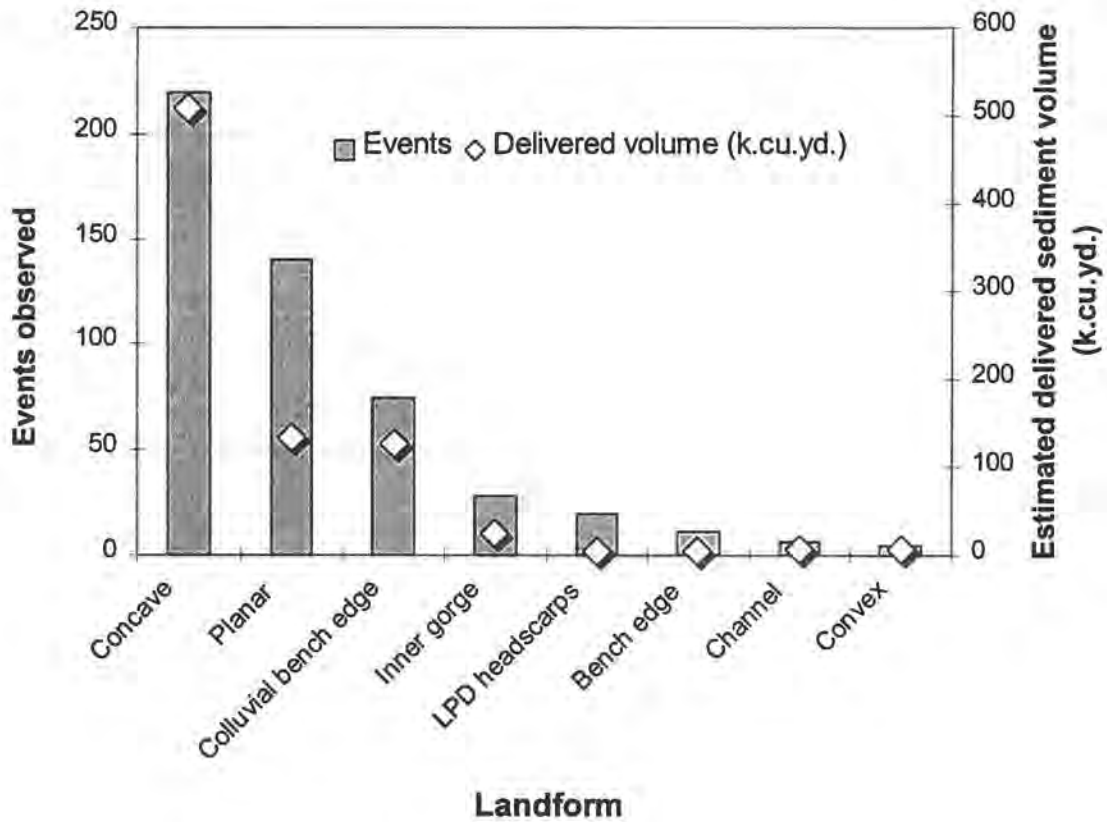


Figure 2 Comparison of estimated sediment volumes delivered by landslides (excluding LPD) from different landforms in the WAU.

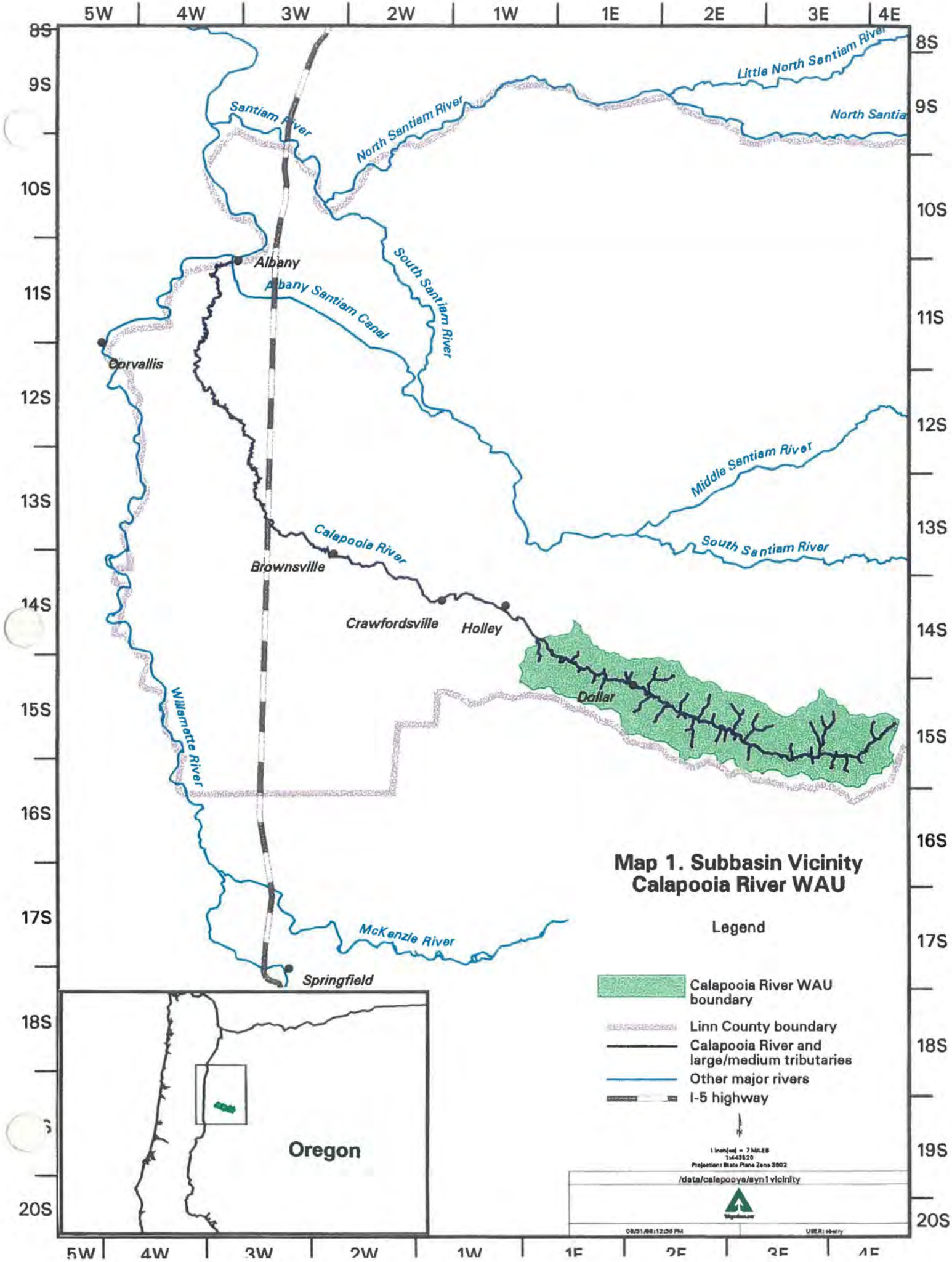
Management practices; particularly sidecast road construction across steep, concave landforms are one of the primary factors influencing landslides. Road–related events accounted for 49% of the inventory. Sidecast failures (including landings) were identified in 70% of the road–related failures, while cutbank failures accounted for 22% of the events.

The frequency of non–road–related failures exceeded road–related failures for all photo years except 1978 and 1987. This trend, which appears to be most strongly correlated to the timing of large hydrologic events during the period of record, suggest the following hypotheses:

- Road–related landslides may result from moderate as well as large storm events across different terrain. For example, while sidecast road failures occur more frequently during the largest storms, the rate of increase is much smaller than the rate of in–unit failures during large storms.

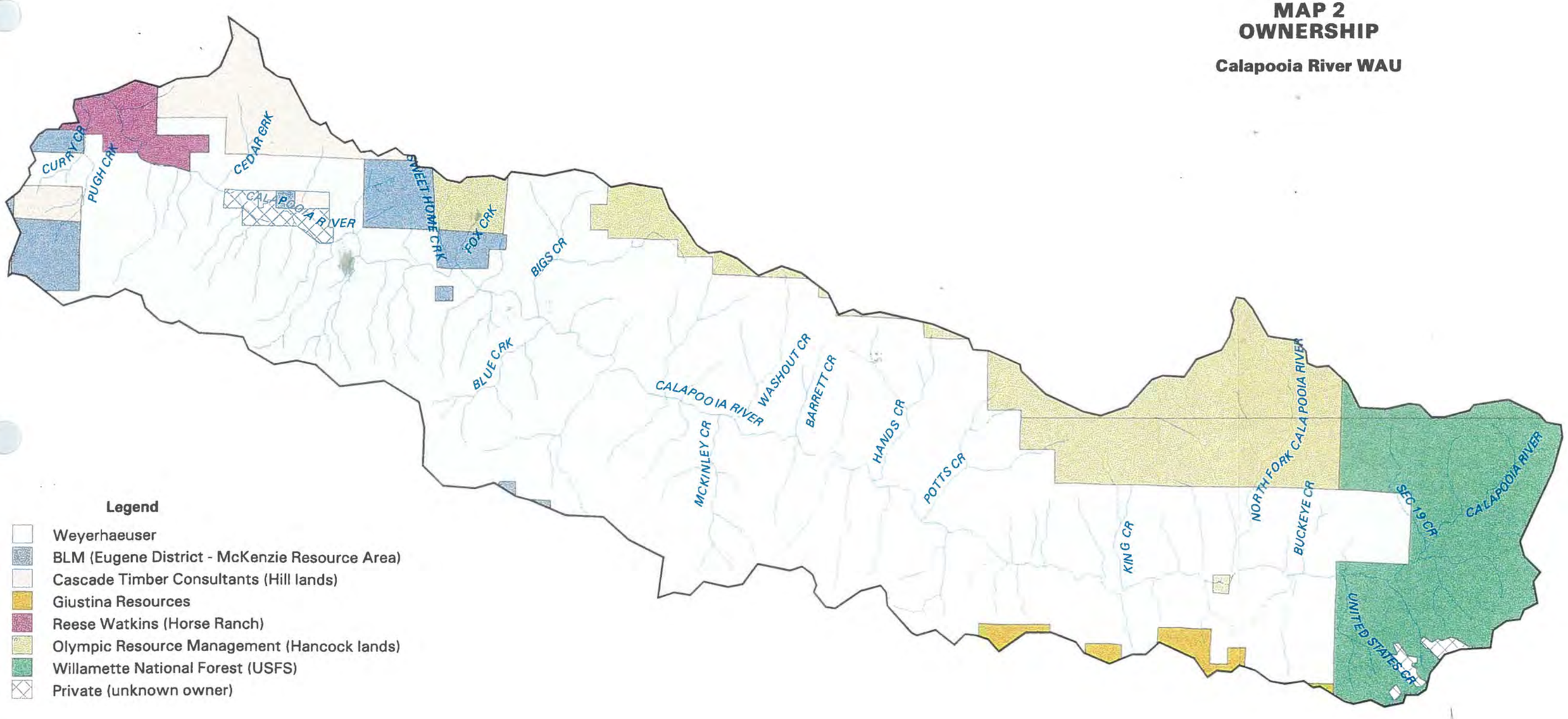
- Steep concave slopes fail at exponentially higher rates above some threshold storm event. The size of that event appears to have been reached in 1964 and 1996.

- The higher proportion of road–related to in–unit landslides in the 1978 and 1987 photos as compared to 1996 suggest that the high harvest and road construction rates during these


Map 1. Subbasin Vicinity
Calapooia River WAU
Legend
Calapooia River WAU boundary
Linn County boundary
Calapooia River and large/medium tributaries
Other major rivers
I-5 highway
Little North Santiam River
North Santiam River
Santiam River
Albany
Albany Santiam Canal
South Santiam River
Corvallis
Middle Santiam River
South Santiam River
Calapooia River
Brownsville
Crawfordsville
Holley
Dollar
Willamette River
McKenzie River
Springfield
Oregon
5W
4W
3W
2W
1W
1E
2E
3E
4E
8S
9S
10S
11S
12S
13S
14S
15S
16S
17S
18S
19S
20S

MAP 2
OWNERSHIP

Calapooia River WAU



Legend

- Weyerhaeuser
- BLM (Eugene District - McKenzie Resource Area)
- Cascade Timber Consultants (Hill lands)
- Giustina Resources
- Reese Watkins (Horse Ranch)
- Olympic Resource Management (Hancock lands)
- Willamette National Forest (USFS)
- Private (unknown owner)

1.0MI 0MI 1MI 2MI 3MI 4MI

1 : 90000

1 inch = 7500 feet

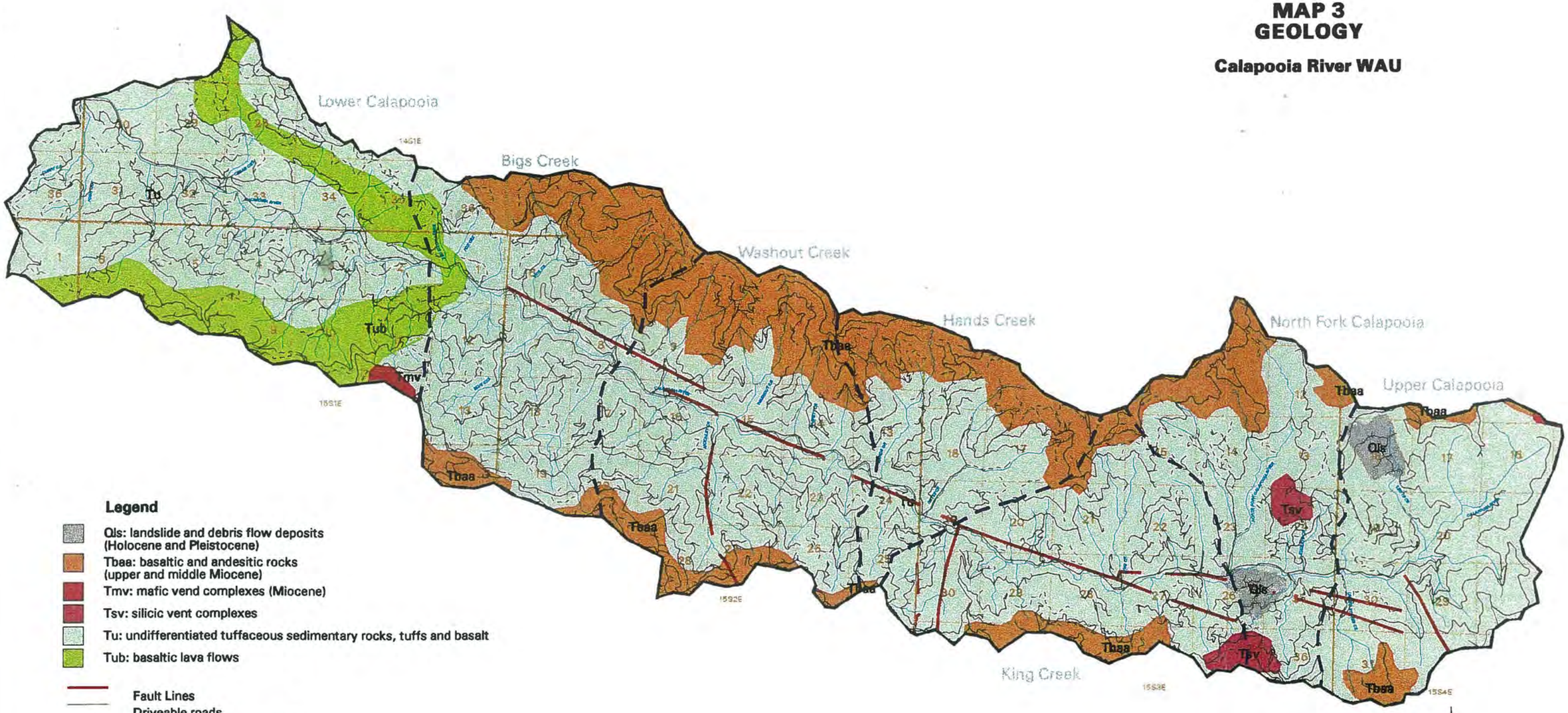
Map 2 Ownership

Weyerhaeuser

DATE: 08/31/98

MAP 3
GEOLOGY

Calapooia River WAU



Legend

- Qls: landslide and debris flow deposits (Holocene and Pleistocene)
- Tbaa: basaltic and andesitic rocks (upper and middle Miocene)
- Tmv: mafic vend complexes (Miocene)
- Tsv: silicic vent complexes
- Tu: undifferentiated tuffaceous sedimentary rocks, tuffs and basalt
- Tub: basaltic lava flows

- Fault Lines
- Driveable roads
- Abandoned/overgrown roads

1 : 90000

1 inch = 7500 feet

Geologic Base Map from USGS 1:500000

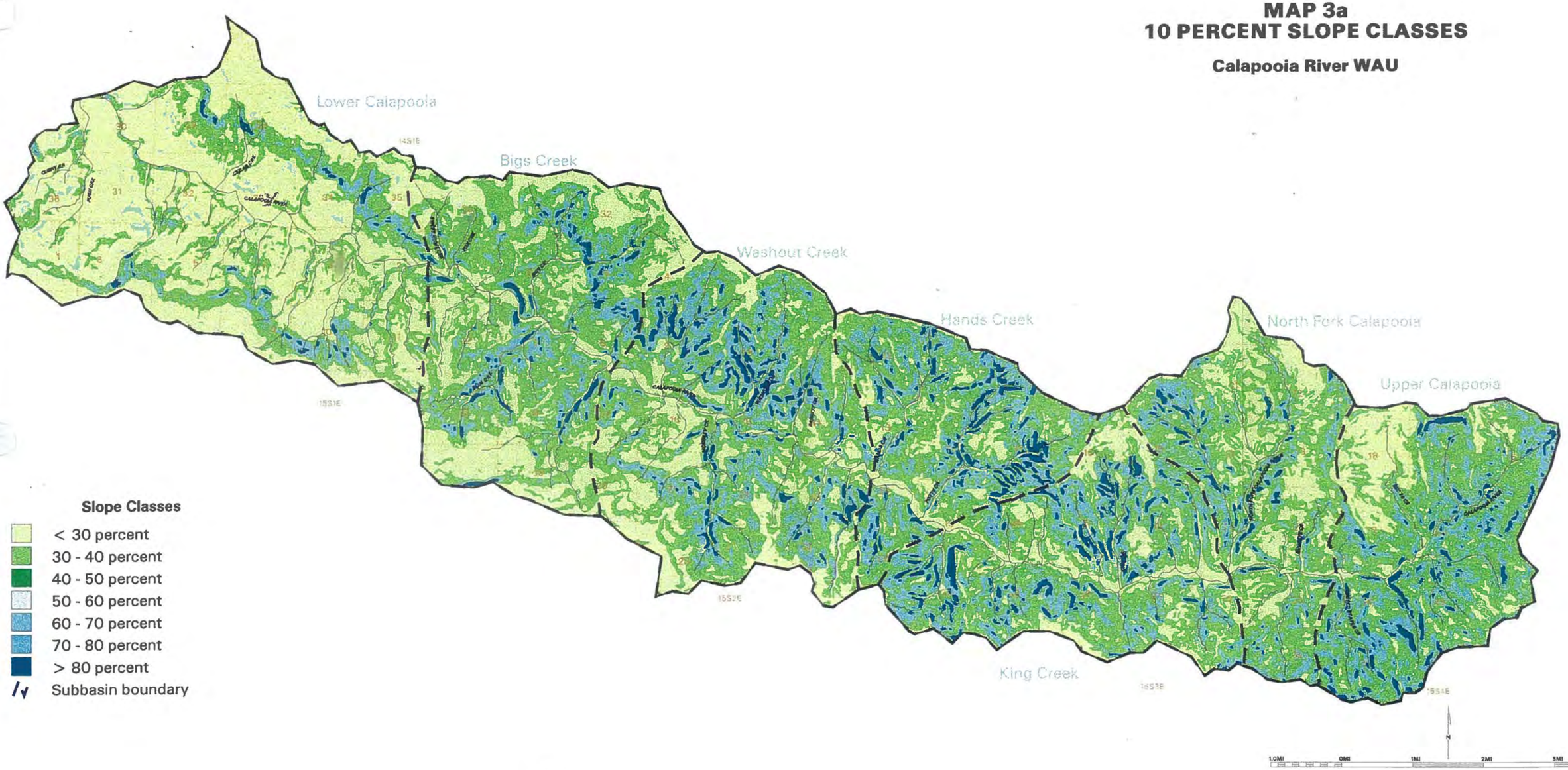
Map 3 Geology

Weyerhaeuser

DATE: 08/18/98

MAP 3a
10 PERCENT SLOPE CLASSES

Calapooia River WAU



Slope Classes

- < 30 percent
- 30 - 40 percent
- 40 - 50 percent
- 50 - 60 percent
- 60 - 70 percent
- 70 - 80 percent
- > 80 percent
- Subbasin boundary

1 : 90000

1 inch = 7500 feet

Map 3a 10 Percent Slope Classes

Weyerhaeuser

DATE: 08/31/98

The highest sediment volumes delivered to the stream network, and the highest landslide densities (normalized by area) were from the central portion of the watershed including the King Creek, Hands Creek, and Washout Creek subbasins. Most observed events from these basins occurred between 1987 and 1997, presumably from storms in 1996.

Soils and Erosion

Soils within the Calapooia River WAU range from moderately deep to deep (2-4.5 feet) and are typically well-drained which readily allows for infiltration of rainfall and snowmelt. The mineral soil is typically covered by a continuous layer of organic litter from 1 to 2 inches thick. The following table (Table 3) provides an overview of the soils in the WAU.

Table 3 General soil characters of the Calapooia River WAU (based on Landridge 1987).

General Location	Dominant Soil Group
Gentle sideslopes in lower watershed	Deep clay loams associated with earthflows
Upland Benches	Shallow upland silt loams
Headwater slopes	Shallow, rocky upland gravelly loams
Midslope areas	Midslope cobbly loams

The combination of soil type, slope and landform leads to differences in sediment yield and delivery rates. For the Calapooia River WAU, the estimated natural background sediment delivery rate from soil creep varied from 13.5 to 29.7 tons/mi^2 per year, averaging 22.5 tons/mi^2 per year for the entire basin

Land use practices influence the natural sediment delivery rate through changes in vegetative cover, routing of sediment and exposing mineral soil to vehicle traffic. The effects of land use practices on sediment production and delivery in the Calapooia River WAU are summarized below.

- Based on observations at seven units harvested within the past five years, surface erosion associated with timber harvest activities is rare, and delivery of sediment via hillslope surface erosion in the Calapooia River WAU is minimal under current management practices.

- Erosion of exposed surfaces of small, sporadic deep seated landslides can contribute large amounts of fine sediment if the intersect the channel network and remain unvegetated.

- Under existing traffic conditions, road surface erosion delivers an average of 11.6 tons of fine sediment per square mile of basin area per year to channels in the Calapooia River WAU. The contributions vary by subbasin, amounting to increases of 23 to 81 percent over the estimated background sediment yield. Sediment yield increases that exceed 50 percent are potentially detectable and may impact aquatic resources.

- The source of sediment delivered to streams from roads varies depending on their position. Erosion of road tread surfaces delivers the most sediment from stream adjacent roads. Under existing traffic conditions, unvegetated cutslope surfaces on mid-slope and ridge-top roads contribute the majority of the fine sediment.

- Gullies associated with logging roads can be a major source of fine sediment. Gullies most commonly originate where blocked stream crossing or ditch relief culverts divert flow onto road tread surfaces. Drainage structures on crowned or insloped roads where the road climbs on the approach and through the crossing have a high "diversion potential" (Weaver and Hagans 1994), and were observed to be the most important initiation mechanism of gully erosion in the Calapooia WAU.

Precipitation and Streamflow

The majority of precipitation falls as rain during the winter months, with snowfall generally occurring above 2,000 ft. The estimated zone where rain-on-snow is most likely occurs from 2,000-2,800 ft and composes approximately 26 percent of the watershed. The rain-on-snow zone coincides with the inherently steep and unstable ground, particularly in the headwaters of Hands, Washout and King Creeks, which have the highest number of landslides in the WAU.

Streamflow follows a similar pattern to precipitation with the highest average monthly flow occurring in December and lowest average monthly flow in August and September (Figure 3). The majority of peak flows (31%) occur in December, based on 55 annual records for the Calapooia River near Holley. The three largest floods on record for the Calapooia River near Holley include February 1996 (estimated) and December 1964 followed by the December 1945 event. Other large events (between a 10 and 25-year event) include water year 1961, 1956, 1972, 1954 and 1958.

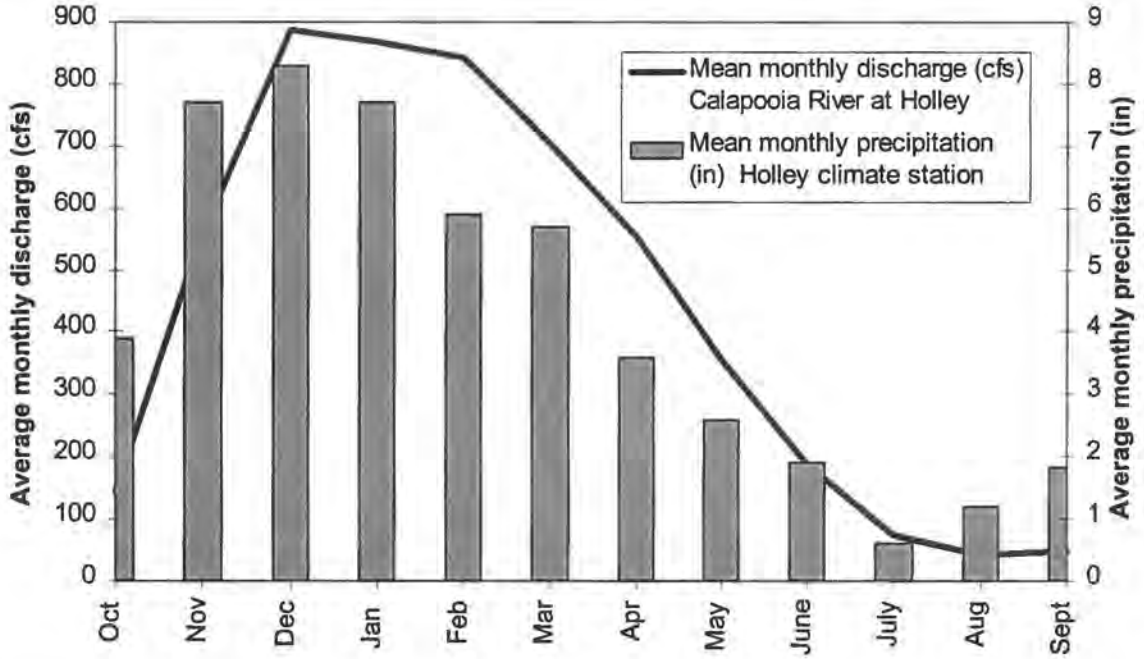


Figure 3 Average monthly precipitation (in) for the climate station and average monthly discharge (cfs) for the Calapooia River near Holley (USGS).

Riparian Areas and Wetlands

Riparian tree species composition, growth and stand density are influenced by several factors including moisture and light gradients, geomorphology, soils and patterns of disturbance. For example, red alder (*Alnus rubra*) generally occurs in disturbed sites, especially along stream channels (Franklin and Dyrness 1973). This is evident in the Calapooia River WAU where red alder occurs along stream channels and areas disturbed by debris torrents or past harvest. Major conifer species found in riparian areas of the Calapooia River WAU include western red cedar (*Thuja plicata*), western hemlock (*Tsuga heterophylla)* and Douglas fir (*Psuedotsuga menziesii*). Other hardwood species besides red alder include big leaf maple (*Acer macrophyllum*). Currently, most of the riparian areas have small diameter conifer, hardwood and mixed stands resulting in an overall low near-term recruitment potential for large wood (64%). However, in the long-term, 77% of the riparian areas are projected to have moderate to high recruitment potential due to the presence of conifer species.

Wetlands are not very common in the WAU, composing only 0.15% of the area. Most wetlands are associated with flowing water and are found in areas ranging from low elevation stream-adjacent areas to higher elevation flatter upland areas. The highest concentration of wetlands is in the flatter bench area in the headwaters of McKinley and Blue Creeks on the southside of the Calapooia River drainage. Many wetlands are strongly influenced by forest roads. For example, wetlands in Township 15S Range 2E Section 19 have apparently formed in low gradient areas behind forest roads. Several wetlands in that area have been colonized by beaver (*Castor canadensis*) that have constructed dams across culverts and backed up water. These wetlands are typically small and most are classified as slope-type wetlands. Some wetlands are associated with large persistent deep-seated landslides (see Mass Wasting Module, Appendix A), which create wetlands known as sag ponds.

Streams

Steep, highly confined, high-energy mountain streams carve the Calapooia River watershed. Steps occasionally punctuate longitudinal profiles where channels cross more resistant bedrock and form cascading waterfalls. Landslides that turn into debris flows are naturally a dominant mechanism of erosion in the western Cascades, and route sediment and wood to downstream reaches. The mainstem channel has cut down and incised into the valley bottom so that it frequently is not connected to higher terraces. This localized entrenchment may have occurred as a result of the removal of large debris jams. By who how many years ago? BS

Coarse sediment and bedrock are the dominant substrates in most of the channels and boulders currently dominate pool formation in steeper channels. Small and large woody debris jams are important for storing sediment and forming pools. In the lower gradient mainstem, pools are mainly formed by scour. Due to a change in geology, fine sediment is a more common substrate in the lower end of the watershed where colluvial material from slumps and earthflows and fine-grained volcaniclastics occur.

Fish Species

The following is a summary of the fish species present within the watershed and their distribution.

Salmonid species

The following table (Table 4) lists the salmonid species (family Salmonidae) present in the Calapooia River WAU and a brief summary of their distribution. The watershed has 58.6 miles of fish-bearing waters. The approximated extent of distribution of each salmonid species is shown on **Map 4**.

Table 4 Salmonid species present in the watershed and a brief summary of their use of the WAU.

Species	Distribution in the watershed (mi)	Summary
Chinook salmon*	24.7	Chinook salmon occur in the mainstem Calapooia river with the primary spawning and rearing habitat in the reach between the town of Holley and the Treadwell Creek confluence.
Steelhead (winter)*	29.2	Winter steelhead use the mainstem as a migration corridor to spawning and rearing areas of the upper mainstem and its tributaries. Both Potts Creek and the North Fork Calapooia River are known spawning streams and it is likely that other larger tributaries may be used by steelhead.
Coastal cutthroat trout (resident)	58.7	Resident cutthroat trout are the most broadly distributed fish species as they are able to inhabit high gradient small streams. Also, cutthroat populations are present above barriers that prohibit anadromous fish use.
Whitefish	24.7	Whitefish are found in the mainstem. It is likely that they are distributed throughout the mainstem to the barrier below Treadwell Creek.

*proposed for threatened status under the endangered species act.

Residualized steelhead (rainbow trout) may be present in the WAU but distinct rainbow trout populations have not been documented.

Non-salmonid species

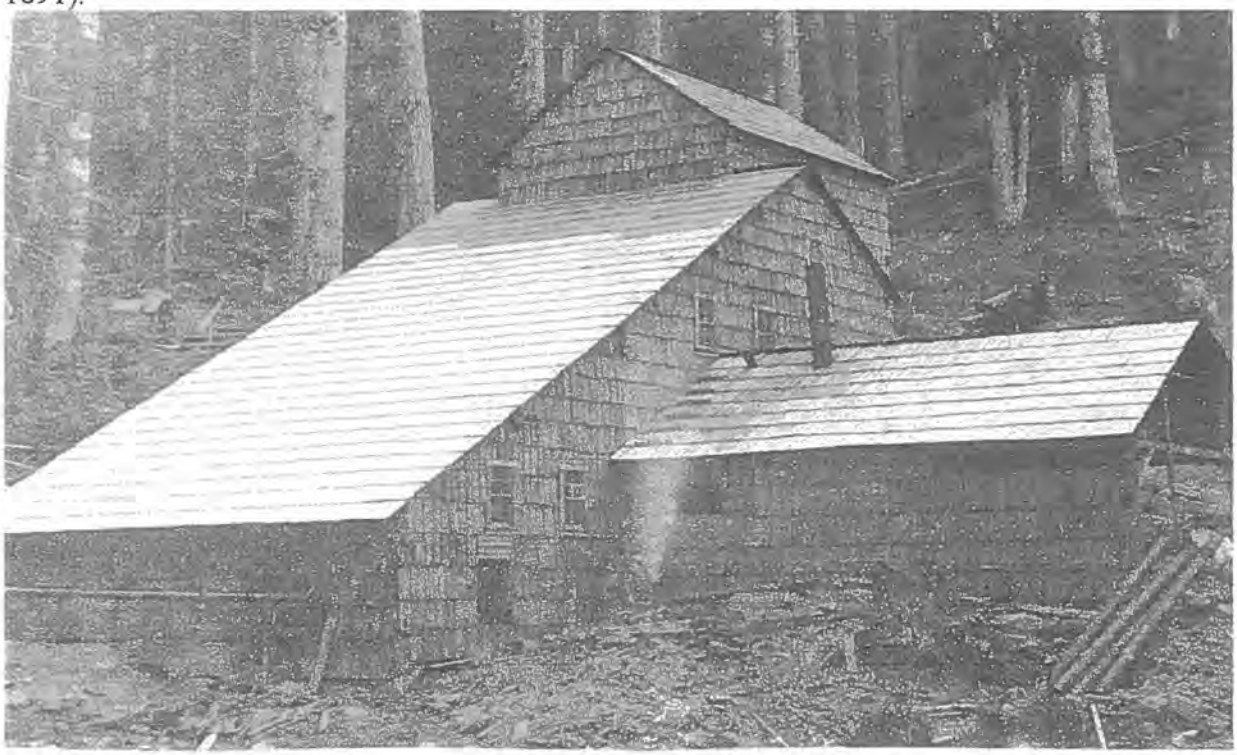
Presence of several native non-salmonid species has been verified in the lower portion of the WAU and other species are likely to be present. Also, many other fish species adapted to slower flows and warmer water temperatures inhabit the lower portions of the Calapooia River below the WAU boundary. Some of these species are non-native introductions. The following is a list of non-salmonid species present or likely to be present in the Calapooia River WAU (Sources: EPA unpublished data, Lee et al.1980, Markle et al. 1996).

- **Minnows** including speckled dace, longnose dace, northern squawfish, redside shiner
- **Suckers** largescale sucker
- **Sculpins** mottled sculpin, Paiute sculpin, shorthead sculpin, reticulate sculpin and torrent sculpin
- **Lampreys** pacific lamprey and western brook lamprey

Land Use History

The Holley area was a winter village site for the Calapooya division of the Kalapooian Family, whose descendants are at Grande Ronde and Siletz. Neighboring bands connected by rivers and trails. The Mollalla trail winds through the upper portion of the WAU and was a major huckleberry resource area where the Indians met for trading and ceremonies (Tony Farque, USFS, Archaeologist, pers. comm.).

In the late 1800s, early settlement below the watershed boundary consisted primarily of farming. The postmaster named the village after a shrub growing there, which he thought was Holly, but which must have been Oregon Grape. By the 1870s gold mining had opened up the headwaters of the Calapooia River (known as Gold Hill). Mineral claims included hard rock mining in the hillslopes and placer mining within the streams of the USFS boundary (Haberkorn, 1998, USFS, pers communication). Early transportation routes into the mines came from the south through the Blue River Mining District, but by 1891 a trail from Crawfordsville to the Calapooia Mines had been established along the mainstem of the Calapooia River (Surveyor Generals Office, 1891).



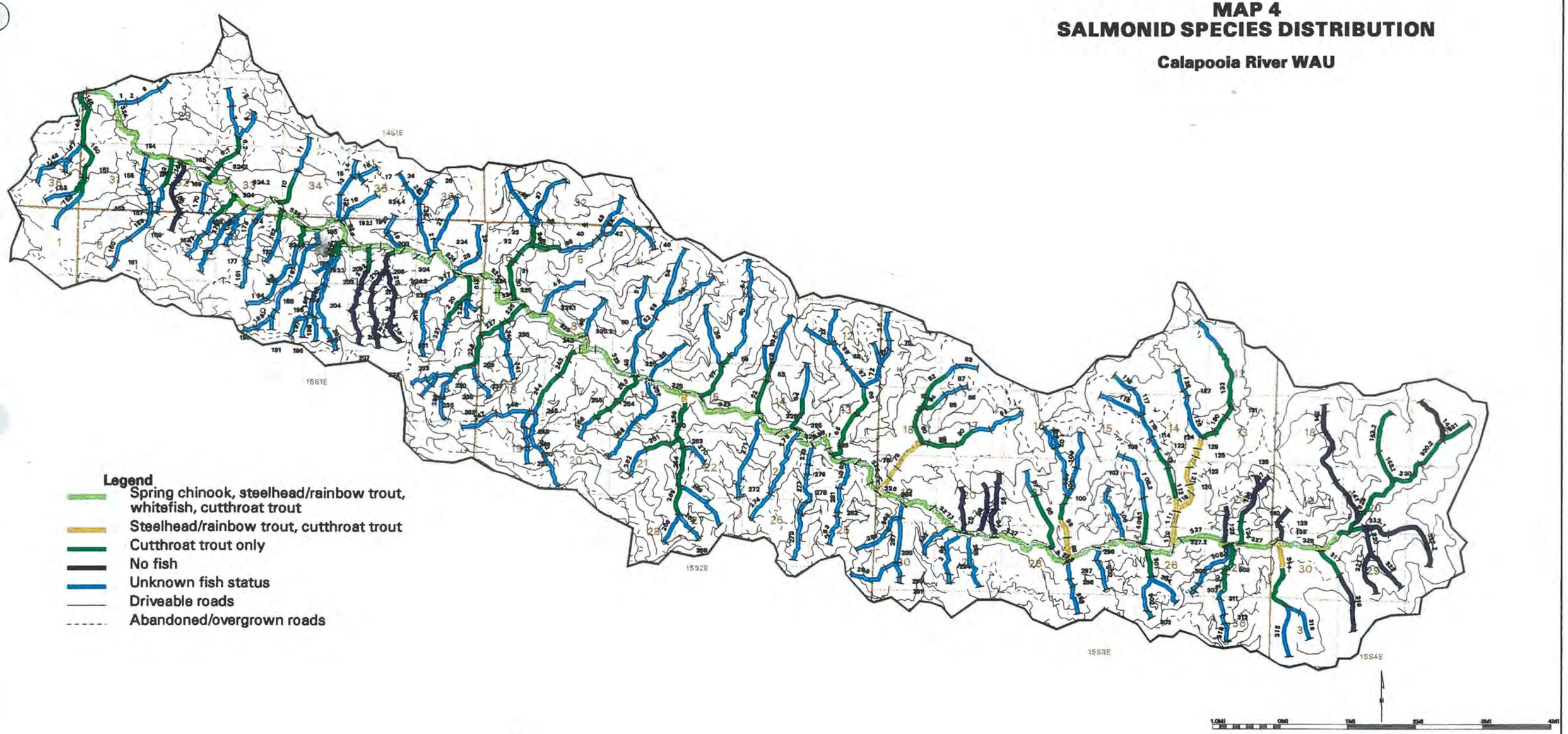
Photograph 1 Calapooia Mines, Gold Hill—Treadwell Creek (maybe). Photograph courtesy of Tom Philpott.

Logging and Splash Dams

In the 1850s James Norval Rice homesteaded upstream of Holley (but below our watershed lower boundary). Logging took place some time later with a team of bulls. A splash dam was constructed upstream of the sawmill on the Calapooia River. When the pond was full, the gates were opened and the logs went down river to the mill (Albany Democrat-Herald, March 7, 1997).

MAP 4
SALMONID SPECIES DISTRIBUTION

Calapooia River WAU



Legend

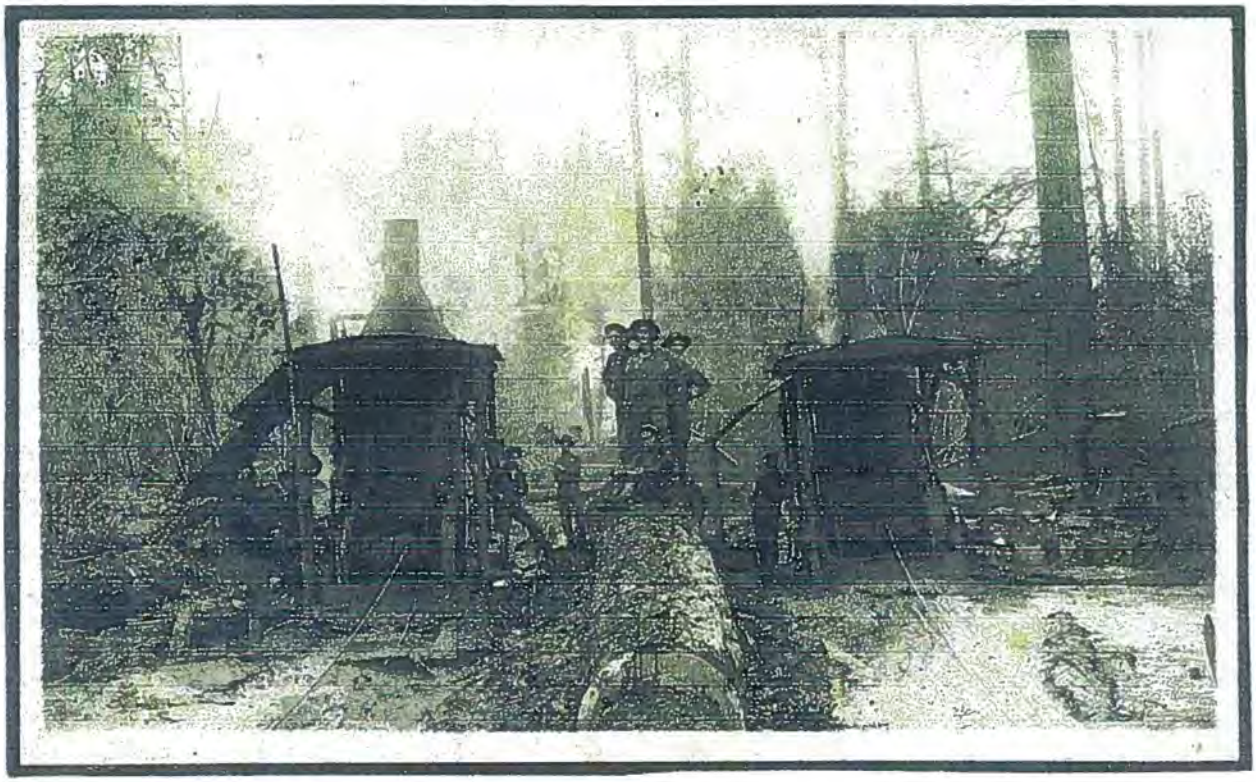
- Spring chinook, steelhead/rainbow trout, whitefish, cutthroat trout
- Steelhead/rainbow trout, cutthroat trout
- Cutthroat trout only
- No fish
- Unknown fish status
- Driveable roads
- Abandoned/overgrown roads

Map 4 Salmonid Species Distribution

Weyerhaeuser

DATE: 08/18/98

In 1906, the Thurston Brothers Lumber Company had a "River Camp" twelve miles up the Calapooia River from Crawfordsville (placing it just downstream of Big Creek). The camp was headquarters for the drive crew that drove the logs down the Calapooia to their mill at Crawfordsville (Repetto, 1970). Steam donkeys were used to bring the logs to the river and a large boom held the logs at the Thurston sawmill. Dynamite was used to blast boulders, hung up logs and dams built with dirt and logs. In the early 1900s there were several logging operations along the Calapooia River (Reece Watkins, pers comm., 1998).



Photograph 2 Steam Donkeys (Yarders) used by Thurston Lumber Company on the Calapooia River in the early 1900s. Photograph courtesy Tom Philpott.

The Dollar Steamship Lines moved from Mabel (Mohawk Valley) to the Calapooia River around the 1930s (Polley, pers comm., 1998). In 1929-30, a railroad line was built from Vale to what is known as Dollar Camp located downstream of Big Creek (Watkins, pers comm., 1998). Gilbert and Eaton Logging built a camp on King Creek sometime during the mid 1940s on the Calapooia River. By that time log trucks were being used to transport the logs out of the watershed (Gehrman, Rice, pers. comms., 1998). Weyerhaeuser bought the Dollar holdings in 1939 (Gehrman, pers. comm., 1989). Weyerhaeuser used a shear boom in the Calapooia River (Photograph 3) just above Big Creek (Atkinson, pers. comm. Weyco, 1998). A loader took logs captured by the shear boom out from the north bank (Gehrman, pers. comm., 1989). Major instream channel work was done on the mainstem by bulldozer to protect the mainline road in

the late 60s, at a spot between North Fork Calapooia Creek and King Creek (Atkinson, pers. comm., Weyco, 1998).

Photograph 3 Shear Boom (1960s) in the Calapooia River just upstream of Bigs Creek. Photograph courtesy Weyerhaeuser Company.

FISH HABITAT AND HABITAT CONCERNS

The Calapooia mainstem is characterized by a confined single-threaded channel dominated by bedrock, interspersed with more loosely confined cobble/boulder dominated sections. Anadromous fish en route to spawning areas use the deep pools (> 3 ft residual depth) formed in bedrock.

Reaches with accumulations of spawning-sized gravel are typically located downstream of constrictions. Although the location of these reaches is dispersed, significant spawning gravel patches are more common in the mainstem reach above Potts Creek. Spawning habitat is also available in Potts Creek and the North Fork Calapooia River.

Rearing areas adjacent to spawning habitat are not common. Bedrock pools in the thalweg are the primary summer rearing areas. These pools have little overhead cover and lateral complexity. The abundance of coarse substrate provides rearing area in riffles. Overwintering habitat is not abundant in the mainstem because of the moderate to high confinement, lack of side channel and off-channel areas, and high responsiveness to flow events. Also, channel complexity is generally low, contributing to low quantity of hydraulic refuge.

Resident habitat. In most of the smaller channels within the resident fish zone, there is evidence of catastrophic channel alteration due to debris torrents. The signature of recent (<10 year old) debris torrents is abundant coarse sediment, poor pool development, no lateral or overhead cover features, and lack of riparian shading. In streams where these events occurred in the past (>20 years) channels have recovered. Cobbles and boulders are forming pools, banks have become more stable providing cover and riparian alder corridors are shading the streams and contributing organic inputs. As with more recently torrented streams, LWD is very rare in these channels.

FISH HABITAT CONCERNS

The following (Table 5) is a summary of salmonid habitat concerns by life history phase. Areas of concern are summarized on **Map 5** in terms of land management related inputs, including fine sediment from mass wasting and surface erosion, low LWD recruitment and low riparian canopy.

Table 5 Habitat concerns by life history phase within the Calapooia River WAU.

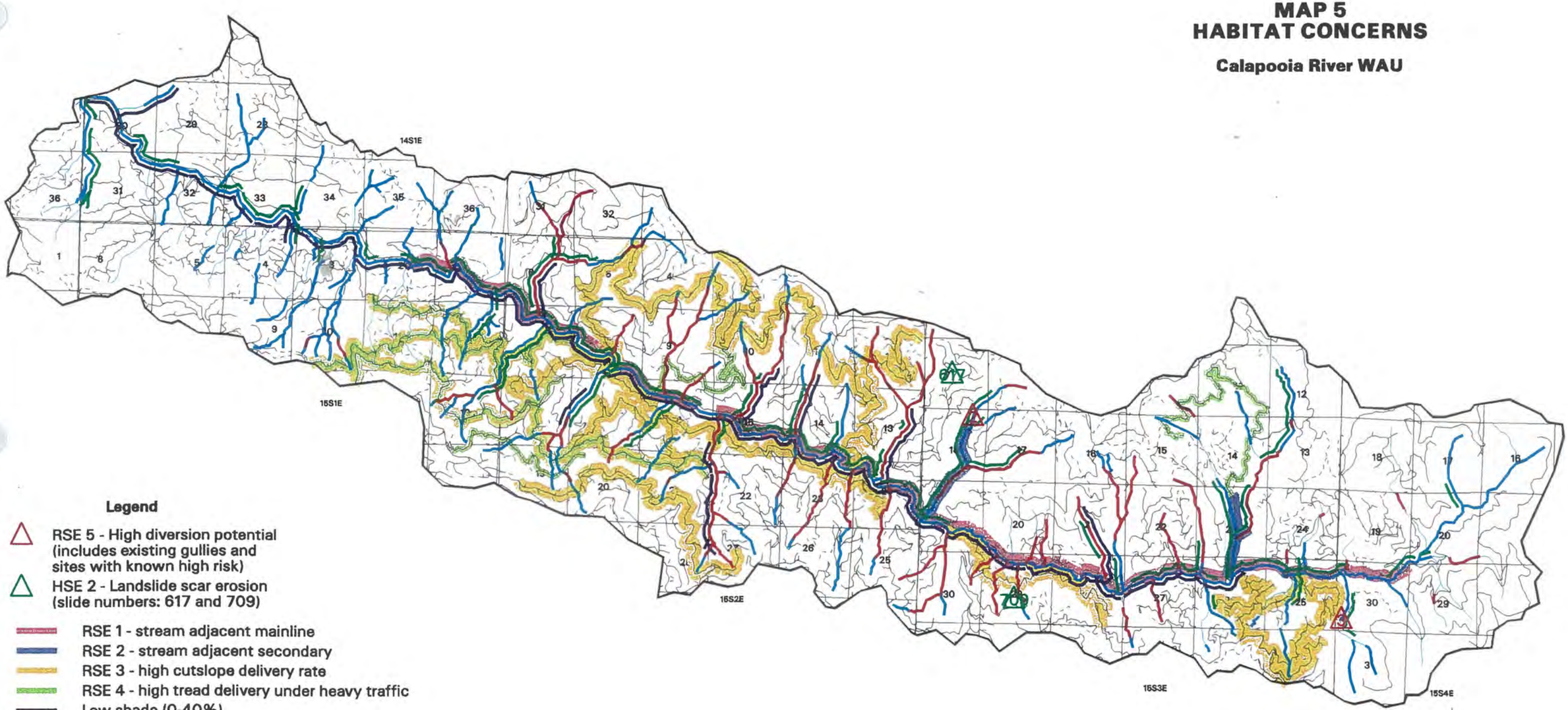
Habitat Characteristic	Habitat Issue
	Upstream migration and instream movement
Low flow barriers	Tributary reaches with large accumulations of sediment from debris torrents have subsurface flow in the summer which limits fish movement as well as rearing habitat.
Road crossing barriers	Six culverts are considered high priority for correction of fish passage hindrances.
Natural barriers How long been here?	Seven isolated resident cutthroat trout populations were identified above impassable falls. These populations are vulnerable to catastrophic events.
	Spawning and incubation
Gravel availability	Sorted patches of gravel size substrate are rare, except in large pools. This is attributed to lack of LWD and to the abundance of newly deposited coarse sediment from debris torrents. – Can't have sediment contribution abv. Peters Tower
Fine sediment	In most of the WAU fine sediment accumulation is minor. GMU 3 has abundant fine sediment and has a high vulnerability to fine sediment accumulation.
	Summer and Winter Rearing
LWD	Low quantities of LWD were observed in most of the fish-bearing reaches. This contributes to low pool frequency, low pool depth, and lack of overhead cover.
Canopy	Past riparian harvest and debris torrents have reduced canopy cover in may reaches resulting in the likelihood of elevated water temperatures.
Off-channel areas and hydraulic refuge areas	The availability of low velocity microhabitat is reduced, due to the lack of large roughness elements in the form of LWD.
Turbidity	GMU 3 is likely to be turbid during storms due to naturally abundant fine sediment. Turbidity may be an issue in some locations receiving inputs from landslide scars.

Downstream fisheries issues

Salmonid habitat quality in the lower portion of the Calapooia River, below the watershed boundary, is adversely affected by several factors including low summer flows, high water temperatures, bank erosion, and barriers to movement. Agricultural and industrial water withdrawals result in decreased flows in the river, primarily in the summer. Removal of riparian vegetation for agricultural purposes results in increased summer water temperatures – a condition that is aggravated by lowered flows. Summer water temperatures are reported to commonly exceed 75°F in the lower Calapooia River (ODFW 1992). Other downstream impacts include removal of riparian vegetation resulting in bank erosion and decreased shading of the River.

MAP 5
HABITAT CONCERNS

Calapooia River WAU



Legend

- RSE 5 - High diversion potential (includes existing gullies and sites with known high risk)
- HSE 2 - Landslide scar erosion (slide numbers: 617 and 709)
- RSE 1 - stream adjacent mainline
- RSE 2 - stream adjacent secondary
- RSE 3 - high cutslope delivery rate
- RSE 4 - high tread delivery under heavy traffic
- Low shade (0-40%)
- Low LWD recruitment potential
- Fish bearing channels potentially receiving fine sediment input from mass wasting
- Debris torrents
- Fish bearing stream
- Non-fish bearing stream
- Driveable roads
- Abandoned/overgrown roads

1.0MI 0MI 1MI 2MI 3MI 4

1 : 90000

1 inch = 7500 feet

Map 5 Habitat Concerns

Weyerhaeuser

DATE: 08/31/98

Barriers to adult and juvenile salmonid movement from water diversion structures are a major habitat concern in the lower Calapooia River. These structures have been in place since the 1950s (Willis et al. 1960). In recent years this situation has been greatly improved by the screening of the Thompson mill ditch (W. Hunt, ODFW, Pers. Comm. 1998).

WATER QUALITY CONCERNS

The water quality of the lower Calapooia River is considered poor by the DEQ (Cude 1998) based on data collected at the mouth of the Calapooia River, which is approximately 46 river miles (RM) below the WAU boundary. Most of the water quality issues in the lower part of the river are related to the extensive agricultural usage in the lower 35 miles of the basin (Cude 1998). The Calapooia River is on the 303(d) list (DEQ 1996) for fecal coliform and temperature standard exceedences. The listing extends from the mouth of the Calapooia River near Albany to Brush Creek, which is approximately 6 miles below the WAU boundary

Water quality parameters such as dissolved oxygen, pH and nutrients are generally not impacted by forest land use . The main water quality parameter that has been impacted indirectly by forest practices is stream temperature, which is addressed in the riparian function assessment (Appendix D). Sediment is a potential concern where it is delivered to depressional closed wetlands. However, this type of wetland only composes a small percent of the total number of wetlands in the WAU (12%) . Sediment delivery to streams addressed in the fish (Appendix F) and channel (Appendix E) assessments.

CONCLUSIONS

The Calapooia River WAU recently experienced a large flood event in 1996, which caused numerous landslides. In fish-bearing tributary streams which experienced debris torrents, fish and fish habitat was impacted by both scour and deposition. In the mainstem of the Calapooia River, the flood event deposited gravel, cobbles and in some areas, wood.

In streams that experienced debris torrents stream-adjacent vegetation was often removed. As a result of the removal of riparian trees, stream temperatures in debris torrented channels have increased. Along the mainstem, stream shading has been reduced by past harvest practices and the presence of a stream-adjacent road, resulting in warm temperatures.

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CALAPOOIA RIVER

WATERSHED ANALYSIS

PART I -SECTION A
SYNTHESIS OF WATERSHED ANALYSIS

Weyerhaeuser

August 1998

Glossary of Terms

active channel The bed, banks, and floodplain of a stream subject to modifications by streamflows. Geometrically synonymous with the bankfull channel.

aggradation A disequilibrium stream channel process that raises the elevation of a reach of an active stream channel by depositing bedload.

alluvial Describing material, usually sediment, deposited by a stream or running water.

anadromous fishes Fish that spend the adult phase of their life cycle in salt water and move up fresh water streams and rivers to spawn.

andesite A dark to medium-colored, fine-grained extrusive rock. Rocks are generally hard and resistant to erosion but are often mixed with less resistant materials.

avulsion The process by which a channel changes course by a sudden diversion. The periodicity of avulsion is controlled by the rate of topographic change, fluctuations in discharge and occurrence of triggering events.

bankfull The cross-sectional elevation of the channel corresponding to the top of the floodplain.

basalt A dark-colored, fine-grained igneous (extrusive) rock. Rocks are generally hard and resistant to erosion but are often mixed with less resistant materials.

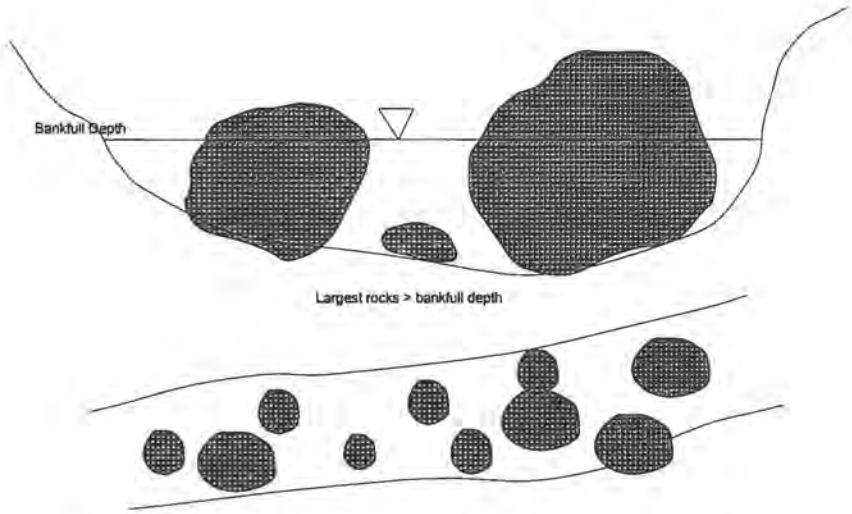
base level The elevation below which a reach of a stream cannot degrade its bed.

bed roughness The frictional resistance to flow in a river or stream system.

bedload mobility The material transported along the floor of a flowing fluid by rolling, sliding or saltation.

cascades A series of small closely spaced waterfalls or steep rapids (channel gradient usually 8-20%). Largest rock in the channel exceeds bankfull depth. Infrequent, small pools (<1 channel width per pool). Low in-channel storage of sediment (high transport relative to supply).

Illustration:



channel migration zone The area that streams have recently occupied (in the last few years or, less often, decades), and would reasonably be expected to occupy again in the near future.

colluvium A deposit of rock fragments and soil material accumulated within depressions or at the base of steep slopes as the result of gravitational action.

confinement The relative ratio of bankfull (active) channel width to valley width where the valley margins may be defined by hillslopes or terrace scarps. This ratio, when assessed in the context of stream gradient, provides a qualitative index of available shear stress as a function of water surface elevation in the channel.

Low confinement (LC) = VW > 4 CW
Moderate confinement (MC) = 2 CW < VW < 4 CW
Tight Confinement (TC) = VW < 2 CW.

Example: Channels with wide floodplains (LC) may shift laterally over the valley bottom, changing course or pattern in response to disturbance but channels confined by bedrock valley walls (TC) can only respond by bedrock modification or channel armoring

dam-break flood (DBF): A dam break flood (DBF) occurs when a natural constriction or dam in a stream channel fails and causes a downstream surge of water and debris caused by the sudden breaching of an impoundment in a stream channel; a form of debris torrent. These dams can be caused by rockfall into a channel, a small slope movement blocking a channel, the deposit of a debris flow, or a debris jam, beaver activity, or a number of other natural mechanisms, and can cause a flood up to two orders of magnitude larger than normal storm runoff floods. These mass wasting events are unusual in that they initiate in areas of generally low slopes, unlike most mass wasting

events. These extreme hyperconcentrated (water > sediment) floods can occur in 1st through 6th order valleys, in both natural and managed landscapes.

debris flood (debris-laden flood) A peak flow event comprised of large volumes of organic debris that can scour and erode the bed and banks of the stream. The woody material can be a component of the waning surge of an upstream debris flow. Distinguished from debris flows and dam break floods by the lack of viscous flow.

debris torrent (DT) Debris flow or dam-break flood, undifferentiated. The effects of debris flow and dam-break floods can appear superficially similar (particularly on air-photos), although the two processes differ in initiation, composition, and travel characteristics. This term is used when it is not possible to distinguish between the two, either because of poor resolution on air-photos or inconclusive evidence in the field.

deep-seated failure Landslide involving deep regolith, weathered rock, and/or bedrock, as well as surficial (pedogenic) soil. As used here, deep-seated landslides commonly include large (acres to hundreds of acres) slope features, associated with geologic materials and structures. In watershed analysis, they are divided into:

- **large-persistent deep-seated failures (LPD)** Commonly slump-earthflows involving large areas of hillside; found in natural and managed landscapes, recognizable over long periods of time, and almost always predate land use. These occur due to climatic changes (periods of high rainfall) or events such as strong earthquakes, geologic weakness, or channel incision. These large persistent deep seated slides appear to have been active at some time in the past, however, they do not appear to have moved on the large scale for many years, perhaps centuries.
- **small-sporadic deep-seated failures (SSD)** Commonly smaller slumps that can be triggered at irregular intervals (by storms or earth movement), and can weather to the point where they are indiscernible.

degradation A disequilibrium stream channel process that lowers the elevation of a reach of an active stream via incision.

dike Long, thin intrusive igneous rock units that cuts across the structure of adjacent rocks.

Illustration:

earthflow: Deep-seated landslide of broken soil and rock, dominated by slow movement (flow-like); produce linear areas of hummocky, disjointed terrain. Earthflow activity is favored in deep, cohesive soil, clay-rich bedrock, or slumped material, and is largely controlled by seasonal (or longer) fluctuations of pore-water pressure.

ephemeral stream A stream that flows only briefly in direct response to rainfall or snowmelt. Its streambed remains above the groundwater table.

extrusive A type of igneous rock that has been erupted onto the surface of the earth. Extrusive rocks include lava flows (which are often composed of basalt and andesite) and pyroclastic material such as volcanic ash.

floodplain The area immediately adjacent to the channel being constructed by the river in the present climate and flooded at high discharge. The level of the floodplain is commonly inferred to be the level of the bankfull stage and is commonly misinterpreted as being coincident with low stream terraces.

flotation load The portion of mobile particles, usually woody debris, in a stream that remain suspended in the water column due to low specific gravities relative to water. A type of suspended load.

geomorphic General shape or features of the landscape.

headwall A steep, wall-like cliff at the back of a hollow or hillslope depression. In reference to slope stability, the term refers to the stability of the entire hollow or depression.

hydrologic maturity Condition of a forest stand in which hydrologic processes operate as they do in a mature or old-growth forest. In particular, snow accumulation is typically lower in thick, dense forest (at middle and lower elevations) than in openings, due to interstorm melt of snow caught in the canopy; and snowmelt is slower, due to decreased wind-aided flux of sensible and latent heat.

intermittent stream A stream that flows during part of the year. Its water is derived from rainfall, snowmelt, or occasional groundwater discharge into the stream channel.

intrusive A type of igneous formed by the injection of magma (molten rock) into pre-existing rock.

iteroparous Capable of repeated reproduction (characteristic of most fishes)

landslide Any mass-movement process characterized by downslope transport of soil and rock, under gravitational forces, by sliding or deformation within a discrete failure zone. Also used to refer to the resultant landform. In common usage, can also include other forms of mass wasting not involving sliding (rockfall, etc.)

large woody debris (LWD) recruitment Large woody debris delivered by the fall of streamside trees, or delivery from upstream sources by stream transport.

longitudinal profile A topographic profile along a valley or stream

mafic Said of an igneous rock composed chiefly of dark, ferromagnesian minerals (iron and magnesium rich minerals).

mass wasting General term for dislodgment and downslope transport of soil and rock under direct gravitational forces (i.e., without major action of water, wind, or ice); mass movement. In watershed analysis, this class of erosion processes is divided into three categories: shallow-rapid landslides, deep-seated failures, and debris torrents.

migration Any mass movement from one habitat to another with characteristic regularity in time according to stages of life history.

peak flow event Maximum instantaneous stream discharge during runoff, commonly caused by an individual rainstorm, rain-on-snow, or spring snowmelt.

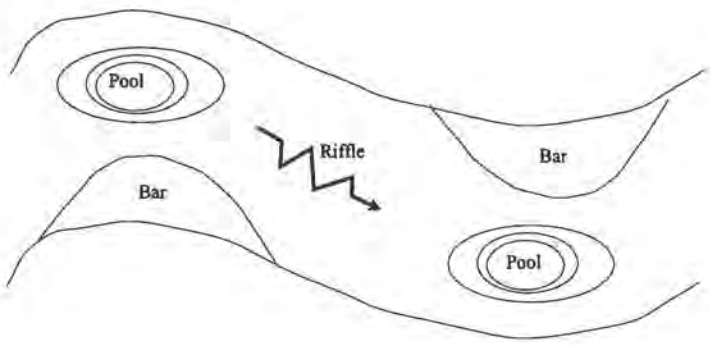
perennial stream A stream that flows continuously as a result of surface runoff and influx of groundwater.

piedmont A plain that slopes away from the base of a mountainous escarpment.

plane-bed channel A channel that lacks well-defined bedforms and are characterized by long stretches of relatively planar channel bed that may be punctuated by occasional channel spanning rapids. Channel gradient is commonly between 1 and 3%, and can have a wide range of confinement (LC to TC). Additions of large woody debris may provide sufficient flow convergence and divergence to cause pool development and transform the channel to a forced pool-riffle morphology. Rapid aggradation (sediment deposition) can change the channel to a braided morphology.

pool-riffle channel A channel with an undulating bed that defines a sequence of bars, pools and riffles. Channel gradient is commonly between 1 and 3%, and generally unconfined. Regular spacing of pools at 5-7 channel widths per pool. Maximum diameter of substrate much less than bankfull depth. Low relative transport capacity makes them particularly sensitive to changes in sediment supply and discharge.

Illustration:



potamodromous A type of fish migration which occurs wholly in freshwater.

Quaternary The second period of the Cenozoic era, following the Tertiary; also, the corresponding system of rocks. It began 1.6 million years ago and extends to the present.

Rain-on-snow zone Area (generally defined as an elevation zone) where it is common for snowpacks to be partially or completely melted during rainstorms several times during the winter.

riparian function Activity relating to the LWD recruitment and stream-shading functions provided by riparian vegetation.

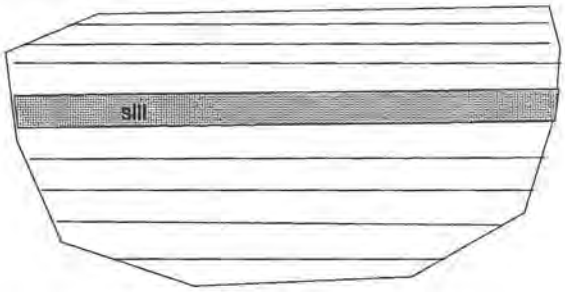
riparian zone Area surrounding a stream, in which ecosystem processes are within the influence of stream processes.

saltation The process of particle transport in stream channels via bouncing along the stream bed. Particle position thus alternates between suspension in the flow and short-term resting on the channel bed.
semelparous Capable of one reproduction (characteristic of salmon).

shallow-rapid landslide (SR): Landslide produced by failure of the soil mantle (typically to a depth of one or two meters, sometimes including some weathered bedrock), on a steep slope. The debris moves quickly (commonly building up and developing into a debris torrent), leaving an elongate, spoon-shaped scar. Shallow-rapid landslides not associated with roading, most often occur in convergent topography on steep slopes in areas where topography or bedrock structure concentrates drainage such as in swales or draws. The main factor contributing to the occurrence of these types of slides are slope, saturation of soil and loss of root strength. Forest practices can effect these factors and influence the occurrence of shallow-rapid landslides.

sill An igneous intrusion that parallels the planar structure of the surrounding rock (like a dike but dikes can bisect rock but a sill has to parallel the planes of the rock into which it is intruded).

Illustration:



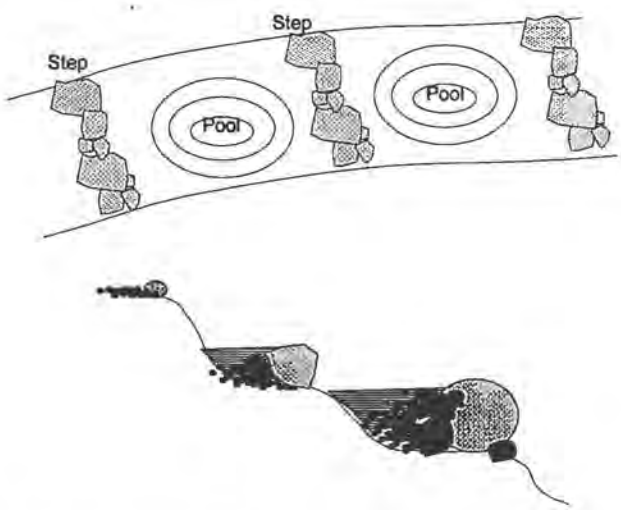
slump: Deep, rotational landslide, generally producing coherent movement (back-rotation) of blocks over a concave failure surface. Typically, slumps are triggered by increased pore-water pressure in mechanically weak materials (deep soil or clay-rich rock).

slump-earthflow: Landslide exhibiting characteristics of both slumps and earthflows: typically the upper part moves by slump (rotation of blocks), while the lower portion moves by flow (hummocky terrain).

snow-water equivalent (SWE) Amount of liquid water (expressed as depth) derived by melting a snowpack.

step-pool channel Channels characterized by large particles (boulders or woody debris) organized into discrete channel spanning accumulations that form a series of steps separating pools. Longitudinal gradients are typically 4 to 8 percent.

Illustration:



strath An extensive terrace-like remnant of a broad valley floor that has undergone dissection, e.g. a river terrace along a valley wall or incised bedrock.

stream power The power available to transport bedload. It consists of those variables (such as discharge and gradient) that, if increased, favor bedload transport and fluvial degradation.

stream terrace A relatively flat surface adjacent to a stream or river that represents an abandoned floodplain (low terraces are frequently confused with the floodplain). Terrace surfaces can rise one to tens of meters above the active channel bed.

Tertiary The first period of the Cenozoic era (after the Cretaceous of the Mesozoic era and before the Quaternary), thought to have covered the span of time between 65 million and 2 million years ago; also, the corresponding system of rocks.

toe The downslope edge of a landslide or slump.

CALAPOOIA RIVER

WATERSHED ANALYSIS

PART I -SECTION B
CAUSAL MECHANISM REPORTS/
PRESCRIPTIONS

Weyerhaeuser

August 1998

Causal Mechanism Report Summary

Mass Wasting Resource Sensitivity A1

Watershed	Upper Calapooia River Watershed Analysis Unit (WAU)
Resource sensitivity	Non road–related failures from steep, concave slopes
Situation summary	Non road–related shallow rapid landslides (SR), and debris flows (DF), in mass wasting map unit (MWMU) 1 deliver coarse and fine sediment directly to steep gradient channels and the lower gradient mainstem (see Appendix E – Stream Channel Assessment for GMU descriptions). The primary concerns for each public resource are provided below.
Fish habitat concerns	The primary concerns for fish habitat include: • Increased fine and coarse sediment deposition can result in pool filling and reduced cobble interstices used by holding and rearing fish. Fish-bearing reaches sensitive to this deposition are GMUs 1, 4, and 5. • Accumulation of fine sediment can also reduce the quality of spawning habitat in these same reaches. • Turbidity during and following storm-flow events temporarily degrade water quality and impact salmonid's ability to feed. • Debris torrent scour can result in loss of fish populations, where barriers isolate these populations. The scour process also reduces rearing and spawning habitat through the reduction of cover features and coarse substrate. In the deposition zone of debris torrents, very abundant accumulations of coarse sediment results in reduced pool habitat and can result in a sub-terranean flow condition that prevents use by fish.
Water supply concerns	There are no water supply concerns.

Continued on next page

Mass Wasting Resource Sensitivity A1, Continued

Public works concerns

There are no public works concerns.

Triggering mechanisms

The following factors lead to the generation and delivery of sediment from non road-related landslides in MWMU 1.

Natural characteristics:

- Steep concave slopes (>60% DEM), including headwalls and hollows, supported primarily by basalts and andesites that concentrate shallow ground water, which can destabilize slopes by increasing pore water pressure (includes ground water seeps).
- Occurrence of large storms, routing large quantities of shallow groundwater to unstable slopes.
- Shallow soils formed from weathered rock and colluvial material.

Contributing management-related characteristics:

- The majority of non road-related landslides for which applicable stand age data is available (from entire watershed), probably occurred within 20 years of harvest. This suggests that in many cases the slope stability was reduced by harvest, possibly associated with:
    - reduction in root strength (Burroughs and Thomas 1977; Krogstad 1996; Ziemer 1981); and/or
    - increases in shallow subsurface pore–water pressure following removal of vegetation during harvest.
- Whether root strength or ground water changes due to harvest is the more important factor affecting slope stability is not known—it will vary based on specific site conditions.
- 84 of 153 total in–unit failures (55%) from MWMU 1 were from concave landforms. Convergent topography concentrates water; therefore, landforms such as headwalls and bedrock hollows are most susceptible to changes in ground water from harvest activities.

Continued on next page

Mass Wasting Resource Sensitivity A1, Continued

Additional comments

Maps and Data

- Detailed information on these landslides is available from Form A1: Landslide Inventory and Form A2: Mass Wasting Map Unit descriptions (see Appendix A: Attachments).
- Map A2 delineates the mass wasting map units for this situation (MWMU 1). The specific areas of concern are subject to field verification.

Causal Mechanism Report Summary

Mass Wasting Resource Sensitivity A2

Watershed

Upper Calapooia River Watershed Analysis Unit (WAU)

Resource sensitivity

Fill failures on steep slopes

Situation summary

Landing and road–related shallow rapid landslides (SR), and debris flows (DF) in mass wasting map units (MWMU) 1, 2 and 7 deliver coarse and fine sediment directly to steep gradient channels and the lower gradient mainstem (see Appendix E – Stream Channel Assessment for GMU descriptions).

The primary concerns for each public resource are provided below.

Fish habitat concerns

The primary concerns for fish habitat include:

- Increased fine and coarse sediment deposition can result in pool filling and reduced cobble interstices used by holding and rearing fish. Fish-bearing reaches sensitive to this deposition are GMUs 1, 4, and 5.
- Accumulation of fine sediment can also reduce the quality of spawning habitat in these same reaches.
- Turbidity during and following storm-flow events temporarily degrade water quality and impact salmonid's ability to feed.
- Debris torrent scour can result in loss of fish populations, where barriers isolate these populations. The scour process also reduces rearing and spawning habitat through the reduction of cover features and coarse substrate. In the deposition zone of debris torrents, very abundant accumulations of coarse sediment results in reduced pool habitat and can result in a sub-terranean flow condition that prevents use by fish.

Water supply concerns

There are no water supply concerns.

Continued on next page

Mass Wasting Resource Sensitivity A2, Continued

Public works concerns

There are no public works concerns.

Triggering mechanisms

The following factors lead to the generation and delivery of sediment from landslides in MWMU 1, 2, and 7:

Natural characteristics:

- Steep concave slopes (>60% DEM), including headwalls and hollows, supported primarily by basalts and andesites (MWMU 1) and moderately steep to steep planar and concave slopes in basalts and andesites (MWMU 2) and weathered volcaniclastics (mostly within MWMU 7) that concentrate shallow ground water, which can destabilize slopes by increasing pore water pressure (includes ground water seeps).
- Occurrence of large storms, routing large quantities of shallow groundwater to unstable slopes.
- Soils formed from weathered volcaniclastics and colluvial material.

Contributing management-related characteristics:

Road-related landslides

- Example: 89 of the 139 total road–related failures (64%) from MWMU 1 were from concave landforms; 44 (32%) were from planar slopes.
- Landslides occur naturally in these units; however, landing fill and sidecast provide additional material that can become saturated and fail. While the slope and low shear strength of the colluvial material probably provides for the natural instability, road-related landslides may also be affected by inclusions of organic debris in sidecast material and inadequate road drainage.
- The road–related landslide densities are:

MWMU #1: 3.6 landslides per mile of road (includes inactive roads)
MWMU #2: 1.7 landslide per mile of road (includes inactive roads)
MWMU #7: 0.2 per mile of road (includes inactive roads)

Continued on next page

Mass Wasting Resource Sensitivity A2, Continued

Additional comments

Maps and Data

- Detailed information on these landslides is available from Form A1: Landslide Inventory and Form A2: Mass Wasting Map Unit descriptions (see Appendix A: Attachments).
- Map A2 delineates the mass wasting map units for this situation (MWMU 1, 2, and 7). The specific areas of concern are subject to field verification.

Causal Mechanism Report Summary

Mass Wasting Resource Sensitivity A3

Watershed

Upper Calapooia River Watershed Analysis Unit (WAU)

Resource sensitivity

Road construction in colluvial deposits (from LPD's and SSD's)

Situation summary

Road–related shallow rapid landslides (SR), debris flows (DF), and small sporadic deep-seated landslides (SSD) in mass wasting map unit (MWMU) 3 and 7 deliver sediment directly to or via steep gradient channels to the lower gradient mainstem (see Appendix E – Stream Channel Assessment for GMU descriptions).

The primary concerns for each public resource are provided below.

Fish habitat concerns

The primary concerns for fish habitat include:

- Increased fine and coarse sediment deposition can result in pool filling and reduced cobble interstices used by holding and rearing fish. Fish-bearing reaches sensitive to this deposition are GMUs 1, 4, and 5.
- Accumulation of fine sediment can also reduce the quality of spawning habitat in these same reaches.
- Turbidity during and following storm-flow events temporarily degrade water quality and impact salmonid's ability to feed.
- Debris torrent scour can result in loss of fish populations, where barriers isolate these populations. The scour process also reduces rearing and spawning habitat through the reduction of cover features and coarse substrate. In the deposition zone of debris torrents, very abundant accumulations of coarse sediment results in reduced pool habitat and can result in a sub-terranean flow condition that prevents use by fish.

Water supply concerns

There are no water supply concerns.

Continued on next page

Mass Wasting Resource Sensitivity A3, Continued

Public works concerns

There are no public works concerns.

Triggering mechanisms

The following factors lead to the generation and delivery of sediment from road–related landslides in MWMU 3 and 7:

Natural characteristics:

- Sharp slope breaks at the margins of LPD's and other benchy terrain within MWMU 3 and 7.
- Occurrence of large storms, routing large quantities of shallow groundwater to unstable slopes.
- Creeping, clay rich soils in deeply weathered colluvial deposits, particularly those with low shear strength. These soils can perch shallow ground water and route groundwater to bench edges, resulting in increased pore water pressures and slope instability.

Contributing management-related characteristics:

Road-related landslides

- Twenty nine percent of landslides in MWMU 3 and 54% in MWMU 7 over the period of record were road–related. Several of these occurred within an inner gorge, created where a landslide toe impinges on a stream.
- Landslides occur naturally in this unit; however, landing fill and sidecast provide additional material that can become saturated and fail. While the slope and low shear strength of the colluvial material probably provides for the natural instability, road-related landslides may also be affected by inclusions of organic debris in sidecast material and inadequate road drainage.
- The road–related landslide densities are:
  - ◊ MWMU #3: 0.3 landslides per mile of road (includes inactive roads)
  - ◊ MWMU #7: 0.2 landslides per mile of road (includes inactive roads)

Continued on next page

Mass Wasting Resource Sensitivity A3, Continued

Additional comments

Maps and Data

- Detailed information on these landslides are available from Form A1: Landslide Inventory and Form A2: Mass Wasting Map Unit descriptions (see Appendix A: Attachments).
- Map A2 delineates the mass wasting map units for this situation (MWMU 3 and 7). The specific areas of concern are subject to field verification.

Causal Mechanism Report Summary

Mass Wasting Resource Sensitivity A4

Watershed

Upper Calapooia River Watershed Analysis Unit (WAU)

Resource sensitivity

Road and non–road related failures in inner gorges

Situation summary

Road and non road–related shallow rapid landslides (SR), and stream adjacent slumps within inner gorges in mass wasting map (MWMU) 4 deliver coarse and fine sediment directly to steep gradient channels and the lower gradient mainstem (see Appendix E – Stream Channel Assessment for GMU descriptions).

Because of the difficulty in identifying inner gorge landforms from maps and aerial photos, these features are not identified on Map A2: Mass Wasting Map Units. Training in field identification of inner gorges is to be provided during prescriptions.

Fish habitat concerns

The primary concerns for fish habitat include:

- Increased fine and coarse sediment deposition can result in pool filling and reduced cobble interstices used by holding and rearing fish. Fish-bearing reaches sensitive to this deposition are GMUs 1, 4, and 5.
- Accumulation of fine sediment can also reduce the quality of spawning habitat in these same reaches.
- Turbidity during and following storm-flow events temporarily degrade water quality and impact salmonid's ability to feed.
- Debris torrent scour can result in loss of fish populations, where barriers isolate these populations. The scour process also reduces rearing and spawning habitat through the reduction of cover features and coarse substrate. In the deposition zone of debris torrents, very abundant accumulations of coarse sediment results in reduced pool habitat and can result in a sub-terranean flow condition that prevents use by fish.

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Mass Wasting Resource Sensitivity A4, Continued

Water supply concerns

There are no water supply concerns.

Public works concerns

There are no public works concerns.

Triggering mechanisms

The following factors lead to the generation and delivery of sediment from road and non road-related landslides within inner gorges in MWMU 4.

Natural characteristics:

- Inner gorges are steep (>60%) stream–adjacent slopes below bench margins. They may be caused by a number of features, but are attributed in MWMU 4 to areas where the inner gorge is created by structural breaks in slope (e.g., bedrock benches), and where streams are incising through or around the toes of deep–seated landslide deposits.
- Sharp slope breaks at the margins of LPD's and other benchy terrain within MWMU 3 and 7.
- Occurrence of large storms, routing large quantities of shallow groundwater to unstable slopes.
- Creeping, clay rich soils in deeply weathered colluvial deposits, particularly those with low shear strength. These soils can perch shallow ground water and route groundwater to bench edges, resulting in increased pore water pressures and slope instability.

Contributing management-related characteristics:

Road-related landslides

- Nine of 31 (29%) inner gorge landslides were road–related.
- Landslides occur naturally in this unit; however, landing fill and sidecast provide additional material that can become saturated and fail. While the slope and low shear strength of the colluvial material provides for the natural instability, road-related landslides may also be affected by inclusions of organic debris in sidecast material and inadequate road drainage.

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Mass Wasting Resource Sensitivity A4, Continued

Additional comments

Maps and Data

- Detailed information on these landslides are available from Form A1: Landslide Inventory and Form A2: Mass Wasting Map Unit descriptions (see Appendix A: Attachments).
- Map A2 delineates the mass wasting map units for this situation (MWMU 4) The specific areas of concern are subject to field verification.
- Like all inner gorges, these features are not readily resolvable from topographic maps, therefore, they are not explicitly identified on Map A2: Mass Wasting Map Units.

Causal Mechanism Report Summary

Mass Wasting Resource Sensitivity A5

Watershed	Upper Calapooia River Watershed Analysis Unit (WAU)
Resource sensitivity	Road cutbank failures
Situation summary	Shallow rapid landslides (SRs) initiating from road cutbanks in Mass Wasting Map Units (MWMUs) 1, 2, 3, and 7 can impact fish habitat, damage downstream engineered structures, and impact water quality.
Fish habitat concerns	The primary concerns for fish habitat include: • Increased fine and coarse sediment deposition can result in pool filling and reduced cobble interstices used by holding and rearing fish. Fish-bearing reaches sensitive to this deposition are GMUs 1, 4, and 5. • Accumulation of fine sediment can also reduce the quality of spawning habitat in these same reaches. • Turbidity during and following storm-flow events temporarily degrade water quality and impact salmonid's ability to feed. • Debris torrent scour can result in loss of fish populations, where barriers isolate these populations. The scour process also reduces rearing and spawning habitat through the reduction of cover features and coarse substrate. In the deposition zone of debris torrents, very abundant accumulations of coarse sediment results in reduced pool habitat and can result in a sub-terranean flow condition that prevents use by fish.
Water supply concerns	There are no water supply concerns.
Public works concerns	There are no public works concerns.

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Mass Wasting Resource Sensitivity A5, Continued

Triggering mechanisms

The following factors lead to the generation and delivery of sediment from cut bank failure in MWMU 1, 2, 3, and 7:

Natural characteristics:

- Occurrence of large storms, routing large quantities of shallow groundwater to unstable slopes.

Contributing management-related characteristics:
Road cutbank failures are due to oversteepening of geologic materials and/or the removal of lateral support by the roadcut. Cutbank failures may occur in all geologic materials, but depend on site-specific conditions such as material type and strength, ground and surface water conditions, slope height, initial and modified slope angle, and other factors. Cutbank failures are most likely to occur where roadcuts are placed in relatively weak materials that are already at steep angles (such as tuffs or altered breccia), in weak materials, or in disturbed materials (such as landslide deposits or colluvium) at steep to moderate slopes. Areas of ground or surface water concentration are also more likely to fail.

Because delivery is typically limited to fines which are carried by the road ditch, the impact of road cutbank failures to fish habitat and water quality is probably small compared to other sources within the WAU; however, this could not be quantified during the assessment.

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Mass Wasting Resource Sensitivity A5, Continued

Additional comments

Maps and Data

- Detailed information on these landslides are available from Form A1: Landslide Inventory and Form A2: Mass Wasting Map Unit descriptions (see Appendix A: Attachments).
- Map A2 delineates the mass wasting map units for this situation (MWMU 1, 2, 3, and 7). The specific areas of concern are subject to field verification.

Causal Mechanism Report Summary

Mass Wasting Resource Sensitivity A6

Watershed	Upper Calapooia River Watershed Analysis Unit (WAU)
Resource sensitivity	Slope breaks and benches
Situation summary	Shallow rapid failures (SRs), debris torrents (DTs), and small sporadic deep seated landslides (SSDs) can be initiated at slope breaks and midslope benches in Mass Wasting Map Units (MWMUs) 3, 5 and 7 resulting in impacts to fish habitat, damage to downstream engineered structures, and impact to water quality.
Fish habitat concerns	The primary concerns for fish habitat include: • Increased fine and coarse sediment deposition can result in pool filling and reduced cobble interstices used by holding and rearing fish. Fish-bearing reaches sensitive to this deposition are GMUs 1, 4, and 5. • Accumulation of fine sediment can also reduce the quality of spawning habitat in these same reaches. • Turbidity during and following storm-flow events temporarily degrade water quality and impact salmonid's ability to feed. • Debris torrent scour can result in loss of fish populations, where barriers isolate these populations. The scour process also reduces rearing and spawning habitat through the reduction of cover features and coarse substrate. In the deposition zone of debris torrents, very abundant accumulations of coarse sediment results in reduced pool habitat and can result in a sub-terranean flow condition that prevents use by fish.
Water supply concerns	There are no water supply concerns.
Public works concerns	There are no public works concerns.

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Mass Wasting Resource Sensitivity A6, Continued

Triggering mechanisms

The following factors lead to the generation and delivery of sediment from road and non road-related landslides at bench edges in MWMU 3,5 and 7.

Natural characteristics:

- Sharp slope breaks at the margins of LPD's and other benchy terrain within MWMU 3, 5, and 7.
- Occurrence of large storms, routing large quantities of shallow groundwater to unstable slopes.
- Creeping, clay rich soils in deeply weathered colluvial deposits, particularly those with low shear strength. These soils can perch shallow ground water and route groundwater to bench edges, resulting in increased pore water pressures and slope instability.

Contributing management-related characteristics:

- Triggering mechanisms are of two types for benches and slope breaks, loading and removal of lateral support, and should be considered in the context of scale of the affected feature. Loading can be from activities, such as waste placement, while road cuts are the primary source of loss of lateral support. In general, the smaller the feature, the less the change in conditions necessary to create instability of the feature, i.e., a small feature can withstand less loading or removal of material than a large feature.

Additional comments

Maps and Data

- Detailed information on these landslides are available from Form A1: Landslide Inventory and Form A2: Mass Wasting Map Unit descriptions (see Appendix A: Attachments).
- Map A2 delineates the mass wasting map units for this situation (MWMU 3, 5, and 7). The specific areas of concern are subject to field verification.

Causal Mechanism Report Summary

Surface Erosion Sensitivity B1

Watershed	Calapooia River Watershed Administrative Unit (WAU)
Resource sensitivity	Ground-based harvest activities
Situation summary	Ground-based harvest activities that expose soil adjacent to small, incised channels or cross surface drainages (i.e. swales and ephemeral channels) in SEMU 1 can deliver silt and clay size material directly to GMUs 1 and 3 via overland flow. Deposition of fine sediment can result in filled pools and reduced cobble interstices used by holding and rearing fish. Accumulation of fine sediment can reduce the quality of spawning habitat. Turbidity during and following storm events may temporarily degrade water quality and impacts salmonids ability to feed.
Triggering mechanism	**Primary** Tractor piling of slash in the vicinity of ephemeral stream channels was observed to expose soils and divert surface flow out of ephemeral channels and across exposed soils on a small portion of Unit 3 in SEMU 1 (Map B3). **Secondary** Exposed soils were noted on the steep inner gorge areas of several weakly incised channels in Unit 3 (Map B3). Surface erosion of such sites can temporarily increase the delivery of fine sediment to stream channels. However, the effects are short term given the rapid recovery of surface vegetation. No exposed soils were observed in harvest units greater than 3 years old in this SEMU.

Causal Mechanism Report Summary

Surface Erosion Sensitivity B2

Watershed

Calapooia River Watershed Administrative Unit (WAU)

Resource sensitivity

Stream adjacent road; heavy use.

Situation summary

The Calapooia Mainline parallels the Calapooia River, and is located within 200 feet of the channel for most of its length (Map B6). The existing traffic use of this road is considered heavy. Heavy traffic can generate significant amounts of fine sediment, and the high tread delivery rate (64%) results in direct inputs of this material to GMU 1. Deposition of fine sediment can result in filled pools and reduced cobble interstices used by holding and rearing fish. Accumulation of fine sediment can reduce the quality of spawning habitat. Turbidity during and following storm events may temporarily degrade water quality and impacts salmonids ability to feed.

Triggering mechanism

Primary

Heavy use of the mainline by logging trucks, especially during wet weather, can generate moderate amounts of fine sediment. Since the road parallels the stream, is directly adjacent to or within 200 feet for much of its length (Map B6), and has a moderately high delivery rate relative to other channels segments, some of this sediment is delivered directly to the mainstem Calapooia River (GMU1).

Secondary

Sediment erosion and delivery are inversely proportional to the level of road maintenance. In May 1998, the road surface was severely potholed in some locations, indicating a general lack of maintenance.

Causal Mechanism Report Summary

Surface Erosion Sensitivity B3

Watershed

Calapooia River Watershed Administrative Unit (WAU)

Resource sensitivity

Stream adjacent roads; moderate use.

Situation summary

The 600 and 700 roads are located directly adjacent to Potts Creek and North Fork Calapooia River respectively. The existing traffic use of these roads is considered moderate. Heavy traffic can generate significant amounts of fine sediment that is delivered directly to GMU 4, and routed to GMU 1. Deposition of fine sediment can result in filled pools and reduced cobble interstices used by holding and rearing fish. Accumulation of fine sediment can reduce the quality of spawning habitat. Turbidity during and following storm events may temporarily degrade water quality and impacts salmonids ability to feed.

Triggering mechanism

Primary

The stream adjacent portions of the 600 and 700 roads have moderately high delivery rates (20 to 40 percent) due to their position (Map B6). While the current use rate is moderate, modeling indicates that heavy use by logging trucks, especially during wet weather, can result in the delivery of moderate amounts of fine sediment from these segments. Fine sediment is delivered directly to GMU 4 and routed downstream to GMU 1.

Secondary

Sediment erosion and delivery are inversely proportional to the level of road maintenance. The road surfaces were generally adequately maintained. However surface cover was thin and some rilling was noted on the 700 road.

Causal Mechanism Report Summary

Surface Erosion Sensitivity B4

Watershed	Calapooia River Watershed Administrative Unit (WAU)
Resource sensitivity	High, exposed cutslopes on roads
Situation summary	Erosion from high, exposed cutslopes on the 2400, 2700, 3000, 3030, 3350 and 3400 roads contributes moderate amounts of fine sediment to GMUs 3, 4 and 5 (Map B6). Fine sediment delivered to these GMUs is routed to GMU 1. Deposition of fine sediment can result in filled pools and reduced cobble interstices used by holding and rearing fish. Accumulation of fine sediment can reduce the quality of spawning habitat. Turbidity during and following storm events may temporarily degrade water quality and impacts salmonids ability to feed.
Triggering mechanism	Erosion of exposed cutslopes in SEMUs 1,3 and 4 delivers fine sediment to inboard ditches that route material directly to stream channels at road crossings. The spacing of ditch relief culverts that would drain runoff to forested slopes exceeded the recommended spacing at numerous sites, particularly on roads that had not received recent major repairs.

Causal Mechanism Report Summary

Surface Erosion Sensitivity B5

Watershed

Calapooia River Watershed Administrative Unit (WAU)

Resource sensitivity

Road tread delivery

Situation summary

Model results indicate that tread surface erosion resulting from high traffic on the 700, 2400, 2600, 3000, and 3100 roads could contribute high amounts of fine sediment to GMUs 3, 4, and 5 (Map B6). Fine sediment delivered to these GMUs is routed to GMU 1. Deposition of fine sediment can result in filled pools and reduced cobble interstices used by holding and rearing fish. Accumulation of fine sediment can reduce the quality of spawning habitat. Turbidity during and following storm events may temporarily degrade water quality and impacts salmonids ability to feed.

Triggering mechanism

Primary

Heavy use by logging trucks, especially during wet weather, can generate significant amounts of fine sediment. Delivery rates on these roads are moderate (15 to 39%), and surface materials are generally thin. Road treads deliver fine sediment to inboard ditches that route material directly to stream channels at road crossings. The spacing of ditch relief culverts that would drain runoff to forested slopes exceeded the recommended spacing at numerous sites.

Secondary

Sediment erosion and delivery are inversely proportional to the level of road maintenance. The road surfaces were generally adequately maintained. A few gullies that extended to stream channels were noted on the 3000, and more likely exist at sites not encountered during the field reconnaissance.

Causal Mechanism Report Summary

Surface Erosion Sensitivity B6

Watershed

Calapooia River Watershed Administrative Unit (WAU)

Resource sensitivity

Road washouts at stream crossings.

Situation summary

Road washouts at stream crossing sites with high diversion potential delivered large amounts of fine sediment directly to GMU5, and routed the material downstream to GMUs 1 and 5. Deposition of fine sediment can result in filled pools and reduced cobble interstices used by holding and rearing fish. Accumulation of fine sediment can reduce the quality of spawning habitat. Turbidity during and following storm events may temporarily degrade water quality and impact salmonids ability to feed. Sites with existing gullies or observed high diversion potential are depicted on Map B6.

Triggering mechanism

Primary

Culvert blockage that form during high flow events (e.g. 675 road) or because of inadequate maintenance of abandoned roads (e.g. Potts Creek spur) can divert streamflow down roads causing catastrophic gullying. This type of failure is most common on insloped or crowned roads at crossing sites with a high diversion potential. Sites with high diversion potential were observed in all GMUs.

Secondary

Small cutslope failures can block ditch relief culverts. Blocked relief culverts with a high diversion potential can divert water down the inboard ditch or tread surface resulting in catastrophic gullying and potentially mass wasting. Few instances of this type of failure were observed in the Calapooia WAU. However, numerous ditch relief culverts with high diversion potential were noted in all GMUs.

Causal Mechanism Report Summary

Surface Erosion Sensitivity B7

Watershed

Calapooia River Watershed Administrative Unit (WAU)

Resource sensitivity

Landslide scars

Situation summary

MWMU 3 includes several chronically active small sporadic deep-seated landslides (Map A1). Modeling of sheet and rill erosion on exposed MWMU 3 landslide scars indicates that a single large landslide (#709, Map A1) may increase annual fine sediment yields by more than 100%. Fine sediment is delivered directly to stream channels in GMU 5 by overland flow during heavy rainstorms, then routed to GMU 1. Deposition of fine sediment can result in filled pools and reduced cobble interstices used by holding and rearing fish. Accumulation of fine sediment can reduce the quality of spawning habitat. Turbidity during and following storm events may temporarily degrade water quality and impacts salmonids ability to feed.

Triggering mechanisms

Primary

Landslide 709 was reactivated in 1997, exposing soil material over an area of approximately 2.5 acres. The steep slope, erodible soil and proximity to the stream channel allow eroded material to enter a small, steep mountain channel (GMU 4) that quickly routes fine sediment to GMU 1.

Causal Mechanism Report Summary

Riparian Resource Sensitivity D1

Watershed

Calapooia River Watershed Administrative Unit (WAU).

Resource sensitivity

Current high large woody debris recruitment potential (dense riparian stands of medium to large-diameter conifers and mixed conifers and hardwoods).

Situation summary

Medium and large-diameter conifer and mixed conifer and hardwood riparian stands are currently of a size sufficient to contribute large wood to channels. LWD can alter stream beds by sorting and storing gravel, increasing pool depth and frequency, and creating cover for anadromous and resident fish species. In many stream reaches adjacent to these stands, in-channel wood loadings are currently low to moderate. Thus, in-channel wood of a size and quantity to affect channel morphology and physical features of fish habitat may be limited.

Triggering mechanism

Currently, dense stands of large-diameter conifer and mixed conifer and hardwood riparian areas are considered to have high LWD recruitment potential. However, harvest of too many conifers or hardwoods of a size suitable to function in adjacent stream channels may diminish the future supply of functional LWD. In addition, harvest of trees greater than 11 in (28 cm) dbh along streams with bankfull widths wider than 8 ft (2.4 m) may diminish the future supply of functional pieces of LWD that wider channels require (see Table D4 in the Riparian Function Assessment for minimum size for functional pieces based on average bankfull width). If wood of a suitable size and amount is not delivered to the stream channel, further loss of pools, spawning habitat and cover is possible.

Additional comments

See the green line on Map CMD1 for the extent of causal mechanism D1 in the WAU.

Channel sensitivity to gains and losses of woody debris is variable throughout the watershed. The following table (Table CMD1) presents the percent of each GMU in Resource Sensitivity D1. Further descriptions of the GMUs and the reasons for their sensitivity to changes in wood loadings can be found in Appendix D and Appendix E.

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Riparian Resource Sensitivity D1, Continued

Table CMD1. Percent of each GMU in Resource Sensitivity D1.

Channel Sensitivity to Wood	Name of GMU	GMU Number	Miles (both sides of stream) of GMU in Resource Sensitivity D1	Percent of GMU in Resource Sensitivity D1
High	Hummocky Earthflow Hillslopes	3	1.4	15.2
	Low Gradient Narrow Valley Floor	4	0.9	13.4
Moderate to High	Steep Mountains (based on local gradient)	5	4.0	9.1
Moderate*	Calapooia River Mainstem	1	8.8	17.3

*Though the channel is only moderately sensitive to wood, fish habitat (cover) sensitivity is high for this GMU.

Causal Mechanism Report Summary

Riparian Resource Sensitivity D2

Watershed

Calapooia River Watershed Administrative Unit (WAU).

Resource sensitivity

Hardwood-dominated stands.

Situation summary

Some stream-adjacent stands are dominated by hardwoods (mainly red alder) as a result of past management practices. The existence of conifers prior to management can be inferred from historical air photos as well as the presence of conifer stumps within some of the hardwood stands. In general, hardwoods, especially red alder, are often too small and do not persist within stream channels. Large diameter wood is required to sort and store gravel, increase pool depth and frequency, and create cover for anadromous and resident fish species. In many stream reaches adjacent to these stands, in-channel wood loadings are currently low to moderate. Thus, wood of a size and quantity to affect channel morphology and physical features of fish habitat may be limited. In some reaches, functional in-channel LWD is currently present, but over time this will decay or be transported out of the system from high flow events. The adjacent hardwood dominated riparian areas in these reaches are not able to provide a source of persistent in-channel wood.

Triggering mechanism

Past forest practices have removed extensive amounts of stream-adjacent conifers throughout the WAU. The resulting hardwood-dominated stands have only low to moderate near-term recruitment potential and generally do not provide long-term channel stability that coniferous LWD can provide. In addition, harvest of trees greater than 11 in (28 cm) dbh along streams with bankfull widths wider than 8 ft (2.4 m) may diminish the future supply of functional pieces of LWD that these channels require (see Table D4 in the Riparian Function Assessment for minimum size for functional pieces based on average bankfull width). If wood of a suitable size and amount is not delivered to the stream channel, further loss of pools, spawning habitat and cover is possible.

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Riparian Resource Sensitivity D2, Continued

Additional comments

See the blue line on Map CMD1 for the extent of causal mechanism D2 in the WAU.

The following table (Table CMD2) presents the percent of each GMU in Resource Sensitivity D2. Further descriptions of the GMUs and the reasons for their sensitivity to changes in wood loadings can be found in Appendix D and Appendix E.

Table CMD2. Percent of each GMU in Resource Sensitivity D2.

Channel Sensitivity to Wood	Name of GMU	GMU Number	Miles (both sides of stream) of GMU in Resource Sensitivity D2	Percent of GMU in Resource Sensitivity D2
High	Hummocky Earthflow Hillslopes	3	2.9	31.5
	Low Gradient Narrow Valley Floor	4	2.1	31.3
Moderate to High	Steep Mountains (based on local gradient)	5	2.5	5.7
Moderate*	Calapooia River Mainstem	1	12.3	24.1

*Though the channel is only moderately sensitive to wood, fish habitat (cover) sensitivity is high for this GMU.

Causal Mechanism Report Summary

Riparian Resource Sensitivity D3

Watershed

Calapooia River Watershed Administrative Unit (WAU).

Resource sensitivity

Small-diameter mixed and conifer-dominated riparian stands.

Situation summary

Some riparian areas are dominated by small-diameter conifer and mixed conifer and hardwood stands, which are not of a size to contribute functional pieces of large wood to stream channels. LWD can alter stream beds by sorting and storing gravel, increasing pool depth and frequency, and creating cover for anadromous and resident fish species. In many stream reaches adjacent to these stands, in-channel wood loadings are currently low to moderate. Thus, wood of a size and quantity to affect channel morphology and physical features of fish habitat may be limited.

The small-diameter conifer stands could conceivably provide recruitable wood within 100 years, depending on riparian condition and management practices. Mixed stands may take longer than 100 years to get medium to large-diameter conifers due to light and nutrient competition from hardwoods and shrubs.

Triggering mechanism

Several mixed stands originated due to natural conditions as well as riparian harvest. Small-diameter conifer stands largely exist as a result of regeneration after past timber harvest in riparian areas. In addition, future harvest of trees greater than 11 in (28 cm) dbh along streams with bankfull widths wider than 8 ft (2.4 m) may diminish the supply of functional pieces of LWD that these channels require (see Table D4 in the Riparian Function Assessment for minimum size for functional pieces based on average bankfull width). If wood of a suitable size and amount is not delivered to the stream channel, further loss of pools, spawning habitat and cover is possible.

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Riparian Resource Sensitivity D3, Continued

Additional comments

See the red line on Map CMD1 for the extent of causal mechanism D3 in the WAU.

The following table presents the percent of each GMU in Resource Sensitivity D3. Further descriptions of the GMUs and the reasons for their sensitivity to changes in wood loadings can be found in Appendix D and Appendix E.

Table CMD3. Percent of each GMU in Resource Sensitivity D3.

Channel Sensitivity to Wood	Name of GMU	GMU Number	Miles (both sides of stream) of GMU in Resource Sensitivity D3	Percent of GMU in Resource Sensitivity D3
High	Hummocky Earthflow Hillslopes	3	1.9	20.7
	Low Gradient Narrow Valley Floor	4	1.8	26.9
Moderate to High	Steep Mountains (based on local gradient)	5	32.9	74.8
Moderate*	Calapooia River Mainstem	1	12.5	24.5

*Though the channel is only moderately sensitive to wood, fish habitat (cover) sensitivity is high for this GMU.

Causal Mechanism Report Summary

Riparian Resource Sensitivity D4

Watershed	Calapooia River Watershed Administrative Unit (WAU).
Resource sensitivity	Sparse conifer and mixed stands.
Situation summary	Conifer and mixed riparian stands that are considered "sparse" lack sufficient sources of recruitable wood due to timber harvest and/or roads. In many stream reaches adjacent to these stands, in-channel wood loadings are currently low to moderate. Thus wood of a size and quantity to affect channel morphology and therefore, physical fish habitat may be limited. Since stand density is low, an adequate supply of wood is currently lacking. Where a road is causing a stand to be sparse, recruitment potential will continue to be low into the future. LWD can alter stream beds by sorting and storing gravel, increasing pool depth and frequency, and creating cover for anadromous and resident fish species.
Triggering mechanism	These stands have low to moderate near-term recruitment potential due to sparse occupancy of the site as a result of timber harvest and roads. In addition, harvest of trees greater than 11 in (28 cm) dbh along streams with bankfull widths wider than 8 ft (2.4 m) may diminish the future supply of functional pieces of LWD that these channels require (see Table D4 in the Riparian Function Assessment for minimum size for functional pieces based on average bankfull width). If wood of a suitable size and amount is not delivered to the stream channel, further loss of pools, spawning habitat and cover is possible..
Additional comments	See the yellow line on Map CMD1 for the extent of causal mechanism D4 in the WAU. The following table (Table CMD4) presents the percent of each GMU in Resource Sensitivity D4. Further descriptions of the GMUs and the reasons for their sensitivity to changes in wood loadings can be found in Appendix D and Appendix E.

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Riparian Resource Sensitivity D4, Continued

Table CMD4. Percent of each GMU in Resource Sensitivity D4.

Channel Sensitivity to Wood	Name of GMU	GMU Number	Miles (both sides of stream) of GMU in Resource Sensitivity D4	Percent of GMU in Resource Sensitivity D4
High	Hummocky Earthflow Hillslopes	3	3.0	32.6
	Low Gradient Narrow Valley Floor	4	1.9	28.4
Moderate to High	Steep Mountains (based on local gradient)	5	4.7	10.7
Moderate*	Calapooia River Mainstem	1	17.4	34.1

*Though the channel is only moderately sensitive to wood, fish habitat (cover) sensitivity is high for this GMU.

Causal Mechanism Report Summary

Riparian Resource Sensitivity Shade 1

Watershed	Calapooia River Watershed Administrative Unit (WAU).
Resource sensitivity	Low riparian shade along fish-bearing streams and along the lower 1,000 ft of non-fishing bearing streams contributing more than 20% of the flow to a fish-bearing stream.
Situation summary	Riparian shade from stream-adjacent trees has been reduced by timber harvest and road construction along the mainstem of the Calapooia River. Debris torrents have reduced shade along tributary streams. Adverse effects on fish feeding, growth and survival could be caused by minor increases in stream temperatures.
Triggering mechanism	Timber harvest and road construction have reduced shading along portions of the Calapooia River. Channelized landslides, potentially as a result of forest practices, has reduced shading levels in tributary reaches including McKinley Creek, Hand Creek and Washout Creek.

Causal Mechanism Report Summary

Fish Habitat Sensitivity F1

Watershed	Calapooia River Watershed
Resource sensitivity	Culverts limiting fish passage.
Situation summary	Culverts that are impassable or partially passable to fish are located in the known fish-bearing stream network and in stream reaches that are potentially fish-bearing. The ability of salmonids to move within a watershed free of artificial barriers is important for several reasons: • Fish must be able to access various habitat types. For example, spawning habitat may not be distributed throughout a system and fish may need to move up or down stream to access these areas. • Fish must also be able to move to adjust to changing habitat conditions such as temperature, food availability or catastrophic events. • Fish may access different portions of the watershed that are seasonally available. For example, the ability of fish to access intermittent streams or upstream areas that are perhaps marginal habitat in summer, but important during higher flow periods. Likewise, during declining flows, fish may need access to mainstream reaches. On a larger scale, entire populations can be impacted by artificial barriers. Barriers can reduce or eliminate the continuity of stream networks that are important to genetic interaction. This can cause population fragmentation, decreasing gene flow and genetic integrity, and ultimately the persistence of populations.
Triggering mechanisms	Impassable and partially passable road culverts hinder fish movement.

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Fish Habitat Sensitivity F1, Continued

Locations

See Map F2 of the Fish Habitat Module (Appendix F) for locations of the culverts of concern, and Table 1 (below) for details. Additional information is provided in the Fish Habitat Module.

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Table 1. Fish passage status of culverts checked in the Calapooia River WAU. Priority codes assigned as follows: 1) High priority--within fish-bearing zone (based on field sampling or ODF stream type map. 2) Moderate priority--require more verification of fish-bearing status above culvert. Currently have unknown status above culvert or have known fish below. Includes culverts with non-permanent natural hindrances to movement (i.e., debris jams). 3) Low priority--have a natural barrier to movement (i.e., waterfall) or no fish below. FIRS fish-bearing status/stream size: unk=unknown, SF=small fish, MF=medium fish, NF=no fish, asterisk indicates if the reach was sampled for fish. Outcome of sampling is given in the fish sampling column. Passage Status column codes are I=impassable and P=passable. Asterisk indicates other barriers are in close proximity to the culvert (see explanation in last column).

Priority code	ID	Seg.#	Road #	Stream name	FIRS status	fish sampling	Pass. Status	struct. Type	Pool dpth(m)	Pool lgth (m)	outlet drop (m)	strct. Grad.(%)	upstr. Grad.(%)	dwnstr. Grad. (%)	Hydr. Control (m)	Explanation
1	1	38	3040	trib. To Biggs	unk*	fish above	I	RCP	1.5	4	3	5	12	18	0.3	3m drop
1	6	81	600	Potts Cr.(west fork)	MF*	Fish in trib. (seg.84)	I (res.)	RCP	1	4	0.6	11	10	7	0	Drop
1	9	98	3370	King Cr.	MF		I (res.)	RCP	2	7	0.3	8	10	9	0	Drop/gradient
1	11	309	3400	noname trib. South side	MF		I	RCP	0	0	0.9	7.5	7	15	0.3	Drop
1	27	134	3000	Buckeye Cr.	MF*	fish above	I (res.)	RCP	0.45	3.5	0.8	5	8.5	16	0.1	outlet drop
1	29	308	3400	noname trib. South side	MF		I (res.)	RCP	--	--	0.3	--	--	--	--	outlet drop
2	10	126	3300	North Fork Trib.	Unk*	none above	I*	RCP	1.5	4	1	5	8	--	0.6	Drop, jam below
2	14	155	102b	noname trib. South side	unk*	none above	I	RCP	0.75	3	0.9	7	15	11	0.1	drop/bent in center
2	16	--	3830	noname trib. South side	unk*	none above/yes below	I (res.)	RCP	0.8	1.5	1.3	7	5	5	0.2	drop to rocks
2	17	192	3830	noname trib. South side	unk*	none above/yes below	I (res.)	RCP	0.4	3.5	2.5	--	5	14	0.2	drop
2	21	36	3040	Biggs Cr. Upper	unk*	none above/yes below	I (res.)	RCP	0.55	2.3	1.3	--	12	12	0.8	drop to rocks
2	23	228	3000	Blue Cr.	MF		I*	RCP	--	--	1	>5	8	20	0.6	outlet drop, downstream debris deposit

Table 1 continued. Fish passage status of culverts checked in the Calapooia River WAU. Priority codes assigned as follows: 1) High priority--within fish-bearing zone (based on field sampling or ODF stream type map. 2) Moderate priority--require more verification of fish-bearing status above culvert. Currently have unknown status above culvert or have known fish below. Includes culverts with non-permanent natural hindrances to movement (i.e., debris jams). 3) Low priority--have a natural barrier to movement (i.e., waterfall) or no fish below. FIRS fish-bearing status/stream size: unk=unknown, SF=small fish, MF=medium fish,, NF=no fish, asterisk indicates if the reach was sampled for fish. Outcome of sampling is given in the fish sampling column. Passage Status column codes are I=impassable and P=passable. Asterisk indicates other barriers are in close proximity to the culvert (see explanation in last column).

Priority code	ID	Seg.#	Road #	Stream name	FIRS status	fish sampling	Pass. Status	struct. Type	Pool dpth(m)	Pool lgth (m)	outlet drop (m)	strct. Grad.(%)	upstr. Grad.(%)	dwnstr. Grad. (%)	Hydr. Control (m)	Explanation
2	25	271	3030	trib. east of Mckinley	unk		I (res.)	RCP	0.3	2	2.5	8	26	17	0.1	outlet drop/steep gradient below
3	2	39	3060	trib. To Biggs	unk*	none above	I*	RCP	--	--	2	5	--	--	0.4	drop, debris jam
3	3	49	3100	noname trib. North side	unk*	none below	I	RCP	2	5	0.7	14	15	14	0.25	grad./drop
3	4	49	3000	noname trib. North side	unk*	none above	I*	RCP	0.3	1.7	0.5	6	12	20.	0.4	drop, 3m falls below
3	12	133	3000	noname trib. North side	NF*	none	I	RCP	0	0	1	3	12	30	0.25	Drop
3	13	284	3351	noname trib. South side	unk*	none above	I*	RCP	0	0	0	9	13	40	0.2	bedrock falls below
3	19	218	3020	noname trib. South side	unk*	none below	I (res.)	RCP	--	--	4	--	--	20	--	drop
3	22	253	3030	trib. West of Mckinley	MF		I*	RCP	0.15	0.9	0.4	5	8.5	20	0.15	outlet drop, steep cascade downstream
3	31	56	1300	trib. W. of Washout	unk*	dry in 1997	I (res.)*	RCP	--	--	3	--	--	--	--	outlet drop, dry sum. 97
3	32	138	3100	Trib. E. of Buckeye Cr.	NF		I (res.)	RCP	--	--	1	--	--	--	--	outlet drop
3	33	63	3190	Barrett Cr.	SF		I*	RCP	--	--	--	--	--	--	--	Drop, falls 30m above rd,steps below
--	5	64	main	noname trib. North side	unk		P*	RCP	0	0	0	12	17	47	0.1	bedrock falls below
--	7	96	3000	noname trib. North side	SF		P	SCP	0	0	0	--	--	--	--	
--	8	98	3000	King Cr.	MF		P	RCP	0.3	0	0	--	--	--	0.3	
--	15	252	2600	noname trib. South side	unk*	none above	P*	RCP	0.6	0.5	0	12	17	34	0.1	series of falls below
--	18	187	3830	noname trib. South side	unk*	none above	P	RCP	0.35	1.3	0	7	9	10	0.1	bent in center
--	20	220	3020	noname trib. South side	unk*	none below	P	RCP	0.25	1.5	0	5	18	10	0.25	bent in center
--	24	259	3030	McKinley	MF*	none above	P	SCP	0	0	0	5	4	<8	0	--
--	26	134	3500	Buckeye Cr.	M/SF		P	RCP	0.35	1.5	0.2	5	4	--	0.2	--
--	28	242	3030	Trib. East of Blue Cr.	MF		P	RCP	--	--	--	--	--	--	--	--
--	30	112	700	North Fork Trib.	NF*	fish above	P	RCP	--	--	--	--	--	--	--	

Fish Habitat Sensitivity F1, Continued

Comments

Based on likely fish distribution (Fish Habitat Module, Appendix F), most of these culverts occur in the resident fish use zone affecting mostly cutthroat trout (resident). Steelhead and coho movement may be hindered by some culverts (Table 1).

Although a comprehensive survey of culvert passability has not been conducted in the WAU, the amount of overlap in the culverts identified in the three available data sets indicates that most culvert barriers have been identified.

Currently the extent of known fish-bearing waters is incomplete. When the entire fish-bearing network is known, it is likely that more culverts hindering the movement of resident salmonids will be found.

The following characteristics should be considered when prioritizing road culvert or fish passage improvement:

- species that may be impacted
- type of blockage (partial or complete)
- length of habitat that is rendered inaccessible (length of Type 3 stream above each culvert is shown in Table F1).