Van Duzen River Watershed Analysis

Cumulative Watershed Effects

Final Report

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1.0 INTRODUCTION

1.1 PURPOSE

Cumulative Watershed Effects (CWE) assessment brings together what is currently known about the Van Duzen Watershed Analysis Unit (WAU). The purpose is to combine information from the technical assessments and focus on the interrelationships between processes and factors that define the conditions of the Van Duzen WAU.

The Van Duzen CWE fits within the adaptive management framework established under The Pacific Lumber Company's (PALCO) Habitat Conservation Plan (HCP) Incidental Take Permit. This assessment lays the foundation for future monitoring and assessment activities that will continue to inform the long-term process to evaluate compliance with the HCP, ensuring that resource protection goals are being achieved. The CWE is the starting point in the adaptive management cycle; this assessment will be updated and improved every 5 years as future watershed analyses are completed. Therefore, this CWE is a beginning assessment for the Van Duzen WAU.

This assessment summarizes the cumulative effects of the processes in the watershed and pulls together the individual pieces of the analysis to tell the watershed's broader story. The CWE assessment is based on 3 components:

1. Evaluation of sediment movement from the watershed land surface into the stream channel.
2. Interpretation of riparian and stream channel responses.
3. Consideration of potential impacts on fisheries, amphibians, and reptiles.

It should be noted that the Van Duzen Watershed Analysis does not include detailed information regarding channel configuration nor does it have access to long-term data to determine sediment routing within the channel.

This CWE assessment departs somewhat from the format used for the Freshwater Creek Watershed Analysis (PALCO 2001) and the approach described in PALCO's Watershed Assessment Methods manual (1999). It is primarily based on a narrative synthesis of assessment data described as rigorously qualitative. For example, the CWE presents the results of an input sediment budget for the WAU by sub-basin, and focuses on the sediment budget (instead of a Disturbance Index) as the primary tool for assessing management- and non-management-related effects on sediment input to streams. The sediment inputs are combined with the results of the Stream Channel Assessment to evaluate potential channel response from estimated sediment inputs to consider possible impacts on aquatic life. Using this approach it is possible to describe vulnerabilities as well as recommendations for future assessment in cases where more information is required.

This Van Duzen Watershed Analysis provides a foundation for future iterations in the watershed analysis process that will be undertaken as part of the HCP. Cumulative effects are identified through:

1. Data collected/compiled during watershed analysis.
2. Scientific literature on known mechanisms and processes (where the relationship between physical processes and biology is well-established).
3. Expert interpretation where data are unavailable, incomplete, or there is a high degree of uncertainty.

Development of a technical definition of cumulative watershed effects is an ongoing (U.C. Committee on Cumulative Watershed Effects 2001). A standard definition of cumulative watershed effects, as defined in the Board of Forestry Practice Rules in reference to CEQA guidelines (Section 14, CCR 15355), is often cited as a starting point. Paraphrased, this definition indicates that cumulative effects are defined as 2 or more individual effects, which when considered together, make a significant (usually adverse) change to some biological population, water quality, or other valued resource, or which compound or increase other environmental effects.

Section 1 of this assessment includes a description of the purpose and approach taken for the Van Duzen River Watershed Analysis. Section 2 includes an overview of the Van Duzen River Watershed Analysis Unit and provides the foundation and context for the CWE assessment. Section 3 provides an overview of issues and concerns identified by residents and the local community at the outset of the watershed analysis process. This section does not provide a detailed response to these issues and concerns but provides the watershed analysis documents where relevant response information is located. Section 4 includes a summary of key findings for the individual assessments across landscape characterization units (e.g., geologic units, channel geomorphic units, riparian classification units) and characterizes the overall condition of biological resources. Section 5 develops a synthesis of the assessments with the results presented by sub-basin. This section also examines the relationship between estimated sediment inputs, potential channel response, and possible resource vulnerabilities. Section 6 describes the key uncertainties and provides monitoring recommendations for collecting the information necessary to address these uncertainties. References are provided in Section 7.

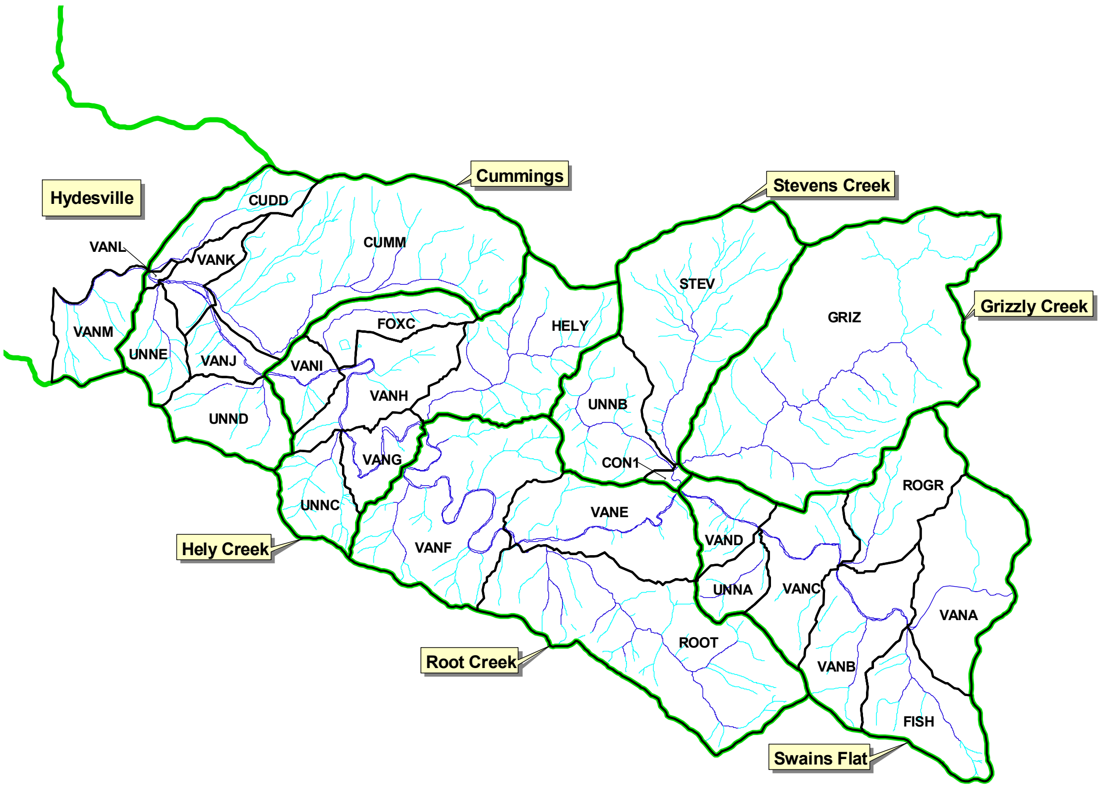
1.2 APPROACH AND PROCESS

The Van Duzen River Watershed Analysis team includes lead analysts for each of the technical assessments identified in the Methods to Complete Watershed Analysis on Pacific Lumber Company Lands in Northern California (PALCO 2000). These lead analysts, working in conjunction with the project managers, developed work plans for each technical assessment. Work plans were required to address several factors in the Van Duzen WAU including: mixed ownership, multiple land uses, upstream impacts, fog zone transition area, highly variable geology, complex vegetation patterns, and a large dynamic mainstem. The approach selected by the project team used sub-basins as the foundation for the watershed analysis. Sediment was identified as a key issue in the watershed. Work plans also explicitly addressed the need for integration and coordination between assessments.

In consultation with hydrology and stream channel analysts, 7 sub-basins and the mainstem were selected within the Van Duzen WAU to localize the study of watershed processes. These sub-basins correspond to major tributaries and include: Cummings Creek, Grizzly Creek, Hely Creek, Hydesville Creek, Root Creek, Stevens Creek, and Swains Flat (Figure 1-1). The Van Duzen mainstem is addressed to a lesser extent in the analyses. Sub-basins were selected because most of PALCO's ownership and activities takes place in these areas and are where prescriptions will be considered most intensively. The mainstem of the Van Duzen River is also heavily impacted by activities (and sediment) from upstream.

The work plans reflected lessons learned form the Freshwater Creek Watershed Analysis (PALCO 2001). The Van Duzen Watershed Analysis team simplified riparian classification units, reduced the number of hydrological analysis units, developed interdisciplinary field teams, coordinated sampling efforts, and focused sampling efforts within sub-basins. In addition, the team refined methods for estimating soil creep rates, surveying for amphibian and reptile presence and habitats, and characterizing riparian stands. The work plans and refinements were presented to the Signatory Review Team (SRT) for review and approval.

Figure 1-1. Van Duzen Watershed Analysis Unit Showing Sub-Basins (green), HAUs (black), Class I Streams (dark blue), and Class II Streams (light blue)



The process also included meetings to identify issues with local residents and community members to solicit issues of concern and to identify information useful to watershed analysis. The results of the issue identification are included in Section 3 of this assessment. Many of the issues identified by local residents are related to sedimentation and channel morphology at a scale that could not be addressed in this analysis. However, the information collected, and the resulting assessment, provides a foundation for reducing the uncertainty related to these issues.

This CWE assessment includes a qualitative analysis of potential riparian and channel responses to activities and inputs. The assessment focuses on an estimated sediment budget for the Van Duzen WAU that identifies and aggregates sources by sub-basin. The sediment budget is used as the primary basis for assessment because it is the primary stressor to the system. The final component of the assessment is consideration of potential resource vulnerabilities. The qualitative nature of the riparian/channel response and resource vulnerabilities reflects uncertainties that restrict our capabilities to describe a well-defined linkage between each component.

2.0 WATERSHED OVERVIEW

2.1 WATERSHED OVERVIEW

The Van Duzen Watershed Analysis Unit (WAU) consists of all or a portion of 7 contiguous CALWATER Planning Watersheds (Figure 2-1). State Highway 36 is the main transportation corridor following the mainstem Van Duzen River throughout the analysis area from Carlotta, California, to just downstream of Bridgeville, California. The entire analysis area encompasses 71.3 square miles. Elevations within the analysis area range from approximately 80 feet just upstream of Yager Creek to approximately 3,400 feet along the northern ridges of Grizzly Creek State Park and the Stevens Creek sub-basin. Slopes in the Van Duzen watershed are generally moderate (less than 35%). The average basin slope is 19%. The Pacific Lumber Company (PALCO) owns approximately 53% of the analysis area. Additional watershed parameters are provided in Table 2-1. Forestry is the major land use in the watershed (85% of the WAU). Agricultural/residential land uses comprise the remainder of the watershed.

Figure 2-1. Van Duzen Watershed Analysis Unit Depicting CALWATER Planning Watersheds, Class I Streams, and Pacific Lumber Ownership (in yellow)

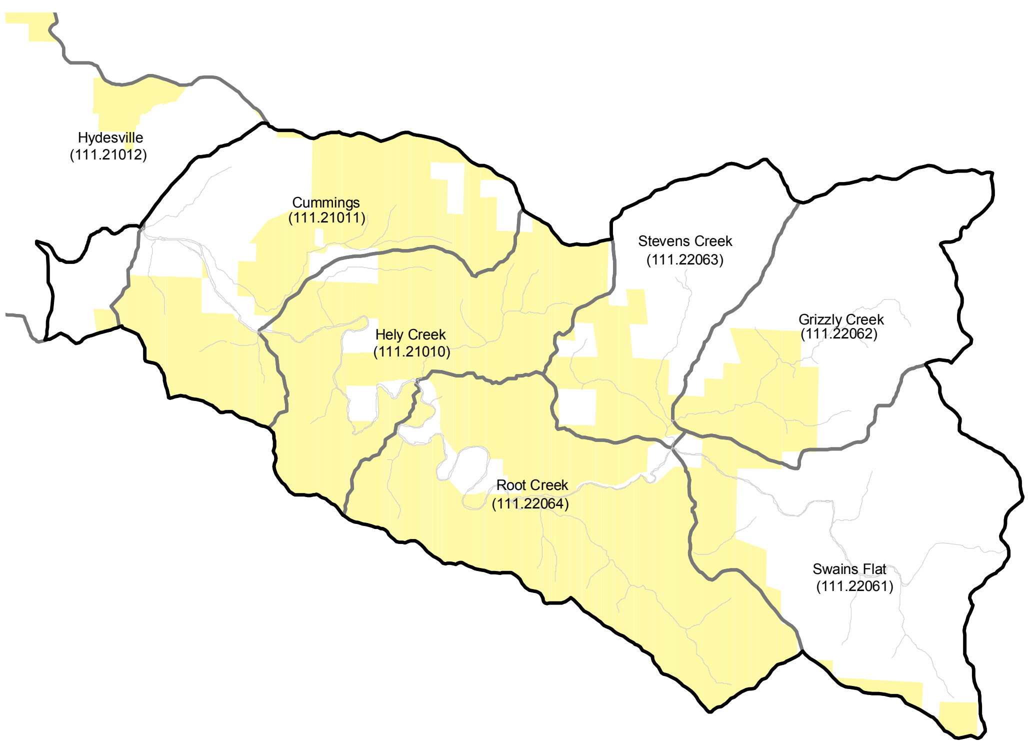


Table 2-1. Watershed Parameters for the Van Duzen Watershed Analysis Unit (WAU)

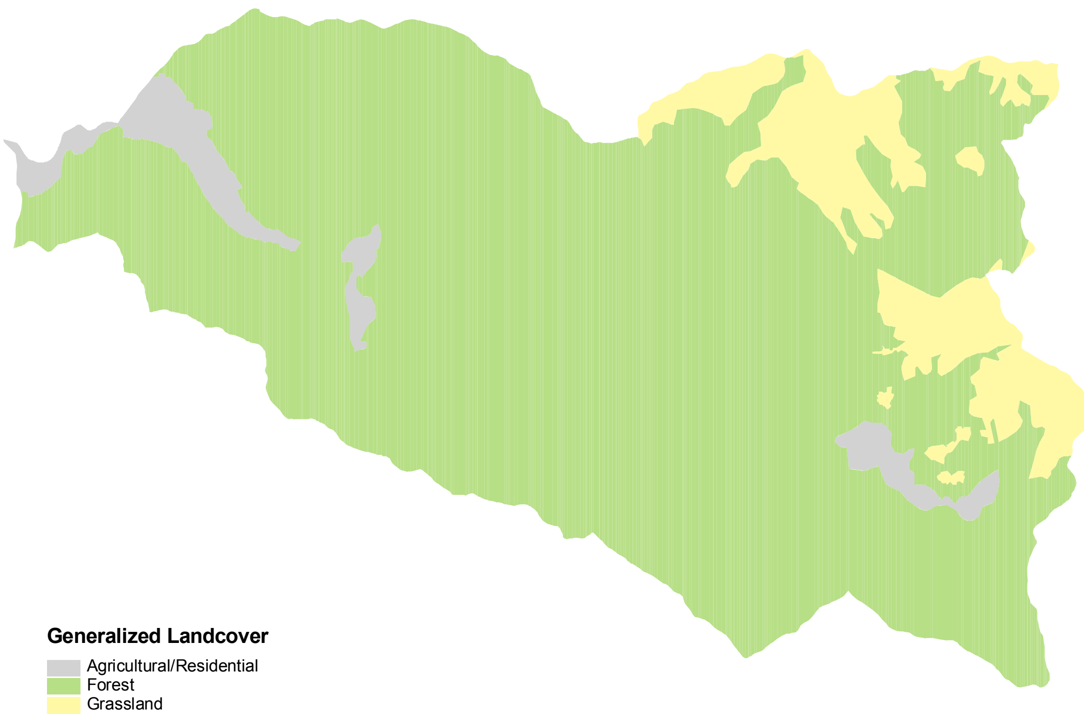
Parameter	WAU
Basin area (mi^2)	71.3
Average elevation (ft)	1,206
Average basin slope (%)	19%
Distance from point in stream closest to centroid to outlet (mi)	7.4
Percentage of area facing south	53%
Distance to furthest point along basin perimeter (mi)	15.1
Basin length divided by basin area (mi/mi^2)	4.9
Perimeter of basin (mi)	45.1

2.2 OWNERSHIP AND LAND USE

Approximately 53% of the Van Duzen WAU is owned by PALCO and managed for commercial timber production. The total area of the Van Duzen WAU is 71 square miles, which is approximately 17% of the total Van Duzen watershed area (429 square miles). Of the lands in the eastern portion of the watershed not owned by PALCO, other commercial timber production activities and grazing of large annual grasslands occur. Private landowners and residences are also located along the Van Duzen mainstem and in the valley floor of several major tributaries, including Fox Creek and Cummings Creek. Private landowners have not developed the major tributaries, including Root Creek and Stevens Creek. Distribution of major land cover within the Van Duzen WAU is illustrated in Figure 2-2.

Ground-disturbing activities in the Van Duzen WAU include road construction and use, timber harvest operations, grazing, agriculture, recreational vehicle use, and development on residential and commercial lots. This assessment addresses surface erosion resulting from these activities, with the focus on road use and timber harvest operations. Timber harvest ground disturbances are associated with clearcuts or partial cuts, constructing layouts for tree felling, tractor/skidder trails, cable yarding; site preparation, and treatment of competing vegetation during revegetation with herbicides, hand thinning or other applicable silvicultural methods.

Figure 2-2. Major Land Use Groups in the Van Duzen Watershed Analysis Unit



2.3 Basin History

Located in the North Coast Range of northern California, the entire Van Duzen River watershed includes 272,911 acres of private and public forested land, agricultural land, recreational land, and communities. Throughout the last 150 years, land in the Van Duzen River basin has been developed, utilized, and transposed by a number of different elements and circumstances. The watershed's history includes an extensive interactive relationship with the people of the area including Native Americans, farmers, ranchers, recreationalists, and logging enterprises. Land use practices have involved controlled burning, agriculture, grazing, and the various methods used in harvesting timber. Environmental factors such as heavy rains, active tectonics, sensitive terrain, and the catastrophic flood of 1964 have also strongly influenced the Van Duzen watershed (USEPA 1999). Due to the diversity and scale in which the Van Duzen watershed has been utilized, one or more of the aforementioned land uses has affected the majority of the sub-basin study areas examined.

Among the earliest settlers of the Van Duzen watershed were the Lassik and the Nongatl sub-tribes of the Athabascan peoples of the Pacific North Coast. Of these native groups, the Lassik inhabited the upper portions of the Van Duzen River; the Nongatl lived in and around Grizzly, Yager, and Larabee Creeks (DWR 1976). Native American land use practices included hunting and gathering, as well as some controlled burning in the low grassland areas.

The arrival of Euro-Americans in the mid-nineteenth century marked significant changes in land use practices throughout the Van Duzen River watershed. Though these Euro-American pioneers typically sought gold upon their arrival, they soon found the fertile lowlands and floodplain of the Van Duzen River basin more reliably profitable. Sheep grazing dominated the mid-region of the valley, with herd sizes numbering in the thousands. Sheep grazing remained dominant until the 1930s when cattle ranching became more common (Moore 1999). Agricultural development was also popular in the early years of Euro-American land use of the basin. With the addition of the railroad in the early 1900s, lumbering of large redwoods intensified land development.

Early timber extraction in the Van Duzen River watershed began with ranchers hiring loggers to clear their lands to provide additional grazing and agricultural land; few landowners made use of the timber resources on their lands as the tools/machinery and lack of transport infrastructure made timber extraction prohibitively expensive. It wasn't until accessibility was well established in the early 1900s that large-scale timber operations in the lower portions of the basin were established. A map of timber harvest history for the period of record is illustrated in Map SE-3.

2.4 Geology and Soils

Coastal northern California is characterized by a history of tectonic subduction and accretion that dates to the early Cretaceous period. The North Coast encompasses the Mendocino triple junction, a complex intersection of three crustal plates. North of the Mendocino triple junction, the youthful Gorda plate is being obliquely subducted in a northeasterly direction beneath the North American continent along the Cascadia Subduction Zone. South of the triple junction, transform motion along the San Andreas fault system separates the Pacific plate from the North American plate.

The leading edge of the overriding North American plate in the Mendocino triple junction region consists of a series of accretionary wedges of the Mesozoic-Cenozoic Franciscan Complex (Blake et al. 1985). The Franciscan Complex forms the basement rock throughout the region. Each accretionary wedge forms an elongate, highly deformed, northwest-trending belt. These belts increase in age and metamorphic grade in an inland direction. There are 3 principal belts within the Franciscan Complex (from southwest to northeast): the Coastal, Central, and Eastern. The Franciscan Complex is locally overlain by sediments deposited in the Eel River basin, a deep Neogene fore-arc basin (Clarke 1992). The Eel River basin sediments consist of up to 4 km of Miocene and younger sedimentary rocks that lie unconformably on portions of the Coastal and Central belts (Clarke 1992). These Eel River basin sediments are referred to as the Wildcat Group in the vicinity of the modern Eel River and Van Duzen River valleys (Ogle 1953).

Throughout the late Cenozoic, the combined effects of the eastward subduction of the Gorda plate and the northward migration of the crustal triple junction has resulted in uplift of the Coast Ranges and extensive erosion of the terrane rocks. The younger sediments deposited in the Neogene fore-arc basins are preserved locally onshore in a series of structural blocks within the complex, actively deforming continental margin north of the triple junction. The area is seismically active and numerous active seismic sources are present that have generated large historic earthquakes.

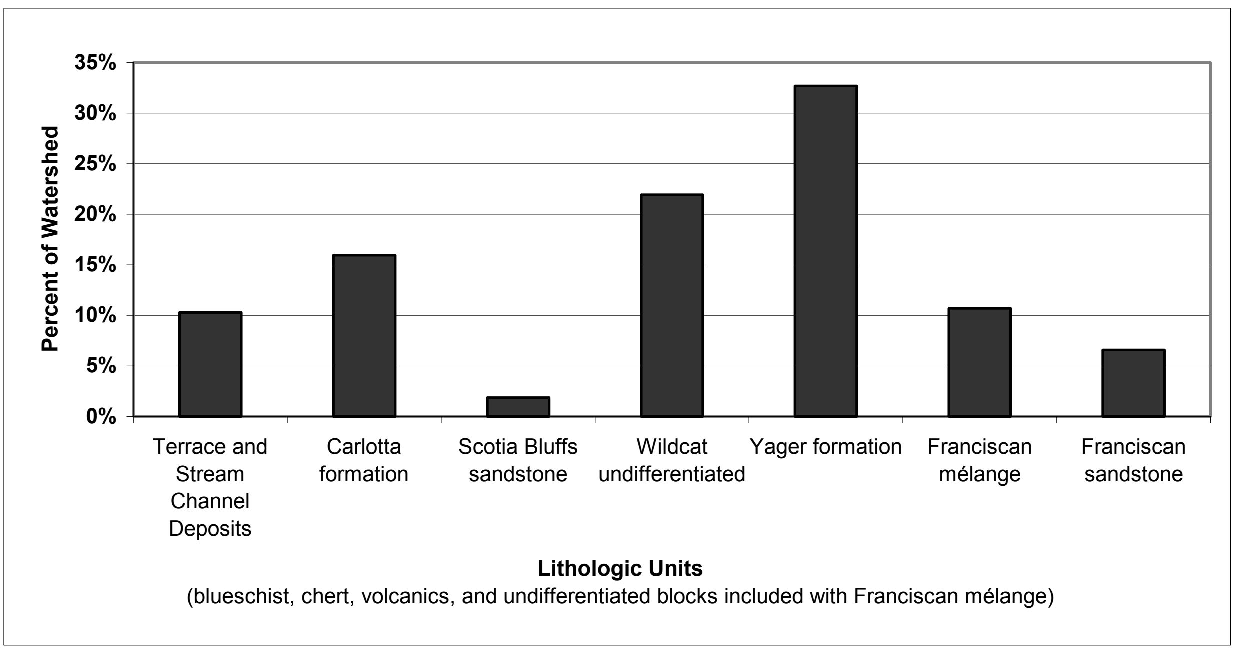
2.4.1 Geologic Units, Stratigraphy, and Structure of the Van Duzen Watershed

The lower Van Duzen WAU encompasses portions of the western edge of the Central belt Franciscan Complex, the Coastal belt, and the Wildcat Group (McLaughlin et al. 2000; Clarke 1992; Kelsey and Allwardt 1974). The distribution of geologic materials is depicted in Table 2-2, Figure 2-3, and Map MW-1). As described above, the Franciscan Complex materials represent the basement rock in the region, with their distribution controlled by the Freshwater and Little Salmon northwest trending faults. These bedrock units are unconformably overlain by sedimentary bedrock of the Miocene to Pleistocene age Wildcat Group, which is concentrated in the western and southern parts of the watershed. Quaternary-age alluvial deposits, landslide debris, and a veneer of soil and colluvium overlie these older geologic bedrock units.

Table 2-2. Distribution of Lithologic Units in the Project Area

Lithologic Unit	Number of Polygons	Area (acres)	Percent of Area
Stream Channel Deposits	4	1,031	2.26%
Terrace Deposits	58	3,661	8.02%
Carlotta formation	4	7,275	15.94%
Scotia Bluffs sandstone	2	845	1.85%
Wildcat undifferentiated	3	10,014	21.94%
Yager formation	5	14,924	32.70%
Franciscan mélange	9	4,766	10.44%
Franciscan sandstone	36	2,996	6.57%
blueschist	15	13	0.03%
chert	23	17	0.04%
serpentinite	8	16	0.04%
volcanic	31	56	0.12%
undifferentiated blocks in mélange	16	18	0.04%
Total	**214**	**45,633**	**100.00%**

Figure 2-3. Percent Area of Lithologic Units in the Project Area



Franciscan Complex – Central Belt Terrane

Franciscan Central belt rocks underlie approximately 17% of the northeastern part of the study area (Map MW-1). The Central belt consists predominantly of a tectonic mélange containing blocks of Middle Jurassic, Cretaceous, and Paleogene greywacke, metagreywacke, blueschist, greenstone, chert, serpentinite, and minor amounts of limestone in a sheared matrix of argillite and greywacke (Blake et al. 1985). Individual rock blocks range in size from very small gravel-size fragments to very large mountain-scale blocks. This bedrock unit is commonly described as a mélange due to its block-in-matrix textural character, its assemblage of disassociated rock types, and its pervasively sheared character. Locally, the Central belt contains large coherent bodies of greywacke sandstone (see unit Kjfs on Map MW-1) or shale turbidites. The Central belt was accreted to the North American continent between the Cretaceous and middle Tertiary (about 70 to 40 million years ago) (Clarke 1992; McLaughlin et al. 2000). The Franciscan mélange forms a rolling, hummocky terrain highly susceptible to earthflow-type mass movement in which the rock blocks form scattered knobs (e.g., Goat Rock at the eastern end of the Van Duzen watershed) that protrude from sparsely forested prairie lands.

Franciscan Complex – Coastal Belt Terrane (Includes Yager Terrane)

The Franciscan Coastal belt has been subdivided into several structural terranes, including the Coastal and Yager terranes (Blake et al. 1985), as well as the smaller, more localized King Range and False Cape terranes (McLaughlin et al. 2000). Of these, only the Yager terrane is present in the Van Duzen watershed, underlying approximately 33% of the northern and eastern parts of the Van Duzen watershed. This bedrock unit consists of Paleogene strata that are as much as 3,000 meters thick (Ogle 1953). It consists of well-indurated marine argillite, with lesser amounts of greywacke and conglomerate. Argillite deposits are thinly bedded turbidites, and may contain significant amounts of interbedded sandstone. The Yager terrane is thought to have been deposited in a continental slope setting. It is less deformed than other portions of the Coastal belt, although it also has been extensively deformed. McLaughlin et al. (2000) recognize at least 3 major fold belts within the Yager terrane. The Yager terrane was probably deposited during the middle to late Eocene.

Wildcat Group

The Wildcat Group (Ogle 1953) represents the Late Miocene to Pleistocene age sedimentary fill of the Eel River basin. The Eel River basin was a structural basin that encompassed the areas now occupied by the modern Eel River valley and Humboldt Bay, extending offshore. The Eel River basin was a broad fore-arc depocenter formed along the Cascadia Subduction Zone (Nilsen and Clarke 1987). Ogle (1953) identified 5 formations within the Wildcat Group, representing a generally upward coarsening (transgressive) sequence. These include, from oldest to youngest: the Pullen, Eel River, Rio Dell, Scotia

Bluffs, and Carlotta formations. As described in Clarke (1992), the Wildcat Group along the south flank of the Eel River syncline represents a basal eastward transgression during the late Miocene (Pullen formation), rapid deepening of the basin to lower abyssal depths during the Pliocene and early Pleistocene (Pullen, Eel River, and Rio Dell formations), and finally, westward regression of the shoreline and overall shallowing (Rio Dell and Scotia Bluffs formations). Lastly, emergence occurred in the Pleistocene, with shallow marine (Scotia Bluffs formation) and non-marine (Carlotta formation) deposition. Tephrochronologic studies indicate that the lithologic units of the Wildcat Group are time-transgressive. The same ash deposit (the Rio Dell ash beds described by Sarna-Wojcicki et al. [1987]), is present within outer shelf deposits of the upper Rio Dell formation at Centerville Beach and in nonmarine deposits in the middle part of the Carlotta formation farther east (Clarke 1992). Portions of the Wildcat Group located north of the Eel River valley are poorly understood, and are generally mapped as undifferentiated (Ogle 1953).

In the study area, Wildcat Group rocks are limited to the upper members (the Scotia Bluffs and Carlotta formations). The Scotia Bluffs formation, which occupies less than 2% of the study area, is described as fine-grained, massive sandstone with minor amounts of siltstone, mudstone, and pebble conglomerate. The Scotia Bluffs is generally moderately consolidated, and is characterized by its ability to form high, near-vertical bluff faces. The Carlotta formation, which occupies nearly 16% of the study area, consists of non-marine sandstone, conglomerate, and minor claystone. The Carlotta formation represents predominantly braided stream deposits. Sandstone in the Carlotta formation is generally coarser than that in the undifferentiated Wildcat. Undifferentiated Wildcat sediments occupy nearly 22% of the study area, and consist of primarily massive marine fine-grained sandstone, siltstone, and mudstone. This material is generally very friable, and the outcrops are frequently structureless within the Van Duzen watershed (Kelsey and Allward 1974).

Alluvial Deposits

Alluvial deposits are found in the Van Duzen watershed both as modern deposits along the active channels of the mainstem Van Duzen River and its tributaries, and as uplifted alluvial terraces beyond the effects of the current stream system. Recent alluvium consists of unconsolidated deposits of boulders, cobbles, gravel, sand, silt, and clay. Older alluvial deposits are present bordering the modern river and stream system, and consist of the same types of materials. These deposits are moved only during infrequent peak flood events. Recent and older alluvial deposits are shown in Map MW-1 (units Qsc and Qt). Uplifted alluvial terraces are also present throughout the watershed (unit Qt in Map MW-1). These surfaces typically consist of a flat abrasion surface buried by a variable thickness of alluvial material. The terraces are likely Holocene to Pleistocene in age. Most of the alluvial terraces in the watershed are concentrated in the valley bottom along the mainstem of the Van Duzen River (e.g., Swains Flat, Weomme Flat, etc.). Flights of alluvial terraces are locally present in the watershed as a series of adjoining terraces that step up progressively from the modern channel. The terrace surfaces increase in age with increased height and separation from the modern channel. Older uplifted terraces, up to 800 feet in elevation, are present as well (e.g., see surfaces mapped along Root Creek, and between Cuddeback and Cummings Creeks); these surfaces are Pleistocene in age.

Landslide Deposits

Landslide deposits are found throughout the watershed. They represent reworked bedrock and colluvial materials that are moved during landslide events and redeposited in downslope positions. These materials may be deposited on hillslopes, in stream channels, or on terraces. As discussed below, landslide deposits vary in both thickness and areal extent. They may remain as coherent, nearly intact blocks on the landscape, or they may completely disaggregate to fluid masses. Landslide deposits range in age from recent to ancient features that may be tens of thousands of years old. Older landslide deposits, particularly those of smaller areal extent, may be difficult to distinguish in the modern landscape. At present, only larger ancient or relict landslide deposits are typically discernable. Individual landslide deposits are not depicted on the geologic map, but are referenced in Figure 6-17 found in the Mass Wasting Assessment.

Colluvium/Residual Soils

Colluvium and residual soils veneer most hillslopes within the watershed. Residual soils form via pedogenic processes (e.g., mechanical and chemical breakdown of bedrock materials) as buried rock masses become exposed to the near-surface environment. Soil mapping by the U.S. Department of Agriculture indicates the watershed is dominated by soils of the Hugo and Larabee series. A detailed description of soil types and their distribution in the Van Duzen watershed is included within the Surface Erosion Assessment (Map SE-1). Colluvium is weathered material that has moved downslope by gravity-induced movement and redeposited on hillslopes and benches. This material is generally thin on ridge crests, and increases in thickness in the direction of toeslopes where it can form thick accumulations. Shallow landslide deposits are often considered a form of colluvium. Colluvial deposits are not shown on the geologic map (Map MW-1), but are assumed to be present throughout the landscape.

2.4.2 Structure

The Van Duzen River watershed lies within a broad fold and thrust belt that is accommodating contractional, upper plate deformation along the southern end of the Cascadia Subduction Zone. This northwest-trending fold and thrust belt includes faults within the Mad River fault zone north of the study area, and the Little Salmon fault zone, which passes through the northern and eastern parts of the watershed. Thrust faults within this system strike northwesterly and dip to the northeast. Folds within this system are strongly asymmetric, with steeply dipping northeast limbs and gently dipping southwest limbs. The Little Salmon fault appears to be the most active structure in the region, and may be associated with about 7 km of Quaternary dip-slip displacement (Carver and Burke 1992). In the Van Duzen watershed, the Little Salmon fault juxtaposes Yager terrane sediments over both the Wildcat Group and Yager terrane sediments. In the eastern part of the study area, the Little Salmon fault crosses, and offsets, the Freshwater fault. The Freshwater fault is an inactive bedrock fault that defines the contact between the Central and Coastal belts of the Franciscan Complex.

2.4.3 Seismic Setting

The North Coast of California is one of the most seismically active regions of the continental United States. Over 60 earthquakes have produced discernible damage in the region since the mid-1800s (Dengler et al. 1992). Historic seismic and paleoseismic studies in the area suggest there are six distinct sources of damaging earthquakes in the region:

1. Gorda Plate
2. Mendocino Fault
3. Mendocino Triple Junction
4. Northern end of the San Andreas Fault
5. Faults within the North American Plate
   (including the Mad River and Little Salmon faults zones)
6. Cascadia Subduction Zone

The Little Salmon fault is the most significant tectonic feature in the Van Duzen watershed. It appears to be the most active on-land fault in the Humboldt Bay region and is capable of generating very large earthquakes. Offset relations within the upper Wildcat Group suggest vertical separation exceeds 5,900 feet (1,800 meters), representing about 4.4 miles (7 km) of dip-slip motion on the Little Salmon fault since the Quaternary (i.e., in the past 700,000 to 1 million years) (Woodward-Clyde Consultants 1980). Paleoseismic studies of the Little Salmon fault indicate that the fault deforms late Holocene sediments at the southern end of Humboldt Bay (Clarke and Carver 1992). Estimates of the amount of fault slip for individual earthquakes along the fault range from 15 to 23 feet (4.5 to 7 meters). Radiocarbon dating suggests that earthquakes have occurred on the Little Salmon fault about 300, 800, and 1,600 years ago. Average slip rate for the Little Salmon fault for the past 6,000 years is between 6 and 10 mm per year (Carver and Burke 1992). Based on currently available fault parameters, the maximum magnitude earthquake for the Little Salmon fault is thought to be between 7.0 (CDMG/USGS 1996) and 7.3 (Geomatrix Consultants 1994).

The Cascadia Subduction Zone represents the most significant potential earthquake source in the North Coast region. A great subduction event may rupture along 200 km or more of the coast from Cape Mendocino to British Columbia, may be up to magnitude 9.5, and could result in extensive tsunami inundation in low-lying coastal areas. The April 25, 1992 Petrolia earthquake (magnitude 7.1) appears to be the only historic earthquake involving slip along the subduction zone, but this event was confined to the southernmost portion of the fault. Paleoseismic studies along the subduction zone suggest that great earthquakes are generated along the zone every 300 to 500 years. Historic records from Japan describing a tsunami thought to have originated along the Cascadia Subduction Zone suggests the most recent event occurred on January 27, 1700. A great subduction earthquake would generate long duration, very strong ground shaking throughout the North Coast region.

Earthquakes originating within the Gorda Plate account for the majority of historic seismicity in the North Coast region. These earthquakes occur primarily offshore along left-lateral faults, and are generated by the internal deformation within the plate as it moves toward the subduction zone. Significant historic Gorda Plate earthquakes have ranged from magnitude 5.0 to 7.5. The November 8, 1980 earthquake (magnitude 7.2) was generated 30 miles (48 km) off the coast of Trinidad on a left-lateral fault within the Gorda Plate.

The Mendocino fault is the second most frequent source of earthquakes in the region. The fault represents the plate boundary between the Gorda and Pacific plates, and typically generates right lateral strike-slip displacement. Significant historic Mendocino fault earthquakes have ranged from magnitude 5 to magnitude 7.5. The September 1, 1994 magnitude 7.2 event originating west of Petrolia was generated along the Mendocino fault. Available data suggests the maximum magnitude earthquake for the Mendocino fault is magnitude 7.4 (CDMG/USGS 1996). The Mendocino triple junction was identified as a separate seismic source only after the magnitude 6.0 August 17, 1991 earthquake. Significant seismic events associated with the triple junction are shallow onshore earthquakes that appear to range from magnitude 5 to 6. Raised Holocene-age marine terraces near Cape Mendocino suggest larger events are possible in this region.

Earthquakes originating on the northern San Andreas fault are extremely rare, but can be very large. The northern San Andreas fault is a right lateral strike-slip fault that represents the plate boundary between the Pacific and North American plates. The fault extends through the Point Delgada region and terminates at the Mendocino triple junction. The 1906 San Francisco earthquake (magnitude 8.3) caused the most significant damage in the North Coast region, with the possible exception of the 1992 Petrolia earthquake (Dengler et. al. 1992).

The Van Duzen watershed is located south of the Mad River fault zone. The Mad River fault zone consists of a series of northwest-trending, northeast-dipping thrust faults, including (from south to north) the Fickle Hill, Mad River, McKinleyville, Blue Lake, and Trinidad faults. Of these, the study area is closest to the Fickle Hill fault, which traverses the southwest flank of Fickle Hill and through the town of Arcata. The maximum magnitude for the Fickle Hill fault is 6.9. The Mad River fault is the next fault north within the Mad River fault zone, and is associated with a maximum magnitude of 7.1. The McKinleyville fault is associated with a maximum magnitude of 7.0 (CDMG/USGS 1996).

In this environment, it should be assumed that the watershed is be subject to moderate to strong ground shaking on a frequent basis. Large seismic events and the associated strong ground shaking can be a triggering mechanism for the initiation of landslides or the reactivation of pre-existing landslides. In the epicentral regions of the 1991 Honeydew and 1992 Petrolia earthquakes, numerous examples of seismically induced landslides were documented (McPherson and Dengler 1992; Dunklin 1992). These earthquakes were associated with Modified Mercalli intensities (MMI) of VII to VIII. Studies by Keefer (1984) show that the minimum shaking intensity that triggers landslides is generally MMI VI to VIII, although sometimes intensities as low as MMI IV to V can initiate sliding in particularly susceptible environments. There are numerous seismic sources in the region that can generate shaking intensities sufficient to generate landslides in the Van Duzen watershed.

Seismically-induced landslides do not always occur coincident with the actual shaking. Ground cracks and ridge top fissures opened up during shaking may weaken slopes such that the threshold of failure is lowered. These slopes may not fail at the time of the earthquake, but they are susceptible to failure during subsequent wet periods, that can occur several years after the actual earthquake. Numerous landslides in the Eel River basin occurred during the wet winters of 1995-96 and 1996-97. The 1996-97 wet winters represented the first high precipitation periods following the 1992 earthquake, and it appears that many of the failures were related to seismically weakened slopes (field observations, T. Stephens, 1975, 1980, 1992, 1994).

2.5 SOILS

The texture (grain size) and consolidation of soils influences how easily soil particles are eroded. Large gravel and cobble-sized particles are more difficult to erode via surface erosion processes, and are left behind as a protective lag deposit on eroding surfaces. Soils with a high sand/silt fraction are generally very erodible. Clay-sized particles, while very small and easily carried once in suspension, are actually more difficult to erode because clay soils are usually consolidated, and electrostatic charges between the small clay particles hold them together. Differences in grain size distribution among the sub-basins for the various geologies and soils, as applied to the various sediment sources, are further discussed in the sediment budget (Section 4.1.3).

Soils in the Van Duzen WAU were mapped in the 1960s (McGlaughlin and Harradine 1965). The NRCS is in the process of updating soil maps for Humboldt County. Map SE-1 shows the most recent (1960s) map of soils in the Van Duzen WAU. Table 2-3 summarizes the properties of soils in the basin pertinent to surface erosion: soil depth, texture, drainage, permeability, and erosion hazard based on the NRCS database.

Methods used to estimate the delivery of sediment from the erosion source area to a stream are based on the assumption that sediment is carried to the stream by overland flow. If the water carrying the sediment infiltrates into the soil, it is assumed that the sediment carried in the flow is deposited and does not reach a stream.

Table 2-3. Properties of Soils in Van Duzen Watershed Analysis Unit

Soil series name	Percent total basin area	Depth range (in.)	Parent Material	Texture of surface/ subsurface	Drainage	Permeability
Hely	<1	40-70	Soft sedimentary rock	Loam/ fine sandy loam	* Well	* Rapid to mod. rapid
Hugo	37	30-60	Sandstone & shale	Gravelly loam/ stony clay loam	* Well	* Mod. rapid
Kneeland	1.0	18-40	Sandstone & shale	Clay loam/clay loam	* Well	* Moderate
Larabee	12	40-70	Soft sedimentary rock	Loam/ clay loam	* Moderate	* Moderate
Larabee Gravel	21	40-70	Soft conglomerate	Gravelly loam/gravelly clay loam	* Well	* Moderately slow
Laughlin	<1	16-36	Sandstone and shale	Loam/ loam	* Well	* Mod.
McMahon	2.2	30-60	Sandstone	Clay loam/clay	Moderately well or somewhat poor (inferred)	Slow (inferred)
Melbourne	3.0	30-60	Sandstone and shale	Loam/ clay loam	* Well	* Moderate
Tyson	1.4	18-48	Sandstone and shale	Gravelly loam/ very gravelly loam	* Well	* Mod.
Yorkville	4.1	30-60	Metamorphosed rock	Clay loam/ clay	* Mod. well to well	* slow to very slow
** Bottom Land	3.7	64-70+	Sedimentary alluvium	Loam/ Silt loam	Mod. well to imperf.	mod. rapid to slow
** Farmland	3.2	64-70+	Sedimentary alluvium	Loam/ Silt loam	Mod. well to imperf.	mod. rapid to slow
** Terraces	3.2	64-70+	Sedimentary alluvium	Loam/ Silt loam	Mod. well to imperf.	mod. rapid to slow
*** Other	7.6	*** Varies	*** Varies	*** Varies	*** Varies	*** Varies

Notes:

* Information on soil drainage and permeability characteristics for these soils was obtained from the USDA NRCS Official Soil Series Descriptions database (http://www.statlab.iastate.edu/soils/osd/), as summarized in the Freshwater Creek Draft Surface Erosion Module Report.

** Mapping units Bottomland, Farmland, and Terraces contain areas mapped by McLaughlin and Harradine (1965) as primarily Loleta and Russ soil series. Estimates of soil characteristics are based on these two series.

*** Mapping unit x7 contains areas classified by McLaughlin and Harradine (1965) as residential, business, and industrial areas. Also, this includes streams and areas with no soil type available. Soil characteristics can be inferred from adjacent map units.

2.6 FISH SPECIES AND DISTRIBUTION

2.6.1 Fish

Chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), steelhead (*O. mykiss*), and coastal cutthroat trout (*O. clarki clarki*) are the anadromous salmonid species present in the greater Van Duzen watershed (Map FH-1). These species are restricted to the lower third of the Van Duzen watershed as anadromous fish distribution ceases above Eaton Rough Falls (RM 47). In high-water years, much of this lower basin contains access to adequate fish habitat except in sub-basins where anthropogenic or natural barriers preclude upstream passage. The Van Duzen watershed also contains several non-salmonid fish species. Native resident fish include the Pacific brook lamprey (*Lampetra pacifica*), prickly sculpin (*Cottus asper*), coast range sculpin (*C. aleuticus*), Sacramento sucker (*Catostomas occidentalis*), and the three-spine stickleback (*Gasterosteous aculeatus*), California roach (*Lavinia ssymmetricus*), speckled dace (*Rhinichthys osculus*), brown bullhead (*Ictalurus nebulosus*), largemouth bass (*Micropterus salmoides*), Sacramento pikeminnow (*Ptychocheilus grandis*), and green sunfish (*Lepomis cyanellus*) represent non-native fish species introduced to the Van Duzen watershed. The Sacramento pikeminnow was not introduced through forestry-related practices. The Sacramento pikeminnow is a predatory threat to all salmonid species of concern where they are co-located.

2.6.2 Steelhead Trout

Steelhead are the most abundant anadromous salmonid species within the watershed. They utilize smaller tributaries with steeper gradients than other anadromous salmonids, and are found in the upper reaches of most large tributaries (unless barriers preclude their upstream migration). Two distinct runs of steelhead exist in the Van Duzen watershed: winter run fish and summer run fish. Both runs belong to the Northern California evolutionarily significant unit (ESU). Of the two runs, winter-run steelhead are more widespread and numerous. In 1965, the California Department of Fish and Game (CDFG) estimated the winter-run steelhead population in the entire Van Duzen watershed at 10,000 individuals. No current estimates of the steelhead population are available. Conversely, summer-run steelhead populations have historically been much lower at an estimated 100 individuals in 1965. Census dives conducted by CDFG during the past decade have indicated the summer steelhead run in the Van Duzen watershed to be less than 30 individuals; as a result the population has been listed as being at risk of extinction/of special concern (Higgins et al. 1992). Winter run steelhead are found within all of the major tributaries of the lower Van Duzen River basin and extend upstream into the upper reaches of the South Fork. Summer steelhead typically hold in the deep pools located between the town of Bridgeville (RM 31) and the confluence of the South Fork Van Duzen River (RM 45). These pools range from 6 to 20 feet deep and provide the cool water refugia that adult fish require. Spawning and rearing of summer run steelhead occurs primarily in the South Fork Van Duzen River.

2.6.3 Chinook Salmon

Chinook salmon typically spawn in large, low gradient channels located in the lower third of the Van Duzen watershed. Mainstem chinook salmon spawning occurs in riffles up to RM 31 at Bridgeville. The Van Duzen WAU encompasses the mainstem Van Duzen River from RM 7 to RM 29.5 and includes most of the mainstem spawning habitat for chinook salmon. In addition, recent CDFG spawing surveys have documented chinook salmon spawning activity in many of the larger tributaries of the lower watershed, namely Hely Creek, Cummings Creek, Root Creek, and Grizzly Creek (all of which are in the Van Duzen WAU). Mark and recovery research conducted by CDFG reported that out of 40 Eel River tributaries sampled during 1982-83, Grizzly Creek was the second most valuable chinook salmon spawning creek (CDFG 1982).

Historical accounts of chinook salmon abundance within the Van Duzen watershed are spotty at best; fish population data have not been gathered on a regular basis since the 1960s for tributaries outside of the Yager Creek sub-basin. A spawning reconnaissance study carried out by the U.S. Fish and Wildlife Service (USFWS) during 1959 indicated that the Van Duzen watershed had the capability to support 7,000 adult chinook salmon at the time. Field verification during the course of the Fish Habitat Assessment documented 1,500 occupied redds. Following the floods of 1955 and 1964, CDFG estimated in 1965 that the annual chinook salmon run in the Van Duzen River numbered 2,500 adult fish.

2.6.4 Coho Salmon

Historically, coho salmon did not represent a large portion of the salmonid population within the Van Duzen watershed. In the CDFG report of 1965 mentioned above, the adult coho salmon population was estimated at only 500 adult fish. More recently, the number of coho salmon in the Van Duzen watershed is much lower, with small populations of fish inhabiting the low gradient reaches of Grizzly Creek, Stevens Creek, Hely Creek, Cummings Creek, and Fielder Creek. CDFG surveys in 2001 did not to locate any coho salmon in the watershed (Froland 2002). The coho and chinook salmon surveys are not frequent or consistent enough to comment on the relative abundances of the surveys in comparison to watershed maximum or minimum conditions. Regardless, the clear trend has been one of overall diminished runs.

2.6.5 Cutthroat Trout

Coastal cutthroat trout are found in Fox Creek above the Highway 36 culvert and in the Van Duzen mainstem downstream of its confluence with Fox Creek. The Fox Creek population has evolved into a resident population due to a migration barrier consisting of the 20-foot drop at the outlet of the culvert under Highway 36. It is currently believed that this population represents the southern extent of West Coast distribution of coastal cutthroat trout (Downie pers. comm.).

2.7 Amphibians and Reptiles Species and Distribution

Species accounts for the 5 amphibian and reptile species covered under the HCP are provided below and (derived from the July 1998 Public Review Draft HCP). Tables 2-4 through 2-8 summarize the life history requirements of each species from *Draft Habitat Needs Matrices* developed from the literature by the U.S. Fish and Wildlife Service (USFWS), CDFG, and other resource agencies (USFWS 1997a, 1997b, 1997c, 1997d). A more complete description of the life history requirements for these species are included in the Amphibian and Reptile Assessment.

2.7.1 Southern Torrent Salamander (Rhyacotriton variegatus)

The southern torrent salamander is a CDFG species of special concern. The range of this species in California coincides with the extent of coastal forests in the northwestern part of the state, and inland forests in the Willow Creek and Ruth-South Fork Mountain areas. The species is found up to approximately 3,900 feet elevation, and as far south as Mendocino County (Anderson 1968) (Map AR-1). The specific habitat of southern torrent salamanders consists of humid coastal forests and includes cold mountain streams, springs, seeps, waterfalls, and moss covered rock rubble with flowing water (Anderson 1968; Bury and Corn 1988a; Welsh 1990; Zeiner et al. 1990). These salamanders seem to inhabit the splash zone and are rarely found more than one meter from water (Anderson 1968; Nussbaum and Tait 1977).

Incidental observations on PALCO-owned lands indicate that this species is widely distributed in suitable habitat (Wroble and Waters 1989, PALCO unpublished data). However, this species has not been previously observed in the Van Duzen River watershed.

Table 2-4. Life History Requirements of the Southern Torrent Salamander

Parameter	Optimal Condition	Source	References
Substrate Composition (% Fines)	<32 (or ≥68% gravel, boulder, or bedrock)	USFWS (1997a)	Diller and Wallace (1996), Welsh and Lind (1996)
Embeddedness (%)	<18-33	USFWS (1997a)	Diller and Wallace (1996), Welsh and Lind (1996)
Canopy Closure (%)	>80	USFWS (1997a)	Welsh and Lind (1996), Welsh unpub. data, Bury and Corn (1989), Chen et al. (1993)
LWD (% Downed Wood/Stream Length)	-	USFWS (1997a)	-
Water Temperature (°C)	6.5-15	USFWS (1997a)	Welsh and Lind (1996), Diller and Wallace (1996)

Notes: (-) The parameter directly affects habitat quality for the species, however,quantitative target values are not available.

*2.7.2 Tailed Frog (***Ascaphus truei***)*

The tailed frog is a CDFG species of special concern. In California, the range of this species is from sea level to approximately 6,500 feet. It is generally found in Siskiyou, Del Norte, Trinity, Shasta, Tehama, Humboldt, and possibly Sonoma counties in areas that receive over 40 inches of rain annually (Bury 1968) (Map AR-2). Tailed frogs apparently avoid marshes, wetlands, and slow sandy streams (Daugherty and Sheldon 1982). The specific habitat of this species, for which they seem highly specialized, is swift, perennial streams with low temperatures (Nussbaum et al. 1983). Although habitat for tailed frogs has primarily been found in mature and old-growth coniferous forests (Bury 1983; Bury and Corn 1988a; Welsh 1990; Welsh et al. 1993) they have also been found in young forests.

Incidental observations indicate that this species has a patchy, yet widespread distribution in suitable habitat within PALCO ownership. However, survey information is limited. Tailed frogs have been observed historically in the Van Duzen River watershed (Wroble and Waters 1989; PALCO unpublished data).

Table 2-5. Life History Requirements of the Tailed Frog

Parameter	Optimal Condition	Source	References
Substrate Composition (Dominant/Subdominant Substrates)	%Boulders + %Cobbles>50% (Boulders or cobbles dominant)	USFWS (1997b)	Hawkins et al. (1988), Altig and Brodie (1972)
Embeddedness (%)	<18-33	USFWS (1997b)	Hawkins et al. (1988), Altig and Brodie (1972)
Canopy Closure (%)	>85	USFWS (1997b)	Welsh et al. (1993), Bury and Corn (1989), Chen et al. (1993)
LWD (% Downed Wood/Stream Length)	>7	USFWS (1997b)	Welsh et al. (1993), Bury and Corn (1988)
Water Temperature (°C)	5-18.5	USFWS (1997b)	Brown (1975), Claussen (1973), Diller and Wallace

2.7.3 Northern Red-legged Frog (Rana aurora aurora)

The red-legged frog is a CDFG species of special concern. The northern subspecies (*Rana aurora aurora*) is a federal species of concern, while the California subspecies (*R. a. draytonii*) has been federally listed as threatened. Red-legged frogs found in the area between southern Del Norte County and northern Marin County exhibit intergrade characteristics of both *R. a. aurora* and *R. a. draytonii* (Map AR-3). The threatened listing status of *R. a. draytonii* does not extend into the intergrade zone, which includes the Van Duzen HCP area (U.S. Federal Register 1996). While the intergrade frog seems relatively common and widespread, populations of the *R. a. draytonii* subspecies of the inland valleys have probably been in decline since the turn of the century due to commercial exploitation, development, and other land use modifications (Jennings and Hayes 1985).

In California's Coast Range, red-legged frogs occur at elevations below 3,900 feet (Zeiner et al. 1990). Specific habitat for red-legged frogs includes ponds, slow moving creeks, puddles, and drainage ditches in or near-moist forests and riparian habitats (Nussbaum et al. 1983; Bury and Corn 1988b). However, dispersal during wet weather conditions may lead to the finding of individuals considerable distances from breeding sites (Zeiner et al. 1990; PALCO unpublished data).

Incidental observations indicate that this species may be locally abundant in suitable habitat on PALCO land. This species has been observed historically in the Van Duzen River watershed (Wroble and Waters 1989; PALCO unpublished data).

Table 2-6. Life History Requirements of the Northern Red-legged Frog

Parameter	Optimal Condition	Source
Maximum Water Depth (ft)	>0.5	Storm (1960)
Water Temperature (°C)	8-18	Dumas (1996)

2.7.4 Foothill Yellow-legged Frog (Rana boylii)

The foothill yellow-legged frog is a CDFG species of special concern. In the Coast Range, this species occurs from the Oregon border south to Los Angeles County from sea level to approximately 6,000 feet (Map AR-4). This species is able to utilize a variety of habitat types including valley-foothill riparian, ponderosa pine, mixed conifer, coastal scrub, mixed chaparral, and wet meadows (Zeiner et al. 1990). In all habitats the species is seldom found far from small, permanent streams with banks that can provide sunning sites (Nussbaum et al. 1983; Zweifel 1968). Home ranges for this species are estimated to be less than 10 meters in the longest dimension (Zeiner et al. 1990).

Incidental observations indicate that this species has a patchy distribution on PALCO lands. It is common in suitable habitat along major watercourses with relatively open, sunny banks such as the Eel River, Van Duzen River, and some of the larger tributaries to these rivers (Wroble and Waters 1989; PALCO unpublished data).

Table 2-7. Life History Requirements of the Foothill Yellow-legged Frog

Parameter	Optimal Condition	Source	References
Maximum Water Depth (ft)	-	USFWS (1997c)	-
Water Temperature (°C)	<24-27	USFWS (1997c)	Kupferberg (1996)

Notes: (-) The parameter directly affects habitat quality for the species, however, quantitative target values are not available.

2.7.5 Northwestern Pond Turtle (Clemmys marmorata marmorata)

The northwestern pond turtle is a CDFG species of special concern, and a California Fully Protected Species. The western pond turtle (*Clemmys marmorata*) ranges from Puget Sound to Baja California. In

California, this species ranges from the Oregon border south to Kern County (Bury 1962) (Map AR-5). The specific habitat of this species includes a variety of permanent and ephemeral aquatic habitats such as ponds, lakes, rivers, marshes, sloughs, and drainage ditches (Zeiner et al. 1990; Bury 1962; Holland 1994; Nussbaum et al. 1983).

The specific habitat of this species is relatively limited on PALCO-owned lands. This species has been detected in or near some of the major watercourses on PALCO lands such as the Eel River and Larabee Creek. One anecdotal account exists for the species at the Root Creek bridge on the Van Duzen River (PALCO unpublished data). No other observations of the northwestern pond turtle exist in the Van Duzen River watershed.

Table 2-8. Life History Requirements of the Northwestern Pond Turtle

Parameter	Optimal Condition	Source	References
Maximum Water Depth (ft)	>1.5	USFWS (1997d)	Bury (1972), Reese (1996)
Canopy Closure (%) (for hiding and shade for nesting)	>50	USFWS (1997d)	Reese (1996)
LWD (% Downed Wood/Stream Length)	-	USFWS (1997d)	-
Water Temperature (°C)	<32	USFWS (1997d)	Bury (1972)

Notes: (-) The parameter directly affects habitat quality for the species, however, target values are not available.

2.8 CLIMATE AND HYDROLOGY

2.8.1 Climate

The Van Duzen WAU experiences climatic conditions typical of coastal Northern California. Climate station locations in the vicinity are shown in Figure 2-4. The Northern California coast has a completely maritime climate, marked by high levels of humidity throughout the year (NOAA 2000). The rainy season runs from approximately October through April, during which time approximately 90% of the annual precipitation occurs (Table 2-9, Figures 2-5 and 2-6). The dry season lasts from May through September. During the dry season morning low clouds and fog are common, often clearing by early afternoon and returning by evening. Mean monthly and annual precipitation estimates for the Van Duzen WAU were calculated using Parameter-elevation Regressions on Independent Slopes Model (PRISM) precipitation maps, and are representative of the climatological period 1961 to 90. PRISM is an analytical model that uses point data and a digital elevation model (DEM) to generate spatial estimates of annual and monthly precipitation. (Descriptions of the PRISM data can be found online at http://www.ocs.orst.edu/prism/prism_new.html.)

Table 2-9. Weather Stations and Climatic Data Used in this Analysis

Station (ID#)	Latitude/ Longitude	Elevation (feet)	Data Used; Available Period of Record (may be missing values)
Bridgeville 4 NNW (1080)	N 40° 32’ W 123° 49’	2,100	Daily precipitation: 6/1/54 – 7/31/00 Daily snowfall: 6/1/54 – 7/31/00 Daily snow depth: 6/1/54 – 7/31/00
Scotia (8045)	N 40° 29’ W 124° 06’	139	Daily precipitation: 1/9/31 - 8/31/00 Daily snowfall: 1/9/31- 8/31/00 Daily snow depth: 1/8/31- 8/31/00 Daily min. & max. air temperatures: 1/9/31 - 8/31/00
Grizzly Creek State Park (3647)	N 40° 29’ W 123° 55’	410	Daily precipitation: 12/1/79 – 8/31/00 Daily snowfall: 12/1/79 - 8/31/00 Daily snow depth: 12/1/79 - 8/31/00 Daily min. & max. air temperatures: 12/1/79 - 8/31/00

Figure 2-4. Climate Stations in the Vicinity of the Van Duzen Watershed Analysis Unit

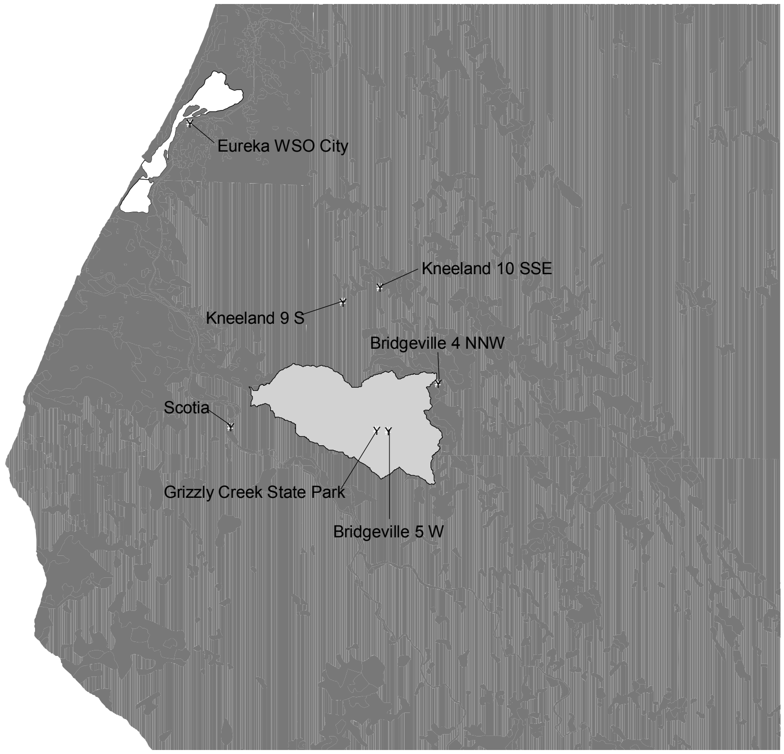
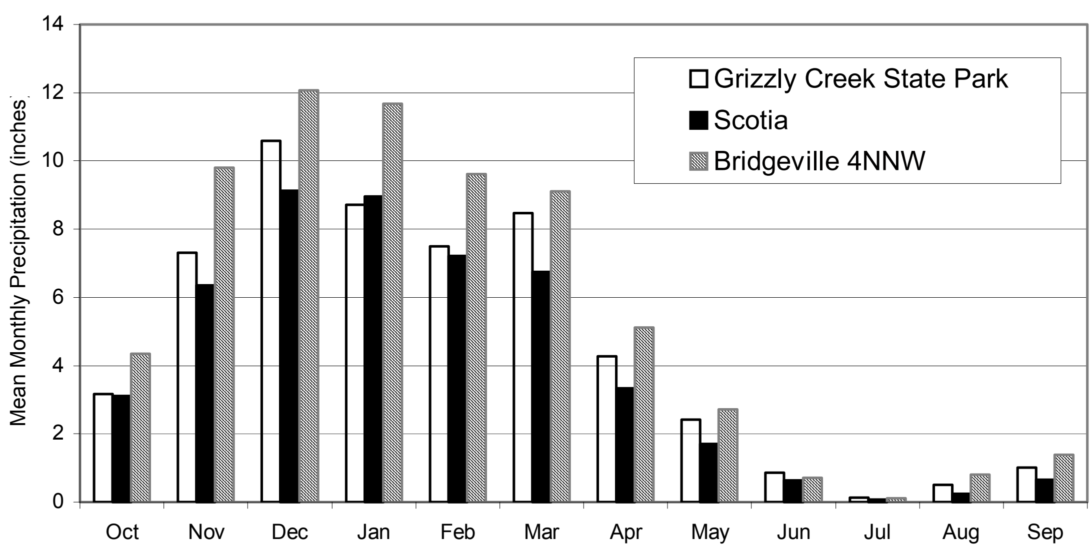


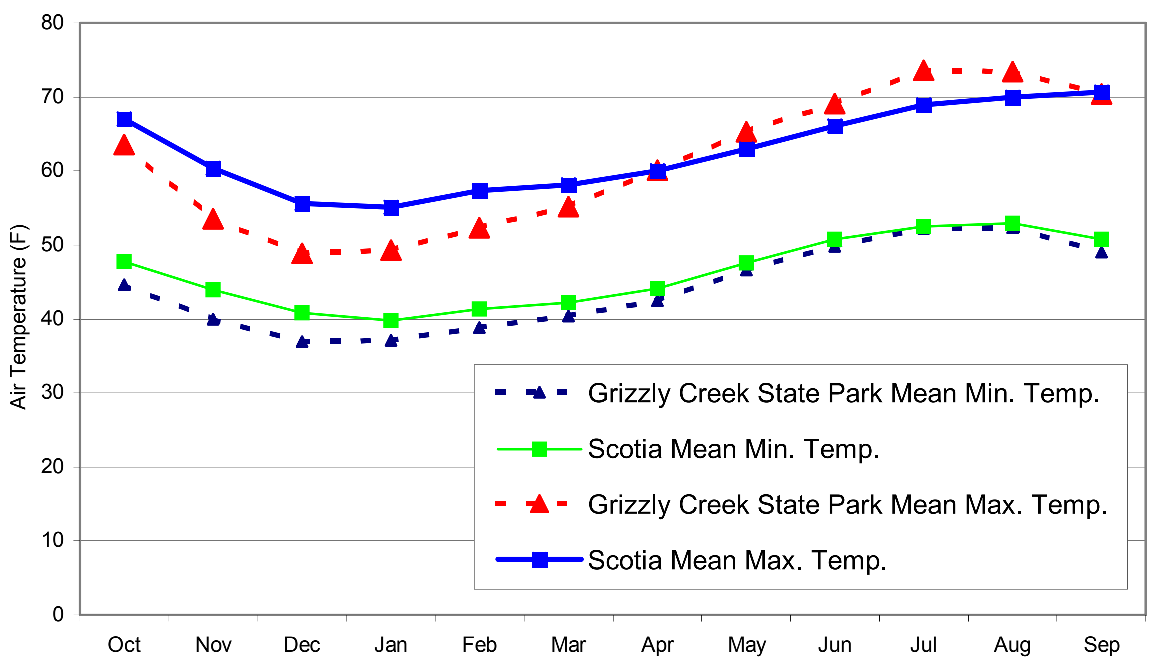
Figure 2-5. Mean Monthly Values for Observed Precipitation at Several Climate Stations in the Vicinity of the Analysis Unit (refer to Table 2-9, Figure 2-4 for locations), and estimated PRISM values for the Van Duzen Watershed Analysis Unit



The area-weighted mean annual precipitation for the analysis area is 55 inches. Precipitation data from the Grizzly Creek State Park Weather Station located within the study are indicate that mean monthly precipitation values range from 0.13 inches for the month of July to 10.58 inches for the month of December. Precipitation amounts vary within the watershed, and roughly correlate with elevation. For example, estimated mean annual precipitation in VANM HAU (exclusive of upstream areas) at the downstream end of the study area is only 47 inches, as compared with 68 inches for the higher elevations of the Grizzly Creek sub-basin. Monthly precipitation amounts follow similar patterns.

Air temperatures in the North Coast area are moderate and the annual fluctuation is one of the smallest in the conterminous United States (NOAA 2000). Seasonal air temperature variation is small due to the close proximity to the Pacific Ocean. The prevailing northwest winds cross cold upwelling waters usually present along the along the Humboldt County coast. Mean minimum temperature in Scotia for the month of January is 40° F (Figure 2-6), and the coldest low temperatures in a typical winter are in the low 30s. Mean maximum temperatures in Scotia for the month of September is 71° F (Figure 2-6), while the highest temperatures are typically in the mid-70s. Inland locations (e.g., Grizzly State Park) experience wider seasonal variation in air temperatures (Figure 2-6).

Figure 2-6. Mean Minimum and Maximum Monthly Air Temperatures at Stations near the Analysis Unit

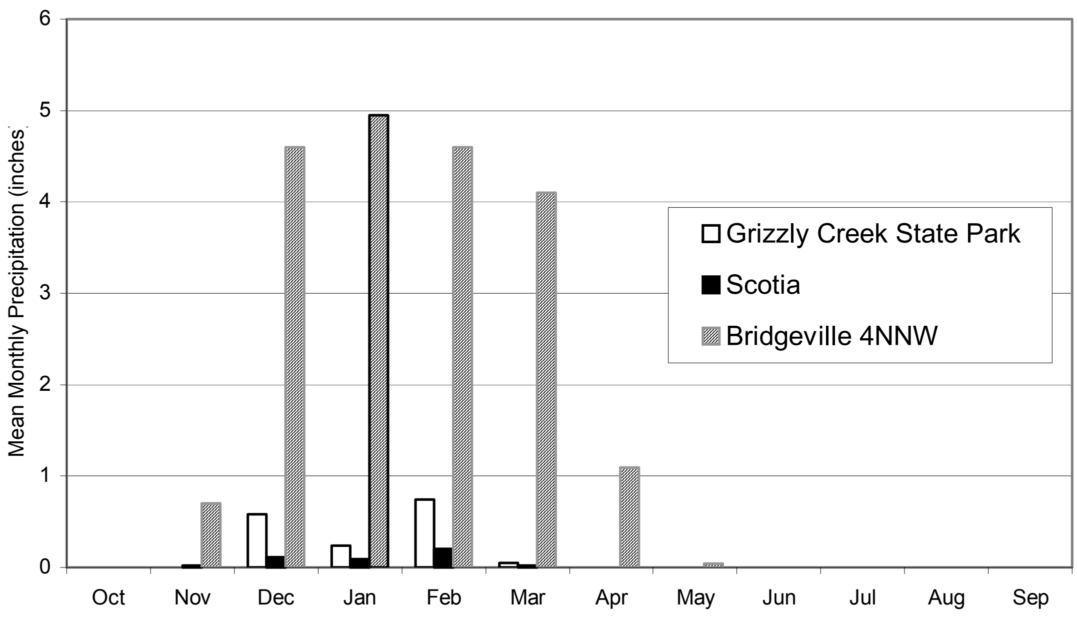


A search for **snow pack** information did not provide data for any stations close to the analysis area. The Western Regional Climate Center lists no SNOTEL stations in the North Coast area in their station inventories (http://wrcc.sage.dri.edu/). The NRCS lists no snow course sites on their web site (ftp.wcc.nrcs.usda.gov/data/snow/snow_course/listca.txt). A search of the California Data Exchange (CDEC) website (http://cdec.water.ca.gov/) revealed no climate stations in Humboldt County with snow pack or snow course information.

Daily snowfall records are available for several stations in the vicinity of the analysis area (Table 2-9, Figure 2-4). Figure 2-7 shows mean monthly snowfall at the Scotia, Grizzly Creek State Park, and Bridgeville 4 NNW stations.

Mean annual snowfall at the Grizzly Creek State Park station over the period of record was 1.72 inches, and ranged from 0 inches (in 13 out of 19 years of record) to 10.0 inches (in 1990). Monthly snowfall values range from a minimum of 0 inches (recorded at least once in every month of the year), to a maximum of 7.5 inches (recorded in February 1989). No snowfall has ever been recorded over the period of record in the months of April through November.

Figure 2-7. Mean Monthly Values for Snowfall at Weather Stations near the Analysis Unit



Mean annual snowfall at the Bridgeville 4 NNW station over the period of record was 24.08 inches, and ranged from 1.40 inches to 78.50 inches (in 1964). Monthly snowfall values range from a minimum of 0 inches (recorded at least once in every month of the year) to a maximum of 45.0 inches (recorded in

December 1988). No snowfall has ever been recorded over the period of record in the months of June through October.

2.9 HYDROLOGY

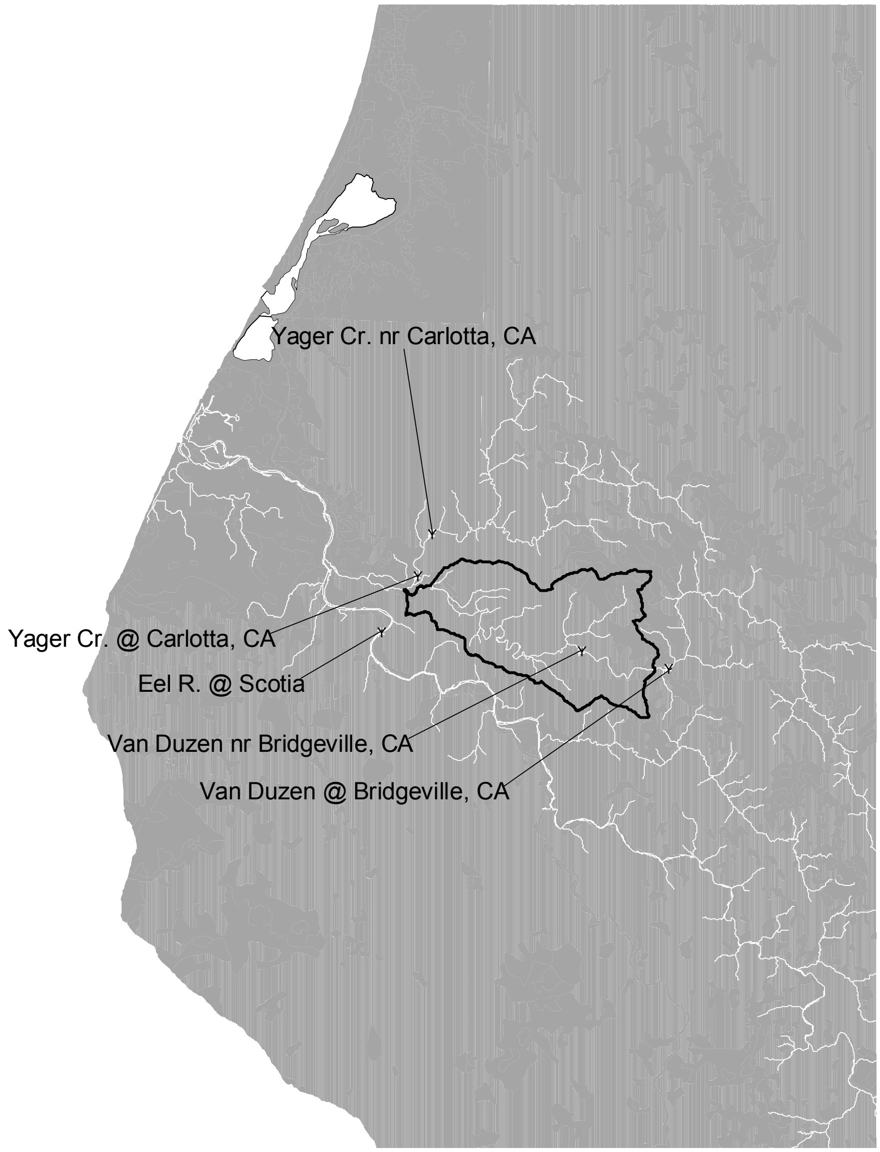
Mean daily stream flow records are available for three U.S. Geological Survey (USGS) gages in the vicinity of the analysis area (Table 2-10, Figure 2-8). Since the Van Duzen River near Bridgeville gage is located within the study area, it was used exclusively to assess seasonal runoff patterns. The drainage area upstream of the Van Duzen near Bridgeville gage is 222 square miles. Approximately 13.2 square miles of that drainage area is located within the Van Duzen WAU. Mean daily stream flow at the Van Duzen River near Bridgeville gage ranges from 4.4 to 33,900 cubic feet per second (cfs) (0.02 to 152.7 cfs per square mile), with an average value of 872 cfs (3.9 cfs per square mile). These values were based on daily data collected from 1950 to 2000.

Table 2-10. USGS Streamflow Gaging Stations Near the Van Duzen WAU

Station Name (USGS #)	Drainage Area (mi^2)	Daily Values Period of Record	Peak Flow Period of Record
Van Duzen River near Bridgeville, CA (11478500)	222	10/01/1950 - 09/30/2000	WY1940- WY2000
Eel River at Scotia, CA (11477000)	3,113	10/01/1910 - 09/30/1914 10/01/1916 - 09/30/98	WY1911- WY2000
Yager Creek near Carlotta, CA (11479000)	127	10/01/1953 - 09/30/1955 10/01/1956 - 09/30/1960 10/01/1965 - 09/30/1972	WY1953- WY1972

Notes: Base discharges (the discharge above which partial peak flows are recorded) are 15, 000 cfs, 72,000 cfs, and 4,000 cfs for the three gaging stations, respectively.

Figure 2-8. USGS Streamflow Gaging Stations in the Vicinity of the Van Duzen WAU



September has the lowest mean monthly stream flow at all locations (Figure 2-9). Mean monthly flow for the month of September was plotted over the period of record for the Van Duzen River near Bridgeville gage (Figure 2-10). (The plot indicates there have not been any significantly higher September streamflows in the last decade that occurred in previous decades). The flows are more consistent and just below the long-term average.

Figure 2-9. Mean Monthly Discharge for the Van Duzen River near Bridgeville Gaging Station

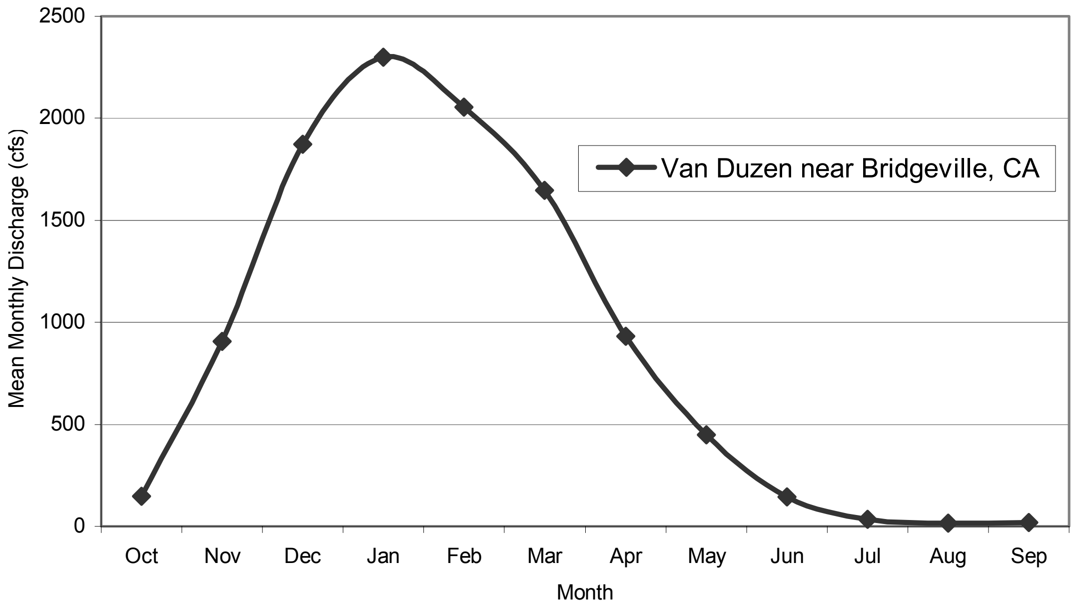
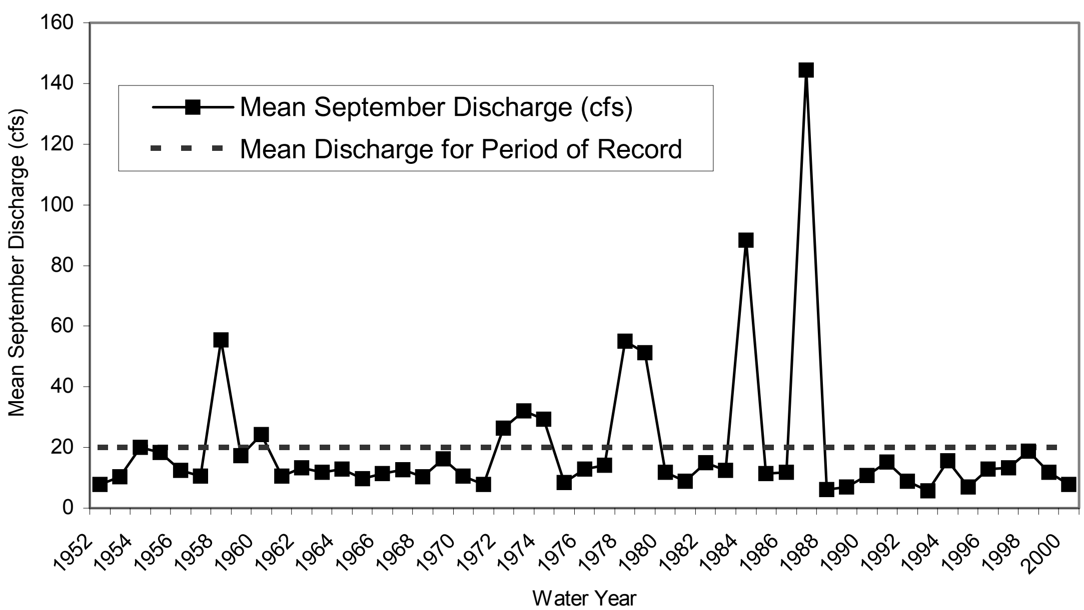


Figure 2-10. Mean September Discharge for the Van Duzen River near Bridgeville Gaging Station over the Period of Record



2.10 FLOOD HISTORY

Section 4.2 of the PALCO methodology (PALCO 2000) provides techniques for evaluating the flood history of a watershed. The primary reasons for investigating flood history are:

- Provide context for the Stream Channel, Riparian Function, and Mass Wasting analysts to interpret historical disturbances.
- Evaluate linkages between historic flooding and climatic conditions that will provide context for interpreting changes in flood peaks assessed in the following sections.
- Evaluate which processes (e.g., rain, rain on snow) are the dominant producers of peak flows in the watershed.

Since the Van Duzen gage near Bridgeville provided representative data to develop a flood history for the WAU, it was used exclusively; no synthetic hydrographs were developed.

2.10.1 Flood History from Historic Gage Records

The Van Duzen River near Bridgeville gage provided 60 years of historic flood data. Annual and partial peaks are listed chronologically in Table 2-11. The base discharge (minimum discharge to constitute a partial peak flow) for the Van Duzen River near Bridgeville gage is 15,000 cfs. For water years 1940 to 1950, no partial peaks were recorded. This was probably due to the fact that the USGS was not collecting daily data, only recording an annual peak. The largest event recorded was 48,700 cfs on December 22, 1964, commonly referred to as the '64 flood (actually occurred in water year 1965). This event will be referenced in all other assessments due to its significant impact on the Van Duzen watershed. Interestingly, three of the top five annual peaks were recorded in the 1990s, during a series of wet years. The lowest annual peak on record was 2140 cfs during the 1977 water year.

Table 2-11. Flood History at the Van Duzen River near Bridgeville Gaging Station. Partial and Annual Peaks Listed Chronologically

Annual Peaks				Partial Peaks			
Flood Date	Discharge (cfs)	Water Year	Peak Rank	Flood Date	Discharge (cfs)	Water Year	Peak Rank
02/28/40	20,100	1940	52	01/21/51	18,000	1951	80
12/24/40	16,800	1941	93	12/01/51	16,900	1952	90
12/18/41	20,400	1942	49	12/27/51	15,300	1952	112
12/11/43	22,900	1943	37	12/07/52	17,200	1953	86
01/05/44	7,560	1944	129	01/09/53	20,000	1953	53
02/02/45	10,700	1945	126	01/23/54	18,200	1954	78
12/27/45	14,600	1946	119	01/28/54	21,800	1954	41
02/21/47	12,800	1947	124	02/12/54	18,400	1954	76
01/07/48	17,100	1948	89	12/19/55	30,200	1956	19
02/21/49	14,200	1949	121	01/15/56	20,500	1956	47
01/17/50	15,700	1950	106	02/21/56	31,100	1956	14
10/28/50	20,000	1951	56	11/29/56	16,300	1957	97
02/11/52	19,500	1952	59	11/13/57	18,700	1958	74
01/17/53	22,300	1953	39	02/16/58	15,500	1958	108
01/16/54	25,200	1954	30	02/18/58	16,100	1958	100
12/31/54	20,900	1955	45	02/24/58	20,000	1958	54
12/22/55	43,500	1956	3	01/09/59	19,000	1959	68
02/24/57	19,000	1957	67	02/16/59	15,400	1959	110
01/29/58	22,600	1958	38	12/17/60	15,000	1961	116
01/21/59	31,400	1959	13	01/31/61	17,300	1961	85
02/08/60	30,000	1960	20	10/12/62	19,400	1963	61
02/11/61	19,100	1961	66	11/26/62	20,200	1963	51
02/13/62	11,800	1962	125	12/02/62	19,800	1963	57
01/31/63	23,100	1963	34	01/06/65	15,000	1965	115
01/20/64	32,000	1964	12	01/24/65	15,000	1965	117
12/22/64	48,700	1965	1	12/28/65	17,700	1966	84
01/04/66	30,300	1966	18	01/29/67	17,900	1967	81
12/04/66	26,600	1967	25	03/16/67	15,600	1967	107
01/15/68	20,700	1968	46	12/10/68	22,900	1969	35
01/13/69	31,000	1969	15	12/15/68	16,200	1969	90
12/21/69	33,500	1970	10	12/24/68	18,900	1969	70
12/03/70	26,500	1971	27	01/20/69	26,600	1969	26
01/29/72	21,200	1972	44	01/17/70	16,300	1970	95
01/16/73	18,200	1973	77	01/23/70	28,400	1970	21
01/16/74	34,600	1974	8	01/27/70	27,200	1970	22

Annual Peaks				Partial Peaks			
Flood Date	Discharge (cfs)	Water Year	Peak Rank	Flood Date	Discharge (cfs)	Water Year	Peak Rank
03/18/75	26,200	1975	28	11/24/70	15,300	1971	111
02/26/76	16,400	1976	94	11/27/70	17,000	1971	89
03/09/77	2,140	1977	131	12/07/70	18,900	1971	69
12/14/77	18,700	1978	73	01/16/71	20,400	1971	50
02/13/79	10,100	1979	127	03/26/71	24,700	1971	32
01/13/80	16,800	1980	91	03/03/72	18,500	1972	75
12/02/80	13,100	1981	123	12/17/72	16,300	1973	96
12/19/81	25,500	1982	29	11/10/73	22,100	1974	40
01/26/83	30,800	1983	16	11/30/73	18,100	1974	79
11/10/83	14,800	1984	118	02/28/74	15,700	1974	105
11/11/84	18,800	1985	72	03/30/74	34,200	1974	9
02/17/86	36,900	1986	6	02/12/75	19,700	1975	58
03/12/87	13,800	1987	122	03/25/75	17,800	1975	82
12/10/87	21,300	1988	43	01/16/78	16,300	1978	95
11/22/88	24,100	1989	33	11/15/81	24,900	1982	31
01/08/90	17,100	1990	87	02/15/82	17,700	1982	83
03/04/91	14,400	1991	120	12/16/82	30,500	1983	17
02/20/92	7,320	1992	130	12/21/82	19,200	1983	64
01/20/93	41,300	1993	4	02/10/83	15,800	1983	103
12/08/93	8,620	1994	128	11/27/84	15,200	1985	113
01/09/95	43,700	1995	2	01/16/86	19,300	1986	62
12/12/95	36,500	1996	7	12/02/87	15,100	1988	114
12/31/96	37,100	1997	5	12/06/87	15,700	1988	104
03/22/98	21,700	1998	42	03/09/89	16,800	1989	92
11/23/98	18,900	1999	71	12/10/92	17,100	1993	88
02/14/00	***20,500	2000	48	01/31/95	15,900	1995	102
				03/09/95	32,500	1995	11
				03/14/95	26,900	1995	24
				12/30/95	20,000	1996	55
				12/09/96	19,300	1997	63
				01/26/97	19,500	1997	60
				01/17/98	19,200	1998	65
				01/26/98	16,200	1998	99
				02/03/98	15,500	1998	109
				02/21/98	16,000	1998	101

Notes:
*Annual = largest event in that water year, partial = peak flow above threshold value of 15,000 cfs
**Relative size ranking out of the 131 events that occurred over the period of record
***Provisional value, subject to change

2.10.2 Summary of Flood History

A flood frequency analysis was performed on the annual peak discharge data from the Van Duzen River near Bridgeville gage. A log-Pearson Type III distribution with a regional skew coefficient of -0.3 was used to develop a frequency distribution for the gage. Figure 2-11 illustrates the historic peak flows used in the analysis and Table 2-12 summarizes the results. The peak discharge from the 1964 flood of 48,700 cfs was just below the 100-year event determined by the analysis. The 3 large peaks recorded in 1998, 1997, and 1995 were approximately the 2-year, 10-year and 50-year events, respectively. The peak flow event of 43,500 cfs recorded on December 22, 1956 also had approximately a 50-year return interval. Figure 2-11 illustrates how generally the late-1990s was a relatively wet period preceded by a generally dry period in terms of peak flows from 1987 to 1994.

Figure 2-11. Annual Peak Flows for the Van Duzen River near Bridgeville Gaging Station

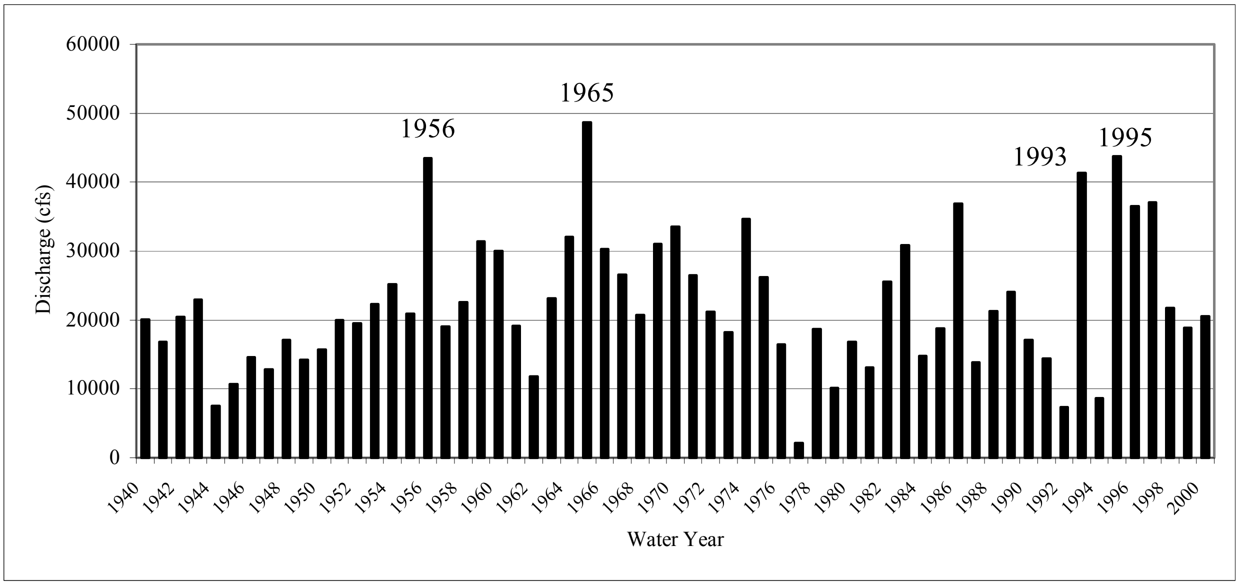


Table 2-12. Flood Frequency Analysis Results

Return Period	Probability	Van Duzen near Bridgeville, CA Gage 1940-2000 (cfs)	Van Duzen near Bridgeville, CA Gage 1940-2000 (cfs/mi^2)
1.01	0.99	6,720	31
1.05	0.95	9,740	44
1.11	0.90	11,700	53
1.25	0.80	14,500	65
2	0.50	21,100	95
5	0.20	29,800	133
10	0.10	35,300	158
15	0.07	39,000	170
25	0.04	42,000	188
50	0.02	47,000	209
100	0.01	51,800	230
Mean Annual Peak		22,300	101
Mean November-April Flow		1,620	7.3
Mean May-October Flow		136	.61

2.10.3 Peak Flow Generating Processes

An analysis of peak-flow generating processes (i.e., rain-on-snow, rainfall only) likely to be active in the Van Duzen watershed was performed to decide if it would be necessary to implement the rain-on-snow (ROS) methodology discussed in section 4.3.2 of the PALCO methodology (PALCO 2000). Snow depth values were checked at the Bridgeville 4 NNW weather station for 123 of the 131 peak flow records dates on record (both annual and partial-duration series) for the Van Duzen River near Bridgeville gage. The depths were checked for the days preceding the peak, the day of the peak and the day after. The Bridgeville 4NNW (Table 2-9, Figure 2-4) weather station (elevation 2,100 feet) is out of the study area but has a longer period of record than the Grizzly Creek State Park weather station. The snow depth record for the Grizzly Creek station was mostly incomplete, therefore, it was not used. Snow was present on 8 of the peak flow dates (6.5% of the peak flow events). The amount of snowfall present on the day of and day preceding the event was less than 3 inches in all but two of the potential ROS events. In addition, all snow-related peaks had less than a 5 year return interval. Based on these observations, it was concluded that rainfall alone drives the majority of the peak flows in the Van Duzen WAU. Therefore, the ROS methodology included in the PALCO methodology was not implemented in this analysis.

2.11 VEGETATION

2.11.1 Historic Vegetation

Available soil moisture and cool, moist climatic conditions have influenced the distribution of vegetation in the southern and western portions of the Van Duzen WAU (Figure 2-12). The soils here are relatively deep and well drained with high available water holding capacity. Flood deposits further enhanced the growth of redwood (*Sequoia sempervirens)* stands in riparian areas. Prior to the 1850s the southwest Van Duzen watershed was predominately old-growth redwood forest in lower slope positions, on alluvial flats, and flood plains. Understory herbaceous plants included sword fern (*Polystichium munitum),* evergreen huckleberry (*Vaccimium ovatum*), and huckleberry (*Vacinium parviloium*).

By contrast, the vegetation in the northern and eastern portions of the watershed is, and has historically been, influenced by the drier, inland climate and Franciscan mélange, bedrock material that weathers to soil with a high clay content and poor drainage (Figure 2-13). As a result, seedling establishment of conifers, such as redwood or Douglas fir (*Pseudotsuga menziesii*), is more difficult. Historically, redwood was found only in ravines or was entirely absent from this portion of the watershed. Grassland and oak woodland were the dominant vegetation types with stands of interspersed white oak (*Quercus alba*) and Douglas fir. Tan oak (*Lithocarpus densiflora*) grew in areas with higher soil moisture such as low-slope zones.

Figure 2-12. Photo of the Southwestern Portion of the Van Duzen WAU

Figure 2-13. Photo of the Northeastern Portion of the Van Duzen WAU

2.11.2 Current Vegetation

The current vegetation found in the southern and western parts of the watershed consists of mixed conifer stands. Redwood is dominant at lower elevations and Douglas fir and grand fir (*Abies grandis*) increase in abundance as elevation increases. Stands of old-growth redwood are found in Grizzly Creek State Park, Humboldt County parks, and Cheatham Grove. Large diameter (greater than 1 meter) redwood stumps are found in many riparian forests in the Van Duzen WAU, indicating that mature/old-growth forests were more widespread in the past (Figure 2-14). The northeastern portion of the watershed was historically dominated by grasslands and remains so today. However, the current vegetation regime consists almost entirely of exotic annual grasses rather than the native prairie and interspersed tree stands that once grew here.

Figure 2-14. Large-diameter Redwood Stumps Located in Cummings Creek Watershed

2.11.3 The Role of Fire

Fire has influenced the development of many stands throughout the Van Duzen WAU and the greater watershed. In general, the pre-settlement composition and structure of forests in the watershed were greatly influenced by fire. Stand dynamics and age-class distributions are both affected by fire. Furthermore, fire played a direct role in processes associated with vegetation succession, nutrient cycling, and soil structure and stability. Redwood seeds must germinate on bare mineral soils such as provided by fire or other disturbances (Cooper 1965; Florence 1965; Rydelius and Libby 1993; Olsen et al. 1990; Ornduff 1998). Data from Humboldt Redwoods State Park (Stuart 1987) indicates that the southwestern part of the watershed has had highly variable fire return intervals and fire severities: fire frequency studies recorded fire intervals of 16 to 52 years (related to pre-settlement, settlement, and post-settlement periods). Since the northeast portion of the Van Duzen WAU is warmer and drier, fires were typically more frequent than in the southwestern part of the watershed. Fire played an important role in stand dynamics, altering age-class distributions and resulting in stand regeneration following wildfires.

3.0 SCOPING OF ISSUES

The Tetra Tech Van Duzen River Watershed Analysis Team met with local residents and community members on 2 occasions to solicit input regarding local issues of concern. Evening meetings were held on Wednesday June 7, 2000 at the River Lodge in Fortuna and on Sunday July 23, 2000 at the Carlotta Grange. The meetings were facilitated and the spoken comments were captured. Participants also provided written comments at the meetings. Several written comments were received by both conventional mail and email, and are included in the Issues Matrix (Appendix A). The Issues Matrix was sent to each meeting participant, commenter, and the Signatory Review Team (SRT) for review. Comments were received on a wide range of subjects (Table 3-1).

The comments were carefully reviewed and screened per the methods detailed in the Watershed Assessment Methods for PALCO Lands (PALCO 1999). Each comment was put into one or more of the following categories:

1) Issue out of the watershed analysis scope.

2) Untested theory: may need to incorporate into assessment.

3) Not feasible to address per the definition in the methods.

4) Issues to address:

    4a) Issue is addressed in the default analysis methods.

    4b) Issue is partially addressed in the default methods and partially falls into categories 1, 2, or 3 above.

    4c) Issue is partially addressed in the default methods; modifications to methods may be needed for this analysis.

5) Comment is either a statement that could not be translated into a theory relating management practices effects on aquatic resources or comment does not address a specific issue (too vague).

Table 3-1. Number of Public Comments Received by Each Subject

Subject	Number
Amphibians	4
Chemicals	2
Community Involvement	8
Cumulative Effects	4
Domestic and Agricultural Water Use	4
Economics	6
Exotic Species	1
Fish	10
Flooding	18
General Project Design or Implementation	16
Hydrology	5
Mass Wasting	1
Multiple Subjects Covered	7
Prescriptions	14
Public Trust	1
Quality of Life/Private Property	4
Recreation	1
Regulations	1
Restoration Projects	5
Riparian Condition	1
Seasonality	2
Sediment Production and Transport	6
Surface and Stream bank Erosion	1
Trends in Condition / Targets	3
Turbidity	2
Water Quality	3
Water Temperature	4

Thirty-six percent of the comments received address issues that were out of the watershed analysis scope, were not feasible to address, or could not be interpreted (Table 3-2). Sixty-four percent of the comments are either fully or partially addressed by the default methods (see category 4 in Table 3-2). Eighteen comments were received regarding the effects of flooding on residential properties. The default methods include an assessment of the effects of forest practices on peak flow events (flooding) but do not directly evaluate the effects of those changes on residential developments on the floodplain (category 4c in Table 3-2). Several of the comments will need to be addressed in the context of adaptive management because of the long-term data required to support the analysis.

Table 3-2. Number of Public Comments and Their Corresponding Screening Categories

Category Number	Screening Category	Number
1	Out of the Watershed Analysis Scope	38
2	Untested Theory	0
3	Not Feasible to Address	3
4a	Addressed in Default Methods	38
4b	Partially Addressed in Default Methods, Partially in one of the Above Categories	25
4c	Partially Addressed in Default Methods, Modifications to Methods Required	12
4d	Not Addressed in Default Methods, Modify Methods	0
5	Comment Vague, Could Not Be Interpreted	2

4.0 MODULE FINDINGS

The story of the Van Duzen WAU is one of sediment sources and delivery. The floods of 1955 and 1964 resulted in legacy effects that still impact the channel structure and sediment storage/transport today. The focus of the analysis on more recent events is justified because the level and timing of sediment inputs remains critical to the overall health of the WAU. However, today, much of the sediment input to the Van Duzen River mainstem continues to be derived from sources upstream of the WAU and from natural earth flows along the channel (e.g., Goat Rock).

While tributary streams generally have good structure, first cycle logging practices have left their effects. A sizeable amount of large woody debris (LWD) remains in the channel either as a result of direct deposit from first cycle logging or due to transport via slides of LWD left on slopes.

Fisheries have some areas of unique value including the southernmost populations of cutthroat trout in Fox Creek, and locally and regionally important chinook salmon population and spawning habitat in lower Grizzly Creek. Other fisheries resources are also present throughout the WAU. The amphibian and reptile surveys indicate that their presence and habitat are ubiquitous throughout the Van Duzen WAU. Therefore, the delivery of sediment to the system is an important factor in the story of the WAU.

The assessment presented in Sections 4 and 5 suggests that the limiting factor currently influencing fish production is the condition of tributary streams on the Van Duzen River mainstem terraces. Terraces restrict migration upstream during seasonally dry periods and droughts. Terraces were created in response to the catastrophic levels of sediment and debris delivered in large part during the 1964 flood. The low gradient areas in the lower tributaries are believed to be the most productive areas (historically) in the WAU. The Stream Channel Assessment has identified these areas as prone to the documented aggradation while the Mass Wasting Assessment and sediment budget identify the potential sources and estimated inputs. Another factor potentially influencing channel response in selected areas (lower Cummings and Flanigan Creeks) are channelization and levees implemented to protect agricultural lands. In addition, channels have been manipulated to maintain transportation infrastructure (Hwy 36 corridor) and remove LWD.

The delivery of fine sediments from very steep and extreme channel gradients (greater than 6.5%) may also be limiting fish and amphibian production in the WAU. Much of the fine sediment comes from areas in the WAU that are composed of unconsolidated Wildcat lithology which is located in many of the steep upper portions of many of the tributaries. Trends in sediment size have been observed in data reported as part of PALCO's Aquatic Conservation Plan 2000 Annual Report (data from 1996 to 2000). The Van Duzen River watershed exhibited a trend of increasing fines and decreasing geometric mean particle sizes

(D50 and D84). This suggests a deficiency of cobbles and, therefore, a slower recovery trend. Fines in excess of approximately 12% have the potential to reduce spawning and incubation success. Fine sediment is delivered along with coarse sediment during mass wasting, and also is derived to a lesser extent in this WAU from surface and road erosion sources. Fines generated from road surface erosion are expected to decrease over time as a result of the PALCO HCP road improvement program. Additional details on sediment impacts to fish habitat is provided in the Fish Habitat Assessment Report.

The following 2 sections provide additional detail to this part of the watershed story. Section 4 evaluates WAU condition and processes using the various landscape characterization units (e.g., channel geomorphic units, hydrological analysis units, riparian classification units). Channel Geomorphic Units (CGUs) are illustrated in Map MW-1. Section 5 pulls the various assessment elements together in the form of sub-basin summaries. Key findings are presented by assessment topic and grouped according to sediment sources, stream processes, and biological resources (see Sections 4.1, 4.2, and 4.3, respectively). The information was obtained from each watershed analysis assessment report and focuses on those aspects that are directly relevant to this Cumulative Watershed Effects report.

4.1 SEDIMENT SOURCES

Sediment source characterization and delivery estimates were developed as part of the Mass Wasting and Surface Erosion Assessments for the Van Duzen WAU. The results are summarized in Sections 4.1.1 and 4.1.2, respectively. The sediment delivery estimates for all evaluated sources, in the overall context of delivery to streams in the WAU, are presented in the sediment budget (Section 4.1.3).

4.1.1 Mass Wasting

Mass wasting is a general term used to describe a variety of processes by which masses of earthen material are moved by gravity from one place to another. For the purposes of the watershed analysis, mass wasting specifically refers to landslide processes, landslide effects, and the distribution of landslide types present in the Van Duzen WAU. Mass wasting is not used in the broader sense that includes soil creep. The main purpose of the Mass Wasting Assessment for the Van Duzen WAU is to develop relative landslide hazard potential maps and landslide-related sediment budget estimates for use in evaluating interim management prescriptions. The assessment evaluated the effects of past and present forest management activities on landslide activity. Key findings from the Mass Wasting Assessment are summarized in the following discussion, as categorized by hillslope landslides and road-related landslides.

Hillslope Landslides

Hillslope landslide delivery volume is depicted in Figure 4-1 by geologic unit and in Figure 4-2 by sub-basin. As shown, the Scotia Bluffs (QTsb) geologic unit yields the largest rate of hillslope landslide delivery per acre harvested, however, this unit has relatively small acreage. Therefore, it does not contribute significantly to sediment delivery from hillslope landslides as does Undifferentiated Wildcat (QTw). Undifferentiated Wildcat yields the largest hillslope landslide delivery volume due to its large acreage combined with its instability. Scotia Bluffs occurs primarily in the Hely Creek sub-basin, whereas, Root Creek contains the largest percentage of Undifferentiated Wildcat compared to other sub-basins.

Figure 4-1. Hillslope Landslide Delivery Volumes by Geologic Unit

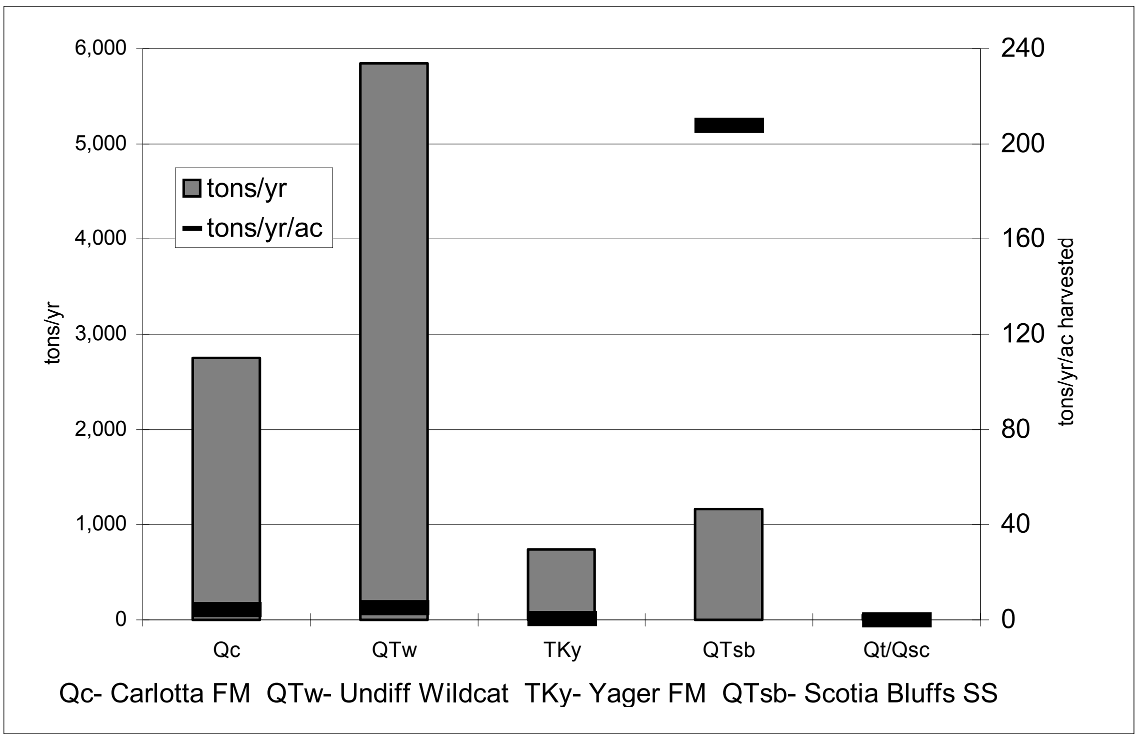
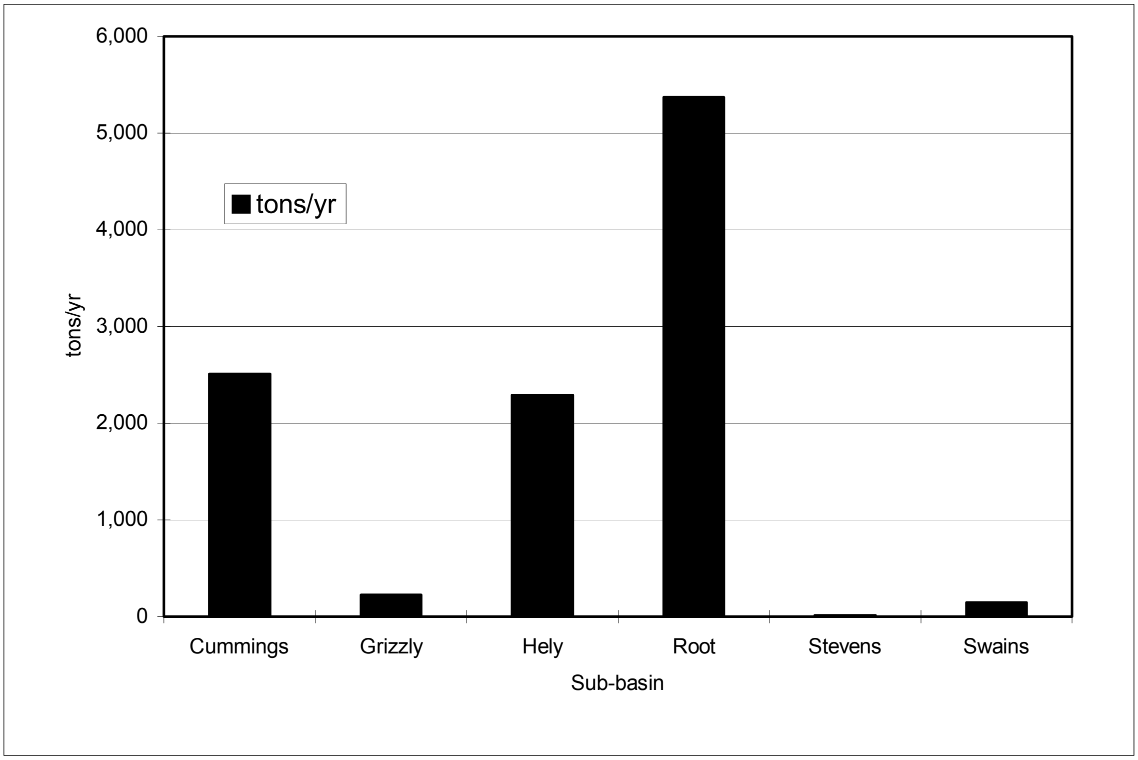


Figure 4-2. Hillslope Landslide Delivery Volumes by Sub-basin



Other evaluations of hillslope landslides focused on relating harvesting, silvicultural practice, and yarding method to landslide occurrence. Key observations of mass wasting occurring from 1987 to 1997, which include effects from land use prior to 1987, are based on the findings of the mass wasting assessment. These observations are listed below:

1. Overall hillslopes exposed to timber harvest practices resulted in approximately 2.3 times more landslides per acre than advanced second-growth hillslopes from 1987 to 1997.

2. Overall advanced second-growth hillslopes yielded approximately 3.9 times more sediment to streams per acre than hillslopes exposed to timber harvest practices from 1987 to 1997. Fewer landslides of larger volumes are present within advanced second-growth hillslopes probably because these large features are avoided when recent harvest plots were selected. Therefore, it is reasonable that more of these features are encompassed on grounds classified as advanced second-growth.

3. In terms of silviculture, the watershed analysis data from 1987 to 1997 indicate that 10% fewer landslides occurred on clearcut hillslopes, relative to partial cut hillslopes. Also, clearcut and partial cut silviculture each resulted in approximately 2.1 times more landslides per acre than land classified as advanced second-growth.

4. In terms of yarding method, the watershed analysis data from 1987 to 1997 indicate that on land subject to clearcut silviculture, 1.6 times as many landslides per acre occurred in areas of tractor yarding, as opposed to cable yarding. Similarly, on land subject to partial cuts, twice as many landslides per acre occurred in areas of tractor yarding, as opposed to cable yarding.

5. Watershed analysis data from 1987 to 1997 indicate that cable yarding delivered more sediment to streams in clearcuts than when used with partial cuts.

Road-Related Landslides

Road-related landslide delivery volume is depicted in Figure 4-3 by geologic unit and in Figure 4-4 by sub-basin. As shown, the Undifferentiated Wildcat (QTw) geologic unit yields the largest rate of road-related landslide delivery rate per mile of road. It should be noted that the largest road-related delivery volume also occurs in this geologic unit due to its large number of road miles. The Hely Creek sub-basin yields the most road-related landslide sediment delivery because of its large proportion of Undifferentiated Wildcat along with the large network of roads.

Figure 4-3. Road-Related Landslide Delivery Volumes by Geologic Unit

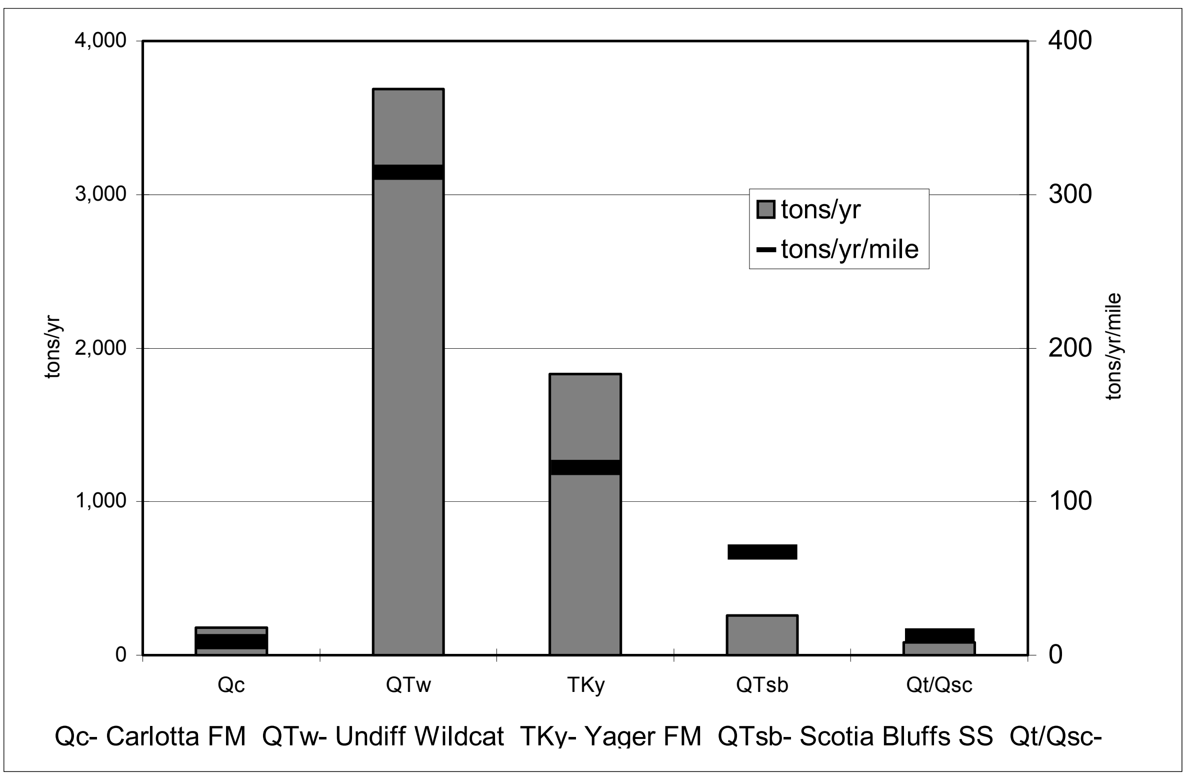
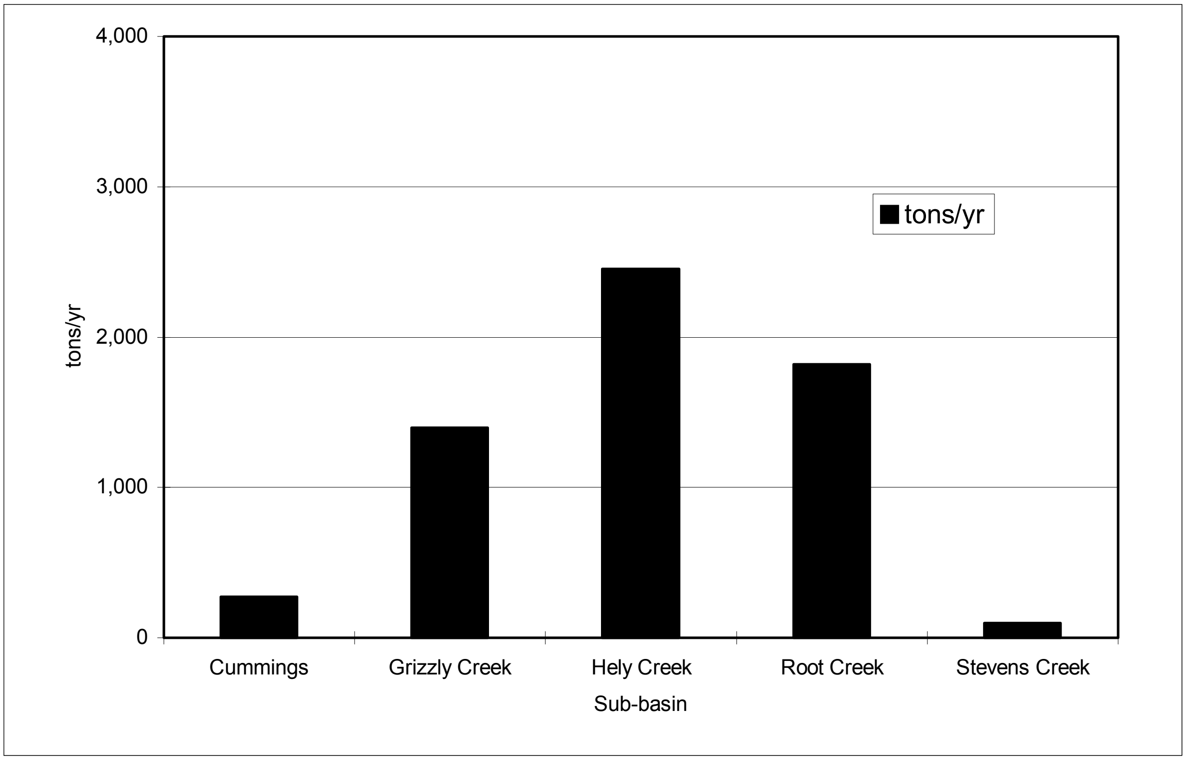


Figure 4-4. Road-Related Landslide Delivery Volumes by Sub-basin



Context of PALCO's Contribution

The contribution of landslides to sediment delivery should be viewed in context of 2 scales for the Cumulative Effects Assessment: (1) the entire Van Duzen watershed; and (2) sub-basins of the WAU within which PALCO owns and manages timberland. Within the entire Van Duzen watershed, PALCO ownership is relatively small; most of the Van Duzen watershed is located upstream of the WAU. The mainstem is the conduit by which sediment moves through the WAU from the larger total volume of upstream sources. Studies by Kelsey (1980) and Pacific Watershed Associates (1999) have documented the magnitude of sediment delivery from these upstream sources as compared with sources within the WAU. Quantitative comparisons of the sediment delivery from the WAU relative to estimates from other studies are provided in the sediment budget (Section 4.1.3).

Evaluation of mass wasting contributions from Van Duzen WAU sub-basins shows the Root Creek sub-basin as the largest contributor from PALCO lands. This is the result of several combined factors which include the large acreage of PALCO ownership, less stable geology, past harvest intensity, high density of streams, and high density of haul roads.

4.1.2 Surface Erosion

Surface erosion is the detachment of soil particles by water, wind, or raveling. The Surface Erosion Assessment focuses on surface erosion by water in the Van Duzen WAU. In the majority of the WAU, because a thick layer of duff protects the soil from surface erosion, most rainfall and snowmelt infiltrates into the soil. However, if the duff layer is removed to expose bare mineral soil, or the soil is compacted to concentrate runoff, surface erosion may occur. Most sediment delivered to streams from surface erosion consists of small particles (sand, silt, clay). The main purpose of the Surface Erosion Assessment is to develop an understanding of surface erosion processes and magnitudes in the WAU, spatially and as influenced by management activities, for use in evaluating interim management prescriptions. Key findings from the Surface Erosion Assessment are summarized in the following discussion, and are categorized by harvest unit erosion, road surface erosion, and natural soil creep.

Harvest Unit Erosion

Surface erosion is reduced under conditions of increased ground cover. The magnitude of surface erosion occurring in harvested areas is dependent on silvicultural practice, yarding method, and time since site disturbance. Surface erosion from timber harvest averaged 43.0 tons per year from 1989 through 1999 (157 tons per square mile harvested per yr). Of the total sediment delivered to the watercourses from management sources, timber harvest source contributions are less than 1%. The largest erosion rates occur in tractor-yarded units where there are erodible soils. Tractor yarded units with high densities of bladed skid trails are the largest sources of harvest unit surface erosion. The smallest erosion rates occur on cable and helicopter yarded units. Erosion is highest in the first 2 years after harvest, although not equivalent, for all combinations of silviculture and yarding. Input from timber harvest is higher following years with more harvest and lower following years when less harvest occurs. Broadcast burning, particularly hot burns or burns combined with mechanical site preparation, can result in erosion on steeper slopes.

Road Surface Erosion

Surface erosion from roads prior to the Habitat Conservation Plan (HCP) was evaluated, and averaged 11,865 tons/yr under current road use conditions (166 tons per square mile per year). A total of 79% of road sediment is produced and delivered by native surfaced roads. Approximately 51 miles (21%) of roads in the watershed deliver directly to streams. And an estimated 73 additional miles (30%) are within 100 to 200 feet of a stream and deliver a portion of their sediment to streams.

Natural Soil Creep

An erosion hazard map (Map SE-2) of the watershed was prepared based on California Board of Forestry guidelines which rate erosion hazard based on soil texture, depth, hillslope gradient, precipitation intensity, and ground cover conditions. With all protective vegetation removed, soils on steeper slopes generally had the highest (i.e., extreme) erosion hazard. Sediment input from soil creep was evaluated, and totaled approximately 23,170 tons per year (330 tons per square mile per year). Sediment input from soil creep is believed to be larger in the North Coast forest lands as compared to default values in Washington Department of Natural Resources methods (WDNR 1997) due to a combination of tectonic influences, increased precipitation, and other geologic factors.

Context of PALCO's Contribution

The Surface Erosion Assessment evaluated portions of natural sediment yield as well as the effects of roads, timber harvesting, and other land uses on surface erosion in the Van Duzen WAU. Results show that natural soil creep contributes 66%, road surface erosion contributes 33%, and timber harvest contributes less than 1% of the total sediment delivery from surface erosion. Surface erosion from other land use activities, including grazing, recreational vehicle use, and residential development, is very small compared with timber harvest activities. This results from the relatively small and widely dispersed disturbance areas associated with these land uses. The Root Creek sub-basin generates the largest volumes and unit rates of soil creep, road surface, and harvest unit erosion.

Inputs from surface erosion and other sediment sources are compiled in the sediment budget. Relative to landslide sediment sources, surface erosion is a small contributor to sediment delivery in the WAU.

4.1.3 Sediment Budget

An input-only sediment budget was developed for the Van Duzen WAU for the period from 1988 through 1997. This time period was selected because the most complete data set covering the range of sediment inputs was available for this period. It also defines the period in which the effects of contemporary management practices are the greatest, and current conditions are represented best by this recent time period. The effects from management- and non-management-related processes occurring prior to 1988 are also included as they influence delivery of sediment during the budget period of 1988 to 1997. For example, the budget would include a landslide delivering sediment to a stream in 1989 that occurred in an area harvested in 1981. Another example includes estimates developed for long-term soil creep and streamside landslide delivery volumes that are applied to the 1988 to 1997 time period.

The goal of this sediment budget is to provide semi-quantitative comparisons of the various sediment sources in the study area. While the budget does not account for sediment storage and routing in the stream system that would give a net sediment yield (discharge), it provides a useful estimation of relative contributions of management and non-management-related sediment sources. The sediment budget serves to: (1) document sediment sources and estimate the relative contributions to total sediment delivery to streams; (2) estimate the contribution of management-related versus natural sediment delivery; and (3) provide basic information for subsequent evaluation of how sediment delivery may affect channel morphology and aquatic habitats. Estimation of relative contributions from potential sediment sources in the study area will facilitate understanding of the interactions between natural influences, land use activities, and resource conditions. Inputs are allocated to either management or non-management (i.e., natural) sources. For the various inputs, sediment quantities are estimated from field observations, interpretation of aerial photography (1987 and 1997), or computer modeling.

This sediment budget incorporates the results for the following types of non-management-related sediment sources: bank erosion; natural soil creep; earthflow; rock topple, rotational slides, translational slides, and complex slides; and debris flows and debris slides. Soil creep is applied to 80% of the stream network (excluding the Van Duzen mainstem), except where streamside landslides occur, and covers sediment source contributions from bank erosion. The following management-related sediment sources are included: debris flows and debris slides, road-related landslides, harvest unit surface erosion, and road surface erosion. Streamside landslides are segregated into management- and non-management-related sources in the same manner as for the Freshwater Creek Watershed Analysis (i.e., an equal 50:50 split due to uncertainty). The division of streamside landslides equally to management- and non-management-related influences was done because the watershed analysis teams were unable to identify any research that provided an empirical basis for any other allocation. The benefit of the equal allocation is that the potential bias is equally weighted. Factors influencing initiation of these features are complex and cannot clearly be attributed to specific land uses or natural processes. In the summaries that follow, distinctions are made between sediment delivery from PALCO or non-PALCO lands for rock topple, rotational slides, translational slides, and complex slides; debris flows and debris slides; and road-related landslides. Sediment delivery from harvest unit surface erosion is included only for PALCO lands. Distinctions between PALCO and non-PALCO lands are not made for sediment delivery from earthflow, soil creep, streamside landslides, and road surface erosion.

Since the majority of the drainage area for the Van Duzen basin is above the Van Duzen WAU, the mainstem is excluded from this input-only sediment budget. This is also the case in the Stream Channel Assessment (because conditions in the mainstem are overwhelmingly determined by sediment inputs upstream of the study area). The sediment budget is summarized, below, by type of source and associated delivery from these sources to the tributaries of the Van Duzen WAU. Results for each sub-basin are discussed in Section 5.0.

Overview

The following discussion provides summaries of each type of source, assumptions used in the estimation of sediment delivery, and results. Definitions and additional details are provided in the respective assessment reports. The sediment budget summary is provided in Table 4-1.

Sediment delivery rates are presented in units of tons per square mile year (tons/sq mi/yr), with equivalent results in units of metric tons per square kilometer per year (metric tons/sq km/yr) (in parentheses). Sediment delivery rates are distinguished according to their occurrence on PALCO or non-PALCO lands (depending on the source type) and association with non-management- or management-related effects. For example, road-related landslides and harvest unit erosion are management-related effects. Examples of non-management effects are soil creep and earthflow.

Shallow hillslope landslides could result from either non-management- or management-related effects, depending on the length of time since harvest. The sediment budget for the Freshwater Creek Watershed Analysis used an assumption of 15 years post-harvest to distinguish management- from non-management-related effects. From a review of literature and data for Freshwater Creek, reductions in root strength and increases in soil moisture due to harvest activities were found to be substantially reduced within 15 years after harvest. Forest stand types in Freshwater Creek were also evaluated over a 10-year period (1988 to 1997) to illustrate higher rates of landsliding in thinned stands compared with unthinned second-growth stands, although clear cut stands had higher landsliding rates than thinned and unthinned stands (PALCO 2000). Based on the Freshwater Creek analysis, a 15-year cutoff between management- and non-management-related effects is assumed to be reasonable for application to the Van Duzen WAU; a 20-year cutoff was applied because there were no aerial photographs available to document changes at a 15-year cutoff. This type of approach was used to distinguish non-management- from management-related effects for shallow hillslope landslides.

Table 4-1. Sediment Source Budget Summary

Sediment Source		Entire Study Area	Cum-mings Creek	Grizzly Creek	Hely Creek	Hydes-ville Creek	Root Creek	Stevens Creek	Swains Flat
Total Area	Square mile	71.3	12.6	11.2	10.1	1.4	14.2	7.8	13.9
NON MANAGEMENT-RELATED									
Earthflow - Active	Tons/sq mi/yr	330	380	250	350	360	410	490	170
Soil Creep	Tons/sq mi/yr	330	370	250	340	350	400	480	170
Streamside Landslides	Tons/sq mi/yr	870	990	660	910	940	1080	1280	460
Rotational, Translational, etc Landslides	Tons/sq mi/yr	880	180	1510	0	380	160	0	2950
Debris Flows and Debris Slides	Tons/sq mi/yr	610	340	150	1040	10	1500	160	330
MANAGEMENT-RELATED									
Debris Flows and Debris Slides [DFDS]	Tons/sq mi/yr	130	200	30	230	250	220	70	10
Road-Related Landslides [RRLS]	Tons/sq mi/yr	90	20	160	240	0	130	10	3
Harvest Unit Erosion [HARV]	Tons/sq mi/yr	0.6	0.7	0.1	0.3	0	1.0	1.4	0.4
Road Surface Erosion [ROAD]	Tons/sq mi/yr	170	140	90	120	60	390	140	90
Streamside Landslides [SSLS]	Tons/sq mi/yr	870	990	660	910	940	1080	1280	460
TOTAL NON-MANAGEMENT RELATED	**Tons/yr**	**215,600**	**28,600**	**31,700**	**26,700**	**2,890**	**50,300**	**18,600**	**56,700**
MGMT-RELATED: PALCO [DFDS, RRLS, HARV]	**Tons/yr**	**14,400**	**2,790**	**1,620**	**4,780**	**-**	**4,920**	**120**	**150**
MGMT-RELATED: non-PALCO [DFDS, RRLS]	**Tons/yr**	**1,460**	**50**	**510**	**-**	**350**	**-**	**520**	**40**
MGMT-RELATED: PALCO + non-PALCO [ROAD, SSLS]	**Tons/yr**	**73,900**	**14,400**	**8,410**	**10,500**	**1,420**	**20,800**	**11,000**	**7,530**
TOTAL-->	**Tons/sq mi/yr**	**4,280**	**3,620**	**3,770**	**4,150**	**3,270**	**5,360**	**3,890**	**4,630**

In addition to comparisons of sediment delivery rates, sub-basins are compared in terms of total sediment delivery (tons per year or tons/yr) and percentages of the total. This sediment-source tabulation estimated that the largest inputs of management-related sediment are delivered from the Root Creek (25,700 tons/yr) and Cummings Creek (17,200 tons/yr) sub-basins. The Hely Creek sub-basin also contributes a relatively large input of management-related sediment (15,200 tons/yr). Throughout the study area, most management-related sediment input is attributed to streamside landslides, road surface erosion, debris flows and debris slides, and road-related landslides. Only a small quantity of sediment input results from harvest unit surface erosion.

Earthflow

Active earthflow is a non-management-related sediment source in origin, with potential for exacerbation due to management activities including road construction (e.g., Highway 36). Two major earthflows are located in the Swains Flats sub-basin, one at Goat Rock and the other at Little Golden Gate. These major earthflows are estimated to have delivered earthflow cross-sectional areas of approximately 32,000 and 750 square feet, respectively, each at an average long-term earthflow creep rate of 4 meters per year. Other earthflow features are located throughout the WAU; for this sediment budget, earthflows were assumed to deliver sediment, on average, from 0.5% of the total stream length in each sub-basin and the total study area (Benda 2001). Also, delivery was assumed to occur along only one side of the stream at a given location. An average earthflow thickness of 2 meters was assumed for delivery to streams, at an average earthflow creep rate of 2 meters/yr, which is within the range noted by Kelsey (1980).

These parameters were included in the calculation of earthflow delivery to streams. For the study area, a stream density of 5.8 miles/sq mi (3.6 km/sq km) was determined through analysis using a Geographic Information System (GIS). The estimated sediment delivery of earthflow to streams in the total study area is 330 tons/sq mi/yr (120 metric tons/sq km/yr). Additional details on earthflow characteristics are provided in the Mass Wasting Assessment.

Soil Creep

Delivery of sediment from soil creep processes is expressed at streambanks throughout the WAU, representing a non-management-related effect. The soil profile is delivered to streams through soil creep. For this analysis, it was assumed that 80% of the total length of stream could potentially deliver soil creep from both sides of the stream. Of this length, it was further assumed (Benda 2001) that 0.68 mi/mi (0.68 km/km) of stream would actually deliver soil creep (the other 0.32 mi/mi would deliver streamside landslides, as discussed below). A uniform thickness of 1 meter was assumed to deliver throughout all sub-basins; this is consistent with depths of the predominant soils in the study area. An average creep rate of 0.017 m/yr was applied to the calculations, as derived from tree throw data for the WAU. With these parameters, along with stream density, the estimated sediment delivery of soil creep to streams in the total study area is 330 tons/sq mi/yr (120 metric tons/sq km/yr). Additional details on characteristics of soil creep and estimation of the average creep rate are provided in the Surface Erosion Assessment and the Stream Channel Assessment.

Rock Topple, Rotational, Translational, and Complex Slides

Volumes of rock topple, rotational, translational, and complex slides delivering to streams were determined from aerial photograph interpretation by Pacific Watershed Associates (PWA) (under contract to PALCO) for the years spanning 1987 to 1997. Often, these types of slides are viewed as deep-seated, but for this analysis the actual descriptors are used. These types of landslidse are almost exclusively associated with non-management effects and are, therefore, considered to be natural. However, the occurrence of these landslide types can increase erosion and sediment source contributions in cases where a landslide toe intersects a management feature such as a road. Sediment delivery estimates for these landslides are separated into those occurring on PALCO or non-PALCO lands. Delivery of sediment is estimated at 570 tons/sq mi/yr (200 metric tons/sq km/yr) for PALCO lands and 1,240 tons/sq mi/yr (430 metric tons/sq km/yr) for non-PALCO lands. Additional details on characteristics of deep-seated landslides, of which rock topple, rotational, translational, and complex slides are included, are provided in the Mass Wasting Assessment.

Debris Flows and Debris Slides

Volumes of debris flows and debris slides delivering to streams have been determined by PWA for the years spanning 1987 to 1997. Debris flows and debris slides, as delineated for this analysis, include slides that could be termed either shallow or deep-seated landslides in the Mass Wasting Assessment. (For this analysis, the actual PWA descriptors are used.) These types of landslides typically can be associated with either non-management or management effects and, therefore, are distinguished accordingly in this sediment budget. Sediment delivery estimates for debris flows and debris slides are further separated into those occurring on PALCO or non-PALCO lands. Delivery of sediment from non-management-related debris flows and debris slides is estimated at 930 tons/sq mi/yr (330 metric tons/sq km/yr) for PALCO lands and 260 tons/sq mi/yr (90 metric tons/sq km/yr) for non-PALCO lands. Delivery of sediment from management-related landslides is substantially lower than for non-management-related landslides, and is estimated at 220 tons/sq mi/yr (80 cubic meters/sq km/yr) for PALCO lands and 30 tons/sq mi/yr (10 metric tons/sq km/yr) for non-PALCO lands. Additional details on characteristics of debris flows and debris slides, which may be included in broader categories of shallow or deep-seated landslides, are provided in the Mass Wasting Assessment.

Road-Related Landslides

Road-related landslides have also been identified through aerial photograph interpretation (for the period spanning 1987 to 1997) as described in the Mass Wasting Assessment. This type of landslide is exclusively associated with the management effects from roads and was inventoried by PWA. Sediment delivery estimates for road-related landslides are separated into those occurring on PALCO or non-PALCO lands. Delivery of sediment from road-related landslides is estimated at 160 tons/sq mi/yr (60 metric tons/sq km/yr) for PALCO lands and 14 tons/sq mi/yr (5 metric tons/sq km/yr) for non-PALCO lands. Additional details on characteristics of road-related landslides are provided in the Mass Wasting Assessment.

Streamside Landslides

The procedure for identifying streamside landslide occurrence is described in the Stream Channel Assessment. Streamside landslides result from a combination of natural and management-influenced processes, and are not easily segregated. Based on field observations and land use activity between 1987 and 1997, the effects of management activities on streamside landslides are believed to be minor compared with legacy effects and ongoing natural processes. Management practices no longer in use, such as near-stream harvest and equipment travel in stream channels, could still be affecting landslide activity. Therefore, the total estimate for streamside landslides is equally divided between management and non-management-related sources for this sediment budget, although the actual effect from management activities is believed to be much lower than this conservative split. This approach was also taken in the Freshwater Creek Watershed Analysis.

For this sediment budget, it was assumed that 80% of the total length of stream could potentially deliver sediment by soil creep or streamside landslides. The length of stream actually delivering streamside landslides was set equal to the stream length not previously assigned to soil creep (i.e., 0.32 mi/mi). This 0.32 mi/mi is defined in the Stream Channel Assessment as the proportion of the channel network prone to inner gorge landsliding and is based on field data collection in a subset of the channel system (approximately 1%). Therefore, there is uncertainty in the estimated length of stream delivering via streamside landslides, with little information to indicate whether 0.32 mi/mi is an underestimate or overestimate. A landslide flux rate (both sides of the channel) of 0.41 cubic meters/m/yr was derived from a limited set of wood flux data also collected as part of the Stream Channel Assessment. As for the length of stream delivering, there is uncertainty in the landslide flux rate. Using stream density along with the other parameters identified above, the estimated sediment delivery of streamside landslides to streams in the total study area is 1,740 tons/sq mi/yr (610 metric tons/sq km/yr) – 870 tons/sq mi/yr attributed to management and 870 tons/sq mi/yr attributed to natural sources. Additional details on characteristics of streamside landslides are provided in the Stream Channel Assessment.

Harvest Unit Erosion

Harvest unit erosion was evaluated as described in the Surface Erosion Assessment. Sediment delivery via surface erosion from timber harvest was analyzed for the period from 1989 through 1999. Timber harvest practices during this period, and corresponding effects on surface sediment delivery, were quantitatively simulated for each year through use of the Water Erosion Prediction Project (WEPP) model, adjusted to simulate climatic, soil, and management conditions in the Van Duzen WAU. The model incorporated the effects of vegetation growth and recovery on reducing sediment delivery in the years after harvest for a given harvest unit. This analysis was completed only for PALCO lands. Delivery of sediment from surface erosion processes on harvest unit areas is estimated at 0.6 tons/sq mi/yr (0.2 metric tons/sq km/yr); note that unit area in these values is square miles of total study area of which only a small portion was harvested during the analysis period. Additional details on characteristics of harvest unit surface erosion are provided in the Surface Erosion Assessment.

Road Surface Erosion

Road surface erosion was evaluated as described in the Surface Erosion Assessment. Sediment delivery via surface erosion from roads was analyzed based on 1999 PALCO GIS roads data, and included roads both on PALCO and non-PALCO lands. The SEDMODL program (Boise Cascade 2000) was used to predict lengths of road delivering to streams, indirect delivery of road drainage to streams, and road surface erosion. Effects of different road characteristics, including road type and use level, were addressed in the analysis. Delivery of sediment from road surface erosion processes is estimated at 170 tons/sq mi/yr (60 metric tons/sq km/yr). This estimate includes all roads (PALCO and non-PALCO), because roads were not separated by ownership in the SEDMODL analysis. Additional details on characteristics of road surface erosion are provided in the Surface Erosion Assessment.

Summary

Major findings of this sediment budget include:

1. A total input amount of 4,280 tons/sq mi/yr (1,500 metric tons/sq km/yr, 920 cubic meters/sq km/yr, or 3,120 cy/sq mi/yr) of sediment was estimated in the current sediment budget for the period from 1988 through 1997. This estimate is comparable to the estimated 5,000 to 7,335 tons/sq mi/yr (3,645 to 5,530 cy/sq mi/yr) developed by Kelsey (1980) for the period from 1941 to 1975 for conditions without and with the 1964 flood, respectively. This estimated delivery quantity was larger than the estimated 1,257 cy/sq

mi/yr developed by PWA (1999) for the Van Duzen Total Maximum Daily Load (TMDL) study (1955 to 1999) which included the Van Duzen WAU area but did not include soil creep, streamside landslides, and surface erosion. However, this total input estimate was lower than other estimates, based on suspended sediment data collected upstream at Bridgeville, before the 1964 flood (6,900 tons/sq mi/yr) and after the 1964 flood (14,700 tons/sq mi/yr). Sediment input estimates for the Garcia River and South Fork Trinity River watersheds were somewhat less at 1,380 and 1,053 tons/sq mi/yr, respectively (U.S. EPA 1998a and 1998b).

2. Total management-related sediment input was estimated at 12 to 38% (29% average) of total sediment delivery in the current sediment budget, as categorized by streamside landslides (20% of total), road surface erosion (4%), debris flows and debris slides (3%), road-related landslides (2%), and harvest unit surface erosion (less than 1%).

3. Ten different types of sediment sources were quantified and grouped into three categories, as follows: non-management-related sources include (1) earthflow, (2) soil creep, (3) rock topple, rotational, translational, and complex slides, and (4) debris flows and debris slides; management-related sources include (5) debris flows and debris slides, (6) road-related landslides, (7) harvest unit erosion, and (8) road surface erosion; and (9) management- and (10) non-management-related streamside landslides. For the entire study area, contributions from management- and non-management-related sources were estimated at 29 and 71%, respectively.

4.2 STREAM PROCESSES

Stream process analyses were developed as part of the Hydrologic Change, Stream Channel, and the Riparian Condition Assessments for the Van Duzen WAU and are summarized in Sections 4.2.1, 4.2.2, and 4.2.3, respectively. Each of these modules addresses processes occurring in the stream network.

4.2.1 Hydrologic Change

Hydrologic change in a watershed is influenced by land management activities, including timber harvest and road construction. The Hydrologic Change Assessment focuses on the effect of timber harvest in the Van Duzen WAU. Effects from road construction also are considered in the analysis. Key findings from the Hydrologic Change Assessment are summarized in the following discussion, as categorized by relative increases in peak flow and effects of the road network on drainage density.

Relative Increases in Peak Flow

The Hydrologic Change Assessment evaluated the effects of timber harvest on peak flows in the Van Duzen WAU. The relative changes were applied to estimate baseline flows to determine what influence land management activities may have on the hydrologic regime of the watershed and to provide context on how hydrologic change may influence flooding, scour, and sediment transport. The highest relative change in peak flows are found in the Cummings Creek sub-basin and in portions of the Stevens Creek sub-basin (Figure 4-5). The relative increases are greater in more frequent, lower magnitude events. Peak flows having a recurrence interval of 2 years or greater are large enough to cause overbank flooding.

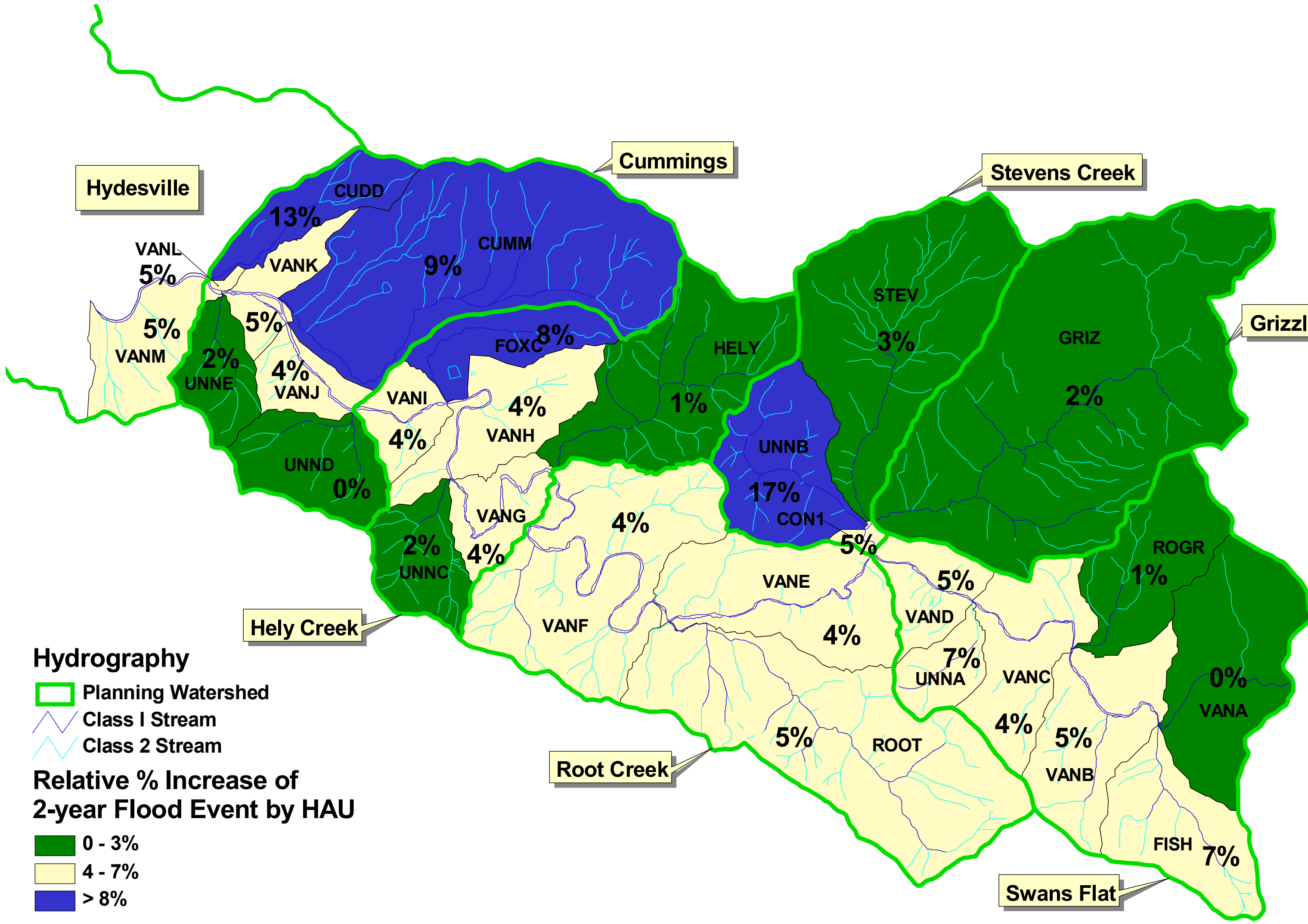
Modeling results indicate that overbank flooding may occur more frequently due to land management activities. However, the change in recurrence interval of flows with magnitudes at approximately the 2-year recurrence interval and above have much less of a relative increase than the smaller event peak flow.

The empirical model used for the peak flow change analysis was developed from Caspar Creek watershed data which represents different conditions than those in the Van Duzen. However, the model was used to estimate relative increases in peak flow as a function of canopy removal for the Van Duzen WAU. Because of the direct link between canopy removal and timber harvest, the model predicts larger increases in peak flows as the result of larger areas of timber harvest. The empirical Caspar Creek model only addresses acres of harvest, without considering effects from roads or other hydrologic factors. Predicted effects from hydrologic change diminish after 8 years, and the model has limited capacity to predict future effects of current harvest practices.

Effects of Road Network on Drainage Density

Observations regarding the impacts of roads and compaction can also be used as a decision making tool for prescriptions. The limited extent to which the road system is connected to the stream system in the Van Duzen watershed has resulted in a relatively small increase in the effective drainage density, which increases over a range of 8 to 20% depending on the sub-basin. For comparison, an estimated 21 to 50% increase in the effective drainage density was observed in the H.J. Andrews Experimental Forest in the Oregon Cascades (Wemple et al. 1996). Also for 2 sub-basins in the Deschutes River watershed in the Washington Cascades, Bowling and Lettenmaier (1997) found the effective channel network density to have increased by 64% and 52% due to road construction.

Figure 4-5. Relative Increase in Peak Flows per Hydrologic Analysis Unit, Van Duzen Watershed



Context of PALCO Hydrologic Effect

PALCO's contribution to peak flow changes in the Van Duzen mainstem must be viewed in the context of land area owned and managed by PALCO relative to the total drainage area. The entire Van Duzen watershed area, including the Yager Creek drainage, is 272,911 acres. Of this, the Van Duzen WAU covers 45,620 acres (17% of total) and PALCO land (within the Van Duzen WAU) covers 23,982 acres (53% of WAU or 9% of the total). A better representation of PALCO contribution involves evaluation of the actual drainage area of the Van Duzen WAU plus areas upstream; this excludes the Yager Creek drainage. The drainage area for the Van Duzen WAU plus areas upstream of the WAU total 179,785 acres. Of this, 134,165 acres (75% of the total drainage) is located upstream of the WAU. PALCO owns and manages 23,982 acres (53% of the WAU), which is equivalent to 13% of the total drainage.

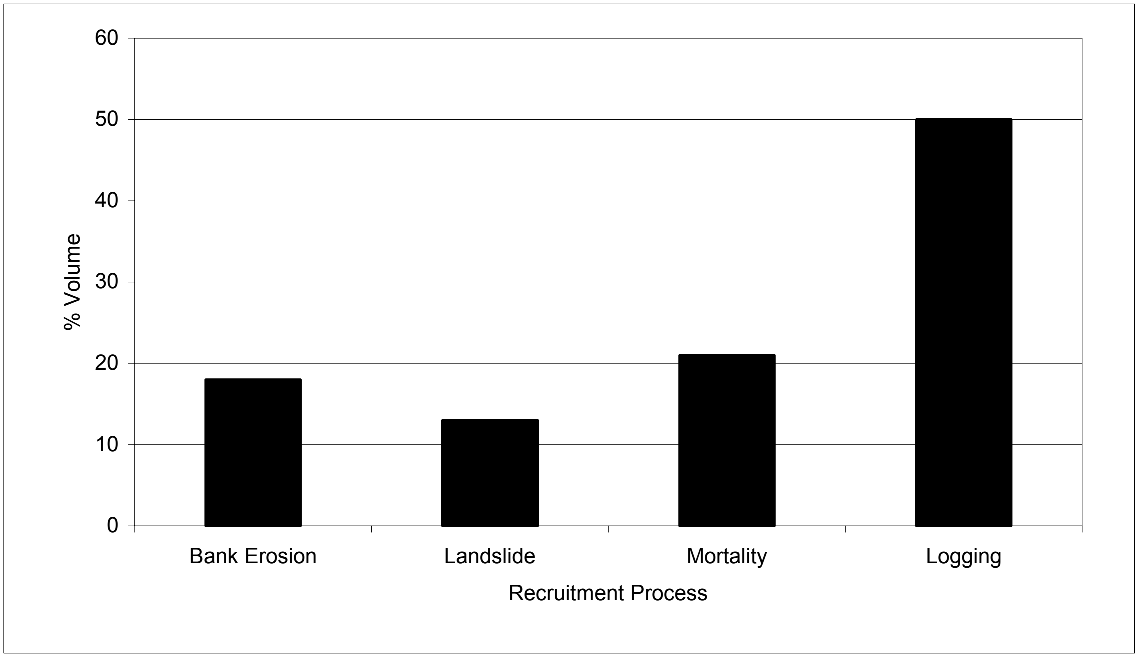
4.2.2 Stream Channel

The Stream Channel Assessment focused on addressing environmental conditions found in the Van Duzen WAU in the context of: questions posed by federal and state agencies participating in the Signatory Review Team (SRT), the public, and by other watershed analysts; availability of field data; limitations in scientific understanding; and critical questions. The analysis was further constrained by the necessity to produce information relevant to the development of management prescriptions. Because the majority of the Van Duzen watershed lies above the Van Duzen WAU, the geomorphic condition of the mainstem reflects both natural and anthropogenic conditions that lie outside of the analysis area. Hence, the analysis, for the most part, was limited to the tributaries to the mainstem Van Duzen River within the WAU. Key findings from the Stream Channel Assessment are summarized in the following discussion, as categorized by large woody debris (LWD) and overall channel response to sediment.

Large Woody Debris

Large woody debris (LWD) was evaluated through site surveys in stream channels as well as in riparian zones. Stream channel results are discussed in this section, and riparian results are discussed in Section 4.2.3. Storage of LWD was found to be highly variable throughout the stream network. However, recruitment volumes in the Van Duzen WAU were greater than for old-growth and second-growth forests. Wood volumes in second-growth sites were, in general, greater than the wood storage reported for old-growth sites in Redwood National Park (Del Norte and Humboldt Counties). Sixteen of 21 sites evaluated in the WAU met properly functioning condition (PFC) targets for LWD. Recruitment at the survey sites included logging, mortality, bank erosion, and landsliding processes (Figure 4-6). A significant portion of LWD results from past logging practices. In terms of LWD source distance related to recruitment process, the following observations were made from the data: (1) bank erosion recruitment (lower gradient streams) yields 90% of wood from within 10 meters from the channel; and (2) streamside landslide recruitment (steeper gradient streams) yields 90% of wood from within 30 meters from the channel.

Figure 4-6. Large Woody Debris Recruitment for All Van Duzen Study Sites



Overall Channel Response to Sediment

High-magnitude events have resulted in sediment supply fluctuations from tributaries that create cut-and-fill terraces. This has caused isolation of the channel from the floodplain and has created fish access barriers during dry periods. A general trend in increasing terrace height can be expected with increasing drainage area or stream size. Terraces form in lower gradient channels that also are more susceptible to aggradation. Not only has terrace development occurred in tributaries to the Van Duzen mainstem, but also deposition from upstream sediment supply (upstream of the WAU) has created terraces in the mainstem.

4.2.3 Riparian Condition

In general, riparian function encompasses a wide variety of processes that both determine the character of the riparian zone and exert influence on the adjacent aquatic and terrestrial environment. In the context of the assessment for the Van Duzen WAU, riparian function is defined more narrowly, with a focus on 3 specific processes: (1) LWD recruitment potential to aquatic systems; (2) canopy closure within the riparian forest; and (3) riparian forest canopy cover over the stream. Key findings for these 3 processes are discussed below. In general, riparian stands on PALCO lands are providing adequate riparian function for 2 of these 3 processes: shade to the forest floor and shade to the stream channel.

Large Woody Debris

The Riparian Function Assessment found that stand composition and LWD recruitment potential are similar across all sub-basins throughout the Van Duzen WAU. Low LWD recruitment potential occurs where young, small diameter trees are abundant. Two-thirds of PALCO lands in the Van Duzen WAU have been harvested since 1954, so most stands are less than 50 years old and exhibit low LWD recruitment potential. Small stands are generally trending toward higher recruitment potential, however, only large stands currently meet the properly punctioning condition (PFC) target for LWD recruitment potential.

Half of the riparian stands are conifer-dominated and represent the best opportunity for both recruitment of LWD to the stream channel and harvest within riparian stands. Of these stands, 62% are small, averaging less than 12 inches diameter; 34% are medium, averaging 12 to 24 inches diameter; and 3% are large, averaging greater than 24 inches diameter. Thirty percent of the small stands have a significant component of 18 to 24 inch conifers.

Riparian Forest Canopy Closure

Riparian forest canopy closure refers to shade within riparian forests. From field data collected in the Riparian Function Assessment, the majority of riparian stands met PFC targets for canopy closure on PALCO land. However, there are portions of the WAU with natural hardwood/conifer riparian forests that will never meet PFCs that are designed for redwood-dominated stands.

Stream Canopy Cover

Riparian stream canopy cover is estimated to be greater than 85% in most of the WAU. However, canopy cover limitations exist in portions of the WAU with larger natural channel widths. The entire Van Duzen mainstem, has less than 20% canopy cover due to its naturally wide channel. The Grizzly Creek mainstem (on PALCO land) has less than 85% canopy cover due primarily to past harvest and secondarily to a naturally wide channel.

Stream temperature is affected by stream canopy cover. In Grizzly Creek, exceedances of PFC limits of 18° C occurred in 1996 and 1997 and exceedance of PFC limits nearly occurred in 2000. Temperature problems on Grizzly Creek may be related to sparse vegetation types upstream, off of PALCO lands, as well as the inadequate canopy cover on PALCO lands.

4.3 BIOLOGICAL RESOURCES

Biological resources for the Van Duzen WAU were evaluated as part of the Fisheries Habitat Assessment and the Amphibian and Reptile Habitat Assessment and are summarized in Sections 4.3.1 and 4.3.2, respectively.

4.3.1 Fisheries Habitat

The overall goal of the Fish Habitat Assessment was to develop an understanding of the natural and anthropogenic factors that limit the distribution and relative abundance of salmonid species in the Van Duzen WAU, with specific emphasis on developing conservation measures to better achieve PFCs in aquatic habitat on and downstream of lands owned by PALCO. Field studies were conducted on PALCO lands, whereas, only readily available existing information for non-PALCO ownership was reviewed. Key findings on limiting factors, as determined from the Fish Habitat Assessment, are summarized in the following discussion. Notably, the Van Duzen WAU contains the southernmost cutthroat population in Fox Creek (although Fox Creek also has a highway culvert barrier). Also, lower Grizzly Creek provides regionally and locally important spawning for chinook salmon.

The primary limiting factor on fish production is the condition of tributary streams on mainstem floodplain terraces. Historically these areas have been the most productive, especially for coho salmon, because of low channel gradients. The Stream Channel Assessment identifies these areas as prone to aggradation, with sediment sources primarily from soil creep (bank erosion). Aggradation can result in pool filling, increased stream temperatures, increased width:depth ratios, and migration barriers during low flows.

4.3.2 Amphibian and Reptile Habitat

The Amphibian and Reptile Assessment was designed to characterize habitat condition and define the potential distribution limits for the 4 amphibian and one reptile species of concern that could occur in the Van Duzen WAU: foothill yellow-legged frog, northern red-legged frog, tailed frog, southern torrent salamander, and northwestern pond turtle. No distinguishing values were determined for the WAU that would render it unique for the amphibians and reptiles of concern, or naturally limit distribution of the species. For example, data gathered during surveys performed for the Van Duzen WAU support no pattern in species occurrence between Channel Geomorphic Units (CGUs) nor geologic units, other than what is explained by each species' potential distribution limits. Potential habitat for all 5 species, therefore, was assumed to exist throughout most of the Class I and Class II streams within the watershed.

The primary limiting factors on amphibian and reptile habitat quality in the Van Duzen WAU are high percent fine sediments and high embeddedness. These factors could impact tailed frogs in Class I streams and tailed frogs and southern torrent salamanders in Class II streams with very steep and extreme gradients (steeper that 6.5%). In addition, PALCO's Aquatic Conservation Plan 2000 Annual Report for stream monitoring stations bioassessment metrics (e.g., taxa richness, EPA taxa richness, Russian River Index of Biological Integrity) ranged from excellent to good for the Van Duzen monitoring sites. These scores suggest that increases in peak flow and scour have not had a significant impact on the benthic macroinvertebrate community. Using these bioassessment results as an indicator should reduce concerns for impacts to amphibians during sensitive stages of their life-cycles (due to increases in peak flows and fines).

5.0 SUB-BASIN KEY FINDINGS

The approach taken for any given Cumulative Watershed Effects (CWE) assessment should be determined by the objectives of the analysis, the characteristics of the watershed being analyzed, and the nature and quantity of information available to the analyst. As a result, several approaches were integrated for this Cumulative Watershed Effects assessment for the Van Duzen Watershed Analysis Unit (WAU). This CWE assessment is the product of our understanding of landscape-level processes in the Van Duzen WAU and establishes a foundation and framework for future analysis of cumulative watershed effects. A qualitative assessment is possible under this framework (i.e., CGU-based descriptors). However, a more rigorous assessment that evaluates combined effects of stressors on receptors requires additional data collection, which can be accomplished during the intervening watershed analysis period.

The scale of our data does not permit delineation of site-specific effects. However, our understanding of landscape-level processes, combined with site-specific data, provides a workable context for evaluating CWE. The CWE for the Van Duzen WAU is intended be a concise description of landscape processes across the WAU, with additional information provided where available for each sub-basin. For example, the characterization of channel processes at a landscape level is derived from a limited number of sample reaches, whereas, our understanding of landslide processes is based on a complete inventory of landslides across the WAU which can also be subdivided by sub-basin.

This section organizes information from the technical assessments to describe estimated sources of sediment, riparian, and channel response, and resource vulnerabilities within each sub-basin. This approach is based on a rigorously qualitative assessment of the relationship between the key stressor (sediment), and its linkage by structural component and process (riparian and channel response) to key endpoints (biological resources: fisheries, amphibians, and reptiles). This approach was selected because it allows integration of multiple lines of qualitative and quantitative evidence at varying levels of certainty. There were not sufficient quantitative data available to characterize every process and at every location in the watershed. This CWE delineates landscape-level processes, as influenced by site-specific conditions, which have the greatest potential to affect aquatic and amphibian biological resources in the Van Duzen WAU.

5.1 SEDIMENT SOURCES

The sediment budget for the Van Duzen WAU is summarized in Table 5-1. Characteristics of each sub-basin are listed in Table 5-2 and discussed below, along with sediment budget results. The potential for generation of fines is presented in relative terms, with gravelly loam rated low, loam rated moderate, and clay loam rated high. As noted previously, the Van Duzen mainstem is excluded from this input-only sediment budget, as is also the case for the Stream Channel Assessment.

Table 5-1. Percentage of Sediment Source Contributions

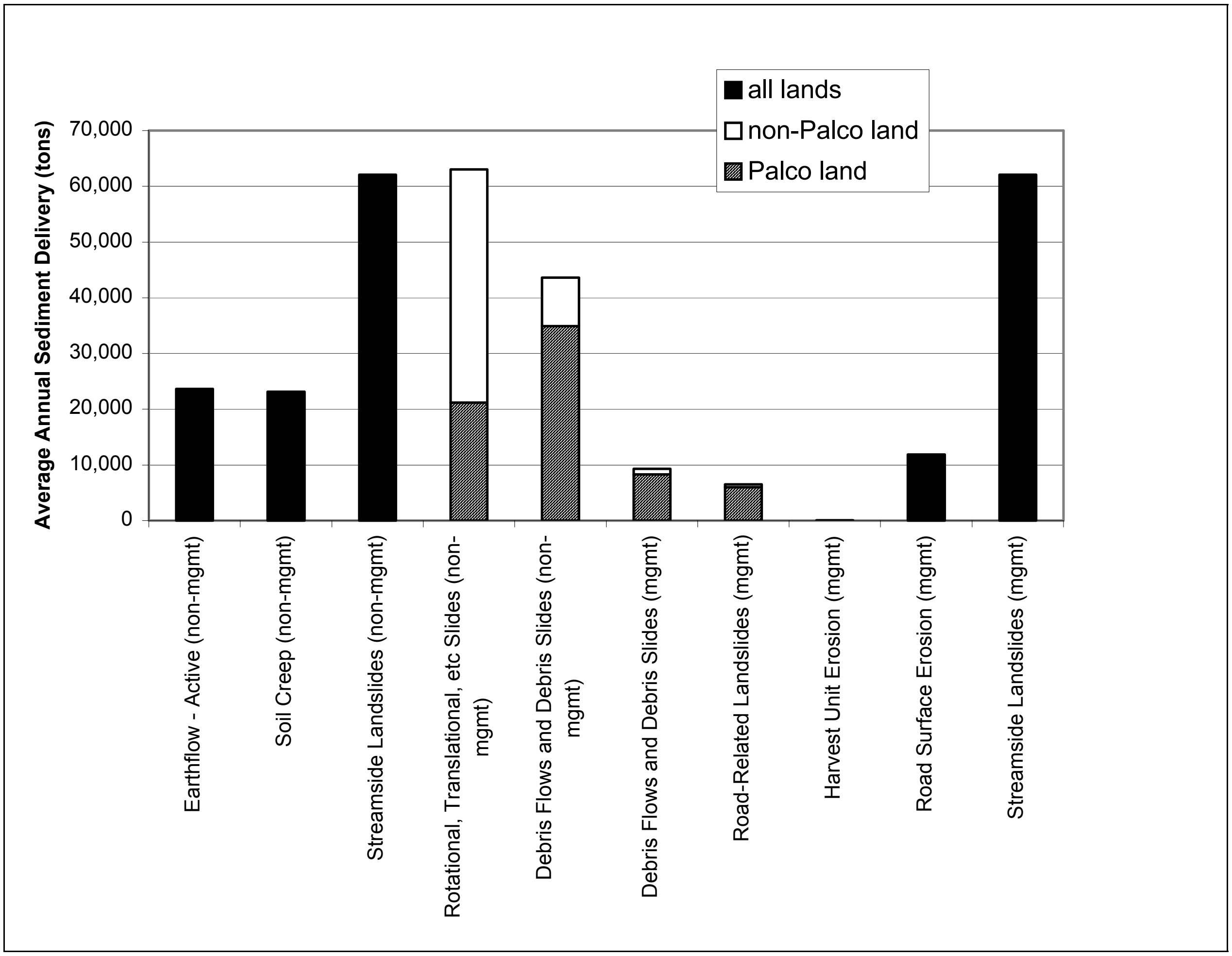
Sediment Source		Entire Study Area	Cum-mings Creek	Grizzly Creek	Hely Creek	Hydes-ville Creek	Root Creek	Stevens Creek	Swains Flat
NON MANAGEMENT-RELATED									
Earthflow - Active	percent	8	10	7	8	11	8	12	4
Soil Creep	percent	8	10	7	8	11	7	12	4
Streamside Landslides	percent	20	27	18	22	29	20	33	10
Rotational, Translational, etc Landslides	percent	21	5	40	0	11	3	0	64
Debris Flows and Debris Slides	percent	14	9	4	25	0.3	28	4	7
MANGEMENT-RELATED									
Debris Flows and Debris Slides [DFDS]	percent	3	6	1	6	7	4	2	0.2
Road-Related Landslides [RRLS]	percent	2	0.6	4	6	0	2	0.3	0.1
Harvest Unit Erosion [HARV]	percent	0.01	0.02	0.002	0.01	0	0.02	0.04	0.01
Road Surface Erosion [ROAD]	percent	4	4	2	3	1.9	7.2	3.5	1.8
Streamside Landslides [SSLS]	percent	20	27	18	22	29	20	33	10
TOTAL NON MANAGEMENT-RELATED	**percent**	**71**	**62**	**75**	**64**	**62**	**66**	**62**	**88**
MGMT-RELATED: PALCO [DFDS, RRLS, HARV	**percent**	**5**	**6**	**4**	**11**	**0**	**6**	**0.4**	**0.2**
MGMT-RELATED: non-PALCO [DFDS, RRLS]	**percent**	**0.5**	**0.1**	**1.2**	**0**	**7.5**	**0**	**1.7**	**0.1**
MGMT-RELATED: PALCO + non-PALCO [ROAD, SSLS]	**percent**	**24**	**31**	**20**	**25**	**31**	**27**	**36**	**12**
TOTAL-->	**Percent**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Table 5-2. Sub-basin Characterization Summary

	Cummings Creek	Grizzly Creek	Hely Creek	Hydesville Creek	Root Creek	Stevens Creek	Swains Flat
Major drainages	Cummings, Fiedler, and Cuddeback Cr.	Grizzly Creek	Hely, Fox, and Flanigan Creeks	None	Root and Blue Slide Creeks	Stevens (drains into Grizzly)	Fish, Rogers, and Pip Creeks
Ownership	63% PL	23% PL	92% PL	7% PL	92% PL	29% PL	16% PL
Land use	Timber, residential, cropland/ grazing (valley floor)	Timber (lower areas), grazing (mid, upper areas)	Timber, residential, commercial (stores)	Timber, some cropland	Timber	Timber, grazing (upper areas)	Timber, grazing, residential
Geology - from lowest to highest elevations	North side VDR: Terrace, Carlotta, Wildcat, Yager South side VDR: Carlotta	Yager, Franciscan mélange, Franciscan sandstone	Hely: Wildcat, Yager Fox, Flanigan: Terrace, Carlotta South side VDR: Carlotta, Scotia Bluffs sandstone	Terrace, Carlotta	Root: Terrace, Wildcat Blue Slide: Wildcat Southwest side VDR: Terrace, Wildcat, Yager	Yager, Wildcat, Yager	North side VDR: Terrace, Yager, Franciscan mélange South side VDR: Terrace, Yager
Soils - from lowest to highest elevations	North side VDR: Bottom land/ Farmland, Larabee gravel, Hugo/ Melborne South side VDR: Larabee/ Larabee gravel	Hugo, Larabee, Melborne/ McMahon/ Kneeland, Yorkville	Hely: Larabee/ Larabee gravel, Hely Fox, Flanigan: Bottom land, Larabee gravel	Farmland, Larabee gravel, Larabee	Root: Bottom land, Larabee, Hugo Blue Slide: Hely, Larabee Northeast side VDR: Larabee, Hugo	Hugo, Larabee, Hugo, Yorkville, Laughlin	North side VDR: Terraces, Hugo, Yorkville, Melborne/ McMahon/ Kneeland South side VDR: Terraces, Hugo
Soil Textures – from lowest to highest elevations	North side VDR: Loam, Gravelly loam, Gravelly loam/ Loam South side VDR: Loam/Gravelly loam	Gravelly loam, Loam, Loam/ Clay loam/ Clay loam, Clay loam	Hely: Loam/ Gravelly loam, Loam Fox, Flanigan: Loam, Gravelly loam	Loam, Gravelly loam, Loam	Root: Loam, Loam, Gravelly loam Blue Slide: Loam, Loam Northeast side VDR: Loam, Gravelly loam	Gravelly loam, Loam, Gravelly loam, Clay loam, Loam	North side VDR: Loam, Gravelly loam, Clay loam, Loam/ Clay loam/ Clay loam South side VDR: Loam, Gravelly loam
Silt/Clay Generation (L=low, M=mod., H=high) - lowest to highest elevations	North side VDR: M, L, L/M South side VDR: M/L	L, M, M/H/H, H	Hely: M/L, M Fox, Flanigan: M, L	M, L, M	Root: M, M, L Blue Slide: M, M Northeast side VDR: M, L	L, M, L, H, M	North side VDR: M, L, H, M/H/H South side VDR: M, L
Other		Monitoring station upstream of confluence with Stevens Creek.	Majority of harvest pre-1974. Monitoring station on Hely.		Upper watershed harvested in 1982-1994. Palco monitoring station.	Post-1954 harvest from 1988-1997.	Goat Rock earthflow. Bridgeville gaging station.

Figure 5-1 presents sediment delivery estimates for each type of sediment source, with the various splits between PALCO and non-PALCO lands as well as non-management- and management-related. For the entire study area, the dominant sediment sources are non-management-related rock topple, rotational, translational, and complex slides (21%), and management- and non-management-related streamside landslides (20% each). The estimate for streamside landslides should be viewed cautiously due to uncertainty regarding the role of management in this process. Other important sediment sources include non-management-related debris flows and debris slides (14%); earthflow (8%); and soil creep (8%). Combined, non-management-related landslides account for approximately 71% of the sediment source input in the Van Duzen study area. Management-related sediment sources account for approximately 29% of all sediment delivery throughout the study area, including 5% attributed to debris flows and debris slides, road-related landslides, and harvest surface erosion on PALCO lands, and 24% attributed to road surface erosion and streamside landslides on all lands (PALCO and non-PALCO combined).

Figure 5-1. Sediment Delivery to Streams for the Van Duzen WAU



5.2 RIPARIAN FUNCTION AND FOG EFFECT

The Forest Science Project (FSP) report (Lewis et al. 2000) included a Zone of Coastal Influence (ZCI) map that delineated the areas along the North Coast that were affected by coastal fog. This map was based on a climate analysis system known as PRISM (Parameter-elevation, Regressions on Independent Slopes Model). According to Dave Lamphear of the FSP, the data that this analysis was based on has been significantly revised since the original mapping effort; the earlier maps and data are considered to be out of date and inaccurate. FSP has not been able to reproduce a useable ZCI map from the new data, thus there is no ZCI map available that relies on air temperatures (Dave Lamphear pers. comm.). Therefore a useable surrogate is distribution of vegetation types. The forests of the Van Duzen watershed have naturally regenerated over the course of this past century and therefore represent a relatively recent reflection of the climate that influenced the establishment of the current vegetation distribution. Pure redwood stands correspond closely with heavily fog influenced areas. Areas of mixed redwood and conifers represent less fog influence and grassland and oak vegetation types represent areas without fog influence.

In the following analyses riparian stands dominated by large conifers are assumed to meet PFC target values for LWD recruitment potential. However, no field-level stand data from this watershed was available to make this comparison. The analysis presented in the Riparian Function Assessment indicates that only the largest old growth riparian stands of redwood such as those found along Bull Creek Flats were able to meet PFC targets.

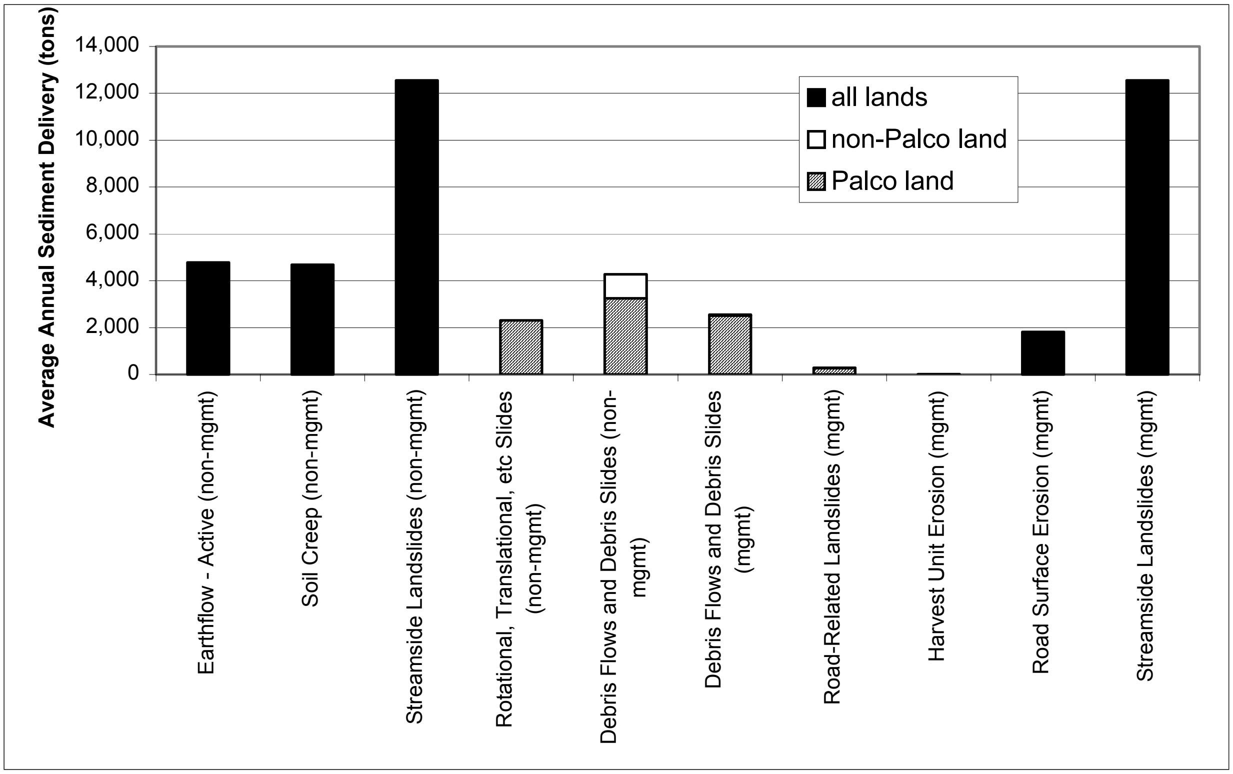
5.3 CUMMINGS CREEK

5.3.1 Estimated Sediment Inputs

The Cummings Creek sub-basin includes the following major drainages: Cummings Creek, Fiedler Creek, and Cuddeback Creek. Approximately 63% of the sub-basin is owned by PALCO. North, from the Van Duzen mainstem to higher elevations, the geology ranges from terrace deposits to Carlotta to Wildcat to Yager. Soil textures are typically loams, with greater proportions of gravelly loam soils with distance upstream from the mainstem. Therefore, the relative generation of fines ranges from moderate to low with distance upstream. The geology on the south side of the mainstem is predominantly Carlotta. Soils are typically loam/gravelly loam which, therefore, yield moderate to low generation of fines.

The dominant sediment source for the Cummings Creek sub-basin is management- and non-management-related streamside landslides, each type accounting for 27% of sediment delivery to streams (Figure 5-2). Other important sediment sources (and percent of total for sub-basin) include earthflow (10%), soil creep (10%), and non-management-related debris flows and debris slides (9%). Management-related sediment sources, aside from streamside landslides, account for approximately 11% of all sediment delivery throughout the sub-basin, with most of this attributed to management on PALCO lands.

Figure 5-2. Cummings Creek Sub-Basin Sediment Source Delivery to Streams



5.3.2 Analysis of Potential Channel Response

A large portion of Cummings Creek is located in the Low Gradient Wildcat and Floodplain tributary Channel Geomorphic Units (CGUs). Field evidence of aggradation (i.e., cut and fill terraces) indicates that these low gradient channels (less than 2%) are sensitive to inputs of coarse sediment from landslide source areas. Channel anastomosing is also likely during large floods and periods of high sediment supply. The gravel beds of the lower half of Cummings Creek will be highly responsive to large woody debris; in general, larger wood pieces will result in larger and deeper the pools. Increased sediment supply can more easily fill in pools associated with smaller wood; larger pools associated with larger logs will be more difficult to impact from heightened sediment supply.

Of all the basins surveyed (including old-growth sites), LWD recruitment rates were highest in the Cummings Creek sub-basin, averaging 14.5 cubic meters per year per kilometer (cu m/yr/km). Bank erosion was the dominant LWD recruitment process in lower gradient (1 to 3%) high order reaches, while landslides recruited the majority of wood in steeper (10 to 26%) low order streams. Of the Cummings Creek reaches surveyed, Site 6, a reach where Cummings Creek flows along the terrace and floodplain of the Van Duzen mainstem (termed Floodplain Tributary CGU), appears to have low LWD recruitment (1.7

cu m/yr/km) of trees with small diameter (0.27 meter average). One likely source of the low recruitment is from active clearing of LWD from the stream to mitigate local flooding. Based on a comparison with old-growth reaches, the other 4 reaches surveyed in Cummings Creek sub-basin appear to be recruiting sufficient LWD to the channel. However, the average diameter of the recruits is smaller in Cummings Creek sub-basin (0.5 meter average) than old-growth sites (0.9 meter average). This likely reduces the residence time and function of LWD in comparison to old-growth sites.

Riparian Response

Generally, canopy closure and canopy cover levels met PFC targets for this watershed. However rural housing development along the creek in the lower reaches resulted in a small percentage (less than 5%) of the watershed not being able to meet PFC targets for canopy cover. A similarly small percentage of riparian areas on PALCO lands did not meet PFC targets for canopy cover due to: 1) complete removal of riparian forest within the past 5 years during timber harvest or, 2) narrow buffer widths. The stream sections that did not meet canopy cover targets due to removal of riparian canopy during harvest on PALCO lands were: CUMM-052, CUMM-028, CUMM-033, CUMM-036, and VANB-010. The stream sections that did not meet canopy cover due to narrow buffer widths on PALCO lands were CUMM-051 and FISH-003.

Canopy closure levels exceeded 85% and met PFC targets on 81% of riparian areas in the Cummings Creek sub-basin. Fourteen percent of stands had less than 85% canopy closure and 6% of stands were classified as open.

PALCO owns 63% of the riparian areas reviewed in the Cummings Creek sub-basin. On PALCO lands, 12% of riparian stands had high LWD recruitment potential, 33% were medium, and 54% were low. There were no large size class, conifer-dominated riparian stands in the Cummings Creek sub-basin. Therefore none of the riparian stands in Cummings Creek met the PFC target for LWD recruitment potential.

5.3.3 Potential Resource Vulnerabilities

Fisheries

Cummings Creek contains runs of steelhead trout, and chinook and coho salmon which use approximately the lower 3 to 4 miles of stream for spawning and rearing. Habitat in the lower reach reflects the low gradient floodplain terrace geomorphology. Pools and side channels can be abundant but are strongly affected by sediment supply and anthropogenic stream channel management. Upstream passage of chinook can be delayed as streamflows remain subsurface in the highly permeable aggradations of coarse sediment in the late summer and fall. Habitat upstream in the low gradient canyon reaches contains a fair quantity of pools though they are typically shallow. Abundant patches of spawning sized gravels were noted and the percentage of fine material was low.

Spawning, rearing and migration habitat in the low gradient floodplain reach is especially vulnerable to changes in sediment supply and decreased LWD input. Increasing sediment supply fills pools, interferes with upstream migration, and results in channel avulsions. Decreased LWD inhibits pool formation, decreases the quality of rearing habitat, and prevents formation of point bars and other gravel features associated with large pieces of in-channel wood. Cummings Creek may provide valuable summer refugia for coho salmon as water temperatures have remained within the range deemed suitable for coho rearing.

Amphibians and Reptiles

The Cummings Creek sub-basin contains potential habitat for all 4 amphibian and one reptile species of concern: northwestern pond turtle, foothill yellow-legged frog, northern red-legged frog, tailed frog, and southern torrent salamander. Potential habitat for the northwestern pond turtle exists within the lower to middle reaches of Cummings Creek and Cuddeback Creek. Potential habitat for the tailed frog and the southern torrent salamander is found in Fiedler Creek and the upper reaches of Class I (tailed frog only) and II tributaries of Cummings Creek and Cuddeback Creek. The foothill yellow-legged frog and northern red-legged frog are expected to occur within all Class I and Class II stream reaches in the sub-basin. Tailed frog larvae were observed in the upper reaches of a Class I tributary of Cummings Creek during 2000 surveys; the northern red-legged frog was observed in a Class II tributary of Cummings Creek.

Water temperatures, canopy closure, and LWD currently meet PFCs in most areas within this sub-basin. Therefore, the northwestern pond turtle, foothill yellow-legged frog, and northern red-legged frog are anticipated to have an overall low vulnerability within this sub-basin.

Habitat for the tailed frog and southern torrent salamander, however, is especially vulnerable to inputs of fines in Fiedler Creek and in the Class II tributaries and upper reaches of Cummings Creek and Cuddeback Creek. It should be noted that Cuddeback Creek and much of Fielder Creek are not owned and managed by PALCO. Most areas surveyed within the upper reaches of Cummings Creek and the Class II tributaries of Cummings Creek do not currently meet PFCs for percent fines and embeddedness. The southern torrent salamander breeds in the splash zone of cold mountain streams, springs, seeps, and waterfalls, and burrows beneath the creek bed during the dry season. High percent gravel and low embeddedness are important for survival and reproduction of this species. Cobble and boulder substrates with low embeddedness have also been determined to be important for larvae of the tailed frog.

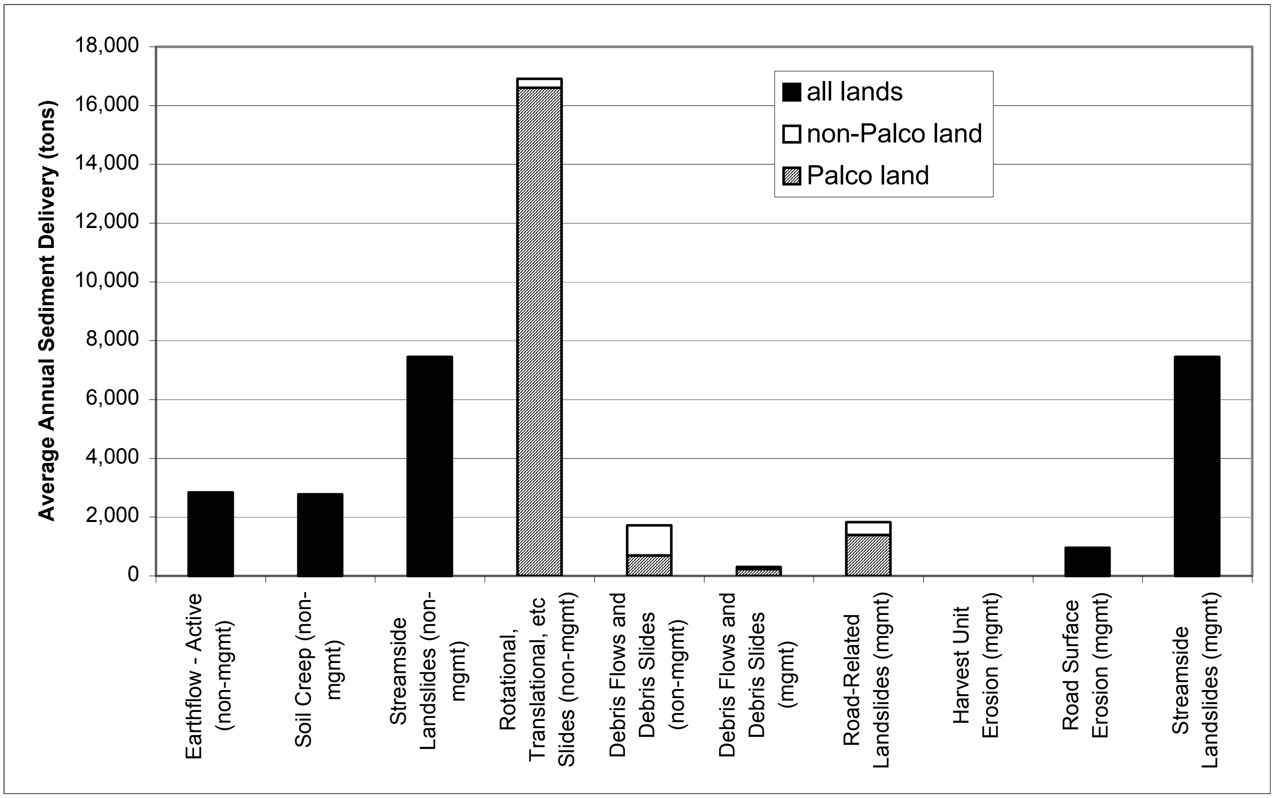
5.4 GRIZZLY CREEK

5.4.1 Estimated Sediment Inputs

The Grizzly Creek sub-basin includes the entire drainage for Grizzly Creek. Approximately 23% of the sub-basin is owned by PALCO. The lower part of the sub-basin includes the Yager formation, and is managed for timber. Much of the middle and upper drainage areas have Franciscan mélange and Franciscan sandstone. Grazing is the main land use in these areas. Soil textures in the lower sub-basin are gravelly loams and loams. In the middle and upper parts of the sub-basin, clay loams dominate. Therefore, the relative generation of fines increases from low to moderate, in the lower sub-basin, to high in the middle and upper parts of the Grizzly Creek sub-basin.

The dominant sediment source type for the Grizzly Creek sub-basin is rock topple, rotational, translational, and complex slides, accounting for 40% of sediment delivery to streams (Figure 5-3). Management- and non-management-related streamside landslides also are important sources, each at 18% of the total. Other important sediment sources include soil creep (7%) and earthflow (7%). Contrary to observations for Cummings Creek and other sub-basins (except for Swains Flat), rock topple, rotational, translational, and complex slides account for a larger portion of sediment input in Grizzly Creek than non-management-related debris flows and debris slides (which account for only 4% of total sediment source delivery). This difference observed in the calculations for Grizzly Creek and Swains Flat (compared with the other sub-basins) is expected due to the predominance of Franciscan geology, which is prone to deeper slides. The Grizzly Creek and Swains Flat sub-basins have the largest proportion of delivery from non-management-related sediment sources among all sub-basins of the study area. Management-related sediment sources, aside from streamside landslides, account for approximately 7% of all sediment delivery throughout the sub-basin, which includes 6% attributed to management on PALCO lands. However, this 6% estimate may be high because estimated road surface erosion for all roads (PALCO and non-PALCO) was not separated by ownership in the SEDMODL analysis and, therefore, was included with results for PALCO lands.

Figure 5-3. Grizzly Creek Sub-Basin Sediment Source Delivery to Streams



5.4.2 Analysis of Potential Channel Response

The Grizzly Creek sub-basin is predominately underlain by competent interbedded sandstone and shale of the Yager terrane. Portions of the upper basin are underlain by Franciscan belt material, but these areas are outside of PALCO ownership. Due to a more competent bedrock material, streams in Yager terrane (includes Swains Flat and Stevens Creeks) generally have a higher component of cobble and boulders than Wildcat streams. Consequently, boulders are often the pool forming element in Yager streams, while LWD is the dominant pool former in Wildcat streams (see Appendix B in Stream Channel Assessment). Three confined low gradient (1 to 4%) reaches were surveyed in Grizzly and Stevens Creeks and one high gradient (41%) cascade reach was surveyed in the Swains Flat sub-basin.

The majority of Grizzly Creek upstream of the confluence of Stevens Creek is comprised of moderate gradient channels. Consequently, the substrate of Grizzly Creekis dominated by cobbles and boulders. Field surveys indicated little gravel and pebbles in storage along the channel bed, however, gravel bars do occur occasionally behind log jams and at the outside of meander bends. In these locations, deposits can include sand. Because of the apparent high energy of Grizzly Creek, the portion of the channel in the 3 to

8% gradient range should not be sensitive to increases in coarse sediment from mass wasting (sensitivity is based on a channel's ability to aggrade or degrade). Because of the dominance of coarse substrate in most of Grizzly Creek, fallen trees and logs should have minimal influence in forming pools and storing sediment.

LWD recruitment rates on all 4 reaches (3.4 to 6.5 cu m/yr/km) were less than old-growth sites (average 9.0 cu m/yr/km). Bank erosion was the dominant LWD recruitment process in the lower gradient (1to 3%) reaches of Grizzly Creek, while conifer mortality recruited wood in a steeper (4%) reach. Wood recruitment within the low gradient reaches of Grizzly Creek was predominantly deciduous (94 to 98% by volume).

Riparian Response

Canopy cover levels are below 85% for the entire mainstem reach of Grizzly Creek on PALCO property and for a distance of 1.2 miles above PALCO property (stream segments Griz 001 – 010). Stream temperature measurements indicated that Grizzly Creek had the highest MWAT values of all monitored sub-basins in the study area and exceeded the PFC temperature threshold for fisheries in 1997 and 2000. The mainstem of Grizzly Creek was harvested to the waters edge in the past 45 years on PALCO lands, and currently has relatively young stands in the riparian areas. It is likely that old-growth trees along the mainstem prior to logging provided adequate shade to the stream that the current young-growth cannot. The difference between Grizzly Creek and other sub-basins with young growth along the mainstem is that Grizzly has a wider channel that is more confined by the valley walls. At high flows the larger channel and confining valley walls results in bank scour which retards succession on the stream banks and development of mid channel bars. There is also a road along the north side of Grizzly Creek on PALCO property that prevents forest establishment in certain sections where the road is close to the creek in the inner gorge.

Canopy closure levels exceeded 85% and met PFC targets on 81% of riparian areas in the Grizzly Creek sub-basin. Seventeen percent of stands had less than 85% canopy closure and 3% of stands were classified as open.

PALCO owns 36% of the riparian areas reviewed in the Grizzly Creek sub-basin. On PALCO lands 20% of riparian stands had high LWD recruitment potential, 29% were medium and 51% were low. Large size class, conifer dominated riparian stands represented 6% of riparian stands in the Grizzly Creek sub-basin. Therefore, 6% of riparian stands in Grizzly Creek met the PFC target for LWD recruitment potential.

5.4.3 Potential Resource Vulnerabilities

Fisheries

Grizzly Creek contains runs of steelhead trout, and chinook and coho salmon which use approximately the lower 2 miles of stream for spawning and rearing. Grizzly Creek contains regionally important spawning habitat for chinook salmon. The lowest gradient floodplain reach is characterized by a low quantity and quality of pool habitat. The pools are relatively shallow and have only fair cover. Spawning habitat is available in moderate quantities but is degraded by the presence of fine sediment. Upstream in the low gradient canyon reach, pool habitat frequency improves but the pools are still relatively shallow. Spawning habitat is very abundant and the percentage of fine material relatively low. Pool habitat in the moderate gradient canyon reach is fair but the pools remain shallow. Increasing LWD creates good habitat cover over the pools. Spawning habitat availability is fair as is the quality of the material. Summer rearing habitat is negatively affected by high water temperatures.

Spawning and rearing habitat in the low gradient floodplain reach of Grizzly Creek (downstream of the confluence of Stevens Creek) is especially vulnerable to changes in sediment supply and decreased LWD input. Increasing sediment supply fills pools and degrades spawning habitat quality with fine material. Decreased LWD inhibits pool formation, decreases the quality of rearing habitat, and prevents formation of spawning gravel accumulations associated with large pieces of in-channel wood. The moderate gradient reaches upstream of the Stevens Creek confluence are less sensitive to LWD and sediment input. The larger sediments providing chinook habitat are generally more stable and less influenced by fine sediment aggradation and LWD frequency.

Amphibians and Reptiles

The Grizzly Creek sub-basin contains potential habitat for all 4 amphibian and one reptile species of concern: northwestern pond turtle, foothill yellow-legged frog, northern red-legged frog, tailed frog, and southern torrent salamander. Potential habitat for the northwestern pond turtle exists within approximately the lower 2 miles of Grizzly Creek. Potential habitat for the tailed frog and the southern torrent salamander exists within the Class I (tailed frog only) and Class II tributaries of Grizzly Creek. The foothill yellow-legged frog and northern red-legged frog are expected to occur within all Class I and Class II stream reaches in the sub-basin. The foothill yellow-legged frog was observed within stream reaches with extreme (greater than 20%) and very steep (6.5 to 20%) gradients within the sub-basin. One southern torrent salamander was observed in a Class II tributary of the Van Duzen River near Grizzly Creek.

Canopy closure, LWD, and percent fines currently meet PFCs with either a good to fair ranking in areas surveyed within this sub-basin. Water temperatures also meet PFCs for the amphibian and reptile species of concern. Therefore, the northwestern pond turtle, foothill yellow-legged frog, and northern red-legged frog are anticipated to have an overall low vulnerability within this sub-basin.

Habitat for the tailed frog and southern torrent salamander, however, is especially vulnerable to increased inputs of fines in the Class I and II tributaries of Grizzly Creek. It should be noted that most of the input of fines is located upstream of PALCO ownership. Most areas surveyed within the tributaries of Grizzly Creek do not currently meet PFCs for embeddedness. The southern torrent salamander breeds in the splash zone of cold mountain streams, springs, seeps, and waterfalls and burrows beneath the creek bed during the dry season. High percent gravel and low embeddedness are important for survival and reproduction of this species. Cobble and boulder substrates with low embeddedness have also been determined to be important for larvae of the tailed frog.

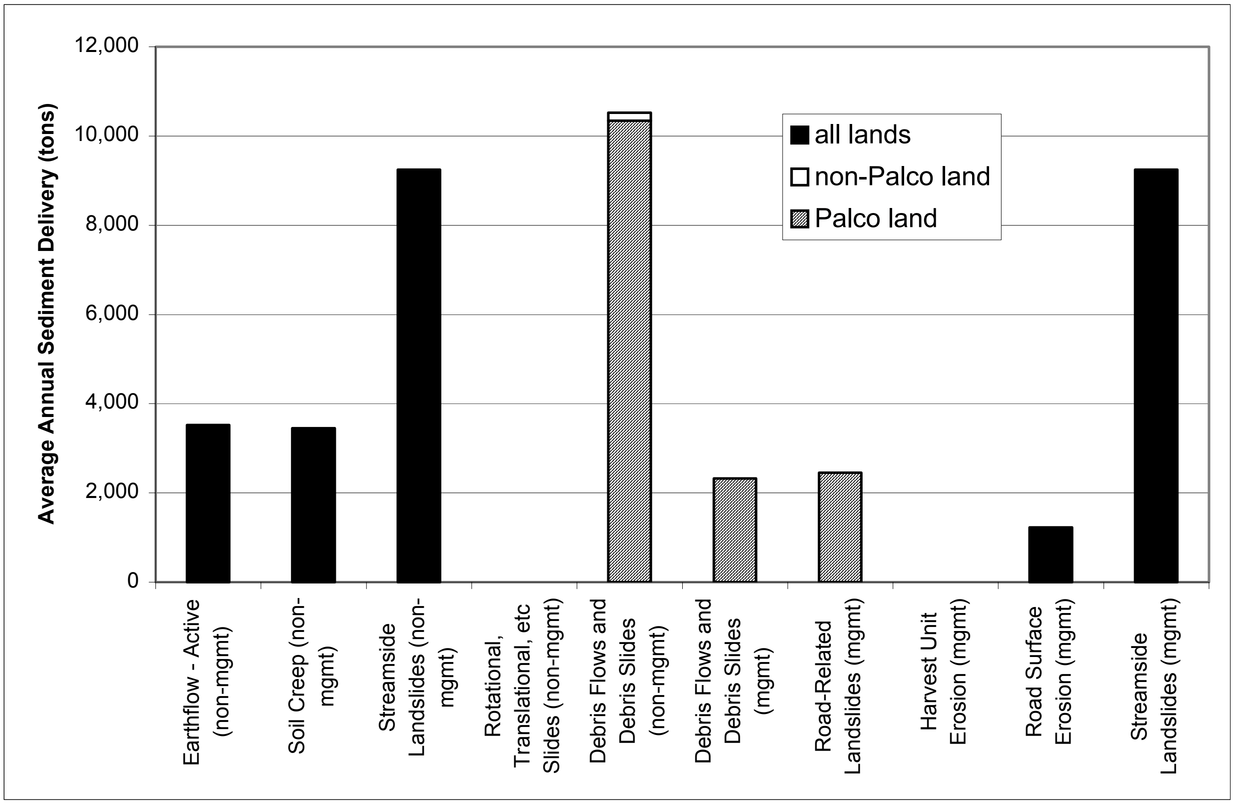
5.5 HELY CREEK

5.5.1 Estimated Sediment Inputs

The Hely Creek sub-basin includes the following major creeks: Hely Creek, Fox Creek, and Flanigan Creek. Each of these drainages are located to the north of the Van Duzen mainstem. Approximately 92% of the sub-basin is owned by PALCO. From the mainstem to higher elevations, the geology for Fox Creek and Flanigan Creek ranges from terrace deposits to Carlotta. Soil textures are loams in lower elevations, with gravelly loam soils increasing with distance upstream from the mainstem. Therefore, the generation of fines ranges from moderate to low with distance upstream. The geology for Hely Creek ranges from Wildcat to Yager, and soil textures range from loam/gravelly loam to loam, from lower to higher elevations in the drainage. Therefore, generation of fines ranges from moderate/low to moderate in this drainage. The geology on the south side of the mainstem ranges from Carlotta to Scotia Bluffs sandstone, and soil textures range from gravelly loam to loam, from lower to higher elevations in the south-side area. Therefore, generation of fines ranges from low to moderate in this area.

The dominant sediment source type for the Hely Creek sub-basin is non-management-related debris flows and debris slides, accounting for 25% of sediment delivery to streams (Figure 5-4). Management- and non-management-related landslides also are an important sediment source, each accounting for 22% of total sediment inputs in this sub-basin. Other important sediment sources include earthflow and soil creep (each 8%). Management-related sediment sources account for approximately 14% of all sediment delivery throughout the sub-basin, which is attributed to management on PALCO lands.

Figure 5-4. Hely Creek Sub-Basin Sediment Source Delivery to Streams



5.5.2 Analysis of Potential Channel Response

Hely Creek basin is also underlain by Wildcat sediments and is similar to the Cummings Creek sub-basin in physical appearance. Only 2 reaches were surveyed on Hely Creek. The lower one-third of Hely Creek is comprised of two CGUs that are sensitive to increases in sediment, namely Lower Gradient Wildcat and Floodplain Tributaries. Consequently, these channel types can aggrade during periods of heightened supply of coarse sediment. Small pools can be filled, small diameter trees can be buried (also decreasing pool space), and channels may braid and meander across the floodplain. In these environments, large logs can create large and deep pools, while smaller diameter logs will create smaller pools. Deposition of fine sediment (sands) is also likely during periods of increased sediment supply. The upper two-thirds of Hely Creek, due to slope (3 to 6%), should be less susceptible to large changes in sediment supply, except at locations where landslides directly deposit sediment and wood into streams.

LWD recruitment rates (average 9.3 cu m/yr/km) were similar to old-growth sites. Deciduous mortality was the dominant LWD recruitment process in the low gradient (1%) unconfined reach, while landslides and mortality both recruited wood in moderate gradient (2.5%) confined reach. Recruits from both reaches had small average diameters (0.3 meter) and were predominantly deciduous (47 to 100% by volume).

Riparian Response

Canopy cover levels met PFC targets for 95% of riparian areas on tributary streams in the Hely Creek sub-basin. The mainstem of the Van Duzen River did not meet PFC targets for canopy cover due the naturally wide channel; this accounted for 28% of the sub-basin area.

Canopy closure levels exceeded 85% and met PFC targets on 78% of riparian areas in the Hely Creek sub-basin. Nineteen percent of stands had less than 85% canopy closure and 3% of stands were classified as open.

PALCO owns 89% of the riparian areas reviewed in the Hely Creek sub-basin. On PALCO lands, 11% of riparian stands had high LWD recruitment potential, 27% were medium, and 62% were low. Large size class, conifer-dominated riparian stands represented 4% of riparian stands in the Hely Creek sub-basin. Therefore, 4% of riparian stands in Hely Creek met the PFC target for LWD recruitment potential. All of the large size class conifer stands in this sub-basin were on the mainstem of the Van Duzen River near Pamplin Grove, not on the tributaries.

5.5.3 Potential Resource Vulnerabilities

Fisheries

Hely Creek contains runs of steelhead trout and chinook salmon. Both Fox and Flanigan Creeks have barriers near their respective mouths which prevent anadromous species from migrating upstream past the lower floodplain area. In Fox Creek, a relict cutthroat trout population survives, possibly due to the absence of competition from anadromous species. The chinook use approximately the lower 0.5 mile of the Hely Creek for spawning but the steelhead move upstream for about two miles. The low gradient floodplain reach of Hely Creek is characterized by a fair quantity but poor quality of pool habitat. The pools are relatively shallow and have only fair cover. Spawning habitat is highly abundant but is highly degraded by the presence of fine sediment. Neither Fox nor Flanigan Creeks contain significant quantities of floodplain habitat. Upstream in the canyon reaches, gradients increase to between 1.5 to 6.5%. Pool habitat frequencies are relatively low. The pools are shallow but have fair overhead cover. Spawning habitat is abundant but is degraded by the presence of fine sediment.

Spawning and rearing habitat in Hely Creek is similar to that found in Cummings Creek. The low gradient floodplain reach is especially vulnerable to changes in sediment supply and decreased LWD input. Increasing sediment supply fills pools, overcomes smaller habitat forming LWD, and degrades spawning habitat quality with fine material. Decreased LWD inhibits pool formation and spawning gravel accumulations, and decreases the quality of rearing habitat by reducing overhead cover and pool size. The moderate gradient reaches are less sensitive to LWD and sediment input. Larger sediment sizes are generally more stable and less influenced by fine sediment aggradation and LWD frequency.

Amphibians and Reptiles

The Hely Creek sub-basin contains potential habitat for all 4 amphibian and one reptile species of concern: northwestern pond turtle, foothill yellow-legged frog, northern red-legged frog, tailed frog, and southern torrent salamander. Potential habitat for the northwestern pond turtle exists within the lower 2 miles of Hely Creek and along most of Fox Creek. Potential habitat for the tailed frog exists within the lower mile of Hely Creek and within the Class I and II tributaries of Hely Creek; potential habitat for the tailed frog exists in only 3 upper tributaries of Fox Creek. Potential habitat for the southern torrent salamander includes the Class II tributaries of Hely Creek and the 3 upper tributaries of Fox Creek. The foothill yellow-legged frog and northern red-legged frog are expected to occur within all Class I and Class II stream reaches in the sub-basin. The foothill yellow-legged frog was observed within the main channel of Hely Creek during 2000 surveys.

Water temperatures, canopy closure, and LWD currently meet PFCs in areas surveyed within this sub-basin. Therefore, the northwestern pond turtle, foothill yellow-legged frog, and northern red-legged frog are anticipated to have an overall low vulnerability within this sub-basin.

Habitat for the tailed frog and southern torrent salamander, however, is especially vulnerable to inputs of fines in areas of potential habitat for these species in this sub-basin. Most areas surveyed within Hely Creek and a Class II tributary of Hely Creek do not currently meet PFCs for percent fines (with a ranking of poor) and embeddedness (with a ranking of poor to fair). The southern torrent salamander breeds in the splash zone of cold mountain streams, springs, seeps, and waterfalls and burrows beneath the creek bed during the dry season. High percent gravel and low embeddedness are important for survival and reproduction of this species. Cobble and boulder substrates with low embeddedness have also been determined to be important for larvae of the tailed frog.

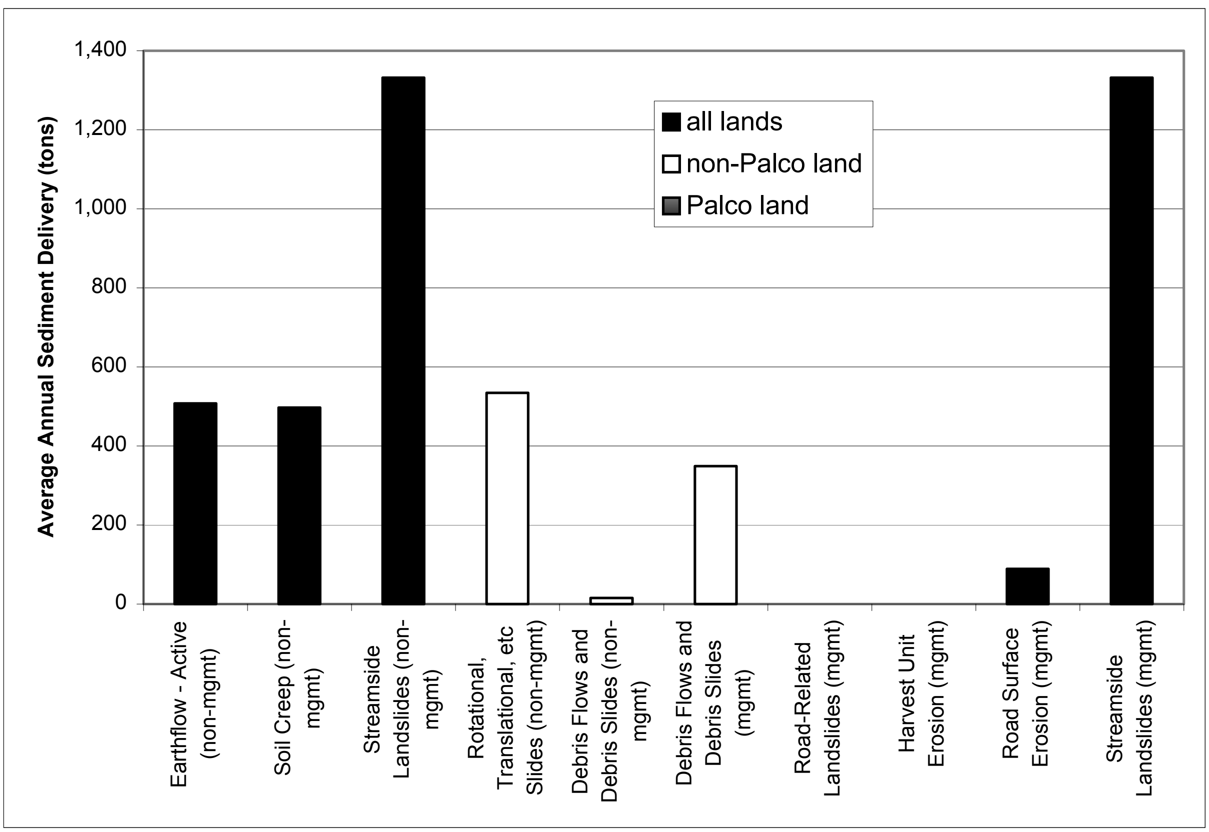
5.6 HYDESVILLE CREEK

5.6.1 Estimated Sediment Inputs

The Hydesville Creek sub-basin does not include any major named creeks, and is located to the south of the mainstem. Approximately 7% of this sub-basin is owned by PALCO. Geology ranges from terrace deposits along the mainstem to Carlotta on the hillslopes and in small drainages. Soil textures range from loam to gravelly loam to loam, with increasing elevation to the south from the mainstem. Therefore, relative generation of fines is moderate to low in this area.

The dominant sediment source type in the Hydesville Creek sub-basin is management- and non-management-related streamside landslides, each accounting for 29% of sediment delivery to streams (Figure 5-5). Other important sediment sources include earthflow and soil creep (11% each). Non-management-related rock topple, rotational, translational, and complex slides account for 11% of total sediment source delivery. Management-related sediment sources include debris flows and debris slides (7%), all on non-PALCO lands. The contribution from road surface erosion is an additional 2%. However, this estimate may be high because estimated road surface erosion for all roads (PALCO and non-PALCO) was not separated by ownership in the SEDMODL analysis and, therefore, was included with results for PALCO lands that cover only a small part of this sub-basin.

Figure 5-5. Hydesville Creek Sub-Basin Sediment Source Delivery to Streams



5.6.2 Analysis of Potential Channel Response

Minimal data collection to support Level II analysis was completed in this sub-basin due to the low percentage of PALCO ownership.

Riparian

Canopy cover met PFC targets for all tributary streams in the Hydesville Creek sub-basin. Canopy cover levels did not attain PFC targets on the mainstem of the Van Duzen River due to the natural width of the channel.

Canopy closure levels exceeded 85% and met PFC targets on 52% of riparian areas in the Hydesville sub-basin. Forty-eight percent of stands had less than 85% canopy closure.

PALCO owns 3% of the riparian areas reviewed in the Hydesville Creek sub-basin. All riparian stands on PALCO lands had low LWD recruitment potential. There were no large size class, conifer dominated stands in this sub-basin, therefore, no riparian areas met PFC targets for LWD recruitment potential.

5.6.3 Potential Resource Vulnerabilities

Fisheries

Fish habitat in the Hydesville area was not examined as there are little if any fish-bearing streams (aside from the mainstem Van Duzen) within PALCO ownership in this sub-basin.

Amphibians and Reptiles

The Hydesville Creek sub-basin contains potential habitat for all 4 amphibian and one reptile species of concern: northwestern pond turtle, foothill yellow-legged frog, northern red-legged frog, tailed frog, and southern torrent salamander. Potential habitat for the northwestern pond turtle exists only along the lower reaches of the unnamed tributaries. Potential habitat for the tailed frog and the southern torrent salamander exists within most of the unnamed tributaries and their Class I (tailed frog only) and II tributaries. The foothill yellow-legged frog and northern red-legged frog are expected to occur within all Class I and Class II stream reaches in the sub-basin. One tailed frog was observed in a Class II stream in this area and northern red-legged frogs and foothill yellow-legged frogs were observed in several locations within this sub-basin.

Water temperatures, canopy closure, and LWD currently meet PFCs in areas surveyed within this sub-basin. Therefore, the northwestern pond turtle, foothill yellow-legged frog, and northern red-legged frog are anticipated to have an overall low vulnerability within this sub-basin.

Habitat for the tailed frog and southern torrent salamander, however, is especially vulnerable to inputs of fines in areas of potential habitat for these species in this sub-basin. Most areas surveyed within this sub-basin do not currently meet PFCs for percent fines and embeddedness. The southern torrent salamander breeds in the splash zone of cold mountain streams, springs, seeps, and waterfalls and burrows beneath the creek bed during the dry season. High percent gravel and low embeddedness are important for survival and reproduction of this species. Cobble and boulder substrates with low embeddedness have also been determined to be important for larvae of the tailed frog.

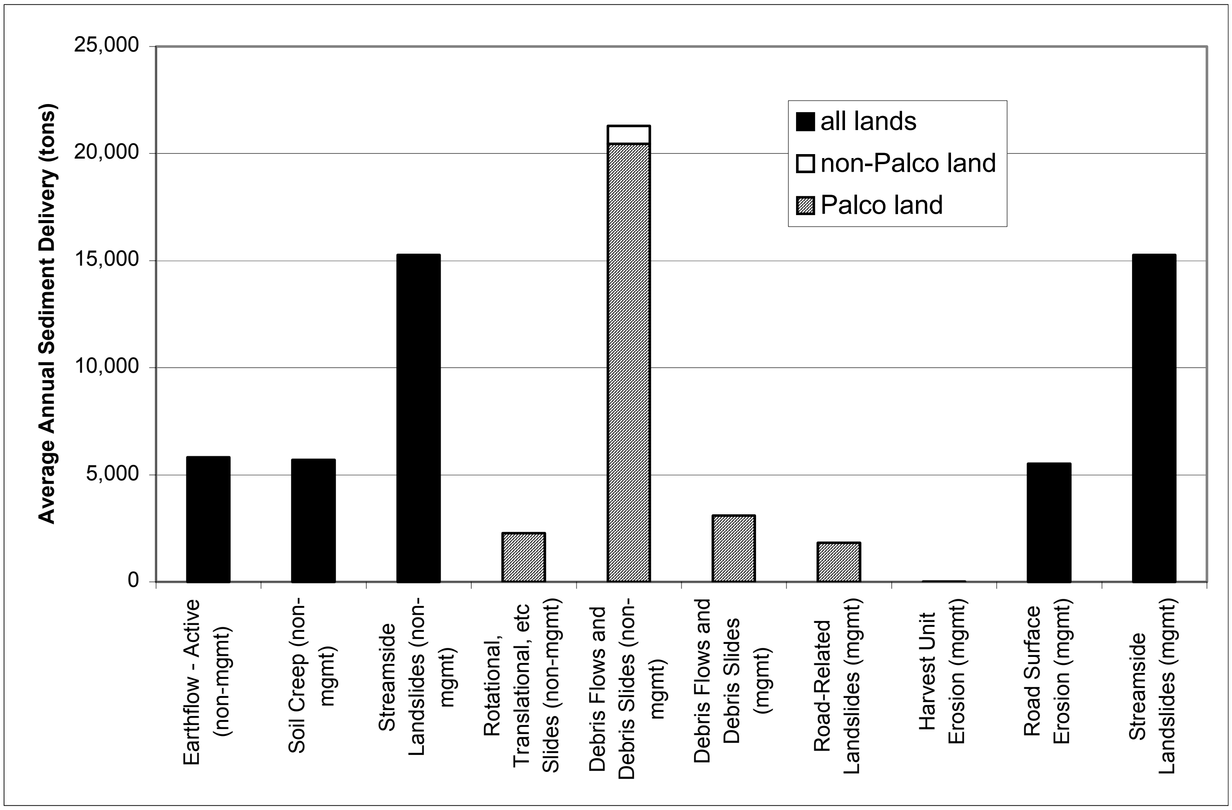
5.7 ROOT CREEK

5.7.1 Estimated Sediment Inputs

The Root Creek sub-basin is dominated by Blue Slide Creek to the north and the Root Creek drainage to the south of the mainstem. There are also some small drainages to the west of Root Creek, on the south side of the mainstem. Approximately 92% of the sub-basin is owned by PALCO. The geology for the sub-basin is predominantly Wildcat, with smaller portions of Yager at the east end of the sub-basin (near Grizzly Creek State Park) and near the south ridgeline. Specifically, the geology in the Blue Slide Creek sub-basin is Wildcat and soil textures are loams with moderate generation of fines. In the Root Creek sub-basin, the geology ranges from terrace deposits, near the mainstem, to Wildcat throughout the rest of the sub-basin. Soil textures in the Root Creek drainage are loams in lower elevations, with gravelly loam soils increasing with distance upstream from the mainstem. Therefore, relative generation of fines ranges from moderate to low with distance upstream. However, Root Creek (along with Stevens Creek) has a higher stream density than other sub-basins. This results in more inner gorge areas with an increased density of landslides and other sediment source inputs.

The Root Creek sub-basin yields the largest delivery volume, and highest proportion (28%), of non-management-related debris flows and debris slides in the study area (Figure 5-6); a total of 1,500 tons/sq mi/yr (530 metric tons/sq km/yr) as compared with 10 to 1,040 tons/sq mi/yr (4 to 360 metric tons/sq km/yr) for other sub-basins (non-management-related debris flows and debris slides). Of the total sediment inputs in the Root Creek sub-basin, other dominant sediment sources include management- and non-management-related streamside landslides (20% each). Other important sediment sources include earthflow (8%) and soil creep (7%). Management-related sediment sources account for approximately 13% of all sediment delivery throughout the sub-basin, all of which is attributed to management on PALCO lands.

Figure 5-6. Root Creek Sub-Basin
Sediment Source Delivery to Streams



5.7.2 Analysis of Potential Channel Response

The Root Creek sub-basin is primarily underlain by Wildcat sediments and, with the exception of the more competent Scotia Bluffs formation, produces bed material that is highly friable. The 5 reaches surveyed within the basin ranged from 1 to 20% and covered a range of channel types. A majority of the network (approximately the lower two-thirds) is comprised of lower gradient CGUs (Lower Gradient Wildcat and Floodplain Tributaries, less than 3% gradients and commonly less than 2%). In addition, numerous large debris jams and landslide deposits that block the channel create localized low gradient areas. Hence, the majority of Root Creek is highly sensitive to aggradation with coarse sediment and is also sensitive to infilling of pools and gravel beds with sands. Pools are shallow even in areas with relatively large woody debris. Hence, both large and small wood will create relatively small pools in the near future. A reduction of sediment supply, in conjunction with increases in large woody debris, should create larger and deeper pools over time.

LWD recruitment rates averaged 13.7 cu m/yr/km, which was higher than recruitment rates in old-growth sites. The relation between recruitment process and channel slope and morphology was not apparent, although landslide recruitment of LWD was dominant in confined reaches with steep hill slopes (e.g., sites 9 and 18). The majority of recruited LWD in the Root Creek sub-basin reaches was deciduous (66 to 93% by volume in 4 of the 5 reaches) and the average recruit diameter was smaller than old-growth sites. Similar to the flood plain tributary reach in Cummings Creek, Site 7 on lower Root Creek appears to have low LWD recruitment (2.9 cu m/yr/km) of predominantly deciduous trees (93% by volume) of small diameter (0.24 m average). LWD in this reach may have a low residence time and function due to the small diameter deciduous source of the wood.

Riparian

Canopy cover levels met PFC targets for 97% of riparian areas on tributary streams in the Root Creek sub-basin. Areas not meeting canopy cover targets were affected by stream side landslides and past harvests. The mainstem of the Van Duzen River did not meet PFC targets for canopy cover due to the naturally wide channel, this accounted for 30% of the sub-basin area.

Canopy closure levels exceeded 85% and met PFC targets on 81% of riparian areas in the Root Creek sub-basin. Twenty two percent of stands had less than 85% canopy closure and 3% of stands were classified as open.

PALCO owns 86% of the riparian areas reviewed in the Root Creek sub-basin. On PALCO lands, 17% of riparian stands had high LWD recruitment potential, 27% were medium, and 56% were low. Large size class, conifer-dominated riparian stands represented 1% of PALCO owned riparian stands in the Root Creek sub-basin. Therefore, 1% of PALCO owned riparian stands in Root Creek met the PFC target for LWD recruitment potential. There were scattered residual mature redwood trees on the mainstem of Root Creek, these trees increased LWD recruitment potential in the watershed.

5.7.3 Potential Resource Vulnerabilities

Fisheries

Root Creek contains runs of steelhead trout and chinook salmon. Blue Slide Creek is principally a resident trout stream. The chinook use approximately the lower one mile of the Root Creek for spawning but the steelhead move upstream for 3 to 4 miles. The low gradient floodplain reach of Root Creek is characterized by a fair to good pool habitat availability but relatively poor pool quality. The pools are relatively shallow but have good cover. Spawning habitat is scarce and is highly degraded by the presence of fine sediment. Upstream in the canyon reach the fair to good pool habitat frequency continues. Pool quality remains similar to downstream. Spawning habitat is still infrequent and highly degraded by the presence of fine sediment.

Spawning and rearing habitat in the floodplain portion of Root Creek is similar to that found elsewhere along the Van Duzen. The low gradient reach is especially vulnerable to changes in sediment supply and decreased LWD input due principally to the effects on pool formation and the aggradation of fine material. Most of the channels in the Root Creek sub-basin are moderate to high gradient but are currently very sensitive to sediment input and less sensitive to the effects of LWD (see 5.5.2). Therefore, fish habitat in this sub-basin is particularly vulnerable to sediment input due to potential loss of pool depth and frequency, and degradation of spawning habitat with fine material. Once sediment supply decreases, the beneficial effects of LWD will increase.

Amphibians and Reptiles

The Root Creek sub-basin contains potential habitat for all 4 amphibian and one reptile species of concern: northwestern pond turtle, foothill yellow-legged frog, northern red-legged frog, tailed frog, and southern torrent salamander. Potential habitat for the northwestern pond turtle exists along most of Root Creek and the upper two Class I tributaries of the creek. Potential habitat for the tailed frog and the southern torrent salamander exists within the lower 1,000 feet of Blue Slide Creek and within the Class I (tailed frog only) and II tributaries of Root Creek and Blue Slide Creek. The foothill yellow-legged frog and northern red-legged frog are expected to occur within all Class I and Class II stream reaches in the sub-basin. The foothill yellow-legged frog was observed within the main channel of Root Creek during 2000 surveys.

Water temperatures, canopy closure, and LWD currently meet PFCs in areas surveyed within this sub-basin. Therefore, the northwestern pond turtle, foothill yellow-legged frog, and northern red-legged frog are anticipated to have an overall low vulnerability within this sub-basin.

Habitat for the tailed frog and southern torrent salamander, however, is especially vulnerable to inputs of fines in areas of potential habitat for these species in this sub-basin. Most areas surveyed within Root Creek and the Class II tributaries of Root Creek do not currently meet PFCs for percent fines and embeddedness. The southern torrent salamander breeds in the splash zone of cold mountain streams, springs, seeps, and waterfalls and burrows beneath the creek bed during the dry season. High percent gravel and low embeddedness are important for survival and reproduction of this species. Cobble and boulder substrates with low embeddedness have also been determined to be important for larvae of the tailed frog.

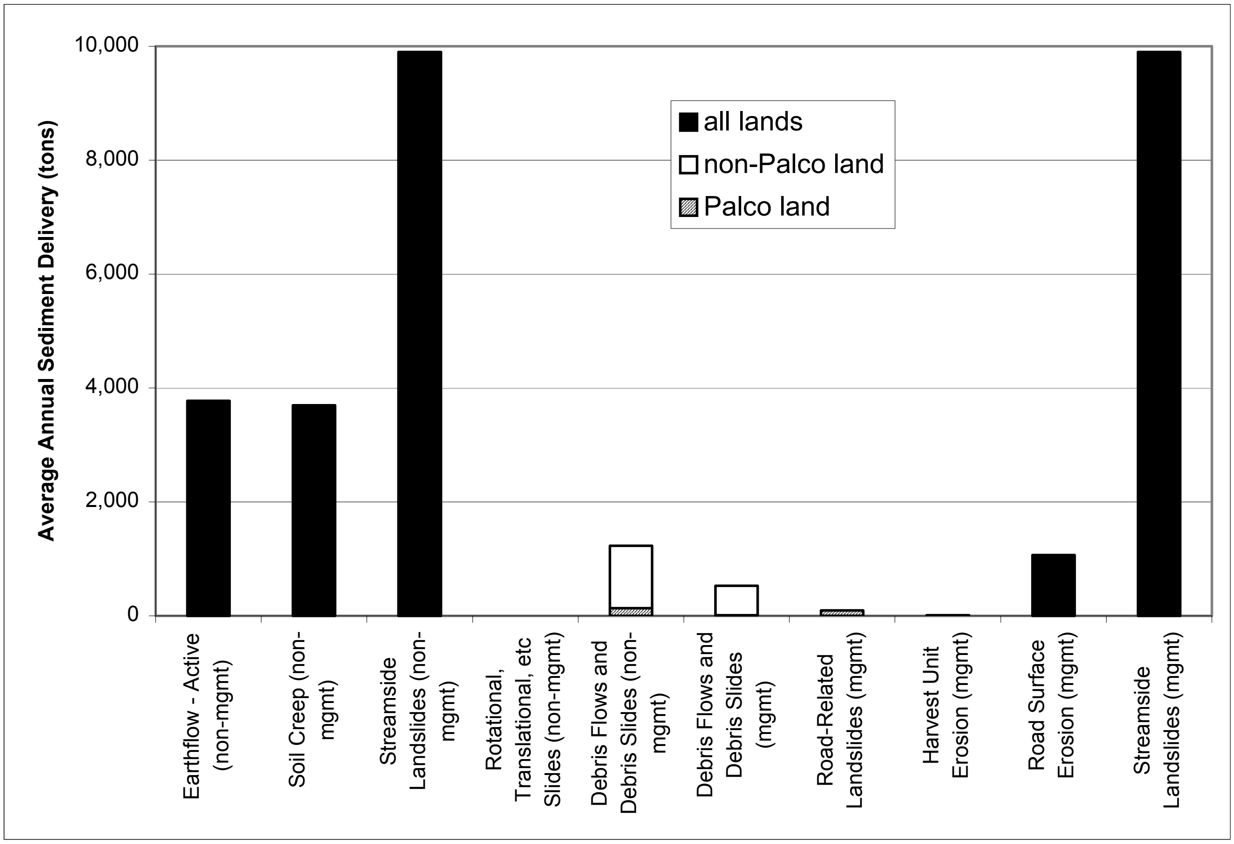
5.8 STEVENS CREEK

5.8.1 Estimated Sediment Inputs

The Stevens Creek sub-basin includes the entire drainage for Stevens Creek. Approximately 29% of the sub-basin is owned by PALCO. The lower part of the sub-basin includes a small area consisting of Yager formation with most PALCO lands on Wildcat geology in the middle part of the sub-basin. The upper part of the sub-basin is predominantly Yager, with Franciscan mélange occurring in the upper reaches. Soil textures range from gravelly loam to loam to clay loam with increasing elevation in the sub-basin. The relative generation of fines increases from low to moderate in most of the sub-basin, with high generation of fines in the upper elevations. The stream density in the Stevens Creek sub-basin is higher than in other sub-basins of the study area.

The dominant sediment source type for the Stevens Creek sub-basin is management- and non-management-related streamside landslides, each accounting for 33% of sediment delivery to streams (Figure 5-7). Other important sediment sources include earthflow (12%) and soil creep (12%). Debris flows and debris slides (non-management-related) account for only 4% of total sediment source delivery. Management-related sediment sources account for approximately 5% of all sediment delivery throughout the sub-basin, which includes 3% attributed to management on PALCO lands as well as roads on PALCO and non-PALCO lands.

Figure 5-7. Stevens Creek Sub-Basin
Sediment Source Delivery to Streams



5.8.2 Analysis of Potential Channel Response

Stevens Creek is underlain by the competent interbedded sandstone and shale of the Yager formation. Consequently, the substrate of Stevens Creek is dominated by boulders and cobbles, particularly in areas of relatively low sediment storage. In areas where sediment storage is increased (behind log jams and landslide deposits), the channel bed contains large quantities of gravel and sand. Stevens Creek is highly sensitive to increases in coarse sediment supply only in those local low gradient areas and the system is not significantly sensitive to coarse sediment where it is steeper (greater than 3%) and boulder bedded. Logs and logjams will have the greatest pool forming potential in localized areas of deformable bed (i.e., gravels and cobbles) but in general, Stevens Creek will not create large quantities of pools associated with logs, unless the sediment storage increases throughout the system.

Riparian Response

Canopy cover levels met PFC targets for 87% of riparian areas in the Stevens Creek sub-basin. Four percent of stands not meeting PFC targets for canopy cover were due to naturally wide channel in the lower reaches, 4% were due to naturally sparse canopy composition, and 3% were due to the frequent streamside landslides observed along Stevens Creek. The Stevens Creek planning watershed did not include any portion of the Van Duzen River.

Canopy closure levels exceeded 85% and met PFC targets on 68% of riparian areas in the Stevens Creek sub-basin. Thirty one percent of stands had less than 85% canopy closure and 1% of stands were classified as open.

PALCO owns 34% of the riparian areas reviewed in the Stevens Creek sub-basin. On PALCO lands 30% of riparian stands had high LWD recruitment potential, 51% were medium and 19% were low. Large size class, conifer dominated riparian stands represented 5% of PALCO owned riparian stands in the Stevens Creek sub-basin. Therefore, 5% of PALCO owned riparian stands in Stevens Creek met the PFC target for LWD recruitment potential.

5.8.3 Potential Resource Vulnerabilities

Fisheries

Stevens Creek contains runs of steelhead trout, and chinook and coho salmon. The chinook and coho use approximately the lower 1 mile of the stream for spawning but the steelhead move upstream for about 1.5 to 2 miles. Stevens Creek begins as a low gradient (1.5 to 3%) canyon reach tributary to Grizzly Creek. The lower section is characterized by a low frequency of poor quality pool habitat. The pools are relatively shallow and have only fair cover. Spawning habitat is abundant but is degraded by the presence of fine sediment. Upstream in the moderate gradient reach pool habitat frequency and quality continues to be poor. Bedrock scour pools are common. Spawning habitat remains abundant but is still degraded by the presence of high levels of fine sediment.

Spawning and rearing habitat in Stevens Creek is dominated by the moderate to high gradients found throughout this stream channel. Moderate gradient reaches are cobble bedded and generally less sensitive to LWD and sediment input. Larger sediment sizes are generally more stable and less influenced by fine sediment aggradation and LWD frequency. Where particularly large pieces of LWD influence the channel, localized low gradient reaches have formed. These areas contain much of the higher quality spawning habitat and deeper pools due to the deformable bed. These areas are sensitive to aggradation and in particular the accumulation of fine sediments. Mass wasting has played a key role in defining habitat in Stevens Creek where large piles of debris and sediment have effectively plugged the channel preventing fish migration upstream past the accumulations.

Amphibians and Reptiles

The Stevens Creek sub-basin contains potential habitat for all 4 amphibian and one reptile species of concern: northwestern pond turtle, foothill yellow-legged frog, northern red-legged frog, tailed frog, and southern torrent salamander. Potential habitat for the northwestern pond turtle exists within the lower mile of Stevens Creek. Potential habitat for the tailed frog and the southern torrent salamander exists within the Class I (tailed frog only) and II tributaries and upper reaches of Stevens Creek. The foothill yellow-legged frog and northern red-legged frog are expected to occur within all Class I and Class II stream reaches in the sub-basin.

Because the sub-basin is primarily located on non-PALCO property, this sub-basin was not evaluated for habitat condition for amphibians and reptiles. However, canopy closure meets PFC targets in 68% of the riparian areas in the Stevens Creek sub-basin and LWD currently meets PFCs in PALCO-owned areas within this sub-basin. Therefore, the northwestern pond turtle, foothill yellow-legged frog, and northern red-legged frog are anticipated to have an overall low vulnerability within this sub-basin.

Habitat for the tailed frog and southern torrent salamander, however, is especially vulnerable to increased inputs of fines in areas of potential habitat for these species in this sub-basin although the reaches of most input of fines are located upstream of PALCO ownership. The southern torrent salamander breeds in the splash zone of cold mountain streams, springs, seeps, and waterfalls and burrows beneath the creek bed during the dry season. High percent gravel and low embeddedness are important for survival and reproduction of this species. Cobble and boulder substrates with low embeddedness have also been determined to be important for larvae of the tailed frog.

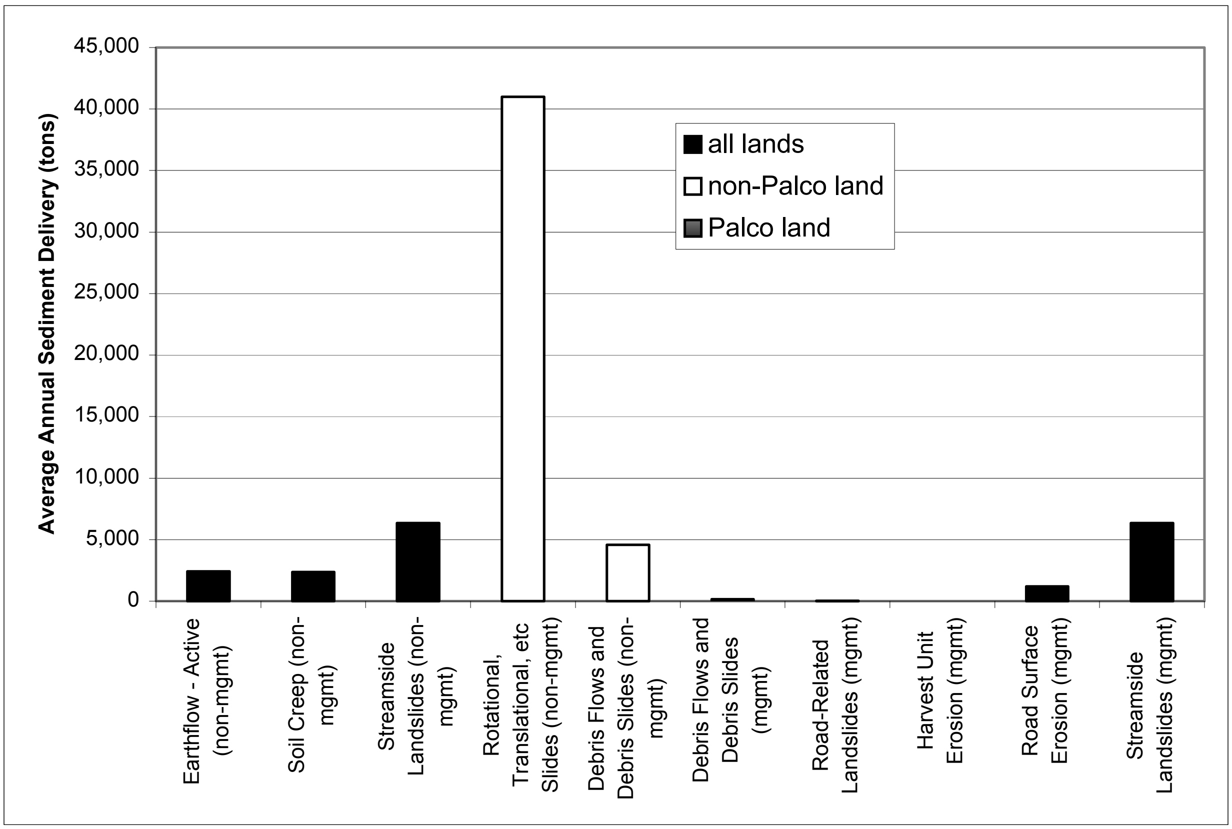
5.9 SWAINS FLAT

5.9.1 Potential and Estimated Sediment Inputs

The Swains Flat sub-basin includes the following major drainages: Fish Creek, Rogers Creek, and Pip Creek. Approximately 16% of the sub-basin is owned by PALCO. North from the Van Duzen mainstem to higher elevations, the geology ranges from terrace deposits to Yager to Franciscan mélange, and soil textures range from loam to gravelly loam to clay loam with increasing elevation. Therefore, the relative generation of fines ranges from moderate to low to high in this area. The geology on the south side of the mainstem is predominantly Yager, with some terrace deposits along the mainstem. Soils are typically loam to gravelly loam which, therefore, yield moderate to low generation of fines.

The dominant sediment source type for the Swains Flat sub-basin is non-management-related rock topple, rotational, translational, and complex slides, accounting for 64% of sediment delivery to streams (Figure 5-8). Other important sediment source types include management- and non-management-related streamside landslides (each at 10%), non-management-related debris flows and debris slides (7%), earthflow (4%), and soil creep (4%). The earthflow contribution (4% of total) may be underestimated because the delivery rate of the Goat Rock earthflow was not explicitly included in the calculation. Overall, management-related sediment sources account for approximately 2% of all sediment delivery throughout the sub-basin, which most delivery attributed to management on PALCO lands as well as roads on PALCO and non-PALCO lands.

Figure 5-8. Swains Flat Sub-Basin
Sediment Source Delivery to Streams



5.9.2 Analysis of Potential Channel Response

Minimal data collection to support Level II analysis was completed in this sub-basin due to the low percentage of PALCO ownership.

Riparian Response

Canopy cover levels met PFC targets for 49% of riparian areas in the Swains Flat sub-basin. Thirty-one percent of stands not meeting PFC targets for canopy cover were due to the naturally wide channel on the

Van Duzen River, 8% were due to naturally sparse canopy composition, and 5% were due to the streamside landslides observed along tributaries in the sub-basin and along the Van Duzen mainstem. Four percent of riparian stands in the upper most reaches of Fish Creek and Pip Creeks did not PFC targets for canopy cover because recent harvest resulted in very narrow riparian buffer widths or no buffer at all, the following stream segments were affected: FISH- 003 and VANB-010.

Canopy closure levels exceeded 85% and met PFC targets on 52% of riparian areas in the Swains Flat sub-basin. Thirty-eight percent of stands had less than 85% canopy closure and 9% of stands were classified as open.

PALCO owns 16% of the riparian areas reviewed in the Swains Flat sub-basin. On PALCO lands, 19% of riparian stands had high LWD recruitment potential, 14% were medium, and 66% were low. Large size class, conifer dominated riparian stands represented 2% of PALCO owned riparian stands in the Swains Flat sub-basin. Therefore 2% of PALCO owned riparian stands in the Swains Flat sub-basin met the PFC target for LWD recruitment potential.

5.9.3 Potential Resource Vulnerabilities

Fisheries

Fish habitat in the Swains Flat area (Fish Creek) was not examined as very little, if any, fish-bearing waters in the sub-basin are within PALCO ownership.

Amphibians and Reptiles

The Swains Flat sub-basin contains potential habitat for all 4 amphibian and one reptile species of concern: northwestern pond turtle, foothill yellow-legged frog, northern red-legged frog, tailed frog, and southern torrent salamander. Potential habitat for the northwestern pond turtle exists within the lower 1,500 feet of Rogers Creek. Potential habitat for the tailed frog and the southern torrent salamander exists within the Class I (tailed frog only) and II tributaries and upper reaches of Rogers Creek, Fish Creek, and Pip Creek. The foothill yellow-legged frog and northern red-legged frog are expected to occur within all Class I and Class II stream reaches in the sub-basin.

Because the sub-basin is primarily located on non-PALCO property, this sub-basin was not evaluated for habitat condition for amphibians and reptiles. Thirty-one percent of stands did not meet PFC targets for canopy cover due to a naturally wide channel of the Van Duzen mainstem, 8% were due to naturally sparse canopy composition and 5% were due to the streamside landslides observed along tributaries in the sub-basin. Therefore, the northwestern pond turtle, foothill yellow-legged frog, and northern red-legged frog are anticipated to be vulnerable to effects on canopy closure in this sub-basin.

Habitat for the tailed frog and southern torrent salamander, is especially vulnerable to inputs of fines in areas of potential habitat for these species in this sub-basin. Although most of the subbasin is not owned and managed by PALCO; areas of increased fine generation are located in higher elevations. The southern torrent salamander breeds in the splash zone of cold mountain streams, springs, seeps, and waterfalls and burrows beneath the creek bed during the dry season. High percent gravel and low embeddedness are important for survival and reproduction of this species. Cobble and boulder substrates with low embeddedness have also been determined to be important for larvae of the tailed frog.

6.0 KEY UNCERTAINTIES AND MONITORING RECOMMENDATIONS

The key findings summarized in previous sections provide a basis for understanding cumulative watershed effects. This watershed analysis shows that management-related inputs are much less than natural background sources and are not overwhelming the physical and biological resources of the Van Duzen Watershed Analysis Unit (WAU). Habitat and structural components of habitat appear to be adequate to sustain populations of species of concern.

Over time, as management practices are refined on PALCO lands in the Van Duzen WAU, there will be a need to refine the understanding of natural processes and their impacts to the surrounding ecosystem (e.g., species of concern). Subsequent watershed analyses (conducted on a 5 year cycle) will include additional data to provide further clarification and address key uncertainties that remain. The following discussion summarizes the current key uncertainties. Monitoring is suggested as the primary means of addressing key uncertainties prior to and during the next round of analysis, and will be specified as part of the prescriptions process. A Geographic Information System (GIS) has been compiled to support this watershed analysis and, as part of the adaptive management program, will enhance future watershed analysis and prescriptions.

6.1 SEDIMENT SOURCES

The key uncertainty in addressing sediment sources in the Van Duzen WAU focuses on the accuracy of mass wasting hazard ratings. Monitoring of mass wasting should include evaluation of hazard ratings relative to actual landslide occurrence. The current watershed analysis information can be refined and updated using data collected from the Timber Harvest Plan (THP) hazard assessment field checklist. This checklist should also include a consistent approach for evaluating sediment delivery to streams from mass wasting events.

6.2 CHANNEL AND RIPARIAN PROCESSES

Key uncertainties related to channel processes are summarized below, with monitoring recommendations to provide data to reduce uncertainty in the next round of watershed analysis. These key uncertainties include:

1. Specific routing of sediments through the channel network and related changes in habitat structure and function.
2. How conifer-dominated stands in the small size class respond to management.

3. Questions regarding canopy closure and the riparian shade/stream temperature relationship in the Van Duzen WAU.

The accuracy of estimated changes in peak flow and the effects of the road network on sub-basin hydrology is a source of uncertainty. This uncertainty can be addressed by continuing review of various hydrologic approaches and developing an improved methodology, including development of algorithms that are better tailored to regional conditions than the Caspar Creek equations. Also, improved information for evaluating the effects of the road network (e.g., connectivity and compaction) on sub-basin hydrology should be considered. Improved information might include training for field teams to record qualitative observations on impacts of roads on stream network. No specific monitoring tasks are envisioned to address this key uncertainty.

Specific routing of sediments through the channel network and related changes in habitat structure and function is another key uncertainty. Indirect measurements of sediment delivery impacts would involve monitoring trends in terrace development in sensitive channel geomorphic units (e.g., low gradient reaches below high hazard sediment delivery areas).

The response of conifer-dominated stands in the small size class from management is another key uncertainty. Questions such as the effect of thinning manipulation on potentially increasing the rate of LWD recruitment potential in these stands can be addressed by monitoring test plots for small stands. Data collection would also address the effect of manipulation thinning on PFCs.

There is some uncertainty associated with the riparian shade and stream temperature relationship in the Van Duzen WAU. Questions regarding canopy closure relative to PFC targets and stream temperature can be addressed through additional field measurements. Additional stream temperature and riparian shade measurements can be collected as part of the regular cycle of watershed analysis and as part of the PALCO stream monitoring program. These data sources should provide adequate information to reduce the level of uncertainty.

6.3 BIOLOGICAL RESOURCES

Key uncertainties related to biological resources are summarized below, with monitoring recommendations to provide data to reduce this uncertainty in the next round of watershed analysis for the Van Duzen WAU. These key uncertainties include:

1. The relationship of amphibian and reptile habitat relative to geologic substrate.
2. The applicability of habitat diagnostics for use in evaluating PFCs for amphibians and reptiles of concern.

3. The effects of peak flow increases on embryo survivability for amphibians that breed in the fall.
4. Species distribution within the watershed and their status.

The patterns of habitat use by amphibians and reptiles within the Van Duzen WAU relative to geologic substrate is a key uncertainty. The key question is whether the prevalence of fine sediments as a result of the Franciscan mélange limits or reduces the presence of several species in those areas of the WAU. The ongoing monitoring program by PALCO will provide data to further evaluate possible relationships.

Another key uncertainty relates to the applicability of habitat diagnostics for evaluating PFCs for amphibians and reptiles of concern. Species presence data, collected over time through the PALCO monitoring program, will be used to better understand habitat requirements.

The effects of peak flow increases on embryo survivability for amphibians that breed in the fall (i.e., tailed frogs) has been identified as a key uncertainty. The benthic macroinvertebrate component of the PALCO stream monitoring program suggests that peak flow is not a concern for these species. However, it is unclear whether these peak flows represent a risk to the early life stages of amphibians. Continued field monitoring will provide data to better evaluate this question.

Key uncertainties remain regarding species distribution within the watershed and their status. Ongoing monitoring will be input and used as part of the Van Duzen WAU GIS. This updated information can be used to further reduce a variety of key uncertainties.

6.4 CUMULATIVE WATERSHED EFFECTS

The current watershed analysis provides the basis for a rigorously qualitative assessment of cumulative watershed effects. The sediment delivery analysis, in combination with the channel geomorphic units and the biological resources assessment, provides the capability to assess questions regarding the potential impact of proposed prescription options. However, due to the combined uncertainties in sediment delivery, channel mapping, and biological resource assessment a more comprehensive and dynamic cumulative watershed assessment is not possible. Addressing the uncertainties in the sediment budget, channel conditions, and biological resources will also contribute to an improved cumulative watershed effects assessment.

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APPENDIX A.
ISSUES MATRIX FOR THE
VAN DUZEN RIVER WATERSHED ANALYSIS

The Issues Matrix lists issues identified in the public scoping process for the Van Duzen River Watershed Analysis. Issues are grouped by topic (Table A-1). The response code indicates categorization as a result of the sorting process (see key below and in footnote at end of table). All issues raised were addressed by the standard assessment methods, therefore, no modifications to the hypotheses, flow chart, or assessment procedures were made.

Table A-1. Van Duzen River Watershed Analysis Issues Matrix

GENERAL TOPIC	ISSUE #	Specific Issues Identified by Van Duzen River Watershed Residents	Response Code	RESPONSE
RESPONSE CODE KEY: 1) Issue outside of Watershed Analysis scope // 2) Untested theory: may need to incorporate into Assessment; see guidance in CWE Manual // 3) Not feasible to address per the definition in the CWE Manual // 4) Issues to Address -- 4a) Issue is addressed in the default WSA methods ; 4b) Issue is partially addressed in the default WSA methods and partially falls into categories 1, 2, or 3 above; 4c) Issue is partial addressed in the default WSA methods; modifications to methods for this analysis may be needed to fully address; 4d) Issue is not explicitly addressed in default methods; modifications to methods may be needed for this analysis // 5) Comment is either a statement that could not be translated into a theory relating management practices to aquatic resources or comment does not address a specific issue (too vague) // * Other response provided				
Addresses range of subjects	29	Concern over the number of Timber Harvest Plans recently submitted and the frequency of re-entry (as indicated on CDF maps) on the following: · Cumulative effects · Viewshed · Jobs for the future · Long-range plans · Restoration of the canopy	4b	> Cumulative Effects - Addressed in Cumulative Watershed Effects assessment > Viewshed - Not applicable to Watershed Analysis > Jobs for the Future - Not applicable to Watershed Analysis > Long range plans - Watershed Analysis is long-term planning process > Restoration of the canopy - Addressed in Riparian Function Assessment
Addresses range of subjects	45	What steps will Pacific Lumber Company take for the recovery of the: · Coho Salmon · Steelhead · Frogs and Toads · Otters · Pine Marten · Osprey · Spotted Owl	4b	The Coho salmon, steelhead, northern red-legged frog, foothill yellow-legged frog, spotted owl, and tailed frogs are Habitat Conservation Plan (HCP) species and will be analyzed in the Watershed Analysis (WA). Regulatory policies require that HCP's provide for the recovery of covered species. The otter, pine marten, osprey, and spotted owl are addressed Timber Harvest Plan (THP) by THP with protections of the Forest Practice Rules.

GENERAL TOPIC ISSUE #		Specific Issues Identified by Van Duzen River Watershed Residents	Response Code	RESPONSE
Addresses range of subjects	64	The river is in the process of healing and should not be compromised.	4b	The purpose of the WA is to achieve, maintain, or restore proper function conditions (PFC). PFCs describe the preferred status of key variables that have been determined to be essential for maintaining favorable habitat for covered species and sustaining key processes within the watershed. PFCs are further described in the Watershed Assessment Methods for PALCO Lands.
Addresses range of subjects	91	Do the high sediment levels in the Van Duzen cause a decline in the diversity of aquatic insects in the stream, and therefore reduce the food base for salmonids?	4b	Sediment loads are examined in the Watershed Analysis. PALCO has been collecting macroinvertebrate data as part of a trends monitoring program. This information will be reviewed in the fisheries module to address the commentor's question.
Addresses range of subjects	114	Aesthetic Value: The beauty of the river has been marred during the winter by sediment. In case of any rain the river now turns brown for days on end. In peak rainfall times, the river stays brown continually. How does this summer study intend to take this feature into account?	4b	We recognize the importance of aesthetics to the local community. However, aesthetics is not an issue that is addressed in Watershed Analysis. The winter turbidity will be assessed as part of the mass wasting and sediment erosion modules. The module identifies sediment sources and prescription writing addresses these actions. The proper functioning condition (PAC) guidelines that are used as a goal in the Watershed Analysis process should result in reduced sediment loads due to management actions and therefore reduced turbidity in the streams that will lead to improvements in aesthetic conditions.
Addresses range of subjects	119	What monitoring mechanisms will be put in place to measure sediment and turbidity, and to analyze the effectiveness of logging operations?	4a	Stream monitoring is ongoing, while hillslope and effectiveness monitoring are being planned. As a product of WA, monitoring questions are developed to address uncertainty in the analysis. The questions will be identified by the agencies and PALCO for needed monitoring. Monitoring plans are developed when the results of the analysis are known.
Addresses range of subjects	127	How will the effects of logging be measured?	4a	The effects of logging are addressed in several modules -- exact monitoring techniques for measuring effect are unknown at this time.

GENERAL TOPIC	ISSUE #	Specific Issues Identified by Van Duzen River Watershed Residents	Response Code	RESPONSE
Amphibians	19	Is a decline in frog population a possible impact from herbicides?	1	The consideration of herbicides in the watershed analysis has a complex and difficult history. A lot of information was submitted to the agecies by PALCO and environmental groups regarding the potential impact of herbicides during the development of PALCO's HCP. It was not possible to review all of this material prior to deadline for completing the HCP. PALCO's application of herbicides is consistent with all state and federal requirements. In addition, CDF has found a lack of substantive evidence showing that herbicide use could be a significant effect within the meaning of CEQA. If there is determined to be a toxic effect the responsibility for changes or alterations in herbicide registration, licensing, labeling and use are within the responsibility and jurisdiction of the CA Dept. of Pesticide Regulation and the US EPA. Direct effects of herbicides on amphibians are outside the scope of the Watershed Analysis and is not a covered activity of the HCP.
Amphibians	100	Loss of frogs and amphibians: Once the home to thousands of frogs, the Van Duzen now supports a small population.	4b	The amphibian and reptile module of the Watershed Analysis will address sediment regimes and riparian forests necessary to protect habitat. It is important to note that a population-level inquiry is not feasible, necessitating an approach based on habitat presence. The project team welcomes any information that would help characterize the population status of amphibians and reptiles over time.
Amphibians	101	Are water temperatures approaching stressful levels for amphibian life?	4a	There is limited temperature data for the basin, but the information will be reviewed as well as an assessment of the role of the canopy in protecting temperatures in the riparian and fisheries modules. Two of the amphibians included in the survey are known to be temperature sensitive (i.e., tailed frog, and southern torrent salamander), and that two are relatively insensitive (northern red-legged frog and foothill yellow-legged frog). Also see response to comment #119.

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Amphibians	102	Does herbicide usage affect amphibian habitat?	1	The amphibian and reptile surveys are keyed to habitat conditions. Assessment analysts are asked to develop an understanding of those processes or factors that are most significantly affecting habitat. It is should be noted however that herbicides are not included in the HCP or explicitly studied in the Watershed Analysis.
Chemicals	69	Herbicide use: The present assessment is lacking in herbicide analysis related to wells, disturbance of soils, surface erosion, and the decrease in fish and wildlife populations. If herbicide use is not considered independently then it should be included in analyzing the other modules. The community is seriously concerned about herbicide use.	1	The commentor's concern regarding the use of herbicides within the Van Duzen River watershed will not be addressed in this Watershed Analysis. As noted above in response to comment number 19 community concerns regarding the use of herbicides will need to be addressed by those agencies overseeing the conditions of their use. The current use of herbicides by PALCO is consistent with State and federal regulations. This issue is outside the scope of the Watershed Analysis because it is not an activity covered by the HCP. The possible effects of herbicides on surface erosion will be qualitatively considered in the Surface Erosion Assessment.
Chemicals	70	Are herbicides and diesel fuel being applied in the Van Duzen Watershed negatively impacting salmonid and other amphibian species?	1	The commenter is referred to responses for comments 69, 19, and 102.
Community Involvement	1	What is the timetable for the process? How long will the analysis take?	4a	Information on the status of the project will be available to the community through the community involvement features of the Watershed Analysis process including direct involvement and public meetings. Other communication tools are also being considered (e.g., newsletter). The complete Watershed Analysis process is expected to take less than a year.
Community Involvement	11	Interest in more public outreach to include more people in the watershed, including residents further upstream.	4b	Another public meeting was held at the Carlotta Grange in July with all module lead analysts in attendance -- more public meetings are planned for the future. In addition, email and voice communication will also be used between the technical team and interested members of the community. The project library will also be available as a resource to interested community members.

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Community Involvement	15	Interest in newsletter to increase communication.	4b	Recommendation is outside the scope of the Watershed Analysis, but is being considered. Other forms of communication and involvement of the community will be presented to the Signatory Review Team for their consideration.
Community Involvement	20	Interest in improved communication with the community via a website. Interest in including a calendar of activities and meetings on the website.	4c	See response to # 15 above.
Community Involvement	25	Community willingness to host team to promote interaction. People in the watershed would be happy to host the team to explain what they know about the watershed.	4c	Have already acted on this comment - see response to # 11 above.
Community Involvement	35	Interest in a community survey to gather individual observations and historical information on what the Van Duzen was like. Suggested as a good way to develop a history of the river.	4c	See response to # 11 above.
Community Involvement	39	The "Grange Facility" was suggested as a site for future community/public meetings. Also suggestions of possible other public outreach sources: Outpost, Bridgeville school newsletter, Swain's Flat, Hydesville Market.	4a	See response to # 11 above.
Community Involvement	117	Community involvement: In this the first scoping section of the Watershed Assessment, many citizens were unaware of the initial meeting.	4a	See response to # 11 above.
Cumulative Effects	72	Cumulative Impact Analysis: The previous history of logging in the watershed must be analyzed to understand how we arrived at our present situation. To understand the full impact of previous logging, timber harvest plans from the past 40 years should be analyzed. Future plans should be looked at as a whole to preserve the integrity of the river.	4a	Not only will harvest plans within the past 40-years be evaluated, but plans prior to this period will be assessed as well. This is necessary due to the large effects of first-cycle logging. Previous logging history and its effects are considered in several assessments (Mass Wasting, Surface Erosion, and Stream Channel). The goal is to understand what led to different conditions and the likely effect of future actions. This comment will also be addressed in the evaluation and discussion related to the sub-basin disturbance indices.

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Cumulative Effects	78	Will the Cumulative Effects Module include the function of the Van Duzen River, including sediment (depths of pools) and water temperature?	4a	Yes, but see response to #55 above.
Cumulative Effects	79	Will the Cumulative Effects Module predict the impact of logging in 10-year periods?	4b	Currently the Watershed Analysis process is to be repeated every five-years for the life of the HCP. Thus past and future time intervals will be periodically updated. It is important to note that some watershed processes will need to be evaluated on time scales that are appropriate for the mechanisms at work. The Cumulative Watershed Effects assessment and Watershed Analysis as a whole try to project future effects of management but not necessarily in 10-year increments. Watershed Analysis also looks at the 10 previous years.
Cumulative Effects	80	Will the Cumulative Effects Module give recommendations for the recovery of the Van Duzen River?	1	The process will lead to prescriptions for PALCO ownership but not for the VDR basin as a whole. The HCP applies to PALCO ownership only, other private and public lands are not subject to the prescriptions developed through this process.
Domestic & Agricultural Water Use	48	What steps will the Pacific Lumber Company take to insure the continued beneficial uses of water for residents of the Van Duzen Watershed?	4b	Watershed Analysis leads to prescriptions that are designed to provide, over time, for properly functioning conditions (PFCs). These include many areas related to beneficial uses of water (e.g., temperature). However, WA is not currently being used to satisfy the requirements of the 303(d) Total Maximum Daily Load (TMDL) process, although that has been discussed with the Regional Water Quality Control Board staff. For those watersheds listed as impaired, the aquatic properly functioning condition (PFC) matrix calls for negative net discharge to lessen the degree of impairment through time.

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Domestic & Agricultural Water Use	71	Are herbicide and diesel fuel affecting wells and drinking water?	1	The monitoring and sampling that would be necessary to address this question is not within the scope of this Watershed Analysis. This question is more within the realm of County health authorities or the Regional Water Quality Control Board, which are agencies that normally oversee issues related to drinking water. In addition, herbicide and diesel fuel use are not covered activities under PALCO's HCP, thus the potential effects of herbicides and diesel fuel use are outside the scope of the Watershed Analysis. Also see response to comment #69.
Domestic & Agricultural Water Use	105	Beneficial use of water: Because of increased sedimentation, many wells that used the river for drinking water have dried up.	1	Watershed Analysis will address sedimentation issues but not well water use. However, it is possible that information from the Hydrology Assessment may shed some light on the fate of wells that have gone dry in recent history.
Domestic & Agricultural Water Use	106	Will you be surveying community members for this loss of beneficial use of water for drinking and irrigation?	3	No. The status of beneficial uses of water within the Van Duzen River watershed is assessed by the Regional Water Quality Control Board. See also response to comment #105.
Economics	3	When does the cost / benefit and risk analysis occur? During the prescription phase?	1	Cost / benefit and risk analysis are not explicitly an element of Watershed Analysis. Where possible confidence intervals are provided and uncertainty is addressed. However, prescription writing may consider cost / benefit and risk. The primary tool used in the analysis is the proper functioning condition (PFC) matrix for watershed elements. The analysis is not risk-based. Rather the main question to be addressed is whether the PFC conditions are met and if not what is the expected rate of attainment.
Economics	13	Route 36 sees 170,000 tourists a year to visit parks. Protection of areas that draw visitors is important to the economic health of the area.	3	The economic health of the area is not covered in PALCO's HCP and is therefore outside the scope of the Watershed Analysis.
Economics	14	What algorithms will be used in economic analysis?	3	The HCP requires the agencies to consider PALCO's economic position. Economic analyses will be done by the company. Any economic analyses will be considered by the agencies related to the properly functioning condition (PFC) and rates of attainment.
Economics	27	Interest in starting a nursery to improve forest canopy and create jobs	1	Acknowledged. However, such jobs programs are outside the scope of the Watershed Analysis.

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Economics	115	Tourism: today tourism is the 2nd leading industry in Humboldt County. Over 70,000 tourists visit the parks along Highway 36 in Carlotta. There is a large economic concern that logging at its present pace will damage the watershed to such a degree that people will no longer visit the parks along the Van Duzen River. Today the parks are full from July – Labor Day.	1	The Watershed Analysis is designed to lead to prescriptions that will achieve, or maintain, over time properly functioning conditions (PFCs).
Economics	116	How will logging in the watershed and the health of the Van Duzen River affect the economic base for tourism?	1	See response to #115. Economic analysis of tourism is outside the scope of the Watershed Analysis.
Exotic species	16	Concern over exotic species, specifically squawfish.	4a	Exotic species will be addressed in the Fisheries Assessment.
Fish	10	Lower Basin is biologically important and is of great concern for fish species.	4a	The Lower Basin will be addressed in the Yager Creek Watershed Analysis.
Fish	18	Interest/concern over timing of surface erosion and its effects on fish, e.g., occurrence in winter when anadromous fish are not in the river, timing of logging operations. Dec., Jan., Feb. logging introduces siltation that covers up steelhead spawning habitat. Logging roads and helicopter logging impacts sediment transport. Part of the problem of doing studies in summer — winter is when sediment goes into stream.	4a	A significant portion of the Watershed Analysis is concerned with where sediment comes from and how it affects fish. The Mass Wasting and Surface Erosion assessments include both dry-weather and wet-weather sediment sources. The HCP requires many wet-weather operating restrictions, and also road upgrading and storm proofing to lessen the impacts of roads on the aquatic environment.
Fish	26	How will fish sampling occur? What methodologies will you be using?	4a	A variety of methods will be used including: diving, electrofishing, and stream habitat surveys.
Fish	41	What happens if no Coho are found?	4a	If a reach historically supported fish species, it is considered a sustainable reach and must be recovered to its former condition.
Fish	58	Cummings Creek is a critical producing-producing stream that is heavily impacted by sediment.	4a	Comment noted. E62 Cummings Creek will be examined in the Fisheries and Stream Channel Assessments.
Fish	59	Presence of a barrier in lower Wilson Creek prevents fish from migrating upstream and out-migrating seasonally.	4a	Comment noted. The Watershed Analysis scientists will consider the effects of fish barriers - both natural and man-made on fish passage.

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Fish	92	Loss of salmon and steelhead: Presently fishing licenses in the Van Duzen are catch and release. Once the home of thousands of fish, the population has diminished to a critical level. Deep holes are rapidly disappearing.	5	Comment noted.
Fish	94	What are the present salmon and steelhead counts for each of the tributaries of the Van Duzen, and for the river itself?	4c	All available data on fish counts will be reviewed and analyzed in the Fisheries Module. However, only limited data (primarily from PALCO lands) are thought to be available. Importantly, PALCO's HCP requires protection of streams regardless of the number of fish present.
Fish	95	Are there maps to show historic and present distribution of streams producing and steelhead?	4c	Some maps were developed by the EPA for the VDR TMDL, others for PALCO's HCP. The Fisheries Module will develop a map of current fish distribution only.
Fish	98	When do scientists project that sediment and temperature conditions in most Van Duzen River tributaries on company property be suitable for the return of steelhead in significant numbers and have the streams be able to support production?	4c	Existing fisheries surveys have documented the presence of steelhead in the Van Duzen River and its tributaries. This information will be reviewed to determine their current status. The Watershed Analysis should be able to indicate whether habitat and temperature trends are improving or declining. That is, the modules should be able to broadly characterize the current and future suitability of habitat in the watershed, but will not be able to predict or estimate population trends in response to these conditions.
Flooding	81	Flooding: Many citizens have had their properties damaged from flooding of the Van Duzen River. Due to the increased sediment and the narrowing of the deeper channel, some citizens of Carlotta are at high risk for flooding.	4a	Changes in channel conditions due to sediment from PALCO's lands will be considered in the Watershed Analysis. However, a formal analysis of flooding is beyond the scope of the Watershed Analysis. This is an issue that is considered in the THP. Also see response to #55.

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Flooding	82	What will be done to deepen the channel to prevent flooding?	1	The HCP limits the scope of prescriptions that can be modified through Watershed Analysis. Elements that can be modified are hillslope management prescriptions, Channel Migration Zone (CMZ) prescriptions, Class I-III Riparian Management Zone (RMZ) prescriptions, disturbance indexes and monitoring. The management actions of direct reworking or modification of the channel cross-section is not on the list. It is also important to note that channel deepening to reduce flood capacity often negatively impacts fish habitat and often leads to increased bank erosion.
General Project Design or Implementation	2	Can methods be added to the WDNR methodology?	1	The Washington Department of Natural Resources (WDNR) methods were significantly expanded and revised during the Freshwater Creek Watershed Analysis. PALCO and the signatory agencies will consider modifications to the existing methods if the need can be demonstrated. The Van Duzen WA Team is also using the lessons learned during the Freshwater Creek WA.
General Project Design or Implementation	7	What are the boundaries of the analysis? How far up river does the analysis go?	4a	Level II Watershed Analysis applies to PALCO ownership from the mouth of Yager Creek to just above Goat Rock but below Bridgeville. Level I Analysis will apply to all lands within those same boundaries.
General Project Design or Implementation	17	Concern over mixed ownership and how the analysis and its resulting recommendations will include the integration of other landowners in the watershed.	4b	PALCO ownership will be analyzed at Level II (more intensive), while other lands will be considered at Level I analysis. The Watershed Analysis goal is management prescriptions for PALCO lands; other landowners will not be considered or included in management recommendations.
General Project Design or Implementation	23	Concern over introduction of pollutants associated with logging operations (chainsaw fuels, vehicles without catalytic converters).	1	This question is outside the scope the scope of PALCO's Watershed Analysis. This question is addressed in the CEQA findings and will also be addressed in THPs.
General Project Design or Implementation	30	What is the purpose of the Watershed Analysis? For restoration opportunities? For better timber harvest plans?	4b	The purpose of the Watershed Analysis is to fulfill the conditions of PALCO's HCP to achieve or maintain proper functioning conditions. Yes, to manage lands better.

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General Project Design or Implementation	32	The institutional knowledge available in the area through local foresters regarding the effects of forest practices should be recognized.	4a	Yes - PALCO manages much of the land; however, foresters from other companies may not be available.
General Project Design or Implementation	34	What ongoing monitoring will be required?	4a	Monitoring is addressed as a final recommendation in the Watershed Analysis. Currently the answer to this question is unknown.
General Project Design or Implementation	37	Interest in the use of local professional archivists to help find and gather information.	4c	Comment noted. May consider their use as we move forward in the process.
General Project Design or Implementation	46	What steps will Pacific Lumber Company take to protect the forests used by the community of Carlotta between Church Lane, Riverside Park Road, and Pamplin Grove?	4b	There are no official or approved public recreation uses of PALCO lands in the areas described in the comment. Public use of the property without permission is trespassing. However, PALCO has modified its practices recognizing the impact of their activities on the local community in the areas described. For example, several cuts have been modified to protect the viewshed in these locations. The company will also continue to give consideration to community interests when evaluating prescriptions to achieve proper functioning conditions in these locations.
General Project Design or Implementation	51	Concerns regarding watersheds upslope from the Grizzly State Park Property and the recovery of the Van Duzen River in general.	4a	The project team will solicit the input of park personnel to help determine the impact of PALCO managed lands on the park lands. The Mass Wasting Module addresses slope stabilities. VDR is a huge watershed and some factors affecting the river are outside the scope of the study and beyond PALCO ownership. Therefore it may be difficult to apportion any potential impact between non-PALCO lands and PALCO lands within the watershed. PALCO is doing its part through the HCP by performing the Watershed Analysis and aquatic monitoring to determine how prescriptions can be modified. A study evaluating the entire Van Duzen River will require a more comprehensive future effort.
General Project Design or Implementation	52	Observations of degradation rather than siltation in lower reaches of the Van Duzen.	1	This portion of the Van Duzen will be addressed in a later Watershed Analysis for Yager Creek.
General Project Design or	56	Recommendation that the Van Duzen be analyzed separately from the Yager watershed.	4a	The Watershed Analysis boundaries are already consistent with this recommendation.

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Implementation				
General Project Design or Implementation	77	Where are the maps that show the frequency of logging in each of the tributaries of the Van Duzen?	4b	The project team is compiling available information on logging history within the study area. This information may not be integrated into a map coverage layer (this is an expensive process). However, logging history is considered in the Watershed Analysis.
General Project Design or Implementation	103	In the Riparian and Amphibian Modules will you be using automated temperature probes at 1 meter, 10 meters, 20 meters, and 30 meters from the stream in three locations with varying canopy cover and width?	4c	No. This level of sampling is currently beyond the scope of agreed upon methodologies. The current approach for this Watershed Analysis is a quick review using existing data with limited field studies. As part of the monitoring component of the HCP and WA, specific hypotheses will be developed to test the effectiveness of specific prescriptions and to clarify areas of uncertainty. This does not imply that this specific concern over temperature is one of the specific uncertainties to be addressed.
General Project Design or Implementation	118	Peer evaluation: Is this plan going to peer review, when, where, and who will be involved?	4c	The public involvement process provides for copies to be provided for peer review by interested community members. Agency representatives also solicit independent professional review of all analysis documents during the public review periods.
General Project Design or Implementation	122	Historical information: What agencies will be involved with collecting past data on the Van Duzen concerning rainfall, flooding, habitat counts, and channel depths?	4a	PALCO and its consultants do the Watershed Analysis work. CDF, CDF&G, NMFS, DMG, USFWS, and RWQCB cooperate in managing the work.
Hydrology	28	Will in-stream gravel mining be considered?	4a*	Gravel mining occurs outside the boundary areas of this Watershed Analysis, but will be considered where appropriate in other Watershed Analyses.
Hydrology	57	Watershed Analysis should include provisions for 100-year storms that are hitting more frequently.	4a	The Hydrology Assessment considers fluctuations in rainfall, including 100 year storms.
Hydrology	62	Root Creek Floods at high water at the mouth where it enters the Van Duzen.	4a	Comment noted.

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Hydrology	84	What is the increase in flood risk associated with recent aggradations in the Van Duzen River tributaries and how is that changing flood frequency?	4a	See comments #55 and # 81.
Hydrology	109	How does clear cutting and rainfall interception apply to issues of flooding, landslides, and sediment in the Van Duzen River Watershed?	4a	The Hydrology Module addresses the impacts of clear cutting on peak flows. The Mass Wasting and Surface Erosion Modules consider sediment impacts.
Mass Wasting	128	Will the study utilize the shallow landslide model which predicts where shallow debris slides will be occur. Will this model be based on 10 meter data versus 30 meter data?	4a	Some modeling with Level 1 Stability Analysis (LISA) is likely -- model selection will be driven by best resolution possible.
Prescriptions	31	How are clear cuts rationalized?	1	It is not the purpose of the Watershed Analysis to rationalize clear cuts. Rather the purpose is to evaluate the watershed's physical processes and to determine the impact of management actions on those processes. The goal is to provide information to the prescription writing team to develop a management approach that ensures positive movement towards proper functioning conditions (PFCs).
Prescriptions	53	Concerned about the effects of logging on a wild and scenic waterway.	4a	The Van Duzen River has not been designated by Congress as a Wild and Scenic River. However, it is understood that the comment reflects concern regarding the status of natural condition of the Van Duzen River. One objective of the Watershed Analysis is to evaluate the river relative to the proper functioning conditions (PFCs) that are described in the Watershed Assessment Methods for PALCO Lands -- the PFCs are the target for maintaining the river.
Prescriptions	54	Will there be consideration of selective logging rather than the use of clear-cut methods?	1	Management practices are covered in prescription writing not in the Watershed Analysis. When evaluating cumulative effects past management practices are evaluated to determine their role in producing current conditions. The information from the Watershed Analysis could be used to support or develop a wide range of harvest prescriptions, including selective logging in areas with identified hazards.

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Prescriptions	65	Concern regarding future harvest in the vicinity of Rainbow Bridge.	1	This information has been provided to Riparian and Stream Channel Assessment analysts.
Prescriptions	73	How many timber harvest plans are expected to be filed and logged in the interim prescription period?	1	THPs in the study area date from 1997 to the present. There are 17 active or approved THPs with 4 additional THPs that have been submitted for approval. This does not mean that there are 21 active THPs -- some were approved and never acted on, while others have been completed and simply have not been signed off on.
Prescriptions	74	What is the Master Plan for Carlotta, Hydesville, and Bridgeville? What regions are going to be logged, and what regions are going to be maintained?	1	We are in the Watershed Analysis phase of this process. The watershed prescriptions will be based on the Watershed Analysis. The watershed prescriptions provide guidance for long-term land management activities. Land areas with lower resource sensitivity will have less in the way of restrictions, and those lands are more likely to be subject to harvest. Lands with higher resource sensitivity will have more restrictive guidelines. On these lands natural processes will be the major force for change in these areas. The current HCP defines existing requirements. Any changes in the prescriptions for the listed areas will not be known until the process is complete.
Prescriptions	75	Why are we looking at logging plans in the Van Duzen watershed on a plan by plan basis instead of the 100 year approach?	1	Watershed Analysis is one method for developing long-term plans. It is possible that this process may provide the capability to develop more comprehensive THPs for the watershed.
Prescriptions	76	Why is Pacific Lumber Company returning every 5-7 years to log an area, and not allowing the forest to recover?	1	The purpose of Watershed Analysis is to provide information for prescription writing that will allow the forest landscape to achieve properly functioning conditions (PFCs) over time. The Watershed Analysis will provide PALCO with the information necessary to determine the sensitivity of lands within the watershed.
Prescriptions	83	What will be done to prevent the flow of sediment which fills in the channels?	1	The purpose of the Watershed Analysis is to identify prescriptions that maintain or achieve proper functioning conditions (PFCs), which includes controlling management related sediment from entering streams.

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Prescriptions	90	What is the current practice for not allowing any more sediment into the Van Duzen River?	1	There is some level of sediment input to the river at natural background levels. Several beneficial management practices (BMPs) are already underway to reduce the amount of sediment that enters the river as a result of management actions (e.g., road improvements). The Watershed Analysis will support a refinement of these BMPs to further restore a sediment budget that allows the river to achieve a properly functioning condition (PFC).
Prescriptions	96	In creeks that are over temperatures that support salmonids, what is the company doing to accelerate recovery?	1	Refer to the HCP for current practices -- see sections on interim riparian management zones (RMZs) standards -- sections 6.3.4.1.2 trough 6.3.4.1.4 (pages 50-56). The point of Watershed Analysis is to identify areas of concern to inform the prescription team so that prescriptions can be modified in a manner that will hasten recovery to the maximum extent possible.
Prescriptions	111	What other methods can be used to prevent sediment from entering the river?	1	The Watershed Analysis of sediment sources should provide improved information on sources and processes for sediment inputs that will allow managers to make informed decisions regarding site-specific prescriptions.
Prescriptions	112	Issue of recovery: We believe that one of the major purposes for the Van Duzen Water Assessment should be to develop prescriptions to aid in the recovery and restoration of the river.	1	The goal of the Watershed Analysis is to develop information that will lead to prescriptions that are designed to achieve or maintain proper functioning conditions (PFCs).
Prescriptions	113	How will this study make recommendations to restore the river to a non-polluted status?	1	The goal of the Watershed Analysis is to develop prescriptions that will achieve or maintain proper functioning conditions (PFCs). Also see response to comment # 112 above.
Public Trust	36	Concern over management history and past changes in ownership and how different owners' management practices (e.g., Louisiana-Pacific) have affected the watershed.	4b	Contacts will be made with adjacent landowners to provide input or to participate in the Watershed Analysis. Previous land use practices will be considered in WA.
Quality of life / Private Property	33	Concern over the impacts of forestry operations, helicopter operations in particular, on the quality of life (noise).	1	The Watershed Analysis required by the HCP focuses on physical processes in the watershed and how these functions are impacted by management practices. Helicopter activity is not one of the management practices identified for evaluation in the Watershed Analysis. Also refer to response to comment # 82.

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Quality of life / Private Property	47	What steps will the Pacific Lumber Company take to lower the decibel levels in the use of helicopter logging in Carlotta communities.	1	Outside the scope of the Watershed Analysis. Refer to the response to comments # 33 and # 82.
Quality of life / Private Property	85	Sedimentation buildup -- natural causes: Many large ranches have lost acres of property due to the aggradations of the river. Because the Van Duzen is a wild and scenic river, cooperation with the Army Corps of Engineers is necessary for any bank protection. This has not occurred within our community.	5	The location of the areas of concern in the comment are outside the study area of this Watershed Analysis. It also important to note that the Van Duzen River has not been designated by Congress as a Wild and Scenic River. The Mass Wasting, Surface Erosion, and Stream Channel Modules should provide some information about how the study is contributing to the area of concern. Also see response to comment #55.
Quality of life / Private Property	86	Can PALCO work with the Army Corps of Engineers to reinforce banks to prevent additional sediment from entering the river?	1	Outside the scope of the Watershed Analysis. The WA describes natural channel processes and how these processes have been impacted by management activities. Also refer to response to comments # 33 and # 82.
Recreation	107	Recreational uses: Today, the Van Duzen is shallower than it has been at any time in the past 20 years. Deep holes are rapidly disappearing. In several places in the river, sediment has filled up to 10 feet taking out the deep holes. Canoe and kayak use in many parts of the river has diminished due to the shallow waters.	4b	Comment noted. Due to the location of the study area within the VDR watershed it makes it difficult to evaluate issues within the mainstem of the river. We also recognize that we are working in a dynamic and highly variable landscape. The Watershed Analysis should provide a better understanding of the status of pools within the river and trends for the future. Also see response to comment to #55.
Regulations	66	The Model for the Assessment: How does this model apply to our specific watershed? The Van Duzen River is at present a 303d sediment impaired river. What modifications, corrections, or adjustments does the assessment make or need to make to address the present status of the Van Duzen River?	1	There are ongoing discussions between the RWQCB and PALCO regarding how the HCP addresses Total Maximum Daily Load (TMDL) implementation recommendations. Currently the HCP does not address TMDLs.

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Restoration Projects	12	Interest/concern for restoration: Big concern is parks and support for restoration projects. · Healy Creek used to support large amount of salmon now scoured out. · There is a lack of access to Stephens Creek.	4b	Comments noted. The objective of the Watershed Analysis is to inform the prescription writing process which calls for management actions that support a trend in the watershed for proper functioning conditions (PFCs) (e.g., restoration of salmon, reducing sediment inputs through improved roads).
Restoration Projects	42	What steps will Pacific Lumber Company take to restore the wild and scenic Van Duzen River?	4b	The goal of the Watershed Analysis is to develop prescriptions that will achieve or maintain proper functioning conditions (PFCs). It is important to note that the Van Duzen River has not been designated as a Wild and Scenic River by the U.S. Congress -- a designation that has been made for several other California rivers (e.g., Merced). The goal of PFCs is not to return the river to pre-settlement or wilderness conditions. Rather PFCs ensure the protection of species listed in the HCP.
Restoration Projects	43	What steps will Pacific Lumber Company take to improve the tributaries of the Van Duzen?	4b	The goal of the Watershed Analysis is to develop prescriptions that will achieve or maintain proper functioning conditions (PFCs).
Restoration Projects	60	Fox Creek not restorable due to a Cal Trans barrier.	4b	Comment noted. Information has been incorporated into the fish distribution map and has also been included into the table of fish migration barriers.
Restoration Projects	89	What is the current plan for removing/moving the sediment from the Van Duzen River?	1	Outside the scope of the Watershed Analysis, but the WA will identify sediment sources and possible prescriptions. Also refer to response to comment #82.
Riparian Condition	126	What changes have taken place in riparian vegetation in the tributaries and the main Van Duzen River?	4a	The Riparian Module evaluates changes in the composition of the riparian canopy over time through aerial photo interpretation. As part of the sediment source inventory, currently being conducted by Pacific Watershed Associates, a historic harvest history map will be developed.

GENERAL TOPIC ISSUE #		Specific Issues Identified by Van Duzen River Watershed Residents	Response Code	RESPONSE
Seasonality	4	Studies generally only occur in summer. Are summertime analysis and field seasons adequate to witness and evaluate winter conditions? Are the dramatic differences in seasonal variations adequately taken into account?	4a	The sampling and assessment methods are robust relative to seasonal conditions. There is also a substantial amount of historical data for flow during winter months that will be used to evaluate models and other forms of analysis that are used to evaluate conditions in the stream during winter months. Summer is the preferred field season for the Amphibian Assessment. The agencies are also working with PALCO to develop effective turbidity monitoring protocols. Information generated as part of the Watershed Analysis will be instrumental in guiding the monitoring.
Seasonality	67	The assessment is being done in the summer of 2000. Winter monitoring is necessary to validate the samples and the analysis. The Van Duzen River today is at its lowest depths in the past 20 years for this time of year. How is this taken into account in the assessment?	4a	The analysis will overlap somewhat with fall and winter conditions. Also the study will use long-term monitoring data at sites located within the study area. Stream Channel Module measures are independent of flow volumes. Critical low-flow refugia for fish will be evaluated during the dry period. Also refer to response to comment # 4.
Sediment production, transport & deposition	6	How much data do you have on sediment transport after harvest?	4a	Sediment transport from all land use categories present in the watershed are evaluated. The PWA sediment source inventory will be used.
Sediment production, transport & deposition	40	How is the sediment budget used in the analysis?	4a	The sediment budget will be used to characterize the relative inputs of natural and human induced sources. This will be used to help focus management efforts to control sediment inputs.
Sediment production, transport & deposition	44	What steps will Pacific Lumber Company take to prevent further sedimentation into the Van Duzen?	4a	The goal of the Watershed Analysis is to develop prescriptions that will achieve or maintain proper functioning conditions (PFCs).

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Sediment production, transport & deposition	87	Sedimentation buildup -- man-made causes. According to the EPA study, there is a high percentage of controllable sediment going into the Van Duzen River from logging roads and skid trails. These problem areas need to be repaired to avoid increased sedimentation into an already impaired watershed. According to the Sediment Source Investigation for the Van Duzen River Watershed 1999 by Pacific Watershed Associates, over a 44 year analysis period, potentially controllable sediment sources in the lower watershed totaled 2,505, 500 cubic yes.	1and 5	Comment noted. The Watershed Analysis will use the Total Maximum Daily Load (TMDL) as existing information. In addition, the Mass Wasting and Surface Erosion Modules will identify sediment sources. PALCO is currently upgrading their road network and existing and future prescriptions will continue to focus on reduced sediment loads from management activities.
Sediment production, transport & deposition	88	What are the recent trends for fine sediment in each of the tributaries of the Van Duzen River?	4b	To the extent possible, sediment input trends will be addressed in the Mass Wasting and SurfaceErosion Assessments.
Sediment production, transport & deposition	93	Are the fine sediment levels exceeding those required for salmon and steelhead?	4a	There is limited information available to describe current conditions for turbidity and suspended sediment. The analysis will rely on existing information as part of the Fisheries Assessment and the Cumulative Watershed Effects assessment. This potential hazard will be evaluated as part of the Watershed Analysis. The agencies are working with PALCO to identify an approach to reduce uncertainty on this key parameter.
Surface and Streambank Erosion	50	Concerns regarding Grizzly Creek State Park and the observed rates of bank erosion.	4b	Channel surveys and large woody debris (LWD) inventories will allow the watershed scientists to characterize the source, process, and volume of functional wood contributed into stream channels. The Stream Channel and Riparian Assessments attempt to characterize natural background rates of bank erosion and identify those activities that have accelerated bank erosion. This information is then used in the prescription writing process to ensure that this aspect of the river is trending to proper functioning conditions (PFCs).
Trends in Condition; Targets	5	Will historic conditions be considered in addition to current conditions?	4a	Historical data is used in the Watershed Analysis.

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Trends in Condition; Targets	8	Concern over disturbing trends in beneficial uses: · Decline in fish populations · Increases in Sediment · Dangerous flooding · Property damage · Damage to residential and ranch water supplies · Loss of recreational opportunities · Impaired aesthetic enjoyment · Landslides · Stagnant water and algae · Excessive Turbidity · Decline in owls, osprey, otters, tadpoles, frogs, salamanders	4b	The Watershed Analysis process should provide information which will contribute to an improved understanding for many of the listed concerns. However, several of the items listed are outside the scope of the Watershed Analysis.
Trends in Condition; Targets	9	How will the Watershed Analysis address 303(d) listing and Total Maximum Daily Load (TMDL) compliance? What is the crossover between TMDL and WA?	4b	The Total Maximum Daily Load (TMDL) covers the entire Van Duzen watershed. This Watershed Analysis does a more intensive (Level II) analysis on PALCO lands, which comprise only a fraction of the total watershed. The WA also does a less intensive (Level I) assessment on lands owned or managed by others within the study area. There is no formal crossover between the Watershed Analysis and the TMDL. However, many of the Beneficial Management Practices (BMPs) that will be considered for implementation in the prescription writing phase will help achieve the TMDL sediment reduction objectives. The RWQCB is evaluating the overlap between watershed analysis and TMDL implementation.
Turbidity	120	How will each tributary be measured for sediment and turbidity in the study?	4c	The Watershed Analysis uses historical information (e.g., TMDL and Kelsey thesis). Back calculations from channel morphology measurements to estimate sediment storage volumes. Also see response to comment #120.
Turbidity	121	How will each tributary be measured for sediment and turbidity following the study?	4c	Monitoring recommendations are developed following the completion of the Watershed Analysis. The methods will be developed by PALCO and the signatory agencies.

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Water Quality	21	Concern over herbicide effects on water quality and public health, link to Surface Erosion Module.	1	The issues of water quality and public health are outside the scope of the Watershed Analysis because herbicides are not an activity covered by the HCP. The Surface Erosion Module will qualitatively evaluate the effects on vegetation from management practices and the impact on increased erosion. Also refer to response to comments for 19, 69, and 102.
Water Quality	22	Why are herbicides not part of the HCP and Watershed Analysis process?	1	The following information was provided by the USFWS and comes from the Record of Decision for the purchase of the Headwaters Forest (Section V. Covered Activities). Forest Chemicals: In the July 1998 Draft HCP, PALCO proposed incidental take coverage for forest chemicals including fertilizer and several herbicides, without providing a detailed analysis of effects. The draft EIS/EIR provided a basic analysis of several herbicide compounds commonly used by the company. During the public comment period, PALCO submitted a detailed risk assessment supporting use of these compounds; detailed comments in opposition to herbicide use were also received. Given the short time period available for highly technical analysis, the Services determined that incidental take permit coverage would not be provided at this time, and informed the company that if such coverage was desired, it would have to be covered by a subsequent permit amendment. This decision does not preclude the company from using herbicides, but authorization is not provided for take of listed species that might occur as a result of herbicide use."
Water Quality	37	Interest in a "water quality emergency hotline" to report events (e.g., a tributary is seen to be carrying excessive dirt).	1	This issue is outside the scope of the Watershed Analysis because it is not an activity covered by the HCP.
Water Temperature	97	Will you be deploying automated temperature probes at the mouths of each tributary and at intervals on the tributaries?	4c	This level of monitoring and data collection far exceeds the sampling that is done for a Level II Watershed Analysis. Temperature monitoring is part of the PALCO long-term trend monitoring that is being conducted on a limited scale.
Water Temperature	99	Are water temperatures approaching stressful levels for Coho and steelhead?	4b	This will be addressed in the Fisheries Assessment.

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Water Temperature	124	What impact has riparian timber harvest had on stream temperatures in other PALCO watersheds?	1	The Riparian Assessment will assess the condition of the riparian shade canopy in the Van Duzen and attempt to determine what role it plays in regulating stream temperature. In the Freshwater Creek Watershed Analysis the dominant factors affecting stream temperature were coastal fog and springs -- there was minimal impact on temperatures in Freshwater as a result of shade canopy. The coastal fog belt covers only a portion of the Van Duzen River and the factors controlling stream temperature are currently not as well understood.
Water Temperature	125	What is the relationship of a multi-tiered canopy structure to relative humidity over the stream and to maintaining cool stream temperatures?	4a	This relationship will be evaluated using published literature. To conduct a field study of this relationship in the Van Duzen River would require research that is outside the scope of Watershed Analysis.

RESPONSE CODE KEY: 1) Issue outside of Watershed Analysis scope // 2) Untested theory: may need to incorporate into Assessment; see guidance in CWE Manual // 3) Not feasible to address per the definition in the CWE Manual // 4) Issues to Address -- 4a) Issue is addressed in the default WSA methods ; 4b) Issue is partially addressed in the default WSA methods and partially falls into categories 1, 2, or 3 above; 4c) Issue is partial addressed in the default WSA methods; modifications to methods for this analysis may be needed to fully address; 4d) Issue is not explicitly addressed in default methods; modifications to methods may be needed for this analysis // 5) Comment is either a statement that could not be translated into a theory relating management practices to aquatic resources or comment does not address a specific issue (too vague) // * Other response provided