Mattole River Watershed Analysis

Cumulative Watershed Effects

Public Review Draft

September 2011

Humboldt Redwood
COMPANY, LLC

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PHOTOGRAPHS

LIST OF APPENDICES

LIST OF MAPS

Maps are located in each respective module report with the same names listed below.

LIST OF ATTACHMENTS

LIST OF ACRONYMS

ATM	Aquatic Trends Monitoring
BLM	U.S. Bureau of Land Management
CC	California Coastal
CDEC	California Data Exchange Center
CDFG	California Department of Fish and Game
CEQA	California Environmental Quality Act
CFPR	California Forest Practice Rules
cfs	Cubic Feet per Second
CLD	Conifer stand, medium to large trees, moderate/dense canopy (RCU type)
CMZ	Channel Migration Zone
CSZ	Cascadia Subduction Zone
CWE	Cumulative Watershed Effects
DBH	Diameter at Breast Height
EBNF	East Branch North Fork
EEZ	Equipment Exclusion Zone
EPA	U.S Environmental Protection Agency
HCP	Habitat Conservation Plan
HMD	Hardwood stand, small trees, moderate/dense canopy (RCU type)
HRC	Humboldt Redwood Company LLC
IP	Intrinsic Potential
LiDAR	Light Detection and Ranging
LWD	Large Woody Debris
MMD	Mixed conifer–hardwood stand, small trees, moderate/dense canopy (RCU type)
MMI	Modified Mercalli Index
MTJ	Mendocino Triple Junction
MRC	Mattole Restoration Council
MSG	Mattole Salmon Group
MWAT	Maximum Weekly Average Temperature
NC	Northern California
NMFS	National Marine Fisheries Service
NRCS	Natural Resource Conservation Service
PALCO	The Pacific Lumber Company
PFC	Properly Functioning Condition
RCU	Riparian Condition Unit
RM	River Mile
RMZ	Riparian Management Zone
SONCC	Southern Oregon Northern California Coasts
SOP	Standard Operating Procedure
THPs	Timber Harvest Plans
TMDL	Total Maximum Daily Load
$tons/mi^2/yr$	Tons per square mile per year
WAU	Watershed Analysis Unit
WLPZ	Watercourse and Lake Protection Zones
WOP	Watershed Operating Protocol
WWII	World War II

1.0 ABSTRACT

Watershed analysis was conducted for the northern sub-basins of the Mattole River watershed as required by the Humboldt Redwood Company (HRC) multi-species Habitat Conservation Plan (HCP) (Pacific Lumber Company [PALCO], 1999). The HCP watershed analysis process identifies management objectives for protecting, restoring, and enhancing the aquatic habitat of specified salmonids, amphibians, and reptiles. These management objectives are identified by monitoring and reporting watershed conditions and trends, and assessing effects of historic and contemporary forest management. The goal is to maintain or achieve, over time, a properly functioning aquatic habitat condition in streams and rivers affected by the landowner's forest mangement activities. Specific areas of assessment include mass wasting, surface erosion, riparian function, stream channel morphology, and habitat conditions for HCP-covered salmonids, amphibian, and reptiles.

The 140-square-mile Mattole River Watershed Analysis Unit (WAU) is located in Humboldt County, California, 30 miles south of the city of Eureka. The WAU is part of the 296-square-mile Mattole basin, which includes the 62-mile-long mainstem of the Mattole River along with 74 tributary streams. Data collection and analysis was primarily focused on approximately 20 percent (18,000 acres) of the WAU currently owned and managed by HRC for timber production under the HCP. This ownership includes the headwaters of the North Fork Mattole and Upper North Fork Mattole, and portions of the McGinnis Creek and Pritchard Creek sub-basins. These lands were previously owned and managed by PALCO until the summer of 2008.

The watershed analysis area is underlain by bedrock associated with the Coastal and Yager terranes of the Coastal belt. Franciscan Complex bedrock comprises the basement rock in the region. The region is seismically and tectonically active, reflecting a history of sediment deposition and uplift related to convergent tectonics and the northward migration of the Mendocino Triple Junction (MTJ). Several recent earthquakes with epicenters in the greater Mattole watershed region illustrate the highly active seismic setting, including the August 1991 "Honeydew" earthquake (magnitude 6.0 to 6.2) and the April 1992 magnitude 7.1 Cape Mendocino earthquake, with an epicenter near the town of Petrolia. This dynamic geomorphic landscape is characterized by steep terrain and deeply incised drainages due to high regional uplift rates, high rates of seismicity, weak earth materials due to the high levels of tectonic shearing, and large amounts of seasonal rainfall. Two large flood-flow events in 1955 and 1964 coincided with peak periods of unregulated logging and road building throughout much of the basin, resulting in significant volumes of sediment delivery to streams.

A landslide inventory developed through the interpretation of aerial photographs covering the period from 1948 through 2003, along with field reconnaissance found landslide-related sediment delivery to streams has decreased substantially on HRC's ownership since its peak in the 1960s, although the north sub-basins of the Mattole watershed region as a whole continue to have some of the highest mass wasting rates in the Pacific Northwest due to inherent conditions and processes noted above.

The landslide inventory found an estimated total delivery of over 22 million cubic yards over this more than 60-year period of record, with over 70 percent of this volume originating from steep streamside inner gorge slopes. A clear relationship between mid-twentieth century intensive logging operations, the 1964 flood event, and mass wasting was observed with an estimated 11 million cubic yards of sediment being delivered to watercourses from logged over areas between 1955 and 1965. The sub-basins of Oil Creek and Rattlesnake Creek were the primary focus of these early logging entries. Total 'management-associated' sediment delivery from more recently harvested areas (less than 20 years between harvest and slide occurrence), including the contemporary haul road system, declined to an estimated 208,000 cubic yards over the period from 1988 through 2003. Management-associated landslide delivery is reduced to 33,000 cubic yards over this same time period when large and very large landslides, less likely to be caused by management impacts, are excluded. For purpose of comparison and understanding cumulative impacts, total landslide delivery during this same time period, including landslides originating from non-managed and historically logged over areas since reforested, totals 2.1 million cubic yards. The inventory found a continued concentration of mass wasting in the Oil Creek and Rattlesnake Creek sub-basins relative to elsewhere on the ownership.

An analysis of surface erosion processes found past sediment delivery to streams from roads to be nearly on par with natural contributions from soil creep, with sediment delivery from harvested areas contributing only a small percentage. Current road density is 3.2 miles per square mile. Approximately one-half of HRC's road system has been 'upgraded' or 'stormproofed' to HCP standards. With the exception of mainline haul roads and upgraded/stormproofed hydrologically-connected road segments, the majority of the road system is native surfaced and intended for primarily dry season use. The highest unit rates of road-related sediment delivery occur in the Oil Creek sub-basin where native surfaced roads cross erosive mélange soils and occasionally run parallel to watercourses in relatively close proximity, thus increasing potential for delivery. HRC's HCP requires its entire Mattole road system be stormproofed by 2019.

Streamside forest conditions were remotely assessed and characterized through aerial photographic interpretation and field verification. Streamside forest measurements were taken at five separate locations using standard 3P mensuration techniques. Results were compared to historical conditions based on 1948 aerial photographs and the NOAA Fisheries Properly Functioning Condition (PFC) Matrix in order to characterize current and future large woody debris (LWD) recruitment and shade canopy values. Species composition was found to be primarily a mixture of Douglas-fir, tanoak, red alder, willow, California bay-laurel, and big-leaf maple. Older forests with late-seral characteristics occur primarily along headwater Class II streams in the North Fork, Alwardt Creek, Sulphur Creek, and Rattlesnake Creek sub-basins; however, the vast majority of Class I and II riparian stands consist of early to mid-seral forest containing trees less than 24 inches at DBH and in early stages of multiple canopy layer development. LWD recruitment potential was found to be greatly diminished relative to historic pre-logging conditions but slowly recovering. Streamside forest canopy is typically dense except for local grassland openings and sparsely vegetated inner gorge slopes. Overstream canopy cover in excess of 85 percent is common for Class II streams, and greater than 70 percent cover is common for smaller Class I tributaries, whereas, canopy cover varies over third- and fourth-order streams with the least shade found in the Oil Creek and Rattlesnake Creek sub-basins. While PFC targets for shade canopy are currently being met throughout much of the watershed, targets for riparian forest tree size are several decades away from being achieved as a whole.

Significant spatial variability in channel and valley morphology was found across HRC's ownership driven by differences in channel gradient, valley width, channel confinement, tributary confluence areas, near-stream topographic roughness, large wood accumulation potential, earthflows and other forms of mass wasting, and sediment supply. Reductions in erosion and sedimentation in many parts of the channel network are evidenced by trends of overall coarsening of the bed substrate, a lowering in channel elevation (incision), and fewer fines in the substrate. Although, sedimentation does not appear to be a common limiting habitat factor, some local areas have either accelerated erosion linked to streamside landsliding or impingement by active earthflows. These processes appear to be unrelated to contemporary management.

Channel morphology is dominated by large substrate (boulders and cobbles) and, with the exception of the lower reach of McGinnis Creek, is typically confined between steep hillslopes, bedrock gorges, high terraces, and earthflow toes or some combination of these landforms thus leading to mostly cascade or step pool bed types. Although massive sedimentation can bury these channels and convert them into laterally and vertically unstable pool riffle or even braided systems for a period of time, the relatively high stream energy of these channels results in relatively rapid recovery. From a habitat perspective, this channel type favors steelhead and cutthroat trout, rather than coho or Chinook. In the context of cascade and step pool channel types, spawning habitat is limited to small pockets, side channels, and to a lesser extent association with large wood. However, spawning habitat is generally considered fair to good in quality with PFC substrate targets being achieved in nearly all categories for the three permanent aquatic trends monitoring stations (Sulphur Creek, Rattlesnake Creek, and McGinnis Creek). Available pool habitat currently makes up approximately 26 to 32 percent of aquatic area in the monitored reaches of Rattlesnake Creek, McGinnis Creek, and Sulphur Creek with average residual pool depths of 0.5 meters. Pools deeper than 0.9 meter are generally limited to the larger drainages including the East Branch of the North Fork and Rattlesnake Creek. McGinnis Creek has shown improvement in average residual pool depth in recent years.

Landslides are the predominant large wood recruitment mechanism and legacy effects of tree removal near streams still limit wood loading. In addition to the influences of smaller wood size and channel morphology, in-stream wood loading remains low due to the lateral shifting of channels in Oil Creek, Rattlesnake Creek, and McGinnis Creek during winter peak flow events. Many of the steeper and confined channel segments will not respond strongly to large wood, as their morphology is dictated by large boulders. Overstream shade canopy provided primarily by hardwoods has increased significantly in recent years along all surveyed fish-bearing tributaries due mainly to continued hardwood growth in floodplain areas. Maximum Weekly Average Temperatures (MWATs) have been on the decline over the last three years and have met the NOAA Properly Functioning Condition (PFC) target (<16.8 ºC) in all three permanently monitored stream reaches (Sulphur Creek, McGinnis Creek, and Rattlesnake Creek) in 2010 after a spike in water temperature in 2006.

High summer and early fall stream temperatures reduce potential habitat and affect the abundance and distribution of salmonids in higher-order streams and in the Mattole estuary downstream of HRC property. The trend of decreasing temperatures in lower-order streams is expected to continue with increases in riparian growth and shading, possibly also resulting in improvement in water temperatures in higher-order streams downstream of these areas.

Fish-bearing streams on HRC property are only known to be occupied by steelhead and resident rainbow trout. However, McGinnis Creek is accessible to Chinook salmon and appears to have suitable habitat conditions for coho salmon. There are no known anthropogenic barriers (e.g., culverts and fill crossings) to upstream migration on HRC’s ownership, although natural barriers exist consisting of wood, boulders, and/or bedrock.

2.0 INTRODUCTION

The goal of Humboldt Redwood Company's (HRC's) Habitat Conservation Plan (HCP) (PALCO, 1999), developed in agreement with federal and state agencies, is to maintain or achieve, over time, a properly functioning aquatic habitat condition in streams and rivers affected by the landowner's forest management activities. The purpose of the HCP watershed analysis process is to identify management objectives for protecting, restoring, and enhancing the aquatic habitat of specified salmonids, amphibians, and reptiles. These species include Northern California (NC) steelhead (*Oncorhynchus mykiss)*, California Coastal (CC) Chinook salmon (*Oncorhynchus tshawytscha)*, Southern Oregon-Northern California Coasts (SONCC) coho salmon (*Oncorhynchus kisutch*), northern red-legged frog (*Rana aurora aurora)*, foothill yellow-legged frog (*Rana boylii)*, tailed frog (*Ascaphus truei)*, southern torrent salamander (*Rhyacotriton variegatus)*, and the northwestern pond turtle (*Emys marmorata marmorata)*.

Parameters for evaluating habitat conditions are identified by the National Marine Fisheries Service (NMFS) Properly Functioning Condition (PFC) matrix (hereafter PFC targets) and include targeted objectives for streambed (spawning gravel) and channel (rearing habitat) conditions, in-stream LWD levels, water temperature, and streamside riparian forest conditions associated shade canopy and LWD recruitment potential. This report compares current habitat parameters in the Mattole River WAU with PFC targets for streams that are considered suitable salmonid habitat.

The habitat objectives in the PFC matrix are generally "one-size-fits-all" thresholds. In regard to in-stream channel conditions, the habitat objectives were derived from and created for streams with less than 3 percent gradient and channel widths ranging from 10 to 19 meters. Because stream characteristics such as depth, pool spacing, LWD functional size, and shade potential are directly proportional to channel width (Bilby and Ward, 1989; Montgomery et al., 1995; Welty et al., 2002), it is important to keep in mind the differences in stream size when reviewing comparisons with PFC targets. Natural factors in this region may also influence the applicability of PFC criteria developed elsewhere in the Pacific Northwest. For example, local lithology will influence the sediment characteristics of the streambed due to the erodibility of the bedrock, unique erosional conditions in the Mattole can heavily influence channel morphology and fish habitat metrics, and native forest vegetation, channel substrate (boulder versus gravel or fine sediment dominated), and stream gradient (transport versus response reach) will influence LWD volume and loading rates. Despite these limitations, PFC targets are useful for assessing the quality of salmonid habitat.

The PFC matrix has over 35 criteria in narrative or numeric form. In this summary, we report on a selected group of the mostly widely recognized parameters for sediment, gravel, pool characteristics, LWD, and water temperature, as discussed in this Cumulative Watershed Effects (CWE) report and accompanying modules (Appendices C, D, and E). The stream gradient map produced from Light Detection and Ranging (LiDAR) digital elevation data, instream habitat and LWD inventory, electrofishing surveys (to determine upper extent of fish use), Aquatic Trends Monitoring (ATM) stations (that provide detailed streambed, habitat and temperature information over a period of recent years), and California Department of Fish and Game (CDFG) stream surveys provide an understanding of summer and winter instream habitat conditions in many of the streams on HCP-covered lands. The methods and intensity with which certain habitat conditions were measured are described in the Fish Habitat Assessment (Appendix E).

This CWE report presents information regarding current overall watershed-wide conditions as well as conditions found in individual sub-basins and compares these findings with PFC target conditions. Future trends are predicted based on current conditions and knowledge of biotic and abiotic processes, assuming forest management measures continue to be implemented for the protection of key resources. Recommendations for the protection, restoration, and enhancement of aquatic habitat based on the environmental needs of the eight target fish and wildlife species are derived from this discussion of current conditions and trends. Recommendations are then implemented through forest management measures relative to timber harvest operations, road upgrading prioritization, and in-stream habitat improvement.

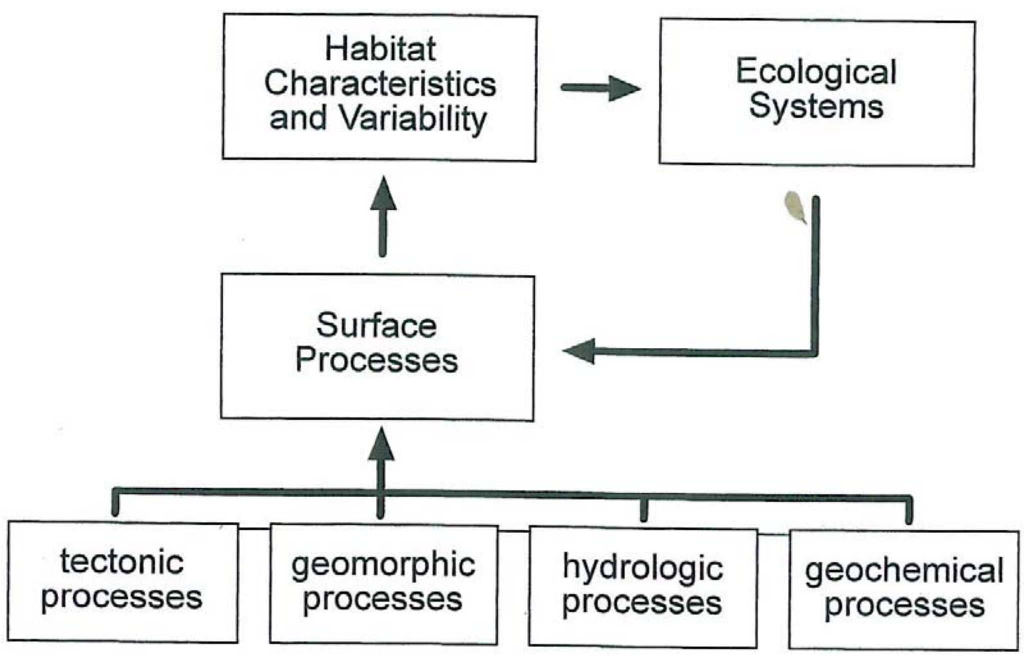
2.1 Overview of Watershed Analysis Process

Watershed analysis is a systematic process for assessing the condition of water, wood, and sediment in a watershed relative to aquatic habitat, and how land management affects this condition. It operates on the basic premise that hillslope (upland and riparian) processes influence aquatic habitat conditions because they generate or modulate inputs of sediment, wood, water, and thermal energy; and that a change in erosion, runoff processes, or riparian function resulting from forest management is significant when it is sufficient to cause an adverse change in aquatic salmonid and/or amphibian and reptile habitat conditions.

Watershed analysis involves evaluation of individual and cumulative management-related impacts to natural processes, which in turn affect aquatic habitat conditions. Natural “background” conditions of the watershed are important to the analysis given the unique geology, unique geomorphic processes, naturally occurring plant communities, water regimes, and other watershed variables, as these background conditions may affect any cause-and-effect relationship linked to forest management. Watershed analysis is conducted primarily to inform the application of watershed-specific forest management practices that achieve and/or maintain, over time, properly functioning aquatic habitat conditions for salmonids, reptiles, and amphibians.

The mechanisms determining the effect of forest practices on inputs of wood, sediment, water, or thermal energy are relatively well understood. Hypotheses regarding potential effects of forest management on streams include increased hillslope erosion and channel sedimentation, increases in peak stream flow during periods of storm runoff, reduced wood inputs to streams, and increases in the temperature of water caused by harvesting trees that shade the channel (Figure 2-1).

Figure 2-1. Schematic illustration of the role of surface processes on shaping habitat characteristics and variability and the potential for ecological systems to influence surface processes. Source: Montgomery (2001).



The guiding philosophy behind watershed analysis is that, although a landscape and its ecosystems are complex and probably impossible to understand or characterize completely, there is enough pattern to the linkages within and between physical and ecological systems that reasonable models of how they interact can be developed through observation (Montgomery et al., 1995). The study of the watershed is accomplished with assessment supplemented by professional judgment using a “weight-of-evidence” approach. Many individual assessments and analyses regarding these processes were performed in the Mattole River WAU, as described in modules and listed in Table 2-1, to assess watershed condition and cumulative effects of land management and natural disturbances.

The key “currencies” of watersheds that are traded between a channel and its watershed are sediment, LWD, water, heat energy, and nutrients. River processes are driven by general physical relations that govern the flow of water, sediment transport, and interactions with bed- and bank-forming materials (Figure 2-2). Riverine ecosystems have particularly tight coupling to geomorphological processes due to gravity-driven routing of materials and disturbances down channel systems (Montgomery, 2001). River systems display rich and varied characteristics, dynamics, and relations to ecological systems despite the generality of the underlying physics. Variability in factors such as local geology, climate, vegetation condition, and the resultant impacts of the history of land use practices create variability in the habitat quality in the watershed at a watershed, reach, and local level.

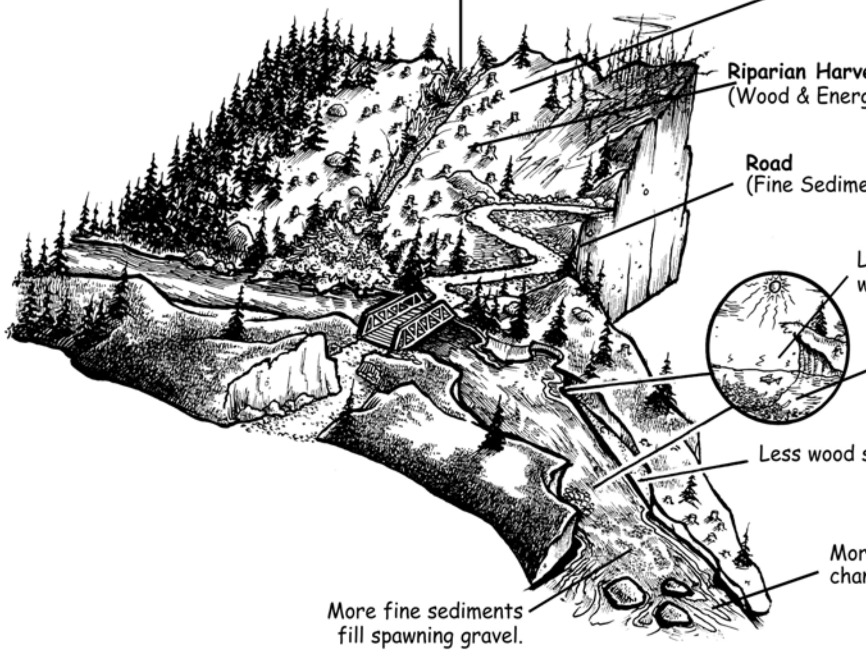
Changes in erosion processes or riparian functions may be relatively easy to observe and document in many cases. However, changes in runoff are more difficult to demonstrate but can be estimated by applying hydrologic principles. Changes in stream channel and aquatic habitat conditions may be easy to document in circumstances where the sources or causes (e.g., landslides or riparian forest harvest) are nearby and recent. However, stream channel or aquatic habitat conditions often must be assessed with respect to a range of watershed disturbances that occurred at distant points in the watershed over a period of decades. This is particularly true with respect to the sources of sediment that comprise the primary substrate upon which aquatic ecosystems are formed. Determinations regarding the strength of the linkage between observed or hypothesized changes in watershed processes (sources or “causes”), and observed or hypothesized effects on aquatic habitat are at the heart of both watershed analysis and assessment of cumulative watershed effects from the perspectives of management associations, legacy effects, and natural factors.

In summary, for watershed analysis to be able to make a determination of impact potential or risk, a link must be made between an aquatic resource and a management-related mechanism that can affect it. The watershed analysis procedure provides for this by: (1) defining resource vulnerability in terms of susceptibility to change in flows of wood, water, energy, and sediment; (2) evaluating how forest management affects these inputs, and (3) determining to what extent and in what locations these effects adversely impact aquatic habitat throughout the watershed.

Table 2-1. Analysis and data collection for the Mattole River watershed analysis.

Type of Assessment or Analysis	Where Reported
Air photo landslide inventory and ground truthing	Appendix A
SEDMODL road surface erosion analysis	Appendix B
WEPP harvest unit surface erosion analysis	Appendix B
Harvest unit surface erosion field reconnaissance	Appendix B
Streamside landslide/bank erosion surveys	Appendix A
Classification of riparian forests in Riparian Condition Units through air photo analysis and field verification	Appendix C
Analysis of LiDAR-based (Light Detection and Ranging) longitudinal channel profiles	Appendix D
Review of historical aerial photographs and field observation in several tributaries – Rattlesnake Creek, Oil Creek, Sulphur Creek, and Lower East Branch of the North Fork Mattole	Appendix D
A computerized terrain analysis of the entire Mattole basin (~200,000 acres) with a focus on the Northern sub-basin (i.e., WAU) geomorphic characteristics	Appendix D
An analysis of channel incision and its role in streamside landsliding and in the continued destablized condition of a portion of the watershed	Appendix D
Time series review of cross sections and channel longitudinal profile data collected since the late 1990s	Appendix D
Collection and analysis of bulk sediment distribution surface and subsurface streambed sediment samples	Appendices D and E
Characterization of present and future riparian stand conditions relative to in-stream LWD recruitment potential, and measurement of LWD loading within the stream channel	Appendices C and E
In-stream habitat typing surveys on total of 32,817 feet of stream for characterization of habitat features including pools	Appendix E
Mapping of Channel Migration Zones (CMZs) based on NetMap's valley floor mapping tool in conjunction with available LiDAR and Google Earth imagery	Appendix D
Review of historical aerial photographs of channels to understand short-term trends in sediment mobilization and storage	Appendix D
Review of direct anthropomorphic impacts to the channel network from historical aerial photographs	Appendix D
Habitat typing and electroshocking fish surveys to determine upstream extent of fish distribution	Appendix E
Analysis of water temperature in streams	Appendix E
Species occurrence surveys, along with reviews of previously collected data for amphibians and reptiles	Appendix F

Figure 2-2. Relationship between unmitigated hillslope activities and stream effects through changes in the five key input factors of coarse sediment, fine sediment, wood, water or energy. Source: PALCO (2000).



While individual models exist for assessing individual watershed processes (e.g., sediment budgets), no "off-the-shelf" or "one-size-fits-all" method is available that comprehensively links the full range of hillslope processes to resource impacts at a watershed scale. This reflects the inherent complexity of the many processes at work in the forest landscape as well as the limitations of the tools associated with each scientific discipline involved. Because of these limitations, individual methods and models must often be linked in a less quantitative fashion, and the judgment and experience of resource professionals must be relied upon given their understanding of the watershed (Benda et al., 2002). Consequently, each watershed analysis typically utilizes unique elements and approaches to assess cumulative effects. In the end, the structural framework developed throughout the analysis provides for a rational, well-documented (transparent), science-based assessment of the linkage between land use and watershed conditions.

2.2 Purpose and Organization of Report

This CWE Report presents a summary of the watershed setting and land use history in the Mattole River WAU, followed by a cumulative watershed effects assessment. The watershed setting is summarized for the entire WAU, including non-HCP lands, as required for a Level 1 analysis on all lands within the WAU (PALCO, 2000). More detailed analysis conducted on HCP lands is also presented in this report, as required for a Level 2 analysis. The CWE assessment evaluates the effects of past, current, and future management practices on aquatic resources; provides pertinent information and justification supporting the delineation of areas and trends of particular ecological interest; and identifies specific management actions affecting aquatic resources. Conditions and trends are organized into the following four components: sediment, wood, shade and temperature, and fish habitat. Detailed methods, results, and information used in this assessment are provided primarily in the individual module reports (Appendices A through F). Also, attachments are provided that present sub-basin data (Attachment 1), the 1988-2003 sediment budget (Attachment 2), forestry prescriptions (Attachment 3), and a glossary (Attachment 4).

The Mattole River CWE Assessment fits within the adaptive management framework established under the HCP Incidental Take Permit and is designed to provide a level of site-specific information necessary for conducting informed forestry operations. The assessment also lays the foundation for future monitoring and assessment activities necessary to ensure that HCP Aquatic Conservation Plan goal of maintaining or achieving properly functioning aquatic habitat conditions are being met over the life of the HCP. The CWE assessment is the starting point in the adaptive management cycle; this assessment will be updated and improved as formal periodic re-visitation occurs.

2.3 Issues Identification

The process of identifying issues and receiving public input for the Mattole River watershed analysis process was initiated at a public meeting held on May 26, 2005 at the Mattole Grange near Petrolia. This meeting involved identifying issues and receiving public input for the Mattole River WAU as the first step in conducting watershed analysis. The well-attended meeting also provided a forum for input from the community for both the Mattole River and Bear River watershed analysis areas, though most of the focus was on the Mattole River area. In addition to issues identified at the May 26, 2005 meeting, written comments were provided by several individuals and organizations including the Mattole Restoration Council (MRC) and Mattole Salmon Group (MSG). These issues were provided to the module analysts for review and incorporation into their assessments, as appropriate. Comments generally covered the following topics:

- Scope and methods of watershed analysis, including the limited protocols, timing, duration, and locations of fish and amphibian surveys; absence of turbidity monitoring; limited characterization of conditions prior to timber harvest; reliance on air photos that may not be effective for evaluating conditions; and disconnect between easily observable on-the-ground data and computer models. *The scope and methods of watershed analysis were developed by the signatory agencies and PALCO, as presented in "Methods to Complete Watershed Analysis on Pacific Lumber Company Lands in Northern California" (PALCO, 2000) and supplemented with "Updated Methods to Complete Watershed Analysis on Pacific Lumber Lands" (PALCO, 2002), and again revisited in 2005 and revised with updated approaches and methodologies based on a collaborative dialogue between the consultants, agency representatives, and company representatives that have completed the previous watershed studies. Computer models are used to create predictions of watershed processes and conditions that otherwise would not be available in a watershed analysis at the scale of the Mattole WAU. For instance, a floodplain mapping tool was used to delineate CMZs across the WAU. Although that prediction only provides an approximation of actual field conditions, a field-based delineation along all channels is not feasible. That type of field-based limitation applies to all watershed attributes necessitating the use of computer models to help evaluate existing and future conditions of the Mattole watershed.*
- Concern about mainly using existing literature and historical aerial photograph review for the riparian change module analysis instead of more ground-truthing. Also, concern that the LWD survey is not complete but should include a more thorough search of the scientific literature documenting the role of LWD recruitment from Class II and Class III watercourses. *The use of historical aerial photography for review of changing riparian conditions is standard scientific practice in the realm of watershed analysis studies. In part this is because aerial photographs provide a reliable means to evaluate riparian forest conditions but also because it is not possible to conduct site-specific field work at the scale of the Mattole WAU. Wood can be transported from Class II and III streams to Class I fish bearing channels by fluvial transport and debris flows. The fluvial transport of wood from smaller to larger (Class I) streams is generally confined to the lower portions of Class II and III streams ranging from several tens to a couple of hundred meters (Zimny, 2008).*
- Recommendation that a Water Quality Module be developed with the North Coast Regional Water Quality Control Board. *A Water Quality Module is beyond the scope of watershed analysis. However, existing water quality monitoring data are used in the analysis for evaluation of fisheries and stream channel conditions.*

- Additions and changes requested for specific individual Watershed Operating Protocols (WOPs) or Standard Operating Procedures (SOPs) covering various data collection activities. *Comments were provided to module analysts for consideration prior to conducting their assessments.*
- Recommendation to use the 1995-1996 and 1996-1997 water year photos to capture effects of storms in the landslide analysis. *Six sets of air photos covering the period from 1948 to 2003 including the 1997 water year photos were used for the assessments, and the potential effects of storm events are generally discussed as part of data interpretation.*
- Concern that the analysis does not mention mycorrhizae, fungi, glomalin, sediment mobility, or water capacity of soils before or after harvest. Recommends assessment of glomalin and the role it has in the ecosystem including glomalin starvation and impacts on landsliding and mass wasting, impacts of glomalin on sediment mobility, and relationship with vegetation cover and glomalin. *Discussion of benefits of glomalin, and potential effects of land use, is included in the surface erosion assessment.*
- Recommendation that no further old-growth stands be logged. This threshold would extend to the entire Mattole basin. Protected Douglas-fir old-growth stands would serve as island habitats for threatened and endangered old-growth dependent species and help promote a viable fishery. Also, protection of late seral stands would provide mitigation corridors for wildlife and avian species. *HRC recognizes that implementing policies that protect areas with high conservation values including old-growth forest stands can enhance biodiversity, benefit endangered species, and add to the overall cultural and ecological values of the landscape. HRC protects all trees meeting their old-growth definition including individual trees and entire stands. Further discussion of HRC's old-growth policy can be found in the Company's Management Plan at www.hrcllc.com.*
- Effects of rate of harvest, yarding method, silviculture, and roads. Need to evaluate the possible impacts that stem from: building new roads; recent timber harvest; increased timber harvest on unstable geology; clearcutting silviculture; and harvesting at a rate too high for these Mattole sub-basins based on the unstable geology, the torrential rains, and threats of future large earthquakes. *Effects of harvest, including silviculture and yarding, on sediment production are assessed in the mass wasting and surface erosion modules.*
- Recommendation that no further harvest occurs in McGinnis Creek watershed due to concern for fish habitat (McGinnis Creek has unstable soils with large landslide). *Forest management guidelines are developed at the watershed and sub-basin scale in response to the site-specific findings of this analysis. Identified sensitive areas receive special consideration including potential for site-specific no-harvest designation. McGinnis Creek is recognized as a recovering*

stream with significant fisheries value including potential coho habitat. Consideration of its fisheries value is part of the basis used in the design of watershed-analysis based forestry prescriptions.

- How various timber harvesting techniques change the stability of the affected slopes. Concerned that nowhere in the Mattole WA is there an analysis of the relationship between timber harvesting and slope stability that employs the "best available science" as required by the HCP. *Effects of timber harvest silviculture and yarding methods on slope stability are assessed in the mass wasting module.*
- Recommendation regarding keeping riparian buffers, or increased no-cut buffer zone widths and no-harvest areas, to maintain cooler stream temperatures. *Review of interim prescriptions will be based on findings of the watershed analysis. Modification of interim HCP prescriptions will be consistent with the HCP's conservation principles and objectives for streamside areas and based on the findings of the watershed analysis and commonly accepted scientific literature. In addition, the HRC policy of not harvesting large old-growth trees will provide protection for old-growth timber in riparian areas and elsewhere across the watershed.*
- Public participation is needed, including third-party review and participation in the field and for data collection. Recommendation that another public meeting be held when the draft module reports are released and before the 60-day comment period begins. The steps taken thus far in inviting members of the Mattole Restoration Council and the Mattole Salmon Group to participate are appreciated. *Data collection and involvement of the public continues for the Mattole watershed analysis as has been the case for the past several watershed analyses. The invitation to participate in the field during the process of data collection was open for watershed analysis. A public meeting to present key findings is scheduled to coincide with the Public Review Draft comment period.*
- Concern that the Mattole was self-sustaining in the old days but, now, it's more profit driven. Has felt lied to before about transparent process. Concern about watershed analysis process; need to implement sustainable logging practices. *The watershed analysis process provides opportunities for field visits and discussion with analysts. HRC's implementation of a non-declining harvest over time, in coordination with voluntary practices of maintaining old-growth trees and discontinuing traditional clearcutting, and continued implementation of a multi-species Habitat Conservation Plan provide evidence of the landowner's commitment to sustainable logging practices.*
- Recommends using data available from previous studies, but do not repeat mistakes of the NCWAP. *Data from previous studies are used as appropriate; comments on NCWAP were taken*

into consideration for this watershed analysis.

- Concern about fire potential, which could be increased due to harvesting old-growth trees – leading to higher fuel loads because it reduces the canopy, inviting young trees and brushy species to grow in. Also, please address the need for a post-harvest protocol in dealing with slash for the life of the HCP. *Harvesting of large old-growth trees (per Management Plan definition) has been discontinued under HRC's management. Prescribed treatment for logging slash is addressed during individual timber harvest plan development. Wildfire, inhibition of conifer regeneration, erosion, and aesthetic values are all considerations of significant importance to the landowner.*
- Concern about impacts of non-timber land use, including subdivision development which could potentially exacerbate erosion and landslides to a greater degree than elsewhere in the Mattole basin. Need to address the threat of subdivision and its probable effects on water flow/water use, fish habitat, and geologic instabilities since PALCO lists subdivision as a potential future project in the Mattole within THP documents. Also need to assess impacts of cattle on erosion, sediment production, and nutrient loading in watercourses and on unstable hillslopes, and resulting impacts on habitat for insect, amphibian, and salmonid populations. *Observed and potential effects from non-timber land use are discussed, as applicable, in the module reports.*
- Concern about herbicide use, including impacts to amphibian and reptile habitat. Other potential effects may include impacts to native wildlife species, including threatened, endangered, and sensitive species, fire danger, noxious weed proliferation due to logging, erosion from loss of vegetation, and long-term health hazards. *This topic is outside the scope of HCP watershed analysis; however, basic information is provided in the discussion on contemporary harvest (Section 4.3).*
- CWE should be addressed from a watershed perspective using multi-disciplinary approaches. A CWE analysis should cover the impacts to the Mattole River estuary and the mainstem Mattole River's aquatic environment. Recommendation that water quality impacts be addressed and a public meeting held after prescription team has developed prescriptions. *The Cumulative Watershed Effects analysis is focused on the effects of forest management on aquatic habitat. The CWE analysis is designed to now provide data more usable for THPs, including issues from the watershed perspective.*

2.4 Definitions

To aid review of this CWE assessment and accompanying module reports, definitions of key terminology used for watershed analysis are provided in Attachment 4, which is the glossary originally provided in the Watershed Analysis Methods for PALCO Lands (PALCO, 2000), with additional terms defined based on the current watershed analysis.

Development of a technical definition of cumulative watershed effects is an ongoing effort (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 California Environmental Quality Act (CEQA) guidelines (Section 14, CCR 15355), is often cited as a starting point. Paraphrased, this definition indicates that cumulative effects are defined as two 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.

3.0 WATERSHED SUMMARY

This section provides a summary of the watershed setting, history, and key themes. The discussion includes background information on the geographic setting and study area delineation, fish use and habitat distribution, topography, stream class, geology and seismic regime, soils, climate and hydrology, forest ecology, and amphibian and reptile habitat. Attachment 1 provides specific watershed tabular information at a detailed, sub-basin-specific level for use throughout the cumulative effects analysis and watershed analysis in general.

3.1 Geographic Setting and Study Area Delineation

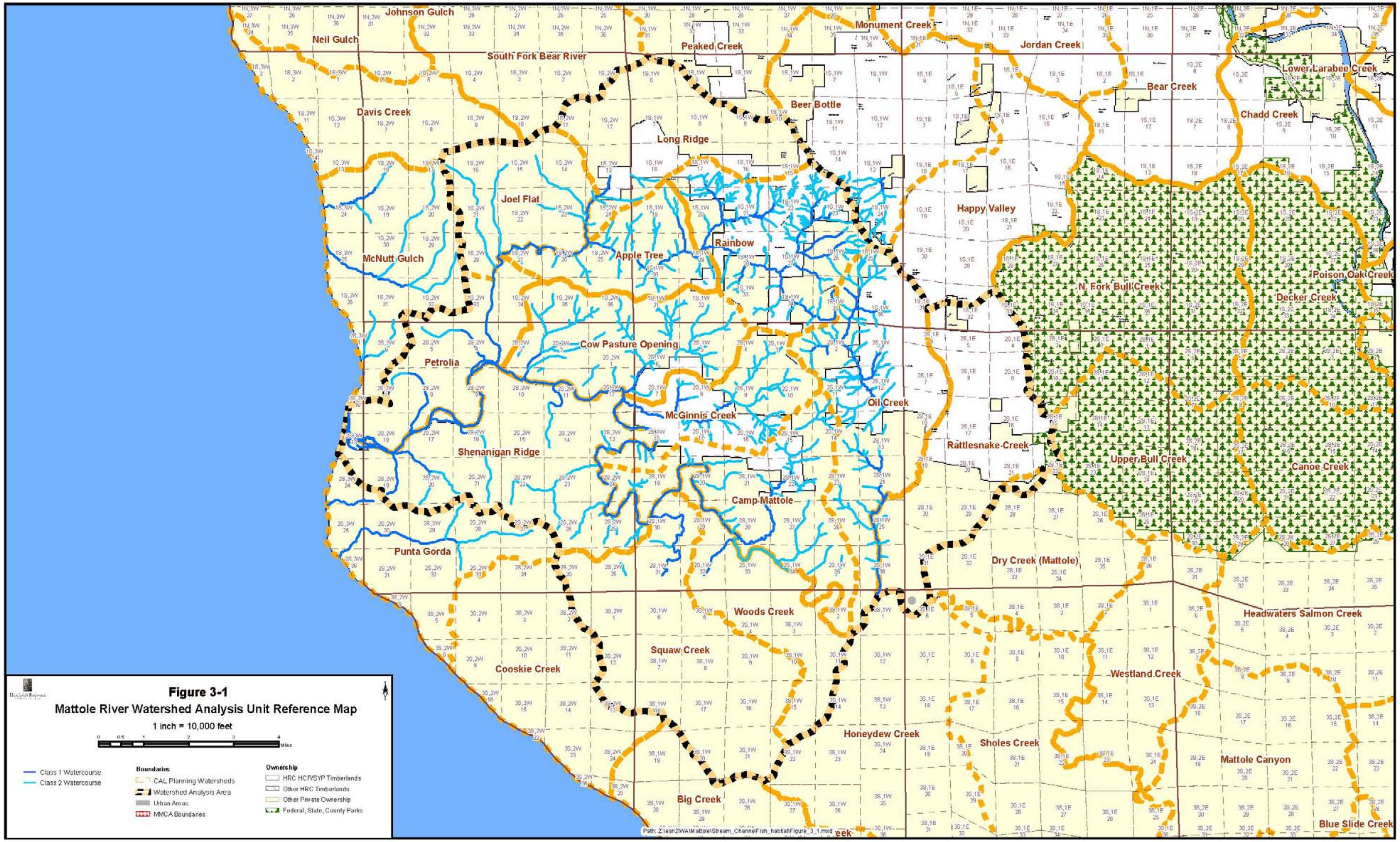
The 140-square-mile Mattole River WAU (Table 3-1, Figure 3-1) covers lands in the northern tier of the Mattole River basin, and is located generally 30 miles south of Eureka in Humboldt County, California. The Mattole River drains approximately 296 square miles (189,440 acres) in the Coast Range within western Humboldt County and northern Mendocino County, flowing generally northwestward to Petrolia before turning west to the Pacific Ocean. The elevation of the watershed ranges from zero feet at the mouth to 4,087 feet on Kings Peak in the headwaters. The Eel River basin is adjacent to the east and Bear River lies to the north.

Table 3-1. Watershed areas for the Mattole River basin.

Parameter	Mattole River basin
Total basin area (mi^2)	296
Total Mattole River WAU (mi^2)	140
Total HCP Area (mi^2)	28.1

The mainstem of the Mattole River is 62 miles long, and is fed by 74 tributary streams. There are approximately 545 perennial stream miles in the basin. The WAU is comprised of the following major tributary basins: 1) Lower North Fork Mattole River; 2) East Branch North Fork Mattole River and its tributaries (Alwardt and Sulpher Creeks); 3) McGinnis and Pritchard Creek (tributaries to the mainstem Mattole River); and 4) Upper North Fork Mattole River that includes Oil Creek and its tributaries (Devils Creek and Green Ridge Creek) and Rattlesnake Creek and its tributaries (Fox Camp Creek).

Figure 3-1. Mattole River Watershed Analysis Unit reference map.



A stream gaging station is located on the mainstem Mattole River near Petrolia, several miles from the mouth. No dams or significant water diversions are present on the Mattole River, though numerous small water diversions exist for domestic and agricultural use. These water diversions are for water supplies, irrigation, and dust control of unpaved roads.

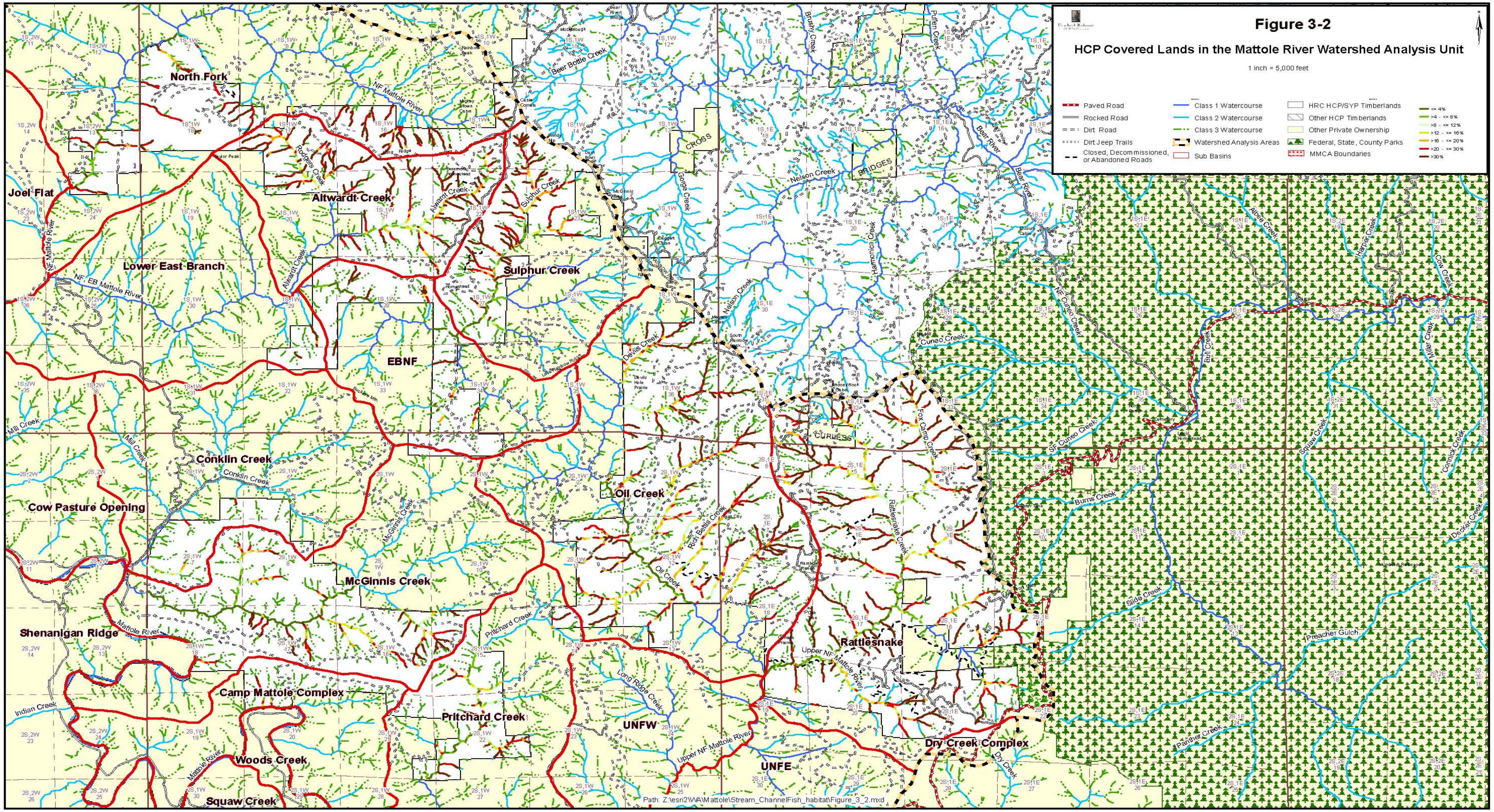
Humboldt Redwood Company, LLC owns and manages approximately 20 percent of the Mattole River WAU for commercial timber production under the HCP. Table 3-2 presents areas of the CalWater planning units that comprise the Mattole River WAU, including planning units for which there is no HRC ownership; these planning units are located generally in the downstream portions of the WAU and are bordered on the downstream end by the Pacific Ocean. All of the area managed under the HCP ("HCP area") is located to the north of the mainstem Mattole and generally in headwaters of these tributary drainages, with the exception of HCP lands in the McGinnis Creek planning unit which is located in the lower portion of the drainage and adjacent to the Mattole. This Level 2 watershed analysis provides output data presented by sub-basin in the context of the HRC ownership managed under the HCP, as this is the area within which management prescriptions will be evaluated and modified based on watershed analysis.

Ownership within the Mattole River WAU includes a mixture of HRC, other private lands, and public lands managed by the U.S. Bureau of Land Management (BLM). The WAU covers an area of 140 square miles (89,590 acres), of which 28.1 square miles (17,992 acres, or 20 percent of the total area) is owned by HRC and managed under the HCP (Table 3-1). Lands managed by the BLM total 0.3 square miles (168 acres) and are located at the mouth of the Mattole River. All other ownership in the Mattole River WAU is private. Attachment 1 provides watershed and land use data, by the sub-basins shown on Table 3-2 and delineated on Figures 3-1 and 3-2, for the HCP-managed lands in the Mattole River WAU.

Table 3-2. HRC ownership and non-HRC ownership by sub-basin.

Sub-basin	HCP Lands (Acres)	Non-HRC Ownership (Acres)	Total (Acres)
Alwardt Creek	1,750	648	2,398
Camp Mattole Complex	357	1,842	2,199
Conklin Creek	509	3,059	3,568
Cow Pasture Opening	0	3,045	3,045
Dry Creek Complex	30	137	168
East Branch North Fork	848	1,494	2,342
Joel Flat	1	4,987	4,988
Lower East Branch Mattole	159	3,764	3,923
McGinnis Creek	2,187	2,526	4,713
North Fork	1,369	5,293	6,662
Oil Creek	4,023	2,066	6,089
Petrolia	0	5,046	5,046
Pritchard Creek	817	3,945	4,762
Rattlesnake Creek	4,757	954	5,711
Shenanigan Ridge	0	9,891	9,891
Squaw Creek	0	10,812	10,812
Sulphur Creek	1,178	1,278	2,456
Upper North Fork East (UNFE)	0	2,960	2,960
Upper North Fork West (UNFW)	0	2,745	2,745
Woods Creek	0	5,113	5,113
GRAND TOTAL	17,992	71,604	89,590

Figure 3-2. HCP-covered lands in the Mattole River WAU.



3.2 Geology and Seismic Regime

The coastal ranges of northern California reflect the history of sediment deposition and uplift related to convergent tectonics and the northward migration of the Mendocino Triple Junction (MTJ). The Mattole River WAU is experiencing rapid uplift as the MTJ migrates northward (Clarke, 1992). Late Mesozoic convergence resulted in a broad complex of highly deformed marine sediments along the western margin of the North American plate. These rocks now comprise the Franciscan Complex, which constitutes the basement of the North Coast region (McLaughlin and others, 2000; see Plate A-1 of Appendix A). The Coastal belt is the youngest of the three belts that comprise the Franciscan Complex of accretionary rocks in northern California. The Coastal belt has been further subdivided into four tectonostratigraphic “terranes,” discrete fault-bounded bodies of rock within the larger belt, which are distinguished by lithology, structure, and/or level of metamorphism. The four terranes within the Coastal belt are: the Yager, Coastal, King Range, and False Cape terranes (Aalto and others, 1995; McLaughlin and others 1997). Mapping by McLaughlin and others (2000) indicates that the WA area is underlain by bedrock associated with the Coastal and Yager terranes of the Coastal belt (Table 3-3). As described above, Franciscan Complex bedrock comprises the basement rock in the region. These bedrock units are locally unconformably overlain by Quaternary age alluvial and colluvial deposits; although, the distribution of these materials is limited due to the steep topography and narrow, high gradient stream channels.

Table 3-3. Distribution of lithologic units in HCP area.

Lithologic Unit	Area (acres)	Area (mi^2)	Percent of Area
Franciscan Coastal Terrane (TKfs) Franciscan Coastal Belt-green stone (TKfs-gs) Franciscan Coastal Belt-undifferentiated (TKfs-u)	17,407	27.2	97%
Yager Formation (Tky)	251	0.4	1.4%
Older terrace deposits (Qort) Terrace deposits (Qrt)	232	0.4	1.3%
Quaternary alluvium (Q) Quaternary stream/river channel deposits (Qsc)	95	0.1	<1%
Total for HCP Area	**17,985**	**28.1**	**100%**

The MTJ is a seismically active region. Several recent earthquakes with epicenters in the greater Mattole watershed region effectively illustrate this point. The August 1991 “Honeydew” earthquake (magnitude 6.0 to 6.2) is hypothesized to have occurred along a northwest-trending, southwest-dipping blind thrust fault whose surface projection may daylight just northeast of the town of Honeydew (Dengler and McPherson, 1992). This theorized fault projection lies southeast of the Petrolia fault zone. The earthquake resulted in damage to chimneys and structure foundations, primarily within a 3 mile radius centered near the town of Honeydew. Changes in groundwater and stream flow were reportedly affected over a wide region surrounding the epicenter.

The April 25, 1992 magnitude 7.1 Cape Mendocino earthquake occurred along the southern end of the Cascadia Subduction Zone (CSZ), with an epicenter near the town of Petrolia. It was followed over the next day by two magnitude 6.6 aftershocks located offshore, about 16 miles west-northwest of Petrolia. The main shock of this earthquake sequence generated some of the highest peak accelerations ever measured (in excess of 2 g), and resulted in significant land-level changes in the epicentral region. The main shock resulted in coseismic uplift of some 16 miles of coastline (up to about 5 feet of uplift), and an associated area of coseismic subsidence directly east of the epicenter. Damage from these events was widespread in the Mattole, Bear, and Eel River valley areas, with some damage estimates approaching $70 million.

In this environment, it should be assumed that the watershed will be subject to moderate to strong ground shaking on a relatively frequent basis. Large seismic events and the associated strong ground shaking can be significant geomorphic events that may have impacts similar in magnitude to large storm events. Specifically, strong ground shaking can serve as a triggering mechanism for the initiation of landslides or the reactivation of pre-existing landslides. Recent examples of coseismic landsliding in the watershed have been documented following the 1991 Honeydew earthquake and the 1992 series of earthquakes near Petrolia. In the epicentral regions for these earthquakes, numerous examples of seismically induced landslides were documented (Dengler and McPherson, 1992; Dunklin, 1992). These earthquakes were associated with Modified Mercalli Index (MMI) intensities of VII to VIII+. Studies by Keefer (1984; 2002) show that the threshold of 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.

Seismically induced landslides do not always occur coincident with the actual shaking. Ground cracks and ridge top fissures opened during shaking, and groundwater flow paths disrupted by seismic 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, sometimes several years after the actual earthquake. For example, numerous landslides occurred in the region during wet winters of 1995-96 and 1996-97. The 1995-96 rainy season was the first high precipitation period following the 1992 earthquakes, and it appears that some of the failures during this period were related to seismically weakened slopes.

3.3 Soils

Soil texture is largely controlled by underlying geology and topography. The Mattole River WAU is dominated by rocks of the Franciscan Coastal Belt. Soils in portions of the Mattole River WAU were mapped by the Soil Conservation Service (now called the Natural Resources Conservation Service, NRCS) and the University of California (McLaughlin and Harradine, 1965). The NRCS is currently updating soil maps for Humboldt County. Table 3-4 summarizes the properties of soils in the HCP area of the Mattole River WAU pertinent to surface erosion, including soil depth, texture, drainage, and permeability.

Soils in the HCP area are mapped primarily as the Hugo, Laughlin, Wilder, and Kneeland soil series. Hugo soils are the most common in the WAU, occurring within 77 percent of the HCP area. Hugo soils have a gravelly loam/stony clay loam texture, whereas, Laughlin soils have a loam texture and Wilder soils have a sandy loam/gravelly sandy loam texture. Laughlin and Kneeland soils occur more commonly in grassland areas; these soils are not as deep and have less gravel than the Hugo and Wilder soils.

3.4 Topography

The topography of the Mattole River WAU is generally rugged, with slopes ranging from gentle to steep. Gentle slopes are present on non-HRC grassed, south-facing areas and lands generally downstream from the HCP area adjacent to lower tributary reaches and the mainstem of the Mattole. Some areas of gentle slopes also occur within the HCP area, mainly in ridgetop areas and lower reaches of stream channels.

Within the HCP area, 10 percent of the slopes are less than 35 percent gradient (Table 3-5), from the LiDAR-based slope analysis depicted on the slope gradient class map shown on Figure 3-3. Slopes steeper than 65 percent account for 35 percent of the HCP area. Approximately 60 percent of the land area in the HRC-owned portion of the Mattole River WAU has slopes steeper than 50 percent gradient. The Rattlesnake Creek and Oil Creek sub-basins collectively contain approximately 50 percent of the

HCP land area with slopes steeper than 65 percent gradient; these two sub-basins account for approximately 50 percent of the total land area managed under the HCP in the Mattole.

Table 3-4. Properties of soils for HCP lands in the Mattole River Watershed Analysis Unit.

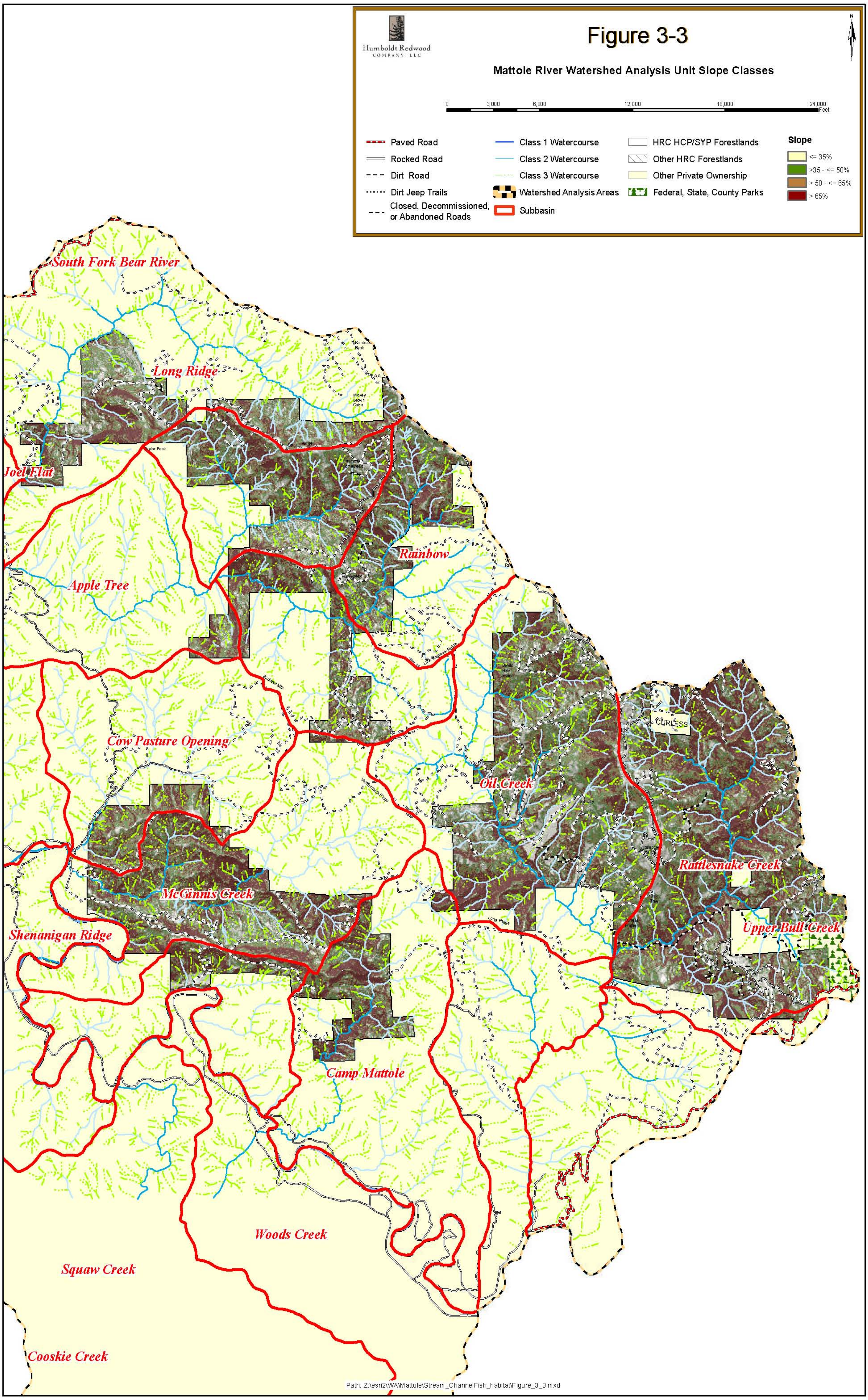
Soil Series Name	Total HCP Acres	Percent of HCP Lands	Depth Range (in.)	Parent Material	Texture of Surface/ Subsurface	Drainage[1]	Permeability[1]
Hugo	13,569	77%	30-60	Sandstone and shale	Gravelly loam/stony clay loam	Well	Moderately rapid
Laughlin	1,256	7%	16-36	Sandstone and shale	Loam/loam	Well	Moderate
Wilder	1,169	7%	26-50	Sandstone	Sandy loam/gravelly sandy loam	N.A.[2]	N.A.
Kneeland	899	5%	18-40	Sandstone and shale	Clay loam/ clay loam	N.A.	N.A.
Boomer	202	1%	26-60	Metamor-phosed basic igneous rock	Gravelly loam/gravelly clay loam	Well	Moderately slow
Atwell	117	<1%	36-72	Sheared sedimentary rock	Loam/gravelly clay loam	Moderately well or somewhat poor	Moderately slow surface; very slow below
Maymen	110	<1%	4-16	Sandstone and shale	Gravelly loam/gravelly loam	Somewhat excessively drained	Moderate to moderately rapid
Kneeland (Variant)	93	<1%	36-72	Sandstone and shale	Loam/clay	N.A.	N.A.
Cahto	91	<1%	6-25	Sandstone, hard	Loam/loam with rock fragments	N.A.	N.A.
Melbourne	88	<1%	30-60	Sandstone and shale	Loam/clay loam	Well	Moderate
Usal	64	<1%	30-60	Sandstone and shale	Loam/clay loam	N.A.	N.A.
Terraces[3]	34	<1%	64-70+	Sedimentary alluvium	Loam/silt Loam	Moderately well to imperfectly	Moderately rapid to slow
Bottom Land[3]	34	<1%	64-70+	Sedimentary alluvium	Loam/silt Loam	Moderately well to imperfectly	Moderately rapid to slow
McMahon	3	<1%	30-60	Sandstone	Clay loam/ clay	Moderately well or somewhat poor (inferred)	Slow (inferred)
Other[4]	255	1%	Varies[4]	Varies[4]	Varies[4]	Varies[4]	Varies[4]

1. Information on soil drainage and permeability characteristics for these soils was obtained from the Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Official Soil Series Descriptions Available URL: "http://soils.usda.gov/technical/classification/osd/index.html".
2. "N.A." indicates information not available from soil survey data sources.
3. Mapping units Bottomland 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.
4. Mapping unit "other" 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.

Table 3-5. Summary of acres in major slope gradient classes in HCP area.

Sub-basin	0-35% (Acres)	35-50% (Acres)	50-65% (Acres)	>65% (Acres)	Total (Acres)
Alwardt Creek	169	541	501	540	1,750
Camp Mattole Complex	58	76	75	148	357
Conklin Creek	51	124	182	152	509
Dry Creek Complex	5	13	8	4	30
East Branch North Fork	76	252	236	283	848
Lower East Branch	13	45	39	61	159
McGinnis Creek	176	589	553	869	2,187
North Fork	154	467	330	418	1,369
Oil Creek	552	1,309	1,060	1,103	4,023
Pritchard Creek	22	188	191	417	817
Rattlesnake Creek	426	1,081	1229	2,021	4,757
Sulphur Creek	100	419	302	357	1,178
Total Acres for HCP Area	1,801	5,103	4,707	6,373	17,985
Percent of Total	10%	28%	26%	35%	100%
Cumulative Percent Total	10%	38%	65%	100%	-

Figure 3-3. Mattole River Watershed Analysis Unit slope classes.



3.5 Stream Class

Stream classes are described in the California Forest Practice Rules (CFPR) by water class characteristics or key indicator beneficial uses. Stream classes are defined as CFPR Class I, II, III, or IV streams. CFPR Class I streams include streams that supply domestic water and/or have fish that are always or seasonally present and includes habitat to sustain fish migration and spawning. CFPR Class II streams include streams that have fish always or seasonally present, offsite within 1,000 feet downstream and/or streams that support aquatic habitat for non-fish aquatic species. CFPR Class III streams includes streams that have no aquatic life present but have evidence of being capable of sediment transport to Class I or Class II streams. Class IV streams include man-made watercourses. Table 3-6 presents a summary of the Class I, II, and III channel lengths by sub-basin in the HCP area of the Mattole River WAU. There are 271 miles of mapped stream channel in the HCP area, per CFPR definitions; 37 miles are Class I, 97 miles are Class II, and 137 miles are Class III.

Table 3-6. Summary of stream channel lengths in HCP area.

Sub-basin	Class I (Miles)	Class II (Miles)	Class III (Miles)	Total (Miles)
Alwardt Creek	2.2	14.1	10.1	**26.3**
Camp Mattole Complex	0.5	0.5	5.4	**6.4**
Conklin Creek	0.2	1.1	6.0	**7.4**
Dry Creek Complex	0.0	0.0	0.2	**0.2**
East Branch North Fork	1.4	3.0	9.8	**14.2**
Lower East Branch	0.0	0.4	2.2	**2.6**
McGinnis Creek	3.6	8.3	20.3	**32.2**
North Fork	1.1	10.0	6.8	**17.9**
Oil Creek	8.6	21.2	35.2	**65.0**
Pritchard Creek	2.3	3.9	7.2	**13.4**
Rattlesnake Creek	13.8	25.2	24.8	**63.8**
Sulphur Creek	3.5	9.2	8.7	**21.5**
Total for HCP Area	**37**	**97**	**137**	**271**

3.6 Climate

The Mattole River WAU has climatic conditions characterized as dry in the summer with warm temperatures, and wet in the winter. Winter storms must pass over significant coastal ridge elevations as they move inland from the Pacific Ocean, before again crossing significant elevations on the eastern ridge of the Mattole basin, resulting in heavy rainfall within the Mattole basin (Downie et al., 2003). A small amount of precipitation occasionally falls as snow in the highest elevations.

The Mattole basin has high annual precipitation, with a mean rainfall depth of 81 inches occurring primarily from November through April (Downie et al., 2003). As described further in the NCWAP report (Downie et al., 2003), 12 precipitation gauges are or were located within the basin, with five of these operating for more than 20 years; eight of these gauges are summarized on Table 3-7. South of the Mattole WAU, the highest annual precipitation depths have been recorded – as high as 256 inches at the Wilder Ridge gauge in 1983 (located several miles south of Honeydew). The longest recording precipitation gauge within the WAU is located at Petrolia (noted as gauge F70 6835 01 on Figure 3-4). As summarized in the NCWAP report (Downie et al., 2003), the mean annual precipitation at the Petrolia guage is 63 inches with annual depths ranging from 27 inches (1977) to 110 inches (1983). Annual total precipitation for Scotia, the nearest long-term reporting precipitation gauge, is presented in Figure 3-5 as obtained from the California Data Exchange Center (CDEC). The Scotia gauge is located in the Eel River watershed approximately 8 miles northeast of the Mattole River WAU.

3.7 Streamflow Records and Flood History

A limited number of streamflow gaging stations have operated historically within the Mattole River basin (Downie et al., 2003), with only one operated continously for more than a six-year period. Since December 1950, a stream gaging station on the Mattole River near Petrolia (Figure 3-6) has monitored streamflow; this gaging station also operated from November 1911 to December 1913. The gage is currently operated by the U.S. Geological Survey on the mainstem of the Mattole River – just upstream of tributary flow into the Mattole from the North Fork Mattole River – on the Mattole Road bridge immediately south of Petrolia. The drainage area above the gage covers an area of 245 square miles (USGS, 2011; http://nwis.waterdata.usgs.gov/ca/nwis/peak?site_no=11469000), which is 83 percent of the 296-square-mile Mattole River basin. As noted above, the streamflow from the North Fork Mattole River drainage enters the Mattole River downstream from the gage. However, the majority of the Mattole River WAU drains into the Mattole upstream of the gage. A brief review of Petrolia gage data, collected

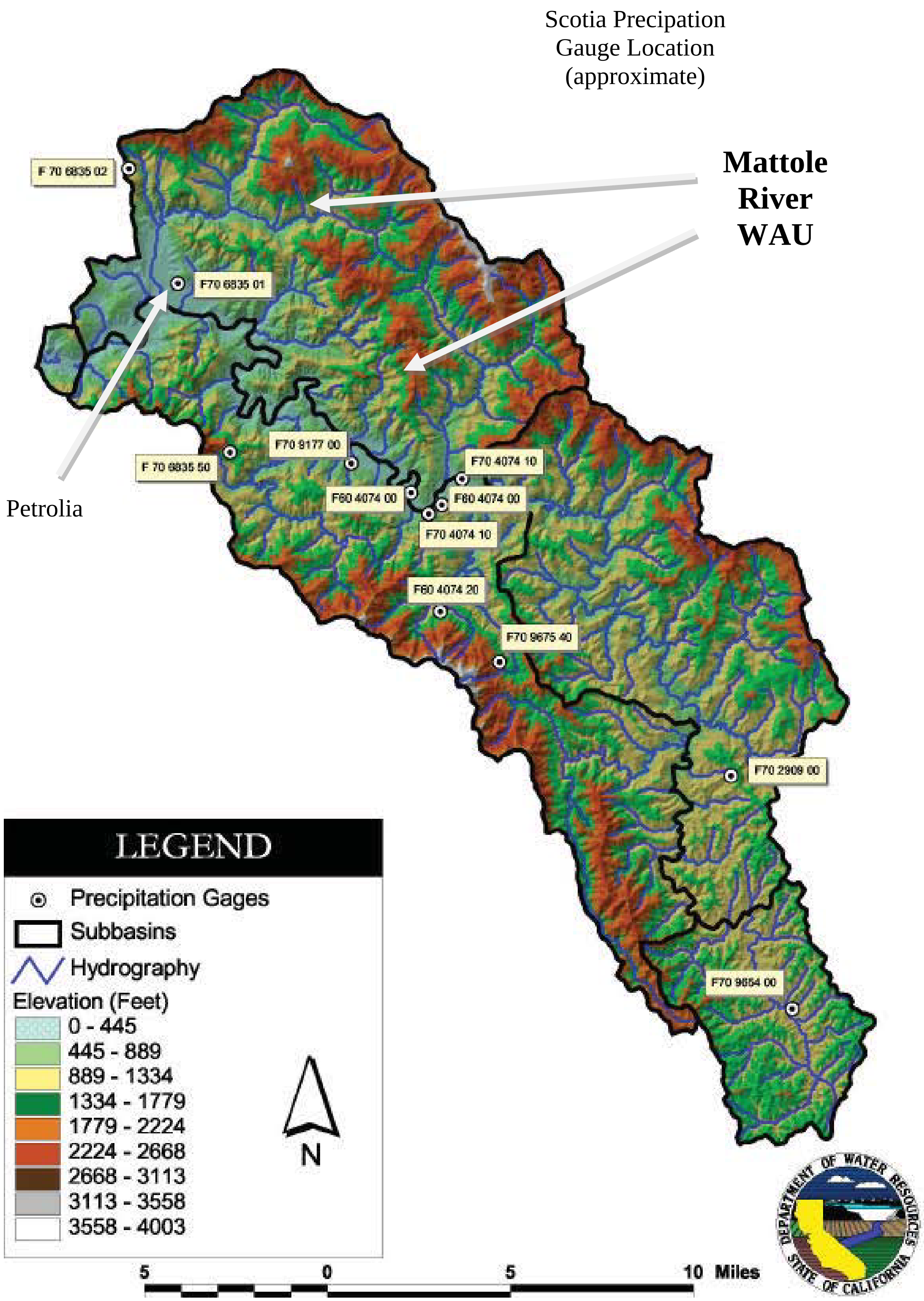
Table 3-7. Existing and discontinued long-term precipitation gauges located within or near the Mattole River basin.

Gage Name	Upper Mattole 1/	Petrolia 1/	Whitethorn 1/	Honeydew 2WSW 1/	Honeydew Store 1/	Scotia	Burlington State Park	Cape Mendocino Light House
Gage #	F70	F70	F70	F60	F70	F60	F60	F70
	9177 00	6835 01	9654 00	4074 00	4074 10	8045 00	1202 00	1504 00
GAGE LOCATION								
County	Humboldt	Humboldt	Humboldt	Humboldt	Humboldt	Humboldt	Humboldt	Humboldt
Longitude	124.183	124.280	123.937	124.150	124.122	124.100	123.907	124.405
Latitude	40.250	40.234	40.022	40.238	40.244	40.483	40.308	40.440
Elevation	255	175	1050	380	339	140	200	425
PERIOD OF RECORD								
Begin	1898	1958	1965	1954	1975	1927	1950	1895
End	1986	1995 2/	1990	1978 3/	1994 4/	present	1998	1943 5/
ANNUAL PRECIPITATION								
Average	78.70	62.43	84.35	101.65	77.33	48.19	65.73	40.11
Maximum	130.64	109.76	144.05	174.40	159.21	84.45	118.57	64.10
Year	1904	1983	1983	1958	1983	1983	1983	1907
Minimum	25.43	27.24	35.37	31.05	33.05	19.71	27.29	14.78
Year	1977	1977	1977	1977	1977	1977	1977	1931
ANNUAL 24-HOUR MAXIMUM PRECIPITATION								
Average	5.13	3.94	5.42	7.71	6.88	3.22	4.39	1.94
Maximum	9.35	6.42	9.61	13.65	11.40	5.95	7.40	3.30
Year	1940	1995	1966	1956	1985	1940	1974	1927
Minimum	1.40	1.97	2.09	5.00	2.60	1.17	1.78	1.00
Year	1977	1977	1977	1978	1992	1977	1977	1930

Notes: 1/ Gage located within the Mattole watershed.
2/ Inactive 1970.
3/ Inactive 1972 - 1974.
4/ Inactive 1986 - 1989.
5/ Inactive 1910 - 1912, 1914 & 1919 - 1924.

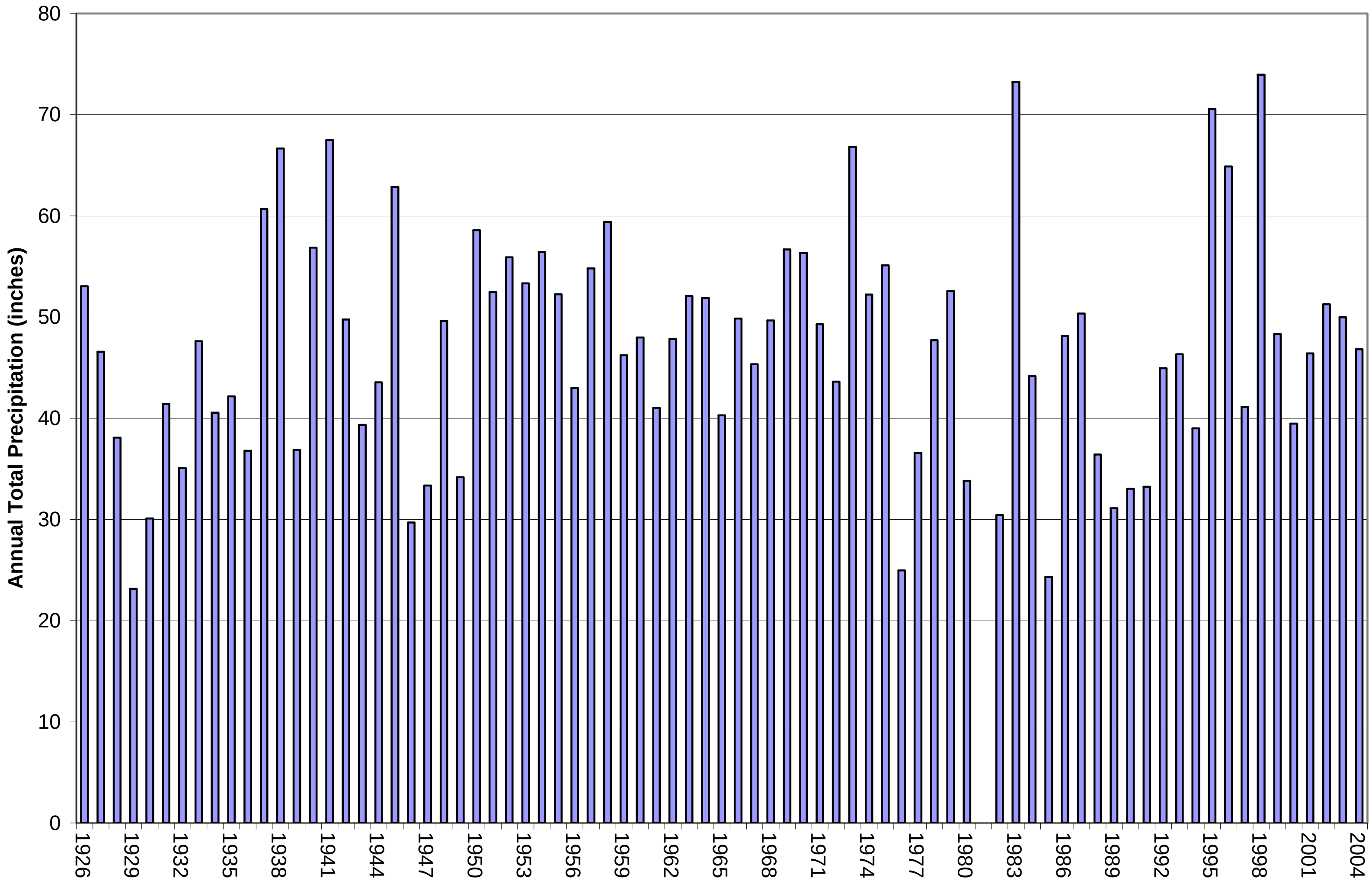
Source: Table II-1 of the NCWAP Report (Downie et al., 2003), Appendix D.

Figure 3-4. Precipitation gauges in the vicinity of the Mattole River WAU.



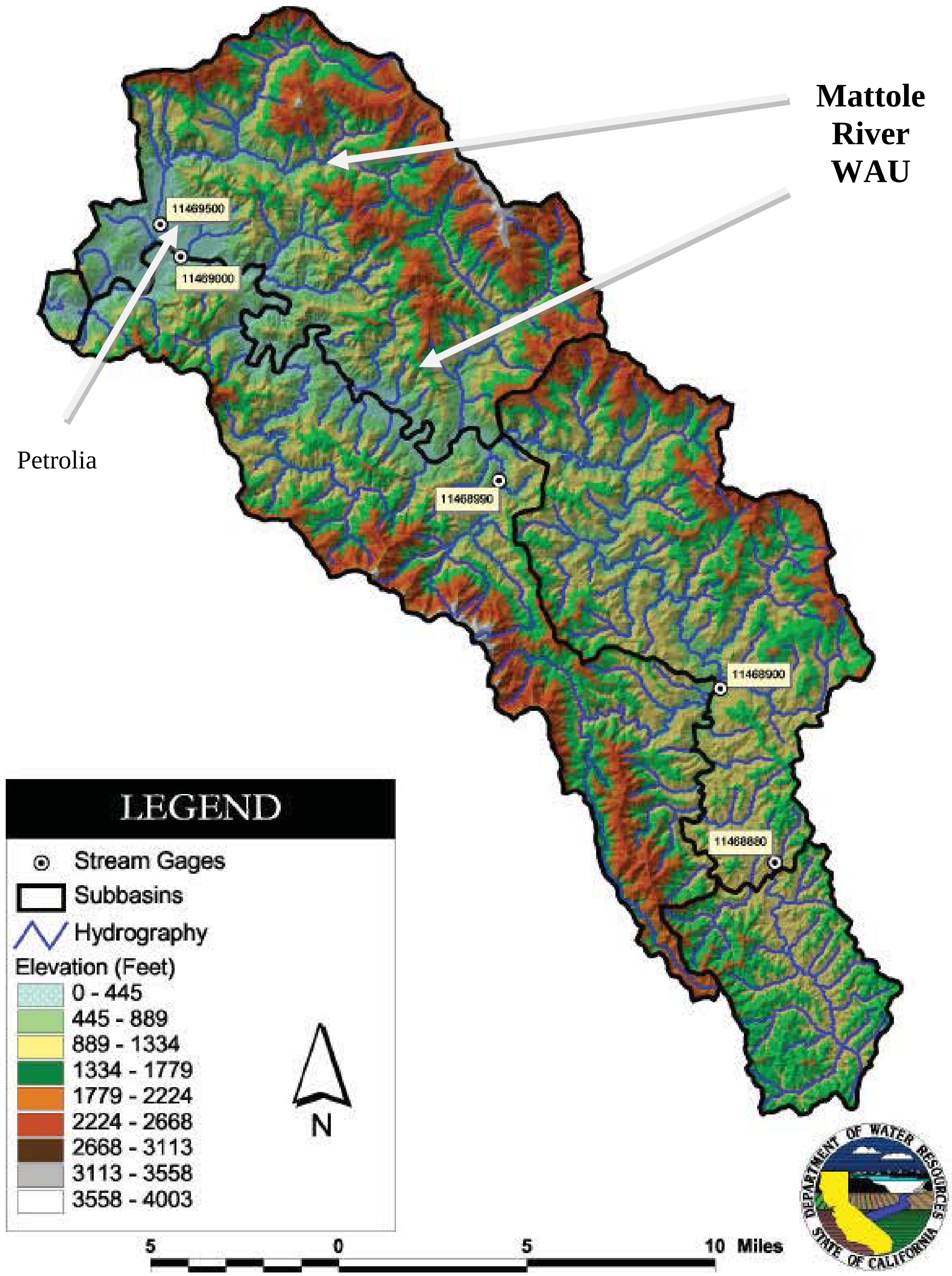
Source: Figure II-1 of the NCWAP Report (Downie et al., 2003), Appendix D.

Figure 3-5. Annual total precipitation for Scotia, California (1926-2004).



Note: Missing data for 1981, 1982 (Jan to Sept), 1983 (March), and 1986 (April).

Figure 3-6. Stream gage locations in vicinity of the Mattole River WAU.



Source: Figure II-1 of the NCWAP Report (Downie et al., 2003), Appendix D.

through 2000, was presented in Appendix D of the NCWAP report (Downie et al., 2003). Streamflow statistics presented in the NCWAP report are included in the following discussion.

Daily discharge values averaged over the period of record (Figure 3-7) show the maximum flow occurring during the winter (November through April), which is typical for river basins in this region, declining to the minimum flow levels in late summer. Annual yield/runoff volume data, by year (Figure 3-8), indicate a slight decline and increasing variability in annual yield with time from 1952 to 2000. A similar trend of increasing variability is indicated by the long-term precipitation record at Scotia (Figure 3-5).

Nine other annual peak flows exceeded 50,000 cubic feet per second (cfs) for this period of record, most occurring in the period from the mid-1960s to the mid-1970s (Figure 3-9). The five-year moving averages for annual peak flows (Figure 3-9) show a possible trend of decreasing peak flow rate since then, with increased variation since the mid-1970s. Annual peak flows for water years 2001-2009 (subsequent to the 1951-2000 data summarized in Appendix D of the NCWAP report) show variations similar to those noted since the mid-1970s, with peak flows ranging from 11,400 to 44,500 cfs (on December 28, 2005) (USGS, 2011).

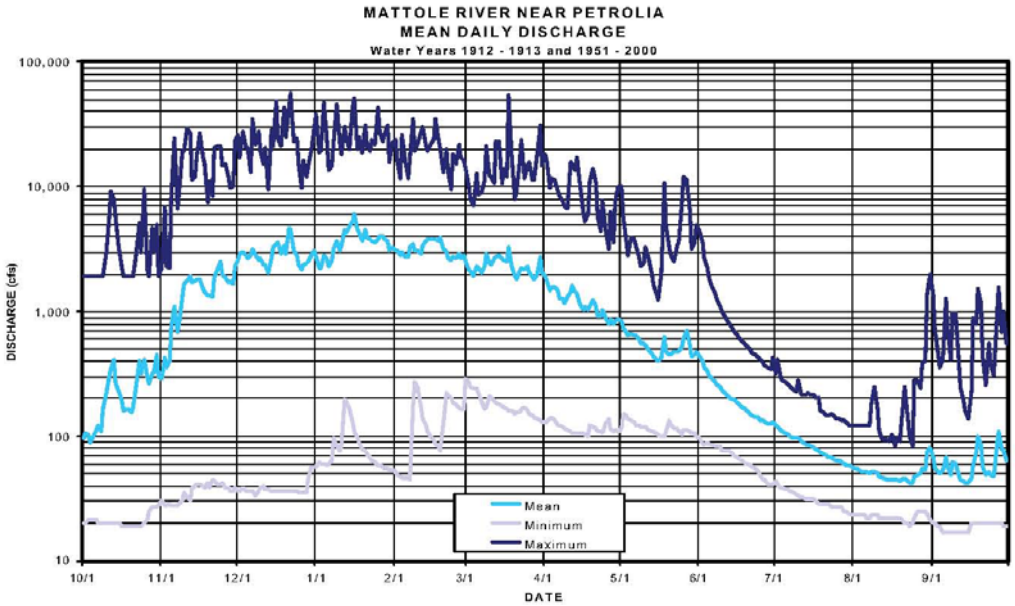
Annual low-flow minimums (and five-year moving averages for low-flow) for the 1951-2000 period show a trend of declining magnitude with time (Figure 3-10). This may reflect increases in water withdrawals from the Mattole River (and tributaries) for domestic and agricultural use coincident with population increases. As noted in Appendix D of the NCWAP report (Downie et al., 2003), water extraction for residential use appears to be increasing in the basin. Furthermore, numerous small volume diversions can have a major impact on surface flows in the basin (Downie et al., 2003).

3.8 Hydrology

The mainstem of the Mattole River is 62 miles long, and is fed by 74 tributary streams. There are approximately 545 perennial stream miles in the basin. This watershed analysis is focused on the lower portion of the Mattole basin, extending upstream as far as the Upper North Fork Mattole drainage, which flows into the mainstem Mattole in the vicinity of the small town of Honeydew.

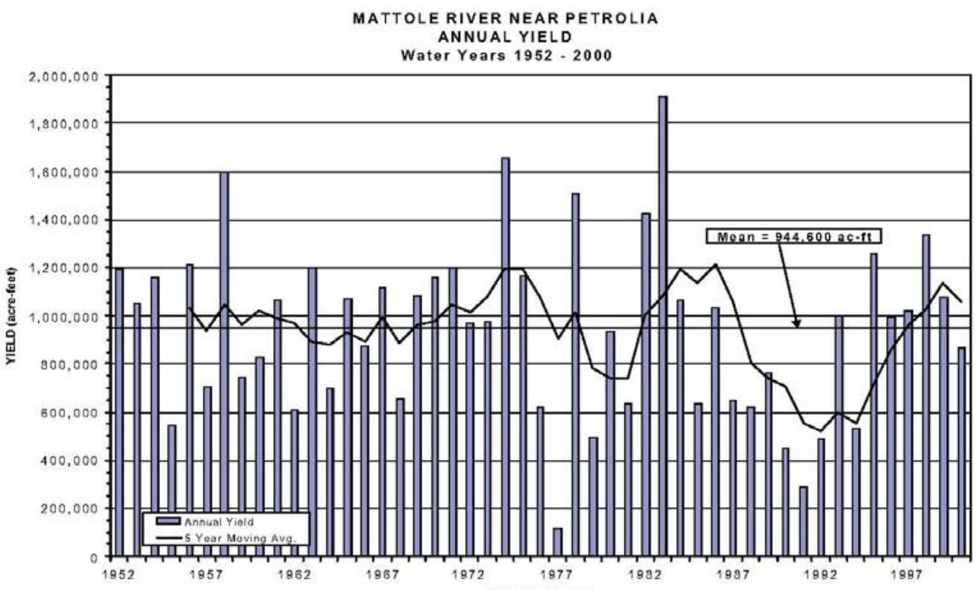
Characteristics of the primary streams in the Mattole River WAU are summarized in the following discussion. Streams located within the three general WAU areas – North Fork Mattole, Upper North Fork Mattole, and McGinnis/Pritchard Creeks – are discussed below and shown on Figure 3-2:

Figure 3-7. Mean, maximum, and minimum daily discharge for water years 1912-1913 and 1951-2000, USGS station #11469000.



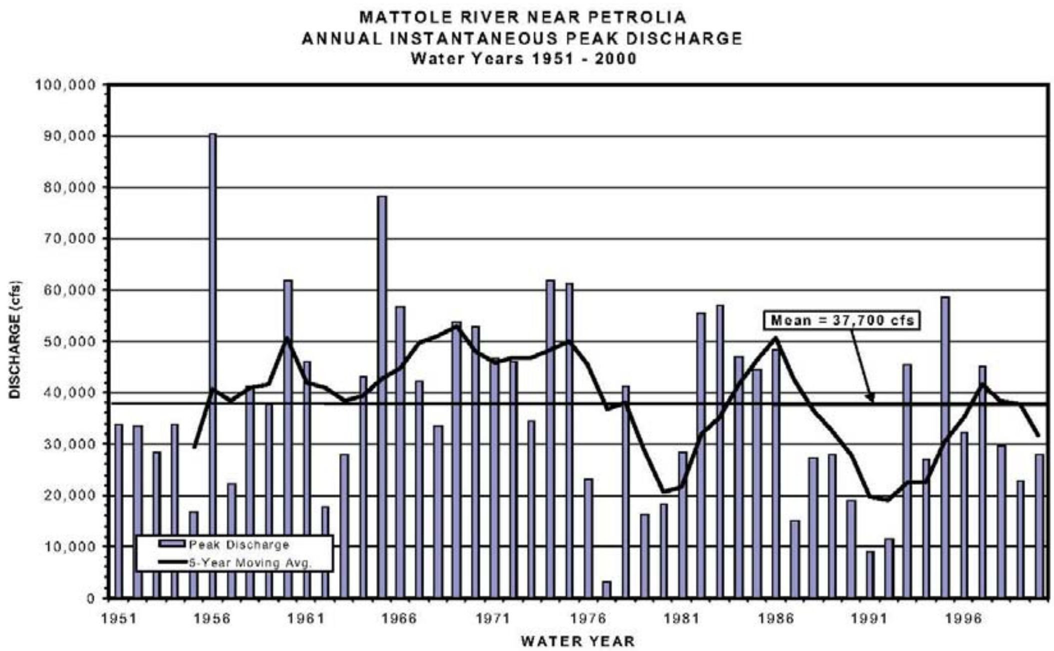
Source: Chart III-4 of the NCWAP Report (Downie et al., 2003), Appendix D.

Figure 3-8. Annual yield and the five-year moving average for water years 1952-2000, USGS station #11469000.



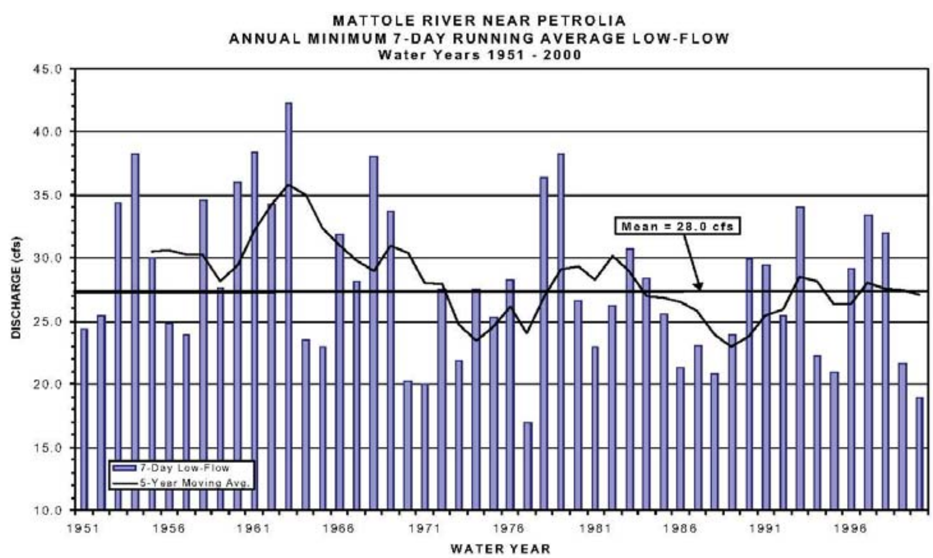
Source: Chart III-5 of the NCWAP Report (Downie et al., 2003), Appendix D.

Figure 3-9. Annual instantaneous peak discharge and the five-year moving average for water years 1951-2000, USGS station #11469000.



Source: Chart III-7 of the NCWAP Report (Downie et al., 2003), Appendix D.

Figure 3-10. Annual minimum seven-day running average low-flow and the five-year moving average for water years 1951-2000, USGS station #11469000.



Source: Chart III-9 of the NCWAP Report (Downie et al., 2003), Appendix D.

- North Fork Mattole – includes the North Fork Mattole, East Branch North Fork Mattole River, and its tributaries Alwardt Creek and Sulphur Creek;
- Upper North Fork Mattole – includes Upper North Fork Mattole River and its tributaries Oil Creek and Rattlesnake Creek, along with Devils Creek (tributary to Oil Creek); and
- McGinnis and Pritchard Creek.

Information on stream characteristics and habitat conditions is provided in the Fish Habitat Assessment report (Appendix E). Results of the assessment of riparian forest conditions are presented in the Riparian Function Assessment report (Appendix C).

3.8.1 *NORTH FORK MATTOLE AREA*

The North Fork Mattole area streams include the East Branch North Fork Mattole River, Alwardt Creek, and Sulphur Creek. As a whole, overstream canopy cover in the North Fork Mattole area is high (>85%) for most of the stream length (see discussion in Appendix C). Most of the low canopy cover segments are in the mainstems of the primary Class I creeks, and the low cover is primarily due to channel width and localized slide-prone inner gorges.

East Branch North Fork Mattole River

The East Branch North Fork (EBNF) Mattole River is tributary to the North Fork Mattole River, with their confluence located approximately three miles downstream of HRC lands. The EBNF Mattole drains approximately 18 square miles and provides a total of 8 miles of perennial stream habitat (Downie et al., 2003), with approximately 1.4 miles of fish-bearing habitat within HRC HCP-covered lands. The lower (off-property) watershed consists of a broad canyon running through rolling hills with a low gradient aggraded channel for approximately 2.5 miles. This lower reach has an abundance of spawning substrates. Upstream of the lower gradient segment, the channel alternates between narrow U-shaped canyons with boulder roughs confined by bedrock to broader V-shaped canyons.

On HRC lands, immediately downstream of Sulphur Creek, the East Branch North Fork Mattole River was observed in 2005 to be within a fluvial confluence zone (see Photo 3-1) characterized by high sedimentation, a relatively unconstrained channel with relatively smaller substrates. Just downstream of the surveyed reach is a debris flow confluence zone that is boulder dominated. Downstream of the debris flow zone is a rock landslide zone dominated by boulder cascades.

Stream temperature data are generally lacking and cannot be assessed, though the westerly aspect of the East Branch North Fork Mattole River results in partial topographic shading provided by steep inner gorges, in addition to shade provided by streamside canopy.

Photo 3-1. East Branch North Fork Mattole River, fluvial confluence reach downstream of Sulphur Creek, August 2005.

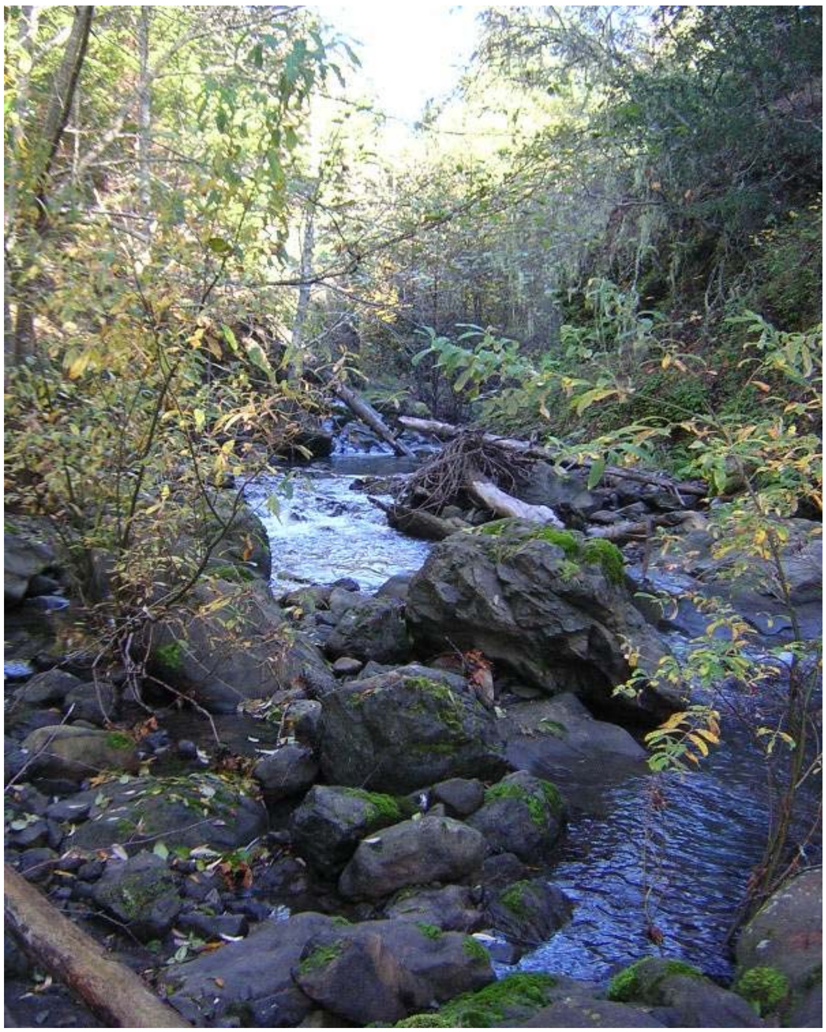
<u>Alwardt Creek</u>

Alwardt Creek is tributary to the East Branch North Fork Mattole River and provides 3.2 miles of perennial stream habitat (plus 1.4 miles on the tributary Rodgers Creek) (Downie et al., 2003). The Alwardt Creek watershed drains an area of approximately 2,400 acres, of which 1,750 acres are owned by HRC and managed under the HCP. The stream has a south to southwest channel aspect with moderate to steep gradients. Stream temperature data are lacking in Alwardt Creek and, therefore, cannot be assessed. Similarly, detailed channel information is not available for Alwardt Creek as this stream was not evaluated in detail through field surveys.

<u>Sulphur Creek</u>

Sulphur Creek is tributary to the East Branch of the North Fork of the Mattole River and provides 2.5 miles of perennial mainstem habitat plus 2.2 miles of tributary habitat (Downie et al., 2003). The watershed has a drainage area of 2,456 acres, of which 1,178 acres are owned by HRC and managed under the HCP. Sulphur Creek is riffle-dominated with irregularly spaced pools, boulder/cobble substrate and moderate gradients (see Photo 3-2). The lower section of the channel is a response reach with gradients from 2 to 8% with short, steep reaches of 16 to 35%.

Photo 3-2. Sulphur Creek, upper end of ATM monitoring reach, September 2005.



The authors walked segments upstream of the ATM monitoring reach (Photo 3-2) that were characterized (refer to the Channel Module Figures 14 and 15) as "earthflow flats" (low gradient, unconfined with floodplains) and observed high amounts of stored alluvial sediments within narrow floodplains on either side of the active channel. It was evident that the active channel was cutting through this material, leaving terraces that are 4 to 5 feet high in many locations. These observations were consistent with past observations made by CDFG (1988) that Sulphur Creek was recovering from past floods as indicated by "flood terraces."

Stream temperature data from 1999 to 2010 at ATM Station 133 indicated MWAT values from 1999 to 2006 ranging from 17.1 to 19.6 °C, followed by MWATs decreasing from 16.5 to 15.4 °C from 2008 to 2010. Achieving the MWAT target since then may be attributed, at least in part, to the growth and maintenance of abundant streamside canopy cover.

Much of Sulphur Creek is boulder-dominated and has a channel gradient and configuration such that LWD would not typically be expected to play a significant morphological role in channel or habitat form. However, pools associated with large woody debris have met PFC targets consistently for the last seven years. Habitat surveys in 2005, starting at the mouth and continuing upstream for a distance of 4,100 feet, reported a decline in overall percent pool area while average pool depths and overstream canopy closure increased.

3.8.2 *Upper North Fork Mattole Area*

The Upper North Fork Mattole area streams include the Upper North Fork Mattole River, Oil Creek, Rattlesnake Creek, and Devils Creek.

Upper North Fork Mattole River

The Upper North Fork Mattole River is a major tributary to the Mattole River providing 4.7 miles of low gradient perennial fish-bearing stream habitat up to "the forks" at the Oil Creek and Rattlesnake Creek confluence (Downie et al., 2003). There is a discrepancy as to where the Upper North Fork Mattole River ends and Rattlesnake Creek begins. Generally, the Upper North Fork Mattole River is considered to end at "the forks". However, maps and data bases maintained by HRC show the Upper North Fork continuing upstream into the Rattlesnake Creek sub-basin (as delineated for watershed analysis). HRC has only minimal ownership of lands draining directly to the Upper North Fork Mattole River downstream of the Oil/Rattlesnake confluence.

Oil Creek

Oil Creek is tributary to the Upper North Fork Mattole River and has a watershed area totaling 6,089 acres, of which 4,023 acres are owned by HRC and managed under the HCP. The Oil Creek mainstem provides 4.6 miles of perennial stream habitat (Downie et al., 2003); perennial stream habitat also occurs in the Oil Creek tributary of Devils Creek (2.3 miles), which is discussed below. Oil Creek's stream gradient on HRC ownership ranges primarily from 2 to 4 percent with short reaches up to 8 percent.

One of the authors of the Fish Habitat Assessment module walked the lower reach of Oil Creek in 2005 and noted that the active channel was small relative to the bankfull channel, which was structurally controlled by steep eroding banks and inner gorges (Photo 3-3). The active channel was subject to areas of vertical and lateral shifts that periodically cut through large deposits of alluvium stored in the floodplain, which indicated a high sediment supply. The young age of vegetation growing within the bankfull channel coupled with the transient appearance of stored alluvium also indicated that this was a high energy stream with flashy flows in response to storm events.

Photo 3-3. Oil Creek, upper reach, August 2005.

Wood storage in Oil Creek is generally low and streamside landslides are the dominant delivery mechanism. Pool quantity has increased over time and pool quality is fair (average residual pool depth was 1.6 feet). Pools are more abundant in upper reaches. Although there are few deep pools, the availability of pool habitat does not appear to be a limiting factor for rearing salmonids. Pool spacing is controlled by bedrock and boulders and these permanent structures form the primary pools in upper reaches. Unstable eroding banks in lower reaches transition to bedrock banks in upper reaches, which are stable and contribute only small amounts of sediment during runoff. Lower reaches have erosive, steep banks that are subject to failure during bankfull events.

Overstream canopy cover is high (>85%) for much of the stream length in the Oil Creek/Devils Creek area. Most of the low canopy cover segments are in the mainstems due to channel width and adjacent grassy areas, but a significant amount is also found on tributaries in the upper slope reaches which flow through meadows.

Oil Creek has a southeast facing basin, resulting in high amounts of solar radiation, and coupled with a general lack of riparian canopy, has elevated mainstem water temperatures that may be a limiting factor to rearing salmonids. The authors noted lower water temperatures in tributary inflow in 2005, indicating that smaller tributaries, many of which have natural barriers in lower reaches, provide critical cool summer inflows to the mainstem. Thus, accessible lower reaches of these tributaries provide thermal refugia habitat.

Analysis of fluvial geomorphic conditions (in the Channel Module) indicated that extensive areas of the upper Oil Creek, including Devils Club Creek, have incised into alluvium, colluvium, and bedrock (ranging from 2 to 10 meters) post 1965. Channel incision has led to streamside landsliding, and incision is propagating upstream in some tributaries. Channel incision and associated hillslope erosion are important determinants to the observed channel and habitat conditions (refer to Appendix D).

<u>Rattlesnake Creek</u>

The Rattlesnake Creek sub-basin is tributary to the Upper North Fork Mattole River. The sub-basin drains 5,711 acres, of which 4,757 acres are owned and managed by HRC. As noted above, discussion of the sub-basin can be confounded by a discrepancy in where the Upper North Fork Mattole ends and Rattlesnake Creek begins. Lower Rattlesnake Creek and its first significant Left Bank Tributary were referred to as the Upper North Fork Mattole River in PALCO habitat data files and on maps inherited by HRC; whereas generally the Upper North Fork Mattole River is considered to end at its confluence with Oil Creek ("the forks"). Nonetheless, beginning at the confluence with Oil Creek, the mainstem Rattlesnake Creek provides a total of 4.8 miles of perennial stream habitat (Downie et al., 2003); while the entire sub-basin provides an estimated 14 miles of fish-bearing habitat in the Rattlesnake/Upper North Fork mainstem and all tributaries including Fox Camp Creek. HRC's ATM Station 169 is located within the reach referred to as either Rattlesnake Creek (by CDFG) or Upper North Fork Mattole (by HRC).

Channel gradients in lower reaches typically range between 2 to 8%, with some short reaches of up to 16%. Upper reaches (upstream of the confluence with Fox Camp Creek) are steeper with average gradients between 8 and 16% and short reaches of 20%.

The Channel Module report identifies distinct channel geomorphic units that influence fish habitat conditions including a fluvial confluence zone near the mouth of Rattlesnake Creek, a rocky landslide influence zone upstream, and a fluvial-moderate gradient zone above. The Channel Module report also notes that Rattlesnake Creek, and its tributaries and nearby Oil Creek/Devils Creek have a "semi-continuous streamside zone of earthflow or deep-seated landslide activity." As a consequence of these conditions, there is a high rate of sediment supply and many reaches appeared "open and disturbed" on air photos over time since the 1960s. Changes in habitat attributes over time reflect inherent susceptibility of the fluvial confluence zone to periodic influxes of sediment from extensive streamside landslides (Photo 3-4) that produce aggradation, followed by degradation/scour and other large scale channel changes associated with high sediment rates.

Photo 3-4. Rattlesnake Creek, streamside landslide, May 2005.

Summer water temperatures exceed those preferred by salmonids and are likely a limiting factor for rearing juveniles. Stream temperature data from 1999-2010 at ATM Station 169 indicated MWAT values from 1999-2009 ranging from a high of 21.7 °C in 2006, declining in the years thereafter to a low of 16.3 °C in 2010. Steep canyon walls provide some shade to the stream during a portion of the day, however, the channel is open and exposed for a majority of its length. Canopy density has increased over time due to hardwood growth near the channel, but overall shade canopy is low.

PALCO biologists reported that the amount of available spawning habitat is low and wood storage was low in surveyed reaches. The function of large wood was limited in lower reaches relative to habitat forming structure due to large substrates. The amount of pool habitat was low; habitat was dominated by flatwater units, indicative of chronic sedimentation. The limited number of pools was associated with scour at boulders.

Overstream canopy cover is high (>85%) for much of the HCP-covered stream length of Rattlesnake Creek. Most of the low canopy cover segments are along the primary Class I creeks, and the low cover is primarily due to channel width and localized slide-prone inner gorges.

Analysis of fluvial geomorphic conditions has indicated that areas located in lower Rattlesnake Creek have incised into alluvium, colluvium, and bedrock (ranging from 2 to 10 meters) post 1965. Channel incision has led to streamside landsliding, and incision is propagating upstream in some tributaries. Channel incision and associated hillslope erosion are important determinants to the observed channel and habitat conditions (refer to Appendix D).

Devils Creek

Devils Creek is the largest tributary to Oil Creek in its headwaters and has a watershed area of 1,613 acres. Devils Creek provides a total of 2.3 miles of perennial stream habitat (Downie et al., 2003). Portions of this sub-basin were subject to extensive forest fires in the summer of 1990. The channel aspect is south by southwest and only portions of the two main forks of this drainage are located within HRC holdings. On HRC lands, gradients range from 8 to 30%.

The lower 1.5 miles of Devils Creek is moderately entrenched with gradients of 2 to 4%, channel bed morphology is dominated by boulders and habitat is characterized by a series of rapids with irregular spaced scour pools. The lower reaches provide areas of good spawning gravels. Rearing habitat is limited due to shallow pools. Upstream, the channel is steep, deeply entrenched and confined in course depositional materials dominated by cobble. The stream is high energy with a high sediment supply. Banks are unstable and contribute large amounts of sediment.

Overstream canopy cover is high (>85%) along much of the stream length in the Oil Creek/Devils Creek area. Most of the low canopy cover segments are in the mainstems due to channel width and adjacent grassy areas, but a significant amount is also found on tributaries in the upper slope reaches which flow through meadows.

Based on limited data, summer water temperatures appear to exceed those preferred by salmonids and canopy density is low. Spawning gravels are limited and stored in pools. Cobble and boulder are dominant in pool tail-outs. Boulders provide the dominant pool forming structure and cover. Pools are shallow and step runs are the dominant habitat type.

Along the majority of Devils Creek, channel incision into alluvium, colluvium, and bedrock (ranging from 2 to 10 meters) has occurred post 1965. Channel incision has led to streamside landsliding, and incision is propagating upstream in some tributaries. Channel incision and associated hillslope erosion are important determinants to the observed channel and habitat conditions (refer to Appendix D).

3.8.3 *McGinnis/Pritchard Creeks*

The McGinnis/Pritchard Creeks area streams include McGinnis Creek and Pritchard Creek.

McGinnis Creek

McGinnis Creek is a major tributary to the Mattole River draining approximately 4,700 acres and providing 5 miles of perennial fish-bearing stream habitat (Downie et al., 2003). HRC owns and manages approximately 2,200 acres of the watershed including 3.6 miles of fish-bearing habitat. While the authors could find no record of documented detections, McGinnis Creek appears the most likely stream on HRC's Mattole ownership to provide readily accessible habitat for Chinook and coho salmon. Several habitat typing surveys of McGinnis Creek have been conducted from 1966 to 2005, and HRC maintains a recently established (2005) permanent ATM station approximately 0.5 miles upstream from the mouth (ATM Station 219). The system appears to have a moderate to high sediment supply as evidenced by depositional features such as point bars and aggraded channel conditions (see Photo 3-5). The channel is susceptible to shifts in both lateral and vertical stability associated with changes in flow and sediment regimes. Streambanks in lower reaches are susceptible to accelerated bank erosion and rates of lateral adjustment (meandering) appeared to be influenced by the presence, condition, and maturity of riparian vegetation.

Photo 3-5. McGinnis Creek, lower reaches, October 2010.

Recent decreases in lower reach stream temperatures favorable to salmonid life cycles have been reported. Stream temperature data collected at ATM Station 219 since 2005 using continuous data loggers during the summer months has reported the following MWAT values ranging from a high of 19.0°C in 2006, declining since then to a low of 15.2°C in 2010. The improvements in temperature correlate with an observed increase in canopy density provided primarily by hardwoods on floodplains and stream banks. Hardwood stands in floodplains appear somewhat transient and are likely periodically reset by flood events.

During the 2010 field visit, the biologists observed that habitat complexity appeared to have improved during the preceding 5 years. The lower reach was meandering through the alluvial deposits, which resulted in some bank erosion, pool formation, and delivery of alder-dominated large and small woody debris along the outside of the meander bends (Photo 3-5; note exposed woody debris, root mass, and pool with alder woody debris recruitment). Pools were also observed along bedrock exposures. It appeared that pools made up about 40% of the stream length. Pool depths ranged from about 1.5 to 3 feet. Evidence of channel downcutting was present as seen by relatively recent exposures of old alder stumps that were previously buried under alluvium. The majority of pools observed in 2010 resulted from development of the meander pattern and associated scour around the recruited hardwood woody debris. The riparian assessment characterized overstream canopy cover as high (>85%) along much of the McGinnis Creek stream length, with some low canopy cover segments primarily on the mainstem, but also occur on scattered reaches on its tributaries.

Pritchard Creek

Pritchard Creek is tributary to the Mattole River draining a watershed area totaling 4,762 acres and providing 5.2 miles of perennial stream habitat (Downie et al., 2003). HRC owns and manages 817 acres in the watershed including 2.3 miles of fish-bearing habitat.

Pritchard Creek has a south by southwest channel aspect, and lower reaches are dry during summer months. Further upstream, the channel has a 5% gradient and is confined within a V-shaped bedrock canyon with an abundance of hardwoods on banks and floodplains. Dense to moderately dense overstream canopy cover has been reported for much of the stream length except for a localized reach.

3.9 Forest Ecology

The lower Mattole drainage, including the Mattole River WAU, consists of grassland and a diversity of tree species including red alder (*Alnus rubra)*, black cottonwood *(Populus trichocarpa)*, willow *(Salix spp.)*, tanoak *(Lithocarpus densiflorus)*, Pacific madrone *(Arbutus menziesii)*, live oak *(Quercus* sp*.)*, California bay-laurel *(Umbellularia californica)*, big-leaf maple *(Acer macrophyllum*), Douglas-fir *(Pseudotsuga menziesii)*, Sitka spruce *(Picea sitchensis)*, and grand-fir *(Abies grandis)*. Redwood *(Sequoia sempervirens)* can be found in the WAU but is uncommon. The vegetative pattern along the valley floor reflects different soil types, some suitable for tree growth and others not, and intensive attempts to convert timberland to grassland by repeated logging and/or burning or by girdling trees. Forest openings are also created by periodic landslide disturbances resulting from inherently unstable geology (see Appendix A for discussion of geologic setting).

3.9.1 *RIPARIAN FOREST*

Prior to ranch and farmland conversion in Mattole valley and extensive commercial timber harvest in the mid-twentieth century, a complex canopy of hardwoods and conifers dominated riparian vegetation along the mainstem and most tributaries of the Mattole. Hardwood species included water-tolerant red alder, black cottonwood, willow, and big-leaf maple, with drier site species such as tanoak and Pacific madrone occurring along smaller headwater tributaries. Conifer species included Douglas-fir, grand fir, Sitka spruce, and to a limited extent coastal redwood. Under story herbaceous plants included sword fern

(*Polystichum munitum*), chain fern (*Woodwardia fimbriata*), evergreen huckleberry (*Vaccinium ovatum*), red huckleberry (*Vaccinium parvifolium*), and poison oak (*Toxicodendron diversilobum*). Persistent natural grass openings in the forest canopy were generally restricted to changes in soil type occurring upslope of riparian forests; however, riparian forest openings were produced by periodic wildfire, aboriginal burning, landsliding, and flood-related riparian scouring events.

While the same species exist today, the variability in riparian forest composition and seral stage has been significantly reduced due to ranch and farmland conversion and the post-World War II (WWII) logging boom which targeted streamside and non-streamside late seral forest stands alike and, consequently, "reset the clock" on stand development. Red alder and other hardwoods currently dominate floodplains along valley floors where review of historical 1948 aerial photographs suggest large Douglas-fir and other conifers were once more common. Older riparian forests representing historic conditions can still be found along smaller headwater streams providing multiple canopy layers and an open understory environment due to shade-rich conditions and less stems per acre. Douglas-fir trees ranging from 30 to 60 inches and greater in diameter and 140 feet or more in height are common in these settings.

3.9.2 *The Role of Fire*

As an integral part of the landscape in the Mattole basin, fire has occurred historically primarily as part of land management or as a result of lightning strikes (MRRP, 2009a and 2009b). Low intensity fires were frequently used by Native Americans to care for their resources and the land. These indigenous peoples burned a large amount of the landscape every three to five years. The historic frequency of fire ignition by humans and lightning strikes maintained a greater area of grassland and an overall lighter fuel load than present today. Therefore, fires rarely burned with the intensity and impact observed in some cases today.

During and subsequent to European settlement, fire was used for maintenance of grasslands for ranching purposes and, in the mid and later twentieth century, following harvest operations to reduce logging slash. Fewer acres burn annually in the Mattole today than burned in the historical fire regime. Because of this, large-scale crown fires are more common as a result of the heavy fuel loads generated from decades of fire suppression, which allow small fires that would otherwise burn through the understory to reach into the tree tops, destroying whole trees and swaths of forest (MRRP, 2009a).

Fire records have been maintained for lands in the Mattole River WAU since the 1950s (California Department of Forestry and Fire Protection [CAL FIRE], 2011). Most of the fires over the last 50 years have started from lightning strikes in dry conditions (MRRP, 2009a). Two significant fires are recorded in the HCP area of the WAU – the 1,610-acre T.K. Clark fire in the North Fork sub-basin in September 1950, and the 2,760-acre Rainbow fire in the Oil Creek sub-basin in August 1990. In addition, several lightning-caused fires in the McGinnis Creek and Pritchard Creek sub-basins in the HCP area of the WAU occurred in August 1977. No other major fires have been recorded for HCP lands in the Mattole River WAU.

The *Mattole Integrated Coastal Watershed Management Plan* (MRRP, 2009a) presents strategic management goals for the Mattole basin. Of these, Goal 6 is to "support the use of fire as a functional ecosystem component without endangering human habitations or existing ecological values." Fire management (MRRP, 2009a) includes activities to: (1) implement shaded fuel breaks around communities and along major access roads; (2) complete fuel reduction projects throughout the watershed in high priority areas and develop monitoring and maintenance agreements to ensure the long-term viability of treatments; and (3) support the use of prescribed fire where appropriate and consistent with the MRC/MRRP Fire Policy. The 2009 State of the Mattole Watershed Series: Number 1 – Fire (MRRP, 2009b) provides further information on basin-wide conditions, the MRC/MRRP Fire Policy, and issues of concern.

3.10 Fish Species Composition and Distribution

Pacific salmonids utilizing habitat within the Mattole River WAU include fall-run Chinook salmon, coho salmon, winter-run steelhead, and summer-run steelhead. Spring-run Chinook salmon may have been present historically, but have been extirpated (Downie et al., 2003) and summer-run steelhead are rare. Table 3-8 shows generalized life history information for Mattole River salmon and steelhead (Barnhart 1986; Brown 1972; Busby et al., 1996; Downie et al., 2003; Meehan 1991; Nickelson et al., 1992), modified by Gary D. Peterson (MSG) based on 25 years of experience in Mattole salmonid monitoring and restoration work.

Downie et al. (2003) presented maps showing estimated historical distribution of coho salmon, Chinook salmon, and steelhead in the Northern sub-basin within which the Mattole River WAU is located. Maps E-5, E-6, and E-7 of the Fish Habitat assessment show coho and Chinook salmon distribution based on Downie et al. (2003). These maps also show steelhead distribution, based on Downie et al. (2003), with modifications to include additional lower order channels that were determined to be accessible according to the stream gradient criteria applied by PALCO (now HRC) analysts, and information collected by PALCO fisheries biologists during the 2005 electroshocking and barrier surveys. In addition, these maps show distribution of steelhead off of HRC's property, though this information has not been verified, which was based on Downie et al. (2003) and modified to include blue line streams shown on USGS topographic maps.

Table 3-8. Life history patterns of salmon and steelhead in the Mattole River.

	Adults Return	Spawn	Eggs in Gravel	Young in Stream	Young Emigration	Estuary/Lagoon Residence	Ocean
Steelhead	Nov.-April (Winter-run); March-June (Summer-run)	Dec.-May	Dec.-July	1-2 years	Oct. -July	Variable	1-3 years
Chinook	Oct.- Jan.	Nov.-Jan.	Nov.-March	3-7 months	April/May-July	Days to months (if oversummering in the lagoon)	2-5 years
Coho	Nov.-Feb.	Dec.—Feb.	Dec.-April	Up to 15 months	March-June	Days to one month	2 years

Source: Table E-1 of Fish Habitat Assessment Report (Appendix E).

Based on the best available information (Downie et al., 2003 distribution maps), McGinnis Creek is the only stream on HRC lands that is accessible to Chinook salmon. Chinook salmon may also access lower gradient reaches of the North Fork Mattole River and East Branch North Fork Mattole River, and Upper North Fork Mattole River downstream of HRC's ownership. Several survey efforts in recent years, including a 2001 CDFG coho salmon inventory, were unable to find coho salmon on HRC's ownership. These "presence surveys" were done by snorkeling short reaches of the most suitable habitat on the ownership in summer-fall 2001 (CDFG, 2002) and 2002 (CDFG, 2004) including the mainstems of Oil Creek and McGinnis Creek. Potential suitable habitat not surveyed is present in other reaches in HRC tributaries based on having cool summer water temperatures; however, migration access is generally limited to steelhead.

Stream surveys conducted by CDFG in 1966, 1982, 1985, 1991, and 1997; the Coastal Headwaters Association in 1982; and by PALCO biologists in 2005, have documented the presence of steelhead and rainbow trout within HRC's ownership in the following streams: East Branch North Fork Mattole River, Alwardt Creek, Sulphur Creek, McGinnis Creek, Pritchard Creek, Rattlesnake Creek/Upper North Fork Mattole (and tributaries), Fox Camp Creek, Oil Creek (and tributaries).

In 2005, PALCO staff identified barriers to upstream migration and the upper extent of distribution of salmonids using an electroshocker and a two-person fisheries biologist crew (see Appendix E for methods and further discussion, Table E-3). Maps E-5, E-6, and E-7 show barriers on HRC lands that were surveyed during the electroshocking effort. All fish recovered during electroshocking were juvenile steelhead or rainbow trout.

The Fish Habitat Assessment report (Appendix E) provides detailed information regarding the habitat requirements and distribution of each species, along with conditions of habitat potentially impacting species distribution.

3.11 Amphibian and Reptile Species Composition and Distribution

Habitat occurs for all five of the amphibian and reptile species of concern in the Mattole River WAU. There is habitat and potential habitat for the headwater species (southern torrent salamander and tailed frog), and a limited amount of existing and potential habitat for the lowland species (red-legged frog, yellow-legged frog, and northwestern pond turtle). There are no records on HRC lands in the Mattole WAU for the pond turtle and tailed frog. In addition, the reported sighting of a red-legged frog may have been a misidentification. The Amphibian and Reptile Assessment report (Appendix F) provides detailed information regarding the habitat requirements and distribution of each species.

4.0 LAND USE

This section presents a brief summary of land use in the Mattole River WAU, including a description of prehistoric land use, forest management from the early days of human settlement to the late twentieth century, and recent harvest and road construction. Harvest, yarding, and hauling methods and locations are discussed, along with rates of harvest over the years and roads within the HCP area of the WAU.

Commercial timber production activities and grazing of rangelands occur on lands in the WAU not owned by HRC. Most of the areas in the WAU have not been developed for residential or commercial use, though the Mattole basin has grown in population over the past several decades. Distribution of major land cover within HCP lands in the Mattole WAU is listed in Table 4-1 and illustrated in Figure 4-1. First harvest acreages, by decade and sub-basin, are provided in Table 4-2.

4.1 Prehistoric land use

Prior to settlement by Europeans, the Mattole River basin was inhabited by groups of Native Americans. Little is known about these early Americans, for they were quickly displaced by settlers from the Eastern United States, who arrived in the early 1850s (Downie et al., 2003). The word Mattole meant "clear waters" in the language of the Athabaskan-speaking Mattole and Sinkyone Native Americans. Based upon the practices of other North Coast native peoples, it is presumed they utilized abundant, native salmon and steelhead resource for an important component of their sustenance (Downie et al., 2003).

One important characteristic shared by these tribes was their seasonal land use pattern. In the winter they settled near streams where salmon were plentiful, whereas, in the summer they settled in the hillside and ridge areas where seeds, acorns, small game, deer, and elk were nearby (Kroeber, 1976). In these summer use areas, they would hunt deer and elk by lengthy pursuit until the animals would tire or, in some cases, would be captured in corrals constructed with bark and logs.

Native American burning practices prior to the arrival of European settlers suppressed the encroachment of Douglas-fir and other woody vegetation (Downie et al., 2003) in favor of maintaining forest openings for the benefit of hunting and gathering. Low intensity fires were frequently used by Native Americans to care for their resources and the land. These indigenous peoples burned a large amount of the landscape every three to five years (MRRP, 2009a and 2009b).

Table 4-1. Timber stand acres by type and age (2011 data) for HCP area of the Mattole River WAU.

Sub-basin	Douglas-Fir [a]				Hardwood				Non-Timber	Total
	<20 yrs	20-39 yrs	40-150 yrs	>150 yrs	<20 yrs	20-39 yrs	40-150 yrs	>150 yrs		
Alwardt Creek	329	128	480	230	58	47	309	0	176	**1,756**
Camp Mattole Complex	1	9	12	11	58	19	100	0	157	**367**
Conklin Creek	10	106	59	3	0	118	160	0	42	**498**
Dry Creek Complex	<1	<1	0	0	0	0	15	0	7	**23**
East Branch North Fork	135	54	179	36	19	56	391	0	41	**912**
Lower East Branch	67	20	0	0	0	5	0	0	6	**98**
McGinnis Creek	105	241	230	32	45	156	1,159	0	222	**2,190**
North Fork	226	181	376	433	19	97	124	0	94	**1,551**
Oil Creek	720	315	729	194	180	66	723	0	1,081	**4,008**
Pritchard Creek	68	59	179	5	21	20	408	0	54	**813**
Rattlesnake Creek	435	382	934	416	7	330	1,576	0	680	**4,758**
Sulphur Creek	189	41	366	64	50	69	177	0	220	**1,176**
Total for HCP Area	**2,286**	**1,536**	**3,545**	**1,423**	**457**	**981**	**5,143**	**0**	**2,780**	**18,150**

[a] "Douglas-Fir" category includes Douglas-Fir/Hardwood.

Figure 4-1. Timber stand type and age classes (2011 data) for HCP area of the Mattole River WAU.

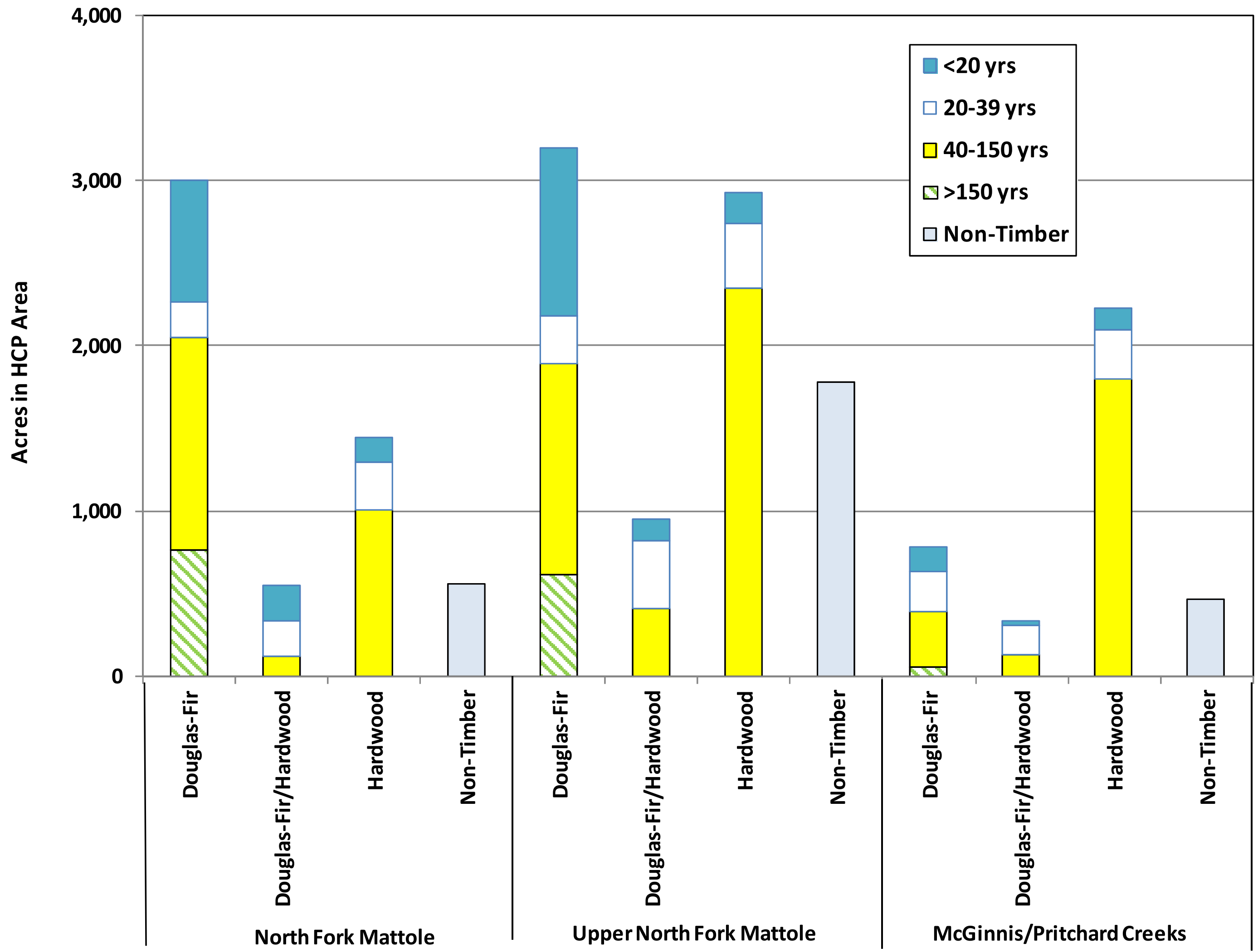


Table 4-2. First harvest entry acres in HCP area (2006 data).

Sub-basin	1890-1899	1900-1909	1910-1919	1920-1929	1930-1939	1940-1949	1950-1959	1960-1969	1970-1979	1980-1989	1990+	All Other Categories	Total
Alwardt Creek	<1	0	0	0	0	0	0	0	0	274	<1	1475	**1750**
Camp Mattole Complex	0	0	0	0	0	0	0	0	0	0	0	357	**357**
Conklin Creek	0	0	0	0	0	0	0	0	0	0	0	509	**509**
Dry Creek Complex	0	0	0	0	0	0	0	0	0	0	0	30	**30**
East Branch North Fork	67	0	0	0	0	0	0	0	0	25	<1	756	**848**
Lower East Branch	0	0	0	0	0	0	0	0	0	0	0	159	**159**
McGinnis Creek	0	0	0	0	0	0	0	0	0	0	0	2187	**2187**
North Fork	0	0	0	0	0	0	0	40	0	0	66	1264	**1369**
Oil Creek	0	0	230	0	0	0	0	1720	0	0	260	1813	**4023**
Pritchard Creek	0	0	0	0	0	0	0	42	0	0	0	775	**817**
Rattlesnake Creek	0	0	104	0	0	0	603	1550	0	0	15	2484	**4757**
Sulphur Creek	0	0	0	0	0	0	0	0	0	16	85	1077	**1178**
Total for HCP Area	**68**	**0**	**334**	**0**	**0**	**0**	**603**	**3352**	**0**	**315**	**427**	**12885**	**17984**

Note: "All Other Categories" include: old growth (4,161 acres); prairie (2,657 acres); unknown (5,276 acres); one unlabeled category (10 acres); and acquired (782 acres).

Natural events (i.e. wildfire, flood, earthquakes) and land-use patterns associated with Native American burning practices, along with management in the early years of European settlement, resulted in a variety of different aged stands. These stands ranged from “true” old-growth forests (not subject to burning) located in the bottom of drainages to advanced prairie in areas cleared for livestock grazing beginning in the mid to late 1800s after routine burning by Native Americans was no longer practiced.

4.2 Harvest History (1900-1988)

HCP-covered lands in the Mattole River WAU, now currently under one ownership, were under numerous separate ownerships at the start of the 20th century. The first recorded harvest activity in the HCP area occurred in the 1890s in the East Branch North Fork Mattole sub-basin (Appendix A – Plate 5). Then, in the 1910s, harvest was recorded for the first time in the Oil Creek and Rattlesnake Creek sub-basins. These early harvest activities were conducted by man and animal power with the lumber and tannin used locally for construction of homes and barns, among other things.

Large-scale industrial timber operations commenced in the 1950s, starting in the Rattlesnake Creek area and continuing into the 1960s in the Rattlesnake and Oil Creek areas, with some first harvest also occurring on HCP lands in the North Fork and Pritchard Creek sub-basins. By the end of the 1960s, approximately 25 percent of HRC’s current Mattole River WAU ownership had been initially harvested. Another 15 percent of the ownership was prairie land which would not produce harvestable timber. The remainder of the land was either old-growth stands or not categorized (per 2006 GIS data).

The management style for this early logging was similar to most areas of the North Coast at the time. Practices included substantial ground disturbance, little protection of stream channels and riparian zones, extensive road construction, and little or no recognition of the potential adverse influence to slope stability caused by harvesting on inner gorge slopes. While the majority of growing timber was harvested at each logging site, Douglas-fir ‘seed trees’ were occasionally retained individually or in patches to facilitate stand regeneration, with mixed success. Mid-twentieth century logging was conducted almost entirely by diesel-powered bulldozers and tractors, with logs typically yarded downhill to landings and haul roads located at or near the bottom of the harvest setting. Where they constituted the least steep, easiest to negotiate terrain, watercourses were used as skid trails during this process. This practice, along with unmitigated cut-and-fill skid trail construction, resulted in the filling of many stream channel segments with soil and logging debris. Logs were generally transferred by truck to the nearest mills active at the time, including two located in the Bull Creek drainage to the east.

The 1955 and 1964 floods drastically altered stream and riparian conditions in the basin. Disturbed by recent skid trail and road construction, and often denuded by extensive timber harvest, streamside slopes in the Mattole River WAU responded to the heavy rains and flash floods with catastrophic mass wasting delivering significant volumes of sediment from harvested hillslopes and roads (see Appendix A for mass wasting discussion and Appendix D for channel analysis). The major flood flows caused significant stream channel aggradation (and subsequent scour) destroying riparian vegetation and transporting sediment downstream, resulting in an over-simplified hydraulic condition (i.e., loss of aquatic habitat diversity). These conditions appear to have persisted for decades after the initial two triggering floods (1955, 1964), and are likely to continue in certain areas within the WAU (see Appendix D).

In the years after the 1964 flood event, growing concern over water quality and aquatic habitat led to scrutiny of timber harvest activities, and in 1973 the Z'berg-Nejedly Forest Practices Act was passed and the CFPRs subsequently established. These rules, among other things, provided protection for water quality and riparian areas in the form of watercourse and lake protection zones (WLPZ) by minimizing ground disturbance and limiting timber removal. Reforestation requirements were also established.

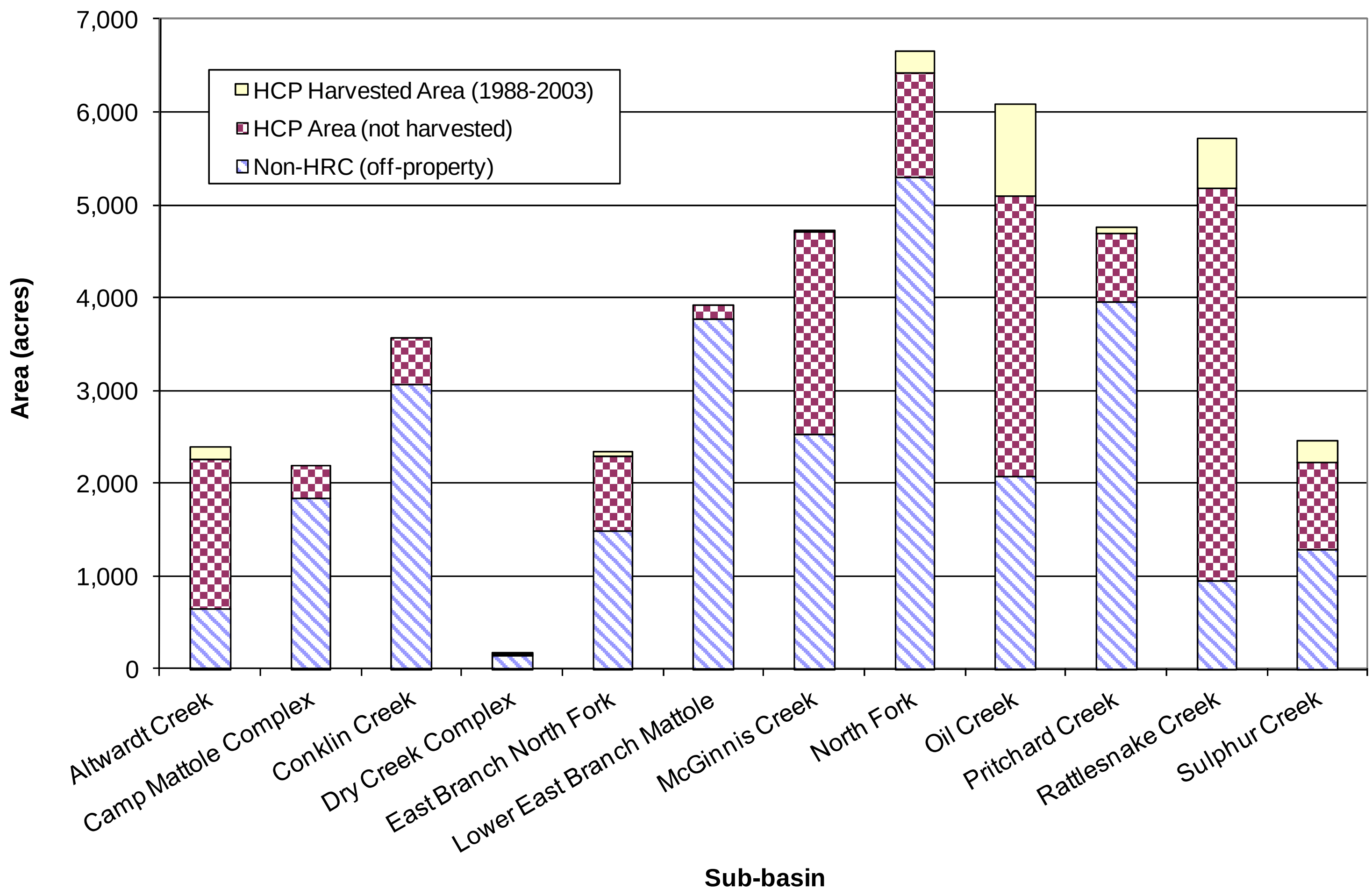
First harvest continued in the 1980s (Table 4-2) primarily in the Alwardt Creek sub-basin (274 acres), with additional first harvest in the Oil Creek (260 acres), Sulphur Creek (85 acres), and North Fork (66 acres) sub-basins in the 1990s and into the 2000s.

4.3 Harvest History (1988-2003)

Timber harvest operations conducted by PALCO, during the period analyzed for the sediment budget (1988 through 2003), primarily involved the harvest of a mixture of first-entry and second-growth Douglas-fir timber in individual 10- to 40-acre clearcut or partial harvest units, along with the conversion of hardwood-dominated stands to conifer. Harvest acres, relative to total acres, by sub-basin during this time period are shown on Figure 4-2. Timber harvest on HCP lands from 1988-2003 occurred primarily in the Oil Creek (993 acres), Rattlesnake Creek (526 acres), North Fork (248 acres), Sulphur Creek (238 acres), and Alwardt Creek (146 acres) sub-basins. No timber harvest has occurred on HRC/HCP lands of the Mattole River WAU since 2006.

In the Oil Creek sub-basin, most of the harvest (751 acres) occurred in 1991 and 1992 as part of a two-year timber salvage operation following the 1990 Rainbow fire. Little harvest occurred in Oil Creek

Figure 4-2. Acres harvested in HCP area by sub-basin from 1988–2003.



following the salvage operation until 1999 when approximately 191 acres were harvested over a four-year period continuing through 2002. In the Rattlesnake Creek sub-basin, 407 acres of harvest occurred from 1999 through 2003, with an annual maximum of 165 acres occurring in 2002. In the North Fork sub-basin, after the annual maximum harvest of 66 acres in 1991, most of the harvest occurred in the period from 2001 through 2003. In the Sulphur Creek sub-basin, no harvest occurred from 1991 through 1999; most of the harvest occurred from 2000 through 2002, peaking in 2002 at 115 acres.

Along with total acres harvested each year, Figure 4-3 depicts yarding systems used from 1988 to 2003, and Figure 4-4 shows silviculture methods used during the same period. As shown, total acres harvested peaked at 730 acres in 1992, with other large harvest years in 2002 (495 acres), 1999 (258 acres), and 2001 (194 acres). No harvest occurred in 1988, 1989, and 1995, with less than one acre in 1994. During this period, yarding systems shifted from a fairly balanced combination of tractor- and cable-based yarding (through 1998) to the emergence and predominant use of helicopter yarding starting in 1999. Helicopter logging was used because of its ability to access otherwise difficult or inaccessible harvest settings with little to no ground disturbance, but at a substantially higher cost. Clear cutting, used to meet management objectives including in some instances conversion from hardwood to conifer occupancy, was applied to more acres than partial-cut silviculture (Figure 4-4), especially considering the 751-acre salvage harvest in Oil Creek in 1991 and 1992 following the 1990 Rainbow fire – the salvage harvest appeared similar in many areas to a clear cut.

Harvest-related ground disturbances are associated with yarding activities and post-harvest site treatment in preparation for planting, although heightened concerns over erosion and water quality beginning in the 1990s resulted in practices less disturbing than those of the earlier logging boom era, particularly in riparian areas and on steep slopes. Post-harvest site preparation treatments, including broadcast burning and mechanical preparation of harvested areas, have been seldom used in the Mattole over the last 20 years. Instead, to address fire hazard and prepare harvest sites for post-harvest regeneration (natural seeding and/or planting), suitable ground conditions have been achieved by yarding logs to the landing with the majority of limbs intact. Logs are subsequently ‘limbed’ at the landing, and the resulting slash is piled and burned at the onset of the rainy season. Herbicides are used on an as-needed basis only, in accordance with applicable county, state, and federal laws, for controlling unwanted herbaceous and woody species in order to promote native conifer forest regeneration and growth. The following chemicals are most commonly used by HRC: imazapyr (brand names – Chopper, Polaris, Arsenol) and triclopyr (brand names – Garlon, Element). Importantly, HRC’s shift from even-age management to all-age selection management is anticipated to result in less herbicide application over time.

Figure 4-3. Acres harvested in HCP area by yarding system from 1988–2003.

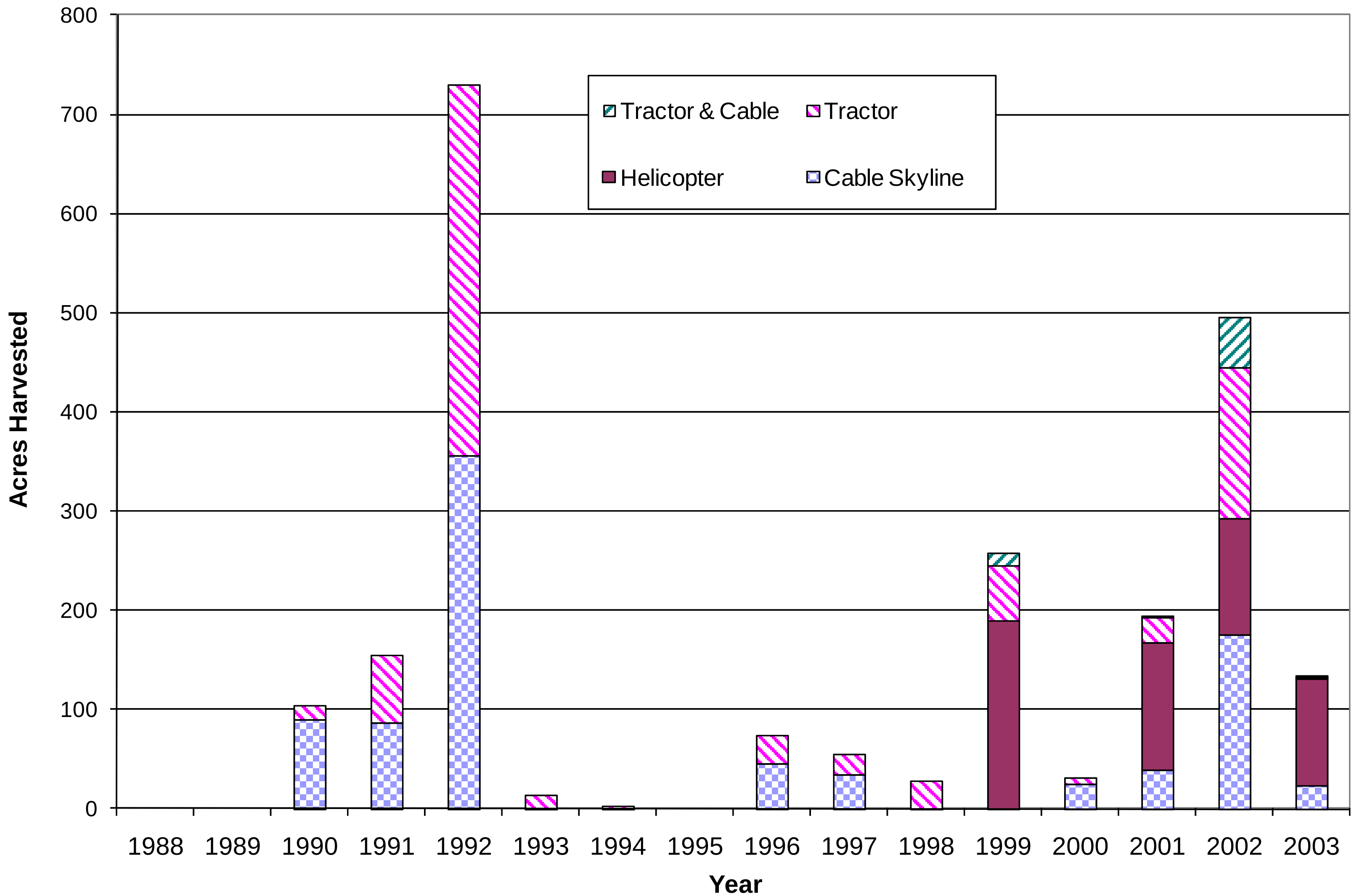
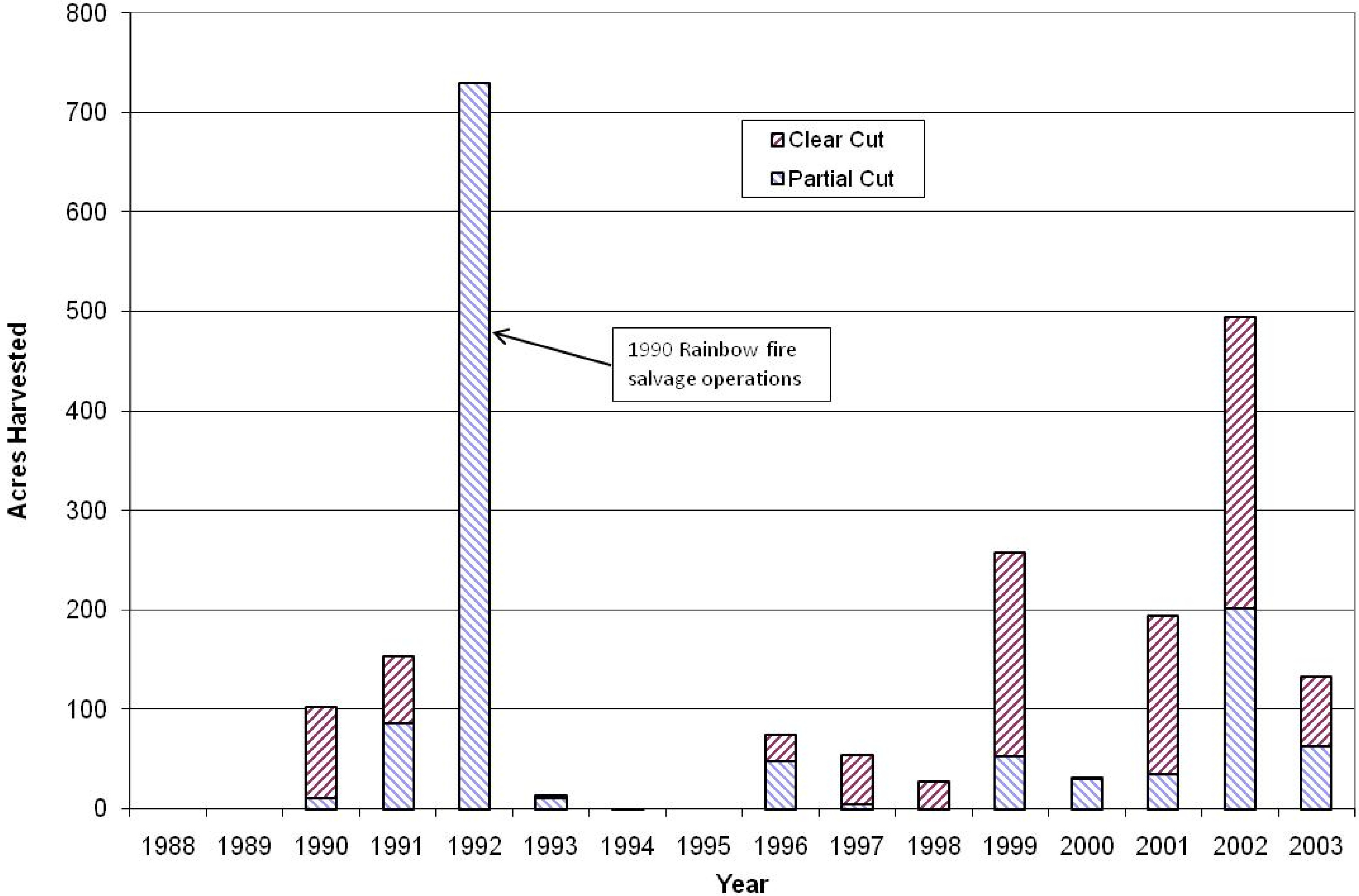


Figure 4-4. Acres harvested in HCP area by silviculture method from 1988–2003.



The 1999 implementation of the HCP provided additional watershed protection beyond the CFPRs. This additional mitigation included wider stream buffers, green tree retention measures, and greater restrictions regarding timber operations on steep and/or unstable slopes, subject to further refinement upon completion of watershed analysis. Along with changes in management practices, the HCP led to the initiation of scientific studies designed to improve the understanding of stream conditions on lands owned and managed by PALCO (now HRC lands). The ATM program provides data for assessment of processes and conditions in streams, including effects of management practices. The stream monitoring program implemented as part of the HCP provided data reviewed as part of this watershed analysis.

Also as part of the HCP, a policy precluding hauling and heavy equipment use of roads during wet weather was implemented to reduce road sediment generation and delivery to streams. HCP road use restrictions involves ceasing all traffic, except for light pickups used for forestry, wildlife surveys, monitoring, and emergency repair work, when there is significant rain. Road stormproofing, reconstruction, and upgrading have occurred on a significant portion of HCP roads effectively reducing sediment inputs to streams. Road improvements include replacement or decommissioning of failing or undersized culverts as well as ‘Humboldt’ and fill-only stream crossings, removal of ‘perched’ fill material, reconfiguration of road prisms to insure a well-drained condition, installation of additional waterbreaks, and the rocking or otherwise ‘treating’ of road surfaces.

As of 2006, the PALCO GIS database showed a total of 90 miles of existing roads on HCP lands in the Mattole River WAU (Table 4-3). ‘Mainline’ rocked haul roads used to access large tracts of land account for approximately 15 miles of the existing road system. There are approximately 73 miles of dirt, primarily native-surfaced roads, many of which are ‘spur roads’ not used for year-round traffic. Overall road density on HRC lands of the Mattole River WAU is 3.2 miles of road per square mile of land area (Table 4-3), which is significantly lower than densities for other nearby WAUs (Bear River at 4.8 miles/square mile, Lower Eel River/Eel River Delta at 6 miles/square mile). Road densities are highest in the Camp Mattole Complex (4.3 miles per square mile) and North Fork (4.2 miles per square mile) sub-basins. Road miles in the Oil Creek and Rattlesnake Creek sub-basins total 24 and 26 miles, respectively, with corresponding densities of 3.8 and 3.5 miles per square mile.

Table 4-3. Roads by sub-basin in HCP area (based on 2006 GIS data).

	Regular			Upgraded Only		Stormproofed		Stormproofed and Decomissioned		
Sub-basin	**Paved**	**Gravel**	**Dirt**	**Gravel**	**Dirt**	**Gravel**	**Dirt**	**Grassed Native**	**Total Miles**	**HCP Area Road Density (miles/sqmi)**
Altwardt Creek	-	1	1	-	<1	1	4	-	**8**	**2.8**
Camp Mattole Complex	-	-	2	-	-	-	-	-	**2**	**4.3**
Conklin Creek	-	-	<1	-	-	-	1	-	**1**	**1.9**
Dry Creek Complex	<1	-	-	-	-	<1	<1	-	**<1**	-[1]
East Branch North Fork	-	-	4	-	-	-	<1	-	**5**	**3.4**
Lower East Branch Mattole	-	-	-	-	-	-	-	-	**-**	**-**
McGinnis Creek	-	-	3	-	2	-	4	-	**9**	**2.6**
North Fork	-	<1	4	-	2	1	2	<1	**9**	**4.2**
Oil Creek	-	<1	13	<1	3	2	5	<1	**24**	**3.8**
Pritchard Creek	-	-	1	-	<1	-	-	-	**2**	**1.2**
Rattlesnake Creek	<1	1	14	1	-	5	5	-	**26**	**3.5**
Sulphur Creek	-	<1	<1	<1	-	1	2	<1	**4**	**2.0**
Total for HCP Area	**<1**	**3**	**43**	**1**	**6**	**11**	**24**	**2**	**90**	**3.2**

[1] Road density not calculated due to exceptionally small area of HCP lands in sub-basin.

HRC acquired ownership of HCP-covered lands in 2008. HRC silvicultural philosophies preclude the use of traditional clearcutting and suggest future harvesting on the ownership will be selective in nature where stand conditions permit. 'Variable retention' and 'Rehabilitation of Understocked Area' silvicultural approaches will be used to promote long-term sustained yield of commercial conifer species where mixed conifer/hardwood or pure hardwood stand conditions currently preclude selection harvest.

5.0 CUMULATIVE EFFECTS OF TIMBER OPERATIONS AND WATERSHED PROCESSES ON AQUATIC HABITAT CONDITIONS

The premise behind the assessment of "cumulative" watershed effects is that although individual management effects (e.g., one road failure) may not result in a significant change to water quality and aquatic habitat, when considered cumulatively across space and over time these effects can alter watershed processes and habitat conditions to the extent that entire biological populations are adversely affected.

In this section, key findings of Appendices A through F are presented and discussed in order to identify and spatially locate activities and areas where historic and contemporary adverse effects associated with forest management have, or could, occur. Also, the extent to which these adverse effects cumulatively prevail upon current and future watershed processes and aquatic habitat conditions is described. In the light of these current conditions and trends, recommendations for future forest and watershed management are made in order to accomplish HCP objectives of maintaining or achieving, over time, properly functioning aquatic habitat conditions for HCP-covered species. Current stream conditions in specific locations within the WAU are discussed with reference to habitat (i.e., PFC) targets.

Potential management-related adverse effects of interest include diminished hydraulic complexity, loss of pool habitat, plugging or burying of streambed gravel (i.e., spawning substrate), and increases in water temperature.

5.1 Overview

The Mattole River historically produced significantly larger runs of salmon than occur today. DFG has made historical population estimates of 5,000 Chinook salmon, 2,000 coho salmon, and 12,000 steelhead using the watershed annually. These numbers are comparable with an earlier estimate made in 1960 by the U.S. Fish and Wildlife Service indicating the watershed could support 10,000 salmonid pairs based on extrapolation of existing spawning gravels (MRRP, 2009a). Declines in population began to be documented in the 1960s with most observers indicating severe declines in the 1980s.

The Mattole Integrated Coastal Watershed Management Plan (MRRP, 2009a) reports an estimate of between 300 and 800 Chinook in the river with downstream migrant trapping from 2001 to 2007 showing an increase in Chinook salmon juvenile estimates for two out of the last three four-year cycles. The adult coho salmon population is estimated to be in the low hundreds, at best. No abundance estimates are available for steelhead, however, they are observed throughout the watershed in significantly greater numbers than salmon.

Available spawning habitat is generally no longer considered a limiting factor for salmonid production and it appears clear that there is far more suitable spawning habitat available than there are spawning adults to utilize it (MRRP, 2009a). Salmonid rearing habitat on the other hand, appears to be a critical limiting factor, as there is a lack of suitable thermal habitat for all species of juvenile salmonids throughout much of the mid and lower river mainstem. The mainstem Mattole River (particularly the lower 26 miles downstream from Honeydew including the estuary/lagoon at the mouth [Photo 5-1]), along with downstream, lower gradient reaches of tributaries, store significant amounts of sediments contributed from higher gradient tributaries. Lack of deep pools due to persistent stored sediment, and low summer flow leads to this adverse thermal condition, as well as to low levels of dissolved oxygen in late summer.

Photo 5-1. Mattole River estuary.

This sedimentation has also aggraded estuary channels and backwater pools reducing the ability of tides and riverflows to flush the sediments that accumulate in both the estuary and mainstem. As a result, current conditions in the estuary are considered a significant bottleneck to Chinook salmon survival and large numbers of over-summering juveniles have been reported to die off on an annual basis due to lethal water temperatures, limited foods sources, and lack of shelter from predators (MRRP, 2009a).

Smaller tributaries, including those found on HRC's ownership, generally have lower temperatures and can provide summer rearing refugia habitat as well as cool summer flows to the mainstem Mattole River near confluences. For example, maximum water temperatures in the Mattole's tributaries and portions of its mainstem outside of the WAU during 2008 ranged from 16 to 28ºC during the summer (MSG, 2009).

The lowest maximum water temperature was recorded in Ancestor Creek (river mile [RM] 60.8) on July 10, 2008, and the highest maximum water temperature was recorded in the mainstem Mattole at RM 15 on the same date (MSG, 2009).

Downie et al. (2003) identified several additional limiting factors for Pacific salmonids in the Mattole River basin including excessive water extraction during summer low flows, chemical contamination in tributaries, low stream shade, and low large woody debris recruitment to streams. Summer and fall low flows are a significant limiting factor resulting in unsuitable or marginal summer rearing habitat in the mainstem and certain tributaries, particularly in the upper Mattole basin.

In March of 1994, the U.S. Environmental Protection Agency (EPA) added the Mattole River to its list of impaired watersheds (303d list), with regard to temperature, turbidity, and sedimentation. The Total Maximum Daily Load (TMDL) program was implemented for the Mattole River, and other rivers on California's North Coast, to assure that salmon habitat in streams would be protected from excess sediment and temperature increases – see *Mattole River Total Maximum Daily Loads (TMDLs) for Sediment and Temperature* (EPA, 2003).

5.2 Salmonid Distribution

Distribution of salmonid populations in the Mattole River basin, including the WAU and within HRC's ownership is currently affected by poor estuarine habitat conditions, lack of habitat complexity in mainstem and tributary habitat, excessive sedimentation, high summer water temperatures, inadequate summer flows and reduced basin-wide coho and Chinook meta-populations (Downie et al., 2003). DWR (1965 *in* Downie et al., 2003) estimated that increases in siltation and debris jams following intensive logging that started in 1952 has caused a significant reduction in the size and distribution of anadromous runs since 1955 (Downie et al., 2003).

The potential distribution of coho salmon and steelhead in the Mattole basin was evaluated in the Stream Channel Assessment (Appendix D), which included an analysis of a habitat index known as intrinsic potential (IP) applied to the basin as part of a computerized terrain model (NetMap, www.netmaptools.org). Intrinsic potential indices are based on empirical relationships between physical channel characteristics (gradient, confinement and mean annual flow) and salmon abundance. In the WAU, moderate to high IP values for coho salmon were concentrated in lower reaches of tributaries along the mainstem Mattole River as well as the lower reaches of the North Fork Mattole and Upper North Fork Mattole River. The same model predicted high IP values for steelhead in upper reaches of tributaries in the WAU, and in particular on HRC's ownership (see Figures 18 and 20 of the Channel Module report, Appendix D). Predicted IP values indicate that the best coho and steelhead rearing habitat are, for the most part, spatially segregated.

Based on stream surveys and information presented by Downie et al. (2003) and results of surveys conducted by other local biologists, Chinook and coho salmon can access habitat in the WAU including the mainstem Mattole River, the North Fork Mattole River, East Mill Creek, lower reaches of the East Branch North Fork Mattole River, lower reaches of Conklin Creek, lower reaches of McGinnis Creek, Upper North Fork Mattole River, and lower reaches of Oil Creek (see Maps E-5, E-6, and E-7 for distribution within and downstream from HRC property). Within these sub-basins, mainstem barriers to Chinook and coho salmon upstream migration exist just downstream of HRC lands with the exception of McGinnis Creek and possibly Rattlesnake and Oil Creeks. These barriers consist of natural bedrock and boulder falls coupled with steep stream gradients. Potential suitable habitat is present in other reaches in HRC tributaries based on cool summer water temperatures; however, migration access is generally limited to steelhead for which there appears to be an abundance of suitable habitat.

Further information on salmonid distribution is summarized in Section 3.10, along with detailed information on salmonid distribution and migration barriers in the Fish Habitat Assessment report (Appendix E).

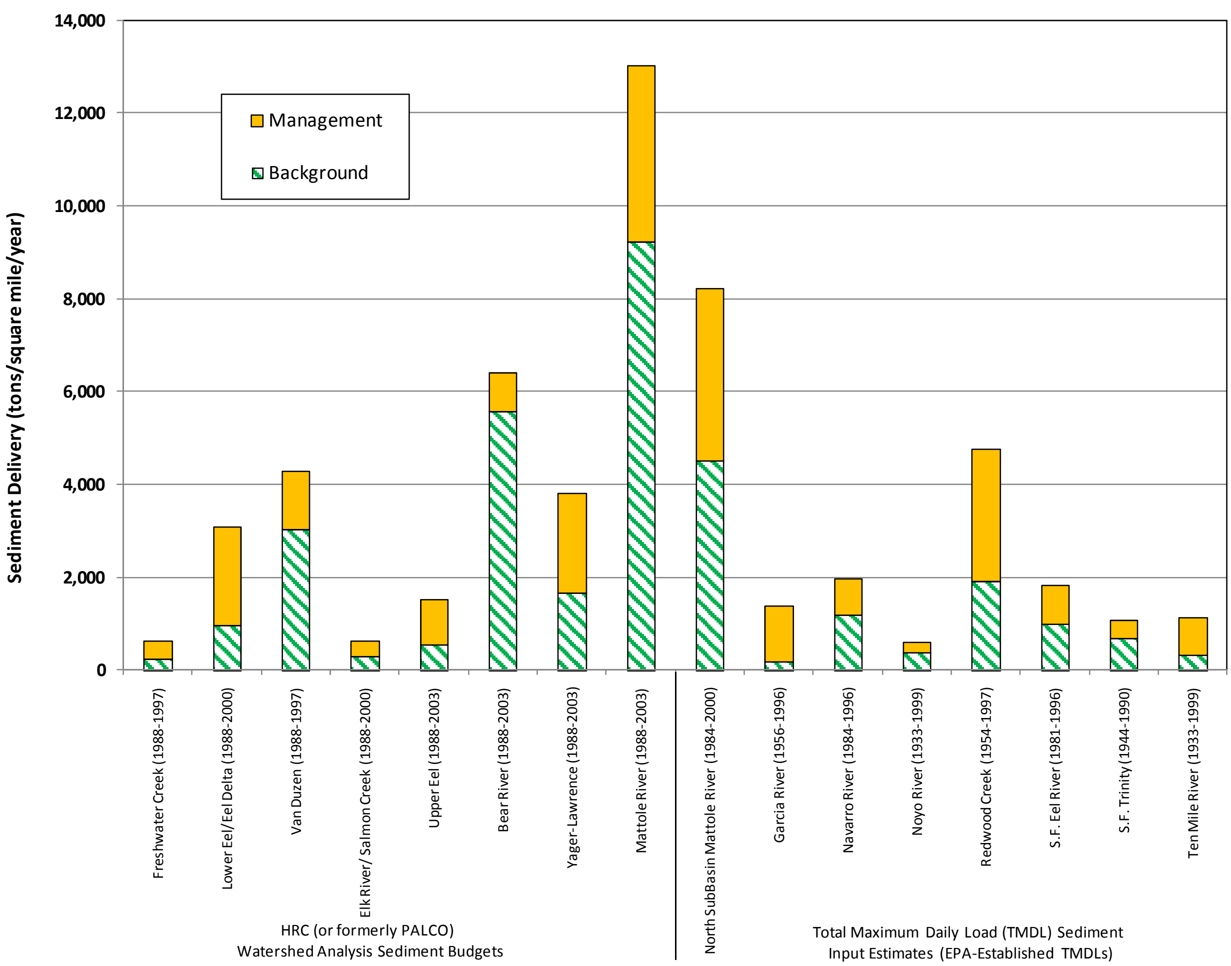
5.3 Habitat Conditions for Streams on HRC Property

Relative to the mainstem Mattole, streams within lands owned and managed by HRC in the northern sub-basins are generally smaller, lower-order tributaries with moderate to steep gradients (3 to 5 percent or greater) and low sinuosity with known salmonid occupancy limited to winter-run steelhead and resident rainbow trout. Fish habitat and riparian conditions in these streams can and do change suddenly in response to periodic disturbance (i.e., landslides and peak flow events). However, the channel morphology of these streams results in resiliency to sediment-related impacts; these lower order streams recover relatively rapidly after disturbance due to their substantial sediment transport capacity.

Large quantities of sediment have been exported from tributaries of the northern sub-basins since approximately the 1950s and 1960s following large erosional events. Hence, it appears that many parts of the channel system are in a state of recovery. However, there are other areas where there are intensive streamside landsliding and active earthflows (i.e., upper Rattlesnake Creek and its tributaries, upper Oil Creek). At least part of the cause of the continuing accelerated erosion appears to be related to hillslope-adjacent channel incision (see discussion on channel incision in the Channel Module report, Appendix D). Continuing streamside landsliding is not believed to be related to historical or recent forest management considering the time elapsed since intensive timber harvest and road construction (40 years) and the little harvest that has recently taken place in the tributary basins.

Trend monitoring and field observations indicate ongoing coarsening of substrate to varying degrees (in conjunction with channel incision) despite the inherently high sediment supply resulting from significant ongoing channel incision and near-stream landsliding. These significant sediment inputs place the Mattole basin average annual sediment delivery rates substantially higher than those estimated for other watersheds in the North Coast region (Figure 5-1).

Figure 5-1. Annual sediment delivery for HCP watershed analysis units and other watersheds in the North Coast region.



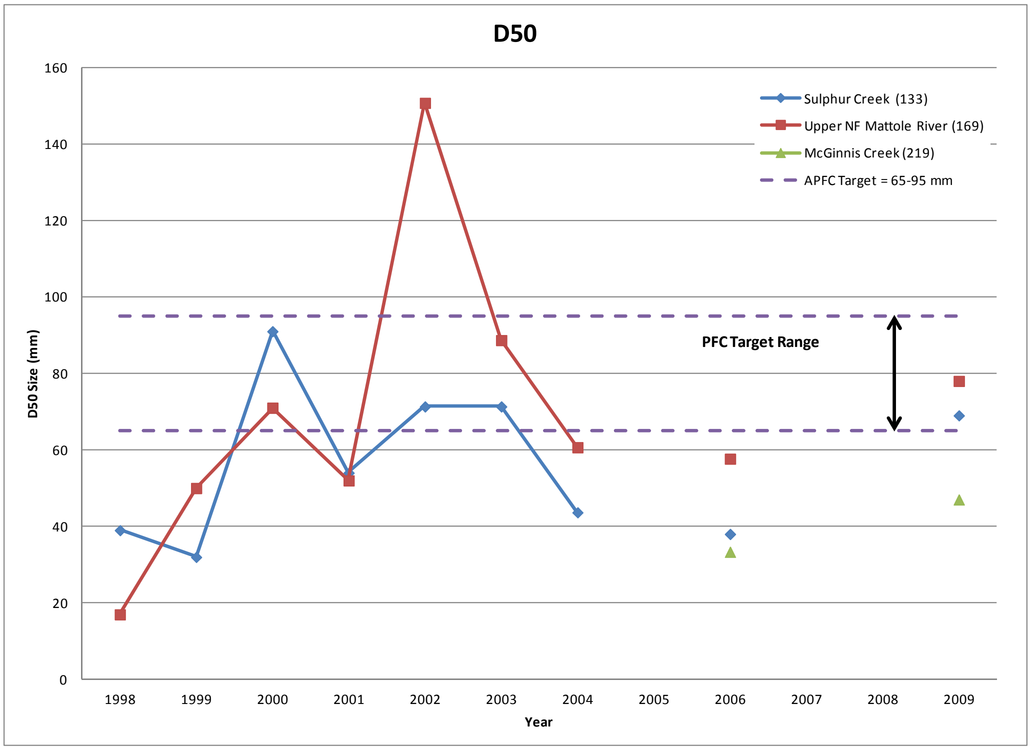
Habitat conditions for streams on HRC's HCP lands are discussed in the following sub-sections, covering spawning habitat and rearing habitat (pools and temperature). Additionally, riparian and hillslope processes potentially impacting stream habitat are discussed in terms of observed (current) conditions and expected influences of future management.

5.3.1 *SPAWNING HABITAT*

Confined and moderate to steep headwater morphology limits available spawning habitat on HRC's ownership due to a preponderance of large substrate (boulder and large cobble) in pool tailouts in all but the largest drainages. With the exception of abundant spawning habitat within the lower reach of McGinnis Creek, spawning habitat in HRC ownership occurs only in small pockets within lower gradient reaches and side channels and is more suitable for steelhead than coho or Chinook salmon. Where available, spawning substrate quality is fair to good (Photo 5-2) and currently (2009 data) meets PFC targets for D50 sediment size and percent fines (see Figures 5-2 through 5-4) in most instances at the three permanent Class I ATM stations (Sulphur Creek, McGinnis Creek, and Upper North Fork Mattole/Rattlesnake Creek).

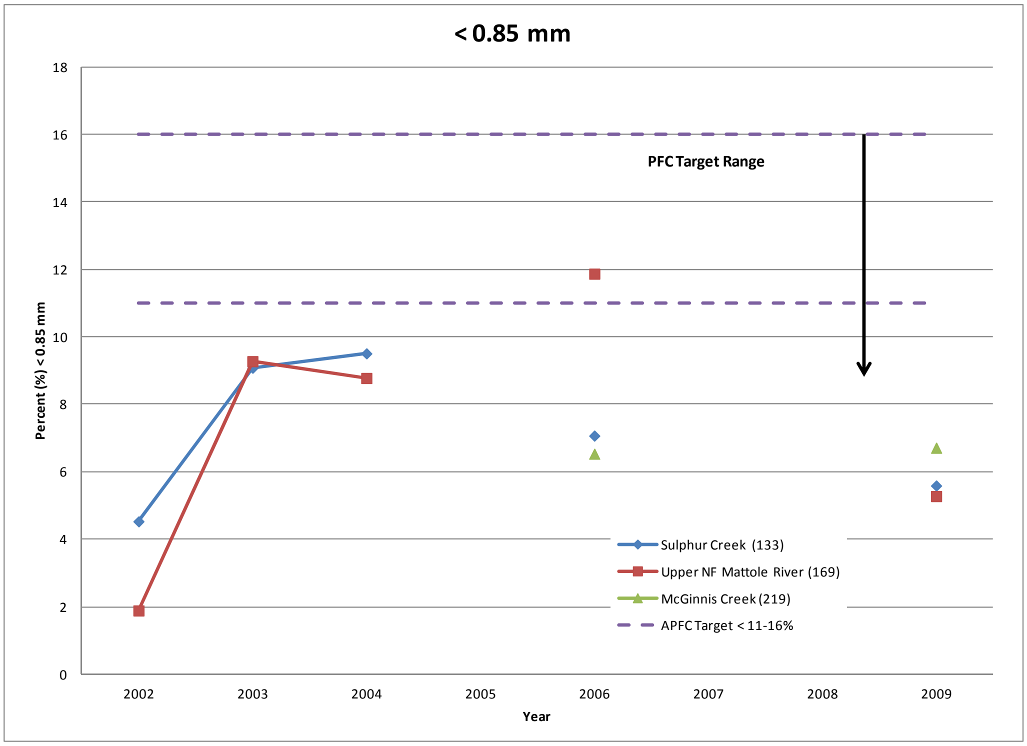
Photo 5-2. Pool tail-out and suitable spawning habitat.

Figure 5-2. Sediment D50 size.



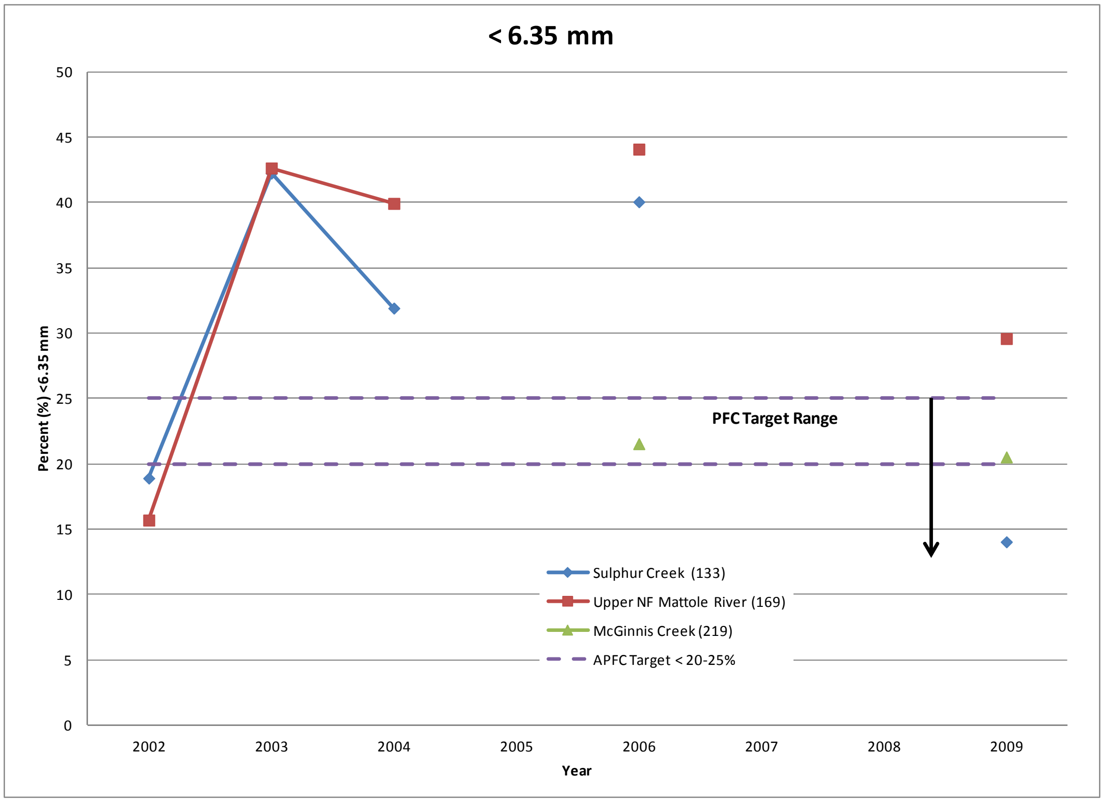
Source: Figure E-1, Fish Habitat module.

Figure 5-3. Percent sediment <0.85 mm in diameter.



Source: Figure E-2, Fish Habitat module.

Figure 5-4. Percent sediment <6.35 mm in diameter.



Source: Figure E-3, Fish Habitat module.

The D_{50} sediment size fluctuates, as would be expected in natural systems, throughout the recent period of record (Figure 5-2), with some measurements outside of the PFC range of 65-95 mm. Measurements of D_{50} for the Rattlesnake Creek and Sulphur Creek ATM locations in 2009 are within the PFC range, although variability is expected to continue in the future. Such variability can occur even in the absence of land use due to natural disturbances and, hence, natural variability which confounds accurate interpretation. The measurements for the McGinnis Creek ATM location, taken only in 2006 and 2009, show a smaller D_{50} (below the PFC) indicating finer-grained sediment than for the other ATM locations.

The proportion of sediment sizes less than 0.85 and 6.35 mm fluctuates over time, as would be expected, generally declining from 2006 to 2009 (Figures 5-3 and 5-4, respectively). This suggests improvement in sediment for spawning due to the coarsening of the sediment. However, ongoing channel incision, streamside landsliding, sedimentation, and sediment transport occurring throughout the stream network continues to locally affect the quality of spawning and rearing habitat. This process is expected to continue to be significant as an inherent part of the overall morphologic system in the Mattole WAU, although channel incision and hillslope instability might be waning. Still, as indicated above, the channel morphology of the streams on HRC ownership results in resiliency to sediment-related impacts, with relatively rapid recovery after disturbance due to their substantial transport capacity.

5.3.2 *Rearing Habitat – Pools*

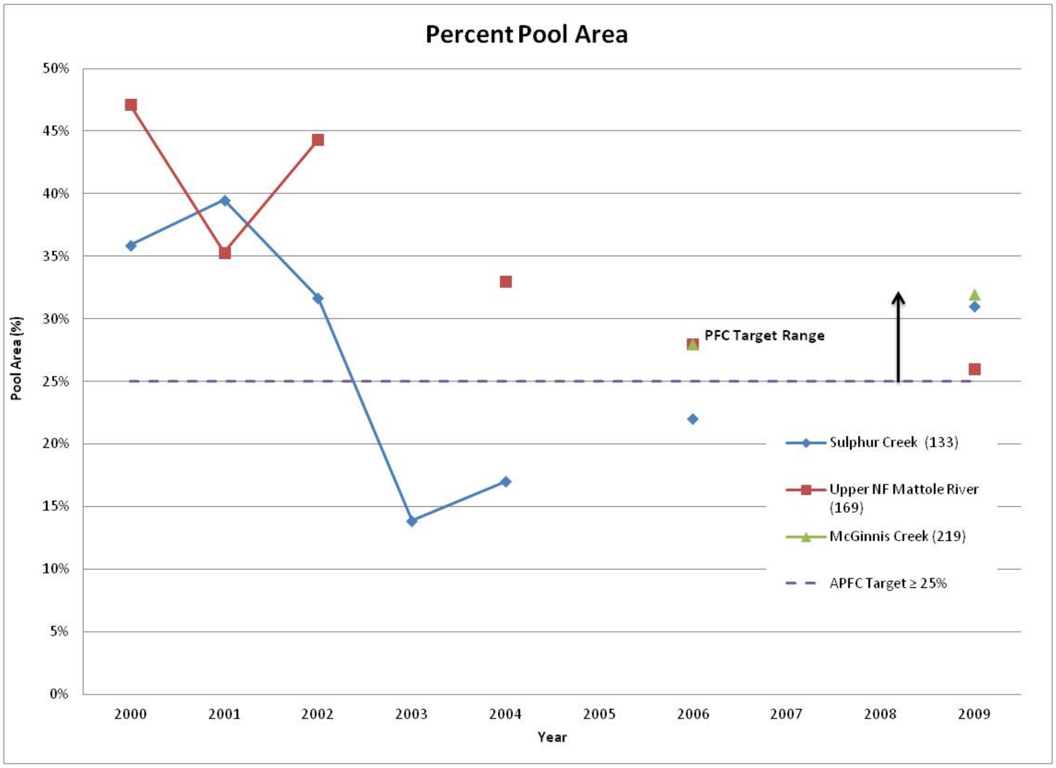
Rearing habit is characterized by the area occupied by pools, pool depth, and LWD size and frequency. Water temperature is also an important component of rearing habitat, as discussed in the next section. The areas and depths of pools were measured for all but three years since 2000 at the stream reaches associated with the Sulphur Creek and Rattlesnake Creek ATM locations, and in 2005 during stream surveys in reaches located in the East Branch North Fork Mattole, Sulphur Creek, Oil Creek, Rattlesnake Creek, and McGinnis Creek (see Fish Habitat Assessment report, Appendix E). Habitat data were also collected in 2006 and 2009 at a new ATM location on McGinnis Creek. Likewise, LWD data were collected as part of the 2005 stream surveys and at the three ATM locations during the same time periods as the pool data with the exception of Sulphur Creek and Rattlesnake Creek ATMs for which LWD data collection started in the late 1990s. Data collection is continuing at the three ATM locations as part of HRC's ATM data collection and evaluation program. Maps E-8, E-9, and E-10 (Appendix E) show the locations of the ATM stations relative to the 2005 stream survey reaches.

Pool Area

Despite high spatial variability, the collected data show that the PFC target of 25 percent or greater pool area appears to be met consistently at the ATM locations with the exception of the Sulphur Creek ATM (see Figures 5-5 through 5-8).

As shown on these figures, in 2009 pool area data met the PFC target (25 percent) with percent pool area ranging from 26 to 32 percent (Figure 5-5) at all three ATM stations. Data collected in 2005 (Figure 5-6), for three of the habitat typing survey reaches, showed Oil Creek (46 percent) and McGinnis Creek (25 percent) meeting the PFC target for percent pool area, whereas, the surveyed Sulphur Creek pool area was only 14 percent. Since data collection began in 2000, pool frequency data for the three ATM locations (Figure 5-7) meet the PFC target for most of the years measured with the exception of 2003 and 2004 for the Sulphur Creek location. Similarly, the only exceedance of the PFC target for pool frequency, for the 2005 habitat typing reach surveys, was observed in Sulphur Creek (Figure 5-8). Several streamside landslides were identified in Sulphur Creek, during 2003 aerial photograph review, which may have played a role in the reduction in pool habitat in Sulphur Creek. Achievement of PFC targets in 2006 and 2009 demonstrate the resiliency and capacity of these headwater streams to transport sediment loads.

Figure 5-5. Percent pool area.



Source: Figure E-6, Fish Habitat module.

Figure 5-6. Percent pool area from 2005 stream survey data.

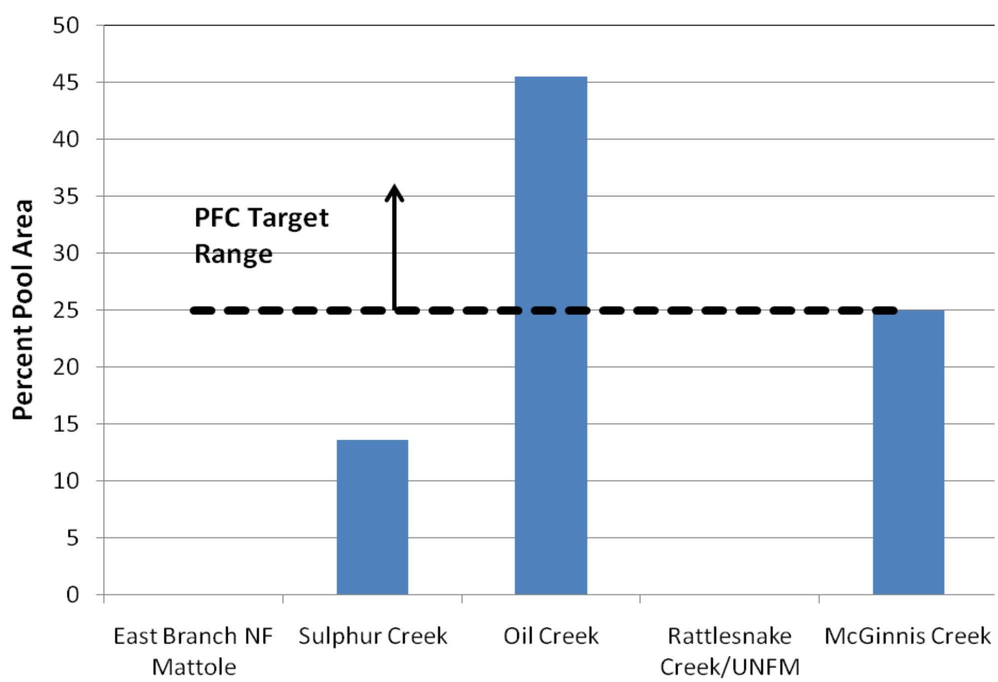
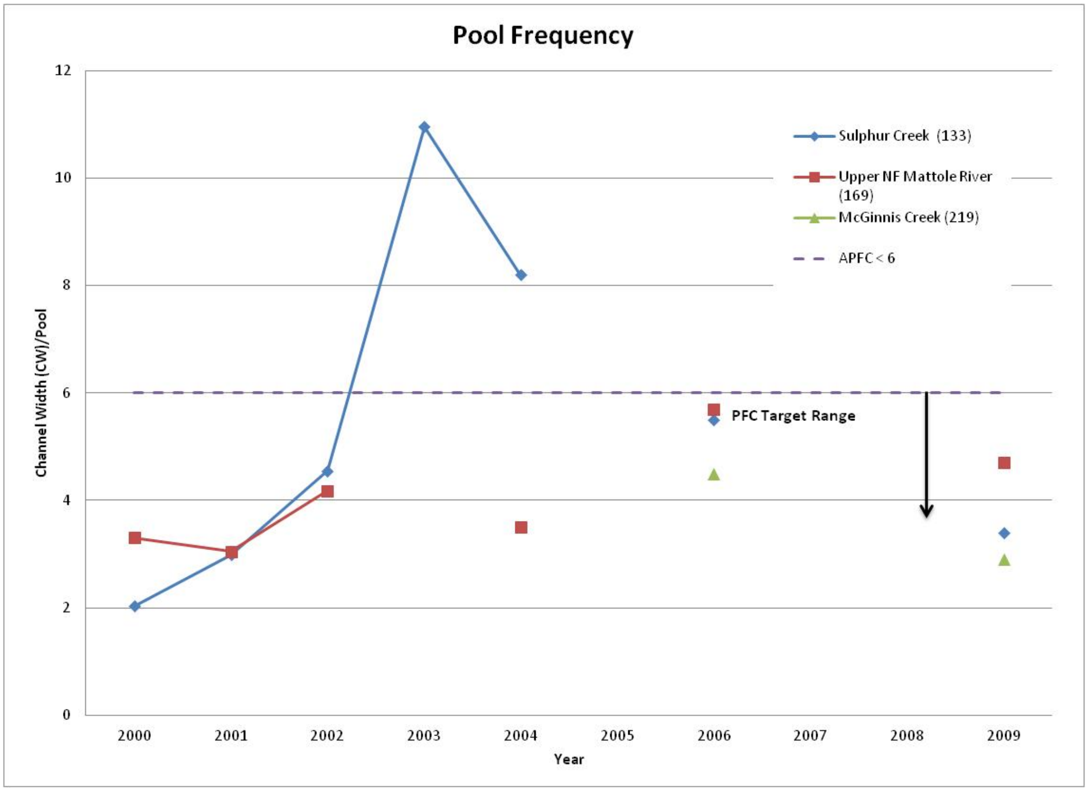
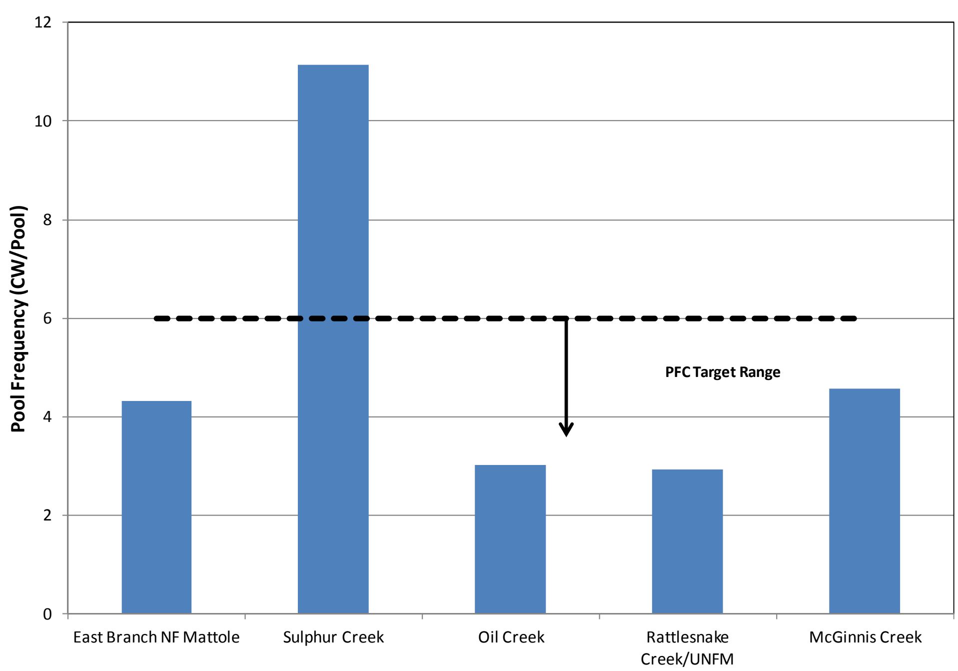


Figure 5-7. Pool frequency.



Source: Figure E-7, Fish Habitat module.

Figure 5-8. Pool frequency from 2005 stream survey data.



Pool Depth

In general, pool depths are expected to be relatively shallow in the typically boulder-dominated stream channels of HRC ownership in the Mattole. Pool scour associated with peak flows during large storms affect pool geometry, but the effect is constrained by the prevalence of pools floored in bedrock and relatively limited amounts of channel alluvium that are available to help form deep pools due to the transport-dominated stream system. It is also important to note that the PFC target for pool depth does not take into account basin area or channel confinement when designating the requirement for pools to be greater than 3 feet (0.91 meter) in depth, limiting its meaningfulness with regard to defining a PFC for pool depth in smaller streams.

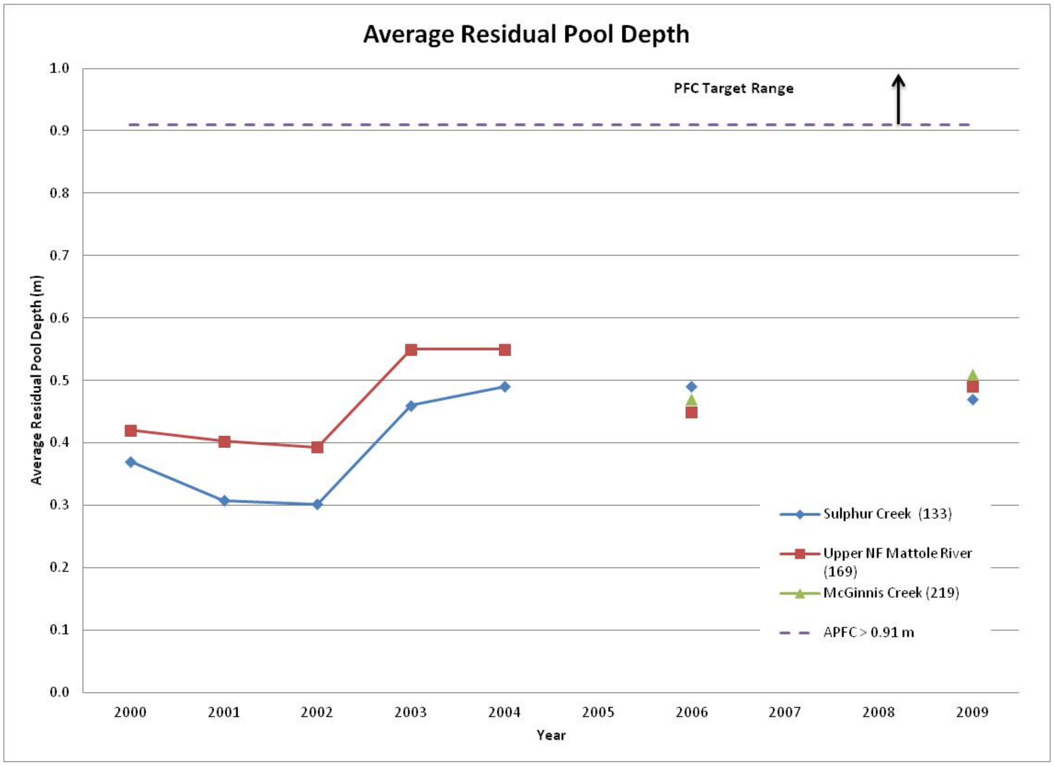
The observed average residual pool depth of approximately 0.5 meter is fairly consistent among the three ATM stations (Figure 5-9). Deep pools meeting the PFC target of 0.91 meter are generally lacking in all mainstem reaches accessible to salmonids with the exception of the East Branch North Fork Mattole and Rattlesnake Creek (Figure 5-10), though 2005 habitat survey data for these reaches show more deep pools than for other surveyed reaches but still not the percentage needed to meet the PFC target.

Based on the typical residual pool depth data (Figure 5-9), pool depths of 0.5 meter may represent intrinsic conditions for most streams on HRC's ownership – a factor of channel width and drainage area, as evidenced by the coarsening of channel substrate and exposure of bedrock. If this is the case, any future increases in pool depths will rely upon channel obstructions such as large wood pile ups in the few locations where accumulation of sediment does occur (e.g., earthflow flat-related response reaches).

Large Woody Debris

Trend monitoring data and field observations indicate a general lack of large in-stream wood (Figures 5-11 through 5-15), though data collected at the ATM reaches in the past several years show exceptions (i.e., a slow trending towards recovery) in terms of percent pools associated with wood for the Sulphur Creek and McGinnis Creek locations (Figure 5-16). Streamside landsliding is considered the likely predominant wood-recruiting mechanism in the watershed, accounting for probably more than half of the wood loading to streams (see Stream Channel Assessment, Appendix D). In general, the primary role of large wood in streams would include formation of pools, providing cover, and storing sediment. Generally, these functions of large wood occur on HRC ownership primarily in relatively low gradient channels with a deformable bed (i.e., gravels). These conditions are not widespread on HRC ownership, consistent with the observed lack of in-stream LWD and limited role of LWD in habitat formation.

Figure 5-9. Average residual pool depth.



Source: Figure E-8, Fish Habitat module.

Figure 5-10. Percent pools $\geq$ 3 feet deep from 2005 stream survey data.

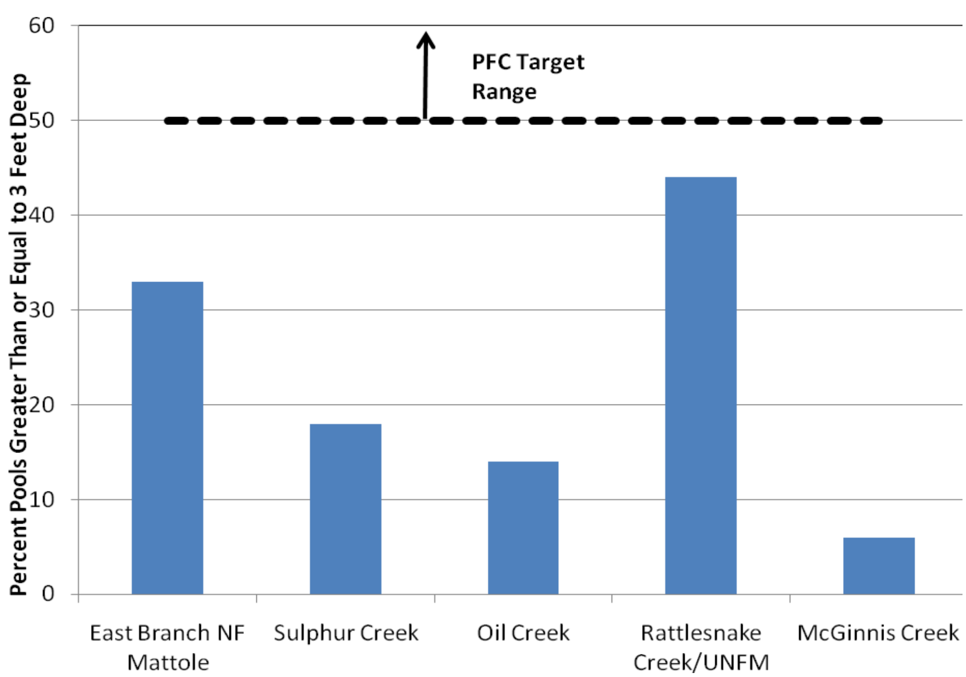
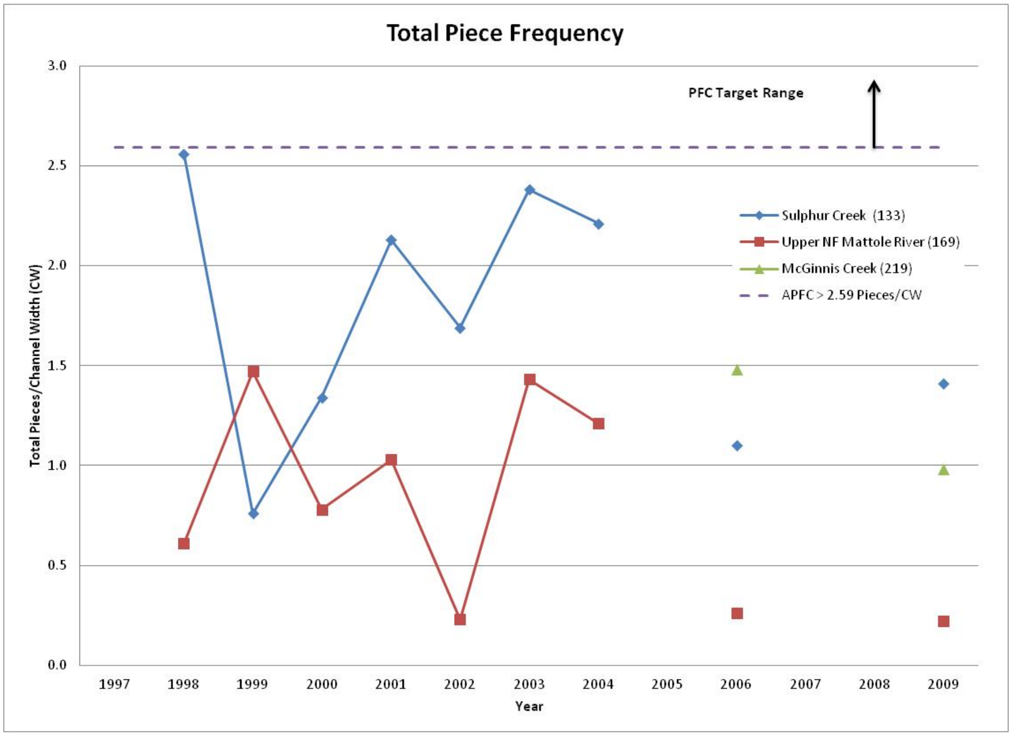
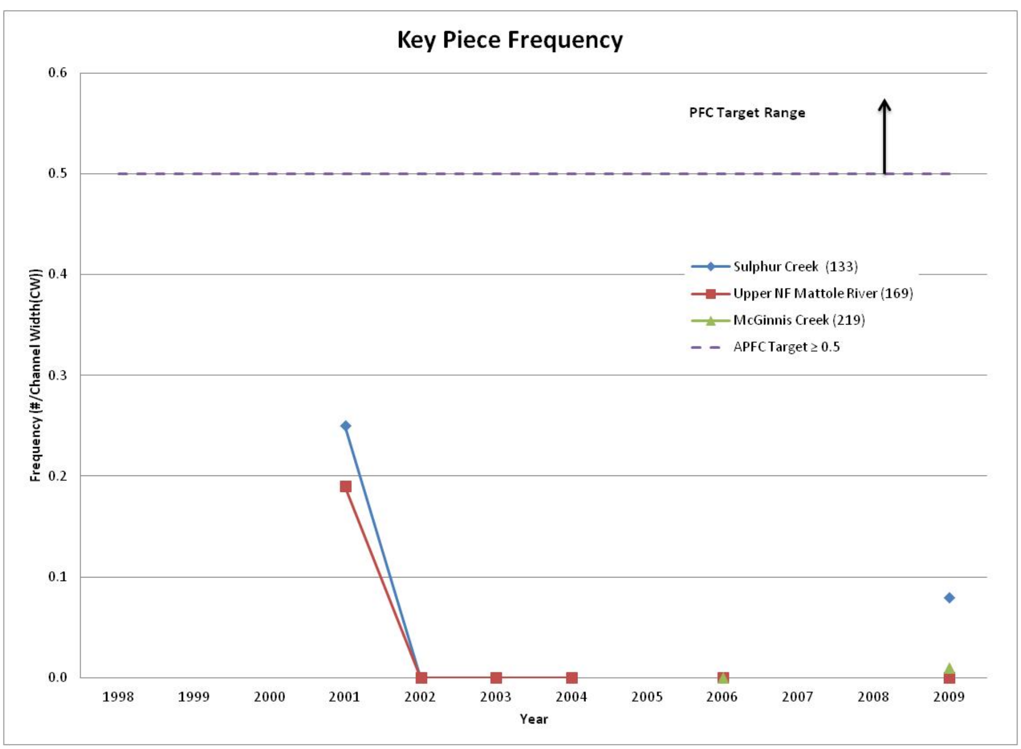


Figure 5-11. Total piece frequency.



Source: Figure E-10, Fish Habitat module.

Figure 5-12. Key piece frequency.



Source: Figure E-11, Fish Habitat module

Figure 5-13. Pools associated with wood from 2005 stream survey data.

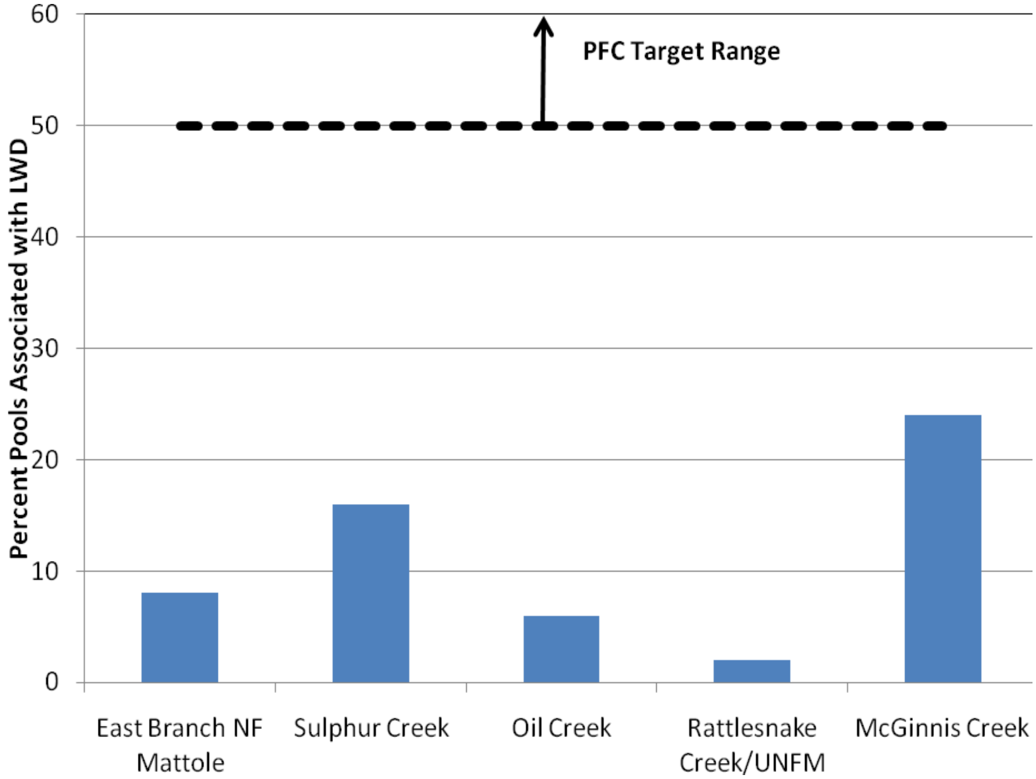
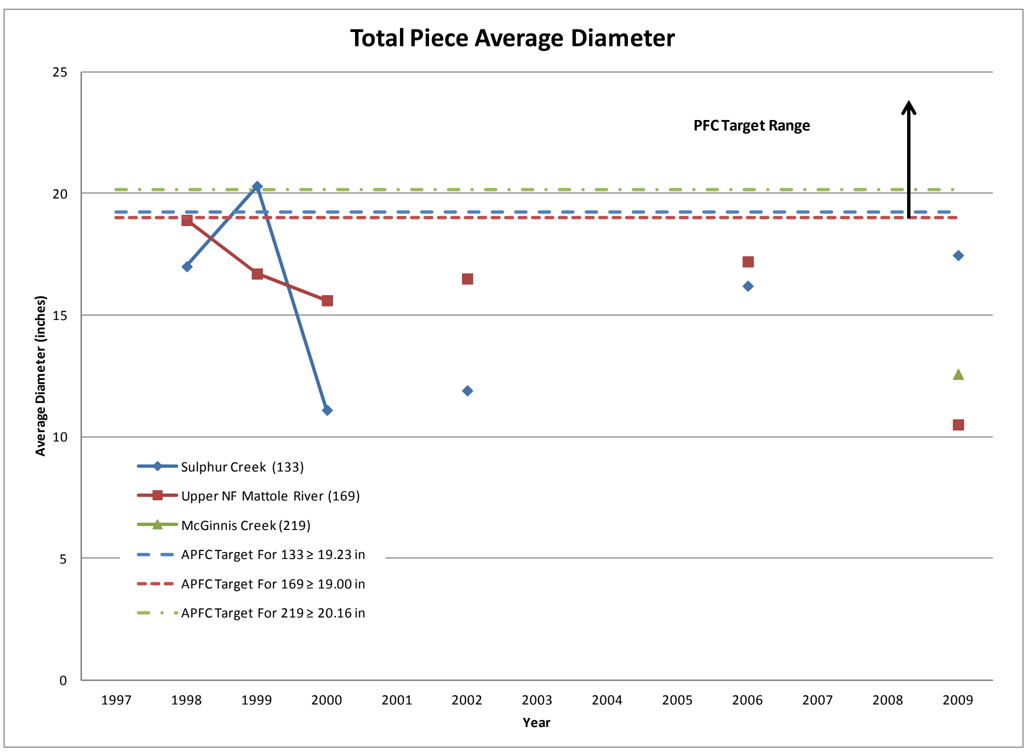
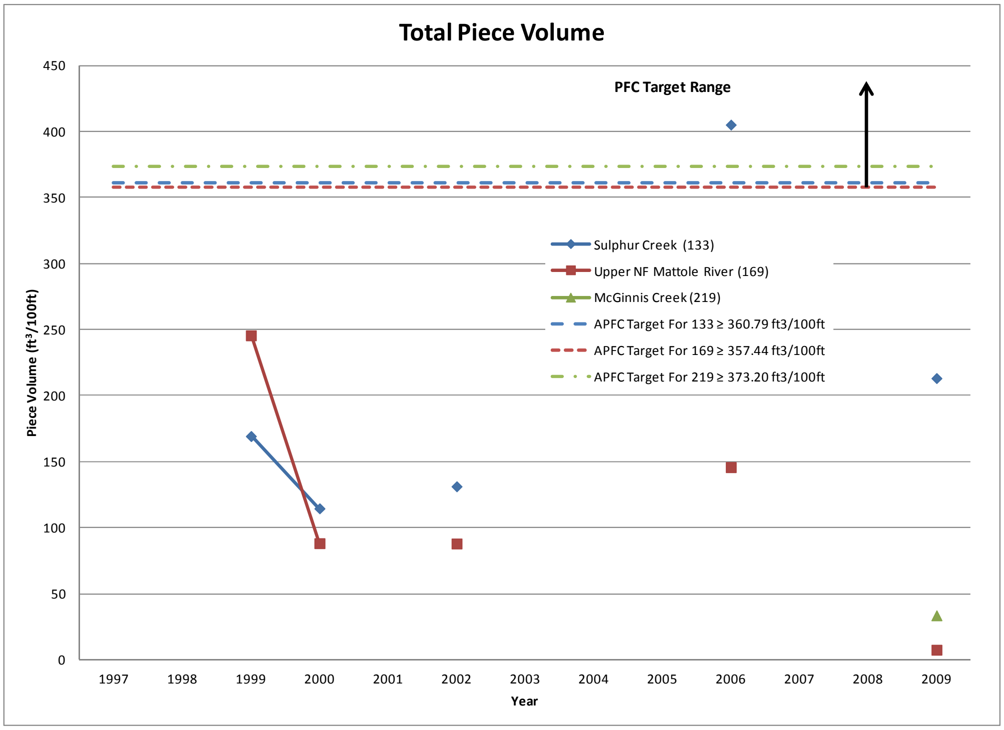


Figure 5-14. Total piece average diameter.



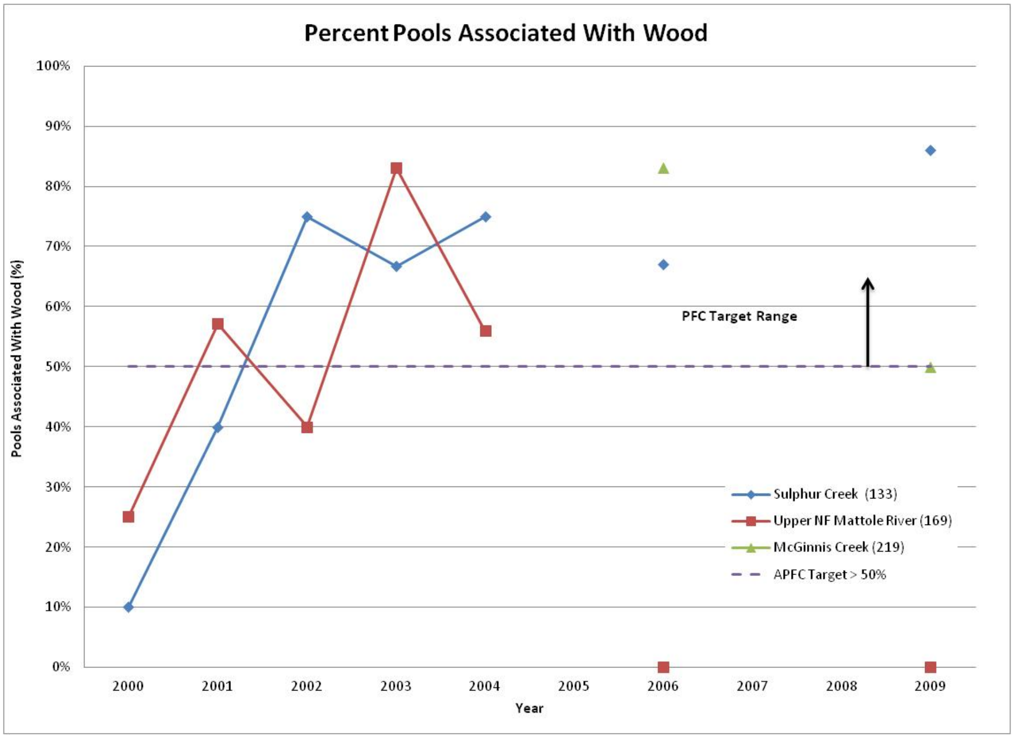
Source: Figure E-12, Fish Habitat module.

Figure 5-15. Total piece volume.



Source: Figure E-13, Fish Habitat module.

Figure 5-16. Percent pools associated with wood.



Source: Figure E-9, Fish Habitat module.

The general lack of wood in streams results from a reduction of large trees in near-stream areas due to legacy effects of intensive 20th century streamside harvest, widespread channel-valley aggradation (post mid-1960s) with subsequent lateral shifting of the channel, subsequent channel incision, and high (wood) transport capacity with regard to smaller pieces of wood. Lateral shifting of channels in Oil Creek, Rattlesnake Creek, and McGinnis Creek during winter peak flow events, and channel incision, limits the growth of LWD-producing trees in near-stream areas. Current riparian conditions for the most part remain several decades away from producing wood of large enough size to contribute significantly to the formation and maintenance of instream habitat function. However, as noted above, boulders rather than large wood are the dominant pool-forming structure in many streams within HRC's ownership and are the dominant pool cover type. The steeper and confined channels will not respond strongly to more large wood because their morphology is governed by large boulders. Instead, the greater benefit of future increases in large wood recruitment may occur downstream in off-property response reaches.

On HRC lands, the lower reach of McGinnis Creek is the notable exception to the morphologic limitations noted above; increased wood loading in this reach would result in substantial aquatic habitat benefit including deeper pools, sediment storage, and cover. The reach is low gradient and unconfined and has a highly deformable, gravel-dominated bed. Increases in average residual pool depth have occurred in recent years and once buried stumps and logs are recently becoming exposed.

Forestry prescriptions promoting Class I riparian forest growth (i.e., thinning from below) and precluding harvest of trees with LWD recruitment value are of utmost importance as these measures will ensure that large trees become available for future in-stream recruitment. The introduction of additional LWD to these smaller fish-bearing streams will contribute to pool habitat and overall aquatic habitat diversity. Though the effect of introduction of LWD into the smaller streams may not be fully realized, due to channel shifting and high transport rates, as discussed below (Section 5.4), approximately 10 percent of Mattole River HCP riparian condition unit (RCU) acres were classified with high LWD recruitment potential dominated by the North Fork, Sulphur Creek, and Alwardt Creek sub-basins. These areas of high recruitment are generally confined to the upper reaches of several scattered Class II watercourses with little potential to benefit fish habitat directly. Most of the RCU acres were classified with moderate LWD recruitment potential, that is not currently meeting PFC targets but trending towards and likely to achieve the targeted riparian condition within the next 40 years as trees continue to grow. Areas with low LWD recruitment potential typically have insufficient tree size and hardwood dominance, due in part to the presence of difficult growing conditions on steep, rocky inner gorge slopes, and naturally occurring open grasslands as well as hardwood dominance, harvest history, and natural disturbance regimes.

5.3.3 *REARING HABITAT – TEMPERATURE*

Water temperature is a critical factor to the survival and growth of juvenile salmonids. Different species of salmonids have different tolerances to stream temperature, with steelhead having greater tolerance than Chinook or coho.

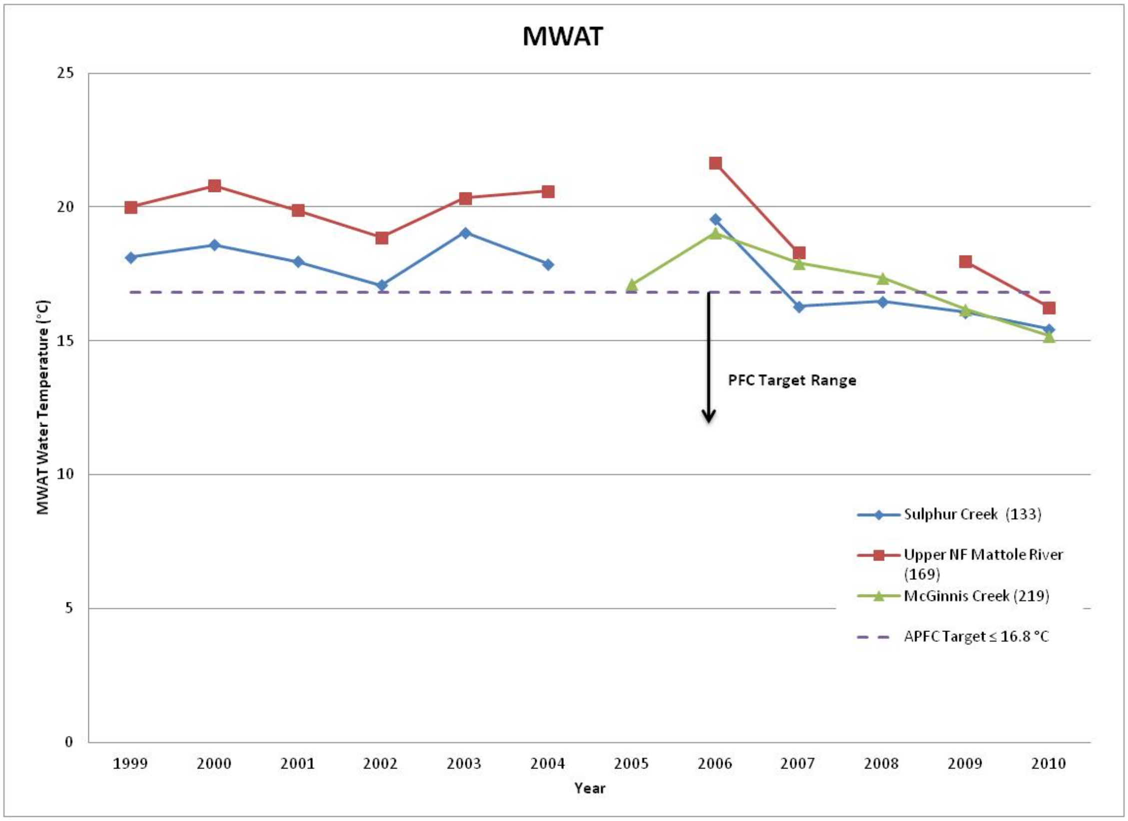
High summer and early fall stream temperatures limit habitat capacity and affect the abundance and distribution of salmonids, particularly in higher-order streams. Lower-order watercourses, including those on HRC property, tend to have cooler water temperatures and are therefore critical to the survival of juveniles.

Summer and early fall stream temperatures in mainstem tributaries on HRC ownership have until recently exceeded those preferred by coho salmonids. All three monitored (ATM) mainstem tributaries (Sulphur Creek, Upper North Fork/Rattlesnake Creek, and McGinnis Creek) have met the PFC target (<16.8°C) in 2009 and 2010 with the exception of Rattlesnake Creek in 2009 when the MWAT was 18.0°C. Smaller Class I and II streams provide critical thermal refugia in lower accessible reaches as well as cool water inflows to mainstem tributaries. While water temperatures have decreased in the headwaters on HRC property, temperatures generally remain high farther downstream in the higher-order streams of the Mattole basin. The trend of decreasing temperatures in lower-order streams is expected to continue with increases in shading, possibly also resulting in improvement in water temperatures in higher-order streams downstream from these areas.

The MWAT standards (i.e., PFCs to which data are compared) were developed for the protection of coho, which has the most restrictive optimal preferred temperature range. MWAT temperatures do not become a problem until fish are actively avoiding an area for prolonged periods of time. Steelhead do not actively avoid an area until temperatures exceed 18.9°C (Moyle, 1976). Water temperatures within HCP-covered lands, as measured at the three ATM locations, have not exceeded the 18.9°C threshold since 2006 (Figure 5-17). Since temperature monitoring started in 1999, this threshold was exceeded a number of times, through 2006, at the Upper North Fork/Rattlesnake Creek ATM station.

The Upper North Fork Mattole/Rattlesnake Creek has the highest recorded MWAT on HRC lands and, along with Oil Creek, is the most likely sub-basin in which movement and survival of juvenile salmonids may be impeded during summer and early fall months. Although no temperature data have been collected in Oil Creek, a situation similar to Rattlesnake Creek likely exists considering similar canopy cover and a fairly exposed southeast aspect.

Figure 5-17. Maximum weekly average temperature (MWAT).

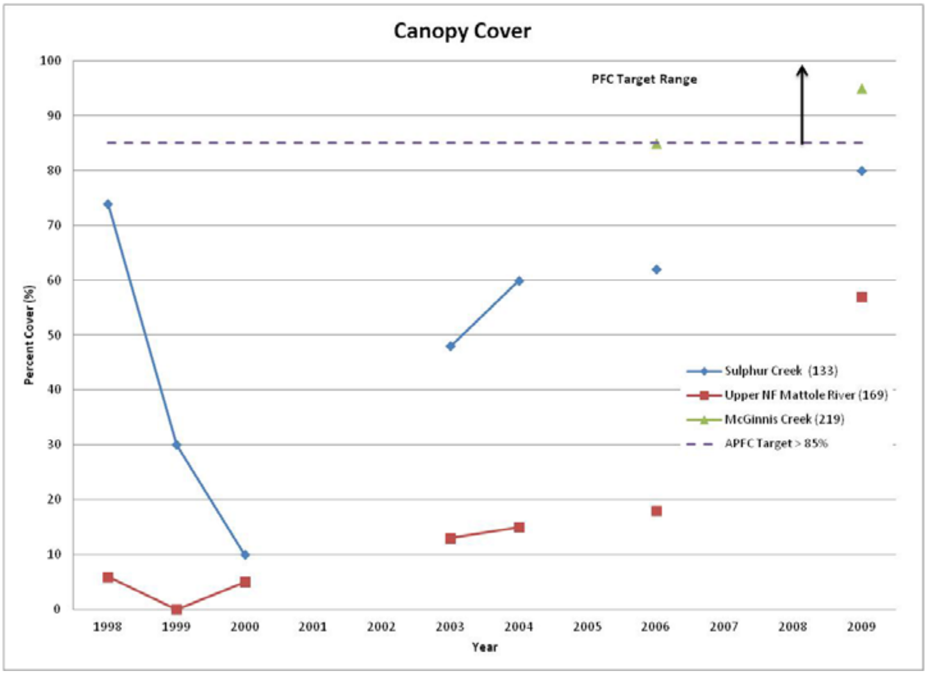


Source: Figure E-5, Fish Habitat module.

The range of stream temperatures documented in HRC's ownership during the summer months appears to play a critical role in the distribution of juvenile salmonids. For example, surveyors observed that juvenile steelhead may utilize mainstem tributary habitat in early and mid-summer months then move up into or near the mouth of small tributaries as temperatures warm in late summer. Diurnal migration of juvenile steelhead has also been observed; as mainstem habitat becomes too warm, fish move upstream into the lower reaches of small tributaries. However, adult migration and spawning is not impeded by temperature regimes because the timing of runs coincides with significant rain events and cool climatic conditions.

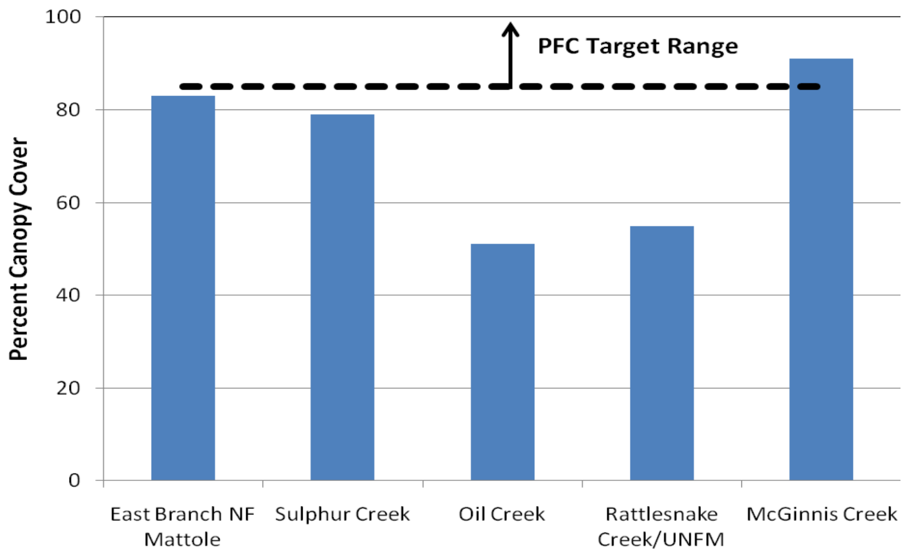
Overstream shade canopy has increased significantly in recent years along all surveyed fish-bearing tributaries (Figures 5-18 and 5-19) due primarily to continued hardwood growth in floodplain areas. While PFC targets for shade canopy are currently being met throughout much of the watershed; targets for riparian forest size are several decades away from being achieved. Overstream canopy cover in excess of 85 percent is common for Class II streams, and greater than 70 percent cover is common for smaller Class I tributaries, whereas canopy cover varies greatly over second and third order streams with the least shade found in the Oil Creek and Rattlesnake Creek sub-basins (Figures 5-18 and 5-19).

Figure 5-18. Percent mid-channel canopy cover.



Source: Figure E-4, Fish Habitat module.

Figure 5-19. Percent canopy cover from 2005 stream survey data.



Throughout HRC's ownership, landslide-related sediment inputs and associated channel and floodplain lateral instability have been minimal since the winter of 1996-97 and channel incision has resulted in further stabilization of streamside terraces allowing for sustained hardwood growth, primarily red alder. On terraces in excess of 5 m above the channel, conifers are intermixed with hardwoods. Also, riparian forests have not been entered for harvest for a number of years, allowing riparian growth to continue in these near-stream areas. In areas where only single-tiered hardwood canopy is establishing, it does not provide the same insulating benefits as multi-tiered shade canopy associated with conifers when present in greater numbers along flood plains and stream banks. The increase in overstream canopy cover correlates with an observed decrease in stream temperatures. In the nearby Eel River drainage at Scotia, an increasing trend in air temperature has been observed. However, this phenomenum may apply only to a limited extent in the Mattole River WAU area, as the Scotia monitoring location is coastal-influenced, whereas, the Mattole River WAU area typically has warmer summer temperatures with less coastal influence.

5.4 Riparian Conditions and Future Management

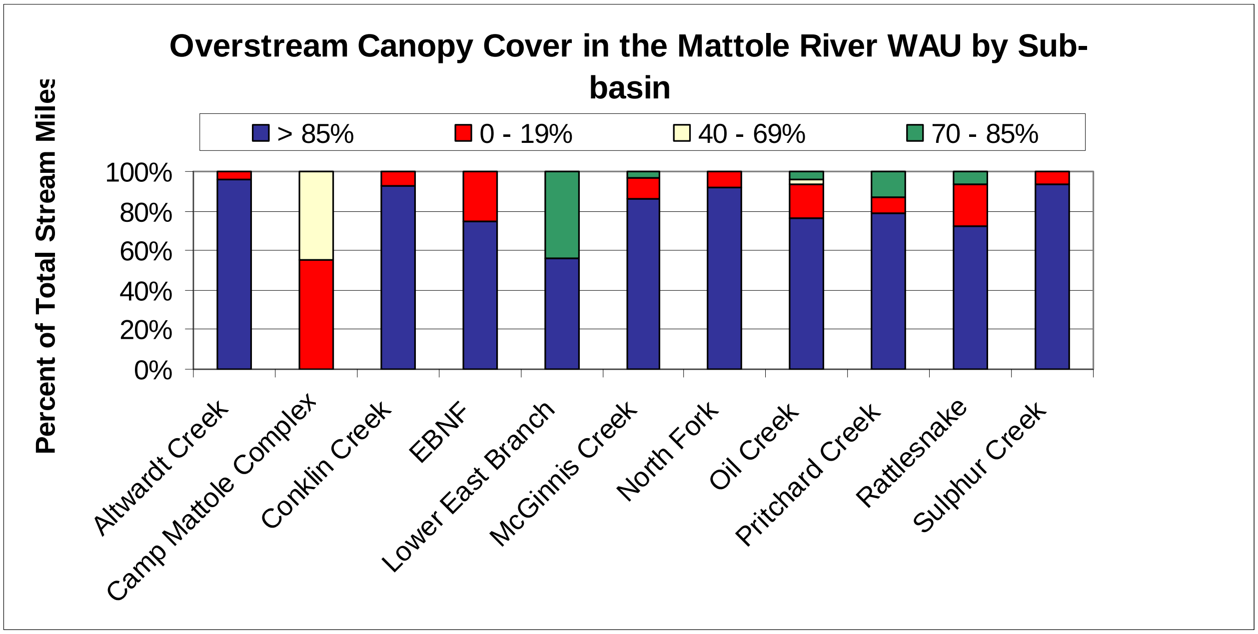
Riparian areas are transition zones between terrestrial and aquatic ecosystems and provide important ecological functions, including temperature regulation and input of LWD, organic matter, and nutrients (Gregory et al., 1987). Riparian forests affect stream channel complexity, bank cohesion, fish and wildlife habitat, thermal factors determining stream temperature and riparian microclimate, and the aquatic and terrestrial food web in the form of insect and organic matter. These processes may be lost or degraded as riparian vegetation is altered in size, density, or species composition (USDA, 1995).

The Riparian Function Assessment for HCP lands in the Mattole River WAU (Appendix C) characterizes existing riparian key habitat elements and compares results to PFC targets. The assessment focuses on LWD and canopy shade function, but also acknowledges other criteria that define PFCs. The greatest constraints on riparian forest management will likely be imposed by the need to provide LWD to both the stream channel and the forest floor. The maintenance or achievement of PFCs for the purpose of aquatic and terrestrial LWD recruitment are assumed to provide adequately for these other criteria as well, such as a cool micro-climate, bank stability, sediment filtration, and terrestrial riparian habitat diversity.

To determine the current and future LWD recruitment functionality and micro-climate value of riparian areas in the HCP lands, the stand type (based on predominant tree species), tree size, canopy closure, and overstream canopy cover were assessed using field-verified air-photo analysis (see Appendix C for detailed methodology, Figure 5-20 for overstream canopy cover results by sub-basin). The assessment area included 100 feet on each side of the bankfull channel, or CMZ if present, of Class I and II streams, but did not include isolated seeps and springs or ephemeral Class III watercourses. The Mattole River

HCP lands contain approximately 2,752 acres of riparian forest within 100 feet of Class I and II watercourses. Segments with similar characteristics are termed RCUs.

Figure 5-20. Overstream canopy cover by sub-basin.



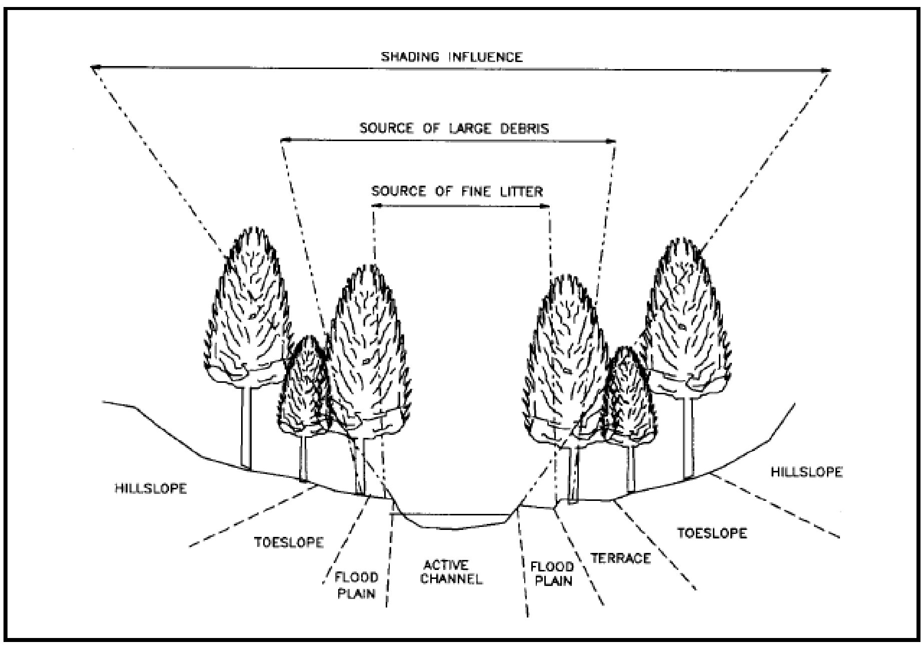
Source: Figure C-7, Riparian Function module.

In the Mattole River HCP area, the RCUs ranged from 500 to 4,000 feet in length. Field verification of RCU classifications was conducted on randomly distributed groups of RCUs totaling approximately 13 percent of the total RCU acres in the HCP area. Field verification included qualitative assessments and, at selected locations, quantitative standard forest mensuration measurements (see Appendix C for methods and variables measured).

Retention and promotion of streamside and overstream shade canopy is a vital aspect of riparian forest management necessary for controlling stream temperatures, providing litter and invertebrate fall, and maintaining streambank cohesion. In general, a high percentage of overstream canopy exists throughout much of the watershed (Figure 5-20), although it is important to note that along Class I streams this canopy is provided primarily by red alder (*Alnus rubra*) which until mature is a species very susceptible to removal by moderate to large flood events. Low shade conditions are a function of wide channel conditions along the mainstem Mattole and larger tributaries, at times combined with adjacent non-forested areas in the form of debris slide slopes or grasslands. With the exception of the mainstem Mattole (Camp Mattole Complex sub-basin) much of these stream channels receive topographic shading due the rugged, incised terrain through which they flow.

Ongoing recruitment of LWD to stream channels is an important function of riparian forests (Gregory et al., 1987). Trees growing near the stream die through natural mortality processes, and some that fall will enter the channel where they direct flow and create hydraulic diversity within the channel, thus improving fish habitat (Figure 5-21). The probability of a tree falling into the channel diminishes with distance from the channel with most woody debris recruitment from tree fall originating within 20 meters of the stream channel (Murphy and Koski, 1989; Robison and Beschta, 1990; McDade et al., 1990; Reid and Hilton, 1998); in northern California, streambank erosion may be the dominant wood recruitment agent (Benda et al., 2002). In addition to LWD recruitment from mortality processes or wind effects, other LWD is delivered from landsliding adjacent to streams.

Figure 5-21. Functional roles of riparian zones.



Source: Lamberti and Gregory (1989)

For trees to affect habitat within streams, they must be large enough relative to channel dimensions to significantly deflect stream flow (Bilby and Ward, 1989). Ongoing recruitment from the adjacent forests is required through time since woody debris is also transported out of a stream reach through fluvial processes and decay. Conifer species are generally preferred, because they tend to be larger and have significantly greater longevity within the stream (Grette, 1985). The goal of riparian area management is to maintain forests that naturally sustain LWD of sufficiently sized wood within the channel through time. The characteristics of forest stands within the riparian area will determine the type, size, and rate at which LWD may be replenished (Murphy and Koski, 1989; Benda et al., 2002; Welty et al., 2002).

Conifer-dominated forests of large size and high stand density are capable of recruiting LWD through natural mortality in the short term. Stands of this nature are likely to perpetuate through time with old-growth stand dynamics eventually dominated by individual tree replacement of widely spaced trees (approximately 30 per acre, PALCO, 2004). Large woody debris recruitment is potentially greatest in even-aged conifer stands of approximately 60 to 120 years of age, when trees are relatively large and stands are naturally self-thinning resulting in mortality (Lindquist and Palley, 1967).

Though the transition of a hardwood-dominated stand to a conifer-dominated stand may eventually occur, LWD recruitment to adjacent streams may ultimately be impaired for multiple decades to a century or more (Murphy and Koski, 1989; Welty et al., 2002). Mixed hardwood–conifer stands may transition to conifer-dominated stands if understory growth of conifers beneath the hardwood overstory is sufficient. In this case, adequate LWD recruitment may occur, but will require a fairly lengthy time frame. Examination of mixed hardwood–conifer stands is necessary to determine whether there is sufficient conifer undergrowth for conversion to a conifer-dominated stand to occur naturally over time. If species conversion is desired where such understory conditions do not exist, species manipulation is required.

Large woody debris recruitment potential was categorized as high, moderate, or low based on RCU stand type (dominant tree species), tree size class, and stand canopy closure (Table 5-1) and assigned one of the three categories to all RCU acres in the Mattole River HCP area. High LWD recruitment potential was assigned to RCU areas that met PFC matrix targets for canopy closure (moderate to dense), stand type (conifer- or mixed conifer–hardwood-dominated), and tree size class (mean tree diameter at breast height [DBH] >24 inches). Moderate LWD recruitment potential was assigned to RCU areas that currently did not meet those PFC targets, but had some current LWD delivery potential trending toward, and likely to achieve, the desired PFC condition within the 50-year life of the HCP. Low LWD recruitment potential was assigned to RCU areas that did not meet PFC targets and, due to hardwood dominance and/or low stocking levels, are not likely to reach PFC target conditions within the 50-year life of the HCP.

Table 5-1. LWD recruitment potential categories (H = High; M = Moderate; L = Low) as defined by RCU stand type, tree size class, and canopy closure.

Stand Type	Medium to Large Trees (L)		Small Trees (M)		Sapling/Pole Trees (S)	
	Dense Canopy	Sparse Canopy	Dense Canopy	Sparse Canopy	Dense Canopy	Sparse Canopy
Conifer	H	M	M	L	M	L
Mixed	H	L	M	L	M	L
Hardwood	M	L	L	L	L	L

Source: Figure C-11, Riparian Function module.

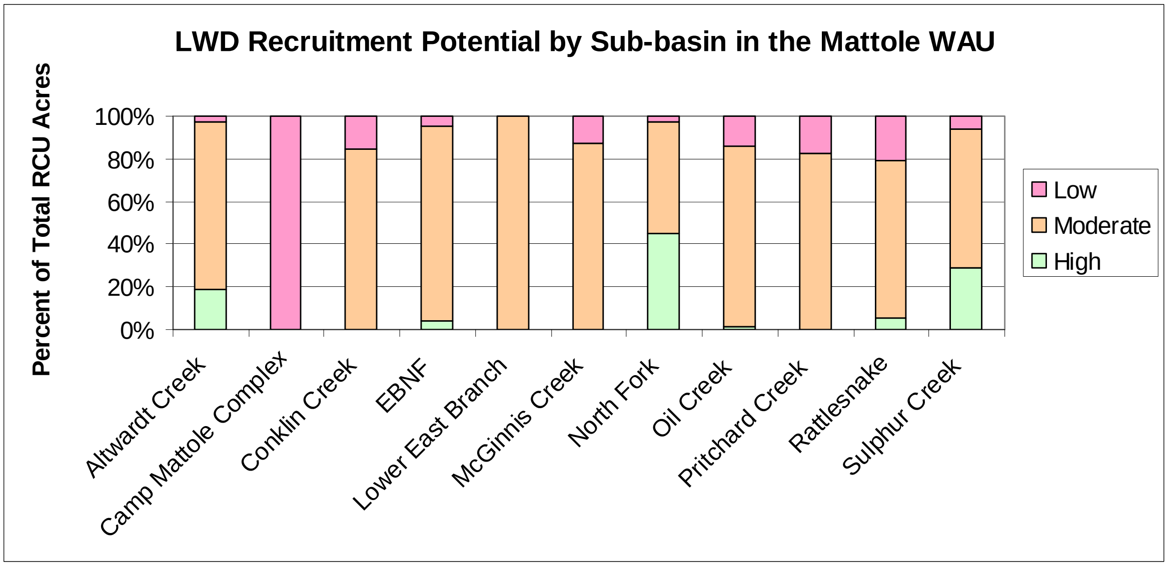
Riparian habitat on HCP-covered lands typically consists of relatively evenly mixed conifer–hardwood stands (approximately 80 percent of total riparian acres). Hardwood-dominated stands with little conifer component account for approximately 9 percent of riparian acres, while pure conifer stands (mainly Douglas-fir) with little hardwood component account for approximately 11 percent. Regardless of species composition, most of these stands are populated by trees with DBH ranging from 12 to 24 inches, with multiple canopy layers just beginning to develop. Stands where the average tree diameter exceeds 24 inches occupy approximately 10 percent of the total riparian assessment area, with older forests with trees ranging from 36 to 100 inches DBH located along headwater Class II streams in the North Fork, Alwardt Creek, Sulphur Creek, and Rattlesnake Creek sub-basins. Over 94 percent of Class I and II riparian stands within the Mattole River HCP area have moderate to dense canopy closure (greater than 40 percent), with the remainder of the acres classified as sparse, mainly due to the presence of naturally-occurring prairies in several of the higher Class II reaches or sparsely vegetated inner gorge slopes along Class I streams.

The RCU type MMD (mixed conifer–hardwood stand, small trees, moderate/dense canopy) represented approximately 64 percent of all riparian habitat on Mattole River HCP lands (Photo 5-3). The next most-common RCU type CLD (conifer stand, medium to large trees, moderate/dense canopy) represented approximately 8 percent of all riparian habitat on HCP lands, followed by the RCU type HMD (hardwood stand, small trees, moderate/dense canopy) at approximately 5 percent of total riparian habitat.

Photo 5-3. Riparian stand with RCU code MMD.

Approximately 10 percent of Mattole River HCP RCU acres were classified with high LWD recruitment potential (Figure 5-22); the North Fork, Sulphur Creek, and Alwardt Creek sub-basins showed the highest proportions of high LWD recruitment potential, although these areas are generally confined to the upper reaches of several scattered Class II watercourses where they have little potential to benefit fish habitat directly other than by metering out sediment transport from these small non-fishbearing tributaries. Approximately 76 percent of the RCU acres were classified as moderate, that is not currently meeting PFC targets but trending towards and likely to achieve the targeted riparian condition within the next 40 years as trees continue to grow (Table 5-2, Photo 5-4). The remaining approximately 13 percent of RCU acres were classified as having low LWD recruitment potential; the sub-basins with the highest proportions of low LWD recruitment potential are Camp Mattole Complex, Rattlesnake Creek, Pritchard Creek, Conklin Creek, and Oil Creek. These areas typically have insufficient tree size and hardwood dominance, due in part to the presence of difficult growing conditions on steep, rocky inner gorge slopes, and naturally occurring open grasslands. Other influencing factors for low recruitment potential, due to hardwood dominance, include a combination of harvest history and natural disturbance regimes (e.g. landslides, fire, and flood).

Figure 5-22. Percent of LWD recruitment by sub-basin in the Mattole River WAU.



Source: Figure C-3, Riparian Function module.

Table 5-2. Number of Class I and Class II stream RCU acres by LWD recruitment potential category, Mattole River HCP lands.

Recruitment Potential	Class I	Class II	Total
Low	126	241	367
Moderate	650	1,451	2,101
High	5	279	284
Total	781	1,971	2,752

Source: Tables C-8 through C-10, Riparian Function module.

Photo 5-4. Moderate recruitment potential of a mixed, medium size, dense stand.

5.5 Hillslope Conditions and Future Management

Sediment is an important and vital component of aquatic ecosystems. In an active streambed, gravel, cobble, boulders, and organic debris that form critical components of fish habitat must be continuously replenished from upland or near stream sources since they are transient and move through the stream system during high flows (Flosi et al., 1998). Sediment is input to streams within a watershed through a variety of natural and anthropogenic mechanisms. Natural mass wasting mechanisms include landsliding and soil creep, which is the gradual downhill movement of soil under the force of gravity that generally manifests along streams as bank erosion. Logging and other land use activities have historically input significant amounts of sediment into streams, especially in combination with record rainfall events. These activities have included:

- Use of creeks or creek beds as skid roads, haul roads, and landing locations.
- Skid road and haul road construction across steep and unstable streamside slopes.
- The filling of stream channels during stream haul road and skid road crossing construction.
- Road use (resulting in surface erosion).
- Timber harvest on unstable slopes.
- Removal of streamside vegetation.

Human activities such as those described above usually disturb (increase) the natural supply rate of sediment which, depending upon extent, can in turn affect stream channel conditions and aquatic habitat. Increased sediment yield, if not scoured by seasonal flows, can result in streambed aggradation which leads to widening of stream channels, stream shallowing, increased bank instability, and loss of pool habitat and overall hydraulic diversity. Widening of stream channels, along with loss of stream depth and pools, makes streams more vulnerable to solar heating and increased water temperatures. Excessive input of inorganic fines can reduce egg and embryo survival rates and impede fry emergence. These changes in stream conditions can cause adverse impacts in aquatic habitat suitability, species composition, and aquatic biomass production.

Much of the impaired condition in the mainstem Mattole, described at the start of this section, is strongly linked to widespread and unregulated logging in conjunction with the massive 1955 and 1964 floods, as discussed in the Mass Wasting and Channel Assessments (Appendices A and D). Massive landsliding occurred as a result of these two flood-flow events, and mass wasting has continued to be the dominant source of sediment input in the Mattole lower-order tributaries. The discussion in this section provides an overview of historic sediment input, including the short-term effects of the 1955 and 1964 floods, along with a 1988-2003 sediment input budget that reflects management prior to and since implementation of the HCP for mass wasting and surface erosion sources. A summary of the effects of hillslope conditions/sediment delivery on fish habitat is also presented.

5.5.1 *Overview of Mass Wasting Sediment Input Analysis*

As described further in the Mass Wasting Assessment (Appendix A), the Mattole WAU is a dynamic geomorphic landscape with naturally high rates of mass wasting. The area is characterized by steep terrain and deeply incised drainages due to high regional uplift rates, high rates of seismicity, weak earth materials due to the high levels of tectonic shearing, and large amounts of seasonal rainfall. It is well documented that the two large flood-flow events in 1955 and 1964 coincided with peak periods of unregulated logging and road building throughout much of the basin. Estimates of landslide sediment delivery from lands now under HRC management indicate that over 17 million cubic yards (26 million tons) entered the stream system during the 17-year period from 1949 to 1965 (Table 5-3, Figure 5-23), as captured in 1965 air photos. The majority of landslide delivery (approximately 78 percent) during this period was from management-related (road and hillslope) landslides (Figure 5-23), with a significant portion also from background processes. Some landslide contributions during this period can also be attributed to intensive early post-WWII logging operations.

Table 5-3. Landslides in project area by time period.

Photo Year	Number of Slides	Number of Delivering Slides	Sediment Delivered (cubic yards)	Percent of Sediment Delivered	Unit Sediment Delivered (tons per square mile)
1948	101	67	2,058,719	9%	112,085
1954	133	104	2,833,961	12%	154,293
1965	796	632	14,539,882	64%	791,613
1987	861	730	1,150,378	5%	62,631
1997	998	749	1,715,708	8%	93,411
2003	552	428	422,325	2%	22,993
Totals:	**3,441**	**2,710**	**22,720,973**	**100%**	**1,237,027**

Source: Table A-2, Mass Wasting module.

Figure 5-23. Landslide sediment delivery by photo year and general land use association.

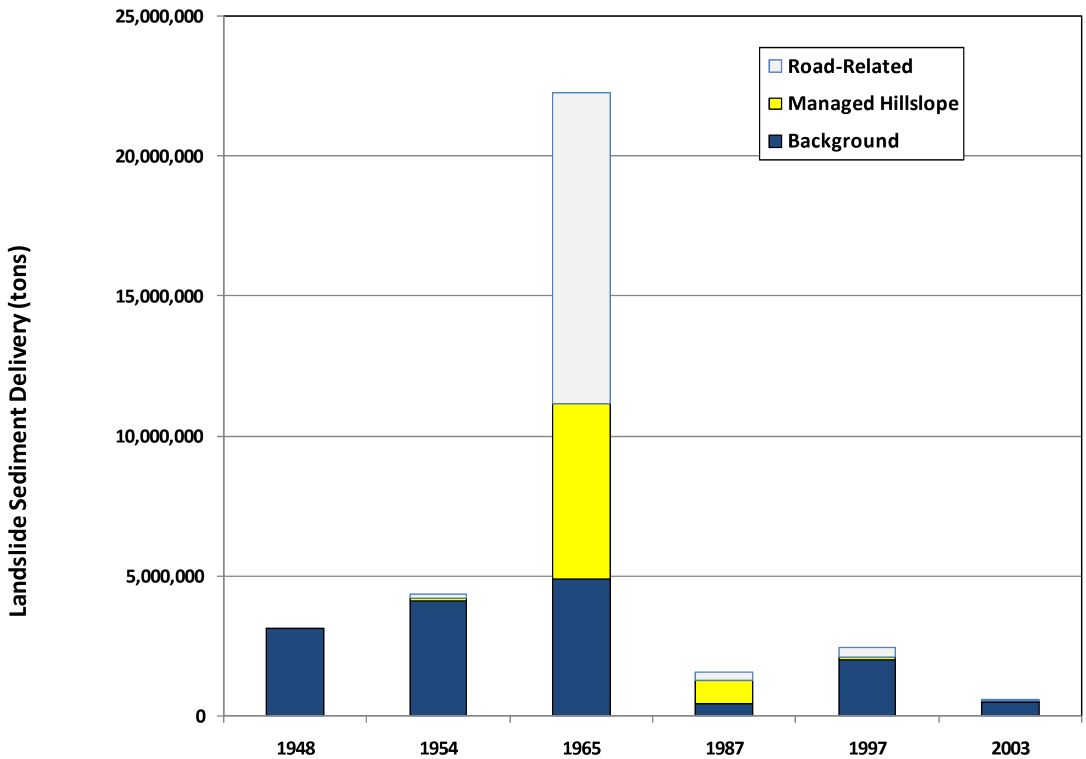


Photo periods subsequent to 1965 show reduced levels of mass wasting, suggesting long-term recovery following the extreme condition in 1965 along with improvement in land use practices, as shown by the decrease during the 38-year period (1966-2003) in which landslide sediment delivery dropped significantly to an estimated 3.3 million cubic yards (87,000 cubic yards per year). Relative to background landslides, the 1987 photo period (the next photo period after 1965) shows a significant proportion of landslides associated with managed hillslopes for that photo period, although the magnitude of landslide delivery was significantly decreased from the 1965 photo period. Also, the relative increase in sediment delivery in the 1997 photo period is inferred to be a result of seismically-induced landsliding associated with the nearby 1992 Cape Mendocino earthquakes. Furthermore, the most recent photo-analysis period of 6 years (1998-2003), yielded an even lower estimated 420,000 cubic yards (70,000 cubic yards [107,000 tons] per year) of sediment delivery from landslides (Table 5-3, Figure 5-23), with approximately 11 percent of the total sediment delivery for this period from management-associated landslides. This may have resulted, in part, from increasingly effective mitigation measures associated with contemporary forestry management. These measures were designed to avoid sediment delivery and began with the inception of the 1973 Z'Berg-Nejedly Forest Practice Act and numerous other state and federal environmental laws. Since 1998, Timber Harvest Plans (THPs) on HCP lands have required sediment reduction measures to offset potential sediment production resulting from timber harvest.

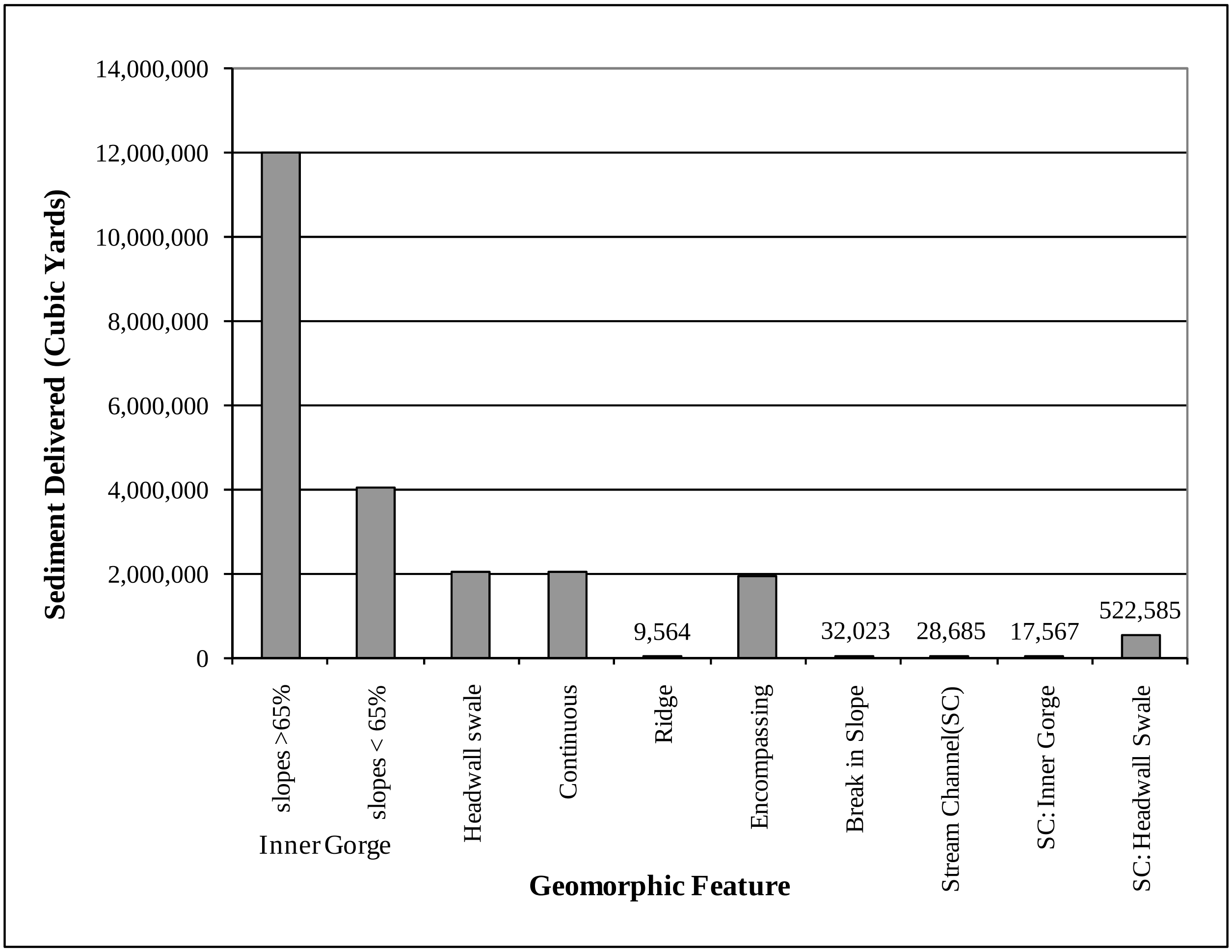
Due to the topographic character of the Mattole River WAU (steep, deeply incised stream canyons), streamside inner gorge debris slide slopes are the primary geomorphic association for mass wasting (Table 5-4, Figure 5-24) during the landslide inventory period (1948-2003), as detailed in the Mass Wasting Assessment (Appendix A), followed by headwall swales and other unstable areas. Inner gorge landslides occurring on slopes steeper than 65 percent delivered significantly more volume than those on gentler slopes (Figure 5-24).

Table 5-4. Landslide delivery (cubic yards) in project area by geomorphic association.

Year	Inner Gorge		Headwall Swale	Continuous	Ridge	Encompassing	Break In Slope	Stream Channel	Stream Channel	
	Slopes >65%	Slopes <65%							Inner Gorge	Headwall Sale
1948	0	321,191	430,695	659,366	0	618,806	28,662	N/A	N/A	N/A
1954	1,596,741	399,163	28,408	806,297	0	0	3,352	N/A	N/A	N/A
1965	8,814,692	2,513,782	1,565,702	324,335	9,564	1,311,806	0	N/A	N/A	N/A
1987	741,197	239,782	31,760	130,487	0	7,145	8	N/A	N/A	N/A
1997	662,659	505,600	11,440	16,067	0	0	0	17,524	8,836	493,582
2003	191,809	55,951	33	125,638	0	0	0	11,161	8,731	29,002
Totals:	**12,007,098**	**4,035,468**	**2,068,037**	**2,062,189**	**9,564**	**1,937,757**	**32,023**	**28,685**	**17,567**	**522,585**

Source: Table A-4, Mass Wasting module.

Figure 5-24. Landslide sediment delivery by geomorphic association.



Source: Figure A-3, Mass Wasting module.

Inner gorge landslides accounted for more than 60 percent of the landslide sediment delivered to streams for air photo periods from 1948 to 2003, though inner gorge landslides were relatively minor in the 1948 photo period. For the sediment budget period (1988-2003), inner gorge landslides accounted for more than 65 percent of the total landslide sediment delivery. However, the landslide sediment delivery for the sediment budget period was significantly lower than for any of the previous photo periods.

Because of the steep, incised nature of the watershed, the inner gorge slopes can extend several hundred feet upslope from stream channels, with significant sediment contributions originating from farther than 400 feet from streams. For photo periods from 1948 to 2003, nearly 70 percent of landslide volume delivered to streams initiated more than 400 feet from streams. In contrast, only 28 percent of the landslide volume delivered to streams during the sediment budget period (1988-2003) initiated more than

400 feet from streams; nearly 40 percent of landslide volume delivered to streams during the sediment budget period initiated within 200 feet from streams.

The Oil Creek and Rattlesnake Creek sub-basins were identified as particular “hot spots” of both historic and more recent inner gorge activity. In these two sub-basins, intensive ground-based logging and clear-cutting on steep streamside slopes (before establishment of the CFPRs) was common, leaving portions of the watershed in a vulnerable condition. These disturbed slopes responded in a predictable fashion, as large swaths of inner gorge slope were subject to debris sliding during the high rainfall events in 1955 and 1964. Subsequently, evidence of significant post-1964 lateral channel erosion into hillside bedrock and vertical channel incision into valley bedrock is linked to continued relatively high rates of streamside mass wasting in the Oil Creek and Rattlesnake Creek sub-basins.

A geomorphically unique condition in the upper tributaries of the North Fork of the Mattole basin is post mid-1960s channel incision of 2 to 10 meters in alluvium, colluvium, and bedrock. Incision into bedrock of 4 to 6 meters was measured in the Rattlesnake and Oil Creek sub-basins since the mid-1960s. This magnitude of incision into bedrock is only possible because of the extreme mechanical weakness of the bedrock. Channel incision was observed to be undercutting the toes of hillslopes leading to semi-continuous (along channel) inner gorge landsliding (see Appendix D). In addition, channel incision was observed to be propagating upstream in small tributaries, triggering streamside landsliding. Channel incision-induced streamside landsliding represents a “bottom-up” control on mass wasting in contrast to the more common “top down” control that involves stability conditions of the hillslope including soil properties, precipitation intensity, and vegetation rooting strength. Therefore, because of channel incision, inner gorge landsliding may be occurring that is unrelated to past or current land use and present day storms.

As noted above, landslides originating from steep tributary headwall locations also play a significant role in sediment delivery. Inherently prone to debris torrents due to their frequently over-steepened condition and the common emergence of groundwater, these features have proven sensitive to management activities such as haul road, skid road, and landing construction.

The Mass Wasting Assessment (Appendix A) documents a substantial reduction in landslide-related sediment delivery in the years following 1965. Recognizing that the size and timing of storm events coupled with other factors such as seismic events and land use contribute to a period’s sediment delivery, it is reasonable to conclude that changes in harvest and road construction practices over the years have played a role in this reduction. Overall reductions in sediment delivery since 1965 have occurred despite significant storms and seismic events, with some short-term increases associated with these events. For example, a short-term increase in sediment delivery apparently resulted from seismically-induced landsliding associated with the nearby 1992 Cape Mendocino earthquakes. While landslide frequency remains high, landslide-related sediment delivery during the 1988-2003 sediment budget period (discussed below) is comparable to that of the pre-industrial delivery volumes documented in the 1948 aerial photographs.

5.5.2 *Sediment Budget – 1988-2003*

As part of the Mattole River watershed analysis, a sediment source budget was prepared as a quantitative accounting of estimated sediment delivery to streams for the period from 1988 through 2003. Sediment delivery on HCP lands during this period was estimated at 13,011 tons/sq mi/yr. The sediment budget includes sediment delivery estimates, by source type, for the HCP area of each sub-basin in the Mattole River WAU. The complete sediment budget (Attachment 2) presents the definition, data source (module), and management association for each source type. Details of methods used to develop sediment delivery rates are provided in the Mass Wasting and Surface Erosion Assessment Reports (Appendices A and B, respectively). Delivery rates were determined through air photo and field inventories or surveys for past erosion (e.g., landslide inventories); modeling of harvest unit surface erosion; a combination of field surveys and modeling for road surface erosion; or use of available literature for processes difficult to observe in the field such as soil creep. Table 5-5 lists the sediment sources included in the sediment budget, and the summarized sediment budget in Figure 5-25 shows the annual sediment delivery for the sub-basins within the WAU with sources grouped in categories of natural, legacy, and management. The “legacy” category estimates ongoing sources of sediment delivery associated with historic land use activities, typically pre-dating implementation of the CFPRs in 1974. These legacy practices are no longer used and include many of the land use activities listed above, while the “management” category estimates sediment delivery linked to more recent land-use activities.

The 1988-2003 Mattole River sediment budget is designed to assist in identifying significant sources of past sediment delivery and to assess the extent to which these sources were associated with land use. Where management-associated delivery is found to be significant, relative to background (i.e., natural), specific management activities can be further scrutinized to determine the extent to which they are controllable in the future through feasible mitigation. The sediment budget is informed through watershed analysis and provides a baseline rate of delivery based on recent watershed performance. ***The sediment budget does not necessarily provide an estimate of current or future delivery, as this will be determined by the frequency and magnitude of storm and seismic events combined with the***

effectiveness of contemporary erosion control management practices. In addition, the process of channel incision and the undercutting of steep streamside slopes leading to landsliding (bottom-up control) should be taken into consideration when evaluating current or future causes of mass wasting in the Mattole WAU.

Table 5-5. Sediment sources included in each land use association category.

Natural	Legacy	Management
Deep-seated landslides; Shallow landslides; Streamside and bank processes; and Soil creep .	Landslides from untreated abandoned roads; Hillslope landslides from older tractor yarded units (15-30 year old partial cut) and 20-30 year old clearcut); Streamside and bank processes; and Surface erosion from untreated abandoned roads.	Landslides on HCP roads; Hillslope landslides in partial cuts <15 years; Hillslope landslides in clearcuts <20 years; Streamside and bank processes; Surface erosion in harvest units; Road surface erosion; and Road washouts and gullies.

Figure 5-25. Annual sediment budget for the Mattole River WAU, 1988-2003.

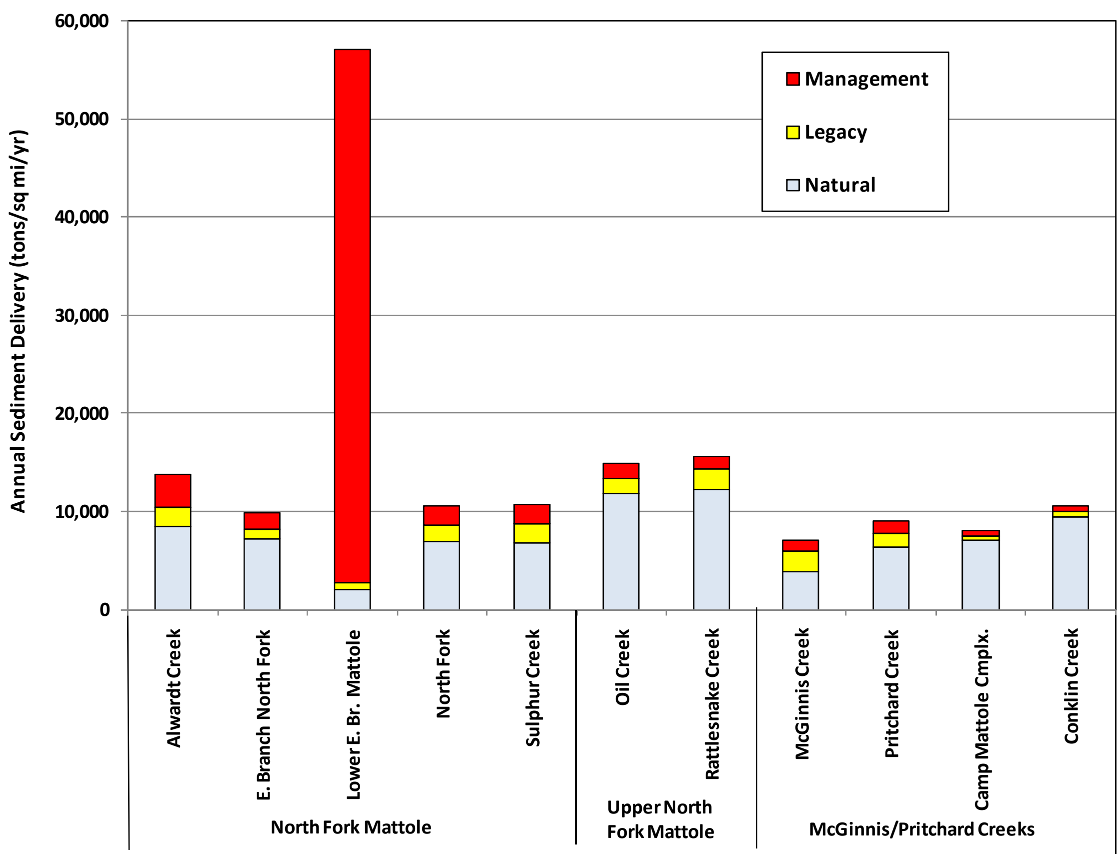


Figure 5-25 illustrates the extent to which land use has been associated with sediment input on HRC ownership by sub-basin, as well as the proportion to which contemporary delivery originates from lingering legacy effects versus more recent management activities. In the Lower East Branch Mattole sub-basin, HCP roads in areas of ground-based yarding and partial cut silviculture were associated with a few large (3,000 to 5,000 cubic yards each) and very large (greater than 5,000 cubic yards each) streamside landslides that were significant contributors of sediment, in contrast with the lowest background/natural contribution among the sub-basins. The small area of HRC's ownership in this sub-basin, approximately 0.25 square mile, results in the elevated annual rate of delivery.

As discussed in the Mass Wasting Assessment Report (Appendix A), in general throughout the study area, sediment contributions from recent large and very large landslides dominate the total volume of landslide delivery to streams. These large and very large landslides appear to be more likely related to seismicity (the nearby 1992 Cape Mendocino earthquakes) and are less likely to be management-related. Without the contributions of this small number of large (and very large) slides, there are few associations between management and landsliding in the study area. Likewise, background landslide contributions from the Mattole River WAU sub-basins are dominated by a relatively small number of large and very large volume landslides.

For comparison with other watersheds within HRC ownership and off-property in other parts of the North Coast region, Figure 5-1 (located near the beginning of Section 5) presents annual average sediment delivery rates. Different rates within the watersheds analyzed on HRC lands are a result of these watersheds varying from one another with regard to geology, proximity to faults and earthquake zones, uplift rates, topography, precipitation and climate, occurrence of unstable valley floor base levels (e.g., channel incision), and harvest history. The results show substantially higher contributions from both natural and management-associated sources in the Mattole River HCP area compared to other watersheds including those with significant HRC ownership. This observation is not unexpected considering the significance of contributions from large and very large landslides in the Mattole River HCP area, which account for the vast majority of the total sediment delivery volume from all sources in the 1988-2003 sediment budget along with channel incision driven occurrences of streamside landsliding (Appendix D). These large contributions are believed related to inherent regional conditions including close proximity to the Mendocino Triple Junction, underlying geology (Coastal belt of the Franciscan Complex), very steep terrain (see Figure 3-3), and a mean annual rainfall of 81 inches – the highest on HRC's ownership.

Off-property sediment delivery estimates shown in Figure 5-1 were developed as part of TMDLs. In contrast to the 1988-2003 sediment delivery estimate of 13,011 tons/sq mi/yr for HRC lands only in the

Mattole, the sediment source analysis for the *Mattole River Total Maximum Daily Loads (TMDLs) for Sediment and Temperature* (EPA, 2003), for the 1984-2000 period, presented an estimated sediment delivery of 8,000 tons/sq mi/yr for the entire Mattole River watershed. For the Mattole TMDLs, the watershed was divided into four sub-basins – North, East, South, and West. The sediment delivery estimate for the "North sub-basin", within which the Mattole River WAU is located, was 8,200 tons/sq mi/yr, with approximately 55 percent (4,500 tons/sq mi/yr) attributed to natural processes and 45 percent attributed to human activity. This sediment delivery volume from natural sources in the North sub-basin was substantially higher than natural source contributions from the other three sub-basins.

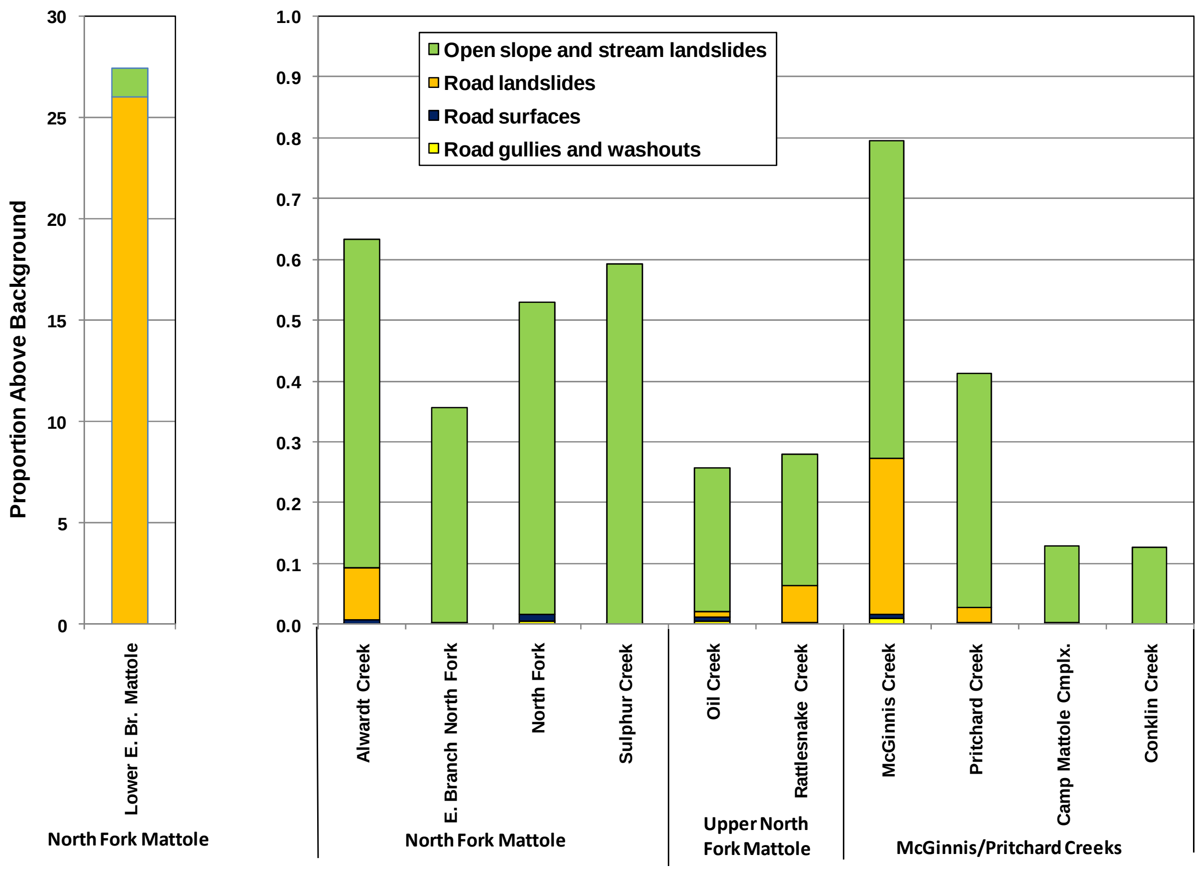
The sediment delivery estimate presented in the Mattole sediment TMDL (EPA, 2003) was significantly higher than estimates prepared for sediment TMDLs in other watersheds in the area, including Redwood Creek (4,750 tons/sq mi/yr) and the Van Duzen River (2,232 tons/sq mi/yr, assuming a bulk density of 1.4 tons/cubic yard) (EPA, 1998; EPA, 1999). As noted in the Mattole sediment TMDL (EPA, 2003), the Mattole sediment delivery estimate is high, but comparable to values from other sediment studies conducted in other rapidly tectonically uplifted regions including the San Gabriel Mountains (California) and the Seaward Kaikoura Range (New Zealand).

Figure 5-26 shows management and legacy-related sediment sources expressed as a proportion above 'background' or 'natural' sources. (A value of one indicates that management plus legacy sediment is the same magnitude as the estimated natural baseline rate.) This figure facilitates comparison of the relative level and management associations of excess sediment among the Mattole River sub-basins (HCP lands only). Landslides deliver the vast majority of sediment to streams on HCP lands, in contrast to surface erosion processes, and therefore are the focus of the following discussion.

For the sediment budget period, the proportion of the high sediment delivery rate for the Lower East Branch Mattole sub-basin attributed to management-related sources is significant due to a small number of large and very large landslides that dominate the delivery volume (as discussed above), along with a relatively small contribution from background sources. As noted above, these large and very large landslides were typically associated with non-stormproofed roads and partial-cut tractor logged areas. For the other 10 sub-basins, the McGinnis Creek, Alwardt Creek, Sulphur Creek, and North Fork sub-basins were identified with the highest proportions of management- and legacy-associated sediment delivery. However, the proportions indicate only the relative contribution from management- and legacy-associated sources in comparison with background sources. This is important to note for the McGinnis Creek sub-basin, which has a higher management/legacy proportion over background but a lower background sediment delivery rate than the other sub-basins with the exception of the Lower East Branch Mattole.

For the McGinnis Creek sub-basin, the higher proportion reflects relatively large contributions from landslides occurring on "untreated" abandoned (legacy) roads, along with streamside landslide contributions.

Figure 5-26. Relative importance of management-related and legacy sediment sources by sub-basin in the Mattole River WAU (HCP lands).



Streamside landslides dominate the management- and legacy-associated sediment delivery estimates for the Mattole WAU sub-basins. This is due to the very steep slopes that often occur in association with toes of hillslopes (inner gorges) and channel incision. The higher proportions of management/legacy sediment delivery, relative to background, were estimated for the Alwardt Creek, Sulphur Creek, and North Fork sub-basins. A relatively small number of large and very large volume road-related landslides also contribute a significant proportion of management-associated sediment delivery in the Alwardt Creek sub-basin.

In general, regardless of road or harvest area association, a small number of large and very large volume landslides, rather than numerous small ones or surface erosion, are responsible for the vast majority of sediment delivery linked to forestry operations, particularly in the Lower East Branch Mattole and Alwardt Creek sub-basins. Although these large and very large landslides coincide with management associations, the resulting sediment contributions are more likely related to seismicity (the 1992 Cape Mendocino earthquakes) and less likely to be management-related. These observations further support characterization of the Mattole River WAU area as a dynamic geomorphic landscape with high rates of mass wasting driven not by management activities presently, but largely by a high level of tectonic activity (uplift, bedrock shearing, earthquakes) and large amounts of seasonal rainfall (see Mass Wasting Assessment Report, Appendix A).

5.5.3 *CHANNEL AND FISH HABITAT CONDITION TRENDS*

Even under natural conditions (in the absence of industrial land use), the dynamic geomorphic setting in the Mattole River WAU has resulted in ever-changing habitat conditions for fish. While the spatially dynamic nature of the system reduces long-term impacts to fish at the scale of the entire watershed, short-term impacts in some locations can be significant. However, spatial variability in erosion and sediment supply at the sub-basin scale, in combination with heterogeneous channel and valley floor environments, ensures a high degree of variability in sediment storage and transport, and substrate attributes and thus in habitat abundance, distribution, and quality.

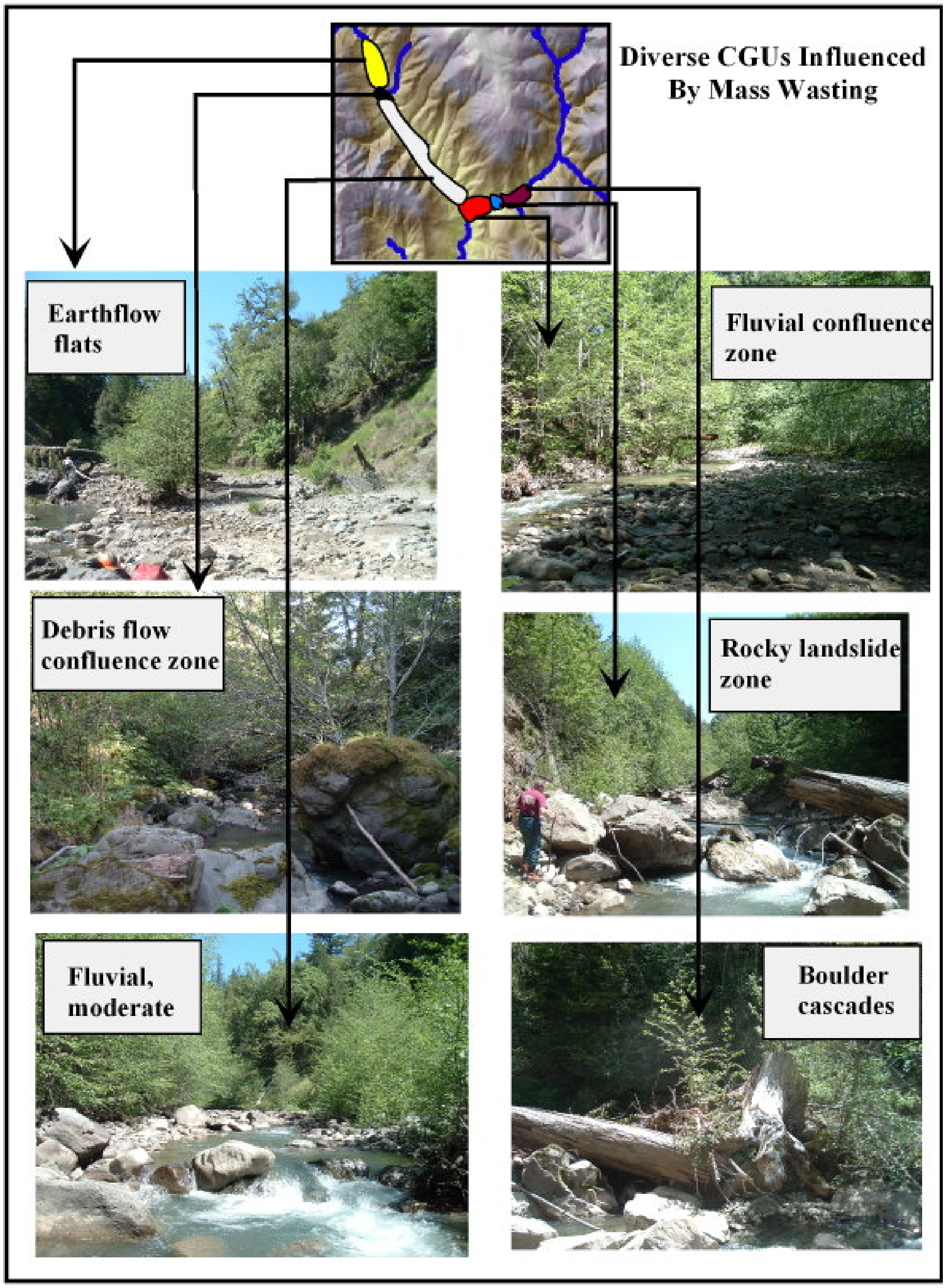
The channel morphology of headwater streams (first- and second-order channels) is characterized by boulders, large wood, and stepped longitudinal profiles which can be resilient to small- to moderate-sized impacts related to erosion, sediment supply, and flooding (due to large substrates). Nevertheless, extreme events such as the combination of unregulated logging with very large storms (mid-1960s) can trigger large-scale changes in headwater streams including scouring debris flows, massive sedimentation, and channel incision (Appendix D). Lower gradient, higher-order channels (larger than 3rd order) are prone to high levels of sedimentation resulting in impacts to fish habitat and water quality. Habitat impacts include filling of pools with finer sediment (gravels to sand), reduction in flow depth, warmer summer stream temperatures, and lateral instability.

Valley aggradation (6 to 10 m) and widespread incision that was documented in Rattlesnake and Oil Creek sub-basins following 1964 (see Appendix D, Stream Channel Assessment) appears to be of a magnitude outside the range of naturally occurring large landslide and earthflow events in the Mattole watershed. The intensive and unregulated building of haul roads and skid roads in support of timber harvest beginning in the 1940s through the 1960s, in combination with the very large 1964 flood event – as evident in the 1964 aerial photographs – indicate an extreme level of watershed disturbance. Following that impact, valleys aggraded 6 to 10 meters and then subsequently incised through the stored alluvium. Channels either shifted laterally by tens of meters into hillslopes, or channels re-established themselves in new locations within their valleys, resulting in bedrock incision (0.2 to 5 m deep). Lateral and vertical incision led to undermining of hillslopes and concentrated streamside landsliding. In certain areas, incision propagated up tributaries and triggered streamside failures in new areas. The result was heightened erosion and sediment supply to the channel network in tributaries in the North Fork Mattole sub-basin up to the present day, almost 50 years following the original main impact. Although the upper, steeper parts of the channel network appear to be recovering (reduced sediment transport and storage and stabilized terraces), increased sediment transport and storage is evident in the lower areas of the channel network (e.g., lower portion of the upper North Fork and the mainstem Mattole River).

Despite the intense history of disturbance throughout much of the Mattole WAU, many stream reaches located in the upper portions of the tributary basins appear to be in a state of recovery, as evidenced by channel incision into alluvium and bedrock, minimal thickness of alluvium over bedrock (~ 1m), and increases in riparian vegetation. This is coinciding with an overall decrease in mass wasting, even though local areas continue to be impacted by streamside landslides and earthflows, particularly in areas with channel incision or where the channel is incising through hillside bedrock (in areas where the channel has migrated across the valley during the period of aggradation onto toeslopes of hillsides). The generally decreased input of hillslope sediment to streams has resulted in an increase in channelization as stream sediment is mobilized from streambeds for transport downstream. The mobilized streambed sediment is readily transported through the system which is dominated by reaches with a high sediment transport capacity, particularly in the HRC portion of the Mattole basin.

Even within the lower gradient channels located in the tributaries (Oil, Rattlesnake, McGinnis Creeks), the morphology is dominated by large substrate (boulders and cobbles) and is confined between steep hillslopes, bedrock gorges, high terraces, and earthflow toes or some combination of those landforms thus leading to mostly cascade or step pool bed types (Figure 5-27). Although massive sedimentation can bury these channels and convert them into laterally and vertically unstable pool riffle or even braided systems for a period of time, the relatively high stream energy of these channels results in relatively rapid recovery (to an inherent boulder-cobble dominated morphology, Figure 5-27).

Figure 5-27. Example of the spatial distribution of channel geomorphic units.



Source: Figure 15 of the Channel Assessment Module (Appendix D)

From a habitat perspective, this channel type favors steelhead and cutthroat trout, rather than coho or Chinook (see habitat modeling results in the Channel Module report, Appendix D). In the context of cascade and step pool channel types, spawning habitat will be localized to small patches at channel margins, in pool tail-outs and in association with large wood.

The trends in the PFCs are encouraging and generally support the findings in the mass wasting, channel assessment, and riparian assessment modules. An overall reduction in erosion and sedimentation in many parts of the channel network is evidenced by trends in the PFCs that show an overall coarsening of the bed substrate, a lowering in channel elevation (incision), and fewer fines in the substrate. Therefore, overall, sedimentation does not appear to be, at present, a limiting habitat factor, particularly in the upper portions of tributaries on HRC ownership. Nevertheless, there exist local areas in the sub-basins that either have accelerated erosion linked to streamside landsliding (and perhaps channel incision) or are impinged upon by active earthflows where habitat conditions are unstable and not favorable. Neither of these processes appear to be related to recent or present-day land management in the sub-basins.

Although additional large wood would contribute to habitat development, its role in pool formation and cover appears to be minimal in the boulder-cobble dominated system in the upper tributaries of the Mattole WAU. Nevertheless, the management target should be to improve streamside forest conditions to allow for future recruitment of large wood into streams and to add a large tree component to the riparian ecosystem.

Restoration within the Mattole River basin has been championed by local watershed and salmon restoration groups in cooperation with other private and public landowners since the 1970s. Projects have been focused in the estuary, the lower river, the headwaters area, and key salmon-producing tributaries. Meanwhile, timber harvest has continued on private and industrial timberlands in forested uplands and throughout the upper watershed, although timber harvest practices have been modified relative to earlier practices to provide increased protection for aquatic habitat. For example, identification and avoidance or limitation of harvest and road construction activities on inner gorge slopes, headwall swales, and other unstable areas, along with active remediation policies including road removal and/or “stormproofing”, have been instrumental in continuing the observed trend in reduced volume of landslide-related sediment delivery. These reductions are expected to be continued largely by HRC’s commitment to a high standard of environmental stewardship, including uneven-aged management, no clearcutting, and stormproofing of all roads by 2020. In addition, forest practice restrictions in CMZs will provide additional protection to riparian-aquatic systems of the Mattole basin; use of NetMap’s floodplain tool that utilizes 2.5 m digital elevation data allows for accurate mapping of the CMZ ensuring correct identification of the riparian sensitive areas (Appendix D).

There is considerable information available on hillslope and channel processes in the Mattole River watershed (Downie et al., 2003) to guide restoration activities. To this foundation, the processes of channel incision and streamside instability outlined in the Channel Module report (Appendix D) could be added to provide additional context about evolving watershed conditions. For instance, channel incision in alluvium, colluvium, and bedrock can lead to extended periods of channel instability and channel sedimentation, particularly in lower portions of river networks (despite locally successful restoration projects). Certain types of channel instabilities may continue despite restoration efforts.

Knowledge of continuing channel-focused instability might be useful for planning the locations and types of future in-channel restoration projects. Information about the process and location of lateral channel instability into hillsides could inform the design of restoration activities to reduce channel undermining of hillslopes. The Mattole Restoration Council has already pursued this form of restoration and has designed and constructed in-channel barriers to reduce streamside landsliding. Nevertheless, a watershed scale context for the cycle of channel instability and bottom-up controls on mass wasting may provide additional context for consideration of in-channel restoration projects to stem streamside erosion.

5.6 Amphibian and Reptile Habitat

Using the Watershed Analysis Methods guidelines developed cooperatively between the Wildlife Agencies and PALCO, for lands formerly owned by PALCO and now owned and managed by HRC, existing data and new data collected during the watershed analysis period were utilized to assess the occurrence and habitat of four amphibians and one reptile species of concern on HCP lands within the Mattole River WAU. The five HCP-covered amphibian and reptile species include two headwater species (southern torrent salamander and tailed frog), and three lowland species (foothill yellow-legged frog, northern red-legged frog and Northwestern pond turtle). A summary of habitat is provided in the discussion, below; a detailed discussion of habitat requirements, condition, and distribution is provided in Appendix F.

Habitat for all five of these species exists in the Mattole River WAU. There is habitat and potential habitat for the headwater species (southern torrent salamander and tailed frog), and a limited amount of existing and potential habitat for the lowland species (red-legged frog, yellow-legged frog, and northwestern pond turtle). There are no records on HRC lands in the Mattole WAU for the pond turtle and tailed frog. In addition, the reported sighting of a red-legged frog may have been a misidentification.

Streams and riparian zones have had varying amounts of recovery since the post-WWII logging boom combined with two significant storm events in the mid-twentieth century to adversely impact watercourses of all sizes with excessive sedimentation and removal of riparian forest canopy. The HCP-covered lands analyzed in this watershed analysis appear to be in an improving condition relative to amphibian and reptile habitat. The steep decline in harvest activity in recent decades, coupled with significant improvements in forestry operations associated with inception of the CFPRs and later the HCP, has resulted in this trend towards recovery. Factors contributing to the generally good habitat conditions include: primarily consolidated geologic types, high gradient transport reach streams with gravel and cobble substrates and cool water, relatively high canopy closure in upland areas, instream pool habitat in lowland areas, and pond habitat. For the amphibian and reptile species of concern, management practices should be designed to allow for continued recovery, including maintenance of riparian canopy cover, prevention of large sediment influx, and retention or improvement of instream pools and pond habitats.

6.0 MANAGEMENT RECOMMENDATIONS

One of the primary purposes of the HCP watershed analysis process is to identify management objectives for protecting, restoring, and enhancing the aquatic habitat of specified salmonids, amphibians, and reptiles. The goal is to maintain or achieve, over time, a properly functioning aquatic habitat condition in streams and rivers affected by the landowner's forest mangement activities. HRC's HCP identifies multiple variables, known to be important to properly functioning aquatic habitat conditions and processes, including water temperature, canopy cover, sediment, instream large wood, large wood recruitment, pool frequency, and pool quality. Key findings and management implications for sediment, wood, and solar radiation were considered in the development of the watershed analysis-based forestry prescriptions (Attachment 3).

The beginning of the prescription package (Attachment 3) briefly outlines some general harvest guidelines HRC uses across its ownership including the application of selective harvest where stand conditions allow, restoration silvicultures where necessary to promote a proper balance of conifer and hardwood species over time, the retention of old growth trees and stands, and efforts to minimize wildfire hazard and forestry-related sediment delivery. In addition, HRC is committed to sustainable forest management practices which increase standing timber inventory over time, benefitting and sustaining both biological and cultural resources. One tangible aspect of this commitment is that constraints are placed on acres harvested which, in combination with self-imposed prohibitions on clear-cutting and the protection measures summarized below and presented in greater detail in Attachment 3, minimize the watershed's 'vulnerability' relative to harvest related disturbance at any given time when significant natural events occur, such as during the winters of 1955, 1964, 1996/97, and 2003.

Further information regarding Humboldt Redwood Company's forest and watershed management activities property-wide can be found at *www.hrcllc.com*.

6.1 Hillslope

HRC utilizes a three-step approach for the identification and avoidance or mitigation of high hazard unstable areas during the planning and implementation of forestry activities: (1) slope stability training for foresters; (2) project-specific "screening" and investigation for unstable areas by licensed geologists; and (3) enforceable site-specific prescriptions applicable to road construction, re-construction, or timber harvest on unstable areas designated as "high hazard" including requirements for licensed geologic review. A summary of high hazard prescriptions is presented here.

No harvesting is permitted on inner gorge slopes adjacent to fish-bearing (Class I) and non-fish bearing (Class II) streams. While this no-harvest designation has no upslope limitation for inner gorge slopes adjacent to Class I streams (i.e., inner gorge slopes are no-harvest regardless of distance to Class I watercourse), in some instances a light harvest may be permitted on the upper extent of inner gorge slopes located above Class II watercourses, which are typically less active, provided the harvest occurs farther than 200 feet from the watercourse and licensed geologic analysis of the proposed harvest is conducted and finds harvest can occur in a manner not likely to increase the risk of landslide-related sediment delivery. The watershed analysis identified inner gorges as the most common sediment delivering geomorphic feature associated with shallow debris landsliding.

Shallow debris landslides, including debris torrents, originating from headwall locations were identified as a source of relatively infrequent, but individually significant, sediment delivery. These features typically occur near the top of first-order streams, where colluvium build up over time resulting in a potentially unstable situation, particularly in combination with ground disturbance or placement of fill burden near emergent groundwater. Headwall swales were provided a no-harvest designation unless approved by licensed geologic review and retention of at least 50 percent well-distributed canopy cover is maintained post harvest.

No harvest is permitted on other types of identified dormant historic to active unstable areas, including but not limited to earthflow and translational/rotational features, unless licensed geologic assessment is conducted per state standards (CGS Note 45) and recommendations are incorporated in the harvest prescription.

Road construction across inner gorge slopes and headwall swales, and most other active unstable areas is prohibited without licensed geologic review. In addition, any proposal for road construction across inner gorge slopes requires advance notification to the HCP wildlife agencies.

To further address the general linkage between steep streamside slopes and mass wasting related sediment delivery, no harvest is to be permitted within 150 feet of a Class I watercourse where slopes exceed 65 percent and lead directly to the stream. Similar extended no-harvest buffers from 50 to 200 feet and requirements for licensed geologic assessment have been developed for steep slopes leading to Class II streams, with particular emphasis for additional protection for larger class II streams in the upper North Fork Mattole (Oil Creek and Rattlesnake Creek) and McGinnis Creek sub-basins. These sub-basins have been provided this additional protection to address findings of concentrated mass wasting in the Oil Creek and Rattlesnake Creek sub-basins, and for additional protection in the McGinnis Creek sub-basin considering its coho and Chinook habitat potential and close proximity to the Mattole mainstem. This combination of enforceable no-harvest or limited-harvest prescriptions, and required licensed geologic investigation for these sensitive 'high hazard' areas, will minimize hillslope disturbance and maintain the root strength, rainfall interception, and transpiration values attributed to forested cover, all-in-all benefitting slope stability. In the event of mass wasting occurrence, the retained forest cover will facilitate LWD recruitment to streams and sediment entrapment on the hillslope.

An analysis of surface erosion processes found the unit rate and total sediment delivery to streams from roads to be most prevalent in the Oil Creek sub-basin. Therefore, stormproofing roads in the Oil Creek sub-basin will be made a priority. Types of road improvements which will decrease the potential for road-related sediment delivery include 'hydrologically disconnecting' road segments from watercourses to the maximum extent feasible, applying rock or other measures to minimize fine sediment delivery from the remaining hydrologically connected road segments, and upgrading undersized and/or poorly performing watercourse crossings. HRC's current goal is to stormproof its entire road system by 2019. To date, slightly more than 40 percent of HRC's Mattole road system has been stormproofed.

6.2 Riparian

Older forests with late-seral characteristics occur primarily along headwater Class II streams in the North Fork, Alwardt Creek, Sulphur Creek, and Rattlesnake Creek sub-basins, although the vast majority of Class I and II riparian stands consist of early to mid-seral forest containing trees less than 24 inches at DBH and just entering the early stages of multiple canopy layer development. LWD recruitment potential was found to be greatly diminished relative to historic pre-logging conditions but slowly recovering. As is often the case with early to mid-seral forest, streamside canopy is typically dense except for local grassland openings and sparsely vegetated inner gorge slopes. Overstream canopy cover in excess of 85 percent is common for Class II streams, and greater than 70 percent cover is common for smaller Class I tributaries, whereas, canopy cover varies over third- and fourth-order streams with the least shade found in the Oil Creek and Rattlesnake Creek sub-basins. While PFC targets for shade canopy and stream temperatures are currently being met throughout much of the watershed, targets for riparian forest tree size are several decades away from being achieved as a whole.

Riparian forest management objectives necessary to address these current conditions require maintenance of maximum shade canopy and LWD recruitment immediately adjacent to watercourses where their role is most significant, while allowing for some selective harvest in the mid to outer reaches of the riparian management zone (RMZ) to promote attainment of late-seral stand conditions, prevent early and mid-seral forest stagnation, and allow for economic recovery. Riparian prescriptions establish no-harvest 'inner band' zones immediately adjacent to Class I and II watercourses. At a minimum, these no-harvest zones extend 50 feet each side of Class I streams and 30 feet each side of Class II streams. Where hillslopes leading to streams exceed 65 percent, which includes much of the watershed, the area of no harvest is often extended further upslope toaddress concerns over slope stability. Where not restricted by slope stability concerns, selective harvest is permitted in the RMZ 'outer band', provided sufficient trees and canopy cover exist to maintain cool and relatively moist micro-climate conditions. Retained trees must occur in a well-distributed, multi-storied stand composed of a diversity of species and structure similar to that found prior to harvest. Selective harvest operations in the outer band adjacent to Class I streams are intended to promote increased tree growth rates post harvest and must result in an increased average stand diameter post harvest. Total riparian zone widths incorporating both inner and outer bands are typically 150 feet or greater for Class I streams and 75 to 100 feet for Class II streams depending upon drainage area/stream size. Again, where driven by steep and/or unstable hillslopes, RMZs will typically extend beyond these minimum distances.

Retention of the 18 largest trees per acre adjacent to Class I streams is a continued requirement of the prescriptions as is the requirement to retain all trees with high probability of recruitment to Class I or II streams (e.g., trees leaning towards the stream).

Small, seasonal (Class III) watercourses which flow only in response to large or sustained rain events will receive a 50-foot RMZ within which a minimum 50 percent canopy closure, well distributed throughout, is required to reduce potential for surface erosion resulting from timber operations.

Equipment exclusion zones (EEZs) and retention of all pre-existing down wood are the standard practice within all established riparian management areas.

6.3 Conclusion

Significant spatial variability in channel and valley morphology was found across HRC's ownership, driven by differences in channel gradient, valley width, channel confinement, tributary confluence areas, near-stream topographic roughness, large wood accumulation potential, earthflows and other forms of mass wasting, and sediment supply. Reductions in erosion and sedimentation in many parts of the channel network are evidenced by trends of overall coarsening of the bed substrate, a lowering in channel elevation (incision), and fewer fines in the substrate. Although sedimentation does not appear to be a common limiting habitat factor, some local areas have either accelerated erosion linked to streamside landsliding or impingement by active earthflows. These processes appear to be unrelated to contemporary management.

The legacy effects of removing trees from streamside areas throughout much of the Mattole still limit wood loading, affecting habitat complexity including pool formation and cover as well as shade canopy values (i.e., water temperatures). Therefore, retaining and, where feasible, promoting growth of large trees adjacent to streams and on unstable areas represent best management practices. However, it must be recognized that many of the steeper and confined channel segments will not respond strongly to large wood, as their morphology is dictated by large boulders. In addition to smaller piece size in the few true response reaches, in-stream wood loading remains low due to the lateral shifting of channels in Oil Creek, Rattlesnake Creek, and McGinnis Creek during winter peak flow events. Therefore, a significant increase in pool habitat commensurate with increasing riparian forest size may not be likely. Nonetheless, the system benefits as a whole from shade and cover provided by down logs caught up in the transport reaches, or large wood transferred downstream during peak flows.

Overstream shade canopy provided primarily by hardwoods has increased significantly in recent years along all surveyed fish-bearing tributaries due mainly to continued hardwood growth in floodplain areas. Maximum Weekly Average Temperatures (MWATs) have been on the decline over the last three years and have met the NOAA PFC target (<16.8 ºC) in all three permanently monitored stream reaches (Sulphur Creek, McGinnis Creek, and Rattlesnake Creek) in 2010 after a spike in water temperature in 2006. The ‘permanence’ of this floodplain hardwood cover is linked to hillslope management to the extent that timber operations do not increase the frequency and magnitude of scouring events. Harvesting or significant direct removal of vegetation on these floodplains is not permitted. It is anticipated that the prescribed riparian management measures with the requirement for significant conifer and hardwood retention, in combination with upslope selection harvest where feasible, will result in streamside forests with sufficient canopy height to provide shade at greater distances from the watercourse, making the forest more resilient to naturally-occurring floodplain scouring events. Where this older forest type already exists (e.g., North Fork Mattole) and provides this benefit, it is retained under Mattole management prescriptions.

While current steelhead populations on HRC property appear relatively abundant and in good health, high summer and early fall stream temperatures limit habitat capacity and affect the abundance and distribution of salmonids in higher-order streams and in the Mattole estuary downstream of HRC property. The trend of decreasing temperatures in lower-order streams is expected to continue under the HRC Mattole prescriptions with increases in riparian growth and shading, possibly also resulting in improvement in downstream water temperatures.

McGinnis Creek presents significant restoration opportunities as it appears to be the most likely stream on HRC's Mattole ownership to provide readily accessible habitat for Chinook and coho salmon. Spawning habitat is abundant in lower reaches, although the quality of rearing habitat appears limited due to lack of pool depth and cover, although some improvement has been seen in recent years. McGinnis Creek may benefit from placing additional instream LWD and developing off-channel habitat to improve conditions for juvenile coho salmon rearing. These potential restoration measures should be investigated and implemented as feasible.

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