North Coast Watershed Assessment Program

Mattole River

Watershed Assessment Report

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State of California
Governor, Gray Davis

California Resources Agency
Secretary, Mary D. Nichols

California Environmental Protection Agency
Secretary, Winston H. Hickox

North Coast Watershed Assessment Program Participants

Contributing Agencies and Departments

Department of Fish and Game
Director, Robert C. Hight

State Water Resources Control Board
Chair, Art Baggett

Department of Forestry and Fire Protection
Director, Andrea E. Tuttle

North Coast Regional Water
Quality Control Board
Executive Officer, Susan A. Warner

Department of Water Resources
Director, Thomas M. Hannigan

Department of Conservation
Director, Darryl W. Young

In partnership with:

Institute for Fisheries Resources
Executive Director, William F. "Zeke" Grader

Mattole Assessment Team

Fisheries:

Scott Downie - Team Leader	California Department of Fish and Game
Beatrijs deWaard	Pacific States Marine Fisheries Commission
Gary Peterson	Mattole Salmon Group

Forestry and Land Use:

Fay Yee	California Department of Forestry and Fire Protection
Jennifer Miller	California Department of Forestry and Fire Protection

Water Quality:

Elmer Dudik	North Coast Regional Water Quality Control Board
John Clements	Department of Water Resources

Geology:

Clifton Davenport, CEG	Department of Conservation/California Geological Survey
Marc Delattre, CEG	Department of Conservation/California Geological Survey
Dale Dell'Osso, CEG	Department of Conservation/California Geological Survey
Jim Falls, CEG	Department of Conservation/California Geological Survey
Jennifer Thornburg, CEG	Department of Conservation/California Geological Survey

Fluvial Geomorphology:

John Curless, CEG	Department of Conservation/California Geological Survey
Wayne Haydon, CEG	Department of Conservation/California Geological Survey

Geographic Information System, Data Management, EMDS, and KRIS:

Vikki Avara-Snider	Pacific States Marine Fisheries Commission
Steve Cannata	California Department of Fish and Game
Chris Fischer	California Department of Forestry and Fire Protection
Kevin Hunting	California Department of Fish and Game
Chris Keithley	California Department of Forestry and Fire Protection
Lisa Ohara	Department of Conservation/California Geological Survey
Gary Reedy	Institute for Fishery Resources
Peter Roffers	Department of Conservation/California Geological Survey
Kira Sorensen	Department of Conservation/California Geological Survey
Jennifer Terwilliger	California Department of Fish and Game
Richard Walker, PhD.	California Department of Forestry and Fire Protection

Research and Documents Production:

David Snider	California Department of Fish and Game
Shannon Stewart	California Department of Fish and Game

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Accessing NCWAP Products

The North Coast Watershed Assessment Program produces a number of reports and other information products. This page provides a guide to what we produce and how to get access to it.

NCWAP Reports

NCWAP's main products are basin level assessment reports for each subject watershed. These reports consist of an integrative synthesis report and a number of discipline oriented appendices. A limited number of these synthesis reports and appendices were produced in printed media for program cooperators, stakeholder groups, and program partners. Printed reports were also distributed to most major libraries. Printed documents are not currently available to the public; however the entire synthesis report document, including appendices and maps, is available on a compact disk (CD) in PDF format or via the NCWAP website www.ncwatershed.ca.gov. The NCWAP watershed assessment reports are currently available for the Gualala River, Mattole River, and Redwood Creek watersheds. Other reports will become available over time. CDs containing the reports, appendices, and maps may be requested from:

California Department of Fish and Game
Wildlife and Habitat Data Analysis Branch
1807 13th Street, Suite 202
Sacramento, CA 95814
(916) 324-9265

Klamath Resource Information System CDs and Website

The Institute for Fisheries Resources (IFR) has produced Klamath Resource Information System (KRIS) projects for six North Coast watersheds. KRIS is a custom software program capable of managing watershed datasets, tables, charts, photos and maps. There are currently KRIS products for the Noyo, Big, Ten Mile, Gualala, and Mattole rivers, and Redwood Creek; they are available via the IFR website (www.krisweb.com). These products may also be requested on Compact Disc from:

Department of Forestry and Fire Protection
Fire and Resource Assessment Program
1920 20th Street
Sacramento, CA 95815
(916) 227-2651
frap@fire.ca.gov

Maps of Landslides and Relative Landslide Potential

The California Geological Survey has produced maps and GIS coverage of landslides and relative landslide potential. To order additional maps contact one of the California Geological Survey offices:

Publications Sales-Sacramento
(916) 445-6199 fax: (916)324-5644

Publications and Information Office-Sacramento
(916) 445-5716

Southern California Regional Office-Los Angeles
(213) 239-0878

Bay Area Regional Office-San Francisco
(415) 904-7707

You may also download the order form from the web site:
www.consrv.ca.gov/cgs/information/publications/ordering.htm

Datasets and GIS Products

NCWAP has produced a number of datasets and GIS products as a part of its work. These are available at the NCWAP website, www.ncwatershed.ca.gov

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Executive Summary

North Coast Watershed Assessment Program

The North Coast Watershed Assessment Program (NCWAP) is an interagency effort between the California Resources Agency and CalEPA, established to provide a consistent body of information on North Coast watersheds for use by landowners, stakeholders, and collaborative watershed groups. The program's work is intended to provide answers to the following assessment questions at the basin and subbasin scales in California's North Coast watersheds:

- What are the history and trends of the size, distribution, and relative health and diversity of salmonid populations?
- What are the current salmonid habitat conditions? How do these conditions compare to desired conditions?
- What are the past and present relationships of geologic, vegetative, and fluvial processes to stream habitat conditions?
- How has land use affected these natural processes?
- Based upon these conditions, trends, and relationships, are there elements that could be considered to be limiting factors for salmon and steelhead production?
- What watershed and habitat improvement activities would most likely lead toward more desirable conditions in a timely, cost effective manner?

To help answer these questions, the basin assessment has been designed to meet these strategic program goals:

- Organize and provide existing information and develop limited baseline data to help evaluate the effectiveness of various resource protection programs over time;
- Provide assessment information to help focus watershed improvement programs, and assist landowners, local watershed groups, and individuals to develop successful projects. This will help guide support programs, like CDFGs Fishery Restoration Grants Program, toward those watersheds and project types that can efficiently and effectively improve freshwater habitat and lead to improved salmonid populations;
- Provide assessment information to help focus cooperative interagency, nonprofit, and private sector approaches to protect the best watersheds and streams through watershed stewardship, conservation easements, and other incentive programs;
- Provide assessment information to help landowners and agencies better implement laws that require specific assessments such as the State Forest Practice Act, Clean Water Act, and State Lake and Streambed Alteration Agreements.

The NCWAP program was established by the California Resources Agency and the California Environmental Protection Agency, and developed by the Departments of Fish and Game (CDFG), Forestry and Fire Protection (CDF), Conservation/California Geologic Survey (DOC/CGS), and Water Resources (DWR), in conjunction with the North Coast Regional Water Quality Control Board (NCRWQCB) and State Water Resources Control Board. The Institute for Fisheries Resources (IFR) is also a partner and participant in this program.

Salmonids, Habitat, & Land Use Relationships

There are several factors necessary for the successful completion of an anadromous salmonid's life history. In the freshwater phase of the life history, stream connectivity, stream condition, and riparian function are essential for survival. Stream connectivity describes the absence of barriers to the free instream movement of adult and juvenile salmonids. Stream condition includes several factors: adequate stream flow, suitable water quality, appropriate stream temperature, and complex, diverse habitat.

Adequate instream flow during low flow periods is essential for good summer time stream connectivity, and is necessary to provide juvenile salmonids free forage range, cover from predation, and utilization of localized temperature refugia from seeps, springs, and cool tributaries. Three important aspects of water quality for anadromous salmonids are water temperature, turbidity, and sediment load. Habitat diversity for salmonids is created by a combination of deep pools, riffles, and flatwater habitat types.

Geology, climate, watershed hydrologic responses, and erosion events interact to shape freshwater salmonid habitats of the Mattole Basin. "In the absence of major disturbance, these processes produce small but virtually continuous changes in variability and diversity against which the manager must judge the modifications produced by nature and human activity. Major disruption of these interactions can drastically alter habitat conditions" (Swanston, 1991). Major watershed disruptions can be caused by catastrophic events, such as the 1955 and 1964 floods or major earthquakes. They can also be created over time by multiple small natural and/or human disturbances.

A functional riparian zone helps to control the amount of sunlight reaching the stream, and provides vegetative litter and invertebrate fall. These contribute to the production of food for the aquatic community, including salmonids. Tree roots and other vegetative cover provide stream bank cohesion and buffer impacts from adjacent uplands. Near stream vegetation eventually provides large woody debris and complexity to the stream (Flosi et al. 1998).

A main component of the NCWAP is the analysis of these stream and watershed factors to identify whether any of them are at a level that limits production of anadromous salmonids in North Coast watersheds. A limiting factor can be anything that constrains, impedes, or limits the growth and survival of a population. This limiting factors analysis (LFA) provides a means to evaluate the status of key environmental factors that affect anadromous salmonid life history. This information will be useful to identify the underlying causes of stream habitat deficiencies and help reveal if there is a linkage to watershed processes and land use activities.

Mattole Basin

The Mattole Basin encompasses approximately 296 square miles of Northern California's Coast Range (Figure 1). Although nearly three percent of the Mattole's headwaters are in Mendocino County; the vast majority of the basin is within Humboldt County. The mainstem Mattole River is approximately 62 miles long, and receives water from over 74 tributary streams. There are approximately 545 perennial stream miles in the basin. The basin drains into the Pacific Ocean just south of Cape Mendocino. Elevation within the basin ranges from sea level at the estuary to 4,088 feet at Kings Peak.

The word Mattole meant "clear waters" in the language of the Athabaskan-speaking Mattole and Sinkyone Native Americans. Little is known about these Native Americans, for they were quickly displaced by settlers from the Eastern United States, who arrived in the early 1850s. 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.

The Mattole Basin has a Mediterranean climate characterized by cool wet winters with high runoff, and dry warm summers with greatly reduced flows. The basin receives one of the highest amounts of annual rainfall in California, averaging 81 inches. Along the coast, average air temperatures range from 46°F to 56°F. Further inland, annual air temperatures are much more varied, ranging from below freezing in winter to over 100° F in summer.

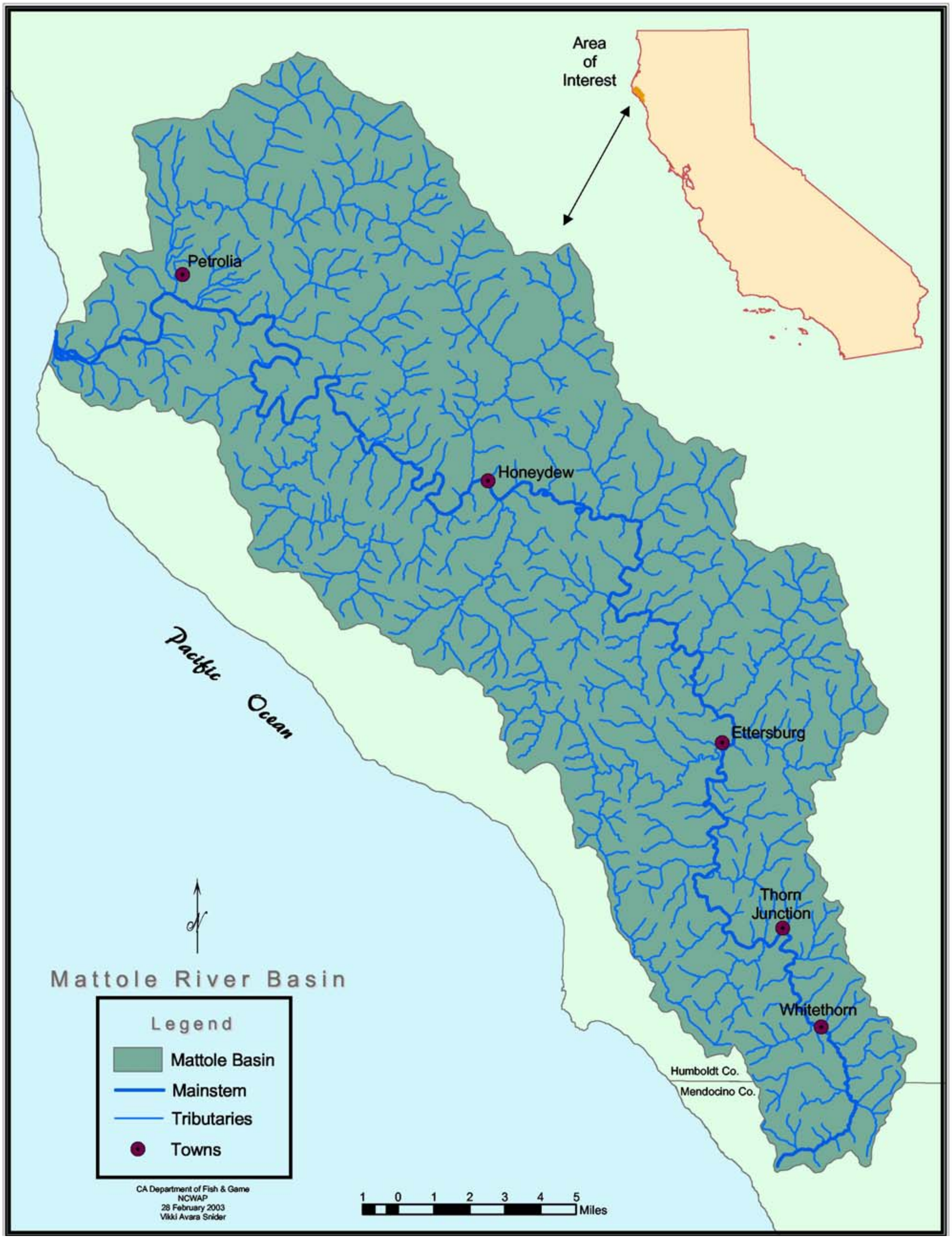


Figure 1. Mattole Basin streams and towns.

The Mattole Basin is located in a complex tectonic setting near the junction of three crustal plates. This region experiences a high level of seismic activity, and major earthquakes have occurred in intraplate areas as well as along well defined faults (Dengler et al. 1992). Bedrock underlying much of the basin has been tectonically broken and sheared making it relatively weak, easily weathered, and inherently susceptible to landsliding and erosion. Certain identifiable portions of the bedrock are more susceptible than others. The unstable bedrock and soil conditions combined with heavy rainfall, high regional uplift rates, and very active seismicity produce widespread naturally-occurring landsliding with associated large volumes of sediment input to streams.

The current vegetation in the Mattole Basin is predominately forestland, although some localized areas are covered primarily by grasslands. Mixed conifer and hardwood forestland occupy 57% of the basin while hardwood forests occupy 17% and coniferous forests occupy another 8%. Annual grasslands occupy 15% of the basin. All other vegetation types occupy the remaining three percent of the basin. The Mattole Basin is unusual within the Northern California coast as having very little redwood forest present; this is thought to be primarily due to the King Range blocking the summer fog needed to stimulate the growth of redwoods.

The total Mattole Basin resident population for the year 2000 census was estimated to be about 1,200 people. Eighty-four percent of the basin is held and managed as private property. In 1941 air photos, the most widespread land use of the basin appears to have been grazing. Timber harvest operations began in earnest during the post World War II boom. By the late 1970s, timber harvesting had decreased to very low levels of production. Meanwhile, environmental awareness had increased among many residents of the Mattole Basin and the North Coast in general. Changes in policy concerning management of federal lands and the designation of the Northern Spotted Owl as federally threatened led to the designation of Bureau of Land Management (BLM) lands within the Mattole Basin as Late Succession Reserve lands that are not subject to timber harvest (BLM, Bear Creek Report 1995). The BLM ownership comprises 15% of the Mattole Basin so their management is very significant to the basin's resources.

Fishery resources of the Mattole Basin include fall-run Chinook salmon, coho salmon, summer-run steelhead trout, and winter-run steelhead trout. The salmon and steelhead trout have been traditionally important as food and recreation resources to local residents and visitors. Though anecdotal evidence provides a convincing case that historic anadromous salmonid runs in the Mattole Basin were large and there has been a sharp decline in the size of these runs since the mid 1950s, little quantitative historic data exist (BLM, 1996).

An estimate of Chinook salmon, coho salmon, and steelhead trout populations in the Mattole Basin was made by the United States Fish and Wildlife Service (USFWS) in 1960. Their estimates were based upon spawner surveys and interviews with sportsmen and local residents. From these two sources, Mattole Basin population estimates of 2,000 Chinook salmon, 5,000 coho salmon and 12,000 steelhead trout were made. Additionally, potential population estimates were projected based on the capacity of surveyed spawning reaches with suitable gravel. Potential populations of 7,900 pairs of Chinook salmon, 10,000 pairs of coho salmon and 10,000 pairs of steelhead trout were estimated.

Recent accounts from Mattole Basin anglers who fished in the 1945 – 1970 time period describe a fabled sport fishery where in good stream conditions a group of four or five anglers could expect to hook and release over a hundred fish, mostly steelhead, in a day of fishing (J. Clary, personal communication). Also, salmon poaching beneath the Petrolia Bridge, and elsewhere, provided a viable means of making a little Christmas money by selling fresh and smoked salmon as late as the 1960s (C. Wright, personal communication).

In 1965, the year following the second major flood event in ten years, the Department of Water Resources (DWR) speculated that there had been a significant reduction in the size of Mattole Basin anadromous fish runs. They felt this was a result of large increases in siltation and debris jams following land disturbance from intensive logging that started in 1950, coupled with the two major flood events. The fisheries began steady declines in the 1960s.

By the late 1970s, fish populations had collapsed to levels that alerted locals to their depressed condition. Local watershed groups, the BLM, various state agencies such as CDFG, and local landowners have worked on numerous restoration projects throughout the Mattole Basin. The Mattole Restoration Council (MRC) and the Mattole Salmon Group (MSG) have obtained contracts for work on such diverse areas of restoration as stream surveys, road assessment, re-vegetation, instream habitat improvement, fish rearing, public education, and monitoring.

Mattole Basin General Issues

Public scoping meetings, workshops with Mattole Basin residents and constituents, and initial analyses of available data by watershed experts developed this working list of general issues and/or concerns:

- Sediment, temperature, pool habitat, escape and ambush cover, and substrate embeddedness in the estuary are thought to be outside of supportive levels for salmonids in the estuary;
- Predation upon depressed fish populations by birds and mammals in the estuary;
- Excessive extraction of water during low flow periods;
- Artificial fish passage barriers exist at some road crossings of streams;
- Abandoned roads, new road construction, and road maintenance issues related to landsliding and sediment input to streams;
- High water temperatures;
- Pollutant spills, such as some recent bulk diesel spills into tributaries;
- Herbicides used on industrial timberlands;
- Location and conduct of timber harvest operations;
- Sub-division development and construction;
- Low stream habitat diversity and complexity;
- Low stream shade canopy cover;
- Large woody debris recruitment to streams;
- Absence of salmonid information, low fish densities, or absences of fish;
- Access for agency personnel to private land for field studies.

General Assessment Approach

Each of the NCWAP's participating departments developed data collection and analysis methods used in their basin assessments. They also developed a number of tools for interdisciplinary synthesis of collected information. These included models, maps, and matrices for integrating information on basin, subbasin, and stream reach scales to explore linkages among watershed processes, conditions, and use. These tools provided a framework for identifying watershed refugia areas and factors limiting salmonid productivity, as well as providing a basis for understanding the potential for cumulative impacts from natural and man caused impacts. This information provided guidance for developing restoration, management, and conservation recommendations.

The roles of the five participating agencies in these efforts included:

- CDFG compiled, developed, and analyzed data related to anadromous fisheries habitat and populations. It also led an interagency evaluation of factors affecting anadromous fisheries production at the stream, subbasin and basin levels, identified areas of refugia, and provided recommendations for restoration and monitoring;
- CDF compiled, developed, and analyzed data related to historical land use changes in the watersheds. It also led preparation of reports that synthesize information, findings, and recommendations, and developed a framework for assessing cumulative impacts;
- DOC/CGS compiled, developed, and analyzed data related to the production and transport of sediment. Tasks included baseline mapping of landslides, landslide potential, and instream sediment, as well as an analysis of stream geomorphology and sediment transport;
- NCRWQCB compiled, collected, and analyzed water quality data for the assessment. The assessment included comparison of recently collected and past available information comprised predominately of a robust water temperature data set, and some limited sediment data;

- DWR installed and maintained stream monitoring gages where needed to develop and analyze stream flow information.

Results of assessments conducted by various agency personnel on the Mattole team were brought together in an integrated synthesis process. This process attempts to describe spatial and temporal relationships between watershed and stream conditions and dynamic watershed processes that have been at work to form them. To assist in this process, the team used Geographic Information System (GIS) based watershed data coverage and an Ecological Management Decision Support (EMDS) model to help evaluate watershed conditions and processes.

The EMDS system software (Reynolds 1999) helps evaluate and synthesize information on watershed and stream conditions important to salmonids. The team has constructed "knowledge base" models to identify and evaluate environmental factors that shape anadromous salmonid habitat. Based upon these models, the system performs calculations with available data it is provided. The synthesized results help provide insights about stream and watershed conditions, and their linked relationships.

EMDS offers a number of benefits for the assessment work that the NCWAP is conducting, and also has some known limitations. An April 2002 peer review of the EMDS system recommended some substantial changes to the system to improve its function and utility. Consequently, at the time of this report, we have been able to implement some, but not all of the system's potential outputs.

Scale of Information

The NCWAP Mattole assessment team subdivided the Mattole Basin into five subbasins for assessment and analyses purposes. These study areas included the Estuary, Northern, Eastern, Southern, and Western Subbasins (Figure 2). In general, each subbasin has somewhat unique attributes that are generally common to the several CalWater 2.2a Planning Watersheds (PWs) contained within a subbasin. These PWs are approximately 3,000-10,000 acres and are used as planning and evaluation units for projects such as Timber Harvest Plans (THP) submitted to CDF. Common PW attributes pertain to a subbasin's landslide propensity, vegetation, climate, land use, streams, fisheries, towns and communities, access corridors, etc.

Subbasins and their planning watersheds are used as the basis of NCWAP's GIS analysis upon which various coverages are overlain. They are also used as the basis of the Ecological Management Decision Support system GIS images and analyses.

Assessment Products

This report and its appendices are intended to be useful to landowners, watershed groups, agencies, and individuals to help guide restoration, land use, and management decisions.

NCWAP products include:

- A basin level Geologic Report that includes:
  - Maps of landslides and geomorphic features related to landsliding;
  - Relative landslide potential maps;
  - A map of features indicative of excess sediment production, transport and/or deposition;
  - Maps of stream reaches classified by gradient and relative landslide potential.
- A basin level Synthesis Report that includes:
  - Collection of Mattole Basin historical and sociological information;
  - Description of historic and current vegetation cover and change, land use, geology and fluvial geomorphology, water quality, stream flow, water use, and instream habitat conditions;
  - Hypotheses and evaluation about watershed conditions affecting salmonids;
  - An interdisciplinary analysis of the suitability of stream reaches and the watershed for salmonid production and refugia areas;
  - Tributary and watershed recommendations for management, refugia protection, and restoration activities to address limiting factors and improve conditions for salmonid productivity;

- o Monitoring recommendations to improve the adaptive management efforts.
- Ecological Management Decision Support system (EMDS) models to help analyze data;
- Databases of information used and collected;
- A data catalogue and bibliography;
- Web based access to the Program's products: http://ncwatershed.ca.gov/, and http://imaps.dfg.ca.gov/.
- A Compact Disk (CD) developed through the Institute for Fisheries Resources (IFR) which uses the Klamath Resources Information System (KRIS).

Figure 2. NCWAP Mattole subbasins and CalWater 2.2a Planning Watersheds.

General Assessment Questions, Conclusions, and Recommendations

The NCWAP Mattole assessment team has utilized the six NCWAP assessment questions (pg. 1) to organize its assessment conclusions and recommendations. The following discussion of the assessment questions and recommendations for improvement activities specific to subbasins, streams, stream reaches, and in some cases potential project sites, are also included in each subbasin section of this report. The CDFG Appendix F to this report contains more specific assessment methods, findings, conclusions, and recommendations for stream and watershed improvements.

Mattole Basin

What are the history and trends of the sizes, distribution, and relative health and diversity of salmonid populations in the Mattole Basin?

Conclusions:

- Historical accounts and stream surveys conducted in the 1960s by CDFG indicate that the Mattole Basin historically supported relatively robust populations of Chinook salmon, coho salmon, and steelhead trout. Fishery surveys have been conducted on many tributaries throughout the Mattole Basin in the last ten years. These biological stream surveys indicate the presence of Chinook salmon and steelhead trout in all five Mattole subbasins and the presence of coho salmon in the Eastern, Southern, and Western Subbasins. Coho salmon also utilize the Estuary Subbasin on their migrations; however, in limited surveys conducted in the Northern Subbasin since the 1980s, coho salmon have not been detected. No studies have been conducted to estimate subbasin or tributary specific population levels of coho salmon or Chinook salmon. However, a nine-year intensive study of three tributaries within the Northern Subbasin indicated stable age classes of steelhead trout. Intensive studies of the Estuary Subbasin have shown depressed populations of over-summering Chinook salmon and steelhead trout, and no coho have been detected. Mattole Basin-wide population estimates indicate depressed meta-populations of Chinook and coho salmon. A metapopulation is a "regional (Mattole Basin) population consisting of semi-isolated local (stream/subbasin) populations" (Levins 1970).

What are the current salmonid habitat conditions in the Mattole Basin? How do these conditions compare to desired conditions?

Conclusions:

- Erosion/Sediment
  - Instream sedimentation in several stream reaches throughout the basin may be approaching or exceeding levels considered unsuitable for salmonid populations. Currently, the estuary is very shallow and lacks channel complexity. Erosion/sediment reduction is the top recommendation category for the Eastern and Estuary subbasins;
- Riparian/Water Temperature
  - High summer water temperatures in many surveyed tributaries are deleterious to summer rearing salmonid populations in the Estuary, Northern, Eastern, and Western Subbasins. Riparian/water temperature improvements is the top recommendation category in the Northern Subbasin;
- Instream Habitat
  - In general, pool habitat, escape and ambush cover, and water depth are unsuitable for salmonids in many mainstem and tributary stream reaches in the Mattole Basin. In the Southern Subbasin summer flow is inadequate or non-existent in many reaches. Large woody debris recruitment potential is poor in the Northern, Eastern, and Western subbasins. Instream habitat improvement is the top recommendation category in the Southern and Western subbasins;
- Gravel/Substrate
  - Available data from sampled streams suggest that suitable, high quality spawning gravel for salmonids is limited in some streams in all subbasins;

- Refugia Areas

Salmonid habitat conditions in the Mattole Basin are generally best in the Southern and Western Subbasins, mixed in the Eastern Subbasin, and worst in the Estuary and Northern subbasins.

  - Table 1 summarizes subbasin salmonid refugia conditions:

Table 1. Subbasin salmonid refugia area ratings in the Mattole Basin.

Subbasin	Refugia Categories:				Other Categories:		
	High Quality	**High Potential**	**Medium Potential**	**Low Quality**	**Non-Anadromous**	**Critical Contributing Area/Function**	**Data Limited**
Estuary Subbasin			X			X	X
Northern Subbasin			X				X
Eastern Subbasin			X				X
Southern Subbasin		X					X
Western Subbasin			X				X

Ratings in this table are done on a sliding scale from best to worst. Subbasin refugia ratings are aggregated from their tributary ratings. See page 70 for a discussion of refugia criteria.

What are the relationships of geologic, vegetative, and fluvial processes to natural events and land use history?

<u>Conclusions:</u>

- Geologic units within the basin can be grouped into one of three bedrock terrains (hard, moderate, and soft) and one for Quaternary alluvial units. Larger landslides are more prevalent in soft terrain and are typically earthflows, while smaller slides, typically debris slides, are more prevalent in hard and moderate terrains;
- Weak geologic materials, steep slopes, high rainfall, and strong earthquakes common to the basin result in high rates of natural landsliding and surface erosion, particularly in soft terrain. These natural processes can be exacerbated by human land use within the basin. About one half of the basin is considered to have a high to very high landslide potential;
- In general, the subbasins can be ranked in terms of relative impacts with geologically unstable areas linked to adverse stream effects. The Northern Subbasin has the largest proportion of geologically unstable (soft) terrain, which is linked to the highest amount of historically active landslides, gullies, and stream features indicative of excess sediment production, transport, and storage. The Southern Subbasin has the lowest proportion of geologically unstable terrain, historically active landslides, gullies, and stream features indicative of excess sediment production and transport. The Eastern and Western Subbasins are intermediate between these two extremes due to the variability in the proportion of soft terrain and steep slopes;
- Source and transport reaches of the blue line streams as depicted on NCWAP stream network maps, were identified primarily in bedrock terrains, while response (depositional) reaches were identified in the Quaternary (alluvial) unit reaches. Features indicative of excess sediment production, transport, and storage have decreased throughout most of the basin in the period between 1984 and 2000. The reduction in these features was greatest in the hard terrain. The distribution of these features in bedrock terrains suggests that portions of the areas interpreted as having a high to very high landslide potential are also the sources of sediment that has been delivered to streams;

- Human activities such as timberland conversion to grasslands and brush, grazing, timber harvest, and road construction and use, have interacted with natural geologic instability to increase sediment production above naturally high background levels. Historic timber harvesting and streamside road construction reduced riparian canopy and increased direct sediment inputs and water temperature. Overall, the current landscape is comprised of smaller diameter forest stands than in pre-European times. Decades of fire suppression have created dense forest stands and brush-lands leading to the designation of Mattole Basin population centers as high wildfire threat areas.

How has land use affected these natural processes?

Conclusions:

- Land use, including road construction and use, timber harvesting, and grazing, have added excess sediment to the fluvial system. Many of the effects from these activities are spatially and temporally removed from their upland sources. Excess sediment remains in the Mattole mainstem despite decades of low timber harvesting activity;
- Currently, roads are a major land use contributor of sediment (CDF, 2002). Large storms or other catastrophic events combined with poor road location and construction practices have the potential to deliver large and adverse amounts of sediment into stream systems;
- Water extraction for agriculture, road maintenance, and residential use has the direct effect of reducing the amount of available habitat for fish;
- Large woody debris recruitment potential is limited by the low percentage of near-stream forest stands containing trees in large diameter classes;
- Grazing is widespread on privately owned grasslands and has shifted to cattle from sheep since the enactment of predation protection measures. Stock impacts to streams are not widespread, but watercourse exclusionary fencing is limited.

Based upon these conditions trends, and relationships, are there elements that could be considered to be limiting factors for salmon and steelhead production?

Conclusions:

Based on available information for the Mattole Basin, the NCWAP team believes that salmonid populations are currently being limited by:

- Impacted estuarine conditions;
- General basin-wide lack of habitat complexity;
- High instream sediment levels;
- High summer water temperatures;
- Reduced basin-wide coho and Chinook meta-populations.

What habitat improvement activities would most likely lead toward more desirable conditions in a timely, cost effective manner?

Recommendations:

Flow and Water Quality Improvement Activities:

- Discourage unnecessary and wasteful use of water during summer low flow periods to improve stream surface flows and fish habitat, especially in the Southern Subbasin;
- Increase the use of water storage and catchments systems that collect rainwater in the winter for use in the drier summer season;
- Support local efforts to educate landowners about water storage and catchments systems, and find ways to support and subsidize development of these systems;

- Support and expand ongoing local efforts that monitor summer water and air temperatures on a continuous 24-hour basis to detect long-range trends and short-term effects on the aquatic/riparian community;
- Support efforts to determine the role of sediment in the mainstem Mattole River in elevated estuarine water temperatures.

Erosion and Sediment Delivery Reduction Activities:

- Reduce sediment deposition to the estuary by supporting a basin-wide road and erosion assessment/control program such as the Mattole Restoration Council's *Good Roads, Clear Creeks* effort. Continue to conduct and implement road and erosion assessments such as the ongoing efforts in the Dry and Westlund planning watersheds in the Eastern Subbasin. Expand road assessment efforts because of the potential for further sediment delivery from active and abandoned roads, many of which are in close proximity to stream channels, especially in the Bridge and Thompson planning watersheds in the Southern Subbasin;
- Establish monitoring stations and train local personnel to track in-channel sediment and aggraded reaches throughout the basin and especially in the North Fork Mattole and the Upper North Fork Mattole rivers, Mattole Canyon, Blue Slide, Squaw, Honeydew, and Bear creeks;
- Consider the nature and extent of naturally occurring unstable geologic terrain, landslides and landslide potential (especially Categories 4 and 5, page 89) when planning potential projects in the subbasin;
- At stream bank erosion sites, encourage cooperative efforts to reduce sediment yield to streams. CGS mapping indicates eroding banks are not a significant basin wide issue, but may be of localized importance. They occur in isolated, relatively short reaches distributed throughout the Mattole Basin;
- Based on the high incidence of unstable slopes in the Northern Subbasin, any future sub-division development proposals should be based on an existing county-imposed forty acre minimum parcel sub-division ordinances;
- Encourage the use of appropriate Best Management Practices for all land use and development activities to minimize erosion and sediment delivery to streams. For example, low impact yarding systems should be used in timber harvest operations on steep and unstable slopes to reduce soil compaction, surface disturbance, and resultant sediment yield.

Riparian and Habitat Improvement Activities:

- Where current canopy is inadequate and site conditions, including geology, are appropriate, initiate tree planting and other vegetation management to hasten the development of denser and more extensive riparian canopy, especially in the Northern Subbasin;
- Landowners and managers in the Northern and Western subbasins should work to add more large organic debris and shelter structures to streams in order to improve channel structure, channel function, habitat complexity, and habitat diversity for salmonids;
- Ensure that stream reaches with high quality habitat in the Mattole Basin are protected from degradation. This is especially important in the Southern Subbasin. The best stream conditions as evaluated by the stream reach EMDS were found in the South Fork of Vanauken Creek, Mill Creek - at Mattole river-mile 56.2 (RM 56.2), Stanley Creek, Thompson Creek, Yew Creek, and Lost Man Creek Tributary in the Southern Subbasin, and in Harrow Creek in the Eastern Subbasin. Refugia investigation criteria, which include biological parameters, indicated Bear Creek was the best stream evaluated in the Mattole Basin.

Supplemental Fish Rescue and Rearing Activities:

- Since 1982 a successful cooperative salmonid rearing facility in the Mattole Basin headwaters has been operated by the Mattole Salmon Group (MSG) and CDFG. They also operate a Chinook juvenile out-migrant rescue rearing program near the estuary, which released 2,400 coded-wire-tagged Chinook sub-yearlings in October 2002. These programs should be continued as needed to supplement wild populations while the improvements from long-term watershed and stream restoration efforts develop;

- Initiate a systematic program to monitor the effectiveness of fish rescue and rearing activities, and determine the need for the continuance of cooperative, supplemental fish rearing efforts;
- Update as scheduled the MSG/CDFG five-year plan that provides guidance to the cooperative rearing and rescue projects. Base the periodic plan updates on the findings of the effectiveness monitoring program and best available science.

Education, Research, and Monitoring Activities:

- Utilize Humboldt State University studies conducted in the early 1990s as baseline information to periodically monitor trends in estuarine conditions and fish production;
- Encourage ongoing stream inventories and fishery surveys of tributaries throughout the Mattole Basin, especially in the Northern Subbasin;
- In order to protect privacy while developing data, the possibility of training local landowners to survey their own streams and to conduct salmonid population status surveys throughout the basin would be advisable;
- Further study to investigate the affects to water quality from timberland herbicide use is recommended;
- Follow the procedures and guidelines outlined by NCRWQCB to protect water quality from ground applications of pesticides;
- Encourage appropriate chemical transportation and storage practices as well as early spill reporting and clean-up procedures;
- Conduct training as needed and desired to assist landowners, managers, consultants, and other interested parties in the construction and appropriate application of landslide occurrence and potential maps from GIS analysis.

Estuary Subbasin

Estuaries normally provide an important transition environment between marine and freshwater environments. They generally provide an abundant and rich food supply and relative isolation from several marine and freshwater predators. Sediment deposition is naturally high in estuaries due to their position at the mouth of rivers and typical low gradient and often restricted outlets. Therefore, excessive erosion rates in a watershed produce negative effects in its estuary.

Key Findings:

- Historical accounts indicate that the Estuary Subbasin supported populations of Chinook salmon, and steelhead trout throughout the summer months, in addition to being a vital transitional step on the seaward migration of juvenile salmonids and the returning spawning migration of adult salmonids. Biological studies were conducted in the estuary in the late 1980s and early 1990s by HSU researchers and the Mattole Restoration Council along with current population counts by the Mattole Salmon Group. These studies indicate that over-summering Chinook salmon and steelhead trout populations in the Estuary Subbasin are currently depressed;
- Instream sediment from both past land use and natural geologic processes upstream has been delivered to the estuary by large storm events, impacting the low gradient estuarine channel. Comparison of 1942 and 1965 photos indicates that the estuary widened, and areas of vegetation were lost during that time frame. However, the 1984 and 2000 aerial photos show some channel narrowing and vegetative improvement during this time period. Whereas dormant landslides, steep terrain and areas with high to very high landslide potential indicate that slopes in the subbasin are susceptible to landsliding and erosion, the bulk of excess instream sediment appears to have been transported from upstream sources;
- Soil disturbance associated with several agricultural and development activities have exacerbated the naturally high levels of sediment delivery to the Mattole River and its tributaries. In particular, vegetation removal and road construction during the post 1950 peak timber harvest period, coupled

with the transport energy of the devastating floods of 1955 and 1964 have created extensive negative stream characteristics in the lower reaches of many large tributaries including mainstem Honeydew Creek. These negative impacts include displaced riparian vegetation; wide, aggraded channels; and very warm summertime water temperatures. These impacts have become resident in the Estuary Subbasin;

- The present state of estuarine habitat is limiting the successful production of salmonids, especially Chinook salmon. Based on known salmonid temperature suitability studies, current sediment, and temperature impacts in the estuary are thought to be deleterious to summer rearing salmonid populations. Results of habitat assessment conducted from 1988 through 1994 in the estuary by Humboldt State University, Mattole Restoration Council, and Mattole Salmon Group researchers identified a critical shortage of adequate pool habitat, water depth, substrate embeddedness, and escape and ambush cover. These are all necessary for survival of salmonids in the critical over-summering life stage;
- Although lack of escape cover for fish increases the risk of predation by birds, mammals, etc., data from other river systems indicate that seal and sea lion predation is usually not limiting to salmonids. These data indicate pinnipeds are not likely to have a large impact on Mattole Basin salmonid runs.

Key Recommendations:

- Continue to support the Mattole Salmon Group's Chinook juvenile rescue rearing and fish-tagging efforts, and incorporate a program to monitor effectiveness;
- Reduce sediment deposition to the estuary by supporting a basin-wide road and erosion assessment/control program such as the Mattole Restoration Council's Good Roads, Clear Creeks effort;
- Avoid potential sedimentation directly into the estuary from the estuary's upland slopes, which are predominantly mélange bedrock and dormant landslides. Encourage the use of appropriate Best Management Practices to achieve this objective;
- Consider the nature and extent of naturally occurring unstable geologic terrain, landslides and landslide potential (especially Categories 4 and 5, page 89) when planning potential projects in the subbasin;
- Maintain and enhance existing riparian cover. Use cost share programs and conservation easements as appropriate;
- Support ongoing local efforts that monitor summer water and air temperatures on a continuous 24-hour basis to detect long-range trends and short-term effects on the aquatic/riparian community;
- Support efforts to determine the role of the mainstem Mattole River in elevated estuarine water temperatures;
- Utilize Humboldt State University studies conducted in the early 1990s as baseline information to periodically monitor trends in estuarine conditions and fish production;
- Protect instream flows in Mill Creek (RM 2.8) and Stansberry Creek for thermal refugia;
- It would be informative to further study the degree to which the cool, summer base flow from Mill Creek (RM 2.8) could temper the warmer mainstem Mattole River waters and provide an area of cool water refugia. To do so, a summer low flow connection between Mill Creek and the river would have to be established through the Mattole's gravel floodplain.

Northern Subbasin

The Northern Subbasin is located between the estuary and Honeydew Creek at river mile 26.5 (RM 26.5) along the northeastern side of the Mattole mainstem. Almost 99% of the subbasin is privately owned and it is largely managed for timber production and cattle ranching. The town of Petrolia is located in this subbasin near the confluence of the North Fork Mattole and Mattole rivers. The Northern Subbasin supports populations of Chinook salmon and steelhead trout.

Key Findings:

- Historical accounts and stream surveys conducted in the 1960s by CDFG indicate that the Northern Subbasin supported populations of Chinook salmon, coho salmon, and steelhead trout. Fishery surveys have been conducted on very few tributaries in the Northern Subbasin in the last ten years. Therefore, current fish population information is poor. However, existing recent biological stream surveys indicate the presence of healthy steelhead trout populations but an absence of coho salmon. Mattole Basin-wide data indicate a depressed population of Chinook salmon, which likely indicates a depressed number of Chinook salmon spawners in the Northern Subbasin;
- Erosion/Sediment
  - Instream sedimentation in several stream reaches in this subbasin may be approaching or exceeding levels considered unsuitable for salmonid populations. Macroinvertebrate data indicate fair to good or good conditions. However, amphibians sensitive to fine sediment were absent from most stream reaches surveyed in this subbasin;
- Riparian/Water Temperature
  - High summer water temperatures in surveyed streams are deleterious to summer rearing salmonid populations in this subbasin;
- Instream Habitat
  - In general, Northern Subbasin pool habitat, escape and ambush cover, water depth, and substrate embeddedness are unsuitable for salmonids. Large woody debris recruitment potential is very poor overall;
- Gravel Substrate
  - Available data from sampled streams suggest that suitable amounts and distribution of high quality spawning gravel for salmonids is lacking in this subbasin;
- There is a lack of stream survey and water chemistry information for much of the Northern Subbasin;
- This subbasin has the most structurally disrupted and least stable geology in the basin, with approximately 43% of the area underlain by soft terrain. Correspondingly, more than half of the total area occupied by historically-active landslides and gully lengths mapped in the basin are located in the Northern Subbasin. Due to the prevalence of soft terrain with its associated high level of active landslides and gully erosion, it appears that comparatively high rates of natural sedimentation are to be expected in this subbasin;
- Stream channels in this subbasin have the greatest total length of features indicative of excess sediment production, transport and storage within the basin, with the smallest reduction in these features observed between 1984 and 2000;
- Grasslands are extensive in the Northern Subbasin, occupying 31% of the area. Grasslands are commonly associated with soft terrain. As a result of past timber harvest and conversion activities, 40% of the Northern Subbasin is occupied by small diameter (twelve to twenty-four inches diameter at breast height) forest stands. Only 7% is in forest stands greater than twenty-four inches. The most significant vegetation change in recent years was the result of two 1990 wildfires burning 10% of the subbasin, primarily in the Oil Creek and Camp Mattole planning watersheds;
- Over 99% of this subbasin is privately owned and is managed for timber production and grazing. Current timber harvesting is concentrated on industrial timberland subject to both the California Forest Practice Rules and a Habitat Conservation Plan. Existing road location and densities primarily reflects construction related to timber harvest access since the 1940s;
- Based on information available for the Northern Subbasin, the NCWAP team believes that salmonid populations are currently being limited by high water temperatures, high sediment levels, and reduced habitat complexity in the subbasin.

Key Recommendations:

- Encourage more stream inventories and fishery surveys of tributaries within this subbasin;
- In order to protect privacy while developing data, the possibility of training local landowners to survey their own streams and conduct salmonid population status surveys should be developed;
- Several years of monitoring summer water and air temperatures to detect trends using continuous, 24 hour monitoring thermographs should be done. Continue temperature monitoring efforts in the North Fork Mattole River, Sulphur Creek, and the Upper North Fork Mattole River, and expand efforts into other subbasin tributaries. Study the role of seeps and springs as cold water refugia in Oil and Rattlesnake creeks;
- Where current canopy is inadequate and site conditions, including geology, are appropriate, initiate tree planting and other vegetation management to hasten the development of denser and more extensive riparian canopy. Low canopy density measurements were found in Conklin, Oil, Green Ridge, Devils, and Rattlesnake creeks;
- Maintain and enhance existing riparian cover. Use cost share programs and conservation easements as appropriate;
- Landowners and managers in this subbasin should be encouraged to add more large organic debris and shelter structures in order to improve channel structure, channel function, habitat complexity, and habitat diversity for salmonids. Pool shelter has the lowest suitability for salmonids in Sulphur Creek Tributary #1, Conklin, and Green Ridge creeks;
- Establish monitoring stations and train local personnel to track in-channel sediment and aggraded reaches throughout the subbasin and especially in the lower reaches of the North Fork Mattole River and the Upper North Fork Mattole River;
- Consider the nature and extent of naturally occurring unstable geologic terrain, landslides and landslide potential (especially Categories 4 and 5, page 89) when planning potential projects in the subbasin;
- Encourage the use of appropriate Best Management Practices for all land use and development activities to minimize erosion and sediment delivery to streams. For example, low impact yarding systems should be used in timber harvest operations on steep and unstable slopes to reduce soil compaction, surface disturbance, and resultant sediment yield;
- Based on the high incidence of unstable slopes in this subbasin, any future sub-division development proposals should be based on existing county-imposed forty acre minimum parcel sub-division ordinances;
- At stream bank erosion sites, encourage cooperative efforts to reduce sediment yield to streams. CDFG stream surveys indicated Sulphur Creek, Sulphur Creek Tributaries 1 and 2, Conklin Creek, Oil Creek, and the lower reaches of the North Fork Mattole River have bank stabilization activities as a top tier tributary improvement recommendation. Rattlesnake, McGinnis, Green Ridge, and Devils creeks also have eroding banks mapped by CGS. These could be of localized importance to reduce stream fine sediment levels;
- Continue efforts such as road erosion proofing, improvements, and decommissioning throughout the basin to reduce sediment delivery to the Mattole River and its tributaries. CDFG stream surveys indicated Sulphur Creek and Sulphur Creek Tributary #1 have road sediment inventory and control as a top tier tributary improvement recommendation.

Eastern Subbasin

The Eastern Subbasin is located between Honeydew Creek (RM 26.5) and Bridge Creek (RM 52.1) along the eastern side of Wilder Ridge, and the Mattole mainstem above Bear Creek, for a distance of about 25.6 miles. Over 94% of the subbasin is privately owned and it is largely managed for timber production and cattle ranching. The Eastern Subbasin supports populations of Chinook salmon, coho salmon, and steelhead trout.

Key Findings:

- No studies have examined the size or health of salmonid populations in the Eastern Subbasin. However, historical accounts and stream surveys conducted in the 1960s by CDFG indicate that the Eastern Subbasin supported populations of Chinook salmon, coho salmon, and steelhead trout. Recent biological stream surveys indicate the presence of steelhead trout throughout the Eastern Subbasin and coho salmon in a few tributaries. Low salmonid populations throughout the Mattole Basin indicate that salmonid populations in the Eastern Subbasin are likely to be depressed at this time;
- Erosion/Sediment
  - o Instream sedimentation in several stream reaches in this subbasin may be approaching or exceeding levels considered unsuitable for salmonid populations. Macroinvertebrates were not sampled in this subbasin. Amphibian sensitive to fine sediment were absent from all stream reaches surveyed in this subbasin;
- Riparian/Water Temperature
  - o Available data from sampled streams suggest that high summer temperatures are deleterious to summer rearing salmonid populations in the lower depositional reaches of most streams in this subbasin;
- Instream Habitat
  - o In general, a high incidence of shallow pools, a lack of cover, and a lack of large woody debris have contributed to a simplification of instream salmonid habitat.
- Gravel Substrate
  - o Available data from sampled streams suggest that suitable amounts and distribution of high quality spawning gravel for salmonids is lacking in this subbasin;
- Gilham, Harrow, Eubank, McKee, and Painter creeks are considered good refugia.
- In April 2000, a serious diesel spill occurred directly into a subbasin tributary. Petroleum spills represent a chemical threat to favorable stream conditions and should be eliminated using all means available;
- Geologic conditions in this subbasin are the most variable in the basin. Areas of relatively intact and stable geologic units are locally interrupted by areas of highly disrupted and unstable soft terrain. These are accompanied by active landslides, gully erosion and, in proximal stream channels, features indicative of excess sediment production, transport and storage in the streams;
- Although stream conditions in bedrock reaches suggest that in 1984 this subbasin had the second highest level of impact within the basin, these conditions have improved dramatically in the period between 1984 and 2000. Considering the low degree of impact by features indicative of excess sediment production, transport and storage observed in the adjacent upstream Southern Subbasin, it appears that the stream features observed in the Eastern Subbasin must be derived either internally within the subbasin or from the adjacent Western Subbasin;
- As a result of past timber harvest and conversion activities, 56% of the Eastern Subbasin is populated with small diameter forest stands (twelve to twenty-four inches diameter at breast height). Twenty-one percent is in forest stands greater than twenty-four inches. Grasslands occupy 11% of the area;
- Over 94% of this subbasin is privately owned. Much of it was sub-divided after extensive timber harvesting. Currently, there is a low level of timber harvest activity;
- Existing road densities and locations reflect construction for timber harvest access since the 1940s. Many of these roads are now used to access homes or parcels;
- Based on information available for the Eastern Subbasin, the NCWAP team believes that salmonid populations are currently being limited by high sediment levels, high water temperatures, reduced habitat complexity, and embedded spawning gravels in some tributaries of the Eastern Subbasin. Harrow Creek has very good salmonid habitat; Westlund, Gilham, Gilham Creek Tributary, Sholes,

Little Grindstone, Harrow, Eubank, McKee, McKee Creek Tributary, and Painter creeks have good canopy density; and Painter Creek has good cobble embeddedness.

Key Recommendations:

- Establish monitoring stations and train local personnel to track in-channel sediment and aggraded reaches throughout the subbasin and especially in Mattole Canyon and Blue Slide creeks;
- At stream bank erosion sites, encourage cooperative efforts to reduce sediment yield to streams. CDFG stream surveys indicate Middle, Westlund, Gilham, Gilham Creek Tributary, North Fork Fourmile, Sholes, Harrow, Little Grindstone, Grindstone, Eubank, and McKee creeks, and the Tributary to McKee Creek have bank stabilization activities as a top tier tributary improvement recommendation. These could be of localized importance to reduce stream fine sediment levels;
- Continue to conduct and implement road and erosion assessments such as the ongoing efforts in the Dry and Westlund planning watersheds. Initiate road improvements and erosion proofing throughout the subbasin to reduce sediment delivery. Middle, Westlund, Gilham, Gilham Creek Tributary, Sholes, Blue Slide, and Fire creeks had road sediment inventory and control as one of their top tier tributary improvement activity recommendations;
- Several years of monitoring summer water and air temperatures to detect trends using continuous, 24 hour monitoring thermographs should be done. Continue temperature monitoring efforts in Dry, Middle, Westlund, Sholes, Mattole Canyon, Blue Slide, Eubank, Gilham, and Grindstone creeks. Start temperature monitoring in Little Grindstone, Fire, and Box Canyon creeks;
- Where current canopy is inadequate and site conditions, including geology, are appropriate, use tree planting and other vegetation management techniques to hasten the development of denser and more extensive riparian canopy. Canopy density has the lowest suitability for salmonids in Dry and Blue Slide creeks;
- Landowners and managers in the this subbasin should work to add more large organic debris and shelter structures in order to improve channel structure, channel function, habitat complexity, and habitat diversity for salmonids. Pool shelter has the lowest suitability for salmonids in Dry, Middle, Westlund, Gilham Creek Tributary, Fourmile, North Fork Fourmile, Grindstone, Little Grindstone, Blue Slide, McKee Creek Tributary, and Painter creeks;
- Consider the nature and extent of naturally occurring unstable geologic terrain, landslides and landslide potential (especially Categories 4 and 5, page 89) when planning potential projects in the subbasin;
- Encourage the use of appropriate Best Management Practices for all land use and development to minimize erosion and sediment delivery to streams;
- Encourage appropriate chemical transportation and storage practices, early spill reporting, and clean-up procedures.
- Ensure that high quality habitat within this subbasin is protected from degradation. The highest stream reach conditions as evaluated by the stream reach EMDS and refugia analysis were found in the Gilham, Harrow, Eubank, McKee, and Painter Creeks.

Southern Subbasin

The Southern Subbasin is located south of Bridge Creek (RM 52.1) and McKee Creek (RM 52.8), both near Thorn Junction, and continues upstream to the Mattole's headwaters near Four Corners (RM 61.5), a distance along the mainstem Mattole of about 9.4 miles. The subbasin is 86% privately owned and is largely managed for timber production and rural subdivision. The Southern Subbasin supports populations of Chinook salmon, coho salmon, and steelhead trout. Except for dewatered channels and low flows in summer, this subbasin currently contains the best salmonid habitat in the Mattole Basin.

Key Findings:

- Dewatered stream channels are a serious problem during summer low flow periods in the mainstem Mattole River and select reaches of many tributaries;

- No systematic, scientific studies have examined the size or health of salmonid populations in the Southern Subbasin. However, historical accounts and stream surveys conducted in the 1960s by CDFG indicate that the Southern Subbasin supported populations of Chinook salmon, coho salmon, and steelhead trout. Recent biological stream surveys indicate the presence of steelhead trout and coho salmon throughout the Southern Subbasin. This subbasin supports coho salmon in more tributaries than the other Mattole subbasins. Low salmonid populations throughout the Mattole Basin indicate that salmonid populations in the Southern Subbasin are also likely to be depressed at this time.
- Erosion/Sediment
  - As indicated by the Potential Stream Sediment Production EMDS, potential fine sediment delivery to streams due to road runoff is high in the Southern Subbasin. Although there are few roads on unstable slopes, there are many roads positioned low on hill slopes and many road crossings of streams throughout the Bridge Creek and Thompson Creek Planning Watersheds. The types and variety of macroinvertebrates indicate fair to good, good, or good to excellent instream conditions. Additionally, amphibians sensitive to fine sediment were present in several stream reaches surveyed in this subbasin;
- Riparian/Water Temperature
  - Available data suggest that summer water temperatures support rearing juvenile salmonid populations in most reaches of most streams with summer flow in this subbasin;
- Instream Habitat
  - Based upon 26 miles of surveyed stream habitat in the past 10 years, the Southern Subbasin is considered to contain some of the best salmonid habitat in the Mattole Basin. The utility of this good habitat for salmonids is compromised because of summer de-watering of the upper mainstem reach and many subbasin tributaries;
- Gravel Substrate
  - Available data from sampled streams suggest that suitable amounts and distribution of high quality spawning gravel for salmonids is lacking in some subbasin stream reaches;
- Most creeks in this subbasin are considered good refugia;
- The geologic conditions in the Southern Subbasin are the most uniform and stable in the Mattole Basin. Nearly all the hillside areas are underlain by hard terrain. Correspondingly, this subbasin has the lowest density of mapped landslides, and stream channels within the Mattole Basin, and is the least impacted by features indicative of excess sediment production, transport and storage in the basin;
- Redwood stands occur in this subbasin because of favorable conditions, including summer fog. As a result of past timber harvest and conversion activities, over 60% of the Southern Subbasin is occupied by small diameter (twelve to twenty-four inches diameter at breast height) forest stands. Another 22% is in forest stands greater than twenty-four inches. Industrial timberlands on the eastern side of the subbasin have been intensively managed in the past decade and are characterized by young, even-aged conifer stands;
- This is the most densely populated area in the Mattole Basin. Many of the landowners have conservation easements as a part of Sanctuary Forest. Roads, abandoned after early timber harvest activities, are being upgraded and stormproofed by landowners. Many of these roads are now used as residential and parcel access roads and are located near streams.

Key Recommendations:

- Encourage reducing the unnecessary and wasteful use of water to improve summer stream surface flows and fish habitat;
- Increase the use of water storage and catchment systems that collect rainwater in the winter for use in the drier summer season;
- Support local efforts to educate landowners about water storage and catchment systems, and to find ways to subsidize development of these systems;

- Ensure that this high quality habitat is protected from degradation. The highest stream reach conditions as evaluated by the stream reach EMDS and refugia analysis were found in the Bridge, West Fork Bridge, South Fork West Fork Bridge, South Fork of Vanauken, Mill (RM 56.2), Stanley, Baker, Thompson, Yew, and Lost Man creeks, the Upper Mattole River, and Lost Man Creek Tributary;
- Improve the culvert on Stanley Creek that is blocking juvenile salmonids from accessing high quality rearing habitat;
- Establish monitoring stations and train local personnel to track in-channel sediment and aggraded reaches throughout the subbasin and especially in Bridge and Thompson creeks;
- Consider the nature and extent of naturally occurring unstable geologic terrain, landslides and landslide potential (especially Categories 4 and 5, page 89) when planning potential projects in the subbasin;
- Encourage the use of appropriate Best Management Practices for all land use and development activities to minimize erosion and sediment delivery to streams. For example, low impact yarding systems should be used in timber harvest operations on steep and unstable slopes to reduce soil compaction, surface disturbance, and resultant sediment yield;
- Expand road assessment efforts because of the potential for further sediment delivery from active and abandoned roads, many of which are in close proximity to stream channels;
- Continue efforts such as road improvements, and decommissioning throughout this subbasin to reduce sediment delivery to the Mattole River and its tributaries. CDFG stream surveys indicated South Fork Vanauken Creek, the Upper Mattole River, Stanley Creek, Thompson Creek, and Yew Creek have road sediment inventory and control as a top tier tributary recommendation. In 2002, road erosion assessments and road erosion control projects were underway in the upper Mattole Basin;
- Further study of timberland herbicide use is recommended;
- Follow the procedures and guidelines outlined by NCRWQCB to protect water quality from ground applications of pesticides;
- A cooperative salmonid rearing facility exists in the headwaters, operated since 1982 by the Mattole Salmon Group. This operation has been successful and should be continued on an as needed basis in order to supplement wild populations of Chinook salmon;
- Initiate a training program for local landowners to survey their own streams and monitor salmonid populations. This will provide important data and protect privacy;
- Monitor summer water and air temperatures to detect trends using continuous 24 hour monitoring thermographs. Continue temperature monitoring efforts in Bridge, Vanauken, Baker, Yew, Thompson, Helen Barnum, Lost Man, Dream Stream, and Ancestor creeks, and expand efforts into other subbasin tributaries.

Western Subbasin

The Western Subbasin lies between the little Bear Creek in the estuary (RM 0.3) and the headwaters of the South Fork of Bear Creek (RM 50) along the western side of the Mattole mainstem and Wilder Ridge for a distance of about sixty miles. The subbasin is largely managed by BLM for conservation and recreation in the King Range National Conservation Area, which comprises 47% of the subbasin. The Western Subbasin supports populations of Chinook salmon, coho salmon, and steelhead trout.

Key Findings:

- No systematic, scientific studies have examined the size or health of salmonid populations in the Western Subbasin. However, historical accounts and stream surveys conducted in the 1960s by CDFG indicate that the subbasin supported populations of Chinook salmon, coho salmon, and steelhead trout. Recent biological stream surveys indicate the presence of steelhead trout throughout the subbasin and coho salmon in a few tributaries. Low salmonid populations throughout the Mattole Basin indicate that salmonid populations in the Western Subbasin are also likely to be depressed at this time. However, populations have a good chance to recover due to public land stewardship that is actively engaged in improving watershed and stream conditions. In addition, salmonid rearing activities within the subbasin are working to supplement native stocks as habitat conditions improve;

- Erosion/Sediment
  - Instream sediment in several stream reaches in this subbasin may be approaching or exceeding levels considered unsuitable for salmonid populations. Macroinvertebrates data indicate good conditions. Additionally, amphibians sensitive to fine sediment were present in most stream reaches surveyed in this subbasin;
- Riparian Water Temperature
  - Available data suggest high summer temperatures are deleterious to summer rearing salmonid populations in some streams in this subbasin; in others it is good;
- Instream Habitat
  - In-stream habitat diversity and complexity, based on available survey data (i.e. pool depths, cover, and large woody debris) may be adequate for salmonid production. Additionally, recent surveys indicate instream habitat appears to be improving. Large woody debris recruitment potential is poor in this subbasin;
- Gravel Substrate
  - Available data from sampled streams suggest that suitable amounts and distribution of high quality spawning gravel for salmonids is lacking in some reaches in this subbasin;
- The upper reaches of Bear, Mill (RM 2.8), North Fork Bear, South Fork Bear, Big Finley, and South Fork Big Finley creeks, and the tributary to North Fork Bear Creek, are considered good refugia, and this will continue due to BLM and cooperative private land owners and current management policies in key headwater reaches. In fact, Bear Creek was the only creek in the Mattole Basin determined to provide high quality refugia.
- Although the Western Subbasin encompasses the dramatic relief of the King Range, with the highest proportion of steep slopes in the basin, approximately half of the subbasin is underlain by hard terrain and it is second only to the Southern Subbasin in terms of stable areas. Slope instability is focused primarily in the abundant areas with steep to very steep slopes and the limited area of soft terrain;
- Based on features indicative of excess sediment production, transport and storage, the pattern of impacts to stream conditions is similar to that observed in the Eastern Subbasin, and is highly variable throughout the subbasin. Considering the low degree of impact by features indicative of excess sediment production, transport and storage observed in the adjacent upstream Southern Subbasin, it appears that the stream features observed in the Western Subbasin must be derived either internally within the subbasin or from the adjacent Eastern Subbasin;
- As a result of past timber harvest and conversion activities, almost 60% of the Western Subbasin is occupied by small diameter (twelve to twenty-four inches diameter at breast height) forest stands. Another 20% is in forest stands greater than twenty-four inches;
- Forty square miles, or nearly half of this subbasin are in public ownership managed by the Bureau of Land Management as part of the King Range National Conservation Area, designated as late seral reserve. Timber harvesting has occurred on less than one percent of the area in the last ten years and has been at low levels for decades. Privately owned acres carrying grassland are grazed while smaller, residential parcels are concentrated along the main county roads. Old roads, many abandoned, are common across the landscape;
- Based on information available for this subbasin, the NCWAP team believes that salmonid populations are currently being limited by reduced habitat complexity, high sediment levels, high water temperatures, and embedded spawning gravels.

Key Recommendations:

- Based upon the latest science on placement of large woody debris in stream channels, managers in the Western Subbasin should work to improve channel structure and function for salmonids. Pool shelter has the lowest suitability for salmonids in Mill Creek (RM 2.8) Tributary #1 and South Fork Big Finley Creek;
- Establish monitoring stations and train local personnel to track in-channel sediment and aggraded reaches throughout the subbasin and especially in the lower reaches of major tributaries and Squaw, Honeydew, Finley, Big Finley, Woods and Bear creeks;
- Continue efforts such as road improvements and decommissioning throughout the basin to reduce sediment delivery to the Mattole River and its tributaries. Road inventories have been completed for much of this planning basin, and it is recommended that this effort be continued until a complete inventory is compiled. CDFG stream surveys indicated Mill Creek (RM 2.8) and Bear Trap Creek have road sediment inventory and control as a top tier tributary improvement recommendation;
- Monitor summer water and air temperatures to detect trends using continuous 24 hour monitoring thermographs. Continue temperature monitoring efforts in Stansberry, Mill (RM 2.8) Clear, Squaw, Woods, Honeydew, Bear, North Fork Bear, South Fork Bear, Little Finley, Big Finley, and Nooning creeks, and expand efforts into other subbasin tributaries;
- Ensure that near stream forest projects retain and recruit high canopy densities in riparian areas to reduce solar radiation and moderate air temperatures;
- Where current canopy is inadequate and site conditions, including geology, are appropriate, use tree planting and other vegetation management techniques to hasten the development of denser and more extensive riparian canopy. Canopy density has the lowest suitability for salmonids in Squaw Creek. Use cost share programs and conservation easements as appropriate;
- The three cooperative salmon rearing facilities in this subbasin should be continued as needed to supplement wild populations while the improvements from long-term watershed and stream restoration efforts develop;
- Initiate a systematic program to monitor the effectiveness of these fish rescue and rearing activities, and determine the need for the continuance of cooperative, supplemental fish rearing efforts on an ongoing, adaptive basis using the best available science;
- The nature and extent of naturally occurring unstable geologic terrain, landslides and landslide potential (especially Categories 4 and 5, page 89) must be considered when planning potential projects in the subbasin;
- Encourage the use of appropriate Best Management Practices for all land use and development to minimize erosion and sediment delivery to streams;
- In order to protect privacy on private lands in this subbasin while developing data, the possibility of training local landowners to survey streams and conduct salmonid population status surveys is advisable;
- Ensure that high quality habitat within this subbasin is protected from degradation. The highest stream reach condition as evaluated by the stream reach EMDS and refugia analysis were found in Bear, Mill (RM 2.8), North Fork Bear, South Fork Bear, Big Finley, and South Fork Big Finley creeks and the tributary to North Fork Bear Creek.

Summary of Subbasin Conditions and Recommendations

Table 2. Summary of Mattole subbasins stream and watershed conditions and recommended action.

	Estuary Subbasin	Northern Subbasin	Eastern Subbasin	Southern Subbasin	Western Subbasin
Identified Conditions					
In-Stream Sediment	-/R	-/R	-	-/R	-
Water Temperature	-	-	~	+	~
Pools	-	-	-	~	-
Flow	+	~	~	-	~
Escape Cover	-	-	-	-	-
Fish Passage Barriers	+	~	~	~	~
Natural Sediment Sources	-	-	~	+	+
Management-Related Sediment Sources	-	-	+	-	+
Recommended Improvement Activity Focus Areas					
Flow				X	
Erosion/Sediment		X	X	X	X
Riparian/Water Temperature	X	X	X		X
Instream Habitat	X	X	X	X	X
Gravel/Substrate			X	X	X
Fish Passage Barriers				X	X

+	Condition is favorable for anadromous salmonids
-	Condition is not favorable for anadromous salmonids
~	Condition is mixed or indeterminate for anadromous salmonids
R	Trend indicates improved conditions 1984-2000
X	Recommended improvement activity focus areas

Propensity for Improvement

Advantages

The Mattole Basin has several advantages for planning and implementing successful salmonid habitat improvement activities that include:

- An active restoration community made up of many highly skilled and experienced individuals. This community includes the comprehensive Mattole River and Range Partnership. The Partnership is composed of several natural resources agencies, Mattole landowners, and watershed groups like the Mattole Salmon Group and the Mattole Restoration Council. This broad base provides a common forum for different points of view and interests concerning the watershed and fisheries within the basin;
- Skilled fundraisers who are capable of recruiting funds from a myriad of grant programs. Currently, a major grant was secured by members of the Partnership from the Coastal Conservancy for a multi-year general watershed improvement program which includes various activities ranging from education to stream work;
- A skilled workforce with a core of experienced workers. This group of community based technicians provides a resource for ensuring successful projects and building future technical capacity in the basin. The logical long range product of this component is better watershed stewardship on a landscape scale;
- An expanding group of cooperative landowners that includes both public and private landowners from all subbasins in the Mattole. The effect of this growing cooperative land-base is the ability to choose locations for projects where the best result can be achieved in the shortest period of time. This accelerates the overall effectiveness of the watershed improvement program. The current Good Roads, Clear Creeks program is an example of this advantage;

- Several watersheds and streams are now well into recovery and should respond well to continued stewardship and improvement treatments.
- This NCWAP assessment containing findings, conclusions, and recommendations for improvement opportunities. This report provides focus from the basin scale, through the subbasin scale and down to the level of specific tributary assessments. With this tool to focus project design efforts, local landowners and restoration groups can pursue the mutual development of site specific improvement projects on an adaptive basis;
- A core population of Chinook salmon, coho salmon, and steelhead trout as well as summer steelhead unique to the Mattole River system. Although depressed from historic levels there remain local stocks that can take advantage of improved conditions. Over time, barring overwhelming outside impacts, the stocks should grow in response to watershed efforts. Currently, efforts by the Cooperative Hatchbox and Rescue Rearing Program are augmenting these core populations.

Challenges

The Mattole Basin also has some challenges confronting efforts to improve watershed and fish habitat conditions, and increase anadromous fish populations:

- Not all landowners are interested in salmonid habitat improvement efforts. Without a watershed wide cooperative land-base, treatment options are limited. In some cases this can remove some key areas from consideration of project development;
- High natural erosion rates will always be a part of the Mattole landscape. These high background erosion thresholds makes the need to reduce human induced erosion rates to as close to zero as possible an imperative;
- Summer and early fall water resources are very limited in some very important parts of the basin, particularly the Southern Subbasin. The very good instream habitat conditions in that subbasin are of no use to fish without water in the streams. As human water use intensifies, the loss of critical fish stocks will continue and compromise other fishery improvement efforts.
- The risk of pollutant spills also becomes problematic with increases in near stream residential and agricultural development and occupation.
- Even if needed watershed improvement efforts succeed in reducing sediment yield to basin streams, the estuary will be slow respond. The scale of the problem and the nature of low gradient, depositional reaches to move sediment slowly cause this situation. Therefore, containing the erosion that exceeds natural background levels will affect estuarine habitat improvements only over a very long period of time. That means basin wide sediment reduction efforts will have to be sustained with a great deal of patience for a very long time, in fact, in perpetuity. Meanwhile, salmonid stocks impacted by the harsh estuarine conditions will have to be protected and perhaps rescued until conditions improve. Fish rescue is a very difficult and risky task and can be problematic itself.
- Chinook and coho salmon and summer steelhead meta-populations are currently reduced to levels that could impact the amount of needed straying of colonizing fish into improved or expanded habitat conditions. Without a high degree of habitat seeding from strays, meta-population increases are compromised and the desired response to improvement efforts are slowed, successes masked, and evaluation difficult.

Conclusion

The likelihood that any North Coast basin will react in a responsive manner to management improvements and restoration efforts is a function of existing watershed conditions. In addition, the status of processes influencing watershed conditions will affect the success of watershed improvement activities. A good knowledge base of these current watershed conditions and processes is essential for successful watershed improvement. Acquiring this knowledge requires property access. Access is also needed to design, implement, monitor, and evaluate suitable improvement projects. This systematic process is dependent upon the cooperative attitude of resource agencies, watershed groups and individuals, and landowners and managers.

The Mattole NCWAP assessment has considered a great deal of available information regarding watershed conditions and processes in the Mattole Basin. This long assessment and analysis has identified problems and made recommendations to address these problems while considering the advantages and challenges of conducting watershed improvement programs in the Mattole Basin.

After considering these problems, recommendations, advantages and challenges, the Mattole Basin appears to be a very good candidate for a successful long term programmatic watershed improvement effort. According to the current NCWAP refugia analysis, the Mattole Basin has medium to high potential to become a high quality refugia habitat basin. Reaching this goal is dependent upon the formation of a well organized and thoughtful improvement program founded on a broad based community commitment to active watershed stewardship. The energy and opportunity appears to be present here, and well underway in many parts of the basin. If these efforts are pursued vigorously and patiently, one day the Mattole could once again be known as "clear waters" and be home to both a healthy fishery resource and a healthy watershed-based community in a uniquely diverse and beautiful area.

NOTES

Program Introduction and Overview

North Coast Watershed Assessment Program (NCWAP)

Assessment Needs for Salmon Recovery & Watershed Protection

The North Coast Watershed Assessment Program (NCWAP), an interagency effort between the California Resources Agency and the California Environmental Protection Agency, was established in 2000 to provide a consistent scientific foundation for collaborative watershed restoration efforts and to better meet the State needs for protecting and restoring salmon species and their habitats under State and Federal laws. The program was developed by a team of managers and technical staff from the following departments with watershed responsibilities for the North Coast:

- California Resources Agency
- California Department of Fish and Game (CDFG)
- California Department of Forestry and Fire Protection (CDF)
- California Department of Conservation/California Geological Survey (DOC/CGS)
- California Department of Water Resources (DWR)
- North Coast Regional Water Quality Control Board (NCRWQCB) of the State Water Resources Control Board.
- The Institute for Fisheries Resources (IFR) is also a partner and participant in this program.

The California Resources Agency in coordination with CalEPA, initiated NCWAP in part in response to specific requests from landowners and watershed groups that the State take a leadership role in conducting scientifically credible, interdisciplinary assessments that could be used for multiple purposes. The need for comprehensive watershed information grew in importance with listings of salmonids as threatened species, the Total Maximum Daily Load (TMDL) consent decree, and the increased availability of assistance grants for protecting and restoring watersheds.

Listings under the federal Endangered Species Act for areas within the NCWAP region (the North Coast Hydrologic Unit) began with coho salmon in 1997, followed by Chinook salmon in 1999, and steelhead in 2000. In 2001, coho was proposed for listing under the California Endangered Species Act. Concerns about the potential impacts of salmonid listings and TMDLs on the economy are particularly strong on the North Coast where natural resource-dependent industries predominate. Cumulative impacts related to human activities including landslides, flooding, timber harvest, mining, ranching, agricultural uses, and development; along with natural processes can adversely affect watershed conditions and fish habitat. In order to recover California's salmonid fisheries, it is necessary to first assess and understand the linkages among management activities, dominant ecological processes and functions, and factors limiting populations and their habitat.

The NCWAP integrates and augments existing watershed assessment programs to conform to proven methodologies and manuals available from each participating department. The program also responds to recommendations from a Scientific Review Panel (SRP) which was created under the auspices of the State's Watershed Protection and Restoration Council as required by the March, 1998 Memorandum of Understanding (MOU) between the National Marine Fisheries Service (NMFS) and the California Resources Agency. The MOU required a comprehensive review of the California Forest Practice Rules (FPRs) with regard to their adequacy for the protection of salmonid species. In addition, the promise of significant new state and federal salmon restoration funds highlighted the need for watershed assessments to ensure that those dollars are well spent.

NCWAP Program Goals

The NCWAP was developed to improve decision-making by landowners, watershed groups, agencies, and other stakeholders with respect to restoration projects and management practices to protect and improve salmonid habitat. It was therefore essential that the program took steps to ensure its assessment methods and products would be understandable, relevant, and scientifically credible. As a result, the interagency team developed the following goals:

- Organize and provide existing information and develop limited baseline data to help evaluate the effectiveness of various resource protection programs over time;
- Provide assessment information to help focus watershed improvement programs, and assist landowners, local watershed groups, and individuals to develop successful projects. This will help guide programs, like the CDFG Fishery Restoration Grants Program, toward those watersheds and project types that can efficiently and effectively improve freshwater habitat and support recovery of salmonid populations;
- Provide assessment information to help focus cooperative interagency, nonprofit and private sector approaches to protect the best watersheds and streams through watershed stewardship, conservation easements, and other incentive programs; and
- Provide assessment information to help landowners and agencies better implement laws that require specific assessments such as the State Forest Practice Act, Clean Water Act, and State Lake and Streambed Alteration Agreements.

Program Objectives and Guiding Questions

During the assessment process, the NCWAP agencies will work together very closely at all stages to consider how man-caused and naturally occurring watershed processes interact and affect stream conditions for fisheries, and other uses, and also consider the implications for watershed management.

During the formulation of the NCWAP's Methods Manual, the participating agencies agreed upon a short list of guiding questions with the key questions being:

- What watershed factors are limiting salmonid populations?
  - What are the general relationships between natural events and land use histories, for example, fire, flood, drought, earthquake, etc.; and urban and rural land development, timber harvest, agriculture, roads, dams, and stream diversions. How is this history reflected in the current vegetation and level of disturbance in North Coast watersheds? How can these kinds of disturbances be meaningfully quantified?
  - What is the spatial and temporal distribution of sediment delivery to streams from landsliding, bank, sheet and rill erosion, and other erosion mechanisms, and what are the relative quantities for each source?
  - What are the current salmonid habitat conditions in the watershed, the aquatic/riparian zone, and the estuary (flow, water temperature/shade, sediment, nutrients, instream habitat, large woody debris, and its recruitment); how do these compare to desired conditions (life history requirements of salmon, Basin Plan water quality objectives)?
  - What are the effects of stream, spring, and groundwater uses on water quality and quantity?
  - What role does large woody debris (LWD) have within the watershed in forming fish habitat and determining channel condition and sediment routing and storage?
  - What are the history and trends of the sizes, distribution, and relative health and diversity of salmonid populations and/or other aquatic community organisms within the watersheds?
  - Does the status of these populations reflect current watershed and stream habitat conditions or does it indicate constraints beyond which the watershed might exist. For example, a lack of stream connectivity that prevents free movement for adults or juveniles, or a poor marine life history, could affect a salmonid population.

These questions have guided the individual team members in data gathering and procedure assessment. The questions have provided direction for those analyses that required more interagency, interdisciplinary synthesis, including the analysis of factors affecting anadromous salmonid production.

Program Assessment Region and Agency Roles

The NCWAP assessment area includes all coastal drainages from Sonoma County north to Oregon. This area corresponds with the North Coast Water Quality Control Board's region. The region has been sub-divided into thirty-one basins for NCWAP assessment purposes (Figure 3). Thus, the program will organize existing information and provide limited baseline environmental and biological information for approximately 6.5 million acres of private and public lands over an estimated seven-year period. The administrative lead for the NCWAP is the California Resources Agency.

Figure 3. NCWAP Basin Assessment Area.

The roles of the five participating agencies in these efforts are as follows:

- CDFG will compile, develop, and analyze data related to anadromous fisheries habitat and populations. It will also lead an interagency evaluation of factors affecting anadromous fisheries production at the watershed level and provide recommendations for restoration and monitoring in the final synthesis report.
- CDF will compile, develop, and analyze data related to historical land use changes in the watersheds. It will also lead on preparing reports that synthesize information, findings, and recommendations, and develop a framework for assessing cumulative impacts.
- DOC/CGS will compile, develop, and analyze data related to the production and transport of sediment. Tasks will include baseline mapping of landslides, landslide potential, and instream sediment, as well as an analysis of stream geomorphology and sediment transport.
- NCRWQCB will compile, collect, and analyze water quality data for the assessments.
- DWR will install and maintain stream monitoring gages where needed to develop and analyze stream flow information.

Salmon, Stream, and Watershed Issues

Pacific coast anadromous salmonids are dependent upon a high quality freshwater environment at the beginning and end of their life cycles. As such, they thrive or perish during their freshwater phases depending upon the availability of cool, clean water, free access to migrate up and down their natal streams, clean gravel suitable for successful spawning, adequate food supply, and protective cover to escape predators and ambush prey. These life requirements must be provided by diverse and complex instream habitats as the fish move through their life cycles. If any life requirements are missing or in poor condition at the time a fish or stock requires it, fish survival can be impacted. These life requirement conditions can be identified and evaluated on a spatial and temporal basis at the stream reach and watershed levels. They comprise the factors that support or limit salmonid stock production.

> "Protection and maintenance of high-quality fish habitats should be among the goals of all resource managers. Preservation of good existing habitats should have high priority, but many streams have been damaged and must be repaired. Catastrophic natural processes that occlude spawning gravels can reduce stream productivity or block access by fish (for example), but many stream problems, especially in western North America, have been caused by poor resource management practices of the past. Enough now is known about the habitat requirements of salmonids and about good management practices that further habitat degradation can be prevented, and habitat rehabilitation and enhancement programs can go forward successfully" (Meehan, 1991).

> "In streams where fish live and reproduce, all the important factors are in a suitable (but usually not optimum) range throughout the life of the fish. The mix of environmental factors in any stream sets the carrying capacity of that stream for fish, and the capacity can be changed if one or more of the factors are altered. The importance of specific factors in setting carrying capacity may change with life the stage of the fish and season of the year" (Bjorrn and Reiser 1991).

Through the course of the year's natural climatic events, hydrologic responses, and erosion processes interact to shape freshwater salmonid habitats. These processes influence the kind and extent of the watershed's vegetative cover as well, and act to supply nutrients to the stream system.

> "In the absence of major disturbance, these processes produce small, but virtually continuous changes in variability and diversity against which the manager must judge the modifications produced by nature and human activity. Major disruption of these interactions can drastically alter habitat conditions" (Swanston 1991).

Major watershed disruptions can be caused by catastrophic events, such as the 1964 flood. They can also be created over time by multiple small natural or human disturbances. These disruptions can drastically alter instream habitat conditions and the aquatic communities that depend upon them. Thus, it is important to understand the critical, interdependent relationships of salmon and steelhead with their natal streams during their freshwater life phases, and their streams' dependency upon the watersheds within which they are nested, and the energy of the watershed processes that binds them together.

In general, natural disturbance regimes like landslides and wildfires do not impact larger watersheds like the 300 square mile Mattole in their entirety at any given time. Rather, they normally rotate episodically across the entire basin as a mosaic composed of the smaller subbasin, watershed, or sub-watershed units over long periods of time. This creates a dynamic variety of habitat conditions and quality over the larger watershed (Reice 1994).

The rotating nature of these relatively large, isolated events at the regional or basin scale assures that at least some streams in the area will be in suitable condition for salmonid stocks. A dramatic, large-scale example occurred in May, 1980 in the Toutle River, Washington, which was inundated in slurry when Mt. St. Helens erupted. The river rapidly became unsuitable for fish. In response, returning salmon runs avoided the river that year and used other nearby suitable streams on an opportunistic basis, but returned to the Toutle two years later as conditions improved. This return occurred much sooner than had been initially expected (Quinn et al. 1991, Leider 1989).

Human disturbance sites, although individually small in comparison to natural disturbance events, are usually spatially distributed widely across basin level watersheds (Reeves et al. 1995). For example, a rural road or building site is an extremely small land disturbance compared to a forty-acre landslide or wildfire covering several square miles. However, when all the roads in a basin the size of the Mattole are looked at collectively, their disturbance effects are much more widely distributed than a single large, isolated landslide that has a high, but relatively localized impact to a single sub-watershed.

Human disturbance regimes collectively extend across basin and even regional scales and have lingering effects. Examples include water diversions, conversion of near stream areas to urban usage, removal of large mature vegetation, widespread soil disturbance leading to increased erosion rates, construction of levees or armored banks that can disconnect the stream from its floodplain, and the installation of dams and reservoirs that disrupt normal flow regimes and prevent free movement of salmonids and other fish. These disruptions often develop in concert and in an extremely short period of time on the natural, geologic scale.

Human disturbances are often concentrated in time because of newly developed technology or market forces such as the California Gold Rush or the post-WWII logging boom in Northern California. The intense human land use of the last century, combined with the transport energy of two mid-century record floods on the North Coast, created stream habitat impacts at the basin and regional scales. The result of these recent combined disruptions has overlain the pre-European disturbance regime process and conditions.

Consequently, stream habitat quality and quantity are generally depressed across most of the North Coast region. It is within this generally impacted environment that both human and natural disturbances continue to occur, but with vastly fewer habitat refugia lifeboats than were historically available to salmon and steelhead. Thus, a general reduction in salmonid stocks can at least partially be attributed to this impacted freshwater environment.

Although no long-term fish counts exist for the Mattole River, Department of Fish and Game fish ladder counts at Benbow Dam and Cape Horn Dam, in the neighboring Eel River system, reflect an over 80% decline in coho salmon, Chinook salmon, and steelhead trout populations over the span of the last century (Figure 4, Figure 5). The Eel River, especially the nearby South Fork Eel River, which is the location of Benbow Dam, has similar watershed conditions and land use history to the Mattole River. Anecdotal evidence from anglers and longtime local residents supports the likelihood of a similar decline in Mattole fisheries (see Mattole Basin Profile). Since 1980, collaborative work between the Department of Fish and Game and the Mattole Salmon Group to collect field data and observations shows there is a record of very low coho and Chinook salmon populations, and depressed steelhead trout populations.

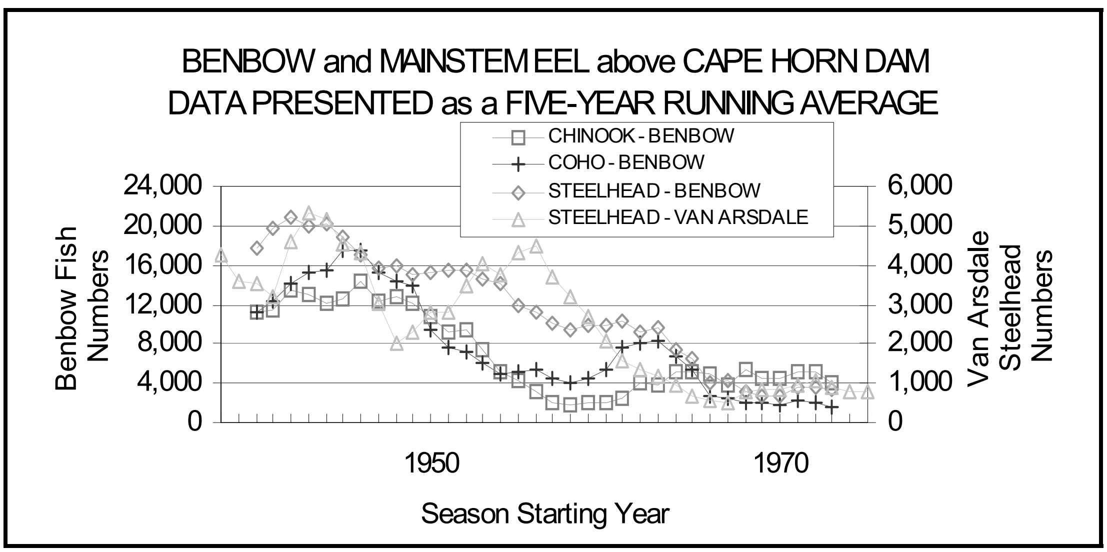


Figure 4. Five-year running average of salmonids at Benbow Dam, South Fork Eel River, and Mainstem Eel River above Cape Horn Dam

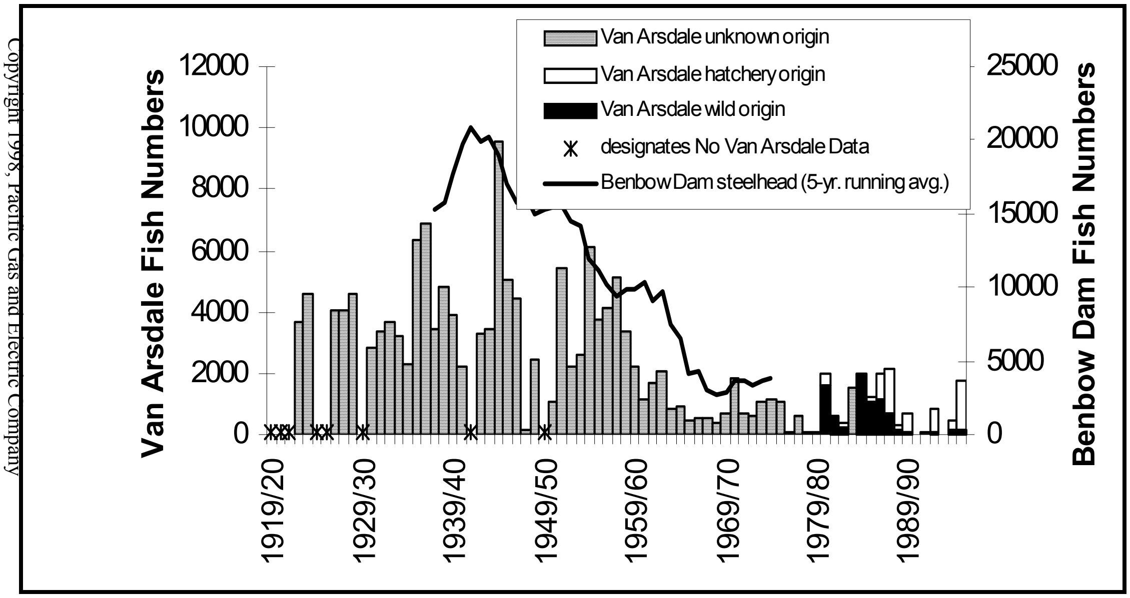


Figure 5. Historical steelhead trout ladder counts at Van Arsdale Fisheries Station, mainstem Eel River, and Benbow Dam, South Fork Eel River.

Factors Affecting Anadromous Salmonid Production

Chinook salmon, coho salmon, and steelhead trout all utilize headwater streams, larger rivers, estuaries, and the ocean for parts of their life history cycles. There are several factors necessary for the successful completion of an anadromous salmonid life history.

A main component of the NCWAP is the analyses of the freshwater factors in order to identify whether any of these factors are at a level that limits production of anadromous salmonids in North Coast watersheds. This limiting factors analysis (LFA) provides a means to evaluate the status of a suite of key environmental factors that affect anadromous salmonid life history.[1] These analyses are based on comparing measures of habitat components such as water temperature and pool complexity to a range of reference conditions determined from empirical studies and/or peer reviewed literature. If a component's condition does not fit within the range of reference values, it may be viewed as a limiting factor. This information will be useful to identify underlying causes of stream habitat deficiencies and help reveal if there is a linkage to watershed processes and land use activities.

In the freshwater phase in salmonid life history, stream connectivity, stream condition, and riparian function are essential for survival. Stream connectivity describes the absence of barriers to the free instream movement of adult and juvenile salmonids. Free movement in well-connected streams allows salmonids to find food, escape from high water temperatures, escape from predation, and migrate to and from their stream of origin as juveniles and adults. Dry or intermittent channels can impede free passage for salmonids; temporary or permanent dams, poorly constructed road crossings, landslides, debris jams, or other natural and/or man-caused channel disturbances can also disrupt stream connectivity.

Stream condition includes several factors; adequate stream flow, suitable water quality, suitable steam temperature, and complex habitat. For successful salmonid production, stream flows should follow the natural hydrologic regime of the watershed. A natural regime minimizes the frequency and magnitude of storm flows and promotes better flows during dry periods of the water year. Salmonids evolved with the natural hydrograph of coastal watersheds, and changes to the timing, magnitude, and duration of low flows and storm flows can disrupt the ability of fish to follow life history cues. Adequate instream flow during low flow periods is essential for good summer time stream connectivity, and is necessary to provide juvenile salmonids free forage range, cover from predation, and utilization of localized temperature refugia from seeps, springs, and cool tributaries.

[1] The concept that fish production is limited by a single factor or by interactions between discrete factors is fundamental to stream habitat management (Meehan 1991). A limiting factor can be anything that constrains, impedes, or limits the growth and survival of a population.

Three important aspects of water quality for anadromous salmonids are water temperature, turbidity, and sediment load. In general, suitable water temperatures for salmonids are between 48-56° F for successful spawning and incubation, and between 50-52°F and 60-64° F, depending on species, for growth and rearing. Additionally, cool water holds more oxygen, and salmonids require high levels of dissolved oxygen in all stages of their life cycle.

A second important aspect of water quality is turbidity, which is the relative clarity of water. Suspended sediments (turbidity) affect nutrient levels in streams that in turn affect primary productivity of aquatic vegetation and insect life. This eventually reverberates through the food chain and affects salmonid food availability. Additionally, high levels of turbidity interfere with a juvenile salmonids' ability to feed and can lead to reduced growth rates and survival (Trush, personal communication).

A third important aspect of water quality is stream sediment load. Salmonids cannot successfully reproduce when forced to spawn in streambeds with excessive silt, clays, and other fine sediment. Eggs and embryos suffocate under excessive fine sediment conditions because oxygenated water is prevented from passing through the egg nest, or redd. Additionally, high sediment loads can cap the redd and prevent emergent fry from escaping the gravel into the stream at the end of incubation. High sediment loads can also cause abrasions on fish gills, which may increase susceptibility to infection. At extreme levels, sediment can clog the gills causing death. Additionally, materials toxic to salmonids can cling to sediment and be transported through downstream areas.

Habitat diversity for salmonids is created by a combination of deep pools, riffles, and flatwater habitat types. Pools, and to some degree flatwater habitats, provide escape cover from high velocity flows, hiding areas from predators, and ambush sites for taking prey. Pools are also important juvenile rearing areas, particularly for young coho salmon. They are also necessary for adult resting areas. A high level of fine sediment fills pools and flatwater habitats. This reduces depths and can bury complex niches created by large substrate and woody debris. Riffles provide clean spawning gravels and oxygenate water as it tumbles across them. Steelhead fry use riffles during rearing. Flatwater areas often provide spatially divided pocket water units that separate individual juveniles which helps promote reduced competition and successful foraging (Flosi et al. 1998).

A functional riparian zone helps to control the amount of sunlight reaching the stream, provides vegetative litter, and contributes invertebrates to the local salmonid diet. These contribute to the production of food for the aquatic community, including salmonids. Tree roots and other vegetative cover provide stream bank cohesion and buffer impacts from adjacent uplands. Near-stream vegetation eventually provides large woody debris and complexity to the stream (Flosi et al. 1998).

Riparian zone functions are important to anadromous salmonids for numerous reasons. Riparian vegetation helps keep stream temperatures in the range that is suitable for salmonids by maintaining cool stream temperatures in the summer and insulating streams from heat loss in the winter. Larval and adult macroinvertebrates are important to the salmonid diet and they are in turn dependent upon nutrient contributions from the riparian zone. Additionally, stream bank cohesion and maintenance of undercut banks provided by riparian zones in good condition maintains diverse salmonid habitat, and helps reduce bank failure and fine sediment yield to the stream. Lastly, the large woody debris provided by riparian zones shapes channel morphology, helps retain organic matter and provides essential cover for salmonids (Murphy and Meehan 1991).

Therefore, excessive natural or man-caused disturbances to the riparian zone, as well as directly to the stream and/or the watershed itself can have serious impacts to the aquatic community, including anadromous salmonids. Generally, this seems to be the case in streams and watersheds in the North Coast of California. This is borne out by the recent decision to include many North Coast Chinook and coho salmon, and steelhead trout stocks on the Endangered Species Act list.

Disturbance and Recovery of Stream and Watershed Conditions

Natural and Human Disturbances

The forces shaping streams and watersheds are numerous and complex. Streams and watersheds change through dynamic processes of disturbance and recovery (Madej 1999). In general, disturbance events alter streams away from their equilibrium or average conditions, while recovery occurs as stream conditions return towards equilibrium after disturbance events. Given NCWAP's focus on anadromous salmonids, an important goal is to determine the degree to which current stream and watershed conditions in the region are providing salmonid habitat capable of supporting sustainable populations of anadromous salmonids. To do this, we must consider the habitat requirements for all life stages of salmonids. We must look at the disturbance history and recovery of stream systems, including riparian and upslope areas, which affect the streams through multiple biophysical processes.

Disturbance and recovery processes can be influenced by both natural and human events. A disturbance event such as sediment from a natural landslide can fill instream pools providing salmon habitat just as readily as sediment from a road failure. On the recovery side, natural processes (such as small stream-side landslides) that replace instream large woody debris washed out by a flood flow help to restore salmonid habitat, as does large woody debris placed in a stream by a landowner as a part of a restoration project.

Natural disturbance and recovery processes, at scales from small to very large, have been at work on north coast watersheds since their formation millions of years ago. Recent major natural disturbance events have included large flood events such as occurred in 1955 and 1964 (Lisle 1981a) and ground shaking and related tectonic uplift associated with the 1992 Cape Mendocino earthquake (Carver et al., 1994). Major human disturbances (e.g., post-European development, dam construction, agricultural and residential conversions, and the methods of timber harvesting practices used particularly before the implementation of the 1973 Z'Berg-Nejedly Forest Practice Act) have occurred over the past 150 years (Ice 2000). Salmonid habitat also was degraded during parts of the last century by well-intentioned but misguided restoration actions such as removing large woody debris from streams (Ice 1990). More recently, some efforts at watershed restoration have been made, generally at the local level. For example, in California and the Pacific Northwest, minor dams from some streams have been removed to clear barriers to spawning and juvenile anadromous fish. For a thorough treatment of stream and watershed recovery processes, see the publication by the Federal Interagency Stream Restoration Working Group (FISRWG 1998).

Defining Recovered

While it is generally agreed that improvements in a condition or set of conditions constitute recovery. In that context, recovery is a process. One can determine a simple rate of recovery by degree of improvement over some time period, and from only two points in time. And one can discuss recovery and rates of recovery in a general sense. However, a simple rate of recovery is not very useful until put into the context of its position on a scale to the endpoint of recovered.

Recovered not only implies, but necessitates, knowledge of an endpoint. In the case of a recovered watershed, the endpoint is a set of conditions deemed appropriate for a watershed with its processes in balance and able to withstand purturbations without large fluctuations in those processes and conditions. Recovered fish habitat could be habitat in an optimum state or in state that allows for a suitable and stable population or something in between. The endpoint of recovered for one condition or function may be on a different time and geographic scale than for another condition or function.

Factors and Rates of Recovery

Over the past quarter-century, several changes have allowed the streams and aquatic ecosystems to move generally towards recovery. The rate of timber harvest on California's north coast has slowed during this period, with declining submissions of timber harvesting plans (THPs) and smaller average THPs (T. Spittler, pers. comm.). In addition, timber harvesting practices have greatly improved over those of the post-war era, due to increased knowledge of forest ecosystem functions, changing public values, advances in road building and yarding techniques, and regulation changes such as mandated streamside buffers that limit equipment operations and removal of timber. For example, Cafferata and Spittler (1998) found that almost all of the more recent landslides occurring in an area logged in the early 1970s were related to the legacy logging roads. In contrast, in a neighboring watershed logged in the late 1980s to early 1990s, landslides to date have occurred with about equal frequency in the logged areas as in unlogged areas.

Further, most north coast streams have not recently experienced another large event on the scale of the 1964 flood. Therefore, we would expect most north coast streams to show signs of recovery (i.e., passive restoration [FISRWG 1998]). However, the rates and degrees of stream and watershed recovery will likely vary across a given watershed and among different north coast drainages.

In addition to the contributions made to recovery through better land management practices and natural recovery processes, increasing levels of stream and watershed restoration efforts also are contributing to recovery. Examples of these efforts include road upgrades and decommissioning, removal of road-related fish passage barriers, installation of instream fish habitat structures, etc. While little formal evaluation or quantification of the contributions of these efforts to recovery has been made, there is a general consensus that many of these efforts have made important contributions.

Some types and locations of stream recovery for salmonids can occur more readily than others. For example, in headwater areas where steeper source reaches predominate, suspended sediment such as that generated by a streamside landslide or a road fill failure may start clearing immediately, while coarser sediments carried as bedload tend to flush after a few years (Lisle 1981a, Madej and Ozaki 1996). Broadleaf riparian vegetation can return to create shading, stabilize banks, and improve fish habitat within a decade or so. In contrast, in areas lower in the watershed where lower-gradient response reaches predominate, it can take several decades for deposited sediment to be transported out (Madej 1982, Koehler et al. 2001), for widened stream channels to narrow, for aggraded streambeds to return to pre-disturbance level, and for streambanks to fully revegetate and stabilize (e.g., Lisle 1981b). Lower reach streams will require a similar period for the near-stream trees to attain the girth needed for recruitment into the stream as large woody debris to help create adequate habitat complexity and shelter for fish, or for deep pools to be re-scoured in the larger mainstems (e.g., Lisle and Napolitano 1998).

Continuing Challenges to Recovery

Given improvements in timber harvesting practices in the last 30 years, the time elapsed since the last major flood event, and the implementation of stream and watershed restoration projects, it is not surprising that many north coast streams show indications of trends towards recovery (Madej and Ozaki 1996). Ongoing challenges associated with past activities that are slowing this trend include chronic sediment delivery from legacy (pre-1975) roads due to inadequate crossing design, construction and maintenance (California State Board of Forestry, Monitoring Study Group 1999), skid trails and landings (Cafferata and Spittler 1998), the lack of improvements in stream habitat complexity (from a dearth of large woody debris) for successful fish rearing, and the continuing aggradation of sediments in low-gradient reaches that were deposited as the result of activities and flooding in past decades (Koehler et al. 2001).

Increasing development on several north coast watersheds raises concerns about new stream and watershed disturbances. Private road systems associated with rural development have historically been built and maintained in a fashion that does little to mitigate risks of chronic and catastrophic sediment inputs to streams. While more north coast counties are beginning to put in place grading ordinances that will help with this problem, there is a significant legacy of older residential roads that pose an ongoing risk for sediment inputs to streams. Other issues appropriate to north coast streams include potential failures of roads during catastrophic events, erosion from house pads and impermeable surfaces, removal of water from streams for domestic uses, effluent leakages, and the potential for deliberate dumping of toxic chemicals used in illicit drug labs.

Some areas of the North Coast have seen rapidly increasing agricultural activity, particularly conversion of grasslands or woodlands to grapes. Such agricultural activities have typically been subject to little agency review or regulation and can pose significant risk of chronic sediment inputs to streams.

Associated with development and increased agriculture, some north coast river systems, such as the Navarro, are seeing increasing withdrawal of water, both directly from stream and from groundwater sources connected to streams, for human uses. Water withdrawals pose a chronic disturbance to streams and aquatic habitat. Such withdrawals can result in lowered summer stream flows that impede the movement of salmonids and reduce important habitat elements such as pools. Further, the withdrawals can contribute to elevated stream water temperatures that are harmful to salmonids.

Key questions for landowners, agencies, and other stakeholders revolve around whether the trends toward stream recovery will continue at their current rates, and whether those rates will be adequate to allow salmonids to recover their populations in an acceptable timeframe. Clearly, the potential exists for new impacts from both human activities and natural disturbance processes to compromise recovery rates to a degree that threatens future salmonid recovery. To predict those cumulative effects will likely require additional site-specific information on sediment generation and delivery rates and additional risk analyses of other major disturbances. Also, our discussion here does not address marine influences on anadromous salmonid populations. While these important influences are outside of the scope of NCWAP, we recognize their importance for sustainable salmonid populations and acknowledge that good quality freshwater habitat alone is not adequate to ensure sustainability.

Policies, Acts, and Listings

Several federal and state statutes have significant implications for watersheds, streams, fisheries, and their management. Here, we present only a brief listing and description of some of the laws.

Federal Statutes

One of the most fundamental of federal environmental statutes is the **National Environmental Policy Act (NEPA)**. NEPA is essentially an environmental impact assessment and disclosure law. Projects contemplated or plans prepared by federal agencies or funded by them must have an environmental assessment completed and released for public review and comment, including the consideration of more than one alternative. The law does not require that the least impacting alternative be chosen, only that the impacts be disclosed.

The federal **Clean Water Act** has a number of sections relevant for watersheds and water quality. Section 208 deals with non-point source pollutants arising from silvicultural activities, including cumulative impacts. Section 303 deals with water bodies that are impaired to the extent that their water quality is not suitable for the beneficial uses identified for those waters. For water bodies identified as impaired, the US Environmental Protection Agency or its state counterpart (locally, the North Coast Regional Water Quality Control Board and the State Water Resources Control Board) must set targets for Total Maximum Daily Loads (TMDLs) of the pollutants that are causing the impairment. Section 404 deals with the alterations of wetlands and streams through filling or other modifications, and requires the issuance of federal permits for most such activities.

The federal **Endangered Species Act (ESA)** addresses the protection of animal species whose populations are dwindling to critical levels. Two levels of species risk are defined. A threatened species is any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. An endangered species is any species that is in danger of extinction throughout all or a significant portion of its range. In general, the law forbids the take of listed species. Taking is defined as harassing, harming, pursuing, hunting, shooting, wounding, killing, trapping, capturing, or collecting a species or attempting to engage in any such conduct. A take of a species listed as threatened may be allowed where specially permitted through the completion and approval of a Habitat Conservation Plan (HCP). An HCP is a document that describes how an agency or landowner will manage their activities to reduce effects on vulnerable species. An HCP discusses the applicant's proposed activities and describes the steps that will be taken to avoid, minimize, or mitigate the take of species that are covered by the plan. Many of California's salmon runs are listed under the ESA, including the Chinook and coho salmon found in the Mattole Basin. Steelhead trout, which are also found in the Mattole Basin, have been proposed for listing.

State Statutes

The state analogue of NEPA is the **California Environmental Quality Act (CEQA)**. CEQA goes beyond NEPA in that it requires the project or plan proponent to select for implementation the least environmentally impacting alternative considered. When the least impacting alternative would still cause significant adverse environmental impacts, a statement of overriding considerations must be prepared.

The **Porter-Cologne Water Quality Control Act** establishes state water quality law and defines how the state will implement the federal authorities that have been delegated to it by the US EPA under the federal Clean Water Act. For example, the US EPA has delegated to the state certain authorities and responsibilities to implement TMDLs for impaired water bodies and NPDES (national pollution discharge elimination system) permits to point-source dischargers to water bodies.

Sections 1600 et seq. of the Fish and Game Code are implemented by the Department of Fish and Game. These agreements are required for any activities that alter the beds or banks of streams or lakes. A 1600 agreement typically would be involved in a road project where a stream crossing was constructed. While treated as ministerial in the past, the courts have more recently indicated that these agreements constitute discretionary permits and thus must be accompanied by an environmental impact review per CEQA.

The **California Endangered Species Act (CESA)**. The California Endangered Species Act (Fish & Game Code §§ 2050, *et seq.*) generally parallels the main provisions of the Federal Endangered Species Act and is administered by the California Department of Fish and Game (CDFG). Coho salmon in the Mattole Basin are listed as threatened under CESA. The State Fish and Game Commission is expected to make the final listing decision of this species in 2003.

The **Z'Berg-Nejedly Forest Practice Act (FPA)** and associated **Forest Practice Rules** establish extensive permitting, review, and management practice requirements for commercial timber harvesting. Evolving in part in response to water quality protection requirements established by the 1972 amendments to the federal Clean Water Act, the FPA and Rules provide for significant measures to protect watersheds, watershed function, water quality, and fishery habitat.

Assessment Strategy and General Methods

Assessment Strategy

In 2000, the North Coast Watershed Assessment Program (NCWAP) developed a draft methods manual that identified a general approach to conducting a watershed assessment, described or referenced methods for collecting and developing new watershed data, and provided a preliminary explanation of analytical methods for integrating interdisciplinary data to assess watershed conditions. NCWAP methods continued to evolve over the course of this assessment.

This chapter provides brief descriptions of data collection and analysis methods used by each of NCWAP's participating departments, and an introduction to methods for analyzing data across departments and disciplines. While the information contained in the report is extensive, more detail is included in a set of appendices to this report:

- California Geological Survey — Appendix A
- California Department of Forestry — Appendix B
- Ecological Management Decision Support — Appendix C
- Department of Water Resources — Appendix D
- North Coast Regional Water Quality Control Board — Appendix E
- California Department of Fish & Game — Appendix F

The reader is referred to those appendices for more detail on methods, data used in the assessment, and assessments of the data.

Watershed Assessment Approach

The NCWAP approach emphasizes close coordination with stakeholders. The manual provides six general steps for working with local groups and other interested and knowledgeable groups or individuals. The following describes how these were implemented in the Mattole Basin:

Step One: ***Scoping.*** The basin assessment team met with stakeholders to identify watershed problems or concerns, local assessment interests, existing data and gaps, and opportunities to work with local interests to answer the critical questions.

Step Two: ***Data compilation.*** The team compiled and screened existing data according to the quality and usefulness for answering critical questions and application to the program's Ecological Management Decision Support system model (EMDS). Quality control processes are described in greater detail in Chapter 4 of the NCWAP's draft Methods Manual. The collected information was shared and coordinated among the several departments.

Step Three: ***Initial analyses.*** The team used a preliminary run of the EMDS stream reach model (described in Chapter 3 of the NCWAP's Methods Manual) to help analyze the habitat factors affecting fish production. Air photo interpretation and GIS analysis also enabled the team to identify data needs and questions. Most importantly, in the Mattole Basin assessment, a series of meetings with landowners and interested parties provided the team with local, historic knowledge and valuable critical discussion with which to establish the value of the information in hand.

Step Four: ***Fieldwork.*** Identified, necessary fieldwork was conducted by some team members, dependent upon landowner cooperation. This fieldwork helped validate existing data and verify imagery or photo-based analyses, and provided new data to fill identified gaps. Throughout this process, there was coordination with local groups and landowners on access to private property and validation of findings.

Step Five: ***Analyze data.*** This includes generation of maps, databases, and more integrative analyses like EMDS outputs, GIS layers, Integrated Analysis tables, Limiting Factors Analyses, and watershed improvement recommendations.

Step Six: ***Develop assessment reports for public review.*** This included development of draft reports, public workshops to discuss the drafts, and the collection and distribution of responses to public and peer review comments. Final products include a revised report with synthesis and detailed appendices, a State website with the report, spatial data, and an interactive GIS.

Mattole Assessment Process Summary

The NCWAP Mattole Team initial public meeting was held in April 2001 to introduced the NCWAP program, solicit public participation in identifying issues, and solicit interested participants from the watershed. As a result, CDFG recruited and hired one contract field technician and one Scientific Aide from within the watershed community. These employees conducted data research and limited data collection. They have also assembled a good portion of the bibliography for CDFG. Additionally, NCWAP was able to hire, on a consultancy basis, a 22-year veteran Mattole River fishery biologist to submit historical information about the fisheries, and analyze with our staff two decades of fishery information.

NCWAP had another public meeting on October 17, 2001. At that time, the nine-person NCWAP team presented the current product status and discussed issues with 25 interested group participants. As a result, specific CGS staff members were invited to conduct verification fieldwork on four major non-industrial properties. Outreach meetings were also held with Pacific Lumber Company (PALCO). Peer review has involved meeting with scientists from Redwood Sciences Lab, BLM, and EPA.

A first draft of the Synthesis Report was completed in November 2001 for internal and agency review. Subsequent drafts for departmental peer review and public comment were completed in January and March 2002. This draft of the Synthesis Report was posted to the NCWAP website (http://www.ncwatershed.ca.gov) and hard copies were distributed to county libraries and constituents.

A public meeting to solicit stakeholder comment was held on February 23, 2002. The workshop was held at the Triple Junction High School near Honeydew. Registration was in the library, and all attendees were given a series of handouts including a copy of the Mattole Synthesis Report, a public comment sheet, geologic maps of the various subbasins, and updated versions of the NCRWQCB and CGS Appendices. The meeting consisted of a general session to orient attendees and focus sessions concerning issues and recommendations to stimulate discussion about the Synthesis Report, and closed with a General Session to recap the day's proceedings.

General sessions were held in a large classroom, and focus sessions were held in five different rooms across the high school campus. The morning general session consisted of an introduction to the workshop and NCWAP process by Scott Downie, CDFG; a presentation explaining the Ecological Management Decision Support System (EMDS) by Rich Walker, CDF; and an introduction to KRIS by Gary Reedy, IFR.

issue and subbasin focus sessions were conducted as discussions led by different agency personnel, with AmeriCorps members taking notes. Issue focus sessions included posters of condensed issues, hypotheses, and recommendations delineated for the Mattole Basin in the Synthesis Report, maps of the Mattole Basin hydrography and CalWater units, and other materials provided by session leaders. Subbasin focus sessions included posters of the condensed issues, hypotheses, and recommendations delineated for the individual subbasins in the Synthesis Report, handouts of these posters, and other materials provided by session leaders. Participants were urged to move between sessions and provide input on the Mattole Synthesis Report.

The afternoon general session consisted of a recap of focus sessions by session leaders, a discussion of important points brought up during the workshop, and discussion of further public input. Another public meeting to generate input was held March 23, 2002.

A follow-up meeting of landowners in the Mattole Basin was held on March 7, 2002 to generate comments on the Synthesis Report. The official public comment period ended on March 11, 2002. Public comments were entered into a database and distributed to all NCWAP team members. Responses to public comments have been entered into the database on an on-going basis. Input is still welcome to the NCWAP team.

A revised draft of the Synthesis Report was prepared on March 22, 2002 for distribution at the March 23, 2002 workshop in Honeydew. The comments received to date were also distributed at the meeting. The report was available on the NCWAP website March 30, 2002.

NCWAP Products

The NCWAP will produce and make available to the public a consistent set of products for each basin assessed.

NCWAP products include:

- A basin level Geologic Report that includes:
  - Maps of landslides and geomorphic features related to landsliding;
  - Relative landslide potential maps;
  - A map of features indicative of excess sediment production, transport and/or deposition;
  - Maps of stream reaches classified by gradient and by Rosgen stream type.
- A basin level Synthesis Report that includes:
  - Collection of Mattole Basin historical and sociological information;
  - Description of historic and current vegetation cover and change, land use, geology and fluvial geomorphology, water quality, stream flow, water use, and instream habitat conditions;
  - Hypotheses and evaluation about watershed conditions affecting salmonids;
  - An interdisciplinary analysis of the suitability of stream reaches and the watershed for salmonid production and refugia areas;
  - Tributary and watershed recommendations for management, refugia protection, and restoration activities to address limiting factors and improve conditions for salmonid productivity;
  - Monitoring recommendations to improve the adaptive management efforts.
- Ecological Management Decision Support system (EMDS) models to help analyze data;
- Databases of information used and collected;
- A data catalogue and bibliography;
- Web based access to the Program's products: http://ncwatershed.ca.gov/, and http://imaps.dfg.ca.gov/.
- A Compact Disk (CD) developed through the Institute for Fisheries Resources (IFR) which uses the Klamath Resources Information System (KRIS).

Report Utility and Usage

This report is intended to be useful to landowners, watershed groups, agencies, and individuals to help guide restoration, land use, and management decisions. As noted above, the assessment operates on multiple scales ranging from the detailed and specific stream reach level to the very general basin level. Therefore, findings and recommendations also vary in specificity from being particular at the finer scales, and general at the basin scale. In the Mattole River, for example, there is a general problem with elevated amounts of sediment in lower gradient stream channels. These are reaches used by Chinook and coho salmon and steelhead trout. This sediment is generally harmful to salmonid habitat as discussed above, and further considered in the following discussion about the EMDS model. Today, this general elevated sediment condition is not uncommon throughout most of the overall NCWAP region. To improve upon that and other unsuitable conditions, and therefore salmonid habitat, will require long periods of time even with reduced levels of erosion brought about by careful watershed stewardship. A goal of this program is to help guide, and therefore accelerate that recovery process, by focusing stewardship and improvement activities where they will be most effective. Scaling down through finer levels guided by the recommendations should help accomplish this focus.

To do so, the report is constructed to help provide guidance for that focus of effort. A user can scale down from the general basin finding and recommendation concerning high sediment levels, for example, to the various subbasin sections, to the stream reach level information to determine which streams in the subbasin may be affected by sediment. There is a list of surveyed streams in each subbasin section. In the general recommendation section, a tributary finding and recommendation summary table indicates the findings and recommendations for the surveyed streams within the subbasin. If indicated, field investigations at the stream reach or project site level can be conducted to make an informed decision on a land use project, or to design improvement activities.

For example in the Mattole's Eastern Subbasin, sediment is an issue in the findings and recommendations. From the list of tributaries in a subbasin section the tributary table can be referenced for potential project sites. For example, Westlund Creek is an Eastern Subbasin stream on that list that has both streambank and road-sourced erosion as issues for treatment related to land use projects or improvement activities. Interestingly, during the past two years, over seventy percent of the landowners in Westlund Creek gave permission for erosion control training and surveys to be conducted on their lands in cooperation with the Mattole Restoration Council and the CDFG Restoration Grants Program. That effort was primarily based upon the recommendations in the 1996 CDFG Westlund Creek Stream Report, which is summarized in this Report's CDFG Appendix F. The NCWAP, using these reports, other watershed assessments, its EMDS analytical tool and the resultant spatial presentations of its findings, will provide the opportunity to conduct better coordinated stewardship and improvement work like this example, but at the much broader, basin scale.

Assessment Report Conventions

Subbasins

In order to be more specific and useful to planners, managers, and landowners, it is useful to subdivide the larger Mattole Basin into smaller subbasin units whose size is determined by the commonality of many distinguishing traits. Variation among subbasins is at least partially a product of natural and human disturbances. Other variables that can distinguish areas, or subbasins, in larger basins include differences in elevation, geology, soil types, aspect orientation, climate, vegetation, fauna, human population, land use and other social-economic considerations.

The NCWAP Mattole assessment team subdivided the Mattole Basin into five subbasins (Figure 6) for assessment and analyses purposes. These subbasins are the Estuary, Northern, Eastern, Southern, and Western Subbasins. In general, each subbasin has somewhat unique attributes that are generally common to the several CalWater 2.2a Planning Watersheds (PWs) contained within a subbasin. These PWs are explained below. Common PW attributes pertain to a subbasin's landslide propensity, vegetation, climate, land use, streams, fisheries, towns and communities, access corridors, etc.

CalWater 2.2a Planning Watersheds

The NCWAP used the California Watershed Map (CalWater Version 2.2a) to delineate planning watershed units (Figure 7). This hierarchy of watershed designations consists of six levels of increasing specificity: Hydrologic Region, Hydrologic Unit, Hydrologic Area, Hydrologic Sub-Area, Super Planning Watershed, and Planning Watershed (PW). CalWater version 2.2a is the third version of CalWater (after versions 1.2 and 2.0) and is a descendent of the 1:500,000-scale State Water Resources Control Board Basin Plan Maps drawn in the late 1970s.

NCWAP used the PW level of specificity in many analyses. PWs generally range from 3,000-10,000 acres in size and each PW consists of a specific watershed polygon, which is assigned a single unique code. NCWAP used PWs for mapping, reporting, EMDS, and statistical analysis of geology, vegetation, land use, and fluvial geomorphology.

An important aspect of CalWater 2.2a PWs is that individual PWs often do not represent true watersheds. In other words, PWs often cut across streams and ridgelines and do not cover the true catchment of a stream or stream system. Large streams, such as the North Fork Mattole River, can flow through multiple PWs. In addition, a stream may serve as a border between two CalWater 2.2a PWs. An example is that a large portion of the North Fork Mattole River is the border between the Oil Creek PW and the Rattlesnake Creek PW. This disconnect with hydrologic stream drainage systems is an artifact of the creation of CalWater 2.2a as a tool for managing forest lands in fairly consistent sized units. NCWAP conventions for describing watersheds are discussed below.

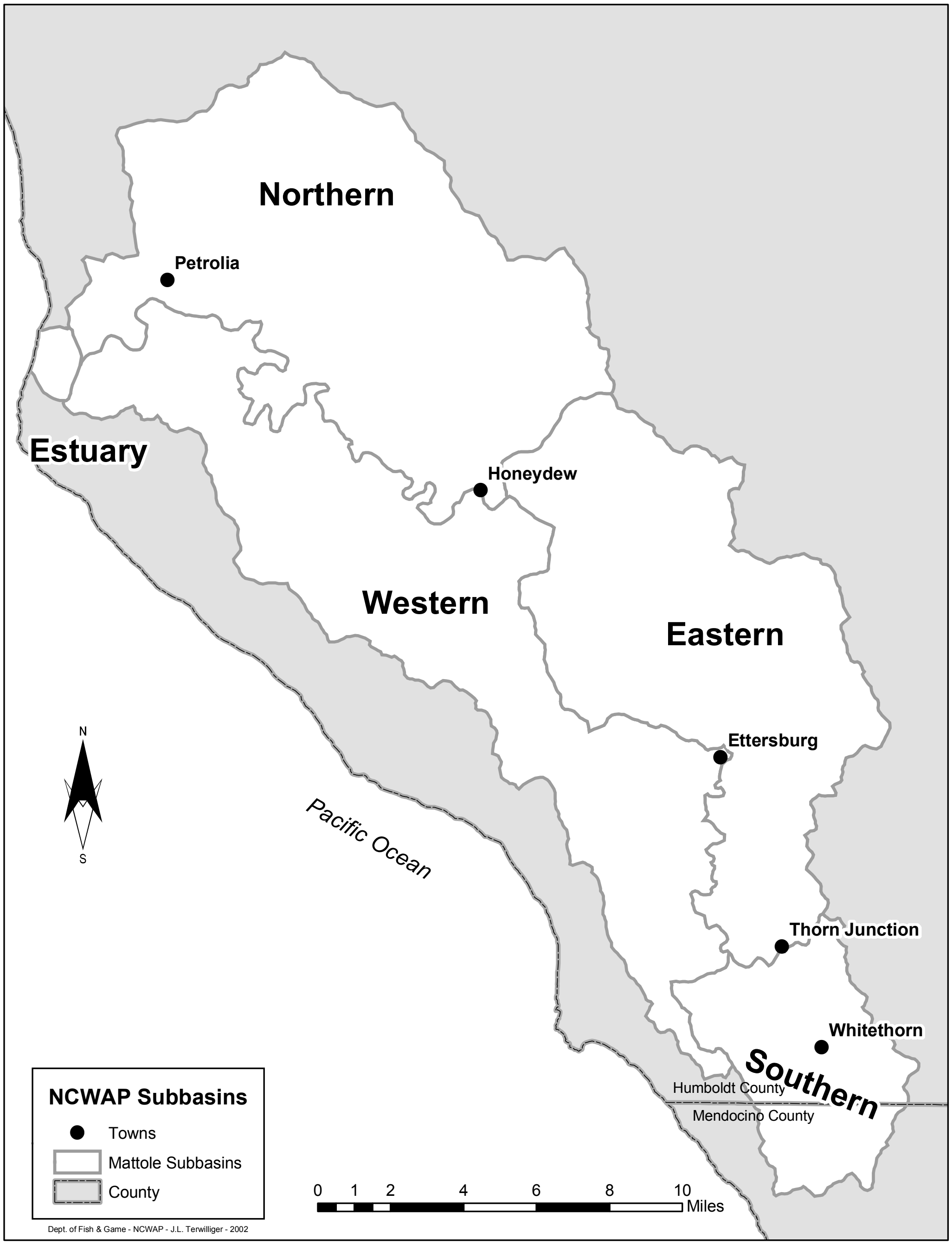


Figure 6. Mattole River subbasins.

Figure 7. NCWAP Mattole subbasins and CalWater 2.2a Planning Watersheds.

Hydrology Hierarchy

Watershed terminology often becomes confusing when discussing different scales of watersheds involved in planning and assessment activities. The conventions used in the Mattole Basin assessment follow guidelines established by the Pacific Rivers Council. The descending order of scale is from *basin* level (e.g., Mattole Basin) – *subbasin* level (e.g., Western Subbasin) – *watershed* level (e.g., Honeydew Creek) – *sub-watershed* level (e.g., Bear Trap Creek) (Figure 8).

The subbasin is the assessment and planning scale used in this report as a summary framework; subbasin findings and recommendations are based upon the more specific watershed and sub-watershed level findings. Therefore, there are usually exceptions at the finer scales to subbasin findings and recommendations. Thus, findings and recommendations at the subbasin level are somewhat more generalized than at the watershed and sub-watershed scales. In like manner, subbasin findings and recommendations are somewhat more specific than the even more generalized, larger scale basin level findings and recommendations that are based upon a group of subbasins.

The term watershed is used in both the generic sense, as to describe watershed conditions at any scale, and as a particular term to describe the *watershed* scale introduced above, which contains, and is made up from multiple, smaller sub-watersheds. The watershed scale is often approximately 20 – 40 square miles in area; its sub-watersheds can be much smaller in area, but for our purposes contain at least one perennial, un-branched stream. Please be aware of this multiple usage of the term watershed, and consider the context of the term's usage to reduce confusion.

Another important watershed term is river mile (RM). River mile refers to a point that is a specific number of miles upstream from the mouth of a river. In this report, RM is used to differentiate between different points along the Mattole River. For example, there are three Mill Creeks in the Mattole Basin. One at RM 2.8, one at RM 5.5, and one at RM 56.2.

Electronic Data Conventions

The NCWAP collected or created thousands of data records for synthesis and analysis purposes and most of these data were either created in a spatial context or converted to a spatial format. Effective use of these data between the five partner departments required establishing standards for data format, storage, management, and dissemination. Early in the assessment process, we held a series of meetings designed to gain consensus on a common format for the often widely disparate data systems within each department. Our objective was to establish standards which could be used easily by each department, that were most useful and powerful for selected analysis, and would be most compatible with standards used by potential private and public sector stakeholders.

As a result, we agreed that spatial data used in NCWAP and base information disseminated to the public through the program would be in the following format (see the data catalog at the end of this report for a complete description of data sources and scale):

Data form: standard database format usually associated with a GIS shapefile© (ESRI) or coverage. Data were organized by watershed and distributed among watershed synthesis teams. Electronic images were retained in their current format.

Spatial Data Projection: spatial data were projected from their native format to both Teale albers, North American Datum (NAD) 1927 and Universal Transverse Mercator (UTM), Zone 10, NAD 1983. Both formats were used in data analysis and synthesis.

Scale: most data were created and analyzed at 1:24000 scale to (1) match the minimum analysis scale for planning watersheds, and (2) coincide with base information (e.g., stream networks) on USGS quadrangle maps (used as Digital Raster Graphics [DRG]).

Data Sources: data were obtained from a variety of sources including spatial data libraries with partner departments or were created by manually digitizing from 1:24000 DRG.

The metadata available for each spatial data set contain a complete description of how data were collected and attributed for use in NCWAP. Spatial data sets that formed the foundation of most analysis included the 1:24000 hydrography and the 10 meter scale Digital Elevation Models (DEM). Hydrography data were created by manually digitizing from a series of 1:24000 DRG then attributing with direction, routing, and distance information using a dynamic segmentation process (for more information, please see http://arconline.esri.com/arconline/whitepapers/ao/ArcGIS8.1.pdf). The resulting routed hydrography allowed for precise alignment and display of stream habitat data and other information along the stream network. The DEM was created from base contour data obtained from the USGS for the entire NCWAP region.

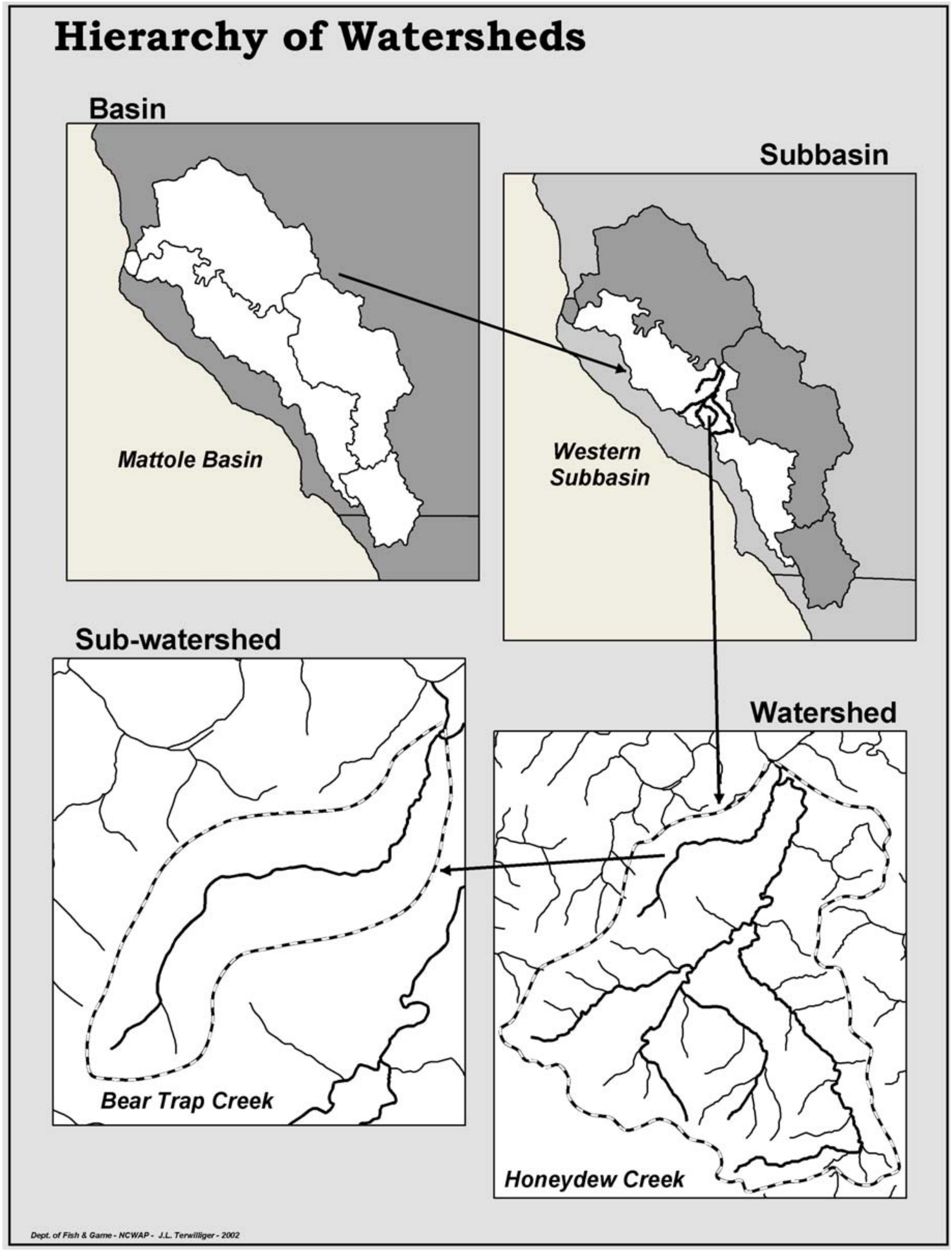


Figure 8. Watershed hierarchy.

Source spatial data were often clipped to watershed, planning watershed, and subbasin units prior to use in analysis. Analysis often included creation of summary tables, tabulating areas, intersecting data based on selected attributes, or creation of derivative data based on analytical criteria. For more information regarding the approach to analysis and basis for selected analytical methods, see Chapter 2, Assessment Strategy and General Methods, and Chapter 4, Interdisciplinary Synthesis and Findings.

Methods by Department

Hydrologic Analyses

Precipitation

The California Department of Water Resources (DWR) analyzed precipitation data for 12 gages with long-term periods of record within the Mattole Basin, summarizing and graphing gages, location, period of record, and annual, and maximum daily precipitation. Five of these gages were in operation longer than 20 years. There are another eight gages located within 10 miles of the watershed boundary. Details about this process are available in the DWR Appendix D.

Streamflow

DWR also analyzed streamflow data. Similar to other watersheds within the North Coast, only a few streamflow gaging stations have historically operated within the Mattole watershed. Only one gage, Mattole River near Petrolia, was operating at the end of water year 2000 and was scheduled to be discontinued due to budget reductions. Beginning in water year 2001, NCWAP began funding this stream. Only one streamflow gage, Mattole River near Petrolia, USGS station #11469000, operated for a significant period (November 1911 – December 1913 and October 1950 – present). This station is located approximately one mile upstream from the town of Petrolia on the main stem of the Mattole River and measures the runoff from 245 or 81% of the total 304 square mile Mattole River watershed.

To gain additional streamflow data, another gage was installed for NCWAP in June 2001 on the Mattole River near Ettersburg in the upper portion of the watershed. The gage will measure the discharge from 58 or 19% of the entire 304 square mile Mattole River watershed. The new gage was also equipped with a temperature sensor. Installation of the new gage by DWR and the USGS was completed in June 2000. The USGS operated the gage during water year 2001and have provided preliminary data for stage, discharge, and water temperature.

Water stage and water quality time series data will be downloaded from the station data loggers, uploaded into a database, and reviewed and edited for accuracy on a monthly basis. Time series streamflow data will be determined by correlating the direct discharge measurements with the simultaneous water stage data. This stage vs. discharge relationship or rating curve will be applied to the stage recordings from the station's stage sensor and data logger to compute streamflow for the same time series interval as water stage, normally every 15 minutes.

Once the rating curves are developed, real-time flow data will be provided over the Internet via the California Data Exchange Center (CDEC) website for those stations equipped with telemetry. Real-time telemetry also allows the station's operator to remotely monitor the operation of the station allowing a timely response to station malfunctions. Real-time data is not reviewed and edited for inaccuracies such as telemetry transmission error, sensor drift or malfunction, or discharge rating curve shift and is considered preliminary and subject to revision. The reviewed and finalized data for the October through September water year will usually be available about three to six months after the end of the water year.

DWR provided information about new and discontinued streamflow gaging stations on location, flow data type, and period of record in DWR Appendix D.

Water Rights

California law recognizes surface and groundwater rights, the latter with few exceptions not being subject to California law. The two predominate types of water rights within the Mattole Basin are riparian and appropriative. No State permit is required for a riparian water right; however, current water appropriation requires a permit which establishes a record. The appendix provides a more detailed discussion of water rights law, history, and application processes.

DWR searched the California State Water Resources Control Board's (SWRCB) Water Right Information System (WRIMS) to determine the number and types of water rights within the Mattole Basin. The WRIMS database is under development and may not contain all post-1914 appropriative water right applications that are on file with the CSWRCB at this time. Some pre-1914 and riparian water rights are also contained in the WRIMS database for those water rights whose users have filed a "Statement of Water

Diversion and Use." A list of water rights and associated information contained within WRIMS for the Mattole Basin is presented in DWR Appendix D.

CDWR also estimated municipal water use based on 1986 land and water use surveys by its Statewide Planning Program, coupled with delineations of cultivated agricultural lands from 1997 aerial photographs. To determine current potential water use by the permanent population of the Mattole watershed, DFG personnel compiled Year 2000 population census data, then applied unit per capita water use factors from the American Water Works Association and the EPA.

Geologic Analyses

Geologic Base Map

The geologic base map (see Plate 1 of Geologic Report, Appendix A) for the Mattole watershed was compiled from a digital version of a previously published-map, interpretation of aerial photographs, and limited field checking where access was available. The map shows the spatial distribution of major geologic units and geologic structures, and describes the general rock types. Most of the bedrock geology was modified from digital version 1.0 of the 1:100,000-scale geologic map MF-2336 (McLaughlin and others, 2000) published by the USGS that covers the portion of the watershed within Humboldt County. Photointerpretive mapping of black-and-white aerial photos (WAC, 2000) was performed by CGS staff to extrapolate bedrock map units and structural elements from the MF-2336 map to cover the southernmost portion of the watershed, located within Mendocino County. It is important to note that although the bedrock geology of MF-2336 has been presented herein at a scale of 1:24,000, the detail and accuracy of the data is limited to the spatial resolution of 1:100,000 scale in which the digital database was originally compiled by the USGS. Mapped landslide deposits, alluvium, and terrace deposits included in the USGS MF-2336 geospatial database were replaced by more detailed mapping of landslides and Quaternary units performed for this and previous CGS studies.

Assessment of Landslides and Geomorphic Features

CGS developed detailed information on landslide and geomorphic features and compiled them into a GIS database, which forms the keystone of its NCWAP work. Mapped landslides were separated into multiple GIS data layers based on activity (historically active or dormant) and the photo set from which the landslide was mapped. Landslides too small to capture as polygons (below the minimum mapping unit of approximately 100 feet in diameter) were captured as lines or points. The majority of the landslide and geomorphic mapping was accomplished through analysis of stereo-paired aerial photographs from 1984 and 2000 using a mirrored stereoscope. Due to better photo quality and smaller scale, landslides were first mapped on the 2000 photos. The 1984 photos were then examined to determine whether additional landslides could be located and whether a given slide appeared larger or smaller. If a historically active landslide observed on the 1984 photos appeared to be the same as was mapped from the 2000 photos, it was not re-digitized into the 1984 layer. Thus, the 1984 layer does not include all the landslides observed in these photos, but only those that were not observed in the 2000 photos, or appeared to differ significantly between the two sets of photos. Debris slide slopes and inner gorges were mapped using the 2000 photos; re-mapping of these features on 1984 photos was not needed, since the geomorphic features are not expected to have changed significantly during that time period.

Additional aerial photographs (USDA, 1965; DOD, 1940/1942) that had been scanned and placed on compact disks were provided to us late in the photo-assessment stage. These images were used in select locations to verify or disprove hypotheses on the presence, age, and/or confidence of interpretation of landslide-related features. Finally, data from the previous CGS watershed mapping program was incorporated into the NCWAP program database.

The terminology used in this document to describe landslide types and geomorphic features related to landsliding was updated from DMG Note 50. The terminology and language is derived from the previous Watersheds Mapping program conducted by DMG in the early 1980s. Our nomenclature is consistent with that presented in Cruden and Varnes (1996), and our mapping protocols and assessment of activity follows that proposed by Keaton and DeGraff (1996). Protocols used to assign landslide type and activity are described further below.

Rockslide

Rockslides were referred to in previous CGS publications as translational/rotational landslides. This slide type is characterized by a somewhat cohesive slide mass and a failure plane that is relatively deep-seated when compared to that of a debris slide of similar areal extent. The sense of the motion is linear in the case of a translational slide, and is arcuate or rotational in the case of the rotational slide (i.e., slump). Complex versions involving rotational heads with translation or earthflow downslope are common.

Earthflow

An earthflow results from slow to rapid flowage of saturated rock, soil, and debris in a semi-viscous, highly-plastic state. Typically composed of clay-rich materials that swell and loose much of their already-low shear strength when wet, slide materials erode easily, resulting in gullying and irregular drainage patterns. The irregular, hummocky ground characteristic of earthflows is generally free of conifers; grasslands and meadows predominate. Failures commonly occur on slopes that are gentle to moderate, although they may also occur on steeper slopes where vegetation has been removed.

Debris Slide

A debris slide is characterized by weathered and fractured rock, colluvium, and soil that moves downslope along a relatively shallow translational failure plane. Debris slides form steep, unvegetated scars in the head region and irregular, hummocky deposits (when present) in the toe region. Debris slide scars are likely to ravel and remain unvegetated for many years. Revegetated scars can be recognized by the even-faceted nature of the slope, steepness of the slope, and the light bulb-shaped form left by many mid- and upper-slope failures.

Debris Flow

A debris flow is a mass of coarse-grained soil that flows downslope as a slurry. Material involved is commonly a loose combination of surficial deposits, rock fragments, and vegetation. High pore water pressures, typically following intense rain, cause the soil and weathered rock to rapidly lose strength and flow downslope. Debris flows commonly begin as a slide of a shallow mass of soil and weathered rock. Their most distinctive landform is the scar left by the original shallow slide. In many cases debris flows leave a linear scar called a torrent track.

Disrupted Ground

The disrupted ground designation is used to capture areas with a hummocky ground surface caused by multiple landslides, possibly of different types of movement, with individual features too numerous and/or too small to delineate at map scale. This classification is also applied to areas that appear disturbed, but where the ground disturbance cannot be positively attributed to specific landslide types or processes, and may include areas affected by downslope creep, differential erosion, and/or expansive soils. Boundaries are typically indistinct, and activity levels may vary throughout the slope. These features are most often mapped in clay-rich, mélange bedrock units.

Debris Slide Slope

Debris slide slopes are geomorphic features characterized by steep, usually well-vegetated slopes that appear to have been sculpted by numerous debris slides and debris flows. Upper reaches (source areas) of these slopes are often tightly concave and very steep. Soil and colluvium atop bedrock may be disrupted by active debris slides and debris flows. Slopes near the angle of repose may be relatively stable except where weak bedding planes, bedrock joints, and fractures parallel the slope.

Inner Gorge

An inner gorge is a geomorphic feature formed by coalescing scars originating from landsliding and erosional processes caused by active stream erosion. The feature is identified as that area of stream bank situated immediately adjacent to the stream channel, having a side slope of generally over 65%, and being situated below the first break in slope above the stream channel. Inner gorges were identified from the 2000 air photos based on breaks in slope or active zones of debris sliding along stream channels. Where map scale permitted, inner gorges were mapped on each bank if appropriate; where the inner gorge was too narrow to differentiate the separate banks at 1:24,000 scale, a single symbol was drawn along the stream channel.

Gullies

Gullies are erosional channels produced by running water in earth or unconsolidated material. The channels usually carry water only during and immediately after heavy rains. They generally have steep sides and near-vertical headcuts, which are generally unvegetated. Gullies typically increase in size by surface flow concentrated near the gully's head, and by subsurface flow undercutting the head scarp or the gully walls.

Landslide Attributes

A variety of landside attributes were evaluated as part of the landside mapping process for NCWAP, with the findings incorporated into the GIS database. These attributes include landslide type, confidence of interpretation, relative age of the feature, thickness, whether material was delivered directly to a watercourse, and whether features such as roads, timber harvests, or stream undercutting were observed in the immediate vicinity of the landslide. The interpretation of landslide activity and the level of confidence in the actual existence of mapped landslides are discussed further below.

Activity

Under NCWAP, landslides were categorized as historically active or dormant. In some cases, dormant landslides were further subdivided. The recency of movement was assessed based on the apparent freshness of features, as outlined in Keaton and DeGraff (1996), with a slight modification to accommodate the lack of man-made structures in much of the Mattole study area. Landslide activity was noted because those landslides that have moved recently are considered more likely to remobilize in the future, as well as to have had some influence on local stream conditions. Activity criteria were not applied to geomorphic features (debris slide slopes, inner gorges, and disrupted ground).

Historically-active slides include those believed to have moved within the last 100 to 150 years, based primarily on observations from the aerial photographs. Historically-active rock slides and earthflows typically have crisp or sharp scarps and lateral flanks, the internal portions of the slide have undrained, hummocky topography, vegetation is typically absent on the lateral and main scarps, and toes are clearly present and well-defined, often pushing out into streams or alluvial flats. Debris slides and debris flow/torrent tracks are considered historically active when recognizable, as are gullies.

Dormant slides are categorized as young, mature, or old. Landslide-related features are still clearly recognizable in dormant-young slides, but some features may appear to have been softened by stream and/or weathering activities. Drainages are just becoming established along the lateral margins of the slide mass. Dormant-mature landslide features are typically recognizable, but have been "smoothed over" significantly, with drainages being incised into the body of the slide. Dormant-old landslides have been extensive modified by stream and/or weathering activities, often are heavily dissected internally, and occasionally other geologic features, such as terraces, can be observed within the slide area.

Confidence of Interpretation

Each mapped landslide is classified as definite, probable, or questionable. Confidence of interpretation is dependent on the distinctness of landforms, variations in vegetation, and other features indicative of landsliding that can be observed from aerial photos or in the field. The classification definite is applied where features common to landslides are clearly distinguishable, including, but not limited to, headwall scarps, ground cracks, pronounced toes, well-defined benches, closed depressions, displaced vegetation, springs, and irregular or hummocky topography. The classification probable is applied where the shapes of the landforms and their relative positions strongly suggest downslope movement, but other explanations are possible such as faulting. The classification questionable is typically applied to an area that lacks distinct landslide morphology, but may exhibit disrupted terrain or other abnormal features that vaguely to strongly imply the occurrence of mass movement.

Relative Landslide Potential

Once relevant relationships between geology and landsliding were recognized, a landslide-potential map was created, using the GIS as a tool to capture the geologists' interpretation of relative landslide potential within the watershed. The landslide-potential map was generated using a decision matrix (see Table 2 of the Geologic Report) prepared by CGS geologists. The matrix format is similar to, and the ranking criteria consistent with that developed for other watersheds within the NCWAP program and used in other CGS programs, but has been crafted to reflect conditions within the study area.

Elements considered, interpreted, and applied iteratively within the GIS by the geologists include: 1) the occurrence and distribution of historically-active and dormant landslides, debris slide slopes and disrupted ground; 2) actively-eroding areas such as inner gorges and gullies; 3) geologic conditions relative to steepness and observed behavior of slopes within the study area, and 4) Shalstab values (Deitrich and Montgomery, 1999) suggestive of additional potential debris flow source areas. Dependant on the nature of these elements, landslide potential was categorically assigned, ranging from 1 (very low) to 5 (very high). Where differing criteria resulted in a region being assigned different potential values, the highest ranking was used on the map.

The landslide-potential map was generated at a scale of 1:24,000, the same as the geologic and landslide-inventory map. Accordingly, local variations in landslide potential may exist at a site that are too small to capture at the map scale. Explanation of the five landslide potential categories are as follows:

- Category 1, **Very Low Landslide Potential:** Landslides and other features related to slope instability are very rare to non-existent within this area. This area includes relatively flat marine terraces, lower stream valleys, and flat-topped ridges within the moderate to hard terrains in the Mattole River Watershed.
- Category 2, **Low Landslide Potential:** Gentle to moderately steep slopes underlain by relatively competent material that is considered unlikely to mobilize as landslides under natural conditions. Landsliding in these areas is not common. This area generally includes the narrow flat-topped ridges and gentler side slopes in the hard and moderate terrains, gentler slopes and broad ridgetops within the soft terrain, and Quaternary units with gentler slopes.
- Category 3, **Moderate Landslide Potential:** Moderate to moderately steep, relatively uniform slopes that are generally underlain by competent bedrock, and may also include older dormant landslides. Some slopes within this area may be at or near their stability limits due to weaker materials, steeper slopes, or a combination of these factors. This area includes portions of dormant landsides with gentler slopes, flat-topped ridges within the soft terrain, many slopes in the moderate and hard terrains, and debris slide/flow source areas with moderate slope.
- Category 4, **High Landslide Potential:** Moderately steep to steep slopes that include many dormant landslides in upslope areas and slopes upon which there is substantial evidence of down slope creep of surface materials. This area includes many of the larger dormant rockslides and dormant old/mature earthflows, moderately steep to steep debris slide slopes, disrupted ground, moderate to moderately steep slopes in the soft terrain, steeper slopes within the moderate terrain, and historically active debris torrent tracks.
- Category 5, **Very High Landslide Potential:** Areas include historically active landslides (<150 years old), inner gorges, and gullies, as well as debris slide/flow source within soft terrain or on steep to very steep slopes. Dormant-young rockslides with very steep slopes and dormant-young earthflows with moderately steep to very steep slopes are also included.

Fluvial Geomorphic Analysis

A reconnaissance-level, fluvial-geomorphic study was made of the Mattole River watershed to document the geomorphic characteristics of streams and upland areas. Our assessment focused primarily on mapping specific stream features associated with sediment source, transport, and response (depositional) areas within the watershed (Investigation findings of the Geologic Appendix A). Fluvial-geomorphology data sets collected for this study were developed from observations of 1984 and 2000 aerial photographs that cover the entire watershed, and are described below. Older photographs were spot-checked in selected portions of the watershed to confirm interpretations.

Rosgen Channel Classification

Channel types were characterized within the study area using a reconnaissance-level interpretation based on Rosgen (1996) channel type. The Rosgen classification system uses three-dimensional properties (entrenchment ratio, width/depth ratio, and sinuosity) to distinguish between stream types (see detailed description in the Geologic Report). These properties are best determined by field measurements; however, for this study they were estimated from air photos and topographic base maps.

Rosgen stream type is further subdivided based on channel slope. For this study, the 10m DEM was used to code the stream drainage network for gradient based on Rosgen class gradient breaks (0.1%, 1%, 2%, 4%, and 10%). The final level of Rosgen classification, differentiating by channel materials, could not be estimated using air photos.

Mapped Channel Characteristics

Thirty-two types of stream characteristics (mapped channel characteristics; MCCs) were considered in the aerial photograph review, and added to the fluvial database where observed (Table 3). Channel characteristics are generally only visible when the channel canopy cover is sufficiently open to allow observation and observations are dependent on imagery scale and quality. Nevertheless, the use of aerial photo mapping of channel geomorphic characteristics taken at different times allows for documentation and detection of channel change. These mapped channel characteristics can be used in assessing relative channel changes, aid in delineation of areas for field studies and document channel associations with upland characteristics and processes. Fluvial geomorphic features mapped by aerial photo interpretation should be considered reconnaissance data.

Table 3. Database Dictionary for GIS Mapped Fluvial Geomorphic Attributes.

wc - wide channel	**ag – aggrading reach**
br – braided channel	**dg – degrading reach**
rf – riffle	**in – incised reach**
po – pool	ox – oxbow meander
fl – falls	ab – abandoned channel
uf – uniform flow	am – abandoned meander
tf – turbulent flow	**cc – cutoff chute**
bw – backwater reach	**tf – tributary fan**
pb - point bar	lj - log jam
lb - lateral bar	**ig - inner gorge**
mb – mid-channel bar	**el - eroding left bank (facing downstream)**
jb - bar at junction of channels	**er - eroding right bank (facing downstream)**
tb - transverse bar	**la - active landslide deposit**
vb - vegetated bar	**lo - older landslide deposit**
vp - partially vegetated bar	**dr – displaced riparian vegetation**
bc – blocked channel	ms – man-made structure

Note: Features in bold represent channel characteristics indicative of excess sediment in the channel.

Within the database, channel characteristics were listed in order of importance for influencing the stream channel. The primary characteristic field (Sed type 1 in the attribute fields) represents that channel characteristic best reflecting conditions observed throughout the mapped channel reach. The secondary characteristic fields (Sed type 2, 3 and 4 in the attribute fields), records channel characteristics also observed within the reach, if present, but they were considered to be of subordinate importance. Images of these mapped features are presented and described in the “Photographic Dictionary of Mapped Channel Characteristics” (Appendix 3 of the Geologic Report).

For the purpose of the EMDS watershed modeling exercise, some channel characteristics were considered indicators of excess sediment in storage (e.g., mid-channel bars), channel instability (e.g., eroding banks), or sediment sources that are less than optimum for fishery habitat. Those indicative of excess sediment production, transport, and/or response (deposition) are referred to as negative mapped channel characteristics (NMCCs) within this report and are shown in boldface type on Table 3. The EMDS modeling used only the “negative” characteristics in the primary data field characteristic (sed_type1) for relative ranking of watershed channel geomorphic conditions. While most of these features are always associated with increased sediment or impaired conditions, others, such as lateral bar, may or may not represent impairment. The actual fisheries habitat value should be determined through field surveys.

Vegetation

CalVeg2000 – California Department of Forestry and Fire Protection / United States Forest Service Remote Sensing Laboratory.

This land cover data was developed based on 1:24,000 aerial photograph interpretation of land cover (primarily vegetation) as the foundation for an automated, systematic processing of 1998 LANDSAT imagery. It is the only available data set that characterizes vegetation at the Mattole watershed scale. This data is still preliminary and is currently receiving an accuracy assessment that includes comparison to permanent inventory plots. Despite the lack of an accuracy assessment, it was used for this report because this update was specifically designed to increase accuracy in the life form, dominant tree size, and crown closure typing, all identified as weaknesses in the 1994 data set. The minimum mapping size is 2.5 acres for contrasting types and no minimum mapping size for lakes and conifer plantations. The minimum mapping size of 2.5 acres limits the use of this data to a general descriptor of vegetation type. In a forest vegetation type, this data does not register habitat attributes of low or occasional frequency such as large trees or snags that may play a vital role in large woody debris recruitment or wildlife habitat. It is also limited in selecting thin ribbons of higher canopy closure along streams or narrow tree and shrub ribbons of vegetation along streams in a grassland vegetation type although improving the ability to capture this characteristic is one of the objectives of this new data set. For the Mattole watershed, the percentage of area in the broad vegetation types essentially remained the same in both the 1994 and 1998 versions, the mixed forest category increased two percent while the herbaceous type decreased the same amount. The most noticeable difference between the two data sets is in tree vegetation size. The 1998 data set reduced the percentage of area in pole (6- 11 inch dbh) and large (>24 inch) tree sizes and increased the percentage in the small (11-24 inch dbh) tree size class.

Land Use

Timber Harvest History

CDF 1941 and 1954 aerial photograph interpretation:

Land use was delineated by placing transparent plastic sleeves directly over the photos and classifying land use change while viewing through a stereoscope. Categories that were delineated were fire, timber harvest, pasture, irrigated crops, orchard, buildings, and urban. Since this is a land use change classification, not all grassland or timberland was delineated or typed. While the full extent of many areas burned by fire could not be estimated, if the fire created a change in vegetation, it was recorded. For example, in 1941, many areas appeared to be burned as evidenced by standing dead trees. In some cases this was recorded as a permanent conversion, usually subjectively determined by proximity to existing grasslands, barns or other buildings, roads, and high fire intensity. This was recorded as a temporary conversion if the fire appeared to be far from existing roads and buildings, thus indicative of a wildfire, or if the fire intensity was low and left substantial tree cover.

Timber harvest activity was broken into silviculture and logging system categories using the closest approximation to the standard definitions. It was apparent that the early harvesting was often a conversion attempt. There is no way of knowing whether the trees removed were old- growth stands that were present prior to European-American settlement or if these were trees that had grown in due to changes in land-use practices between 1860 and 1941. In much of the tan-oak dominated forestland, individual tree crown diameters were often very large and seemed indicative of open growing conditions at some point in time perhaps, as a result of tan-oak bark harvesting or possibly of wildfire. These areas were not mapped since the canopy closure was high at the time of the photos and the cause could not be determined. In some instances trees had been removed or killed and the closest silvicultural category was used. In many of the 1941 photographs, there were no roads or skid trails visible and no logging system was recorded. Since trees were often girdled or burned on-site during this era, this seemed reasonable.

Minimum acreage mapped varied by land use classification. Crops and orchards were mapped when seen. It was assumed that fenced grassland was grazed. Area harvested and silvicultural treatments were the two most difficult categories. The large proportion amount of hardwood and brush was very apparent because there was often a lot of vegetative cover remaining after a harvest that removed most of the conifer. There were many pockets that looked lightly entered with skid trails, may have had a few trees removed, or were excluded from harvest because there was no conifer present. The resultant silviculture was highly variable in many instances. Seed tree removal step was delineated as the silvicultural system used when it appeared that the dominant conifer cover was removed, but considerable hardwood and/or brush remained. When the excluded areas were large relative to the adjacent harvested areas, they were also excluded from the harvest land use polygon.

Disturbance categories were broadly grouped into low, medium and high. Disturbance was based on potential sediment delivery to watercourses. High intensity fire areas, cultivated land and grazed areas immediately adjacent to streams or on steep slopes, and virtually all tractor logging during this time period were classified as high disturbance potential areas. Slides were not mapped although sometimes included as a comment.

The information from the mylar sleeves was inputted as polygon features into the ArcView GIS system by onscreen or "heads-up" digitizing (i.e., creating point, line, or polygon features in a mapping program without using georeferenced data; generally done using aerial photos, Digital Orthophoto Quads, or USGS topographical maps) using 1993 black and white orthographic quadrangles as the background. Distortion was corrected by using watercourses, ridges, and roads as reference indicators. The scale distortion apparent in the aerial photographs compared to the orthoquads during the heads-up digitizing was manually corrected by changing the scale of the orthoquad to match the area near the polygon to provide the best fit.

Recommendations

This data are similar to other aerial photograph interpretations of various types of land use. The aerial photos used appeared to be of the same age as the flight date. Many were faded and had hand-drawn line work on them from past projects. When using these data, it is important to note that timber harvesting is often used as a surrogate for a change in vegetation type, size, or density. In a general sense, this is true, but early harvesting did not follow the classic silvicultural methodology and even-aged harvests in particular varied widely in the application on the ground. Disturbance was based on potential sediment delivery to watercourses and was evaluated based on the project level. The harvest data in these layers were not included in the summary harvest tables because the data did not appear to closely match the Mattole Restoration Council Maps and acreage. There were many similarities and differences could be qualitatively adjusted, but the end result would have mixed numbers without providing advantages. The data are used to describe conditions as they appeared in the earliest basin-wide photographic record.

Harvest History 1940 Through 1984

Harvest history information up to 1978 is based on the Humboldt and Mendocino County Assessor maps prepared for tax purposes while harvest history between 1978 and 1984 was based on aerial photograph interpretation by MRC staff.

The Assessor maps and the information on them were used for tax assessments when both timberland and standing timber were assessed annually. The base maps were developed especially for Humboldt County and, while similar, the maps are not the equivalent of the USGS maps for the same area. The vegetation typing is based on 1960 aerial photograph interpretation work by the office of H. G. Chickering Jr., a consulting aerial photogrammetrist company based in Eugene, Oregon. Harvested timberland that had more than 70 percent of the commercial timber volume removed and thus not taxed was indicated by an "X." Grassland, not forested, brush, and tree vegetation type and size class information was provided based on 1960 data. The harvested areas in these maps were updated when harvesting removed standing timber from the tax rolls. This was recorded by manually delineating the areas on the map by dashed lines and an "X" with the harvest date. The typing was done by foresters who had local knowledge of the county. Silviculture and logging system type are not specified in the maps because it was common knowledge that the logged areas had at least 70 percent of the commercial conifer removed, thus similar to a shelterwood seed cut or clear-cut and tractor logging was the overwhelmingly dominant operating system. Despite the fact that these maps may under-estimate logged acreage, the maps indicate that most of the available timberland, approximately 93 percent, was harvested by 1983. While the maps were not identical to USGS maps, the digitized acreage for the entire Mattole watershed was within 1 percent. Harvest dates in the digitized maps were grouped into time categories by MRC staff.

CDF Northern Region Forest Practice GIS Timber Harvesting Plan Data 1983 to 2000 – Mattole Hydrologic Area

Spatial timber harvesting plan data are digitized into the GIS at a scale of 1:12,000 or better using the on-screen or "heads-up" digitizing method. Digital USGS 1:24,000 topographic quadrangles and USGS 24K DLGs (Digital Line Graphs) serve as base data layer. Timber harvesting plan data are derived from THP maps, amendments, and completion reports contained in the THP of record on file with the California of Forestry and Fire Protection in Santa Rosa, California. The USGS 24K DLG data is augmented with features derived from the THP of record. These records were updated by CDF-NCWAP staff to include all filed and approved NTMPs and completion dates.

The State of California and the Department of Forestry and Fire Protection make no representations or warranties regarding the accuracy of data or maps. Neither the State nor the Department shall be liable under any circumstances for any direct, special, incidental, or consequential damages with respect to any claim by any user or third party on account of or arising from the use of data or maps.

These records are not fitted to aerial photographs or orthoquads and may not be precise in location, but timber harvesting plan boundaries appeared to fit pretty well when qualitatively viewed with 1993 orthoquads and 2000 aerial photographs. As mentioned previously, one should be cautious about using silviculture as a surrogate for vegetative cover descriptions; some of the rehabilitation and seed tree removal step prescriptions were almost indistinguishable to the pre-harvest condition when viewing aerial photographs. The files are organized by the date of THP submittal. The time between plan submittal and actual harvest varies, often by several years. This time delay occurs for a variety of reasons including long THP review periods for controversial plans, litigation, and landowner attempts to harvest when the market is most favorable.

Road Networks

NCWAP Mattole Roads Layer

This roads layer was developed to provide additional information for the assessment of the Mattole Basin as part of the North Coast Watershed Assessment Program. Editing of existing roads layers consisted of at least partially spatially rectifying roads to the 1993 USGS Orthographic Quadrangles available as GIS images. Due to time restrictions, this was not completed, but roads adjacent to watercourses were the highest priority areas. This dataset was based on 1:24,000 for road segment spatial accuracy. This data set incorporates existing datasets and maps while also adding road segments digitized from 1993 USGS Orthographic quadrangles. The number of roads in this dataset underestimates the number of logging roads that have been constructed over the years in the Mattole watershed since many of the abandoned roads were not clearly visible. The number of miles of roads increased by one-third compared to previous watershed-wide data sets. Information describing road segments is partial and biased since some areas are more completely characterized than others due to the incorporation of existing datasets for portions of the watershed. While this data set contains the most comprehensive roads information for the watershed, it is still partial and may be useful for resource management or land use purposes. It does not contain addressing information used by emergency services.

Water Quality

Data Collection:

The North Coast Regional Water Quality Control Board staff in the NCWAP program, in cooperation with staff from the Surface Water Ambient Monitoring Program, and TMDL units, cooperated in collecting physical-chemical data and measurements during 2001 in the Mattole Basin. Sample collection, and analysis followed protocols described in the draft NCWAP Methods Manual and other procedures established by various entities, such as field sample collection guidelines developed by, and/or acceptable to the USEPA, USGS, Forest Science Project (FSP), and others.

Data Analysis and Presentation:

Gathered data were computerized into formats appropriate for the information, e.g., spreadsheets for dissolved oxygen, specific conductance, pH, temperature, sediment, etc. Analysis of the data is specific to the data type and its quality. Specific guidelines for temperature and sediment used in this report are outlined below and apply to all Mattole Subbasins where they are discussed. All of the data were reported in tables, point graphs, and/or a combination of the two depending on the data type.

Other sediment data were gleaned from previous efforts, particularly those of the Mattole Salmon Group, that included year 2000 residual pool filling, or V* (MSG, 2000). V* is the fraction (percent) of residual pool volume filled with fine sediment (silt, fine sand to small- to medium-gravel). It can be used as one of many indicators of the sediment supply and substrate habitat in gravel bed channels. It has proven to be a useful tool to evaluate and monitor stream channel conditions and determine upstream and upslope sediment sources (Knopp, 1993; Hilton and Lisle, 1993).

Temperature data were collected by the TMDL unit and analyzed by NCWAP Regional Water Board staff. The TMDL unit also contracted with a consultant to have aerial thermal infrared radar projections capable of assessing shade canopy and surface water temperatures, the results of which were available from the consultant and included in the Water Quality Appendix E. All temperature data gathered and analyzed followed currently accepted scientific protocols developed by the FSP (FSP, 1998). Summary temperature data was also provided by the MSG and was considered of high quality as it followed similar protocols developed by the FSP.

Temperature plots derived from maximum weekly average temperatures (MWATs) were also compared to the fully suitable range of conditions, between 50-60 °F (10-15.6 °C), that are agreed as optimal for various salmonid life stages. The 50-60 °F range was developed as an average of the needs of several cold water fish species, including coho salmon and steelhead trout (Armour, 1991, FSP, 1998). In addition, stream water temperature ranges of varying suitability to unsuitability above the 50-60 °F fully suitable MWAT range for salmonids were developed and referenced to specific reaches and streams by the NCWAP Team.

Peak temperatures were also derived and are also important to consider as they may reflect short-term thermal extremes that, unless salmonids are able to escape to cool water refugia, may be lethal to fish stocks. A temperature of 75 °F was used as the maximum critical peak temperature that the literature supports, above which death is usually imminent for most Pacific Coast salmonid species (Brungs and Jones, 1977; Sullivan, et al., 2000).

Fish Habitat and Populations

Data Compilation and Gap Identification

CDFG compiled existing available data and anecdotal information pertaining to salmonids and the instream habitat on the Mattole River and its tributaries and entered it into a database. Anecdotal and historic information was cross referenced with other existing data whenever possible, and rated for quality. Both were used when the information was of good quality and applicable. Instream habitat gaps were mapped and matched with corresponding land parcels. Where data gaps were identified, access was requested from landowners to conduct habitat inventory and electrofishing surveys.

Data Collection

Habitat inventories and biological data were collected following the protocol presented in the California Salmon Stream Habitat Restoration Manual (Flosi et al. 1998). Two-person crews trained in those methods conducted physical habitat inventories. Stream reaches were stratified based upon Rosgen channel types, and the habitat type and stream length determined for all habitat units within a survey reach.

The parameters measured were stream flow, channel type, temperature, fish habitat type, embeddedness (amount of fine sediment surrounding larger substrate particles) , shelter rating (habitat complexity based on elements such as overhanging banks, boulders, large woody debris, submerged vegetation, etc.), substrate composition (percent of different sizes), riparian canopy cover, bank composition, and bank vegetation. The data reflect instream conditions at the time of the survey.

During basin level habitat typing, full sampling of each habitat unit requires recording all characteristics of each habitat unit as per the "Instructions for completing the Habitat Inventory Data Form" (Part III). It was determined that similar stream descriptive detail could be accomplished with a sampling level of approximately 10 percent (Flosi et. al 1998).

When sampling 10% of the units all habitat types are measured when encountered for the first time. Thereafter, approximately 10 percent of the habitat units are randomly selected for measurement of all the physical parameters. The habitat unit type, mean length, mean width, mean depth, and maximum depth are determined for the other 90 percent of the units. Pool habitat types are also measured for, instream cover and embeddedness.

Streams were surveyed until the end of anadromy was determined. Crews based this judgment on the presence of physical barriers to fish passage, a steep gradient of 8-10%, or a dry section of the stream 1,000 feet or more in length.

Canopy cover, embeddedness, pool depth, pool frequency, and pool shelter/cover were reported in bar charts for each of the streams surveyed. Salmonid distribution in the Mattole Basin was obtained using the Modified Ten Pool Protocol (Preston et al. 2001) with Smith Root Model 12 backpack electro-fishing units on eight tributaries. The Ten Pool Protocol was designed to detect the presence of coho salmon and is not a valid method for calculating fish density or age class structure (personal communication, L. Preston).

Interdisciplinary Synthesis

Ecological Management Decision Support (EMDS)

The NCWAP has selected the Ecological Management Decision Support system (EMDS) (Reynolds 1999) software to help evaluate and synthesize information on watershed and stream conditions important to salmonids during the freshwater phases of their life history. The EMDS Appendix C describes the general workings of EMDS and the details of the models NCWAP is developing in conjunction with it.

NCWAP scientists have constructed knowledge base models to identify and evaluate environmental factors (e.g. watershed geology, stream sediment loading, stream temperature, land use activities, etc.) that shape anadromous salmonid habitat. Based upon these models, EMDS evaluates available data to provide insight into the conditions of the streams and watersheds for salmonids. The synthesis EMDS provides can then be compared to more direct measures of salmonid production—i.e., the number of salmonids recently found in streams. EMDS offers a number of benefits for the assessment work that NCWAP is conducting, and also has some known limitations. Both the advantages and drawbacks of EMDS are provided in some detail here and in the EMDS Appendix C.

Our use of the EMDS model outputs in this report is tentative. As discussed below, a scientific peer review process conducted in April of 2002 indicated that substantial changes to NCWAP's EMDS modeling approach are needed. At the time of the production of this report, we have been able to implement some, but not all of these recommendations. Hence, we use the model outputs with caution at this time. NCWAP will continue to work to refine and improve the EMDS model, based on peer review.

Details of the EMDS Model

EMDS system (Reynolds 1999), was developed at the USDA-Forest Service, Pacific Northwest Research Station. It employs a linked set of software that includes MS Excel, NetWeaver, the Ecological Management Decision Support (EMDS) ArcView Extension, and ArcView™. Microsoft Excel is a commonly used spreadsheet program for data storage and analysis. NetWeaver (Saunders and Miller (no date), developed at Pennsylvania State University, helps scientists build graphics of the models (knowledge base networks) that specify how the various environmental factors will be incorporated into an overall stream or watershed assessment. These networks resemble branching tree-like flow charts, and graphically show the logic and assumptions used in the assessment, and are used in conjunction with environmental data stored in a Geographic Information System (ArcView™) to perform the assessments and facilitate rendering the results into maps. This combination of software is currently being used for watershed and stream reach assessment within the federal lands included in the Northwest Forest Plan (NWFP).

NCWAP staff began development of EMDS knowledge base models with a three-day workshop in June of 2001 organized by the University of California, Berkeley. In addition to the NCWAP staff, model developer Dr. Keith Reynolds and several outside scientists also participated. As a starting point, NCWAP used an EMDS knowledge base model developed by the NWFP for use in coastal Oregon. Based upon the workshop, subsequent discussions among NCWAP staff and scientists, examination of the literature, and consideration of California conditions, NCWAP scientists then developed preliminary versions of the EMDS models. The first model was for assessing Stream Reach Condition, and the second was designed to assess conditions over the area of the Watershed Condition.

The two initial NCWAP models were reviewed over 2 days in April 2002 by an independent nine-member science panel, which provided a number of suggestions for model improvements. According to these suggestions, NCWAP scientists revised their EMDS models, as presented below.

The Knowledge Base Network

For California's north coast watersheds, the NCWAP team has constructed five knowledge base networks reflecting the best available scientific studies and information on how various environmental factors combine to affect anadromous fish on the north coast. All five models are geared to addressing current conditions (instream and watershed) for salmonids, and to reflect a fish's perspective of overall habitat conditions:

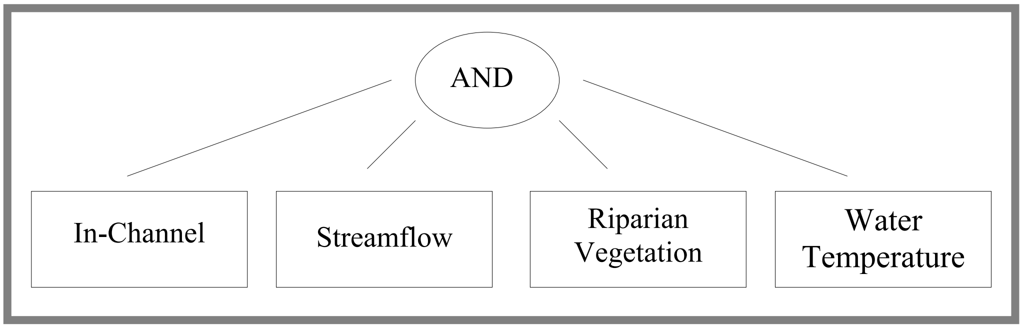
- The Stream Reach model (Figure 12, Table 4), addresses conditions for salmon on individual stream reaches and is largely based on data collected under the Department of Fish and Game's stream survey protocols;
- The Sediment Production model (Figure 11, Table 5), evaluates the magnitudes of the various sediment sources in the basin according to whether they are natural or management related;
- The Water Quality model (Figure 13) offers a means of assessing characteristics of instream water (flow and temperature) in relation to fish;
- The Fish Habitat Quality model (Figure 13) incorporates the Stream Reach model results in combination with data on accessibility to spawning fish and a synoptic view of the condition of riparian vegetation for shade and large woody debris;
- The Fish Food Availability model (Figure 13) has not yet been constructed, but will evaluate the watershed based upon conditions for producing food sources for anadromous salmonids.

In creating the EMDS models listed above, NCWAP scientists have used what is termed a top-down approach. This approach is perhaps best explained by way of example. The NCWAP Stream Reach Condition model began with the proposition: *The overall condition of the stream reach is suitable for maintaining healthy populations of native coho and Chinook salmon, and steelhead trout*. A knowledge base (network) model was then designed to evaluate the truth of that proposition, based upon data from each stream reach. The model design and contents reflect the specific information NCWAP scientists believe are needed, and the manner in which it should be combined, to test the proposition.

In evaluating stream reach conditions for salmonids, the NCWAP model uses data on several environmental factors. The first branching of the knowledge base network (Figure 9) shows that information on in-channel condition, stream flow, riparian vegetation and water temperature are all used as inputs in the stream reach condition model. In turn, each of the four branches is progressively broken into more basic data components that contribute to it (not shown). The process is repeated until the knowledge base network incorporates all information believed to be important to the evaluation.

Although model construction is typically done top-down, models are run in EMDS from the bottom up. That is, data on the stream reach is usually entered at the lowest branches of the network tree (the leaves), and then is combined progressively with other information as it proceeds up the network. Decision nodes are intersections in the model networks where two or more factors are combined before passing the resultant information on up the network. For example, the AND at the decision node in Figure 12 means that the lowest value of the four general factors coming in to the model at that point is taken to indicate the potential of the stream reach to sustain salmon populations.

Figure 9. EMDS stream reach knowledge base network.



EMDS models assess the degree of truth (or falsehood) of each model proposition. Each proposition is evaluated in reference to simple graphs called reference curves that determine its degree of truth/falsehood, according to the data's implications for salmon. Figure 10 shows an example reference curve for the proposition *is the stream temperature is suitable for salmon*. The horizontal axis shows temperature in degrees Fahrenheit, while the vertical is labeled Truth Value and ranges from – 1 to +1. The line shows what are fully unsuitable temperatures (-1), fully suitable temperatures (+1) and those that are in-between (> -1 and <+1). In this way, a similar numeric relation is required for all propositions evaluated in the EMDS models.

For each evaluated proposition in the EMDS model network, the result is a number between –1 and +1. The number relates to the degree to which the data support or refute the proposition. In all cases a value of +1 means that the proposition is completely true, and –1 implies that it is completely false, while in-between values indicate degrees of truth (i.e. values approaching +1 being closer to true and those approaching –1 converging on completely untrue). A zero value means that the proposition cannot be evaluated based upon the data available. Breakpoints (where the slope of the reference curve changes) in Figure 10 example occur at 45°, 50°, 60° and 68 °F. For the Stream Reach model, NCWAP fisheries biologists determined these temperatures by a review of the scientific literature.

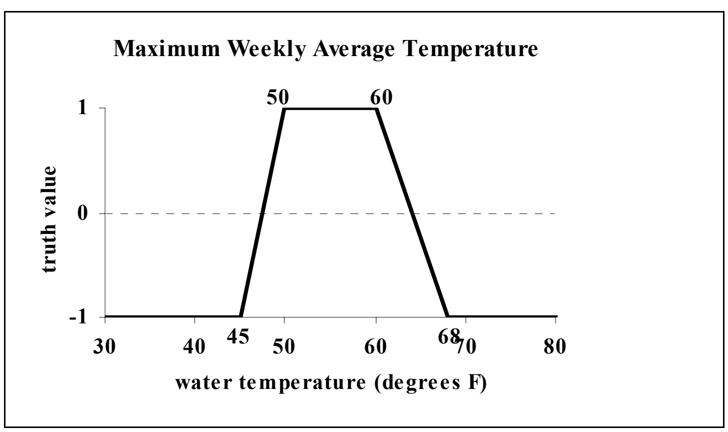


Figure 10. EMDS reference curve.

EMDS uses this type of reference curve in conjunction with data specific to a stream reach. This example curve evaluates the proposition that the stream's water temperature is suitable for salmonids. Break points can be set for specific species, life stage, or season of the year. Curves are dependent upon the availability of data.

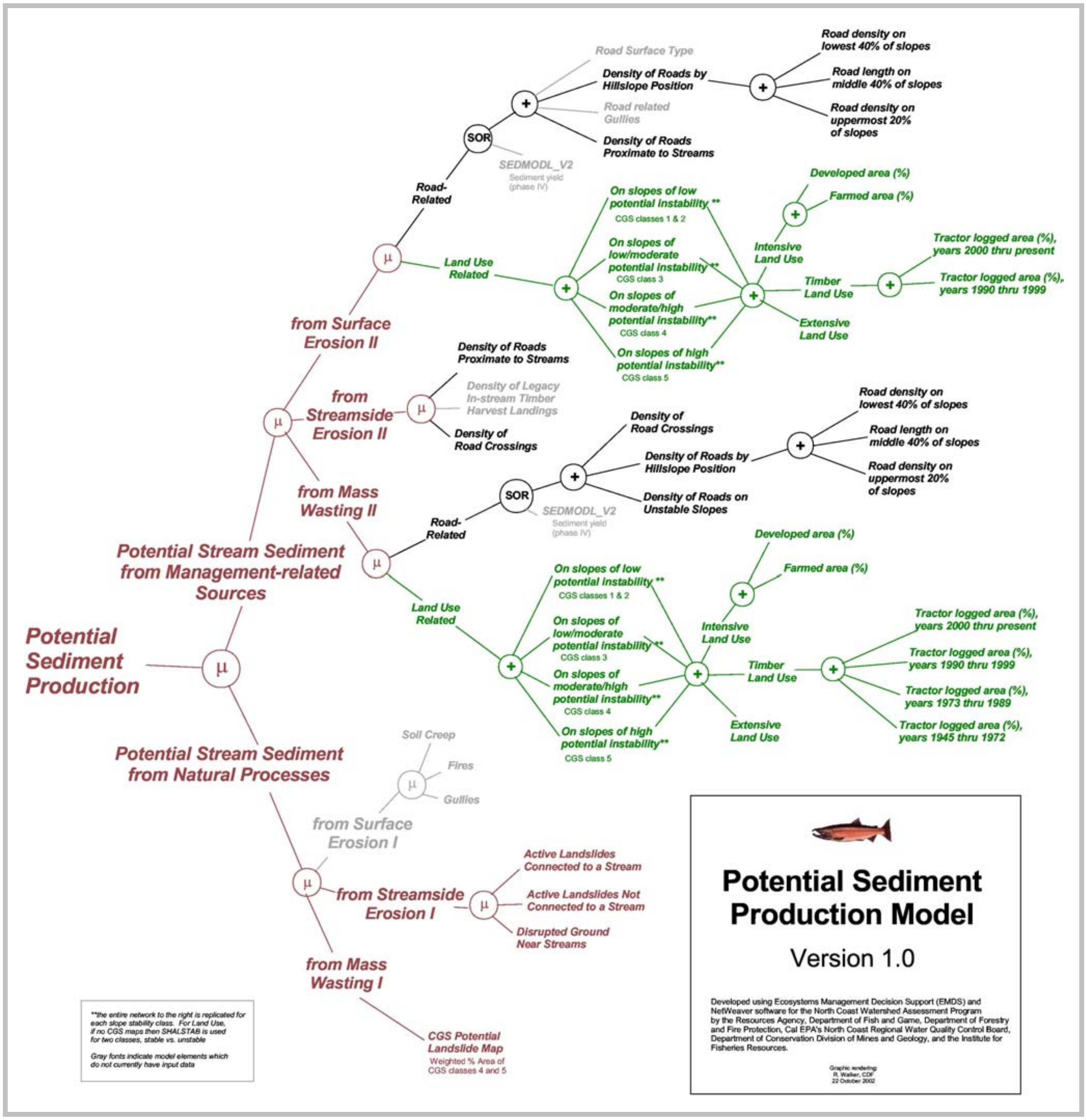


Figure 11. NCWAP EMDS potential sediment production model.

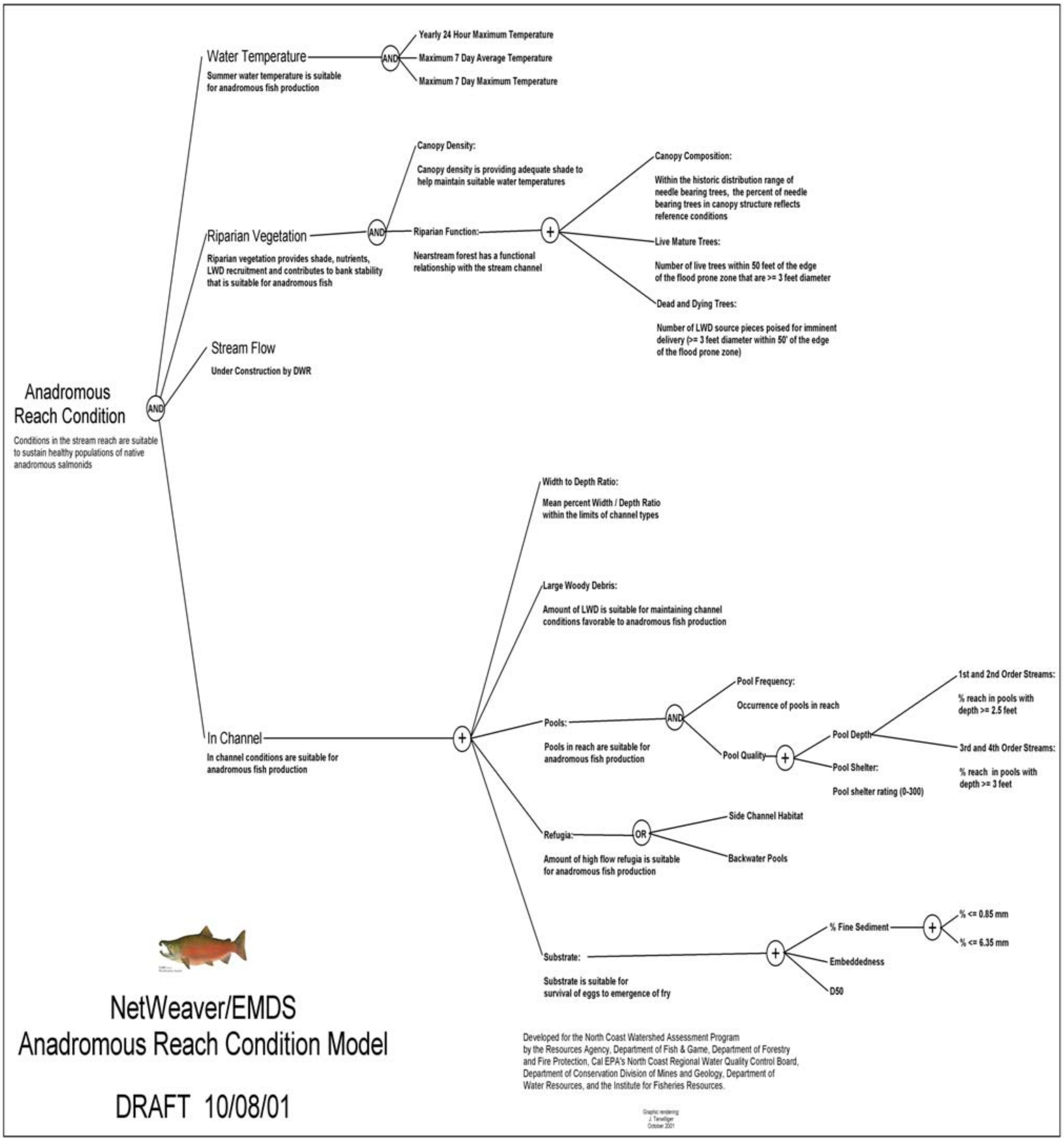


Figure 12. NCWAP EMDS anadromous reach condition model.

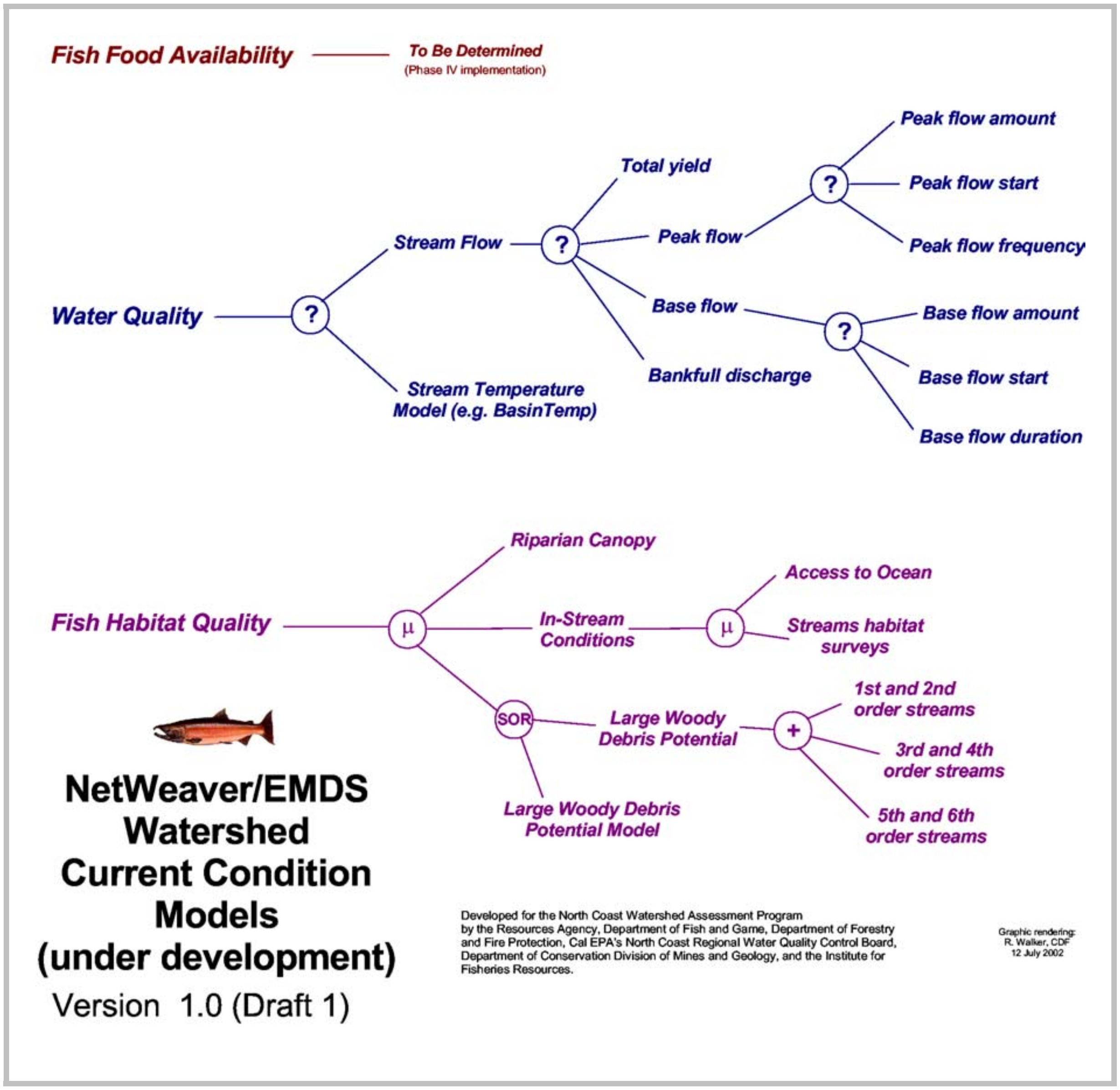


Figure 13. NCWAP EMDS fish food availability, water quality, and fish habitat quality models

Note: None of these models has yet been implemented. This graphic shows their current states of development.

For many NCWAP parameters, particularly those relating to upland geology and management activities, no scientific literature is available to assist in determining breakpoints. Because of this, the NCWAP has had little alternative but to use a more empirically based approach for breakpoints. Specifically, for each evaluated parameter, the mean and standard deviation are computed for all planning watersheds in a basin. Breakpoints are then selected to rank each planning watershed for that parameter in relation to all others in the basin. We used a simple linear approximation of the standardized cumulative distribution function, with the 10th and 90th percentiles serving as the low and high breakpoints (Figure 14). Thus, the truth values for all Potential Sediment Production model variables are relative measures directly related to the percentile rank of that planning watershed. While these relative rankings are not comparable outside of the context of the basin, they do provide an indication of relative conditions within the basin.

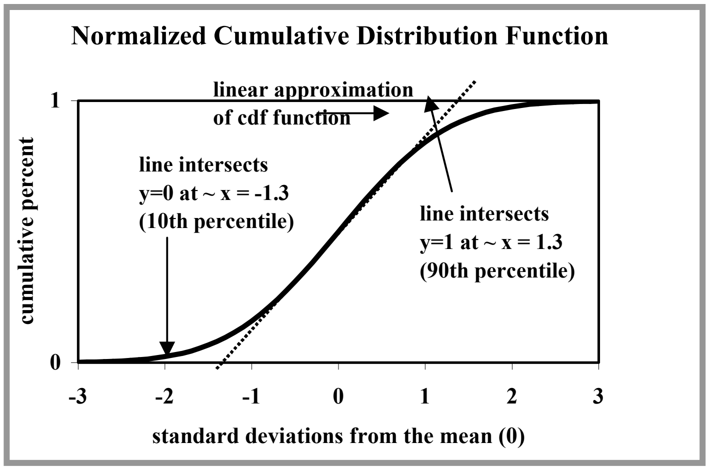


Figure 14. Normalized cumulative distribution function.

Using the 10th and 90th percentiles as breakpoints (as with Land Use) is a linear approximation of the central part of the normalized cumulative distribution function

The science review panel recommended that this method developed by NCWAP scientists be changed. They advised the use of a set of reference watersheds from the region, computing the distributions of land use and other parameters from those watersheds to determine breakpoints. At this point, NCWAP staff have not had the resources to select the reference watersheds, nor to process the data for them. This issue will be addressed in future watershed assessments and the breakpoints adjusted as the information from reference watersheds becomes available.

NCWAP map legends use a seven-class system for depicting the EMDS truth-values. Values of +1 are classed as the highest suitability; values of –1 are classed as the lowest suitability; and values of 0 are undetermined. Between 0 and 1 are two classes which, although unlabeled in the legend, indicate intermediate values of better suitability (0 to 0.5; and 0.5 to 1). Symmetrically, between 0 and –1 are two similar classes which are intermediate values of worse suitability (0 to –0.5; and –0.5 to –1).

In EMDS, the data that are fed into the knowledge base models come from GIS layers stored and displayed in ArcView. Thus, EMDS is able to readily incorporate many of the GIS data layers developed for the program into the watershed condition syntheses. Figure 15 portrays an example map of EMDS results. Reference curves are used in the NCWAP's Current EMDS Models.

The following tables summarize important EMDS model information. More technical details and justification for each parameter are supplied in the EMDS Appendix C.

- The Stream Reach Condition model. Parameter definition and breakpoints for this model (shown in Table 4) are based upon reviews of the scientific literature;
- The Sediment Production Risk model. Parameter definitions and respective weights are shown in Table 5. Parameters currently not being used in the model for lack of data are noted in the table. All breakpoints for this model are determined empirically (i.e. based upon percentiles of the data distribution, Figure 14), due to the use of parameters that have no equivalents nor surrogates in the scientific literature;
- The Fish Habitat Quality model. This model is still in early stages of development. It will incorporate the results of the Stream Reach model, and breakpoints will be based upon the scientific literature of properly functioning reference watersheds;
- The Water Quality model. This model is also under development. Water temperature will be modeled with software such as Stillwater Sciences' BasinTemp. Methods for modeling flow parameters have not yet been determined;
- The Fish Food Availability model. Recommended by the science panel review, this model has yet to be designed and implemented by the NCWAP.

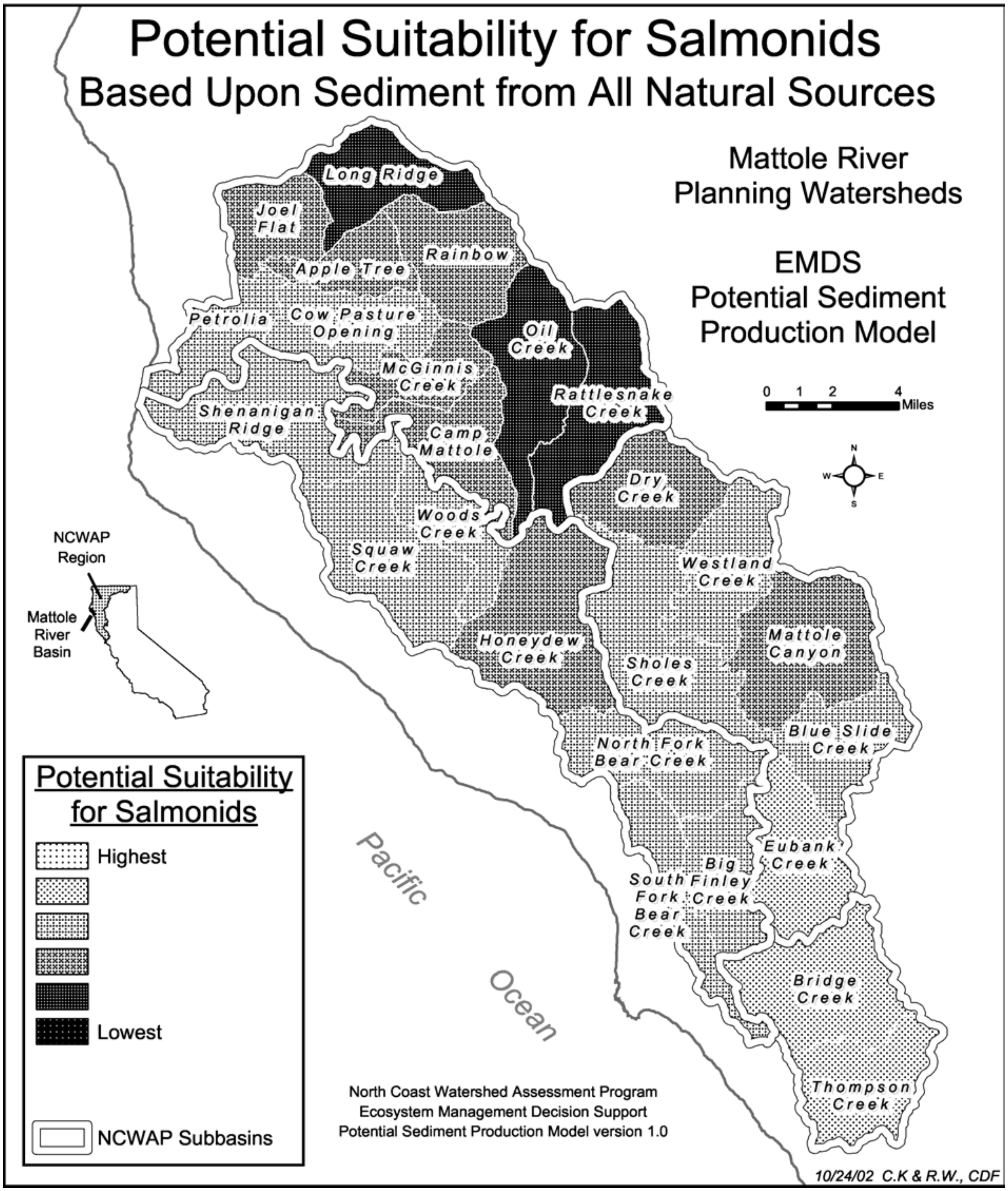


Figure 15. EMDS graphical output.

This example illustrates the graphical outputs of an EMDS run. This demonstration graphically portrays the relative amounts of potential sediment production in the Mattole Basin that comes from natural sources.

Table 4. Reference curve metrics for EMDS stream reach condition model.

Stream Reach Condition Factor	Definition and Reference Curve Metrics
Water Temperature	
Summer MWAT	Maximum 7-day average summer water temperature <45° F fully unsuitable, 50° -60° F fully suitable, >68° F fully unsuitable. Water temperature was not included in current EMDS evaluation.
Riparian Function	
Canopy Density	Average percent of the thalweg within a stream reach influenced by tree canopy. <50% fully unsuitable, ≥85% fully suitable.
Seral Stage	Under development
Vegetation Type	Under development
Stream Flow	Under development
In-Channel Conditions	
Pool Depth	Percent of stream reach with pools of a maximum depth of 2.5, 3, and 4 feet deep for first and second, third, and fourth order streams respectively. ≤20% fully unsuitable, 30 – 55% fully suitable, ≥90% fully unsuitable
Pool Shelter Complexity	Relative measure of quantity and composition of large woody debris, root wads, boulders, undercut banks, bubble curtain, overhanging and instream vegetation. ≤30 fully unsuitable, ≥100 - 300 fully suitable
Pool frequency	Under development
Substrate Embeddedness	Pool tail embeddedness is a measure of the percent of small cobbles (2.5" to 5" in diameter) buried in fine sediments. EMDS calculates categorical embeddedness data to produce evaluation scores between –1 and +1. The proposition is fully true if evaluation sores are 0.8 or greater and -0.8 evaluate to fully false
Percent fines in substrate <0.85mm (dry weight)	Percent of fine sized particles <0.85 mm collected from McNeil type samples. <10% fully suitable, > 15% fully unsuitable. There was not enough of percent fines data to use Percent fines in EMDS evaluations
Percent fines in substrate < 6.4 mm	Percent of fine sized particles <6.4 mm collected from McNeil type samples. <15% fully suitable, >30% fully unsuitable. There was not enough of percent fines data to use Percent fines in EMDS evaluations
Large Woody Debris (lwd)	The reference values for frequency and volume is derived from Bilby and Ward (1989) and is dependent on channel size. See EMDS Appendix C for details. Most watersheds do not have sufficient lwd surveys for use in EMDS.
Refugia Habitat	Refugia is composed of backwater pools and side channel habitats and deep pools (>4 feet deep). Not implemented at this time.
Pool to Riffle Ratio	Under development
Width to Depth Ratio	Under development

Table 5. Reference curve metrics for EMDS sediment production risk model, version 1.0.

Sediment Production Factor	Definition*	Weights**
Total Sediment Production	The mean truth value from Natural Processes and Management-related Processes	
Natural Processes	The mean truth value from Mass Wasting I, Surface Erosion I, and Streamside Erosion I knowledge base networks	0.5
Mass Wasting I	The mean truth value from natural mass wasting: Landslide Potential, Deep-seated Landslides, and Earth Flows	0.33
Landslide Potential	A selective OR (SOR) node takes the best available data to determine landslide mass wasting potential.	1.0
CGS Landslide Potential Map	(1st choice of SOR node) Percentage area of planning watershed in the landslide potential categories (4 and 5)	1.0
Landslide Potential Class 5	Percentage area of watershed in class 5 (CGS rating)	0.8
Landslide Potential Class 4	Percentage area of watershed in class 4 (CGS rating)	0.2
Probabilistic Landslide Model	(2nd choice of SOR node) Where option 1 is missing, the Probabilistic Landslide Model is used to calculate area of planning watershed with unstable slopes	1.0
SHALSTAB	(3rd choice of SOR node) Where options 1 and 2 are missing, SHALSTAB model is used to calculate area of planning watershed with unstable slopes	1.0

Sediment Production Factor	Definition*	Weights**
Surface Erosion I	The mean truth value from natural processes of surface erosion: Gullies, Soil Creep, and Fires	0.33
Gullies	Density of natural gullies in planning watershed (currently no data supplied to model here)	0.33
Soil Creep	Percentage area of planning watershed with soil creep (currently no data supplied to model here)	0.33
Fires	Percentage area of planning watershed with high fire potential (currently no data supplied to model here)	0.33
Streamside Erosion I	The mean truth value from natural processes of streamside erosion: Active Landslides Connected to Watercourses; Active Landslides Not Connected to Watercourses; Disrupted Ground Near Watercourses	0.33
Bank Erosion	Percentage of stream length in planning watershed with bank erosion	0.33
Inner Gorge Landslides	Percentage of stream length in planning watershed with inner gorge landslides	0.33
Non-inner Gorge Landslides	Percentage of stream length in planning watershed with non-inner gorge landslides	0.33
Management-related Processes	The mean truth value from Mass Wasting II, Surface Erosion II, and Streamside Erosion II knowledge base networks	0.5
Mass Wasting II	The mean truth value from management-related mass wasting: Road-related and Land Use-related	0.33
Road-Related	Coarse sediment contribution to streams from roads from either SEDMODL_V2 (first choice) or the mean of Density of Road/Stream Crossing, Density of Roads by Hillslope Position, and Density of Roads on Unstable Slopes	0.5
SEDMODL-V2	(when model is available – 1st choice of SOR node)	1.0
Density of Road/Stream Crossings	(2nd choice of SOR node, averaged with DRHP directly below) Number of road crossings/km of streams	0.33
Density of Roads / Hillslope Position	Weighted sum of road density by slope position (weights determine relative influence, and sum to 1.0)	0.33
Road length on lower slopes	Density of roads of all types on lower 40% of slopes	0.6
Road length on lower slopes	Density of roads of all types on mid-slope (41-80 % of slope distance)	0.3
Road length on upper slopes	Density of roads of all types on upper 20% of slopes	0.1
Density of Roads on Unstable Slopes	Density of roads on geologically unstable slopes	0.33
Land Use related	Coarse sediment contribution to streams from intensive, timber harvest, and ranched areas (see below in table*) <10th percentile highest suitability; >90th percentile lowest suitability	0.5
On slopes of low potential instability	Slope stability defined by CGS map classes 1 and 2 (or SHALSTAB if CGS maps unavailable)	0.04
On slopes of low/moderate potential instability	Slope stability defined by CGS map class 3 (or SHALSTAB if CGS maps unavailable)	0.09
On slopes of moderate/high potential instability	Slope stability defined by CGS map class 4 (or SHALSTAB if CGS maps unavailable)	0.17
On slopes of high potential instability	Slope stability defined by CGS map class 5 (or SHALSTAB if CGS maps unavailable)	0.7
Land Use related mass wasting parameter details (evaluated separately for each category of potential slope instability)	(Weights, showing the relative influence of each parameter, sum to 1.0)	
Intensive land use		
- - developed areas	Percentage of the planning watershed area in high density buildings and pavement	0.2
- - farmed areas	Percentage of planning watershed area in intensive crop cultivation	0.2
Area of timber harvests	Percentage of planning watershed area tractor logged weighted by time period (years)	
- - Era 0 (2000 – present)	Tractor logged area 2000-present	0.2
- - Era 1 (1990 – 1999)	Tractor logged area 1990-1999	0.12
- - Era 2 (1973 – 1989)	Tractor logged area 1973-1989	0.06
- - Era 3 (1945 – 1972)	Tractor logged area 1945-1972	0.12
Ranched area	Percentage of watershed area used for grazing livestock; estimated based on vegetation type and parcel type	0.1

Sediment Production Factor	Definition*	Weights**
Surface Erosion II	The mean truth value from management-related surface erosion: Road-related and Land Use-related	0.33
Road-Related	Fine sediment contribution to streams from roads from either SEDMODL_V2 (first choice) or the mean of Density of Roads Proximate to Streams, Density of Road-related Gullies, Density of Roads by Hillslope Position, and Road Surface Type	0.5
SEDMODL-V2	(when model is available – first choice of SOR node)	1.0
Density of Roads Proximate Streams	(2nd choice of SOR node, averaged with 3 subsequent road-related measures directly below)	0.25
Density of Roads Hillslope Position	Weighted sum of road density by slope position	0.25
Road length on lower slopes	Density of roads of all types on lower 40% of slopes	0.6
Road length on lower slopes	Density of roads of all types on mid-slope (41-80 % of slope distance)	0.3
Road length on upper slopes	Density of roads of all types on upper 20% of slopes	0.1
Density of Road-related Gullies	Density of gullies related to roads	0.25
Road Surface Type	Percentage of roads with surfaces that are more likely to deliver fine sediments to streams (no data currently supplied to model here)	0.25
Land Use related	Fine sediment contribution to streams from intensive, timber harvest, and ranched areas (see below in table**)	0.5
On slopes of high potential instability	Slope stability defined by CGS map class 5	0.7
On slopes of moderate/high potential instability	Slope stability defined by CGS map class 4	0.17
On slopes of low/moderate potential instability	Slope stability defined by CGS map class 3 (or SHALSTAB if unavailable)	0.09
On slopes of low potential instability	Slope stability defined by CGS map classes 1 and 2 (or SHALSTAB if unavailable)	0.04
Land Use related surface erosion parameter details	(evaluated separately for each of the four categories of potential slope instability)	
Intensive land use	Land where human activity is intensive	
- - Developed areas	Percentage of the planning watershed area in high density buildings and pavement	0.2
- - Farmed areas	Percentage of planning watershed area in intensive crop cultivation	0.2
Area of timber harvests	Percentage of planning watershed area tractor logged, by time period	
- - Era 0 (2000 – present)	Tractor logged area 2000-present	0.3
- - Era 1 (1990 – 1999)	Tractor logged area 1990-1999	0.2
Ranched area	Percentage of planning watershed area used for grazing livestock; estimated based on vegetation type and parcel type	0.1
Streamside Erosion II	The mean truth value from management-related streamside erosion: Road-related and Land Use-related	0.33
Density of Roads Proximate to Streams	Length of all roads within 200' of stream ÷ length of all streams	0.33
Density of Road/Stream Crossings	Number of road crossings/km of streams	0.33
Density of Instream Timber Harvest Landings	Number of legacy timber harvest landings instream per unit length of stream	0.33

*All breakpoints for the sediment production risk model were created from the tails of the cumulative distribution function curves for each parameter, at the 10th and 90th percentiles. Thus all resultant values are relative to the basin as a whole, but are not rated on an absolute basis
**weights for parameters at each node sum to 1.0; indentation of weight shows the tier where it is summed

Advantages Offered by EMDS

EMDS offers a number of advantages for use by the NCWAP. Instead of being a hidden black box, each EMDS model has an open and intuitively understandable structure. The explicit nature of the model networks facilitates open communication among agency personnel and with the general public through simple graphics and easily understood flow diagrams. The models can be easily modified to incorporate alternative assumptions about the conditions of specific environmental factors (e.g., stream water temperature) required for suitable salmonid habitat.

Using ESRI Geographic Information System (GIS) software, EMDS maps the factors affecting fish habitat and shows how they vary across a basin. At this time no other widely available package allows a knowledge base network to be linked directly with a geographic information system such as ESRI's ArcView™. This link is vital to the production of maps and other graphics reporting the watershed assessments. EMDS models also provide a consistent and repeatable approach to evaluating watershed conditions for fish. In addition, the maps from supporting levels of the model show the specific factors that, taken together, determine overall watershed conditions. This latter feature can help to identify what is most limiting to salmonids, and thus assist to prioritize restoration projects or modify land use practices.

Another feature of the system is the ease of running alternative scenarios. Scientists and others can test the sensitivity of the assessments to different assumptions about the environmental factors and how they interact, through changing the knowledge-based network and breakpoints. What-if scenarios can be run by changing the shapes of reference curves (e.g. Figure 10), or by changing the way the data are combined and synthesized in the network.

NetWeaver/EMDS/ArcView tools can be applied to any scale of analysis, from reach specific to entire watersheds. The spatial scale can be set according to the spatial domain of the data selected for use and issue(s) of concern. Alternatively, through additional network development, smaller scale analyses (i.e., subwatersheds) can be aggregated into a large hydrologic unit. With sufficient sampling and data, analyses can be done even upon single or multiple stream reaches.

Management Applications of Watershed Synthesis Results

EMDS syntheses can be used at the basin scale, to show current watershed status. Maps depicting those factors that may be the largest impediments, as well as those areas where conditions are very good, can help guide protection and restoration strategies. The EMDS model also can help to assess the cost-effectiveness of different restoration strategies. By running sensitivity analyses on the effects of changing different habitat conditions, it can help decision makers determine how much effort is needed to significantly improve a given factor in a watershed and whether the investment is cost-effective.

EMDS results can be fed into other decision support software, such as Criterium Decision Plus. CDP employs a widely used approach called Analytic Hierarchy Process (AHP) to assist managers in determining their options based upon what they believe are the most important aspects of the problem.

At the project planning level, EMDS model results can help landowners, watershed groups, and others select the appropriate types of restoration projects and places (i.e., planning watersheds or larger) that can best contribute to recovery. Agencies will also use the information when reviewing projects on a watershed basis.

The main strength of using NetWeaver/EMDS/ArcView knowledge base software in performing limiting factors analysis is its flexibility, and that through explicit logic, easily communicated graphics, and repeatable results, it can provide insights as to the relative importance of the constraints limiting salmonids in North Coast watersheds. NCWAP will use these analyses not only to assess conditions for fish in the watersheds and to help prioritize restoration efforts, but also to facilitate an improved understanding of the complex relationships among environmental factors, human activities, and overall habitat quality for native salmon and trout.

Limitations of the EMDS Model and Data Inputs

At the time of the production of this report, we have not been able to implement all of the recommendations made by our peer reviewers. Hence, the current model outputs should be used with caution. NCWAP will continue to work to refine and improve the EMDS model, based on peer review.

While EMDS-based syntheses are important tools for watershed assessment, they do not by themselves yield a course of action for restoration and land management. EMDS results require interpretation, and how they are employed depends upon other important issues, such as social and economic concerns. In addition to the accuracy of the EMDS model constructed, the currency and completeness of the data available for a stream or watershed will strongly influence the degree of confidence in the results. Where possible, external validation of the EMDS model using fish population data and other information should be done.

One disadvantage of linguistically based models such as EMDS is that they do not provide results with readily quantifiable levels of error. However, we are developing methods of determining levels of confidence in the EMDS results, based upon data quality and overall weight given to each parameter in the model.

The NCWAP will use EMDS only as an indicative model, one that indicates the quality of watershed or instream conditions based on available data and the model structure. It is not intended to provide highly definitive answers, such as from a statistically based process model. It does provide a reasonable first approximation of conditions through a robust information synthesis approach; however, its outputs need to be considered and interpreted in the light of other information sources and the inherent limitations of the model and its data inputs. It also should be clearly noted that EMDS does not assess the marine phase of the salmonid lifecycle, nor does it consider fishing pressures.

The NCWAP staff have identified a number of model or data elements needing attention and improvement in the next version. These include:

- modification of canopy density standards for wide streams;
- completion of quality control evaluation of several data layers;
- adjusting the model to better reflect differences between stream mainstems and tributaries;

The NCWAP team will address these limitations as the EMDS model undergoes further development.

Integrated Analyses Tables

The NCWAP Mattole team constructed a series of tables, referred to as the Integrated Analysis tables, to track watershed processes that determine conditions in streams for salmon and steelhead. This approach followed the down-slope movement of watershed products delivered to streams. Fundamental to these watershed processes and products are the underlying geology and geomorphology of the watershed. Geologic conditions determine, in large part, the landslide and sediment production potential of the terrain. Geologic processes are influenced in varying degrees by the vegetative community, which is often linked to human activities across the landscape. Current watershed conditions combine with natural events like fire, flood, and earthquakes to affect the fluvial geomorphology and water quality in the stream reaches of a watershed. Finally, the effects of these combined processes are expressed in the stream habitats, including flow, encountered by the organisms of the aquatic riparian community, including salmon and steelhead.

These integrated analyses are presented at the overall watershed, subbasin, and planning watershed scales.

Limiting Factors Analysis

A main objective of the NCWAP and a task delegated to the CDFG is to identify factors that limit production of anadromous salmonid populations in North Coast watersheds. A loosely termed approach to identify these factors is often called a limiting factors analysis (LFA). The limiting factors concept is based upon the assumption that eventually every population must be limited by the availability of resources (Hilborn and Walters 1992) or that a population's potential may be constrained by an over abundance, deficiency, or absence of a watershed ecosystem component. Identifying stream habitat factors that limit or constrain anadromous salmonids is an important step towards setting priorities for habitat improvement projects and management strategies aimed at the recovery of declining fish stocks and protection of viable fish populations.

Although several factors have contributed to the decline of anadromous salmonid populations, habitat loss and modification are major determinants of their current status (FEMAT 1993). Our approach to a LFA integrates two habitat based methods to evaluate the status of key aspects of stream habitat that affect anadromous salmonid production, species life history diversity, and the stream's ability to support viable populations. The first method uses priority ranking habitat categories based on a CDFG team assessment of data collected during stream habitat inventories. The second method uses the EMDS to evaluate the suitability of key stream habitat components to support anadromous fish populations. These habitat-based methods assume that stream habitat quality and quantity play important roles in a watershed's ability to produce viable salmonid populations. The LFA assumes that poor habitat quality and reduced quantities of favorable habitat impairs fish production. The NCWAP LFA is focused mainly on those physical habitat factors within freshwater and estuarine ecosystems that affect spawning and subsequent juvenile life history requirements during low flow seasons.

Two general categories of factors or mechanisms limit salmonid populations:

- Density independent; and
- Density dependent mechanisms.

Density independent mechanisms generally operate without regard to population density. These include factors related to habitat quality such as stream flow and water temperature. In general, if water temperatures exceed lethal levels fish will die regardless of the population density. Density dependant mechanisms generally operate according to population density and habitat carrying capacity. Competition for food, space, and shelter are examples of density dependant factors that affect growth and survival when populations reach or exceed the habitat carrying capacity. The NCWAP's approach considers these two types of habitat factors before prioritizing recommendations for habitat management strategies. Priority steps are given to preserving and increasing the amount of high quality (density independent) habitat in a cost effective manner. More details of the LFA are presented in the CDFG Appendix F.

Restoration Needs/Tributary Recommendations Analysis

The California Department of Fish and Game (CDFG) inventoried 59 tributaries to the Mattole River and the headwaters of the Mattole from 1991 to 2002 using protocols in the *California Salmonid Stream Habitat Restoration Manual*. The tributaries and the headwaters of the Mattole River surveyed were composed of 93 stream reaches, defined as Rosgen channel types. The stream inventories are a combination of several stream reach surveys: habitat typing, channel typing, biological assessments, and in some reaches LWD and riparian zone recruitment assessments. An experienced biologist and/or habitat specialist conducted QA/QC on field crews and collected data, performed data analysis, and determined general areas of habitat deficiency based upon the analysis and synthesis of information.

The CDFG biologist selected and ranked recommendations for each of the inventoried streams, based upon the results of these standard CDFG habitat inventories, and updated the recommendations with the results of the stream reach condition EMDS and the refugia analysis (Table 6). It is important to understand that these selections are made from stream reach conditions that were observed at the times of the surveys and do not include upslope watershed observations other than those that could be made from the streambed. They also reflect a single point in time and do not anticipate future conditions. However, these general recommendation categories have proven to be useful as the basis for specific project development, and provide focus for on-the-ground project design and implementation. Bear in mind that stream and watershed conditions change over time and periodic survey updates and field verification are necessary if watershed improvement projects are being considered.

Table 6. List of tributary recommendations in stream tributary reports

Recommendation	Explanation
Temp	Summer Water Temperatures Were Measured To Be Above Optimum For Salmon And Steelhead
Pool	Pools Are Below Target Values In Quantity And/Or Quality
Cover	Escape Cover Is Below Target Values
Bank	Stream Banks Are Failing And Yielding Fine Sediment Into The Stream
Roads	Fine Sediment Is Entering The Stream From The Road System
Canopy	Shade Canopy Is Below Target Values
Spawning Gravel	Spawning Gravel Is Deficient In Quality And/Or Quantity
LDA	Large Debris Accumulations Are Retaining Large Amounts Of Gravel And Could Need Modification
Livestock	There Is Evidence That Stock Is Impacting The Stream Or Riparian Area And Exclusion Should Be Considered
Fish Passage	There Are Barriers To Fish Migration In The Stream

In general, the recommendations that involve erosion and sediment reduction by treating roads and failing stream banks, and riparian and near stream vegetation improvements precede the instream recommendations in reaches that demonstrate disturbance levels associated with watersheds in current stress. Instream improvement recommendations are usually a high priority in streams that reflect watersheds in recovery or good health. Various project treatment recommendations can be made concurrently if watershed and stream conditions warrant.

Fish passage problems, especially in situations where favorable stream habitat reaches are being separated by a man-caused feature (e.g., culvert), are usually a treatment priority. Good examples of these are the recent and dramatically successful Humboldt County/CDFG culvert replacement projects in tributaries to Humboldt Bay. In these regards, NCWAP's more general watershed scale upslope assessments can go a long way in helping determine the suitability of conducting instream improvements based upon watershed health. As such, there is an important relationship between the instream and upslope assessments.

Additional considerations must enter into the decision process before these general recommendations are further developed into improvement activities. In addition to watershed condition considerations as a context for these recommendations, there are certain logistic considerations that enter into a recommendation's subsequent ranking for project development. These can include work party access limitations based upon lack of private party trespass permission and/or physically difficult or impossible locations of the candidate work sites. Biological considerations are made based upon the propensity for benefit to multiple or single fishery stocks or species. Cost benefit and project feasibility are also factors in project selection for design and development.

Potential Salmonid Refugia

Establishment and maintenance of salmonid refugia areas containing high quality habitat and sustaining fish populations are activities vital to the conservation of our anadromous salmonid resources (Moyle and Yoshiyama 1992; Liet al. 1995; Reeves et al. 1995). Protecting these areas will prevent the loss of the remaining high quality salmon habitat and salmonid populations. Therefore, a refugia investigation project should focus on identifying areas found to have high salmonid productivity and diversity. Identified areas should then be carefully managed for the following benefits:

- Protection of refugia areas to avoid loss of the last best salmon habitat and populations. The focus should be on protection for areas with high productivity and diversity;
- Refugia area populations which may provide a source for re-colonization of salmonids in nearby watersheds that have experienced local extinctions, or are at risk of local extinction due to small populations;
- Refugia areas provide a hedge against the difficulty in restoring extensive, degraded habitat and recovering imperiled populations in a timely manner (Kaufmann, et al. 1997).

The concept of refugia is based on the premise that patches of aquatic habitat provide habitat that still retain the natural capacity and ecologic functions that support wild anadromous salmonids in such vital activities as spawning and rearing. Anadromous salmonids exhibit typical features of patchy populations; they exist in dynamic environments and have developed various dispersal strategies including juvenile movements, adult straying, and relative high fecundity for an animal that exhibits some degree of parental care through nest building (Reeves et al. 1995). Conservation of patchy populations requires conservation of several suitable habitat patches and maintaining passage corridors between them.

Potential refugia may exist in areas where the surrounding landscape is marginally suitable for salmonid production or altered to a point that stocks have shown dramatic population declines in traditional salmonid streams. If altered streams or watersheds recover their historic natural productivity, either through restoration efforts or natural processes, the abundant source populations from nearby refugia can potentially re-colonize these areas or help sustain existing salmonid populations in marginal habitat. Protection of refugia areas is noted as an essential component of conservation efforts to ensure long-term survival of viable stocks, and a critical element towards recovery of depressed populations (Sedell, 1990; Moyle and Yoshiyama 1992; Frissell 1993, 2000).

Refugia habitat elements include the following:

- Areas that provide shelter or protection during times of danger or distress;
- Locations and areas of high quality habitat that support populations limited to fragments of their former geographic range; and
- A center from which dispersion may take place to re-colonize areas after a watershed and/or sub-watershed level disturbance event and readjustment.

Spatial and Temporal Scales of Refugia

These refugia concepts become more complex in the context of the wide range of spatial and temporal habitat required for viable salmonid populations. Habitat can provide refuge at many scales from a single fish to groups of them, and finally to breeding populations. For example, refugia habitat may range from a piece of wood that provides instream shelter for a single fish, or individual pools that provide cool water for several rearing juveniles during hot summer months, to watersheds where conditions support sustaining populations of salmonid species. Refugia also include areas where critical life stage functions such as migrations and spawning occur. Although fragmented areas of suitable habitat are important, their connectivity is necessary to sustain the fisheries. Today, watershed scale refugia are needed to recover and sustain aquatic species (Moyle and Sato 1991). For the purpose of this discussion, refugia are considered at the fish bearing tributary and subbasin scales. These scales of refugia are generally more resilient than the smaller, habitat unit level scale to the deleterious effects of landscape and riverine disturbances such as large floods, persistent droughts, and human activities (Sidell et al. 1990).

Standards for refugia conditions are based on reference curves from the literature and CDFG data collection at the regional scale. NCWAP uses these values in its EMDS models and stream inventory, improvement recommendation process. Li et al. (1995) suggested three prioritized steps to use the refugia concept to conserve salmonid resources.

- Identify salmonid refugia and ensure they are protected;
- Identify potential habitats that can be rehabilitated quickly;
- Determine how to connect dispersal corridors to patches of adequate habitat.

Refugia and Meta-population Concept

The concept of anadromous salmonid meta-populations is important when discussing refugia. The classic metapopulation model proposed by Levins (1969) assumes the environment is divided into discrete patches of suitable habitat. These patches include streams or stream reaches that are inhabited by different breeding populations or sub-populations (Barnhart 1994,; McElhany et al. 2000). A metapopulation consists of a group of sub-populations which are geographically located such that over time, there is likely genetic exchange between the sub-populations (Barnhart 1994). Metapopulations are characterized by 1) relatively isolated, segregated breeding populations in a patchy environment that are connected to some degree by migration between them, and 2) a dynamic relationship between extinction and re-colonization of habitat patches.

Anadromous salmonids fit nicely into the sub-population and metapopulation concept because they exhibit a strong homing behavior to natal streams forming sub-populations, and also have a tendency to stray into new areas. The straying or movement into nearby areas results in genetic exchange between sub-populations or seeding of other areas where populations are at low levels. This seeding comes from abundant or source populations supported by high quality habitat patches which may be considered as refugia.

Habitat patches differ in suitability and population strength. In addition to the classic metapopulation model, other theoretical types of spatially structured populations have been proposed (Li et al. 1995; McElhany et al. 2000). For example, the core and satellite (Li et al. 1995) or island-mainland population (McElhany et al. 2000) model depicts a core or mainland population from which dispersal to satellites or islands results in smaller surrounding populations. Most straying occurs from the core or mainland to the satellites or islands. Satellite or island populations are more prone to extinction than the core or mainland populations (Li et al. 1995; McElhany et al. 2000). Another model termed source-sink populations is similar to the core-satellite or mainland-island models, but straying is one way, only from the highly productive source towards the sink subpopulations. Sink populations are not self-sustaining and are highly dependant on migrants from the source population to survive (McElhany et al. 2000). Sink populations may inhabit typically marginal or unsuitable habitat, but when environmental conditions strongly favor salmonid production, sink population areas may serve as important sites to buffer populations from disturbance events (Li et al. 1995) and increase basin population strength. In addition to testing new areas for potential suitable habitat, the source-sink strategy adds to the diversity of behavior patterns salmonids have adapted to maintain or expand into a dynamic aquatic environment.

The metapopulation and other spatially structured population models are important to consider when identifying refugia because in dynamic habitats, the location of suitable habitat changes (McElhany et al. 2000) over the long term from natural disturbance regimes (Reeves et al. 1995) and over the short term by human activities. Satellite, island, and sink populations need to be considered in the refugia selection process because they are an integral component of the metapopulation concept. They also may become the source population or refugia areas of the future.

Methods to Identify Refugia

Currently there is no established methodology to designate refugia habitat for California's anadromous salmonids. This is mainly due to a lack of sufficient data describing fish populations, meta-populations and habitat conditions and productivity across large areas. This lack of information holds true for NCWAP basins especially in terms of meta-population dynamics. Studies are needed to determine population growth rates and straying rates of salmonid populations and sub-populations to better utilize spatial population structure to identify refugia habitat.

Classification systems, sets of criteria and rating systems have been proposed to help identify refugia type habitat in north coast streams, particularly in Oregon and Washington (Moyle and Yoshiyama 1992; FEMAT 1993; Li et al. 1995; Frissell et al. 2000; Kisup County, 2000). Upon review of these works, several common themes emerge. A main theme is that refugia are not limited to areas of pristine habitat. While ecologically intact areas serve as dispersal centers for stock maintenance and potential recovery of depressed sub-populations, lower quality habitat areas also play important roles in long-term salmonid metapopulation maintenance. These areas may be considered the islands, satellites, or sinks in the metapopulation concept. With implementation of ecosystem management strategies aimed at maintaining or restoring natural processes, some of these areas may improve in habitat quality, show an increase in fish numbers, and add to the metapopulation strength.

A second common theme is that over time within the landscape mosaic of habitat patches, good habitat areas will suffer impacts and become less productive, and wink out and other areas will recover and wink in. These processes can occur through either human caused or natural disturbances or succession to new ecological states. Regardless, it is important that a balance be maintained in this alternating, patchwork dynamic to ensure that adequate good quality habitat is available for viable anadromous salmonid populations (Reeves et al. 1995.)

NCWAP Approach to Identifying Refugia

The NCWAP interdisciplinary team identified and characterized refugia habitat by using expert professional judgment and criteria developed for North Coast watersheds. The criteria used considered different values of watershed and stream ecosystem processes, the presence and status of fishery resources, forestry and other land uses, land ownership, potential risk from sediment delivery, water quality, and other factors that may affect refugia productivity. The expert refugia team encouraged other specialists with local knowledge to participate in the refugia identification and categorization process.

The team also used results from information processed by NCWAP's EMDS at the stream reach and planning watershed/subbasin scales. Stream reach and watershed parameter evaluation scores were used to rank stream and watershed conditions based on collected field data and air photo analysis. Stream reach scale parameters included pool shelter rating, pool depth, embeddedness, and canopy cover. Water temperature data were also used when available. The individual parameter scores identified which habitat factors currently support or limit fish production (see EMDS and limiting factors sections).

Planning watershed scale parameters used are road density, number of stream crossings, road proximity to streams, riparian cover, and LWD loading potential. The refugia team used the potential sediment production and other planning watershed scale EMDS evaluations in a similar manner as they became available.

When identifying anadromous salmonid refugia, the NCWAP team took into account that anadromous salmon have several non-substitutable habitat needs for their life-cycle. A minimal list (NMFS 2000) includes:

- Adult migration pathways;
- Spawning and incubation habitat;
- Stream rearing habitat;
- Forage and migration pathways;
- Estuarine habitat.

The best refugia areas are large and meet all of these life history needs and therefore provide complete functionality to salmonid populations. These large, intact systems are scarce today and smaller refugia areas that provide for only some of the requirements have become very important areas, but cannot sustain large numbers of fish. These must operate in concert with other fragmented habitat areas for life history support and refugia connectivity becomes very important for success. Therefore, the refugia team considers relatively small, tributary areas in terms of their ability to provide at least partial refuge values, yet contribute to the aggregated refugia of larger scale areas. Therefore, the team's analyses use the tributary scale as the fundamental refugia unit.

The NCWAP team created a tributary scale refugia-rating worksheet (CDFG Appendix F). The worksheet has 21 condition factors that were rated on a sliding scale from high quality to low quality. The 21 factors were grouped into five categories:

- Stream condition;
- Riparian condition;
- Native salmonid status;
- Present salmonid abundance;
- Management impacts (disturbance impacts to terrain, vegetation, and the biologic community).

Tributary ratings were determined by combining the results of air photo analyses results, EMDS results, and data in the CDFG tributary reports by a multi-disciplinary, expert team of analysts. The various factors' ratings were combined to determine an overall tributary rating on a scale from high to low quality refugia. Tributary ratings were subsequently aggregated at the subbasin scale and expressed a general estimate of subbasin refugia conditions. Factors with limited or missing data were noted. In most cases there were data limitations on 1 – 3 factors. These were identified for further investigation and inclusion in future analysis.

The NCWAP has created a hierarchy of refugia categories that contain several general habitat conditions. This descriptive system is used to rank areas by applying results of the analyses of stream and watershed conditions described above and are used to determine the ecological integrity of the study area. A basic definition of biotic integrity is "the ability [of an ecosystem] to support and maintain a balanced, integrated, and functional organization comparable to that of the natural habitat of the region" (Karr and Dudley 1981).

The Report of the Panel on the Ecological Integrity of Canada's National Parks submitted this definition:

The Panel proposes the following definition of ecological integrity: "An ecosystem has integrity when it is deemed characteristic for its natural region, including the composition and abundance of native species and biological communities, rates of change and supporting processes. "In plain language, ecosystems have integrity when they have their native components (plants, animals and other organisms) and processes (such as growth and reproduction) intact.

NCWAP Salmonid Refugia Categories and Criteria:

High Quality Habitat, High Quality Refugia

- Maintains a high level of watershed ecological integrity (Frissell 2000);
- Contains the range and variability of environmental conditions necessary to maintain community and species diversity and supports natural salmonid production (Moyle and Yoshiyama 1992; Frissell 2000);
- Relatively undisturbed and intact riparian corridor;
- All age classes of historically native salmonids present in good numbers, and a viable population of an ESA listed salmonid species is supported (Li et al. 1995);

- Provides population seed sources for dispersion, gene flow and re-colonization of nearby habitats from straying local salmonids;
- Contains a high degree of protection from degradation of its native components.

High Potential Refugia

- Watershed ecological integrity is diminished but remains good (Frissell 2000);
- Instream habitat quality remains suitable for salmonid production and is in the early stages of recovery from past disturbance;
- Riparian corridor is disturbed, but remains in fair to good condition;
- All age classes of historically native salmonids are present including ESA listed species, although in diminished numbers;
- Salmonid populations are reduced from historic levels, but still are likely to provide straying individuals to neighboring streams;
- Currently is managed to protect natural resources and has resilience to degradation, which demonstrates a strong potential to become high quality refugia (Moyle and Yoshiyama 1992; Frissell 2000).

Medium Potential Refugia

- Watershed ecological integrity is degraded or fragmented (Frissell, 2000);
- Components of instream habitat are degraded, but support some salmonid production;
- Riparian corridor components are somewhat disturbed and in degraded condition;
- Native anadromous salmonids are present, but in low densities; some life stages or year classes are missing or only occasionally represented;
- Relative low numbers of salmonids make significant straying unlikely;
- Current management or recent natural events have caused impacts, but if positive change in either or both occurs, responsive habitat improvements should occur.

Low Quality Habitat, Low Potential Refugia

- Watershed ecological integrity is impaired (Frissell, 2000);
- Most components of instream habitat are highly impaired;
- Riparian corridor components are degraded;
- Salmonids are poorly represented at all life stages and year classes, but especially in older year classes;
- Low numbers of salmonids make significant straying very unlikely;
- Current management and / or natural events have significantly altered the naturally functioning ecosystem and major changes in either of both are needed to improve conditions.

Other Related Refugia Component Categories:

Potential Future Refugia (Non-Anadromous)

- Areas where habitat quality remains high but does not currently support anadromous salmonid populations;
- An area of high habitat quality, but anadromous fish passage is blocked by man made obstructions such as dams or poorly designed culverts at stream crossings etc.

Critical Contributing Areas

- Area contributes a critical ecological function needed by salmonids such as providing a migration corridor, conveying spawning gravels, or supplying high quality water (Li et al. 1995)
- Riparian areas, floodplains, and wetlands that are directly linked to streams (Huntington and Frissell 1997).

Data Limited

- Areas with insufficient data describing fish populations, habitat condition watershed conditions, or management practices.

Development and Evaluation of Hypotheses

NCWAP provides a first cut at watershed assessment evaluating current watershed conditions, exploring linkages among current and historic conditions and processes, and providing concrete direction for future activities. Given the challenge of accomplishing so complex a task at multiple watershed scales, the program has not established controlled experimental studies, but has instead brought together many types of information and examined it from various perspectives.

Using this material, NCWAP has formulated a set of reasonable hypotheses that can be used to take immediate steps to protect and improve watersheds and streams and to implement additional focused monitoring, assessment or research to fill information. This approach provides a framework for adaptive management.

NCWAP uses hypotheses to assess watershed conditions for supporting salmonids, to identify likely limiting factors and potential causes for areas with unsuitable conditions, and to consider potential trends.

The NCWAP team used a weight-of-evidence approach to reach conclusions and to develop appropriate restoration, management, conservation, and monitoring recommendations. They articulated both supportive and contrary findings as well as limitations of the information. This process included results from both disciplinary and interdisciplinary data analyses. Hypotheses and recommendations are provided for each subbasin in the Subbasin Profiles and Synthesis.

Working Hypotheses

After conducting public scoping meetings and initial analyses of available data, the NCWAP team compiled a preliminary list of issues affecting the Mattole Basin.

Issues

- Sediment, temperature, pool habitat, escape and ambush cover, and substrate embeddedness in the estuary are thought to be outside of supportive levels for salmonids in the estuary;
- Predation upon depressed fish populations by birds and mammals in the estuary;
- Excessive extraction of water occurs during low flow periods;
- Artificial fish passage barriers exist at some road crossings of streams;
- Abandoned roads, new road construction, and road maintenance issues related to landsliding and sediment input to streams;
- High water temperatures occurring in summertime;
- Pollutant spills, such as some recent bulk diesel spills into tributaries;
- Herbicides used on industrial timberlands;
- Location and conduct of timber harvest operations;
- Sub-division development and construction;
- Low stream habitat diversity and complexity;
- Low stream shade canopy cover;
- Large woody debris recruitment to streams;
- Absence of salmonid information, low fish densities, or absences of fish;
- Access for agency personnel to private land for field studies.

Assessment Focus Areas:

Based on these issues, a list of Assessment Focus Areas was developed, including:

- Variability in the geology, climate, vegetation, and land use in the Mattole Basin is too high for a single general analysis and assessment to be representative of the entire basin. The establishment of an analytical framework comprised of large subbasins with common attributes and characteristics will provide a more satisfactory assessment scale;

- The current abundance and distribution of salmonid populations observed in the basin are indicators of the current habitat conditions;
- Summer stream temperatures in parts of the basin are not within the range of temperatures that fully support healthy anadromous salmonid populations;
- Aggradation from fine sediment in some stream channels has reduced channel diversity needed to fully support anadromous salmonid populations and has compromised salmonid health;
- High natural rates of sediment input to streams are augmented by human land use activities in some parts of the basin;
- Some stream reaches in the basin are not fully supportive of salmonids due to stream flow reductions related to human diversion;
- A lack of large woody debris in some stream reaches has reduced channel diversity needed to fully support anadromous salmonid populations and has compromised salmonid health;
- Air photo documentation after the 1955 and 1964 floods indicate significant changes instream channel and riparian conditions as a result of those events;
- Watershed and stream conditions in the Southern Subbasin are the most supportive of salmonids in the Mattole Basin;
- Watershed and stream conditions in the Eastern and Western Subbasins vary between being supportive and non-supportive of salmonids;
- Watershed and stream conditions in the Northern Subbasin are the least supportive of salmonids in the Mattole Basin;.
- The present state of estuarine habitat is limiting the production of salmonids, especially Chinook, in the Mattole Basin.

Guiding Assessment Questions and Responses

The NCWAP assessment team developed lists of questions that they considered important to understanding and implementing watershed assessments. From those lists, a short list of guiding assessment questions evolved and was adopted to provide focus for the assessments and subsequent analyses, conclusions, and recommendations.

- What are the history and trends of the sizes, distribution, and relative health and diversity of salmonid populations within this subbasin?
- What are the current salmonid habitat conditions in this subbasin? How do these conditions compare to desired conditions?
- What are the relationships of geologic, vegetative, and fluvial processes to natural events and land use history?
- How has land use affected these natural processes?
- Based upon these conditions, trends, and relationships, are there elements that could be considered to be limiting factors for salmon and steelhead production?
- What habitat improvement activities would most likely lead toward more desirable conditions in a timely, cost effective manner?

These six questions focus the assessment procedures and data gathering within the individual disciplines and also provide direction for those areas of analyses that require more interagency, interdisciplinary syntheses, including the analysis of factors limiting anadromous salmonid production. The questions systematically progress from the relative status of the salmon and steelhead resource, to the focus of the NCWAP assessment effort, and lastly to the watershed components encountered directly by the fish – flow, water quality, nutrients, and instream habitat elements, including free passage at all life stages. These habitat elements are shaped by the products delivered to streams by watershed processes and the influence of human activities on those processes. The watershed processes and human influences determine what factors might be limiting fishery production and what can be done to make improvements for the streams and fish.

The first two assessment questions point out the importance of salmonid population information for validating the assessment and predicting habitat conditions. In many watersheds, robust population data may not be available, implying a need for future monitoring efforts. In some watersheds, a need for additional physical habitat sampling may be indicated.

The third and fourth assessment questions consider the past and present conditions of the watersheds and their natural and man-caused watershed processes. The answers to these questions provide us with insights into the future of NCWAP watersheds and streams, and the feasibility of different management techniques for salmon and steelhead in each watershed.

The last two assessment questions consider factors directly encountered by fish that could be limiting salmonid production. These questions seek to identify opportunities and locations for prudent management practices and pro-active salmonid habitat improvement activities.

These six guiding assessment questions are presented and answered in the overall basin section and in each of the subbasin sections of the assessment report. They are also considered in the DFG Refugia Rating process at the subbasin and tributary scales. The responses become more specific as the assessment focuses from the course to the finer scales.

NOTES

Mattole Basin Profile and Synthesis

Introduction

Mattole meant “clear waters” in the language of the Athabaskan-speaking Mattole and Sinkyone Native Americans when the first settlers from the Eastern United States arrived in the early 1850s. Little is known about these Native Americans, for they were quickly displaced by the new settlers. Disputes over hunting ground and domestic stock culminated in a massacre at Squaw Creek in 1864. Survivors were sent to the Round Valley Reservation in the Middle Fork of the Eel River, where most succumbed to the measles epidemic in 1868 (Elements of Recovery, 1989). Based upon the practices of other North Coast native peoples, it is presumed they utilized an abundant and local salmon and steelhead resource for their sustenance.

We have little specific information about the levels of abundance of those mid-nineteenth century fishery stocks. However, based upon turn-of-the-century cannery records from the river systems in northwestern North America, including the neighboring Eel River, we can infer a great deal about the historic plenitude of Chinook, coho, and steelhead in the Mattole Basin. Old-timers and descendants of those early settlers, like Cecil Etter, born at the beginning of the twentieth century in a house that still stands near the confluence of Honeydew Creek and the Mattole River, reported an ever-ready supply of salmon and steelhead before the floods of 1955 and 1964. Those fish were easily caught for the table or smokehouse with a pitchfork or gaff hook in “any creek of the Mattole.” With a twinkle in his eye, he added, “before the war (WWII) no-one knew what a fishin’ pole was, or what one was good for in regards to salmon or steelhead,” (C. Etter, personal communication).

More recent accounts from Mattole anglers like Lynn Mantooth, “Hippie Bob,” and the “Nevada Boys,” fishing in the 1945 – 1970 period, describe a fabled sport fishery where in good stream conditions a group of four or five anglers could expect to hook and release over a hundred fish, mostly steelhead, in a day of fishing (J. Clary, personal communication). Salmon poaching beneath the Petrolia Bridge, and elsewhere, was a viable means of making a “little Christmas money” by selling fresh and smoked salmon as late as the 1960s, (C. Wright, personal communication).

By the late 1970s, those fish populations had collapsed to levels that alerted locals to their depressed condition, and initiated the formation of the Mattole Salmon Group. In 1981, the Mattole Salmon Group with the cooperation of landowners, and the support of the California Department of Fish and Game (CDFG), and others like the Mattole Restoration Council, began stock restoration activities that included public education, artificial propagation, and habitat improvements. Their efforts have been important in preserving the Mattole’s fragile fishery stocks in the face of very challenging conditions.

Today, those ancient and robust Mattole Basin salmon and steelhead stocks, like most on California’s North Coast, are depressed to levels that have led to listing of coho, Chinook, and steelhead under the authority of the Endangered Species Act. Additionally, we have enough current water quality observations to believe that the residents of the Mattole Basin in 2001 would likely not have thought to name their valley’s river “clear water.”

Location and Area

The Mattole Basin encompasses approximately 296 square miles of Northern California’s Coast Range (Figure 7). Although nearly three percent of the Mattole’s headwaters are in Mendocino County; the vast majority of the basin is within Humboldt County. The mainstem Mattole River is approximately 62 miles long, and receives water from over 74 tributary streams. There are approximately 545 perennial stream miles in the basin. The basin drains into the Pacific Ocean just south of Cape Mendocino. During most summers, a sand-spit encroaches all the way across the river mouth to form a bay mouth barrier, which creates a lagoon behind it. Generally, the barrier remains until runoff from fall rains breeches it. However, in some years, large swells at times of high tide overtop the barrier and a new outlet channel is carved through the barrier. This overtopping has occurred up to six times during a year before the lagoon finally remained closed.

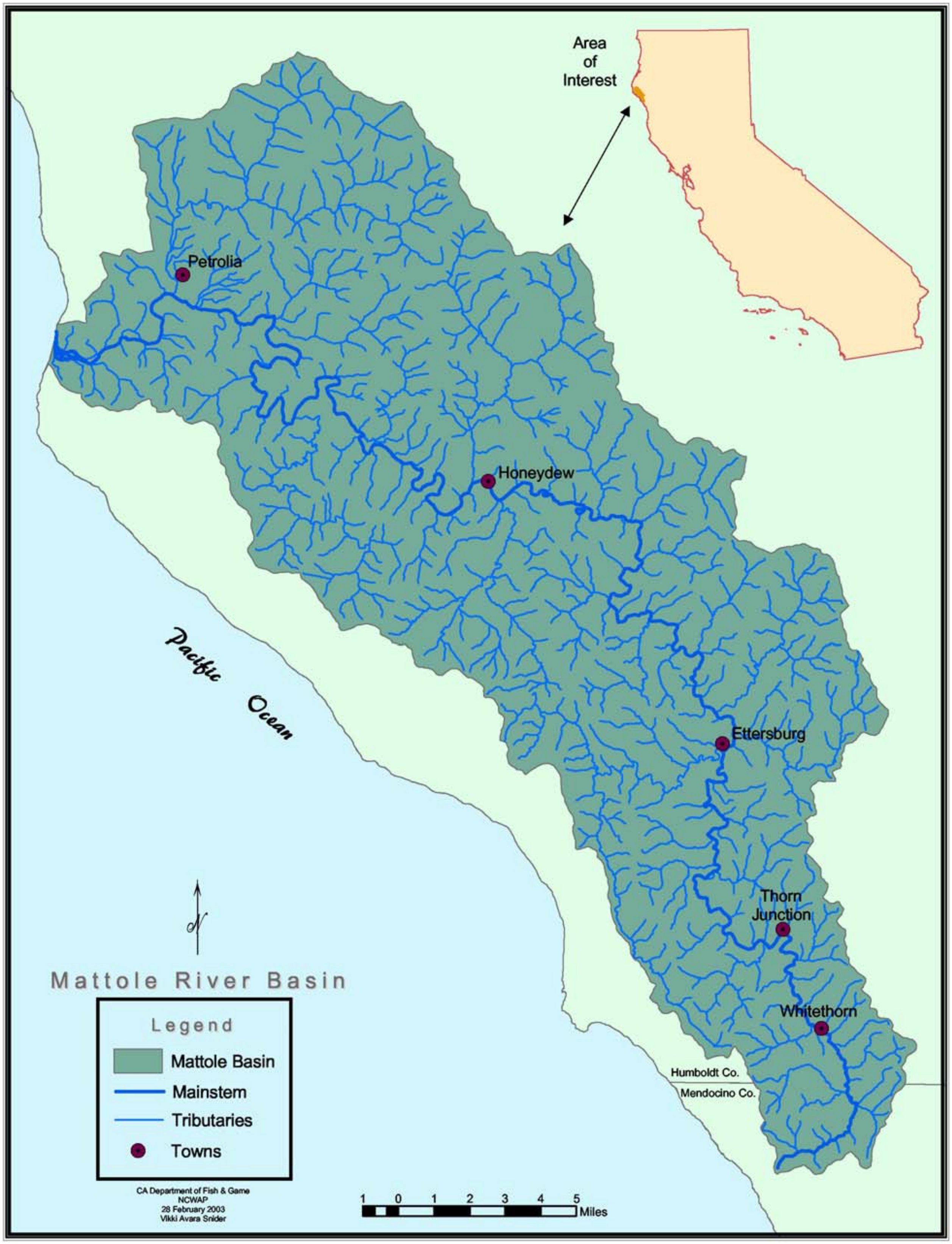


Figure 16. Mattole Basin and Tributaries.

The Mattole Basin is mostly steep mountainous topography. The basin's higher elevation slopes commonly exceed 15 percent gradient. Broad, alluvial streamside flats are present in the lower valleys. The lower stream channels are dominated by large gravel bars typically composed of cobble, gravel, and fine sediments (Elements of Recovery, 1989). Headwater elevations range from 1,350 feet at Four Corners at the mainstem headwaters, to 4,088 feet at Kings Peak, which is located less than three miles from the ocean and is the tallest mountain in the coastal range.

Mattole Subbasin Scale

For the purpose of the NCWAP study of the Mattole Basin, the basin has been divided into five subbasins based on twenty-five distinct planning watersheds as defined by CalWater 2.2a. Four of the five subbasins in the basin were designated based on geography, geology, climate patterns, and land use, and conforms to CalWater 2.2a Planning Watershed boundaries. The fifth subbasin, the Estuary, has been designated as a distinct subbasin for this study because of the importance of the estuarine environment as a down-migrant holding area for juvenile fish stocks.

- The Estuary Subbasin is two square miles in area and contains the basin downstream of the confluence of lower Bear Creek and the Mattole mainstem. The estuary drains the Mattole River to the Pacific Ocean. The Mendocino Triple Junction, where the Gorda, the North American, and the Pacific geologic plates meet, occurs in the vicinity of the estuary, making the Mattole Basin as a whole one of the most tectonically active in California. The southern extent of the basin is owned and managed by the BLM as part of the King Range National Conservation Area.
- The Northern Subbasin is located between the estuary and Honeydew Creek; one of three towns in the watershed, Petrolia, is located near the confluence with the North Fork Mattole River and the Mattole mainstem. It drains an area of 98 square miles and contains some of the largest continuous areas of large landslides and high to very high landslide potential of all the subbasins. The largest contiguous old growth forest remaining in the entire watershed can be found here, but vegetation type is predominantly second-growth mixed hardwood/Douglas Fir forest, although grasslands are a significant component. It is partially bordered on the east side by Humboldt Redwoods State Park. Steelhead are currently present in the subbasin. Based on previous CDFG surveys, coho were once found here.
- The Eastern Subbasin is located between Honeydew Creek and Bridge Creek; the second of the three towns, Honeydew, is located near the confluence of Honeydew Creek and the Mattole mainstem. It drains an area of 79 square miles and geology and slope stability varies widely. Much of the land in this subbasin has been converted from large ranchlands to rural sub-divisions. The predominant vegetation type is second growth mixed hardwood/Douglas fir forests. Coho, Chinook, and steelhead trout can all be found in this subbasin.
- The Southern Subbasin is located south of Bridge and McKee Creeks and encompasses the headwaters of the Mattole River at the southern end. It is divided between Humboldt and Mendocino Counties. The third of the three towns, Whitethorn is located near the confluence of upper Mill Creek (RM 56.2) and the Mattole mainstem. It drains an area of 28 square miles and contains the largest continuous areas of hard terrain and lowest landslide density of the subbasins. The predominant vegetation type is mixed hardwood/coniferous forest including old and second growth Redwood forests. This subbasin is the most densely populated of the subbasins but is considered to have some of the best remaining fish-rearing habitat of the entire basin. Coho, Chinook, and steelhead trout can all be found in this subbasin.
- The Western Subbasin is located from the border with the Estuary in the north to the headwaters of Bear Creek in the south. It drains 89 square miles and geology and slope stability varies. Much of this subbasin is under public ownership, managed by the BLM as part of King Range National Conservation Area. The predominant vegetation type is second growth mixed hardwood/Douglas fir forest. King Peak, at 4,088 feet is the highest elevation in the basin. Coho, Chinook, and steelhead trout can all be found in this subbasin.

Figure 17. Mattole River with Subbasins and Tributaries.

Table 7. General attributes for the Mattole subbasins.

	Estuary	Northern	Eastern	Southern	Western	Total
Square Miles	2	98	79	28	89	296
Acreage, Total	1,326	62,857	50,794	17,640	57,144	189,761
Private Lands (Acres)	939	62,028	47,897	15,158	30,462	156,484
Public Lands (Acres)	385	829	2,897	2,482	26,682	33,277
Principal Communities	Petrolia	Petrolia, Honeydew	Ettersburg, Thorn Junction	Thorn Junction, Whitethorn	Honeydew, Ettersburg	
Predominant Geology	Quaternary fluvial, beach, and dunes deposits	Franciscan Coastal Terrane; minor Yager terrane & Wildcat Group; Quaternary surficial deposits	Franciscan Central belt; Yager terrane; Coastal terrane	Franciscan Coastal Terrane	Franciscan Coastal terrane; King Range terrane	
Predominant Vegetation Type	Grassland, Hardwood Forest	Oak, Grassland, Douglas Fir, Hardwood Forest	Douglas Fir, Hardwood Forest	Douglas Fir, Hardwood Forest, Redwood Forest	Douglas Fir, Hardwood Forest	
Predominant Land Use	Recreation	Ranching Timber Production	Ranching Timber Production	Rural Residential Timber Production	Recreation	
Rainfall	60 in.	50-115 in.	80-115 in.	70-85 in.	60-100 in.	
Miles of Blue Line Stream	61.0 (Mainstem Mattole)	69.4	49.9	27.5	85.6	303.4
Low Elevation (ft)	Sea Level	20	344	930	20	Sea Level
High Elevation (ft)	20	2,500	2,300	1,500	2,800	4,087
Fish Habitat Conditions	High summer temps; heavy sediment; lack of pool depth and cover; Steelhead only	Good Steelhead populations despite warm summer temps; little canopy; Steelhead only	High summer temps; high sediment little canopy; LWD adequate; Steelhead and Coho	Favorable water temps; good canopy; good LWD; Steelhead, coho, Chinook	Favorable temps in small tribs/upper reaches of larger tribs; good canopy; Steelhead, coho, Chinook	
Fish Species	Chinook salmon Coho salmon Steelhead trout Pacific Lamprey Coast Range sculpin Prickly sculpin Threespine stickleback Surf smelt Redtail surfperch Shiner surfperch Walleye surfperch Staghorn sculpin Speckled sanddab Starry flounder	Chinook salmon Coho salmon Steelhead trout Pacific Lamprey Coast Range sculpin Prickly sculpin Threespine stickleback	Chinook salmon Coho salmon Steelhead trout Pacific Lamprey Coast Range sculpin Prickly sculpin Threespine stickleback	Chinook salmon Coho salmon Steelhead trout Pacific Lamprey Coast Range sculpin Prickly sculpin Threespine stickleback Green sunfish	Chinook salmon Coho salmon Steelhead trout Pacific Lamprey Coast Range sculpin Threespine stickleback	Chinook salmon Coho salmon Steelhead trout Pacific Lamprey Coast Range sculpin Prickly sculpin Threespine stickleback Surf smelt Redtail surfperch Shiner surfperch Walleye surfperch Staghorn sculpin Speckled sanddab Starry flounder

Climate

The Mattole Basin has a Mediterranean climate characterized by cool wet winters with high runoff, and dry warm summers with greatly reduced flows. Most precipitation falls as rain. Along the coast, average air temperatures range from 46 to 56°F. Further inland, annual air temperatures are much more varied, ranging from below freezing in winter to over 100°F in summer. The Mattole Basin receives one of the highest annual amounts of rainfall in California averaging 81 inches. Average rainfall near the coast in Petrolia is about 60 inches per year and well over 100 inches per year falls near the center of the basin in Honeydew. Extreme rain events do occur, e.g. over 240 inches fell over parts of the basin during 1982-83.

Hydrology

The Mattole Basin lies within the Cape Mendocino Hydrographic Unit, a subunit of the Eel River Hydrographic Area as described by the Department of Water Resources in Bulletin Series 94-8. The Mattole River Hydrographic Unit Code: 18010107 as described by the United States Geologic Survey (USGS). The Department of Water Resources (DWR), Statewide Planning Program delineates the Mattole Basin within the North Coast Hydrologic Region (HR), the Coastal (#03) Planning Subarea (PSA), and the Mattole-Bear (#27) Detailed Analysis Unit (DAU).

Winter monthly stream flows in the Mattole River measured near Petrolia average between 1,710 and 4,170 cubic feet per second (cfs). However, peak flows measured on December 22, 1955 and December 22, 1964 were 90,400 and 78,500 respectively. Bank full discharge at Petrolia occurs at approximately 31,000 cfs. "Summer and fall flows drop below 60 cfs, with a minimum measured flow of 15 cfs" (Department of Water Resources).

High seasonal rainfall on bedrock and other geologic units with relatively low permeability and steep slopes contribute to the very flashy nature of the Mattole's watersheds. In addition, the runoff rate has been increased by extensive road systems and other land uses. High seasonal rainfall combined with a rapid runoff rate on unstable soils delivers large amounts of sediments to the river. As a result, the Mattole River transports a very high sediment load. This sediment is deposited throughout the lower gradient reaches as it is transported downstream through the system.

Diversions, Dams, and Power Generation

There are 50 licensed, permitted, or pending water rights within the Mattole Basin. This number does not include riparian users and other diversions that are not registered with the State Division of Water Rights (State Water Resources Control Board, 2001). No major dams or power generating facilities are located within the Mattole Basin.

Geology

Bedrock underlying much of the basin has been tectonically broken and sheared making it relatively weak, easily weathered, and inherently susceptible to landsliding and erosion. The unstable bedrock and soil conditions combined with heavy rainfall, high regional uplift rates, and seismicity produce widespread landsliding and large volumes of sediment input to streams. The geologic unit and/or landslide type present can affect the nearby sediment load (i.e., coarse versus fine-grained). The following provides a brief description of the basin geology and related landslide processes. Detailed discussions of the basin geology, associated mass wasting processes and land use issues are provided in the Geology Appendix A, along with 1:24,000 scale maps illustrating spatial distributions of the geologic units and mass wasting features.

Table 8 summarizes the geologic attributes by subbasin. The Mattole Basin is situated in a geologically complex and tectonically active area, with some of the highest rates of crustal deformation, surface uplift, and seismic activity in North America (Merritts, 1996). Basement rocks, assigned to the Coastal belt and Central belt of the Franciscan Complex by Irwin (1960) are predominantly structurally deformed marine sedimentary rocks (McLaughlin and others, 1982, 1983, 1994). The Coastal belt has been divided into three pervasively folded, sheared, and otherwise tectonically-disrupted terranes; from northeast to southwest, separated by generally northwest-trending shear zones, are the Yager, Coastal, and King Range terranes (McLaughlin and others, 1997). Late Cenozoic marine and non-marine deposits (Wildcat Group or equivalent) underlie a limited area of the watershed west and northwest of Petrolia. Quaternary alluvial deposits cover the bedrock along streambeds in the lower reaches of some tributaries and mainstem Mattole River, while remnants of older surficial deposits are locally preserved on elevated fluvial terraces in some valley areas and on wave-cut terraces along the coast.

Table 8. Geologic attributes summary in the Mattole Basin.

	Estuary	Northern	Eastern	Southern	Western	Coastal
Predominant Geologic Unit(s)	Quaternary fluvial, beach, and dunes deposits	Franciscan Coastal Terrane; minor Yager terrane & Wildcat Group; Quaternary surficial deposits	Franciscan Central belt; Yager terrane; Coastal terrane	Franciscan Coastal terrane	Franciscan Coastal terrane; King Range terrane	King Range terrane; Franciscan Coastal terrane
Predominate Rock/Soil Conditions	Unconsolidated, migrating sand and gravel deposits	Weak, broken argillite and mélange; thick, clayey soils	Intact sandstone and argillite cut by broad shear zones with weak rock and clayey soils	Relatively strong, intact sandstone and argillite; thin, sandy soils	Relatively intact sandstone and argillite in King Range; more broken in eastern and northern areas	Relatively intact sandstone and argillite in King Range; more broken in eastern and northern areas
Typical Mass Wasting	Sediment transport/ deposition	Abundant earthflows; rock slides; composite slides; gully and stream bank erosion	Debris and rock slides in strong rock areas; earthflows, composite slides and gullies around shear zones	Debris slides; scattered deep-seated rock slides	Debris slides, deep-seated rock slides and debris flows	Debris slides, deep-seated rock slides and debris flows
Relative Degree of Stream Disturbance	N/A	Highest in basin	High in specific portions of subbasin	Lowest in basin	Highly variable throughout subbasin	N/A

Through photo-interpretive mapping, McLaughlin and others (2000) further subdivided the Central belt and each terrane within the Coastal belt into three or four subunits, which form the geologic map units depicted on Plate 1 of the geologic report. These subunits are based on topographic expression and general changes in lithology and structural condition of the rock. For example, where sandstone dominates and is relatively intact (i.e., subunits y3, co4, and krk3 on Plate 1), hard topography, consisting of sharp-crested ridges with steep slopes and well-incised drainages, tends to develop. The pervasively sheared, clay-rich mélange (i.e., subunits cm1 and co1) generally form soft topography, characterized by rounded hilltops with gentle slopes and poorly developed sidehill drainages. Additional subunits of McLaughlin and others (2000) show topographic characteristics between these two end members. These subunits show a good correlation with the different types of mass wasting processes that occur in the study area, as discussed in Analyses and Results by Subbasin later on in this document.

The bedrock map units have been consolidated into three groups, herein referred to as hard, moderate, and soft geomorphic terrains. Specifically, the bedrock map units have been grouped into geomorphic terrains as follows:

- Soft Terrain – Geologic subunits identified as having the greatest landslide density (cm1, serpentinite, and co1 on Plate 1, geologic report).
- Moderate Terrain – Geologic subunits identified as having intermediate landslide density (y1, co2, and krk1), along with the small units of different lithology (e.g., cols, krb) which collectively underlie less than 1% of the study area.

- Hard Terrain – Geologic subunits identified as having the lowest landslide density (y2, y3, co3, co4, krk2, and krk3).

The unconsolidated Quaternary deposits mapped overlying the bedrock are grouped together as a fourth geomorphic terrain. The terrain distribution for the entire Mattole Basin is presented on Figure 18. These terrains show a strong correlation with mapped landslide occurrence and type, and provide a simplified division of the watershed based on geology and landform that is useful in the analysis of other spatial data. The distribution of active and dormant slides in each of the three bedrock geomorphic terrains is shown on Figure 19, Figure 20, and Figure 21.

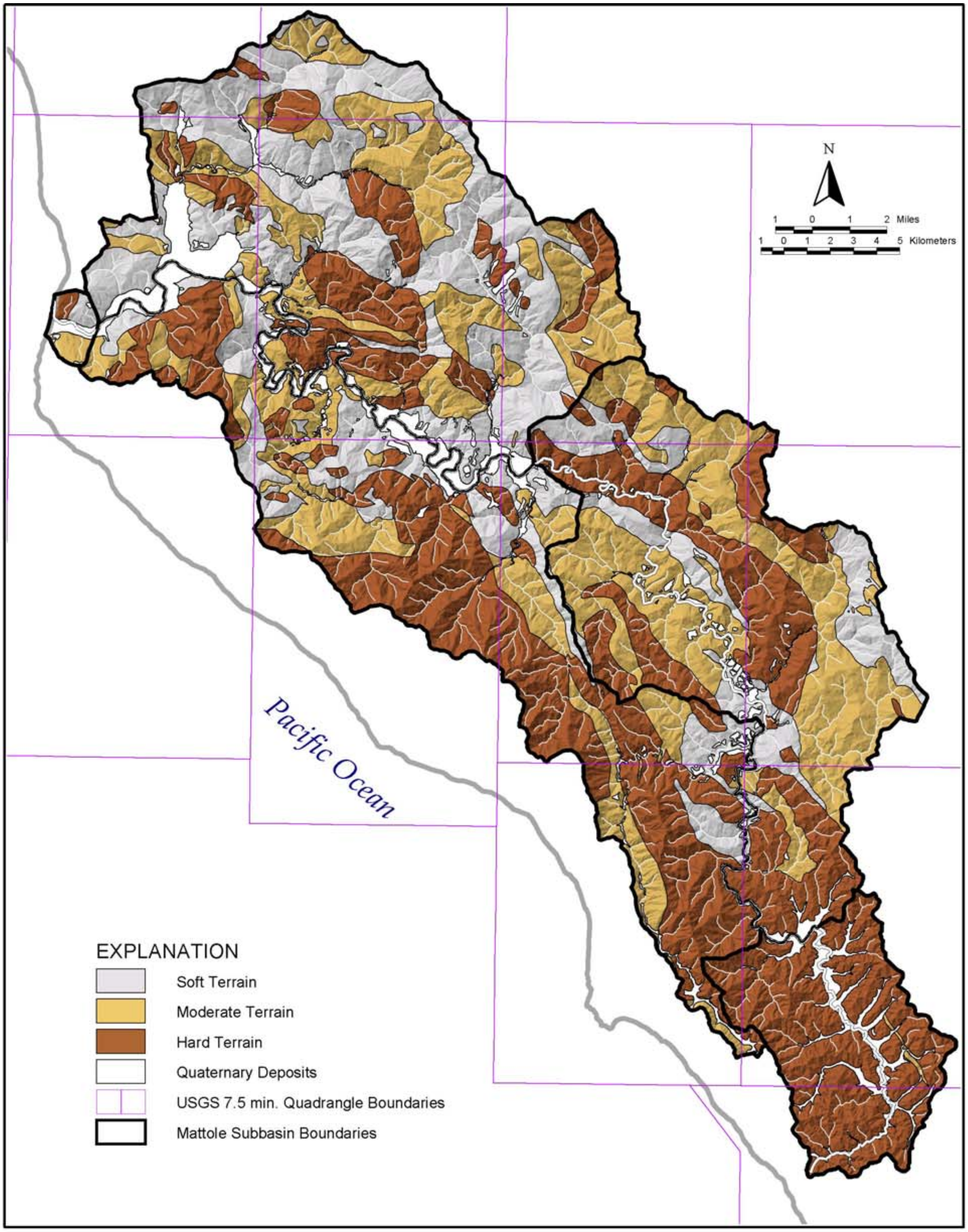


Figure 18. Distribution of geomorphic terrains within the Mattole Basin.

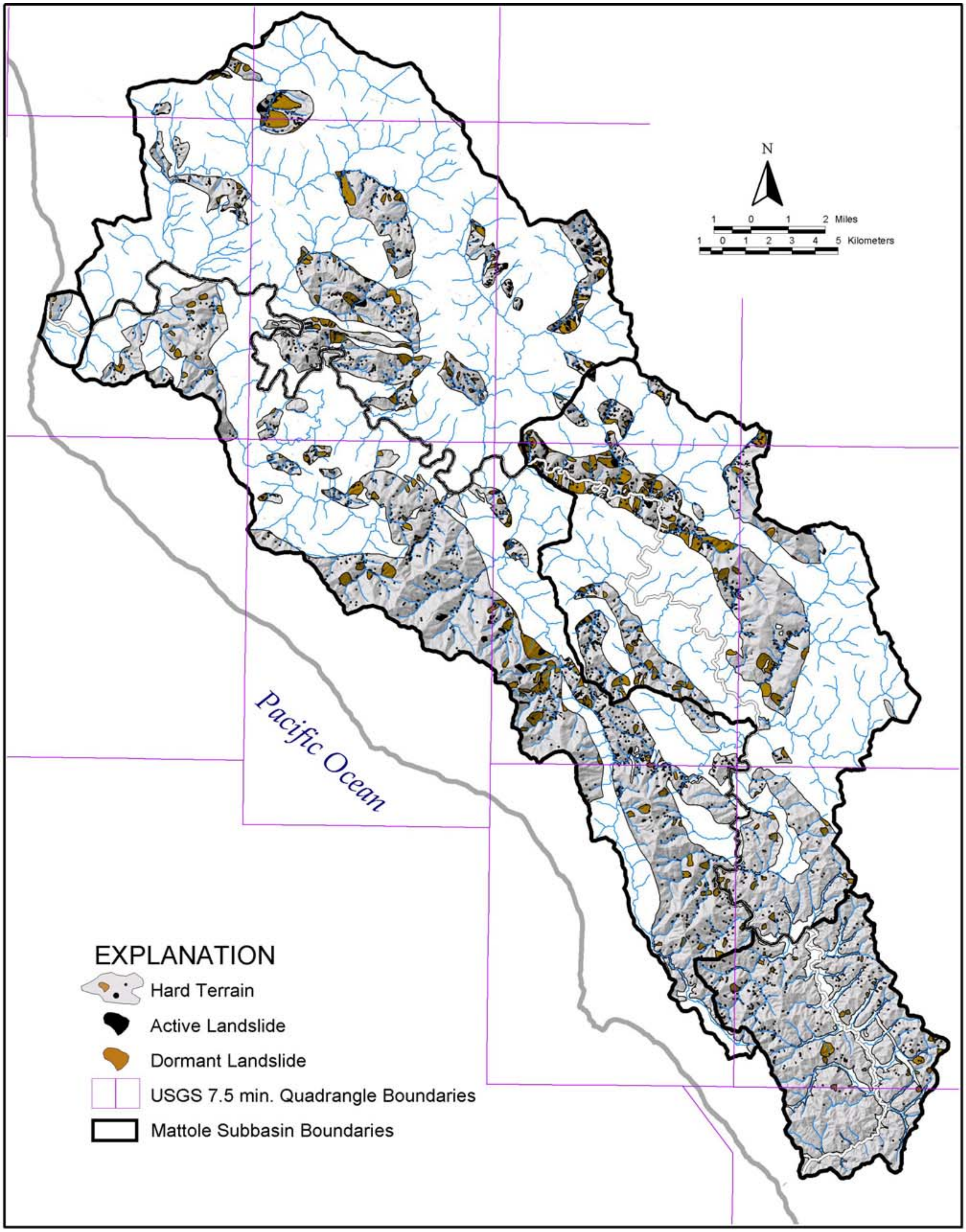


Figure 19. Occurrence of historically active and dormant landslides on hard terrain.

Dots represent slides smaller than approximately 100 feet in diameter.

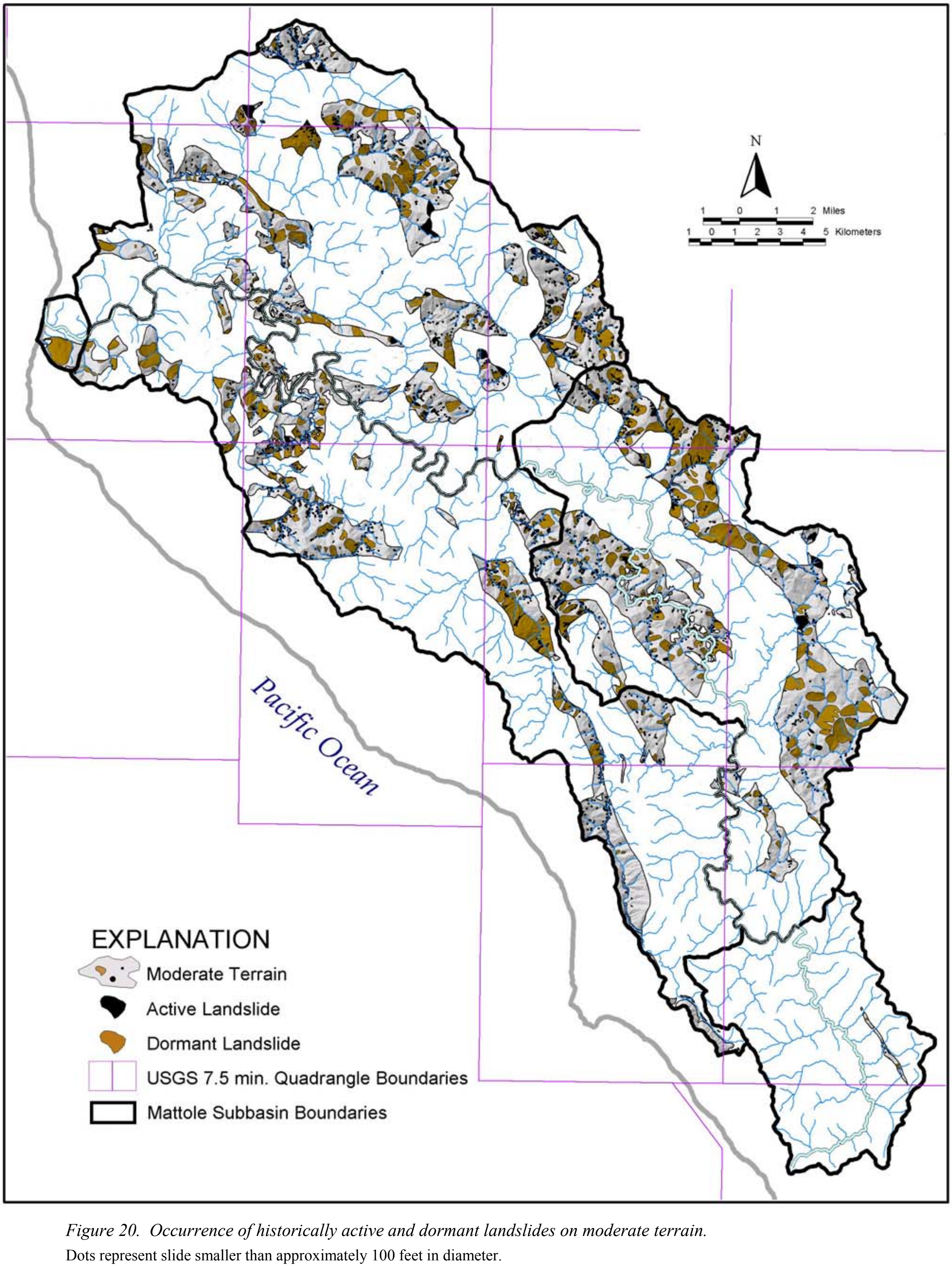


Figure 20. Occurrence of historically active and dormant landslides on moderate terrain.

Dots represent slide smaller than approximately 100 feet in diameter.

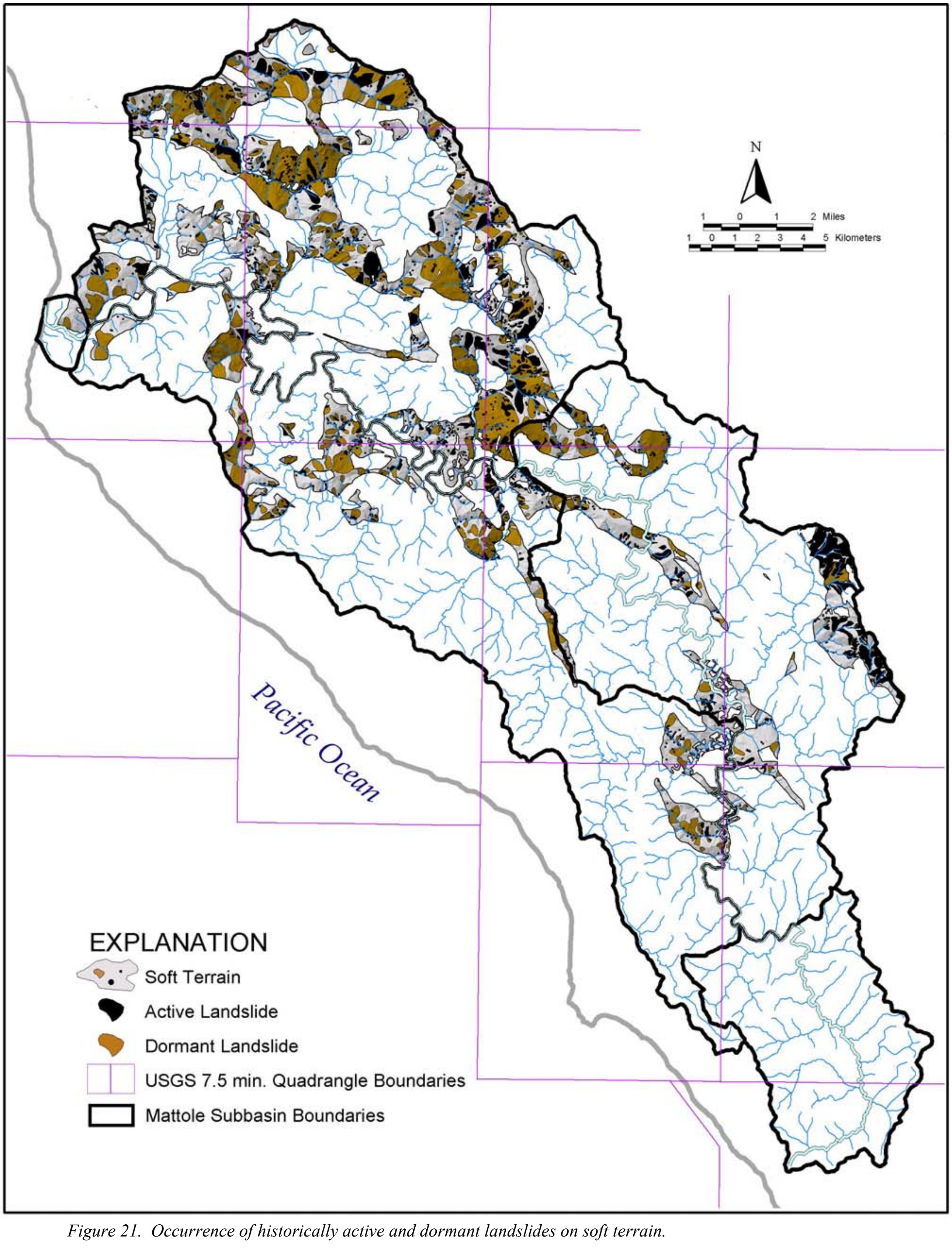


Figure 21. Occurrence of historically active and dormant landslides on soft terrain.

Faulting, Seismicity, and Regional Uplift

The Mattole Basin is located in a complex tectonic setting near the junction of three crustal plates (North American, Pacific, and Gorda). The region experiences a high level of seismic activity, and major earthquakes have occurred in intraplate areas as well as along well-defined faults (Dengler et al., 1992).

The major fault structures within the Mattole Basin study area are the Cooskie and Petrolia shear zones, and the San Andreas Fault (Geology Report, Appendix A, Figure 3). The Cooskie shear zone, a poorly defined zone of sheared and broken rock, extends easterly from Punta Gorda. The Petrolia shear zone is a similar structure, extending southeast through Petrolia toward Honeydew along the Mattole River. If the Cooskie and Petrolia shear zones are on-land extensions of the offshore plate boundary fault systems (the Mendocino fracture and the Cascadia subduction zone, respectively), they may represent significant, potentially-active fault zones (McPherson and Dengler, 1992; Clarke and McLaughlin, 1992).

Major historical earthquakes in the region have occurred in intraplate zones as well as along well-defined faults (Dengler and others, 1992; Oppenheimer and others, 1993). For example, the rapid uplift described below is being accommodated along a system of thrust faults, some of which may not extend upward to the ground surface (McLaughlin and others, 2000; Geology Report, Appendix A, Figure 5). The Honeydew earthquake (August 1991, M 6.2) occurred on one of these faults, when the southwest block was thrust upward over the northeast block at depth. Although the earthquake reactivated landslides and resulted in a zone of ground cracking, the rupture surface along the fault plane did not extend to the ground surface (McPherson and Dengler, 1992). Similarly, the main shock of the Cape Mendocino earthquake (April 1992, M 7.1) centered near Petrolia occurred on a low-angle thrust fault near the base of the North American plate that caused significant ground shaking and coastal uplift, but did not produce surface rupture (Oppenheimer and others, 1993). The two largest aftershocks to the Cape Mendocino earthquake apparently occurred within the Gorda plate offshore and were both M 6.6 events (Oppenheimer and others, 1993).

High rates of regional uplift provide a regenerating source of sediment to the watershed. Wave-cut Holocene (<10,000 years old) platforms along the coast have been elevated up to more than 50 feet above a rising postglacial sea level (Merrits, 1996). Elevated alluvial and strath terraces along the Mattole River indicate that relatively high rates of uplift persist inland within the watershed. Following the 1992 Cape Mendocino earthquake sequence, extensive mortality of intertidal organisms from coastal emergence indicated a rough maximum of 1.4 m of coseismic uplift occurred between Cape Mendocino and the South side of Punta Gorda (Carver and others, 1994).

Landslide Potential

Once relevant relationships between geology and landsliding were recognized, a landslide potential map was created by CGS using the GIS as a tool to capture the geologists' interpretation of relative landslide potential within the study area. This Landslide Potential Map was generated using a matrix that assigns relative landslide potential levels to areas, based on landslide feature type and activity, geomorphic features, geology, and slope found within the watershed. The Relative Landslide Potential for the Mattole Basin was defined and illustrated in five categories, from 1 (lowest) to 5 (greatest landslide potential). The Landslide Potential Map was produced at a scale of 1:24,000, and is presented on Plate 2 in the Geologic Report, Appendix A. The methods and matrix used to develop the Landslide Potential Map are discussed in further detail in the Geologic Report Appendix A

The results of the landslide potential evaluation are dominated by potential categories 3 through 5. This is considered reasonable in this geologically active watershed (Figure 22,

Figure 23, Figure 24, and Figure 25). Overall, approximately 52% of the Mattole Basin has high to very high landslide potential. The results of the landslide potential evaluation are discussed further in the Analyses and Results by Subbasin section of this report.

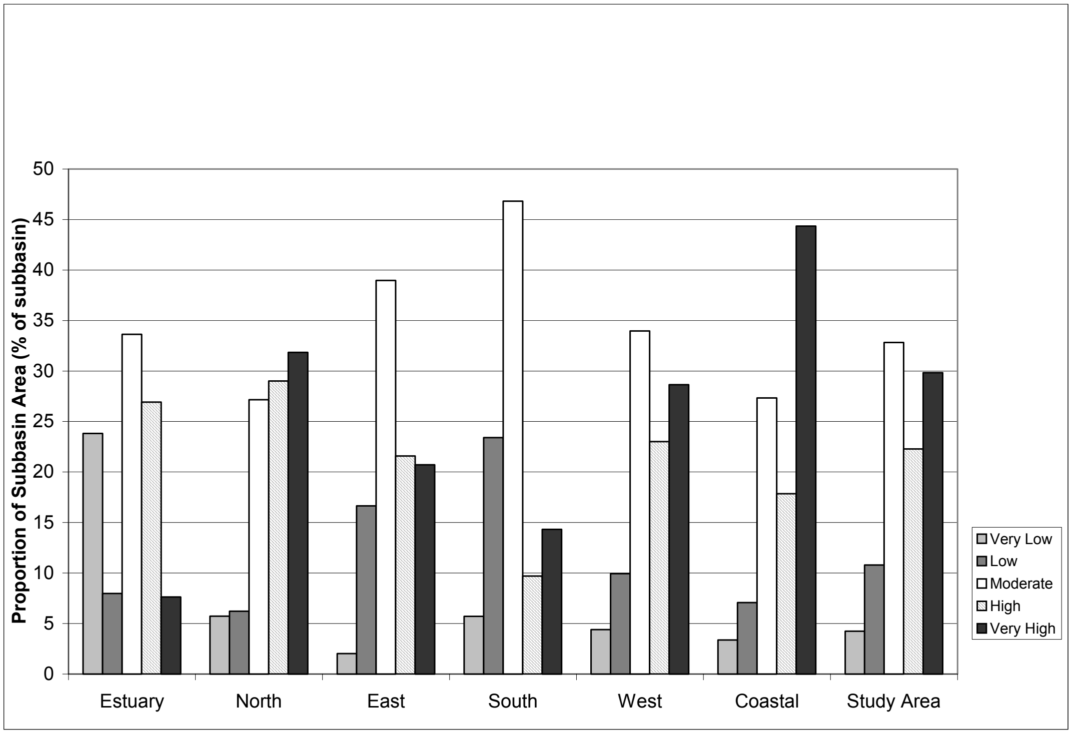


Figure 22. Proportions of each subbasin area that was assigned to the various landslide potential categories.

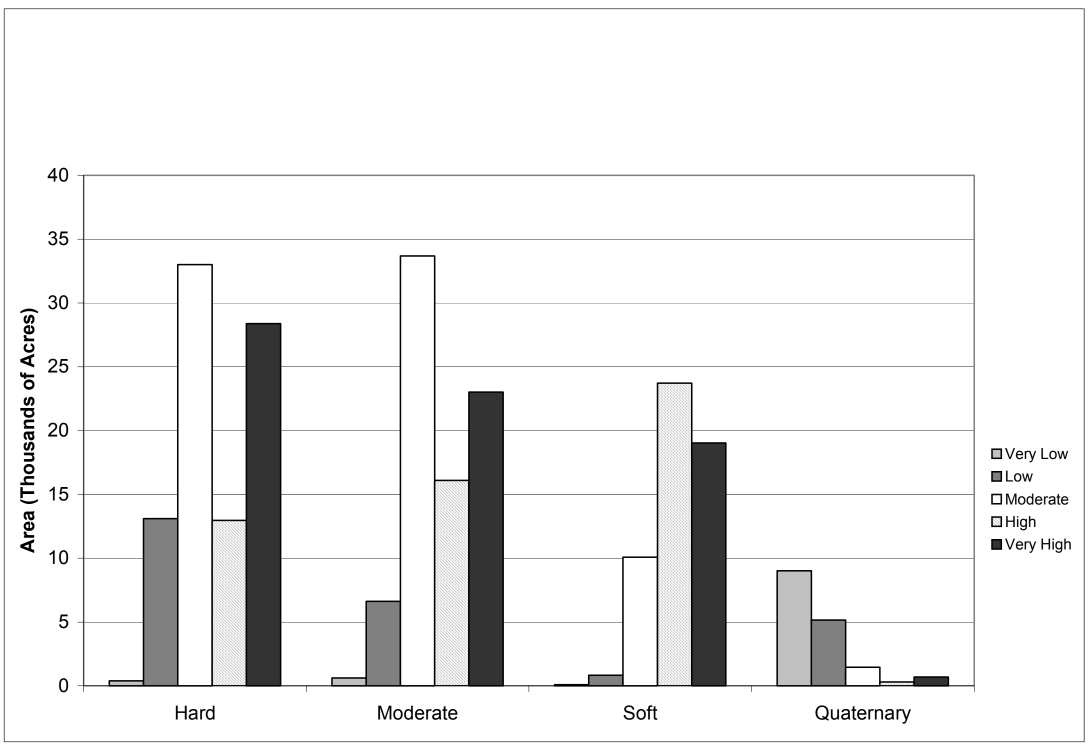


Figure 23. Area within each terrain type that was assigned to the various landslide potential categories.

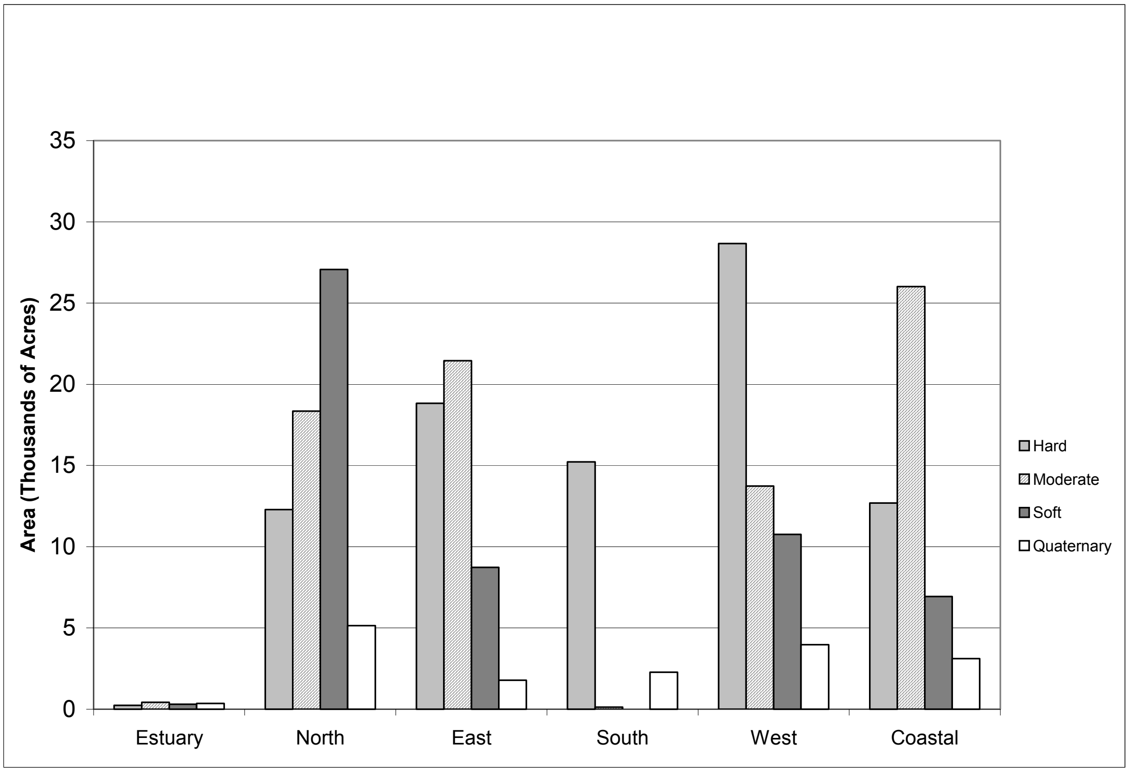


Figure 24. Area within each subbasin occupied by each of the various geomorphic terrains.

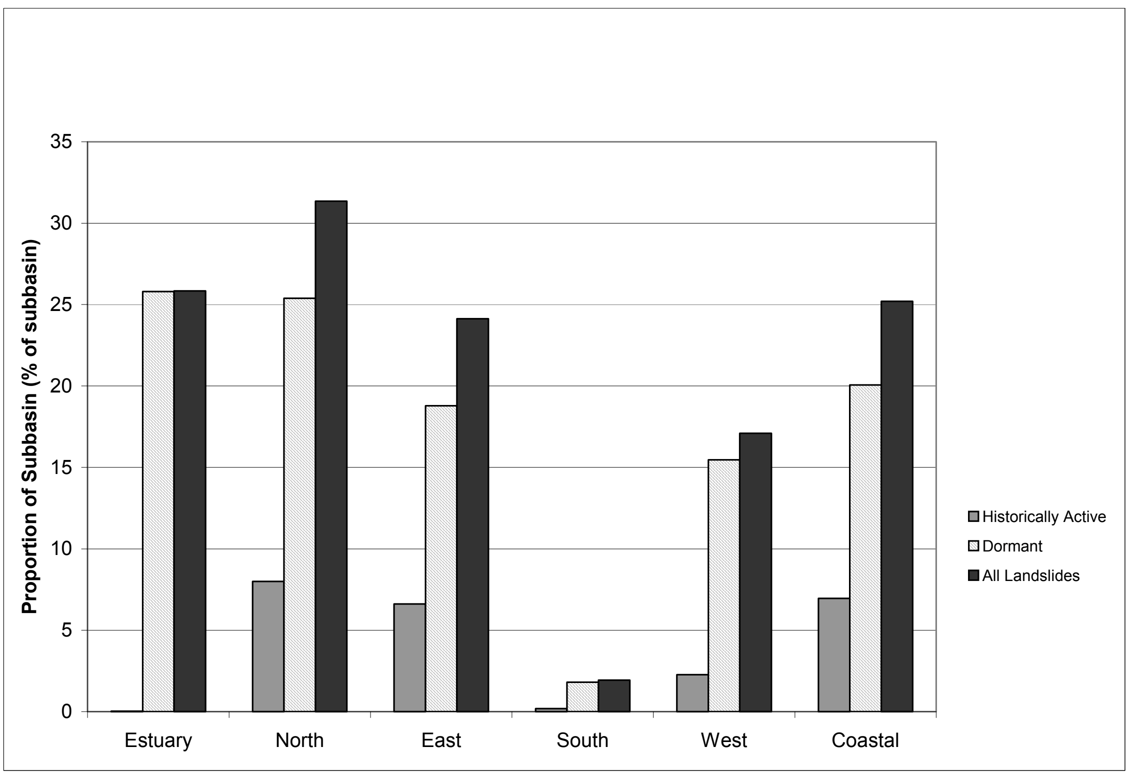


Figure 25. Percentage of each subbasin underlain by historically active and/or dormant landslides.

Those too small to delineate at map scale were assumed to have an average area of 400 square meters (approximately 4,505 square feet), and were combined with larger mappable landslides. Histogram reflects data from 1981, 1984, and 2000 photographs. Portions of dormant landslides overlain by historically active landslides were not included in the collective totals.

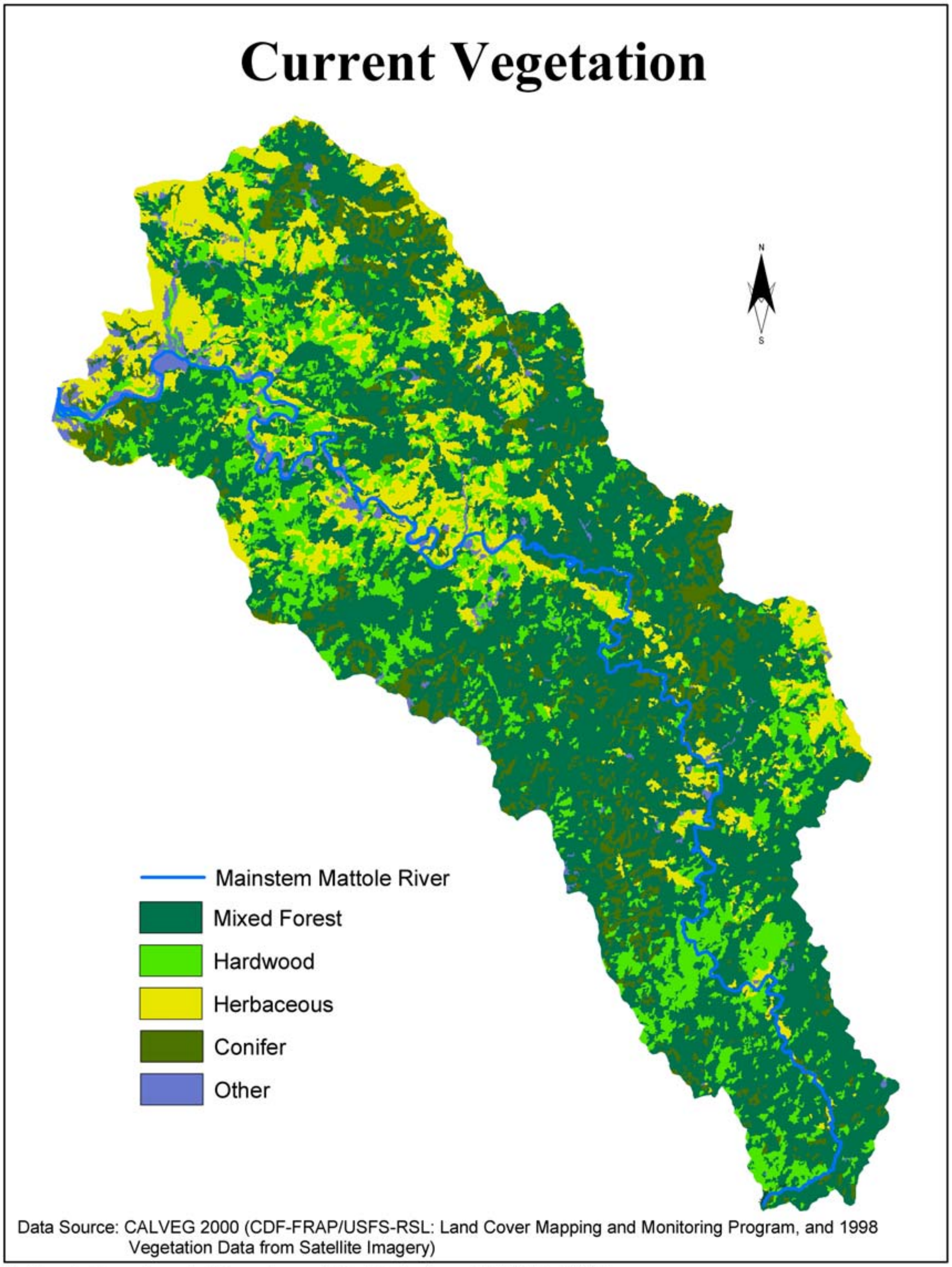
Vegetation

Prior to European settlement, coniferous forest extended throughout most of the 190,000 acre Mattole Basin. Natural prairie grassland is concentrated on the northwestern portion of the basin, but prairie soils occur throughout the basin, mostly on ridgetops. The structural attributes, seral stages, and mix of species on the forestlands are determined by a combination of physical, biological, and disturbance factors. Physical factors include soil, moisture, temperature, and topography. The Mattole Basin is unusual within the Northern California coast as having very little redwood forest present; it is thought to be primarily due to the King Range blocking the summer fog. The interaction between soil types and strong salt-laden air are also possible factors that influence the redwood free areas of much of the Mattole and Bear River basins (Zinke, 1996). Forested stands consist primarily of tan-oak and Douglas-fir as the major tree species. Madrone, big-leaf maple, chinquapin, bay, canyon live-oak, and alder occur as minor components whose occurrence generally varies according to soil type, slope, and aspect controlling summer moisture regimes. Seral stages are dependent upon disturbance regimes, both natural and human induced. Natural disturbance includes fire started by lightning. Other coniferous species include yew, isolated sugar pine stands, and redwood in the southern headwaters.

The current vegetation (Figure 26) is predominately forestland. Mixed conifer and hardwood forestland occupy 57% of the watershed while hardwood forests occupy 17% and coniferous forests occupy another 8%. Annual grasslands occupy 15% of the watershed. All other vegetation types occupy the remaining three percent of the watershed. With the exception of the estuary and areas where the river broadens out, there are no lakes or other reservoirs of significant size. Half of the watershed is covered by trees that have an average size of 12-24 inches diameter at breast height (dbh). Twenty percent of the area is covered by stands that average greater than 24-inch dbh trees and another 11% is covered by pole-sized trees 6-11 inches dbh.

Vegetation age classes in the Mattole Basin are quite young except for the scattered remaining un-entered old-growth stands. These are in protected status where they are in public ownership. The last stands of old growth in the Northern Subbasin are in private ownership and timber-harvesting plans there are invariably controversial. The previous harvest and grazing activities moved most stands to an earlier successional stage and consequently, hardwoods are now a part of the dominant canopy cover. However, it is clear from aerial photographs from the 1940s that hardwood was a major stand component. Early harvesting activities had a splotchy appearance from small stands and corners being left entirely un-entered and other areas having the appearance of an over-story removal, which left a substantial amount of vegetation in place. Other areas that are classified as forestland have a low level of livestock grazing. The size and location of mapped grasslands has also changed in response to past activities. Many of the existing grasslands are being encroached by woody vegetation. Studies cited in the draft Redwood Creek Watershed Analysis (RNSP 1999) suggest a number of causes including a climatic shift towards the currently cooler and moister climate about 2500 to 2800 years ago (West 1983). While Native American burning practices prior to the arrival of European settlers suppressed the encroachment of Douglas-fir and other woody vegetation, in Redwood Creek the loss of about one-quarter of the prairie and oak woodlands since 1850 is attributed to fire exclusion and road building (Popence et al. 1992).

The hypothesis that the mosaic of vegetation that existed prior to the historic land practices of the last 150 years was probably more varied and in smaller patches than now was tested by the BLM as part of the BLM Honeydew Watershed Analysis (1996). The BLM made a comparison of the 1948 vegetation from soil and vegetation maps prepared by the USDA Forest Service and the State of California Division of Forestry using 1947-48 aerial photography and vegetation data acquired as a part of their analysis project. Their text indicates that of their three sub-watersheds, 90% of the Upper Honeydew sub-watershed has never been harvested, while Beartrap and Eastern Honeydew sub-watersheds were harvested between 1954 and 1966; thus, the patchy and variable 1948 vegetation is characteristic of the pristine vegetation for that time period.



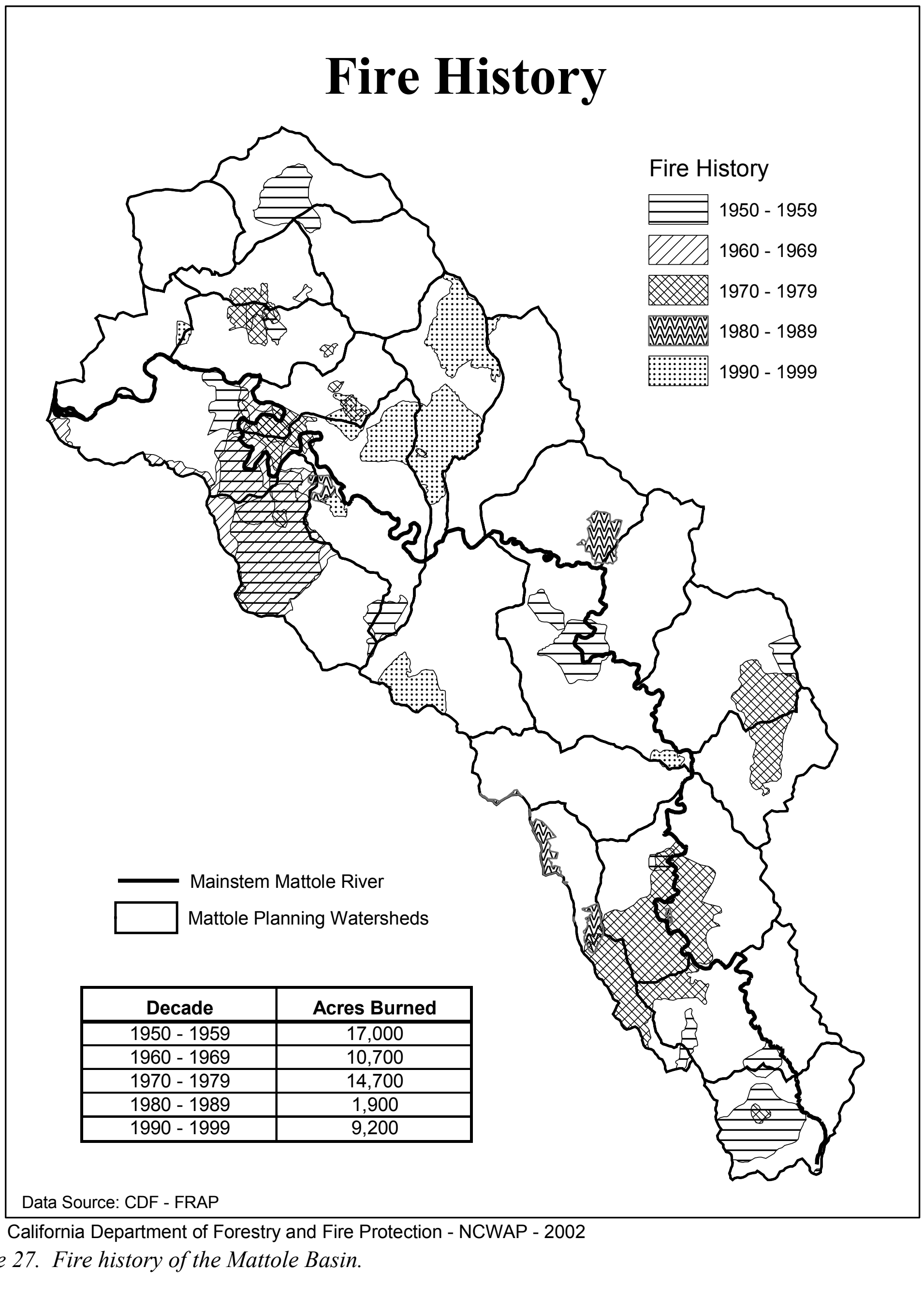
California Department of Forestry and Fire Protection - NCWAP - 2002

Figure 26. Vegetation map of the Mattole Basin.

Current vegetation is the result of fire history in addition to timber harvesting and grazing. As noted earlier, fire was a natural and frequent visitor to the Mattole Basin. Interviews of Honeydew Creek Watershed residents, as part of the BLM watershed analysis, indicated that many ranchers burned the same areas every two or three years to control poison oak and other brush (Anders 1995). However, active suppression efforts beginning in the 1940s changed the nature of wildlife from frequent, low intensity ground fires to occasional, catastrophic fires. Fires now have the ability to burn through large acreages and to severely damage both upslope and riparian areas, setting back the seral stage. A summer weather pattern of lightning and periods of strong winds, combined with unnaturally high fuel loading may lead to forest stand replacement wildfire as a major upslope contributor to the quality of anadromous fish habitat within the Mattole Basin.

The towns of Petrolia, Ettersburg, Whitethorn, and Honeydew are all listed in the California Fire Plan as being in a high wildfire threat area and that some or all of the threat comes from federal lands (http://firesafecouncil.org/fireplanindex.html, May 2002). The Mattole Valley/Prosper Ridge area and the Shelter Cove subdivisions, which extend to the watershed boundary, are identified in the CDF Humboldt/Del Norte Ranger Unit Fire Management Plan as being two of the highest risk areas in the County.

A fire risk and fuels model for Humboldt County is being prepared for release at the end of 2002. This same report notes that some of the largest fires in Humboldt and Del Norte County have occurred in this area and suggests that there is a microclimate that provides the potential for the occurrence of extreme fire behavior (CDF 2002). Figure 27 displays wildfires over 300 acres in size and CDF-managed prescribed burns of any size. It does not include site preparation burns after timber harvesting or non-agency sponsored prescribed burning of grasslands by ranchers.



Decade	Acres Burned
1950 - 1959	17,000
1960 - 1969	10,700
1970 - 1979	14,700
1980 - 1989	1,900
1990 - 1999	9,200

California Department of Forestry and Fire Protection - NCWAP - 2002

Figure 27. Fire history of the Mattole Basin.

Population

There are three post office towns in the Mattole Basin: Whitethorn in the headwaters region; Honeydew near the center of the basin; and Petrolia near the mouth. The total Mattole Basin resident population in the year 2000 census was estimated at about 1,200 people.

Census data for the year 2000 was analyzed to provide population estimates for each subbasin. The main Census Bureau statistical levels (in descending order) are: State, County, Census County Division (CCD), Census Tract, Block Group, and Block. The Mattole Basin straddles the Ferndale CCD (northern portion) and the Garberville CCD (southern portion). Additionally, the basin is almost evenly divided between Census Tract 112 (Ferndale) and Census Tract 113 (Garberville). Figure 28shows population and density by square miles and stream miles.

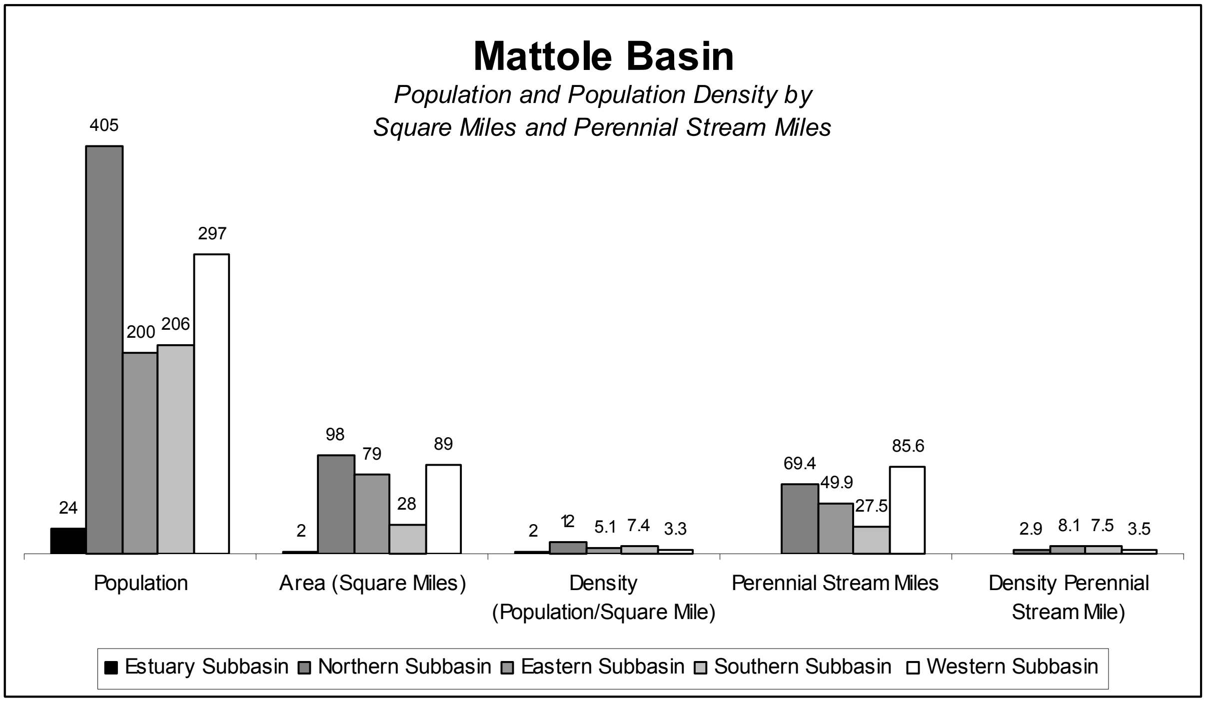


Figure 28. Mattole Basin 2000 census population by subbasin.

Ninety percent of the Northern Subbasin's total population lives within three miles of the population centers of Petrolia or Honeydew, which are both near the southern boundary of this subbasin. The Eastern Subbasin has the most pockets of population. This is due to the numerous rural subdivisions in this area. This trait is shared with the Southern Subbasin. The major difference is that Southern Subbasin populations are concentrated along the Mattole River and its major tributaries. Most of the Western Subbasin population lives near the county roads running along the northern, eastern, and southern edges of this area. These roads lie near the river from the Estuary to Honeydew, near the downstream terminus of the Eastern Subbasin, and then generally follow the ridgetops until reaching the boundary of the Southern Subbasin.

Land Use

The Mattole Basin was occupied by Athabaskan-speaking Mattole and Sinkyone Native Americans when the first settlers from the Eastern United States arrived in the early 1850s. Disputes over hunting ground and domestic stock culminated in a massacre at Squaw Creek in 1864. Survivors were sent to the Round Valley Reservation on the Middle Fork of the Eel River, where most succumbed to the measles epidemic in 1868 (Elements of Recovery, 1989).

The first known white explorer of the Mattole Basin was John Hill of Fort Humboldt, who glowingly described, in an 1854 report, tall clover in the prairies, rich grassland in the valleys, and timbered slopes underlain by wild oats and other grasses (Humboldt Times Weekly, September 23, 1854). Within this report he noted streams with riparian corridors of alder, willow, and cottonwood and the Douglas fir and tan-oak on the slopes. He mistakenly described redwood forests in the nearby woods (W.W. Roscoe, 1940). He also commented on the numerous Indians who appeared to have not seen white men before. This was the only first hand description of the land cited in Elliott's History of Humboldt County, 1881.

W.W. Roscoe provided a series of personal accounts in his self-published monograph, A History of the Mattole Valley, 1940. He recorded this interview of Samuel S. Pollock, one of the first Mattole Valley settlers, in which Mr. Pollock describes the vegetation and condition of the Grange area, about 9 miles upriver of Petrolia. Pollock said:

> "The Mattole Valley was certainly a wonderful sight when I first saw it in the spring of 1857. There were no fences to stop a horseback rider then. I rode my horse all over the valley and right through the tall grass. My horse had hard work to get through the tall grass because it was so badly tangled up. My head would just stick above the grass heads as I sat in my saddle and guided my horse. Every little way a big buck deer or a buck elk, not to mention the little ones, would jump up and run away in the tall grass."
>
> "One day I say (sic) three big grizzly bears besides a number of black and brown bears. Gee whiz, weren't those grizzlies independent! They didn't try to hurt me. They just lumbered out of the way, then sat down and looked at me in a curious sort of way. I felt that it would be best not to go too close to them, so I turned my horse to one side and gave them wide berth. Jingoes, how different things look now. I wonder what the teacher and the children of the Upper Mattole School would think now if I could make them realize what their schoolyard and the country around looked like in June 1857, with the tall grass on the flat six or seven feet high, my horse out of sight as I rode, and that big grizzly bear looking at me from the ridge while the deer and the elk were running away. They can't understand it."

In 1858, just four years after Hill explored the valley, and with the influx of new pioneers, farming began in earnest. The very first settlers were farmers and ranchers who converted native grassland into home sites, home gardens, orchards, and rangeland. As grazing activities increased, conversion of the adjoining forests began. Timber was harvested for local needs or simply felled and then areas broadcast burned for conversion to grazing lands.

Petrolia grew rapidly during the short-lived oil boom of 1864-65. Natural gas vents and oil seeping from the ground began a local land rush that almost doubled the Valley population of 282 to over 450 people by 1870 (Elliott). While many land patents were obtained and numerous test wells drilled, there was never a truly commercial volume of oil produced. Many of the oil seekers remained.

Elliott's 1882 Encyclopedia of Humboldt County noted that the Mattole area produced butter, cheese, wool, beef, mutton, and pork. The encyclopedia further states that though the best fruit of the county grows in the Bear River and Mattole districts, the distance to market was too great for commercial production. This theme of distance to market and poor roads is recurring and has stymied rural prosperity in the Mattole (Roscoe, 1977).

Just after the turn of the century, tannin produced from the bark of tan oak trees became a commercial commodity in the Mattole Basin. The Wagner Leather Company in Briceland processed tan-bark and shipped the solution in barrels to the wharf in Shelter Cove between the years 1901 and 1922 (Cook, 1997). During the boom years, over three thousand cords of bark were processed each year by Wagner Company (Raphael, 1974). The Mattole Lumber Co. in the lower Mattole utilized a one-mile rail line, which led to a wharf constructed in 1908 at the mouth of the Mattole. The valley's tan oak bark was first hauled out by mule and then transferred to horse and wagon (Clark, 1981). The wharf required constant and expensive maintenance and was not rebuilt after a storm in the winter of 1913/1914. Tan bark harvesting continued until the supply was depleted in the early 1920s, (Clark, 1981) at about the same time that the tannin extract was replaced by synthetic products.

In 1941, the most widespread use of the watershed appears to have been grazing and is indicated by the amount of grassland and recent fires, which appear to be deliberate conversion of pre-existing brush and timberland. Conifer timber harvesting activities are readily apparent near Harris Creek and continue further upstream into the redwood belt. Timber harvest operations began in earnest as Douglas fir became a merchantable building material during the post World War II boom. The 1952 air photos show the beginning of the large-scale timber-harvesting era in the Douglas-fir forests of the Mattole Basin. This was the first entry into most of the forestland by mechanized equipment. Harvests were not designed as silvicultural treatments and were an extractive land use. The on-the-ground effects varied from a type of selection to a seed tree cut with a large amount of remaining vegetation consisting of unmerchantable conifers, tan-oak, and brush. Many of these harvests became precursors to range conversion. The roading was typical of the time period; log landings and access roads were generally at the bottom of the slopes in or adjacent to stream channels.

By the late 1980s, timber harvesting decreased while environmental awareness increased. Changes in policy concerning management of federal lands and the designation of the Northern Spotted Owl as federally threatened led to the designation of BLM lands, a large proportion of the Western and a smaller percentage of the Eastern Subbasins, as Late Successional Reserve (BLM, Bear Creek 1995) lands that are not subject to harvest. In the Eastern Subbasin, Eel River sawmill proposed several harvest plans, some in old-growth, which were hotly contested. These lands became part of the effort by some groups, including those formed to influence BLM land use designations and policies on Gilham Butte, to create a Redwoods to the Sea wildlife corridor. In the Southern Subbasin, increased harvest plans reflect the value of redwood timberlands and efforts to bring previously cut-over lands into greater productivity. The Northern Subbasin contains the bulk of Pacific Lumber/Scopac ownership in the Mattole Basin. Although Pacific Lumber Company is operating under an approved HCP, some of their timber harvesting plans are first entries into old-growth stands, causing protests that include civil disobedience.

In Table 9, harvest periods are broken into irregular time intervals as a result of the way existing data were compiled. For the most part, the first period consists of the post-war logging boom although portions of the southern headwaters were harvested just prior to the 1942 aerial photos. This category includes most of the area harvested and roaded before the 1964 flood which is estimated to be a one hundred year event, meaning that in any given year there is a one percent chance of the stream carrying the same volume of water. Thirty-eight percent of the basin was harvested during this time period. The harvest period 1964-1974, also prior to the establishment of the first iteration of the Forest Practice Rules authorized by the Z'Berg-Nejedly Forest Practice Act of 1973, brought the cumulative total of 49% of the basin area logged by tractor and skidded downhill to log landings and access roads low on the slopes and often adjacent to streams. The next interval, 1974-1983, is a time period of Forest Practice rules prior to substantive watercourse protection. The acres listed in the years 1984-2001 are based on the completion date of timber harvesting plans (THP) and submission dates for non-industrial timber management plans (NTMP) submitted to the California Department of Forestry and Fire Protection. There were 1,022 acres submitted as NTMP's in the time interval of 1990-1999 and 73 acres in 2000-2001. This latest time period reflects increasingly restrictive measures for harvesting practices, including reduced activities near watercourses. These years are broken into intervals that are similar to those used for other analyses in the NCWAP program.

Table 9. Timber harvest history, entire Mattole Basin.

TIMBER HARVEST HISTORY - ENTIRE WATERSHED*				
	Total Harvested Acres	**Total Area Harvested (%)**	**Average Annual Harvest (ac)**	**Average Annual Harvest Rate (%)**
Harvested ~1945 – 1961**	72,897	38%	4,288	2%
Harvested 1962 – 1974**	21,141	11	1,626	<1
Harvested 1975 – 1983**	6,948	4	772	<1
Harvested 1984 – 1989	3,900	2	650	<1
Harvested 1990 – 1999	8,405	4	840	<1
Harvested 2000 – 2001	1,809	1	905	<1
Not Harvested:				
Grasslands	33,504	18		
Brush and Hardwoods	38,828	20		

* Does not add to 100% due to data discrepancies, re-harvest areas, and uncut timber areas.

** NCWAP has not yet validated the accuracy of this data (obtained from MRC).

A rough rate of harvest would indicate that from 1945-1966, an average of 2.2 % of the basin was harvested per year, from 1962-74, 1%, and about .0.5% of the basin harvested per year from 1984-2001. Much of the basin is in young stands of trees. As these grow into harvestable size, one could reasonably anticipate an increased rate of harvest on private lands in about ten to twenty years.

Ranching has focused almost entirely on cattle since the passage of propositions limiting predator control options. County-wide, beef cattle numbers between 1980 and 2001 have ranged between 21,000 to 24,000 head, while sheep numbers have plummeted from 25,000 animals in 1980 to 15,600 animals in 1992 and 4,500 sheep in 1997, the latest figures available (http:/www.nass.usda.gov, 2002). Land holdings in the Mattole Basin are increasingly fragmented (and Figure 29) and the amount of livestock is difficult to quantify. Many of the smaller ownerships have hobby livestock, but there is no way to estimate numbers.

The 1960s were the beginning of the back to land movement of young, largely urban people onto subdivided property, generally recently logged. Many of these new residents were interested in learning how to work on their land, to rehabilitate it, and to find an income. Both Honeydew and Petrolia are about two hours driving time south of Eureka and provide few business opportunities for employment or shopping. There are some home-based businesses, but many people commute to the Highway 101 corridor in their own vehicles, as no public transportation exists (Figure 30). Local unemployment was estimated at around 50% in 1999, but is acknowledged as variable because of seasonal work and an underground economy of marijuana cultivation. In 1999, over half of the elementary students were on the federal reduced lunch program, but the enrollment of approximately 117 students does not include charter school students (www.co.humboldt.ca.us, 2001). There is a strong pride of place amongst many local residents that belies bleak and dismal statistics. Current census data indicate that approximately 1200 people call the Mattole Basin their home.

More recently, much of the land use in the Mattole Basin is centered on relatively small, private non-industrial timber management, cattle and sheep ranching activities, and other agricultural pursuits like orchards, pasture, and field crops. Recreational activities in the King Range National Conservation Area are also important land uses (Figure 31). In association with most of these current non-recreational land uses are many roads that have been newly constructed or re-built from old, abandoned logging roads. Many of these roads have increased the amount of sediment contributed to streams.

However, many private non-industrial landowners are currently concerned about their ability to manage their property for income products such as livestock and timber. Non-industrial landowners fear that sustained low livestock prices and the escalating cost of additional regulatory requirements associated with timber, ranching, and agricultural activities will destroy their economic viability. Timber harvest plan preparation is costly and landowners feel regulatory requirements are exorbitant and counter-productive to good stewardship since the high cost must be absorbed through increased short-term timber harvest rates.

Non-industrial Timber Management Plans (NTMP), established as an alternative permit process in 1991, are not extensively utilized by Mattole Basin landowners. Landowners provided a number of reasons for not using NTMP's: the maximum acreage is too low, high preparation costs forces initial harvest of more timber than the landowner wants to cut, the fear of un-anticipated long-term and expensive mitigations required after the major cost of plan preparation, and the fear that future regulations will change and economically impact previously approved plans. When several landowners were asked how they envisioned their land being managed ten years from now, not one of them knew.

Table 10. Land ownership of Mattole Basin.

Ownership	Percent	Acres	Square Miles
Private Lands*	83.6	158,509	247.7
Bureau of Land Management**	15.8	30,022	46.9
Other Public Lands	0.6	1,230	1.9
Total		**189,761**	**296.5**

* Private lands ownership may include parcels scheduled to be placed into public ownership.
** The percentage of BLM owned lands may be higher due to recently acquired lands

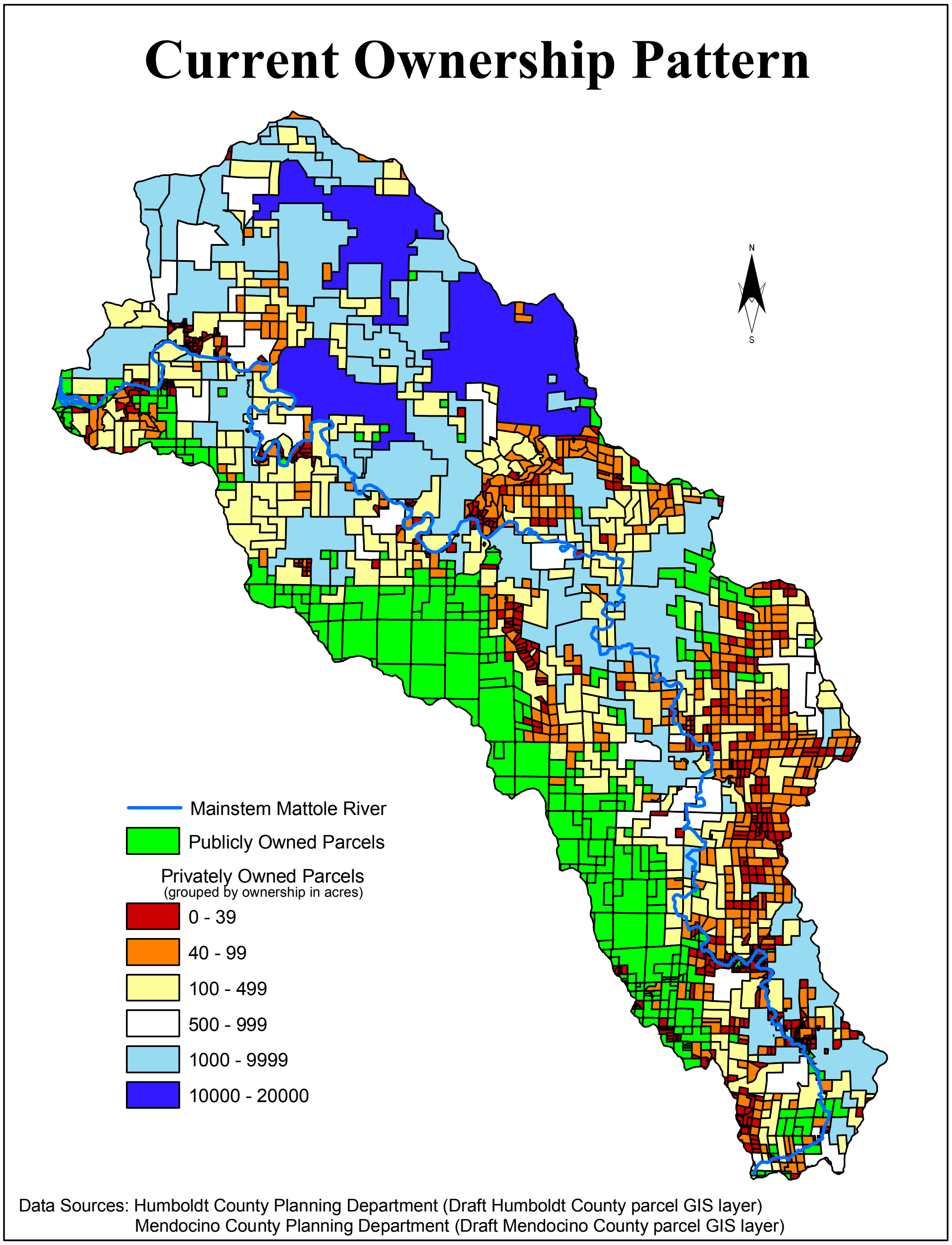


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Figure 29. Land ownership in the Mattole Basin.

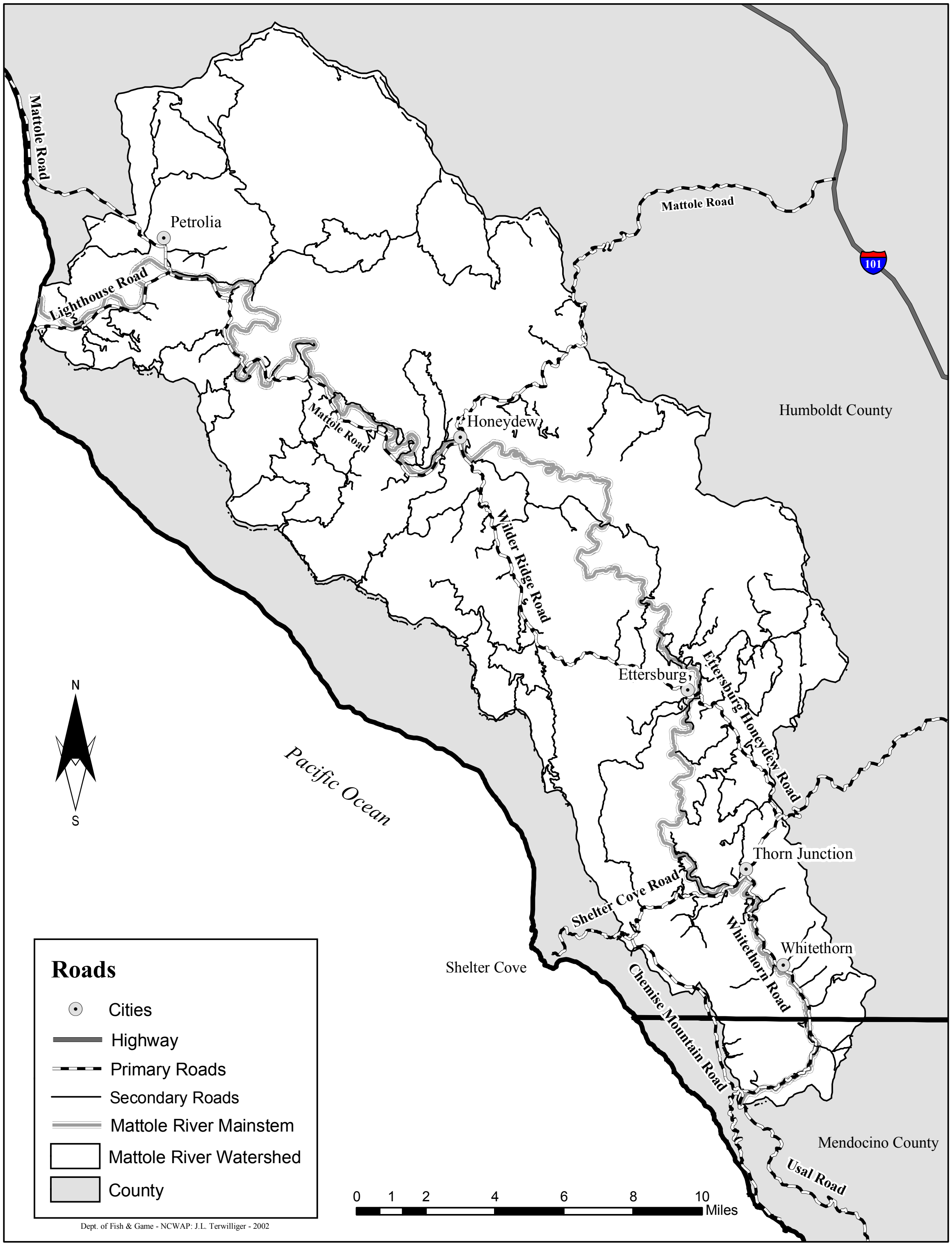

Figure 30. Major roads in the Mattole Basin.

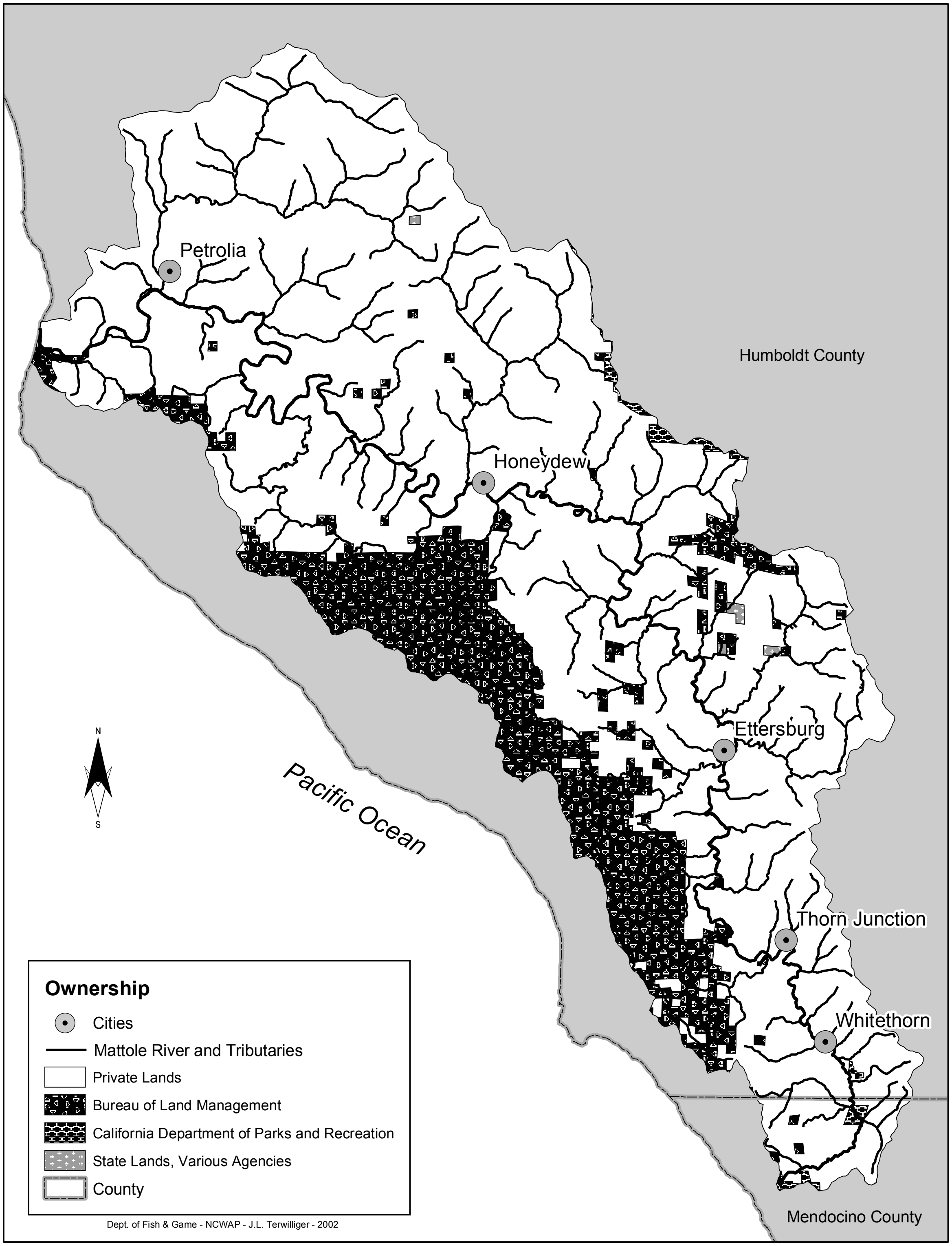

Figure 31. Major land ownership in the Mattole Basin.

Fluvial Geomorphology

The Mattole Basin contains about 692 miles of blue-line streams (CGS Geologic Report-Table 10). The blue-line streams were chosen because they are a consistent depiction of the major streams within the network and include perennial, ephemeral, and intermittent streams. The river system within the Mattole Basin is arranged in a contorted or irregular drainage pattern. The mainstem of the Mattole River flows in a general northwesterly direction, parallel to the structural grain of the Franciscan Complex. Tributaries to the mainstem flow generally to the northeast or southwest, perpendicular to the Mattole River, and often the larger tributaries branch upstream into channels that trend parallel to the mainstem.

Stream Density

Streams are about evenly distributed spatially throughout the subbasins of the study area. That is the cumulative lengths of streams within a subbasin, expressed, as a percentage of the total stream length for the study area, is similar to the area of each subbasin expressed as a percentage of the total study area. The stream density calculated for the entire Mattole Basin study area is 2.3 (miles/square mile). Stream density varies considerably between areas underlain by bedrock and alluvial terrains; these density values forms the point of comparison for portions of the study area. The results are presented in CGS Geologic Report-Table 10.

Within bedrock terrains, stream density across the entire study area is 1.9 and, dependant on subbasin, varies between 0.9, and 2.1 (miles/square mile). Stream density varies within the three bedrock terrains, with higher densities found in the harder terrains. Specifically, stream densities within the moderate and hard terrain average 1.9 and 2.0 respectively. Stream densities within the soft terrain average 1.7.

Stream density within the Quaternary deposits is 8.3 (miles/square mile), and ranges by subbasin from a low in the Northern Subbasin of 5.9 to a high in the Eastern Subbasin of 12.5. These relatively high stream densities in the Quaternary deposits are expected, because the relatively small area occupied by Quaternary deposits (7% of the study area) are preferentially located along the longer, larger streams, particularly the mainstem Mattole.

Rosgen Classification

The Rosgen (1996) classification system (CGS Geologic Report-Figure 6) was applied by CGS to all blue-line streams within the Mattole Basin study area using aerial photographs and topographic maps. Channel slope, derived from the DEM, was used to subdivide primary stream types into subcategories. The areal distribution of Rosgen stream classification is shown in CGS Geologic Report-Figure 19, and a histogram showing the prevalence of specific Rosgen stream types (Rosgen stream class versus percent of total stream length) within the study area is presented in CGS Geologic Report-Figure 20. The two most common mapped stream classes are the A and A+ types, which combined account for about 66% of all blue-line streams. In general, the majority of smaller, lower order tributaries are A and B types. Type A channels are typically relatively straight, high-gradient, narrow reaches in the tributary headwaters that flow through bedrock with little alluvium. B channels are commonly found in larger tributaries, G and Gc channels in lower tributary reaches, and the majority of the mainstem channel is classified as C type channel.

The Southern Subbasin is unique for its abundance of F type streams. This stream type is found along the mainstem Mattole where the river is entrenched within a broad alluvial valley from approximately Thorn Junction to Thompson Creek.

Predictably, the distribution of Rosgen classes mapped along inner gorges are typically those defined as moderately entrenched to entrenched (A, B and G classes) and these classes occur more frequently along inner gorges then generally along all of the streams throughout the study area.

Source, Transport and Response Reaches

The spatial distribution of source, transport, and response reaches governs the distribution of potential impacts and recovery times for the stream system. We used channel slope to classify stream sections as source (>20%), transport (4-20%) or response (<4%) reaches. Streams with gradients greater than 20 percent are considered source areas for sediment, while those with gradients less than four percent are considered areas of sediment deposition (Montgomery and Buffington, 1997). Figure 32 shows the distribution of these slope classes for the Mattole Basin study area.

Source and transport reaches are most common in the bedrock terrains, while response reaches are more common in the Quaternary deposits (Table 39. Virtually all (99%) of the source reaches are found in bedrock terrains and comprise 24% of the total length of blue-line streams. Most of the transport reaches (91%) are found in bedrock terrains and this reach type comprises approximately 36% of all blue-line streams. Response reaches predominate in Quaternary deposits and comprise the remaining 40% of blue-line streams throughout the study area. Whereas, the Quaternary deposits account for only 7% of the study area, 53% of all the response reaches were identified in this terrain. Approximately 86% of the streams within the Quaternary deposits are response reaches.

The areas of greatest susceptibility to sediment deposition are those where higher gradient reaches transition into low gradient reaches. For example, a given transport reach could have high velocity and streamflow, resulting in a large carrying capacity for sediment. If the gradient changes to a slow moving response reach, sediment can rapidly fall out and deposit in the channel or along the banks. Examples of this phenomenon can be found at major slope breaks along Lower and Upper North Forks of the Mattole River. A specific example is shown in CGS Geologic Report-Figure 22, which is a photograph showing a tributary fan at the confluence of Conklin Creek and the mainstem Mattole River. Response reaches are found primarily in the Quaternary alluvium; these are reaches where sedimentation is most likely to occur.

Negative Mapped Channel Characteristics

Stream characteristics that may indicate excess sediment production or transport were mapped and quantified for comparison between streams. These features are termed negative mapped channel characteristics (NMCCs) within this report. Comparison of what proportion of a stream is occupied by these features was used as an indicator of disturbance, sediment source, or stored sediment in the river system. Quantitative analyses of NMCCs were conducted only on data assigned to the primary characteristic field because this field represents the channel characteristic that best reflected conditions observed throughout the entire mapped channel reach. The areal distribution of NMCCs is shown in Figure 31. The measured lengths and the proportion of streams affected by NMCCs recorded from both 1984 and 2000 aerial photo sets are shown in CGS Geologic Report-Table 12.

Negative Mapped Channel Characteristics, 1984-2000

Negative mapped channel characteristics observed on the 1984 photos affected approximately 36% of all blue-line streams (Table 39). In the 2000 photos, the total affected length decreased to approximately 21%. The stream reaches affected by observed NMCCs during these two photo years is shown in Figure 33. In both photo years, the features observed were dominated by wide channels and, secondarily, by displaced riparian vegetation (CGS Geologic Report – Figure 24). Figure 34 and Figure 35 visually depict the occurrence of these two NMCCs, recorded as either primary or secondary characteristics for the two photo years.

The overall trend for the Mattole Basin shows improvement (i.e., reduction in the length of observed NMCCs and/or reduction in the percentage of streams affected by NMCCs) in channel conditions for every subbasin between 1984 and 2000 (Table 39). In this time, the total length of NMCCs decreased by a low of 7% in the Northern Subbasin to a high of 88% in the Southern Subbasin. The largest absolute (actual length) reduction in the length of NMCCs occurred in the Eastern Subbasin. Most of this improvement is seen as a reduction in the proportion of streams affected by displaced riparian vegetation and, to a lesser extent, wide channels (CGS Geologic Report-Figure 24).

Similarly, reductions were observed when evaluating the percentage changes in the length of blue-line streams affected by NMCCs. The greatest change was observed in the Southern and Eastern Subbasins (18% and 27%, respectively), while the Northern Subbasin showed the least amount of improvement (3%). For the entire Mattole Basin, there was a 42% reduction in the total length of observed NMCCs, and 15% reduction in the proportion of blue-line streams affected by NMCCs (Table 39 and CGS Geologic Report-Table 12).

Despite the overall reduction in length and proportion of streams affected by NMCCs, three segments of the Mattole Basin showed a small overall increase in these features. The total length of streams affected by negative NMCCs within the soft terrain in the Northern Subbasin and within the Quaternary deposits in the

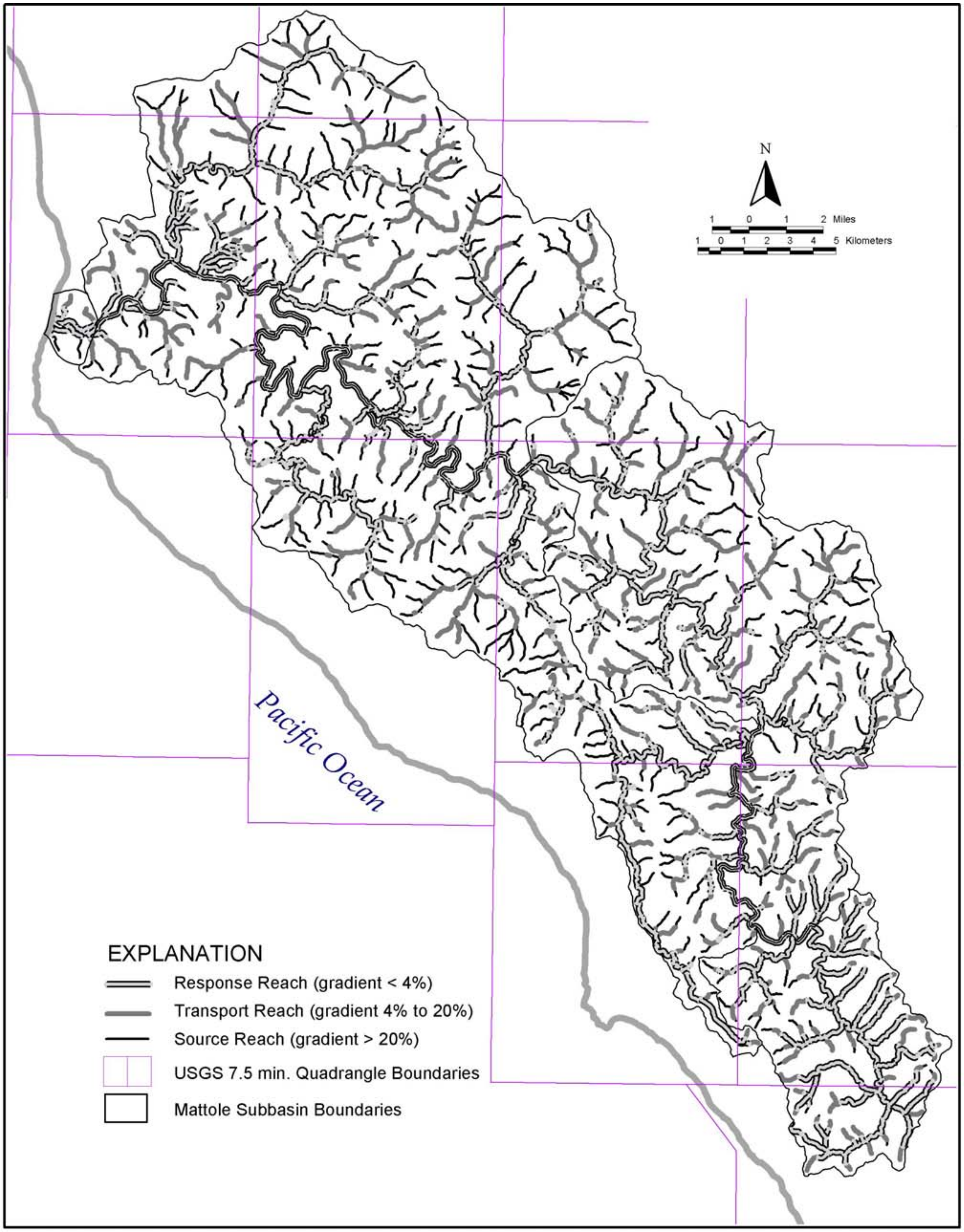

Figure 32. Distribution of stream reaches classified by gradient.

Eastern and Western Subbasins increased between 1% and 2%. These increases result primarily from a greater amount of wide channels, lateral bars, eroded banks and braided channels observed in the 2000 photos.

Improvements in channel conditions were greatest in the bedrock terrains, with the highest calculated values observed in the hard terrain, and the least amount of improvement recorded for the soft terrain. The total length of NMCCs within the Quaternary deposits remained nearly constant between 1984 and 2000 (Table 39 and CGS Geologic Report-Table 12). When compared to the percentage of total stream length within a terrain, these changes in the distribution of NMCCs result in features suggesting excess sediment being disproportionally observed in the bedrock in 1984 and distributed evenly across the entire study area in 2000.

We interpret the concentration and redistribution of NMCCs in streams within Quaternary deposits to suggest that the effects of historic excess sediment input are moving downstream through the river system. The spatial pattern of channel improvements within bedrock terrains implies that the rate of sediment input to the fluvial system has decreased since 1984.

Spatial Relationship to High Landslide Potential

To evaluate a potential linkage between delivery of sediment to streams resulting from slope instability and negative impacts to streams, correlations between NMCCs and streams adjacent to areas of high and very high landslide potential (landslide potential map (LPM) categories 4 and 5) were assessed. The LPM serves as a summary of our understanding of current and future hillslope instability, and therefore potential sediment sources. To facilitate this correlative analysis, NMCCs were represented by those occurring within 150 feet of LPM categories 4 and 5.

In this analysis, only streams and NMCCs within bedrock terrains were evaluated; those within Quaternary deposits were excluded. Streams in the Quaternary alluvium are commonly separated from the surrounding hillslopes by alluvial terraces and floodplains. Therefore, NMCCs observed in alluvial units do not directly result from input into the streams by landslides occurring on the surrounding hillslopes, but rather NMCCs within these alluvial reaches are likely derived from migration of upstream sediment.

Within the bedrock portions of the study area, 75% of the blue-line streams are adjacent to or within LPM categories 4 and 5 (CGS Geologic Report-Table 13). This value varies by subbasin according to the proportion of high to very high landslide potential in each subbasin. Within this subset of streams, 47% of streams were affected by NMCCs in 1984, and 26% were affected by NMCCs in 2000 (CGS Geologic Report-Table 14).

Throughout the study area, and in both sets of air photos evaluated, the NMCCs within LPM categories 4 and 5 represent between 98% and 100% of all the NMCCs mapped within bedrock terrains (CGS Geologic Report-Table 14 and Table 39). Stated another way, for both photo years (1984 and 2000); NMCCs in bedrock terrains have occurred almost exclusively in streams adjacent to or within LPM categories 4 and 5. Conversely, this indicates that only a very small proportion of NMCCs observed in bedrock (0% to 2%) occur in bedrock streams not within 150 feet of LPM categories 4 and 5. Our mapping indicates that LPM categories 4 and 5 are in close proximity to categories 1, 2, and 3 throughout the bedrock terrains of the study area. Therefore, it appears that only a very small proportion of the sediment currently or recently delivered to streams has been transported any great distance downstream along stream reaches in bedrock terrains. However, sediment has clearly been delivered to the downstream alluvial response reaches in the past, and the measured affected stream length within the Quaternary deposits has remained about constant from 1984 to 2000. These last observations suggest that much of the sediment currently impacting the lower reaches of the mainstem of the Mattole River was delivered some time ago (i.e., prior to 1984), perhaps during major flood events.

Additionally, our mapping indicates that virtually all NMCCs within bedrock terrains of the Mattole Basin study area occur on only 26% (2000) to 47% (1984) of streams adjacent to or within LPM categories 4 and 5. This information indicates that even within LPM category 4 and 5, only a portion of the adjacent streams have been impacted by NMCCs.

Based on the above findings, it appears that in the Mattole Basin study area there is a clear linkage (relationship) between areas of slope instability and portions of streams with negative sediment impacts. This investigation indicates that some portion of hillslopes with a high landslide potential (represented by

LPM categories 4 and 5) have delivered sediment to the adjacent streams (such effects being represented by NMCCs). The fact that NMCCs are not ubiquitous in bedrock streams adjacent to or within LPM categories 4 and 5 indicates that although the entire length of the streams have potentially unstable slopes above them, only a portion of LPM category 4 and 5 is delivering sediment to the streams, and therefore only portions of streams are being affected by sediment delivered by landslides. Furthermore, that portion with NMCCs is declining through time. Areas for further research should include evaluations of which portions of hillslopes in LPM category 4 and 5 are most likely to deliver sediment to streams, which portions are not, and what measurable attributes could be identified to discern this difference.

Despite this, hillslopes in LPM category 4 and 5 are clearly the most likely areas for landslides to occur and these landslides have a high potential to be a source of excess sediment to the streams. The clear linkage (relationship) between these areas of slope instability and features indicating excess sediment production/transport in the adjacent streams provides the opportunity to identify which portions of bedrock uplands are most likely to negatively impact streams. For these reasons, hillslopes in LPM category 4 and 5 need to be identified as areas of special concern. Further refinements in our ability to identify areas of high landslide potential, will allow us in the future to more closely define these areas of special concern.

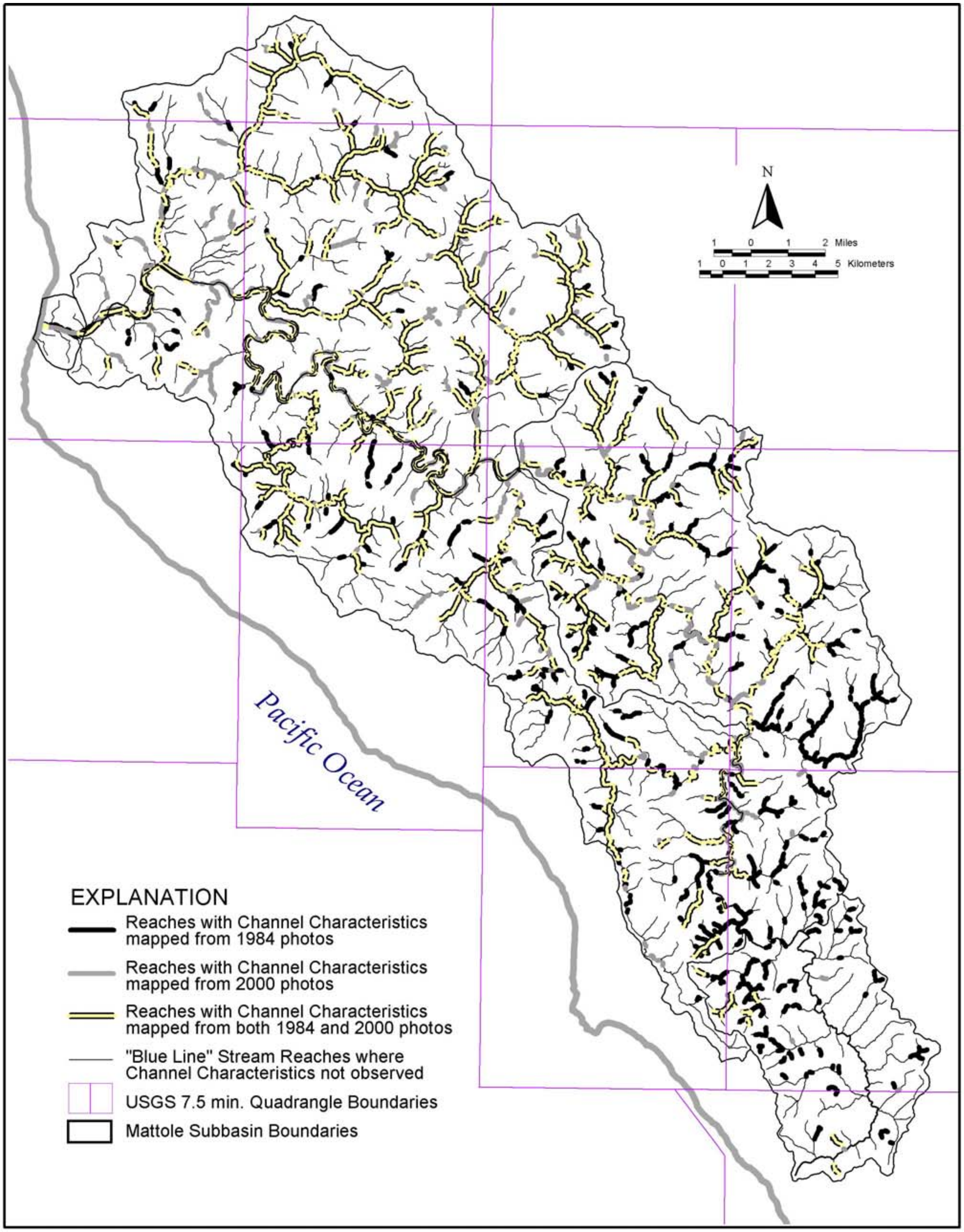

Figure 33. Compilation of mapped stream channel characteristics that may indicate excess sediment production, transport, and/or deposition.

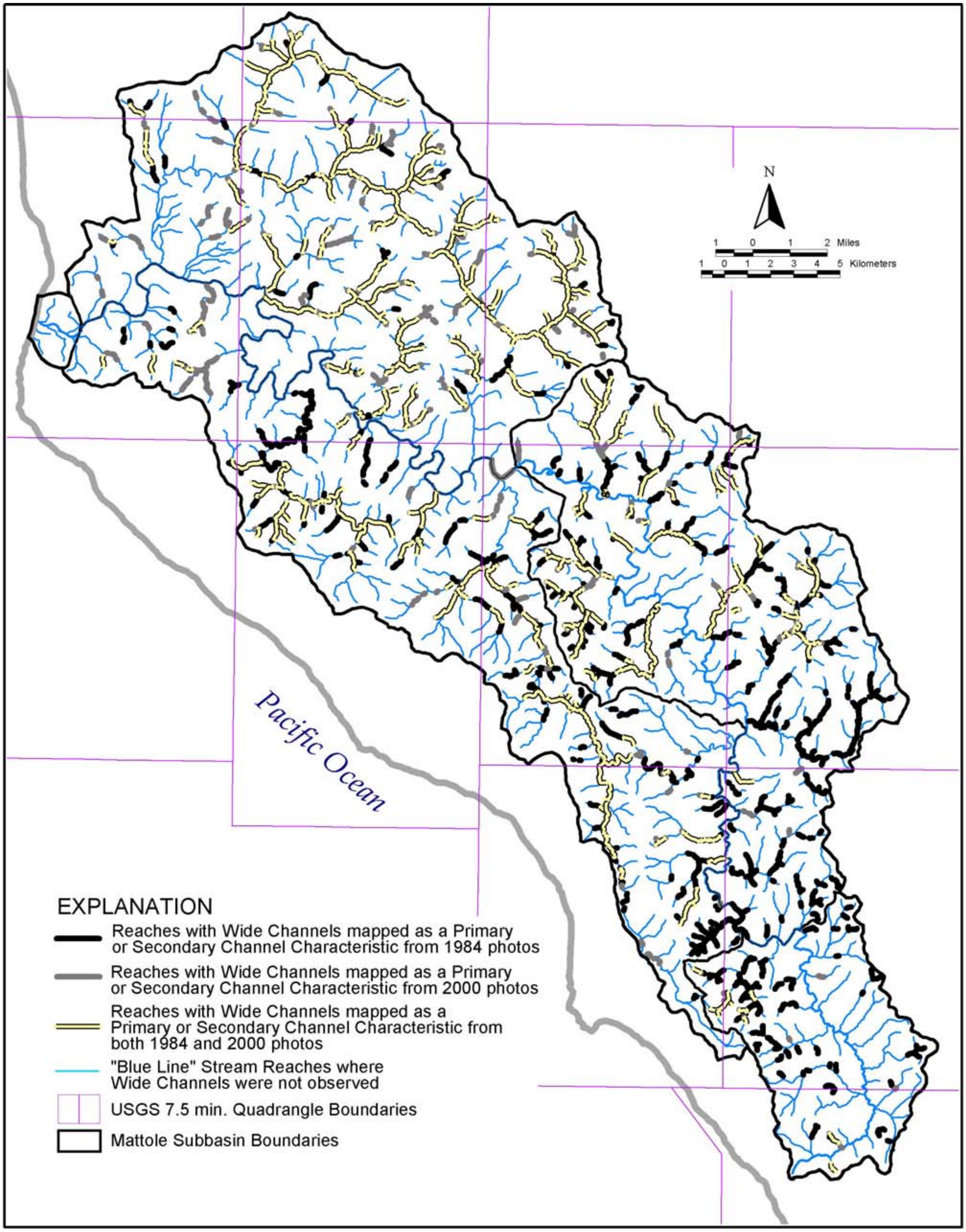

Figure 34. Stream reaches along which wide channel was mapped as a primary or secondary channel characteristic.

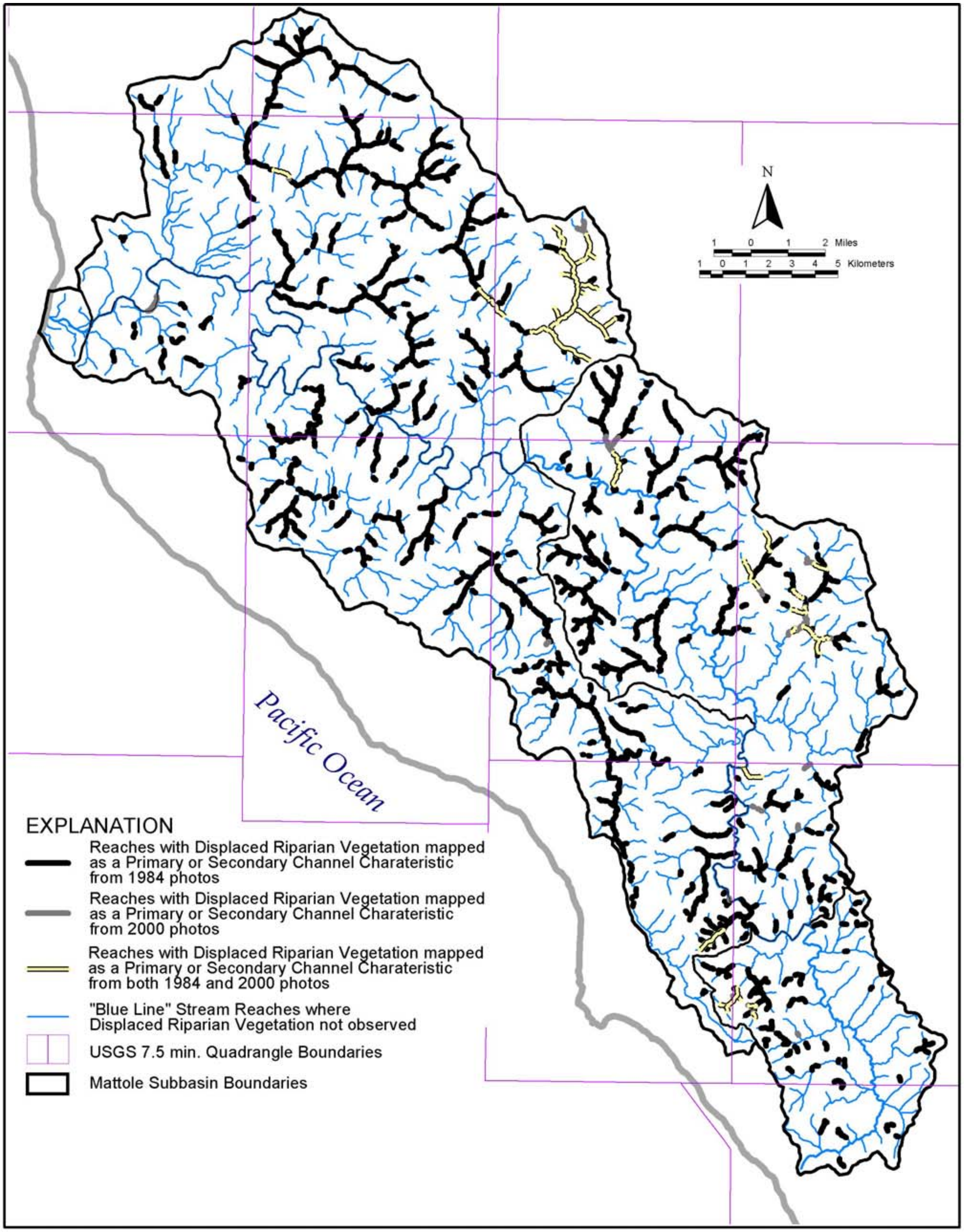

Figure 35. Stream reaches along which displaced riparian vegetation was mapped as either a primary or secondary channel characteristic.

Water Quality

The Mattole River has been placed on a list of water bodies for impairment or the threat of impairment by sediment and temperature as required by Section 303(d) of the Clean Water Act. The 303(d) list describes water bodies that do not fully support all beneficial uses or are not meeting water quality objectives, and the pollutants for each water body that impair beneficial use and water quality. The listing of the Mattole River will eventually result in numeric targets for sediment and temperature allocations being developed by the North Coast Regional Water Quality Control Board (Regional Board) that are expressed as a total maximum daily load (TMDL) for each pollutant.

At the time of the listing sediment and temperature were judged to be impacting the cold (COLD) water fishery and associated beneficial uses, described in the Water Quality Control Plan, North Coast Region, Region 1 (Basin Plan, 1996). Nearly all aspects of the cold water fishery are presumed affected by sediment and temperature pollution, including the migration, spawning and reproduction, and early development of cold water fish such as coho and Chinook salmon, and steelhead trout.

Other beneficial uses of water in the Basin Plan for the Mattole River include municipal, agricultural, industrial, water contact and non-contact recreation, commercial and sport fishing, wildlife habitat and those plant and animal populations associated with terrestrial ecosystems, as well as similar attributes in estuarine ecosystems. Aquaculture in the Mattole River is also foreseen as a potential beneficial use in the Basin Plan.

The Basin Plan also describes specific water quality objectives for the Mattole River that include limitations for in stream specific conductance, total dissolved solids, dissolved oxygen, and pH or hydrogen ion concentration. If exceedences to specific water quality objectives are discovered during NCWAP data gathering, collection, and analysis they will be elucidated and addressed in pertinent report sections. It should be noted that data was not available or not analyzed for all the Basin Plan objectives.

Although numeric targets for a sediment and temperature TMDL have not yet been developed for the Mattole River, much of the following discussion focuses on issues of concern relative to their adoption. Brief references are made to numeric targets adopted for the Garcia River sediment TMDL and, at this time, should not be construed as regulatory targets applicable to the Mattole River.

Key Regional Water Board findings, summarized below, disclosed that the following may be affecting the Mattole River and many of its tributaries:

Temperature

For temperature, the NCWAP team proposed the following suitability-unsuitability ranges for maximum weekly average temperatures (MWATs), and a single value for maximum temperature, referred to in the following discussions, as affecting salmonid viability, growth, and habitat fitness:

- Fully suitable = 50-60°F
- Moderately suitable = 61-62°F
- Somewhat suitable = 63°F
- Between somewhat suitable and somewhat unsuitable = 64°F
- Somewhat unsuitable = 65-66°F
- Moderately unsuitable = 67°F
- Unsuitable ≥ 68°F
- The instantaneous maximum that may lead to salmonid lethality ≥ 75 °F

MWATs were fully unsuitable (≥68°F) and likely impacting the salmonid fisheries and other beneficial uses of water in the estuary and the mainstem up to the Southern Subbasin near RM 50. Maximum temperatures that may lead to salmonid mortality (≥75 °F) were also prevalent downstream from approximately RM 50; however, there are isolated yearly maximums that did drop below the 75°F threshold. Table 11 and Table 12 contain the minimum and maximum MWATs and peak maximum temperatures for available sample years along the mainstem of the Mattole River and various tributaries. If applicable to the following tables, a single temperature entry at a particular station indicates that records were not analyzed or available for more than one year. Most of the stations have temperature records for multiple years; however, for the sake of brevity, individual yearly temperatures are not included. Refer to the Water Quality Appendix E for more detailed discussions.

Table 11. Minimum and maximum MWATs and peak maximum temperatures for all available sample years for the mainstem Mattole River from the estuary to the headwaters.

Nearest "Upstream" Watercourse	River Mile*	MWAT (Minimum / Maximum)	Seasonal Maximum Temperature (Minimum/Maximum)
Estuary	0.1	68.2 / 73.4	73.0 / 83.0
Mill Creek	1.0	69.4 / 71.5	79.0 / 83.0
North Fork Mattole River	3.5	69.9 / 72.3	78.0 / 86.0
Conklin Creek	6.2	71.5 / 72.4	80.0 / 81.0
Pritchett Creek	15.5	73.6 / 73.9	80.0 / 85.0
Honeydew Creek	26.4	69.8 / 71.7	78.0 / 81.0
Big Finley Creek	43.0	70.0 / 74.4	72.0 / 82.0
Bridge Creek	50.7	66.6 / 68.7	65.0 / 76.0
Gibson Creek	56.5	62.4 / 64.1	62.0 / 65.7
Ancestor Creek	60.8	58.5 / 64.1	62.0 / 68.0
"Headwaters"	61.0	52.7 / 55.4	53.0 / 64.0

*Indicates the distance upstream along the mainstem from the Pacific Ocean.

Although seasonal maximum temperatures and MWATs along the mainstem were generally elevated at locations where thermographs were placed, a helicopter flyover employing thermal infrared imaging technology (thermal imaging) added additional information useful in evaluating water temperature characteristics in the Mattole Basin.

Thermal imaging is capable of discerning median surface water temperatures in a continuous path above watercourses. Thermal imaging revealed several tributaries with visible plumes of cooler water flowing into the mainstem that persisted for short distances downstream that could have furnished thermal refugia for salmonids (Watershed Sciences, 2002). For example, Bear, Squaw, Honeydew, and Grindstone Creeks all had median surface temperatures between 71-72°F, entering a much warmer mainstem that ranged between 76-78°F. Within the mainstem, and also several of the tributaries, thermal imaging also detected that feeder springs and intragravel flow were additional sources of colder water that, at times, were as much as 6-8°F cooler than their receiving waters. These isolated pockets of cool water, in all likelihood, also provide critical thermal refugia during low flow, late summer conditions when stream and river temperatures become extremely elevated and stressful to salmonids.

Temperature extremes as MWATs and instantaneous maximums detrimental to salmonids are affecting the lower gradient, downstream reaches of nearly all of the larger tributaries to the Mattole River. This includes the North Fork (NFK) and Upper North Fork (UNFK) Mattole Rivers, Honeydew, Blue Slide, Bear, Mattole Canyon, and Squaw Creeks. The following table shows that the aforementioned larger tributaries all exceeded the fully unsuitable MWAT extreme of 68°F within a maximum of two miles upstream from the mainstem. Average maximum temperatures in the largest streams, except Bear and Squaw Creeks, exceeded the 75°F range deemed unsuitable for salmonid survival. The remaining tributaries in the following table are, in general, smaller in stream length and basin size than the previously cited streams, and most had MWATs and instantaneous maximum temperatures that were within varying degrees of suitability for salmonids. The only exception was an MWAT of 67.9°F at Westlund Creek, a temperature considered moderately unsuitable for salmonids.

Table 12. Minimum and maximum MWATS and peak maximum temperatures, lower to mid-reaches of various basin tributaries.

Watercourse	NCWAP Subbasin	River Mile*	MWAT Minimum / Maximum	Seasonal Maximum Temperature Minimum / Maximum
Mattole Canyon Creek	Eastern	41.1 + 0.1	70.8 / 73.3	80.0 / 88.0
Upper North Fork Mattole River	Northern	25 + 2.0	69.8 / 71.1	72.0 / 82.0
Bear Creek	Western	42.8 + 0.1-0.6	67.8 / 71.5	68.0 / 78.0
Honeydew Creek	Western	26.6 + 0.5	68.9 / 71.9	76.0 / 80.0
North Fork Mattole River	Northern	4.7 + 0.5	69.7	74.0 / 81.0
Blue Slide Creek	Eastern	42.0 + 0.1	68.2 / 70.8	74.4 / 79.0
Squaw Creek	Western	15.0 + 0.1	69.1 / 70.0	72.0 / 77.0
Westlund Creek	Eastern	37.1 + 0.1	62.5 / 67.9	67.0 / 69.5
Bridge Creek	Southern	52.1 + 0.2	59.8 / 65.0	62.0 / 72.0
Thompson Creek	Southern	58.4 + 0.6	60.6 / 62.5	64.0 / 68.7
Baker Creek	Southern	57.6 + 0.1	58.6 / 61.3	63.0 / 68.7
Eubanks Creek	Eastern	47.7 + 0.1	59.7 / 61.1	67.0 / 70.0
Vanaukin Creek	Southern	54 + 0.1	58.9 / 60.8	62.2 / 64.5
Lost River Creek	Southern	58.8 + 0.5	58.4 / 60.3	59.0 / 65.0
Yew Creek	Southern	58.4 + 0.4	57.6 / 61.5	61.6 / 66.0
Big Finley Creek	Western	47.4 + 0.1	59.2 / 60.3	61.0 / 63.0
Mill Creek-Lower	Western	2.8 + 0.1	57.7 / 58.4	57.0 / 68.0
Ancestor Creek	Southern	60.8 + 0.2	56.7	57.0 / 60.1

*Indicates locations of the confluence of the tributary from the Mattole River mouth, the + indicates distance upstream the thermograph is located in the tributary.

In contrast to the borderline suitable and unsuitable MWATs and maximum temperatures mentioned above, median surface temperatures derived from a single day, thermal imaging flyover showed that only the NFK and UNFK Mattole Rivers, and Oil Creek, tributary to the UNFK Mattole, exceeded the 75°F lethal maximum temperature for salmonid survival. Caution is urged, though, in trying to draw analogies between surface derived median temperatures from thermal imaging and those of seasonally deployed thermographs.

Thermographs, unless measuring air temperatures, are always placed below the water surface and because of this placement can provide information not visible to thermal imaging of the water's surface. For example, thermographs can indicate areas of deep water thermal refugia where salmonids often escape to during times of heat stress, such as from reaches or habitat units where sparse or non existent riparian canopy shelter allow excess inputs of solar energy to elevate stream water temperatures.

MWATs and instantaneous maximum temperatures are mostly within suitable to somewhat suitable conditions for salmonids in the upper reaches of many of the larger tributaries. summarizes minimum and maximum temperature conditions, where available, in many of the upper reaches of the same tributaries previously discussed.

Table 13 summarizes temperatures found in select upstream reaches shows that, except for Mattole Canyon Creek, NFK and UNFK Mattole Rivers, and Sulphur Creek, tributary to the NFK Mattole River, MWATs are grouped slightly above and below the 63 °F range considered somewhat suitable for salmonids. Temperatures in the same tributaries that are somewhat suitable as MWATs are also below the 75°F instantaneous maximum considered lethal to salmonids. CGS's NCWAP analysis and the thermal imaging video revealed that the upstream reaches of Mattole Canyon Creek, and the NFK and UNFK Mattole Rivers, including Sulphur Creek, have open, widened, and disturbed alluvial flood plains providing very little effective shade canopy over their wetted channels. These watercourses also had average maximum temperatures above the 75°F threshold of lethality for salmonids.

Table 13. Minimum and maximum MWATs and peak maximum temperatures, middle to upper reaches of various Mattole Basin tributaries.

Watercourse	NCWAP Subbasin	River Mile*	MWAT (Minimum / Maximum)	Maximum Temperature (Minimum / Maximum)
Mattole Canyon Creek	Eastern	41.1 + 3.1	70.8 / 73.3	81.6
Upper North Fork Mattole River	Northern	25 + 4.5	69.4 / 67.8	76.9 / 78.3
North Fork Mattole River	Northern	4.7 + 9.0	65.0	74.6
Sulphur Creek	Northern	4.7 + 10.5	64.4 / 65.5	75.0 / 76.0
Bear Creek -upstream	Western	26.5 + 4.8	60.5 / 64.7	71.0 / 72.0
Honeydew Creek	Western	26.5 + 3.2-4.8	62.9 / 63.9	N/A
South Fork Bear Creek	Western	42.8 + 5.1	60.9 / 64.2	65.4 / 69.0
North Fork Bear Creek -	Western	42.8 + 5.1	60.0 / 61.5	66.6 / 74.0

*Indicates locations of the confluence of the tributary from the Mattole River mouth, the + indicates distance upstream the thermograph is located in the tributary.

Temperature may currently be impacting the salmonid fisheries and other beneficial uses of water in some isolated tributaries for an unknown distance upstream from their confluences with the mainstem, such as Bridge, Squaw, Westlund, and Dry Creeks. Presently there is insufficient data to properly assess the upstream reaches of these tributaries. The latter tributaries had thermographs placed only within 0.1miles upstream from their confluences with the mainstem. Except Bridge Creek, with an average temperature of 62.4°F, all had average MWATS over 65°F that are presumed representative of a thermal reach for some distance upstream. In all likelihood, the same tributaries probably had temperatures for an unknown distance upstream that may have been between 64-66°F, the ranges determined to be between somewhat suitable, somewhat unsuitable, and fully unsuitable for salmonids. Bridge Creek's 62.4°F average MWAT for all record years did have individual MWATs of 63.9°F and 65.0°F during 1996 and 1998, respectively, but during 1999 and 2001, fluctuated near the upper 60°F range considered suitable for salmonids. Additional monitoring would be necessary at the mid- and upstream reaches of these particular watercourses to determine if MWATs remain elevated, stabilize, and/or decrease over prolonged sampling periods.

Sediment

Available evidence indicates that sediment is likely currently impacting the salmonid fisheries and other beneficial uses of water in the estuary, the mainstem up to the Southern Subbasin, and the lower gradient, downstream reaches of Lower North Fork and Upper North Fork Mattole Rivers, Lower Bear, Mattole Canyon, and Squaw Creeks. Observations by professionals, local residents, and time sequenced aerial photographs, and CGS's NCWAP analysis show that the low gradient, downstream reaches of nearly all of the preceding watercourses have open alluvial floodplains with numerous mid- and side channel gravel bars, and shallow pools filled to varying degrees with fine sediment. Recent eyewitness accounts and videos from the thermal imaging overflight during 2001 show Mattole Canyon Creek with extensive sedimentation at its mouth that resulted in the stream drying up, possibly flowing subsurface before reaching the Mattole River.

During 2000 in the Mattole mainstem the MSG collected and calculated V* = 0.31 near Petrolia at mile 1.3. V* measures the percent sediment filling of a streams pool with deposits such as silt, sand, and gravel compared to the total pool volume. Lower V* values may indicate relatively low watershed disturbances. Some ranges for V*, and also D50, a measure of the median sizes of particles deposited on riffles, that can be useful as indicators of upslope disturbances and/or in-channel pool and riffle sediment deposition and transport characteristics, respectively, are:

- V* ≤ 0.30 = low pool filling; correlates well with low upslope disturbance.
- V* > 0.30 and ≤ 0.40 = moderate pool filling; correlates well with moderate upslope disturbance.
- V* > 0.40 = high (excessive) rates of pool filling; correlates well with high upslope disturbance.
- *Garcia River TMDL maximum V* = 0.21.
- *Garcia River TMDL minimum D50 = 0.69.

*The Garcia River TMDL is used for discussion purposes only and is not a regulatory target for the Mattole River.

The V* = 0.31 at Petrolia is an average value for ten individual pools that were measured, and varied from a high V* per pool = 0.49, to a low V* per pool = 0.17. The average V* = 0.31, as referenced above, indicate moderate rates of pool filling, but would not be protective of the beneficial uses of water for this metric only if adopted as a TMDL numeric target for the Mattole River.

In Squaw Creek the MSG, for seven pools, calculated a reach averaged V* = 0.24, indicating a low rate of pool filling, but still exceeding the Garcia River TMDL threshold of V* = 0.21, considered protective of the beneficial uses of water. The CGS's NCWAP analysis calculated that the Squaw Creek planning watershed has the largest total length of eroding banks, approximately 5700 lineal feet, than all other planning watersheds in the Western Subbasin. Channel characteristics mapped by the CGS, some considered detrimental and others not to salmonid habitat, are also prevalent along almost the entire length of Squaw Creek. Although there is a paucity of verifiable scientific data collected, recent information gathered and analyzed strongly suggests that excess sediment is probably impairing the beneficial uses of water of Squaw Creek.

The Lower North Fork and Upper North Fork Mattole Rivers, and Lower Bear Creek were mapped, analyzed, and found, in all likelihood, to be impacted with excess sediment from a combination of natural and anthropogenic sources. CGS's NCWAP analysis, previously referred to, show the lower reaches of each stream flowing through open, widened, alluvial floodplains with a number of mapped channel characteristics indicative of excess sediment deposition. CGS's assessment also agrees with low altitude, live video footage from recent thermal imaging profiles flown along the three watercourses. The profiles photographed all three-stream systems with features, such as elevated alluvial terraces, mid- and side channel sand and gravel bars, and displaced riparian vegetation indicating excess sediment may be impairing the beneficial uses of water in their lower reaches (Watershed Sciences, 2002). The observations of residents and others familiar with these stream systems also corroborate the various agencies' conclusions that excess sediment has accumulated in the lower reaches of these streams (MSG, 1997). Field observations by Regional Board staff during 2000 and 2001 indicate that all three watercourses are slowly downcutting through many of the historically aggraded flood terraces and steam channels. However, the lower gradient reaches of these watercourses still possess characteristics of simplified riverine systems in a state of succession from past disturbances, lacking complex habitat features preferable to most salmonid species, such as regularly spaced deep pools and riffles, large woody debris, and riparian cover.

In mainstem Honeydew Creek a V* = 0.10, and a D50 (or median particles size) = 105.9 mm were collected and calculated during 1992; both values are within the adopted numeric target of V* = 0.21, and D50 = 0.69 established for the Garcia River Sediment TMDL. A V* = 0.22 was also collected by the MSG in 2000, which exceeds the Garcia River Sediment TMDL target for V* by only 0.01. All three data sets appear to indicate efficient sediment transport and/or low rates of pool filling through the lower Honeydew Creek system. More thorough and recent sediment collection and analysis would be desirable in other locations, preferably upstream, in Honeydew Creek to ascertain if there are spatially and temporally differentiated trends between the two sediment metrics. For this metric only, the eight-year span between the two V* results tend to indicate a system that is in a relative state of isostasy between sediment transport and deposition.

Elevated temperatures associated with a widened, open alluvial floodplain often combine to impair the beneficial uses of water in the lower reaches of most of the larger tributaries to the Mattole River. However, in Honeydew Creek, even though temperatures analyzed from thermographs are mostly unsuitable for salmonids, the two sediment metrics gathered to this point in time are protective of the beneficial uses of water and would meet or exceed these numeric targets established for the Garcia River Sediment TMDL. However, like the Garcia River Sediment TMDL, a suite of parameters, including spawning gravel embeddedness, maximum pool depths and widths, and percent fines in different size classes, may also be applied to the future Mattole River sediment TMDL before it can be stated to what degree that Honeydew Creek, and other stream systems in the Mattole Basin are impacted by excess sediment depositions.

Physical-Chemical Water Quality

Although data were gathered inconsistently spatially, temporally, and volumetrically it does not appear that water chemistry and basic physical parameters, such as pH, specific conductance (conductance), and dissolved oxygen are impacting the salmonid fisheries, other vertebrate species, macroinvertebrates, and floral constituents in the Mattole River. The most consistent sampling was conducted in the mainstem Mattole River by the Dept. of Water Rights from 1974-1988 at the USGS gaging station near Petrolia. The Dept. of Water Rights collected basic water quality physical parameters that included pH, dissolved oxygen, and conductance during that time frame. Table 14 summarizes minimum and maximum results for all three parameters. Of the three metrics only one, a single pH = 8.6 collected during September 1979, exceeded the Basin Plan numeric standard of pH = 8.5 by 0.1 pH units. This single exceedance would only be cause for alarm if continuous sampling over time revealed a trend of maximum pH results that consistently violate the Basin Plan numeric targets.

Table 14. Summary of physical parameters collected at USGS Petrolia gage by DWR, 1974-1988.

Physical Parameter	No. of Samples	Maximum / Date	Minimum / Date
pH (standard units)	25	8.6 / Sept, 1979	7.4 / Feb, 1987
Dissolved Oxygen (mg/l)	26	13.2 / Feb, 1977	9.2 / Sept, 1975
Conductivity(micromhos)	23	282 / Feb, 1978	100 / Feb, 1978

There were three additional, single day sampling events conducted by the Regional Board in the mainstem. Two isolated sampling events took place at the Mattole-Petrolia Bridge, the Honeydew Bridge, near Ettersburg, and in the NFK Mattole River. Results from the Regional Board sampling at these locations were all within Basin Plan targets. The third sampling event was conducted on October 29, 2002, at eleven sample points in nine pools along the mainstem in the Southern Subbasin. Except for one sample point at 8.4 mg/l dissolved oxygen, the other ten sample points had dissolved oxygen levels ranging from 6.8 mg/l down to 0.2 mg/l, all levels that would be considered stressful to salmonids. All other physical parameters were within the beneficial use targets in the Basin Plan for the Mattole River. Sampling has not taken place in a systematic manner in any of the other NCWAP subbasins.

There is anecdotal evidence that dissolved oxygen may approach anoxia in deeper pools in the estuary but there has been no recent sampling to confirm or refute this conclusion. Past sampling conducted in the lagoon/estuary from 1987-1990 by Humboldt State University students and faculty obtained results for dissolved oxygen that varied between 8.7-10.4 mg/l, well within limits necessary to support aquatic life and other beneficial uses of water (Zedonis, 1992). It was not stated at what depths dissolved oxygen was measured but, in all likelihood, it was probably at, or slightly below the waters surface if handheld devices were used.

Limited depth integrated sampling was also conducted in the lower mainstem during lagoon conditions from September through November, 1987. At one sample location approximately 1.7 feet from the bottom dissolved oxygen levels were measured at 2.8 and 4.7 mg/l, and, at another location a dissolved oxygen level of 5.2 mg/l was reported (Busby, et al., 1988). These data for dissolved oxygen are stressful to salmonids but are not considered true anoxia where dissolved oxygen levels approach 0.0 mg/l. However, the low oxygen levels observed during 1987 would induce salmonids, and most other fauna capable of movement, to escape from locations where those conditions exist. Additional depth integrated sampling would be necessary in any deeper pools to determine if true anoxic conditions do prevail during periods of low flow, lagoon conditions.

Herbicide and pesticide residues from commercial timber applications have been anecdotally linked to impacts to water quality. There have been no scientifically conducted sampling efforts and associated data collection in any of the Mattole subbasins to determine if chemical residues are affecting the beneficial uses of water on and from industrial timberlands to local watercourses.

Aquatic/Riparian Condition

The riparian zone is the area between a stream or other body of water and the adjacent upland and forms a vital link between terrestrial and aquatic ecosystems. It is identified by soil characteristics and distinctive vegetation. The riparian zone includes wetlands and those portions of floodplains and valley bottoms that support riparian vegetation. Riparian vegetation is the vegetation growing on or near the banks of a stream or other body of water on soils that exhibit some wetness characteristics during some portion of the growing season. The structure and composition of the riparian zone can be affected by the stream type and its active channel, as well as by geologic and topographic features. Functions of the riparian zone include:

- Controlling the amount of light reaching the stream;
- Providing litter and invertebrate fall;
- Providing stream bank cohesion;
- Buffering impacts from adjacent uplands;
- Providing large woody debris (Flosi et al. 1998).

Riparian zone functions are important to anadromous salmonids for numerous reasons. Riparian vegetation helps keep stream temperatures in the range that is fully supportive of salmonids by maintaining cool stream temperatures in the summer and insulating streams from heat loss in the winter. Larval and adult macroinvertebrates are important to the salmonid diet and they are in turn dependent upon nutrient contributions from the riparian zone. Additionally, stream bank cohesion and maintenance of undercut banks provided by riparian zones maintains prime salmonid habitat. Lastly, the large woody debris provided by riparian zones shapes channel morphology, helps a stream retain organic matter, and provides essential cover for salmonids (Murphy and Meehan 1991). Therefore, disruptions to the riparian zone can have serious impacts to the aquatic community, including anadromous salmonids.

Fish Habitat Relationship

Anadromous Salmonid Natural History

Anadromous fish migrate to the ocean early in their life, mature in the ocean, and return inland as adults to spawn in freshwater streams and rivers. Chinook salmon, coho salmon, and steelhead are the predominant anadromous fish using the waterways of the Mattole River. Habitat requirements of salmon and steelhead in the freshwater environment vary to some degree for each species but are generally similar.

Chinook Salmon

Mattole River Chinook salmon are fall-run, migrating into the river as adults from October through February and spawning during the same period. Shortly after fry emerge from redds, the gravel incubation nests built by spawning females, they begin to move downstream and arrive at the estuary throughout the spring. In California, most Chinook smolts enter the ocean during their first seven months of life. Chinook salmon generally mature at 3 to 4 years of age. Some precocious males mature at age two (commonly called jacks) and return to spawn and die along with the older, larger fish from earlier year classes.

Chinook salmon generally spawn in swift, relatively shallow riffles or along the edges of fast runs where there is an abundance of loose gravel. The females dig spawning redds in the gravel and deposit their eggs in the redd pocket. Eggs are immediately fertilized by a male and covered with gravel by the female. The adults die within a few days after spawning. Water flows through the gravel and supplies oxygen to the developing embryos. An average female Chinook salmon produces 3,000-6,000 eggs depending on the size of the fish.

Chinook salmon select spawning sites within narrow ranges of water velocity and depth. Spawning requires well oxygenated cool water. Velocity is generally regarded as a more important parameter than depth for determining the suitability of a particular spawning site. The velocity determines the amount of water which will pass over the incubating eggs. Depths fewer than 6 inches can be physically prohibitive for spawning activities. In general, optimum spawning velocity is 1.5 feet per second (fps), ranging from 1.0 to 3.5 fps. Mattole River fall-run Chinook typically spawn at depths ranging from 1-5 feet.

Substrate composition is another critical factor in determining the suitability of spawning site selection. For successful reproduction, Chinook salmon require clean and loose gravel that will remain stable during incubation and emergence. Average size of Chinook salmon redds ranges from 75 to 100 square feet. In areas where spawning activity is high, redds of later spawners may be dug adjacent to, or super-imposed upon, earlier redds and some egg disturbance may occur. The territory required for pre-mating activity has been estimated to be between 200 and 650 square feet for a pair of salmon but this varies widely according to population density. Where spawning occurs throughout a protracted spawning season, as many as three or four redds may be dug in the area equivalent to the territorial requirement of one pair.

In general, the substrate chosen by Chinook salmon for spawning is composed mostly of gravels from 0.5 to 5 inches in diameter with smaller percentages of coarser and finer materials with no more than about 5 percent fines. Although some spawning will occur in sub-optimal substrates, incubation success will be lower. Substrate composition must be low in sand and silt so that oxygenated water is allowed to freely permeate and flow through intra-gravel spaces, and to allow newly hatched salmon to move up through the gravel into the water column. Sediments deposited on redds can reduce water flow through the gravel and suffocation of eggs or newly hatched fry may occur. Gravel is completely unsatisfactory when it has been cemented with clays and other fines, or when sediments settle out and cover eggs during the spawning and incubation period.

The preferred temperature for Chinook salmon spawning is generally 52°F with lower and upper threshold temperatures of 42°F and 56°F. Holding adults prefer water temperatures less than 60°F, although, acceptable temperatures for upstream migration range from 57°F to 67°F.

In the Mattole River system, Chinook salmon eggs usually hatch in 40 to 60 days, and the young sac fry usually remain in the gravel for an additional 30 days until the yolk sac is nearly entirely absorbed. The rate of development is faster at higher water temperatures. Significant egg mortalities can occur at temperatures in excess of 57.5°F with total mortality normally occurring at 62°F.

After emergence, Chinook salmon fry attempt to hold position in the water column and feed in low velocity slack water and back eddies. They move to somewhat higher velocity areas as they grow larger and make their way to the estuary. In the Mattole River system Chinook salmon juveniles are detained in the estuary because of the creation of lagoon conditions early in the summer. This prevents them from going to the ocean until it reopens in the Fall. Unfortunately, conditions in the estuary through the summer are not hospitable and studies conducted by Humboldt State University within the past fifteen years have shown high, and perhaps total, mortality in some years. Juveniles that enter the ocean and survive to adulthood, usually return to the system after their third or fourth year at sea.

Coho Salmon

Coho salmon adults enter the Mattole River from October through December and reach the upper spawning reaches in November and January. In the shorter California coastal streams, most return from mid-November through mid-January. Spawning commences shortly after arriving at the spawning sites provided that water conditions, including flow and temperature are satisfactory.

Redd construction behavior is similar to that displayed by other salmonid species, with the female excavating a depression in the gravel by turning on her side and using her body and tail to displace gravel downstream. The number of eggs produced by the female is directly related to her size. Four-pound and ten-pound females produce about 2,000 and 2,700 eggs, respectively.

The amount of time required for the incubation of coho eggs varies primarily with water temperature. Normally, four to eight weeks are required for incubation. Another two to seven weeks are required from hatching to emergence from the gravels (Shapovalov and Taft, 1954). Mortalities during this period can vary substantially. Under optimum conditions, mortalities can be as small as ten percent. However, under very adverse conditions such as scouring flows or heavy siltation, close to a complete loss may occur. Shapovalov and Taft (1954) estimated that under favorable conditions (in the absence of heavy silting) survival to emergence in Waddell Creek (Santa Cruz) was between 65 and 85%of the eggs deposited.

Juvenile coho will normally attempt to remain in the stream, in the vicinity where hatched, for one year. However, environmental factors, such as low summer flows or high water temperatures, or population pressures due to limited rearing space and food, will force the smaller, weaker individuals to relocate. Most of this movement is manifested in a downstream migration of fry during the first spring and summer.

Smoltification, the physiological change adapting young anadromous salmonids for survival in saltwater, normally occurs in California coho during the spring of the fish's second year. In recent downstream migrant studies on several Mendocino County streams and on Lagunitas Creek, juvenile coho emigrating from the streams ranged in size from 2.5 to 8 inches fork length indicating age 0+ and age 1, and averaged approximately 4.5 inches (Bratovich and Kelley, 1988; W. Jones, personal comm.).

Coho typically spend two growing seasons in the ocean and return to spawn near the end of their third year of life. However, some males return to spawn near the end of their second year. Nearly all are precocious males (jacks) which, like their adult counterparts, die after spawning. Murphy (1952) estimated that the percentage of jacks returning to the South Fork Eel River above Benbow Dam from 1939-40 through 1950-51 ranged from 6.9% to 33.8%, with a mean of 18%.

Steelhead Trout

Steelhead trout are an anadromous strain of rainbow trout that migrate to sea and later return to inland rivers as adults to spawn. In contrast to all Pacific salmon, not all steelhead die after spawning. In the Mattole River, upstream migration occurs from November through May with the peak run occurring in January-February. Mattole River steelhead spawners are typically age four or five years and weigh 2 to 12 pounds or more. Female steelhead carry an average of 3,500 eggs, with a range of 1,500-4,500.

Like other salmonids, steelhead prefer to spawn in clean, loose gravel and swift, shallow water. Gravel from the redd excavation forms a mound or tail-spill on the downstream side of the pit. Eggs deposited along the downstream margin of the pit are buried in the gravel as excavation proceeds. An average of 550-1,300 eggs are deposited in each pit. The males fertilize the eggs as they are deposited. Water flowing through the gravel supplies oxygen to the developing embryos.

Water depth and velocity criteria for spawning and rearing steelhead differ slightly from those for salmon. Spawning velocity appears to be about the same as for Chinook salmon, 1.5 fps, but depth is slightly less, to about 0.75 foot. Gravel particle sizes selected by steelhead vary from about 0.25-3.0 inches in diameter, somewhat smaller than those selected by Chinook salmon.

Steelhead eggs seem less tolerant of fine sediment than Chinook salmon, probably because eggs are smaller and oxygen requirements for developing embryos are higher. A positive correlation has been demonstrated between steelhead egg and embryo survival and the rate of water flow through the gravel. Egg survival is highly dependent upon the flow of well oxygenated water. The average size of a steelhead redd is smaller than that of a Chinook salmon. Redd sizes range from 22.5 to 121 square feet and average 56 square feet.

All freshwater life stages of steelhead, except rearing, require lower temperatures than Chinook salmon. The preferred temperatures for steelhead are between 50EF and 58EF, although they will tolerate temperatures as low as 45EF. Studies show that the upper preferred temperature limit for rainbow trout in Sierra Nevada streams is 65EF. The temperature range for spawning is somewhat lower, ranging from 39 to 55°F, and the preferred incubation and hatching temperature is 50EF. During the egg's tender stage, which may last for the first half of the incubation period, a sudden change in water temperature may result in increased mortality.

Egg incubation in the Mattole River system takes place from December through April. The rate of embryo development is a function of temperature with higher temperatures contributing to faster development. At 50EF, hatching occurs in 31 days; at 55°F, hatching occurs in 24 days.

Newly hatched steelhead sac fry remain in the gravel until the yolk sac is completely absorbed, a period of 4-8 weeks. Emergence is followed by a period of active feeding and accelerated growth. The diet of newly emergent fry consists primarily of small insects and invertebrate drift. As they grow, fry move from the shallow, quiet margins of streams to deeper, faster water.

Unlike juvenile fall-run Chinook salmon, which typically emigrate within 3 to 4 months after emerging from the gravel, juvenile steelhead usually remain in fresh water for two years. Because rearing steelhead are present in fresh water all year, adequate flow and temperatures are important to the population at all times.

Generally, throughout their range in California, steelhead that are most successful in surviving to adulthood spend at least two years in fresh water before migrating downstream. In the Mattole River, steelhead generally migrate downstream as 2-year old smolts during spring and early summer months. Emigration appears to be more closely associated with size than age, 6-8 inches being the size of most downstream migrants. Downstream migration in unregulated streams has been correlated with spring freshets.

Summer Steelhead Trout

Summer steelhead enter the Mattole River between March and June. Fish remain in clear, cool, deep pools until late winter and spring of the following year before spawning. Mattole River summer steelhead can be large in size, averaging 26 inches and 24 inches, or more for males and females respectively. Egg deposition occurs in early spring with the young hatching about 50 days later. Generally, young summer steelhead will remain in the Mattole River for two years followed by another one to three years of ocean life before returning to complete their life cycle. Ninety percent of the returning adults are three and four year old fish. (Adapted from Jones and Ekman, 1980.)

Fish Passage Barriers

Stream connectivity is essential for juvenile and adult anadromous fish. Stream connectivity describes the absence of barriers to the free instream movement of adult and juvenile salmonids. Free movement in well-connected streams allows salmonids to find food, escape from high water temperatures, escape from predation, and migrate to and from their stream of origin as juveniles and adults. Dry or intermittent channels can impede free passage for salmonids; temporary or permanent dams, poorly constructed road crossings, landslides, debris jams, or other natural and/or man-caused channel disturbances can also disrupt stream connectivity. Culverts are one potential fish passage barrier that has been examined in the Mattole Basin.

Culverts constructed of steel, aluminum, or plastic are the most common stream crossing devices found in rural road systems. Culverts often create temporary, partial, or complete barriers for adult and/or juvenile salmonids during their freshwater migration activities (Table 15, Taylor 2000/2001). Passage barriers that can be created by culverts include an excessive drop at the culvert outlet (too high of entry jump required); an excessive velocity within the culvert; a lack of depth within the culvert; an excessive velocity and/or turbulence at the culvert inlet; and a debris accumulation at and/or within the culvert. The cumulative effect of numerous culvert-related passage barriers in a river system can be significant to anadromous salmonid populations (Taylor, 2001). Inventories and fish passage evaluations of culverts within the Humboldt County and the coastal Mendocino County road systems were conducted between August 1998 and December 2000 by Ross Taylor and Associates, under contract with the Department of Fish and Game's Fishery Restoration Grants Program (Taylor, 2000, 2001). These inventories included 67 and 26 stream crossings in Humboldt and Mendocino Counties, respectively, of which 18 were in the Mattole Basin.

Table 15. Definition of barrier types and their potential impacts to salmonids.

Barrier Category	Definition	Potential Impact
Temporary	Impassable to all fish some of the time	Delay in movement beyond the barrier for some period of time
Partial	Impassable to some fish at all times	Exclusion of certain species and lifestages from portions of a watershed
Total	Impassable to all fish at all times	Exclusion of all species from portions of a watershed

These culvert inventories and fish passage evaluations followed a standardized assessment procedure. First, all culverted stream crossings that may inhibit fish passage were located and counted. Second, each culvert location was visited during both late-summer/early fall low flow conditions and after early storm events. Third, information was collected regarding culvert specifications. Fourth, fish passage at each culvert was assessed using culvert specifications and passage criteria for juvenile and adult salmonids (from scientific literature and Fish Xing computer software) and on-site observations of fish movement. Last, the quality and quantity of stream habitat above and below each culvert was assessed. Habitat information was obtained from habitat typing surveys conducted by CDFG, watershed groups and/or timber companies.

Following the culvert inventory and fish passage assessment, a prioritized list of culverts that impede fish spawning and rearing activities was compiled for Humboldt and Mendocino counties. Criteria for priority ranking included salmonid species diversity, extent of barrier problem present, and culvert risk of failure, current culvert condition, salmonid habitat quantity, salmonid habitat quality, and a total salmonid habitat score. The reports of the culvert inventories and fish passage surveys were provided to the Humboldt and Mendocino counties' Public Works, Natural Resources and Engineering Divisions, the CDFG Native Anadromous Fish and Watershed Branch, and the CDFG Region One Headquarters.

Culvert repair, upgrade, and improvement are an important part of stream restoration projects. In the Mattole Basin, the CDFG North Coast Watershed Improvement Program includes culverts as a part of stream restoration and improvement efforts and was able to supply NCWAP with information on recent culvert assessment and treatment contracts. Typically, following culvert assessments, the County or landowner follows up with improvement proposals to CDFG for funding support to implement recommendations. In the Mattole Basin, some of the recommended treatments are currently proposed or being implemented.

Fish History and Status

Fishery resources of the Mattole Basin include fall-run Chinook salmon, coho salmon, winter-run steelhead trout, and summer -run steelhead trout. Other fish present in the Mattole Basin include sticklebacks, lampreys, and sculpins (Table 16). Two notable fish species that have apparently been extirpated in the Mattole Basin are spring-run Chinook salmon (CDFG 1972) and green sturgeon (Moyle et al. 1989).

Table 16. Fish species in the Mattole Basin.

Common Name:	Scientific Name:
Anadromous	
Chinook salmon	*Oncorhynchus tshawytscha*
Coho salmon	*Oncorhynchus kisutch*
Rainbow trout	*Oncorhynchus mykiss*
Pacific lamprey	*Lampetra tridentata*
Freshwater	
Coast Range sculpin	*Cottus aleuticus*
Prickly sculpin	*Cottus asper*
River lamprey	*Lampetra ayresi*
Western brook lamprey	*Lampetra richardsoni*
Sacramento sucker	*Catostomus occidentalis*
Threespine stickleback	*Gasterosteus aculeatus*
Marine or Estuarine Dependent	
Pacific staghorn sculpin	*Leptocottus armatus*
Shiner perch	*Cymatogaster aggregata*
Redtail surf perch	*Amphistichus rhodoterus*
Walleye surf perch	*Hyperprosopon argenteum*
Speckled sanddab	*Citharichthys stigmeus*
Starry flounder	*Platichthys stellatus*
Surf smelt	*Hypomesus pretiosus*
Topsmelt	*Atherinops affinis*

Many fish in the Mattole Basin use the estuary during some part of their life history. Anadromous salmonids and pacific lampreys pass through the estuary on migrations. Threespine stickleback (Busby et al. 1988), pacific staghorn sculpin, prickly sculpin, shiner perch, and topsmelt spawn within the estuary. Juvenile Chinook salmon, some steelhead trout, threespine stickleback (Busby et al. 1988), Coast Range sculpin, shiner perch, starry flounder, surf smelt, and topsmelt rear in the estuary.

Though anecdotal evidence provides a convincing case that anadromous salmonid runs in the Mattole Basin were large and have experienced a sharp decline since the mid 1950s, little quantitative historic data exists (BLM, 1996). Estimates of Chinook salmon, coho salmon, and steelhead trout populations in the Mattole Basin were made by the United States Fish and Wildlife Service (USFWS) in 1960. Existing population estimates were based on spawning gravel surveys and interviews with sportsmen and local residents. Potential population estimates were based on spawning gravel surveys. Existing populations of 2,000 Chinook salmon, 5,000 coho salmon and 12,000 steelhead trout were estimated, while potential populations of 7,900 pairs of Chinook salmon, 10,000 pairs of coho salmon and 10,000 pairs of steelhead trout were predicted (Figure 36).

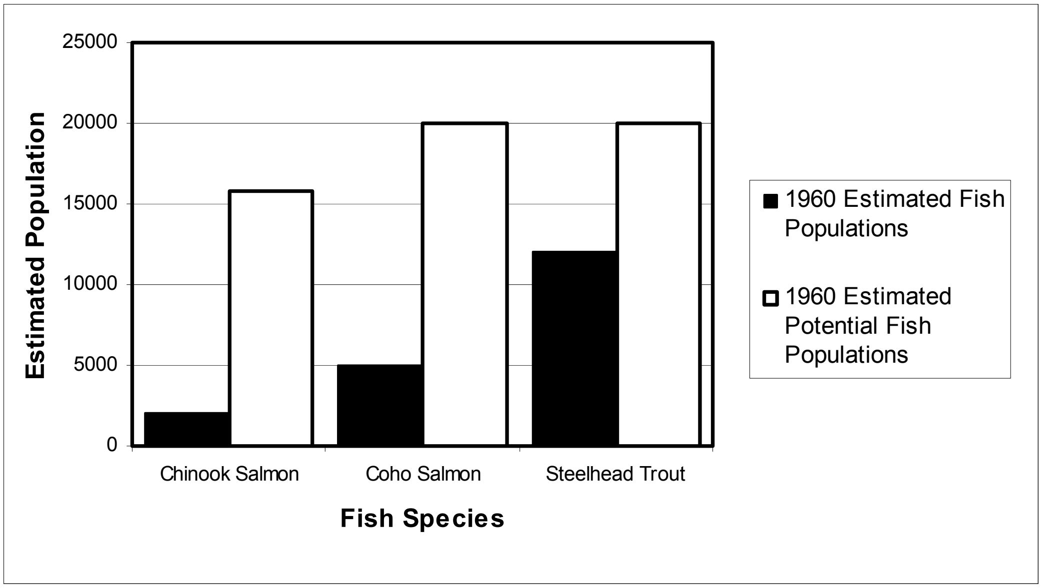

Figure 36. 1960 USFWS estimates of fish populations and potential fish populations in the Mattole Basin.

In 1965, the Department of Water Resources (DWR) reported that Chinook salmon were able to access the Mattole River for 45 miles, while coho salmon and steelhead trout used several more miles of the river. Chinook salmon spawned mostly on the mainstem according to DWR, though several tributaries such as the North Fork of the Mattole River, Squaw Creek, Honeydew Creek, and Bear Creek also provided suitable spawning areas. Coho salmon and steelhead trout were thought to spawn mostly in smaller tributaries throughout the basin. However, ongoing spawner surveys conducted by CDFG and MSG since 1981 have documented Chinook salmon, as well as coho salmon and steelhead trout, spawning clear to the Mattole River's headwaters (river mile (RM) 70).

Figure 37, Figure 38, and Figure 39 depict the estimated historic distributions of coho salmon, Chinook salmon, and steelhead trout, respectively. The limits of the estimated range of steelhead trout, the most athletic of the Mattole salmonids, was initially defined to be a stream reach of 1000 feet or more with a gradient in excess of 10%. The limits of the coho and Chinook salmon range estimates were defined as reaches of 1000 feet or more with a gradient in excess of 5%. These estimates were based on 10 meter digital elevation model (DEM) analyses. The preliminary range estimates were then reviewed by a team of CDFG and Bureau of Land Management (BLM) fishery biologists in collaboration with Mattole Salmon Group (MSG) biologists and Mattole Basin residents.

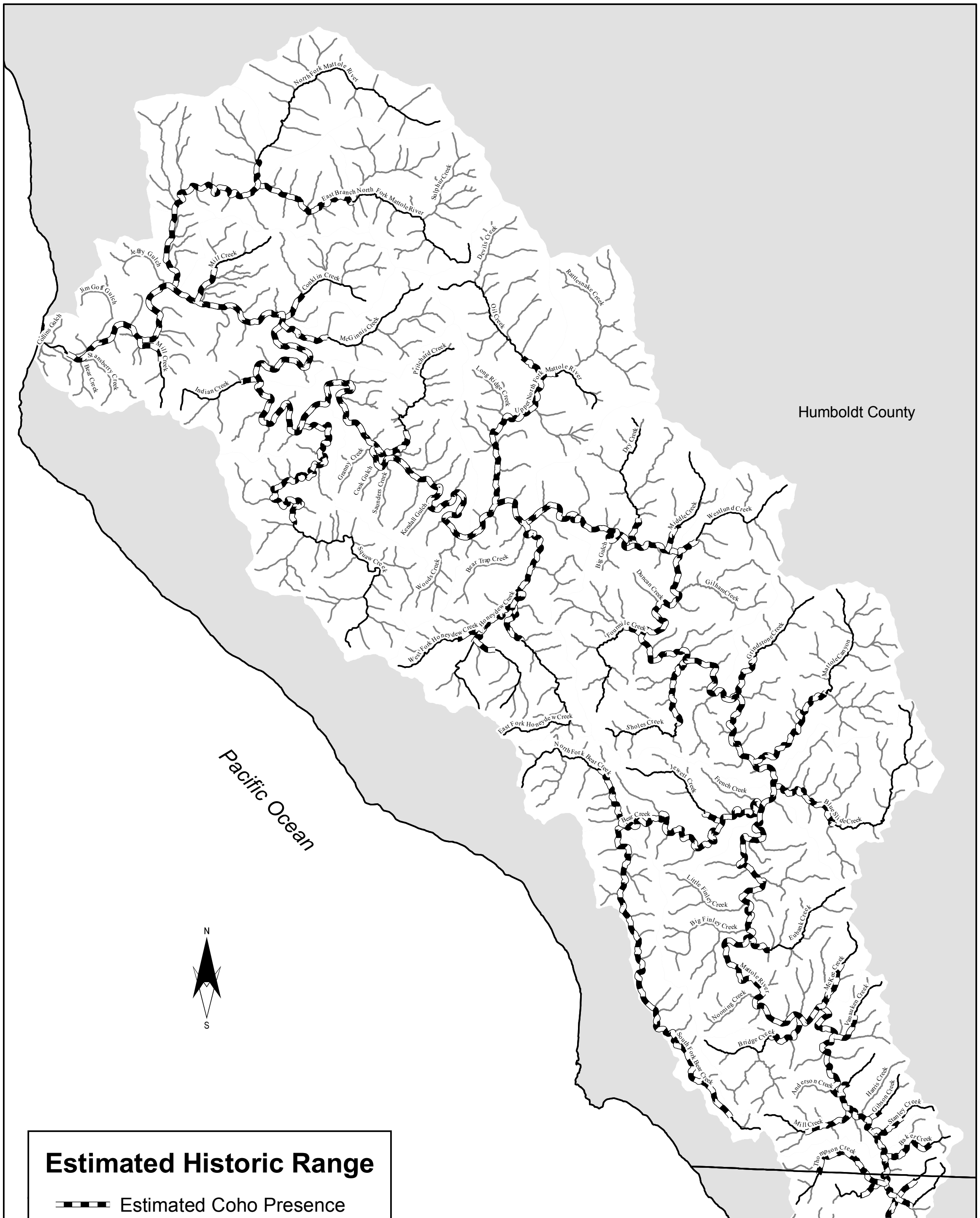

Figure 37. Mattole Basin estimated historic coho distribution.

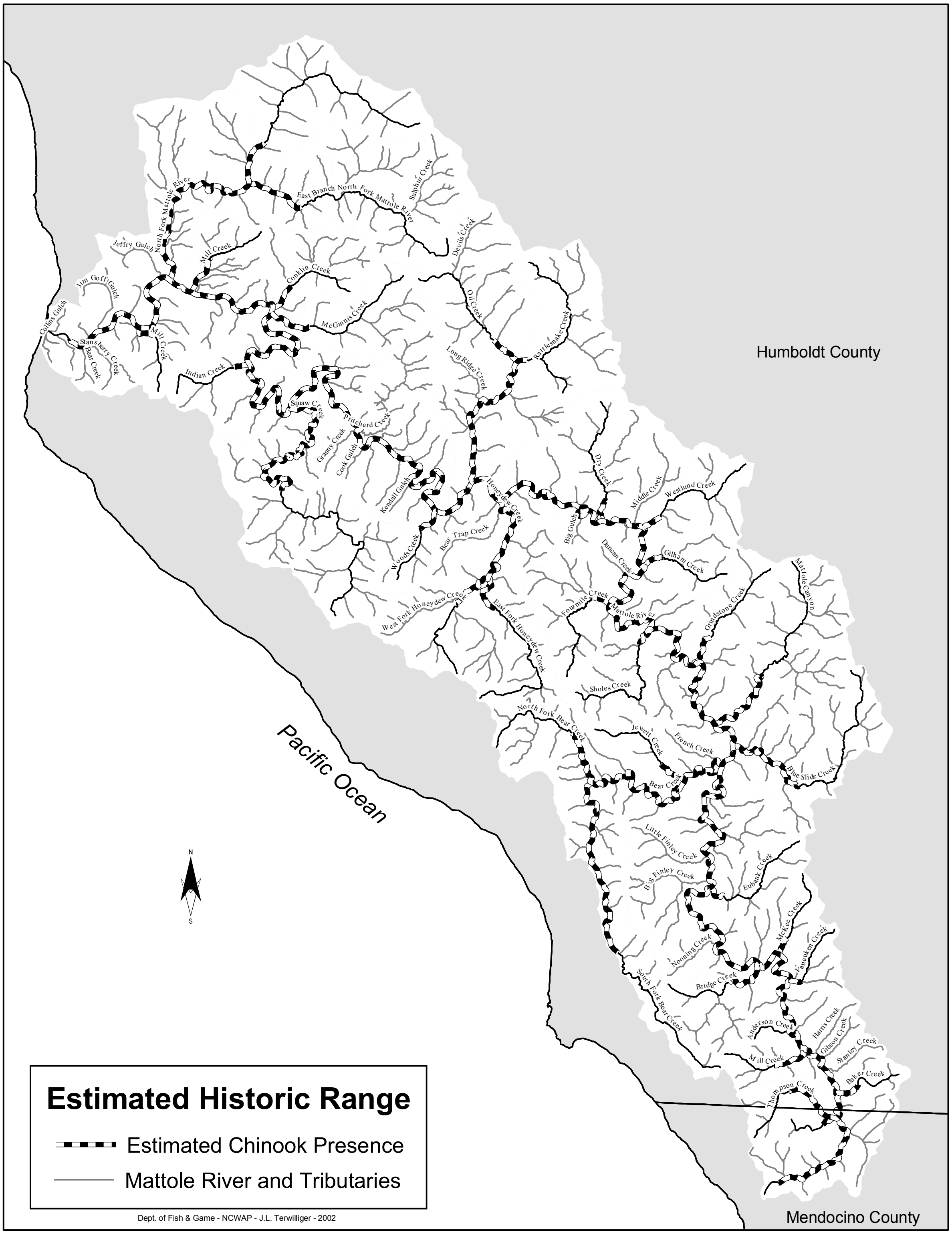

Figure 38. Mattole Basin estimated historic Chinook distribution.

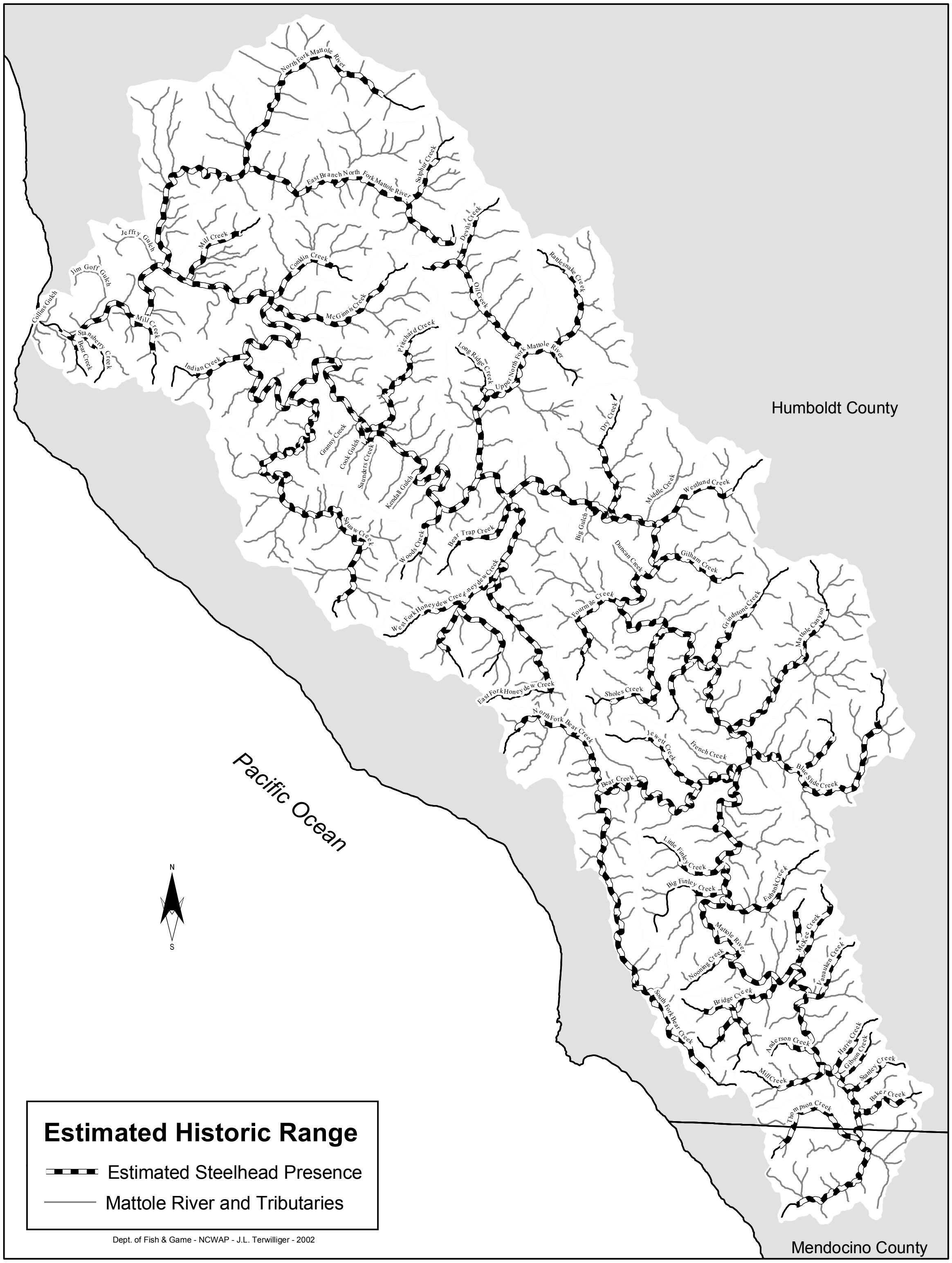

Figure 39. Mattole Basin estimated historic steelhead distribution.

DWR (1965) speculated that increases in siltation and debris jams following intensive logging that started in 1952 caused a significant reduction in the size of anadromous fish runs since 1955. Prior to 1954, the Mattole River had an exceptionally good winter steelhead trout fishery. The fishery had deteriorated seriously since the 1950s. In fact, DWR stated that:

> "It is sufficient to note here that the Mattole River was formerly one of the better king salmon (Chinook salmon), steelhead (trout), and silver salmon (coho salmon) producers of the entire coast. Since 1950, excessive logging operations have taken place in the drainage, which has severely damaged the stream, primarily from siltation. The stream is still considered to have the potential to again be the major fish producer that it was historically if improved logging and land management principles are followed."

Most of the Mattole Chinook salmon catch after 1954 was taken during November, although an occasional fish was caught in the estuary as early as October. Steelhead trout and an occasional coho salmon were taken whenever water conditions were favorable. USFWS surveys during 1956-1957 and 1957-1958 seasons indicated that an average of 4300 angler days were spent on the river, resulting in a catch of 400 salmon, 700 steelhead trout, and about 8000 juvenile steelhead trout. A need for better stream survey data was recognized in 1965, when it was recommended that thorough surveys of existing conditions be carried out so as to permit management of the resource by knowledge, not guesswork.

CDFG conducted 65 stream surveys on 58 Mattole River tributaries in the mid 1960s. Survey reports included drainage, stream condition, habitat suitability, stream obstruction, and fisheries descriptions. Salmonid presence and habitat characteristics were usually determined by direct stream bank observation. Survey reports concluded with recommendations for management. CDFG continued to survey streams in the Mattole Basin in the 1970s and 1980s with an emphasis on locating possible salmonid passage barriers. Coho salmon and steelhead trout presence was documented in tributaries throughout the Mattole Basin (Table 17).

Table 17. Coho salmon and steelhead trout presence reported in CDFG stream surveys from 1950-1989.

Subbasin	Number of Streams Surveyed	Number of Streams Where Coho Salmon Were Reported*	Number of Streams Where Steelhead Trout Were Reported *
Estuary Subbasin	NA	NA	NA
Northern Subbasin	14	2	13
Eastern Subbasin	16	3	8
Southern Subbasin	8	1	8
Western Subbasin	26	5	16

*These numbers do not include unidentified salmonid observations.

With the publication of the *California Salmonid Stream Habitat Restoration Manual* in 1991, stream survey methodologies used by CDFG became standardized and more quantitative. Sixty-two tributary reports were completed for the Mattole Basin in the 1990s. Biological inventories were conducted on 33 of the surveyed tributaries; coho salmon were detected in 11 surveyed tributaries and steelhead trout were detected in all 45 surveyed tributaries. More details about CDFG stream surveys and inventories are in the analyses and results by subbasin section of this report and the CDFG Appendix F.

The BLM also conducted 40 stream surveys in the Mattole Basin starting in the 1970s. BLM survey reports included access, drainage, stream conditions, habitat suitability, and fisheries descriptions. Salmonid presence and habitat characteristics were usually determined by direct observation. Survey reports concluded with recommendations for management. BLM surveys documented the presence of steelhead trout in tributaries throughout the Mattole Basin, but only document coho salmon in one(Table 18). More details about BLM stream surveys are in the analyses and results by subbasin section of this report and the CDFG Appendix F.

Table 18. Coho salmon and steelhead trout presence reported in BLM stream surveys.

Subbasin	Number of Streams Surveyed	Number of Streams where Coho Salmon Were Reported *	Number of Streams where Steelhead Trout Were Reported *
Estuary Subbasin	NA	NA	NA
Northern Subbasin	1	0	1
Eastern Subbasin	3	0	2
Southern Subbasin	3	0	1
Western Subbasin	18	1	6

*These numbers do not include unidentified salmonid observations.

C.J. Brown (1972, 1973a, 1973b) conducted a study of the downstream migrations of salmonids, a creel census and fisherman-use count, and an estimate of salmonid standing stocks for the Mattole River. Downstream outmigrant salmonids were trapped in the spring of 1972 to gain some insight into their distribution within the Mattole River and the timing of their outmigration (Brown 1972). Nets were set on the Mattole River 1.5 miles above the Petrolia Bridge, and 100 yards below the mouth of Bear Creek in between April and June. Results indicated that juvenile Chinook salmon outmigration in the Mattole River ceased by May, coho salmon outmigrants were present from April through June, and steelhead trout exhibited some downstream movement in May and June. Brown (1972) also speculated that the Mattole estuary may be an important rearing area for Chinook salmon and steelhead trout.

A census of angler use and catch was made in February 1972 and from September 1972 through February 1973 on the Mattole River downstream from Honeydew to determine the general nature of the fisheries and the number of fishable days occurring during a typical year (Brown 1973a). Two distinct groups of anglers were found to fish in the Mattole River: salmon anglers and steelhead anglers. Salmon anglers were characterized as local residents who fished from boats in the estuary from late September until winter storms allowed salmon to move upstream in early November. Fourteen anglers sampled in October 1972 had a catch per angler hour of 0.124.

Steelhead anglers were characterized as excellent fishermen who traveled long distances, put in long days fishing, and were frequently successful. An average angler-day was 7.1 hours, the average catch per angler day was 0.45, and the average catch per angler hour was 0.064 in February 1972.

The Mattole River was fishable for only 9 ½ days during February of 1972, though every day from May through August 1972 was fishable. Most of September and October were fishable, but turbid water limited fishing to only a few days per month by November 1972. Turbidity prevailed throughout most of the steelhead-fishing season (November 21, 1972 through February 28, 1973), though at least 28 days were fishable. The river had been fishable for 24 days during the 1971-72 steelhead-fishing season.

Estimates of the abundance and distribution of juvenile salmonids in the Mattole Basin were made in 1972 to determine the effect of a proposed dam on salmonid resources (Brown 1973b). The proposed dam was to be built at Nooning Creek (RM 50.2). Standing stocks of salmonids were estimated at 24 stations (18 stations above the proposed dam and six below the proposed dam) in the Mattole Basin using electrofishing surveys (Table 19). Salmonid populations on the mainstem Mattole River averaged 136 salmonids per 100 feet near Ettersburg and 61 salmonids per 100 feet in the headwaters above Bridge Creek (RM 52.1). Young-of-the-year steelhead trout predominated at these stations. Coho salmon fry were found at only one station on the mainstem Mattole River, at RM 58.6 in the Southern Subbasin.

Table 19. Mattole Basin steelhead trout and coho salmon population estimates, 1973 (after Brown 1973b).

Subbasin	Location	# of 100 ft Stations	Average Population Estimate for a 100 ft Stations (95% confidence intervals)		
			Steelhead Trout		Juvenile Coho Salmon
			Young-of-the-Year	Yearling and Older	
Mainstem	Mattole River near Ettersburg	2	131	5	0
Northern Subbasin	Lower North Fork of the Mattole River	2	172	14	0
Eastern Subbasin	Mattole Canyon Creek	1	596	6	6
	McKee Creek	2	124	15	0
Southern Subbasin	Upper Mattole River	7*	54	7	<1
	Vanauken Creek	2	74	<1	0
	Mill Creek (RM 56.2)	2	39	0	0
	Harris Creek	1	47	0	1
	Baker Creek	2	43	1	10
	Thompson Creek	2	59	3	6
Western Subbasin	Squaw Creek (near mouth)	1	74	0	0

* Juvenile steelhead not separated by age at one station so estimates taken from other six stations.

Average salmonid populations at 15 stations on tributaries to the Mattole River ranged from 39 to 596 salmonids per 100 feet. Young-of-the-year steelhead trout predominated at all tributary stations. Coho salmon were found at four stations on tributaries (Harris Creek, Baker Creek, Thompson Creek, and Mattole Canyon Creek). Sampling effort was not sufficient to accurately estimate the numbers of salmonids in the mainstem Mattole River above the proposed Nooning Creek dam site. Nevertheless, Brown (1973b) very roughly estimated that the proposed dam would eliminate nursery areas for 125,283 juvenile steelhead trout and 1,713 juvenile coho salmon.

The Coastal Headwaters Association surveyed just over 200 perennial stream miles in the Mattole Basin in the early 1980s under contract with CDFG. They conducted five different types of stream surveys: pre-inventory surveys, visual surveys, detailed habitat surveys, spot-checks, and high-water surveys.

Pre-inventory surveys consisted of obtaining land-owner permission to access streams, and obtaining and reviewing all available maps for an area, previous stream surveys, and historical information. Visual surveys provided a basic description of fish populations, habitat conditions, and rehabilitation needs but usually did not involve the collection of quantitative data. Detailed habitat surveys were similar to ocular surveys, but included actual measurements of habitat features such as pools, runs, and riffles. Spot-checks consisted of fish and habitat observations at point locations in easily accessible areas like bridges. Spot-checks often included the use of minnow-traps to sample juvenile salmonids. Lastly, high-water surveys were used to estimate spawning salmonid populations and followed procedures used by the Anadromous Fisheries Branch (1981).

Findings of the Coastal Headwaters Association's stream surveys were summarized in the First Annual Report of the Mattole Survey Program in 1982. Coastal Headwaters Association stream surveys document the presence of steelhead trout throughout the Mattole Basin, and coho salmon in every subbasin except the Northern Subbasin (Table 20). More details about stream surveys are in the analyses and results by subbasin section of this report and the CDFG Appendix F.

Table 20. Coho salmon and steelhead trout presence reported in Coastal Headwaters Association stream surveys

Subbasin	Number of Streams Surveyed	Number of Streams where Coho Salmon Were Reported *	Number of Streams where Steelhead Trout Were Reported*
Estuary Subbasin	NA	NA	NA
Northern Subbasin	6	0	5
Eastern Subbasin	8	3	6
Southern Subbasin	9	4	7
Western Subbasin	15	5	9

*These numbers do not include unidentified salmonid observations.

Recent CDFG surveys for coho salmon have determined coho presence in four tributaries in the Eastern Subbasin; seven tributaries and the upper mainstem Mattole River in the Southern Subbasin; and four tributaries in the Western Subbasin (Table 21). Steelhead trout were present at all sites.

Table 21. Recent coho salmon and steelhead trout presence surveys in the Mattole Basin

Subbasin	CDFG 2001 Coho Inventory			1990s CDFG Basin Planning Project		
	Number of Streams Surveyed	Number of Streams where Coho Salmon Were Reported	Number of Streams where Steelhead Trout Were Reported	Number of Streams Surveyed	Number of Streams where Coho Salmon Were Reported	Number of Streams where Steelhead Trout Were Reported
Estuary Subbasin	NA*	NA	NA	NA	NA	NA
Northern Subbasin	3	0	3	3	0	3
Eastern Subbasin	10	3	10	10	1	10
Southern Subbasin	7	5	7	10	5	10
Western Subbasin	11	3	11	10	2	10

*NA is not applicable as there are no fish bearing tributaries in the Estuary Subbasin.

Additional sources of information about anadromous salmonids in the Mattole Basin include watershed analyses, other studies of tributaries and salmonids, and stocking records. Detailed Watershed Analyses have been carried out by the BLM for Bear Creek (1995), Honeydew Creek (1996), and Mill Creek (lower) (2001), and Hamilton (1982) surveyed Nooning Creek as part of a research proposal. Additionally, Nehlsen et al. (1991) and Higgins et al. (1992) both mention Mattole salmonid runs in their overviews of the risk of extinction of salmon runs in the Pacific and Northern California, respectively. They postulated that fall-run Chinook salmon and coho salmon in the Mattole Basin had a high risk of extinction. More details are in the analyses and results by subbasin section of this report and the CDFG Appendix F.

The Mattole Basin was stocked by CDFG with steelhead trout, coho salmon and/or Chinook salmon from 1930 to 1981 (Table 21). The vast majority of fish released were steelhead.

Table. CDFG stocking records for the Mattole Basin from 1930 to 1981.

Year	Steelhead Trout	Coho Salmon	Chinook Salmon
1930	50,000		
1931	50,000		
1932	105,000		
1933	70,000		
1934	40,000		
1935	132,000		
1936	65,000		
1938	2,690	1,000	4,940
1961	187,000		
1972	30,065		
1973	19,067		
1975	30,012		
1981	100,000		

The Mattole Salmon Group (MSG) was formed in 1980 as a response to local citizen's concerns about declining salmonid populations. MSG represents a watershed-wide, entirely citizen-run effort to begin restoring native salmon runs. MSG promotes and operates a broad-based program aimed at restoring the native salmonid fishery in the Mattole Basin. Two important focus areas of the MSG program are monitoring fish populations, and maintaining and enhancing the remnant runs of native fall-run Chinook salmon and coho salmon (MSG 2000).

MSG monitors fish population in the Mattole Basin through spawning surveys and downstream migrant trapping. As a part of their activities, MSG has conducted annual spawning surveys since the 1981-1982 season to provide estimates of salmon escapement in specific index reaches and for extrapolation to basin-wide population levels. Estimated basin-wide populations of Chinook salmon and coho salmon for the 1999-2000 season were 700 and 300, respectively (Table 22). The coho salmon population has been estimated to be less than 1,000 since 1981 and below 100 from 1989 to 1992. Chinook salmon populations, although higher, also ranged to critically low levels- with only an estimated 100 to 400 adults in the years 1989-1993.

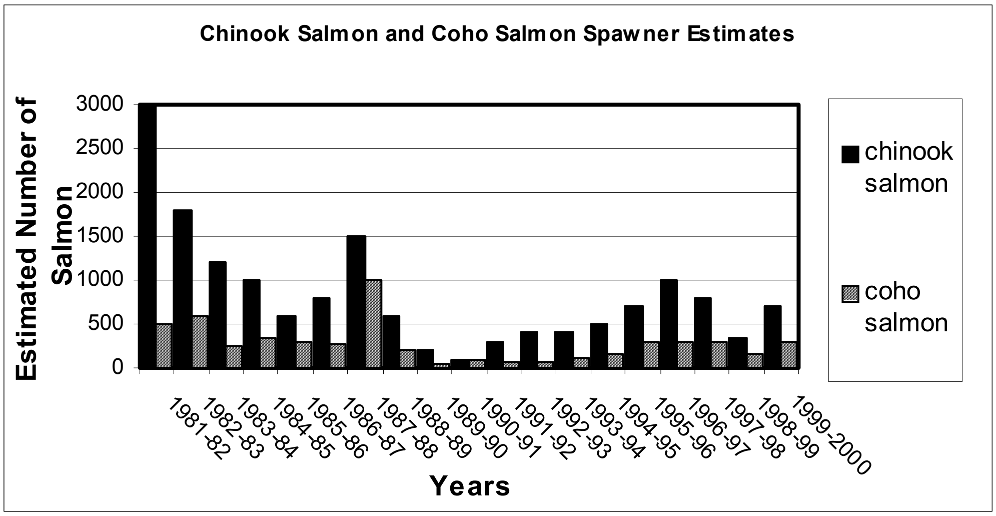

Table 22. Mattole Salmon Group estimates of returning adult Chinook and coho salmon spawners to the Mattole Basin from 1981-2000.

Data is based on annual synthesis of spawning surveys and counts at a temporary fish weir in the Mattole River near the confluence with Mill Creek. Data provided by the Mattole Salmon Group.

Small populations of organisms are at a greater risk of extinction from genetic problems, demographic fluctuations, and environmental fluctuations. A loss of genetic variability can be caused by inbreeding, loss of heterozygosity, and genetic drift. Demographic fluctuations are caused by random variations in birth and death rates. Environmental fluctuations include variation in predation, competition, disease, and food supply; and natural catastrophes resulting from single events that occur at irregular intervals, such as fires, floods, earthquakes, storms, or droughts (Primack 1993).

In general, populations of organisms need 50 individuals to avoid inbreeding depression (Franklin 1980), 500 individuals to avoid long-term loss of genetic variation (Franklin 1980, Lande and Barrowclough 1987), and 5,000 individuals to maintain potentially adaptive variation for the long term (Lande 1995). Various studies have investigated the minimum number of salmonids necessary to avoid the high risk of extinction associated with small populations. Allendorf et al. (1997) concluded that salmon populations below 2,500 individuals are at a high risk of extinction, and salmon populations below 250 are at an even greater risk. Given the current low population estimates of Chinook and coho salmon, Mattole Basin salmon populations are likely at a high risk of extinction.

MSG has also conducted downstream migrant trapping in the lower mainstem Mattole near Mill Creek, at RM 2.9, in the spring and early summer to monitor the timing of down-migration and to document the size of emigrating salmonid juveniles since 1985. The number of fish caught cannot be construed as a fish population estimate because of unknown trap efficiency and avoidance of the trap by fish at high flows. Data from 1995-2001 indicate that the majority of salmonids trapped were steelhead trout, followed by Chinook salmon and coho salmon (Figure 40 and Figure 41).

MSG started another downstream migrant trap on Bear Creek 300 ft upstream from its confluence with the Mattole River in 1997. The confluence of Bear Creek and the Mattole River is at RM 42.8. Data from the trap on Bear Creek also show that more steelhead trout are caught than Chinook salmon and coho salmon (Figure 42 and Figure 43). A third fish trap was placed on the mainstem Mattole River at Ettersburg in 2001 (RM 42.9). This trap caught 1,923 Chinook salmon, 6 coho salmon, 4,863 young-of-the-year steelhead trout, 541 steelhead trout 1+, and 33 steelhead trout smolts.

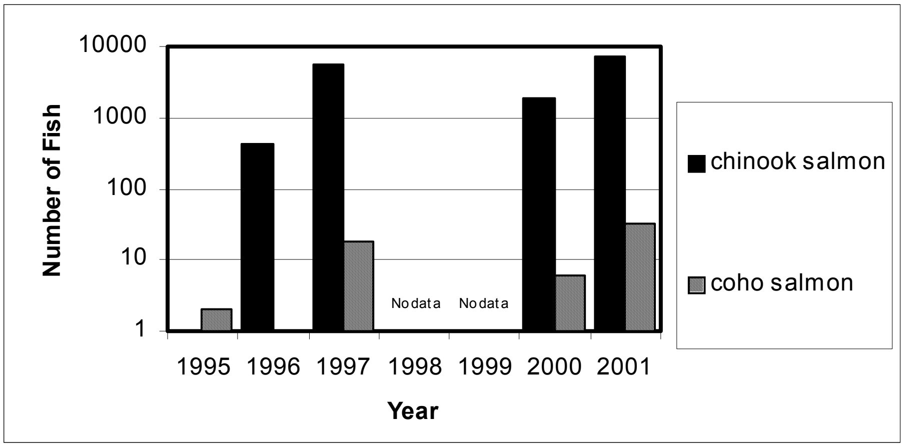

Figure 40. Outmigrant salmon trapped at Mill Creek (RM 2.9) from 1995-2001.
Data provided by the Mattole Salmon Group.

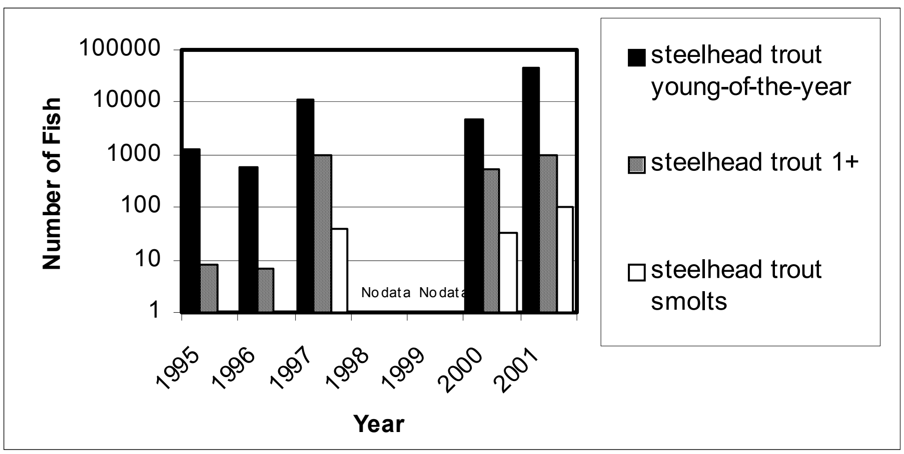

Figure 41. Outmigrant steelhead trout trapped by the Mattole Salmon Group
Spring and Early Summer in the Mattole River Near Mill Creek (RM 2.9) from 1995-2001
Steelhead were separated into young-of-the-year, 1+, and smolts. Data provided by the Mattole Salmon Group.

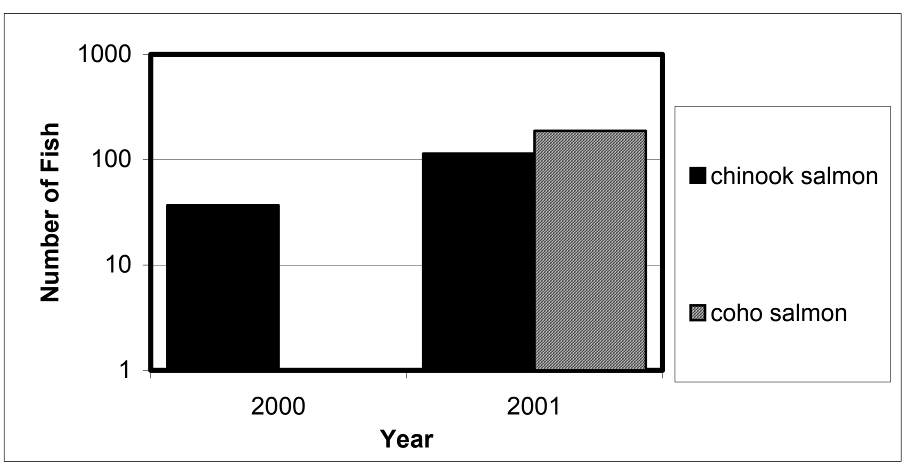

Figure 42. Outmigrant Chinook and coho salmon trapped by the Mattole Salmon Group.

Spring and Early Summer in Bear Creek 300 Ft From its Confluence with the Mattole River from 2000-2001. Data provided by the Mattole Salmon Group

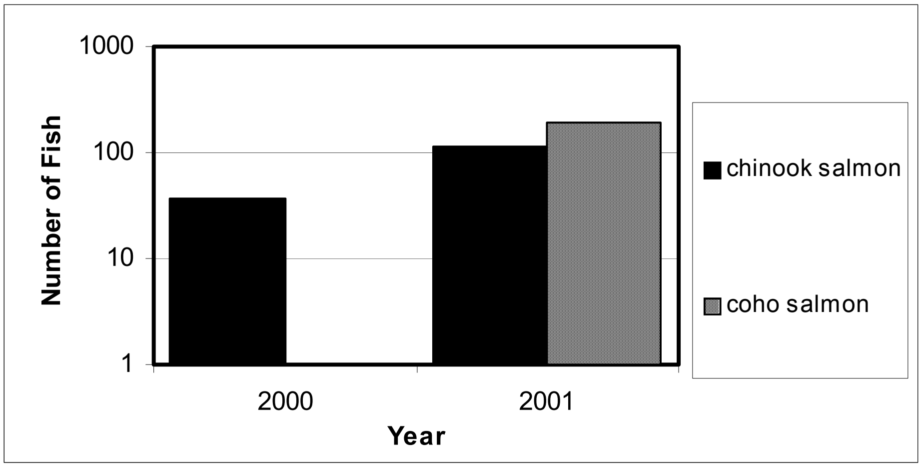

Figure 43. Outmigrant steelhead trout trapped by the Mattole Salmon Group.

Spring and early summer in Bear Creek, 300 feet from it confluence with the Mattole River from 2000-2001. Steelhead were separated into young-of-the-year, 1+, and smolts. Data provided by the Mattole Salmon Group.

MSG maintains and enhances the native fall-run Chinook salmon and coho salmon in the Mattole Basin through a hatchbox program and a rescue-rearing program. The goal of these programs is to restore native salmon runs to self-sustaining levels that can be maintained without artificial propagation or other significant human intervention. MSG is part of the CDFG Cooperative Fish Rearing Project.

Beginning in 1981, MSG has trapped wild adult Chinook and coho salmon in the Mattole Basin for use as broodstock. Eggs are obtained from females and fertilized. Fertilized eggs are incubated in hatchboxes. After hatching, fry are reared for 6 weeks before release. Over 350,000 hatchbox fish had been released by 1999 (Figure 44). All artificially propagated fish are marked, in order to provide estimates of hatchery-to-wild ratios. Adult trapping data from 1995 to 1999 suggest an overall hatchery-to-wild ratio of 1:10, and spawning ground surveys over the same time period suggest a hatchery-to-wild ratio of 1:33.

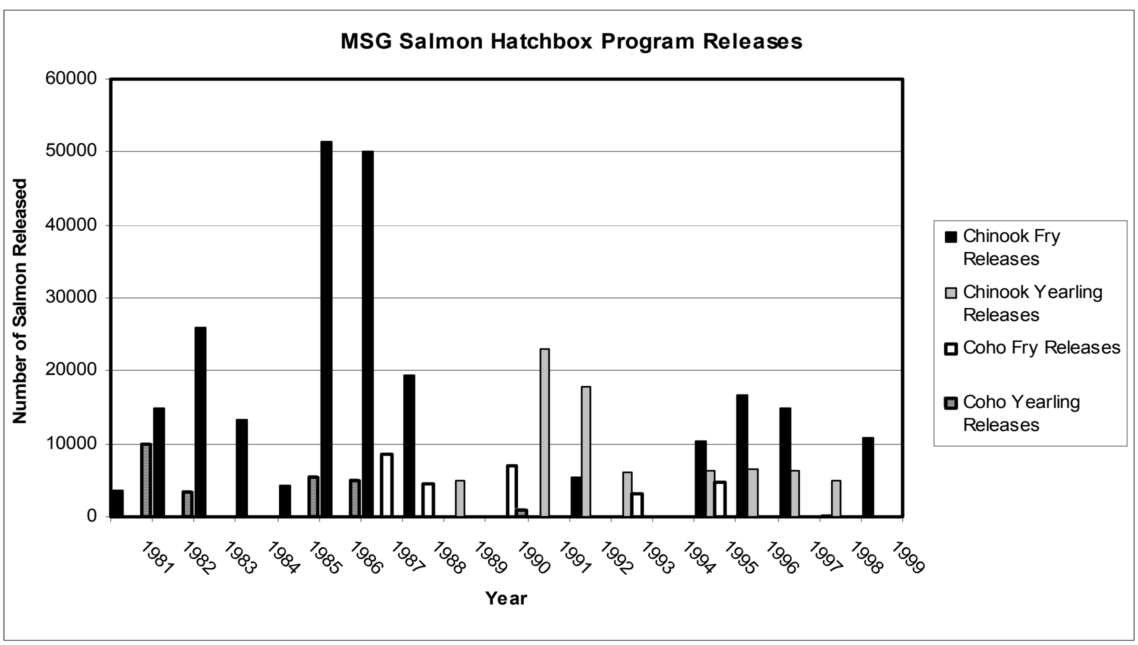

Figure 44. Mattole Salmon Group hatchbox program salmon releases from 1981-1999.

Data provided by the Mattole Salmon Group.

For the past several years in May and June, MSG has also trapped Chinook outmigrants just upstream of the estuary. Extensive studies from 1985-92, led by Humboldt State University, found that Chinook juveniles were suffering lethal impacts during summer rearing in the estuary. Therefore, MSG project personnel and volunteers net up to 6,000 naturally spawned outmigrant juvenile Chinook salmon each year and hold them in rearing ponds at Mill Creek. Volunteers rear the fish until water temperatures drop and/or the lagoon opens to the sea with fall rains. The combined number of Chinook salmon released from the MSG's hatchbox rearing program and their rescue-rearing program since 1981 is approximately 400,000.

Fishing Interests, Constituents

Historically, during the winter months sport fishing for salmon and steelhead has drawn anglers from throughout California and other states to the Mattole River, which has been an important contributor to both sport and commercial marine fisheries. Due to declining populations, Chinook and coho salmon, and steelhead are currently listed as threatened under the federal Endangered Species Act. The threatened status now restricts river sport fishing on Mattole Basin stocks. The Mattole Estuary, from the river mouth to 200 yards upstream, is closed to fishing all year. The winter salmon and steelhead fishery of the Mattole River is managed as a catch and release fishery from January 1 to March 31. Only artificial lures with barbless hooks may be used. This area consists of the Mattole mainstem from a point 200 yards upstream of the mouth to the confluence with Honeydew Creek. Additionally, the Mattole River mainstem from the confluence with Stansberry Creek to the confluence with Honeydew Creek is open from the fourth Saturday in May through August 31, for catch and release fishing using only artificial lures with barbless hooks.

The Mattole River is also subject to low-flow restrictions. From October 1 through January 31, the mainstem Mattole River from the mouth to Honeydew Creek shall be closed to all angling from Tuesday through Thursday when the flow on the previous Monday morning is less than 320 cfs at the Petrolia Bridge gauging station. Additionally, the river shall be closed to all angling from Friday through Monday when the flow on the previous Thursday morning falls below 320 cfs at the Petrolia Bridge gauging station.

These regulations were adapted from Department of Fish and Game's 2002 Freshwater Sport Fishing Regulations Booklet and are in effect March 1, 2002 through February 28, 2003. They are not presented here for use as official, current information. Anglers must rely upon the latest regulations booklet for official, current information. These are available free from:

Department of Fish and Game
Northern California & North Coast Region
619 Second Street
Eureka, CA 95501
(707) 445-6493

Fish Restoration Programs

Local watershed groups, the BLM, various state agencies such as CDFG, and local landowners have worked on numerous restoration projects throughout the Mattole Basin. The Mattole Restoration Council (MRC) and the Mattole Salmon Group (MSG) have obtained contracts for work on such diverse areas of restoration as stream surveys, road assessment, revegetation, instream habitat improvement, fish rearing, public education, and monitoring.

Stream surveys provide basic information about a stream and identify salmonid habitat problems. Examples of stream surveys done in the Mattole Basin include spawning surveys, habitat typing and channel typing surveys, and large woody debris surveys. Many of these surveys are conducted or funded by CDFG and BLM.

Road assessments help identify current and potential sources of erosion related to roads. One current road assessment project in the Mattole Basin is a Department of Water Resources funded assessment of roads in the Eastern Subbasin. CDFG is also funding erosion assessments in the Eastern Subbasin.

Revegetation is important both in riparian areas, to stabilize stream banks, provide cover for salmonids, and provide shade; and in upslope areas, to help stabilize hillslopes. Examples of revegetation activities in the Mattole Basin include tree planting in the Middle Creek headwaters in 1996 funded by Sunlaw

Cogeneration Partners, lower Mattole Basin riparian reforestation funded by CDFG in 1996, and willow planting in the estuary funded by CDFG in 1993.

The addition of instream improvement structures to a stream deficient in habitat diversity and complexity can provide escape and ambush cover needed by salmonids. These projects are most effective in watersheds in good health. The Mattole Salmon Group has added instream structures to the Mattole headwaters, the mainstem Mattole River, and various tributaries since 1980 with funding from CDFG.

Fish rearing projects can be a way to supplement salmonid populations before habitat restoration activities can improve conditions. Beginning in 1981, MSG has trapped and raised native Chinook and coho salmon in the Mattole Basin on a limited basis. In the upper reaches of the river system, the group has used hatch boxes placed instream to incubate fertilized eggs taken from locally trapped Chinook and coho broodstock. Extensive studies from 1985-92, led by Humboldt State University, found that Chinook juveniles were suffering lethal impacts during summer rearing in the estuary. For the past several years in May and June, the group has also trapped Chinook downstream migrants just upstream of the estuary / lagoon. Due to a combination of watershed factors, the estuary outlet closes in June or July in most years, preventing smolts from escaping very warm to lethal freshwater temperatures into the relative safety of the ocean. Project personnel and volunteers net up to 6,000 naturally spawned downstream Chinook migrants each year and then hold them in rearing ponds at Mill Creek (RM 2.8). Volunteers rear the fish until they are released to the estuary when river stream temperatures drop and/or the lagoon opens to the sea with fall rains. In the 14 years between 1981 and 1995, 338,000 Chinook salmon and 52,550 coho salmon have been released between the program's upstream and estuarine operations.

Public education programs are effective in expanding awareness about day-to-day activities that impact a watershed. Two important public education campaigns in the Mattole Basin are the MRC's *Good Roads, Clear Creeks* initiative, and the Mattole Salmon Group's campaign to encourage water conservation.

Stream monitoring is important for restoration work in the same way that stream surveys are important; however, monitoring also allows restoration workers to study stream conditions over time. USGS sponsored sediment sampling at the Petrolia Bridge by MSG since 2000 is an example of a monitoring program in the Mattole Basin.

For more information about the extent of restoration projects throughout the Mattole Basin, please see the CDFG Appendix F.

Special Status Species

Ten plant and animal species in the Mattole Basin have been found to have declining populations across their ranges and thus warrant special concern (Table 23). Species with declining populations are eligible to be listed under the federal Endangered Species Act (ESA) and the California Endangered Species Act (CESA) for special attention. Detailed explanations of federal and state listings criteria are in the CDFG Appendix F.

Table 23. Special status species of the Mattole Basin.

Major Group	Name	Scientific Name	Federal Listing	State Listing
Plants	Beach layia	*Layia carnosa*	Endangered	Endangered
	Leafy reed grass	*Calamagrostis foliosa*	None	Rare
Fish	Coho salmon	*Oncorhynchus kisutch*	Threatened	Threatened
	Chinook salmon	*Oncorhynchus tshawytscha*	Threatened	None
	Steelhead trout	*Oncorhynchus mykiss*	Threatened	None
Amphibians	Foothill yellow-legged frog	*Rana boylii*	Species of concern	Species of special concern
	Tailed frog	*Ascaphus truei*	Species of concern	Species of special concern
	Southern torrent salamander	*Rhyocotriton variegatus*	None	Species of special concern
Birds	Northern spotted owl	*Strix occidentalis caurina*	Threatened	None
	Marbled murrelet	*Brachyramphus marmoratus*	Threatened	Endangered

Amphibians of Interest

Southern torrent salamanders (*Rhyacotriton variegates*) and tailed frogs (*Ascaphus truei*) are two of the many amphibian species that inhabit the Mattole Basin. Like coho salmon, these two amphibians are sensitive to temperature and sediment. However, they live in small, lower order streams, upstream from coho salmon habitat. Therefore, torrent salamander and tailed frog populations can serve as indicators of environmental stressors such as increased water temperature and excessive fine sediment (Welsh and Ollivier 1998), which are also potential habitat problems for coho salmon.

Welsh et al. (2002) conducted a study to determine the linkages between landscape processes and torrent salamanders and tailed frogs in the Mattole Basin. They surveyed 49 stream reaches for amphibians from 1994-1996, eleven in the Northern Subbasin, six in the Eastern Subbasin, 15 in the Southern Subbasin, and 17 in the Western Subbasin (Figure 45). Torrent salamanders were found in eleven stream reaches and tailed frogs were found in15 stream reaches (Figure 46).

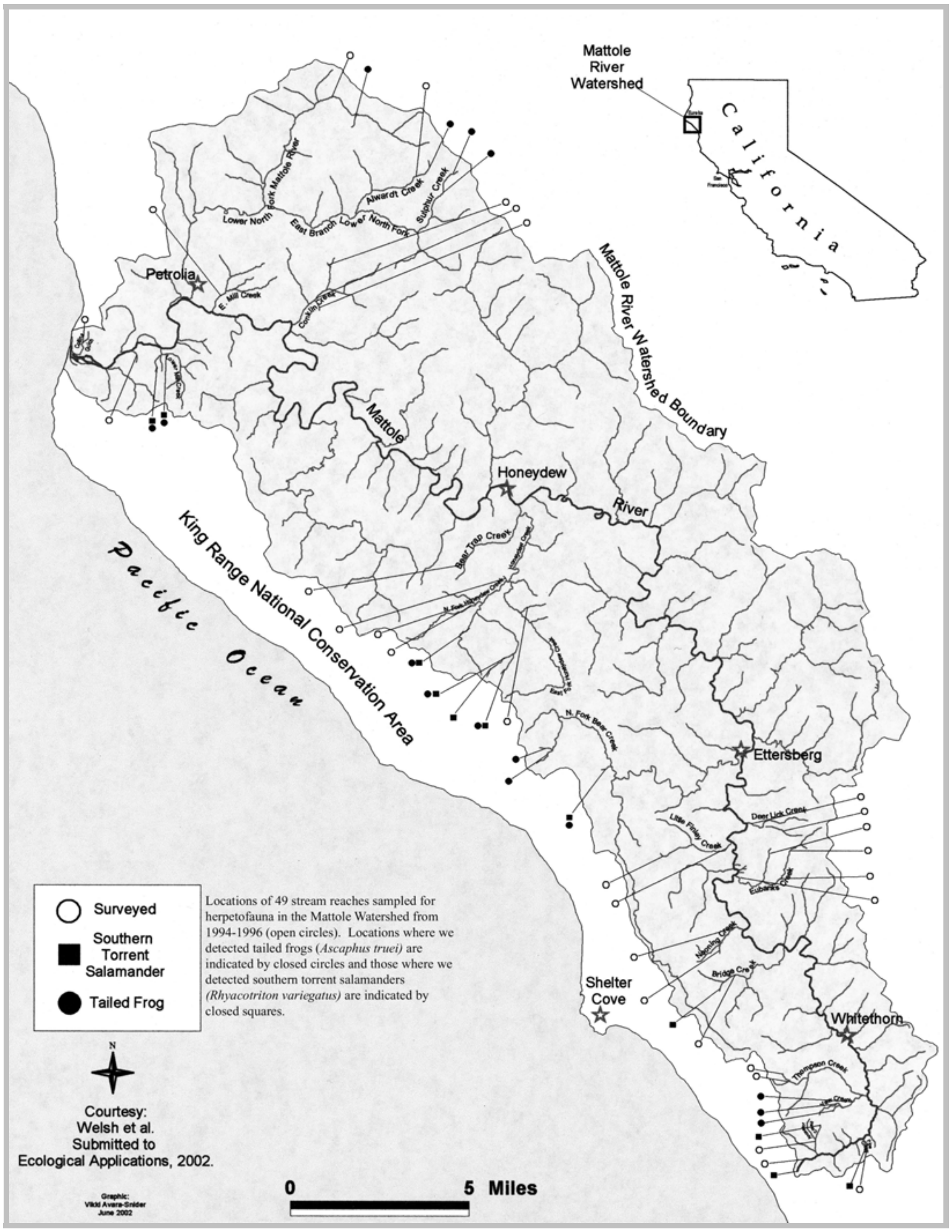

Figure 45. Amphibian survey (Welsh et al. 2002).

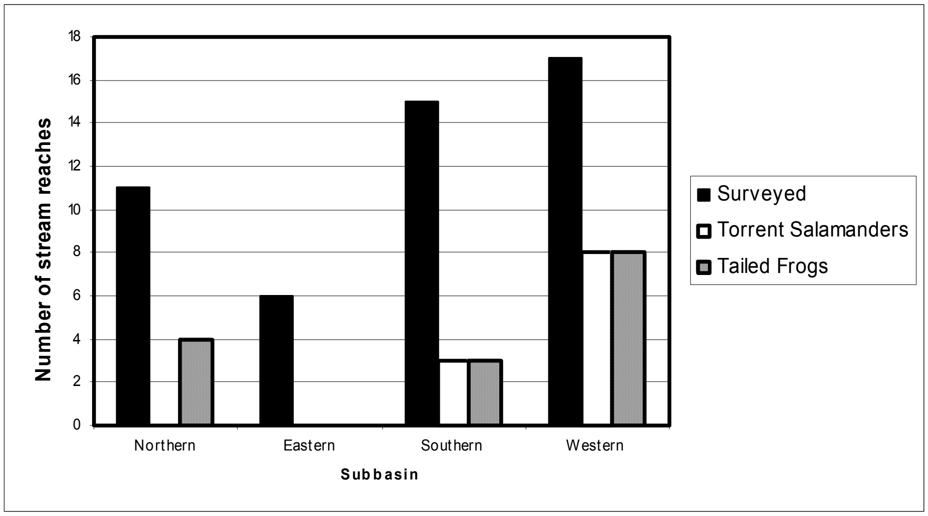

Figure 46. The number of surveyed stream reaches containing torrent salamanders and tailed frogs in each subbasin of the Mattole Basin (Data from Welsh et al. 2002).

No torrent salamanders were found in Northern Subbasin surveyed stream reaches, while tailed frogs were found in four reaches. Neither species of amphibian was found in surveyed stream reaches in the Eastern Subbasin. The Southern Subbasin had torrent salamanders in three surveyed stream reaches and tailed frogs in three additional surveyed stream reaches. The Western Subbasin also had occurrences of both torrent salamanders and tailed frogs. Five surveyed stream reaches contained both species of amphibian, two reaches only contained torrent salamanders, and two reaches only contained tailed frogs.

The high number of surveyed stream reaches in the Western Subbasin with torrent salamanders and tailed frogs could be an indication of good habitat conditions for coho salmon in this subbasin. These amphibians were found in headwaters reaches of the North Fork of Bear Creek, the West Fork of Honeydew Creek, and Mill Creek (RM 2.8). In fact, coho salmon have been found in downstream reaches of these streams by CDFG stream inventories, the 2001 CDFG Coho Inventory, CDFG electro-fishing, and/or Welsh et al. (2001). Similarly, coho salmon have been found downstream from headwaters reaches of the Mattole River, Yew Creek, and upper Mill Creek (RM 56.2), where torrent salamanders or tailed frogs were detected in the Southern Subbasin.

When the occurrence of torrent salamanders and tailed frogs in stream reaches was examined in terms of the seral stage of the stream canopy, torrent salamanders and tailed frogs were abundant in late seral forests, less common in second growth forest habitats, and not found in mixed forest/grassland ecosystems in the Mattole Basin (Figure 47).

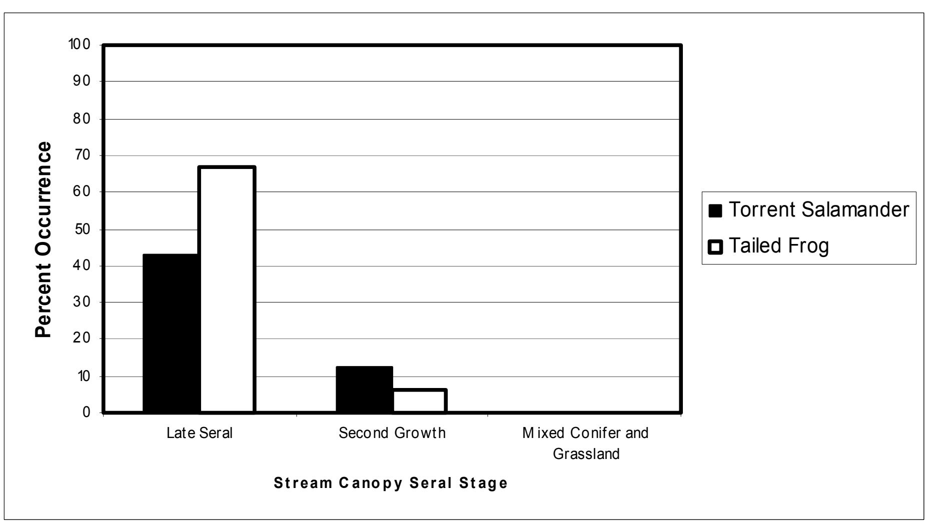

Figure 47. Percent occurrence of torrent salamanders and tailed frogs.
In Stream Reaches with Late Seral, Second Growth, and Mixed Conifer and Grassland Canopy in Surveyed Stream Reaches in the Mattole Basin (data from Welsh et al. 2002).

Mattole Synthesis

Integrated Analysis

The following tables provide a dynamic, spatial picture of watershed conditions for the freshwater lifestages salmon and steelhead. The tables' fields are organized to show the extent of watershed factors' conditions and their importance of function in the overall watershed dynamic. Finally a comment is presented on the impact or condition affected by the factor on the watershed, stream, or fishery. Especially at the tributary and subbasin levels, the dynamic, spatial nature of these processes provides a synthesis of the watershed conditions and indicates the quantity and quality of the freshwater habitat for salmon and steelhead.

Geology

Introduction

The potential for sediment production is strongly influenced by the underlying geology. The following IA tables compiled by CGS examine the influence of geology on sediment production by comparing the distribution of geomorphic terrains (hard, moderate, and soft bedrock terrains, and the separately grouped Quaternary surficial deposits) against the observation of landslides and geomorphic features related to mass wasting within the basin. Table 24 presents the proportions of the basin underlain by each of the terrains. Table 25 looks at hillside gradient, which is influenced by the type of underlying terrain and, in turn, has a variable influence on slope stability within the different terrains. Table 26 looks at distribution of small landslides (historically active and dormant), gullies, and inner gorges by terrain are then considered.

Table 24. Geomorphic terrains as a proportion of Mattole Basin.

Proportion of Mattole River Basin Underlain by the Different Geomorphic Terrains			
Feature/Function		**Significance**	**Comments**
Terrain Type	**Proportion of basin Area**	The geomorphic terrains represent groupings of geologic map units based on similarities in geology, geomorphic expression, and landslide occurrence. They provide a simplified division of the watershed useful in comparing the influence of bedrock geology to the distribution of other mapped features.	Soft terrain, where landslides and gully erosion are most abundant, is concentrated in the Northern Subbasin, and scattered through the Eastern and Western Subbasins. Quaternary units (primarily alluvium) occupy only a minor portion of the basin and are concentrated along valley bottoms.
Hard	40%		
Moderate	28%		
Soft	25%		
Quaternary[1]	7%		

1 Areas where young (Quaternary) surficial units have been mapped covering bedrock; includes alluvium, terrace deposits, active stream channel deposits, and other alluvial deposits.

Table 25. Hillside gradient by geomorphic terrain in the Mattole Basin.

Hillside Gradient by Geomorphic Terrain in the Mattole Basin								
Feature/Function							**Significance**	**Comments**
Terrain Type	**Percentage of Watershed Area — Range in % slope**						Hillside slope is an important indicator of potential instability (steeper is generally less stable). The terrain type influences the degree to which hillside slope affects the slope stability.	High rates of tectonic uplift in the region are reflected in the rugged topography and relative abundance of steep to very steep slopes in the watershed. Steeper slopes are typically found in the hard, and to a lesser degree moderate terrains. More gentle slopes predominate in the soft terrain, as it is typically less able to support development of steep slopes without failing.
	0-10	**10-30**	**30-40**	**40-50**	**50-65**	**>65**		
Hard	1	4	5	7	11	11		
Moderate	<1	5	6	6	7	5		
Soft	1	6	7	5	4	2		
Quaternary	4	3	<1	0	0	<1		
Total	6	18	18	18	22	18		

Table 26. Small historically-active landslides by terrain.

Distribution of Small Historically-Active Landslides by Terrain in the Mattole Basin				
Feature/Function			**Significance**	**Comments**
Terrain Type	**Small Point Landslides[1] Mapped from year 1981[2], 1984, or 2000 Photographs**		The relative number of small point slides is used to evaluate which geomorphic terrains are more prone to small, localized slope failures.	The majority of small-localized failures occur in the hard and moderate terrains; these failures consist primarily of shallow debris slides associated with steep slopes. Significant portions of small failures in the soft terrain on less steep slopes are earthflows.
	Point Count	**Area[3] (acres)**		
Hard	2,355	233		
Moderate	1,900	188		
Soft	1,346	133		
Quaternary	41	4		

1 Mapping was compiled at a 1:24,000 scale. Landslides smaller than approximately 100 feet in diameter were captured as points in the GIS database; larger features were captured as polygons.
2 Landslides included from year 1981 photographs are from previous mapping by Spittler (1983 and 1984) covering limited portions of the Mattole Basin.
3 Based on assumed average area of 400 square meters (roughly 1/10th acre) for small landslides.

Table 27. All historically-active landslides by terrain in the Mattole Basin.

Distribution of All Historically-Active Landslides by Terrain in the Mattole Basin				
Feature/Function			Significance	Comments
Terrain Type	**Combined Area (acres) of All Historically-Active Landslides[1]**	**Proportion of Total Active Landslide Area within Basin**	The relative percentage of area covered by historically-active slides identifies which geomorphic terrains are most prone to slope failures.	The soft terrain, despite underlying a smaller proportion of basin area and having relatively more gentle slopes, contains the majority of the area occupied by historically-active landslides. Most of the larger slope failures in the soft terrain are earthflows.
Hard	1,921	19%		
Moderate	2,553	25%		
Soft	5,586	55%		
Quaternary	69	1%		

1 Includes small point and larger polygon features mapped from year 1981, 1984 and 2000 photos. Where landslides overlapped (i.e., the same or similar features mapped from more than one photo set) the area of overlap was counted only once. Small landslides captured as points in the GIS database were assumed to have an average area of 400 square meters (roughly 1/10th acre).

Table 28. Distribution of dormant landslides by terrain in the Mattole Basin.

Distribution of Dormant Landslides by Terrain in the Mattole Basin				
Feature/Function			Significance	Comments
Terrain Type	**Combined Area (acres) of All Dormant Landslides[1]**	**Proportion of Total Dormant Landslide Area within Basin**	The relative percentage of area covered by dormant landslides identifies which geomorphic terrains have been most prone to the larger, more deep-seated types of slope failures.	The area of dormant landslides is somewhat more evenly distributed between soft and moderate terrains than are active landslides; however, the soft terrain is still substantially over represented when considering its smaller size. Over 85% of dormant landslides are rock slides, with the remainder being earthflows. Over half of the earthflows are found in soft terrain.
Hard	6,338	18%		
Moderate	12,276	35%		
Soft	16,145	46%		
Quaternary	238	1%		

1 Includes features mapped from year 1981, 1984, and 2000 photos. Where landslides overlapped (i.e., the same or similar features mapped from more than one photo set) the area of overlap was counted only once.

Table 29. Gullies and inner gorges by terrain in the Mattole Basin.

Distribution of Gullies and Inner Gorges by Terrain in the Mattole Basin				
Feature/Function			Significance	Comments
Terrain Type	**Proportion of Total Mapped Gully Lengths[1] in Basin**	**Proportion of Total Mapped Inner Gorge Lengths[1] in Basin**	Gullies and inner gorges are an important indicator of ongoing sources of sediment to the fluvial system.	The large majority of mapped gullies are located in soft terrain; gully erosion is a significant, on-going contributor of sediment load from soft terrain areas. Roughly half of all inner gorges were identified in hard terrain; inner gorges act as sediment source areas primarily through debris sliding.
Hard	5%	51%		
Moderate	11%	29%		
Soft	81%	18%		
Quaternary	3%	2%		

[1] Includes only those features mapped from year 2000 photographs.

Table 30. Landslide potential by terrain on of Mattole Basin.

Distribution of Landslide Potential Categories by Terrain as a Proportion of the Total Mattole Basin							
Feature/Function						Significance	Comments
Terrain Type	Landslide Potential Category[1]						
	1	2	3	4	5		
Hard	0.2%	6.5%	15.6%	6.2%	11.2%	Categories 4 and 5 represent the majority of unstable areas that are current or potential future sources of sediment.	Unstable soft terrain is disproportionably represented because of its inherent instability (over 4/5 of soft terrain is in LPM Category 4 and 5). Hard terrain has the largest proportion of area, steep slopes, and small slides in basin, yet has the lowest proportion of basin area occupied by LPM Category 4 and 5. Moderate terrain has an intermediate proportion of LPM Category 4 and 5, consistent with its intermediate nature of all slope related categories.
Moderate	0.2%	2.7%	13.8%	6.1%	5.7%		
Soft	0%	0.4%	4.3%	11.0%	9.0%		
Quaternary	4.0%	2.2%	0.6%	0.1%	0.3%		
Basin Total[2]	4.4%	11.8%	34.3%	23.4%	26.2%		

1 Categories represent ranges in estimated landslide potential, from very low (category 1) to very high (category 5); see Geologic Report, Plate 2.
2 Percentages are rounded to nearest 1/10 %; sum does not equal 100% due to rounding.

Discussion

As highlighted in the tables, areas of sediment production associated with landslides and gullies are concentrated in the soft terrain. Although soft terrain has more gentle slopes and occupies only 25% of the basin, over half of the area occupied by historically active landslides and over 80% of the total gully lengths observed in the basin are located in soft terrain. In addition, over 80% of the soft terrain falls into Landslide Potential Categories 4 or 5 (high or very high). Landslides in hard terrain, and to a lesser degree moderate terrain, are predominantly small debris slides associated with sleep slopes or inner gorges. In contrast, landslides in soft terrain include a significant proportion of larger earthflows on gentler slopes and more deep-seated rock slides.

Vegetation and Land Use

Introduction

CDF NCWAP developed a number of tables that are intended to help identify and highlight how current patterns of vegetation and land use are expressed in relation to the geology of the watershed. First, vegetation and land use are related to the underlying bedrock geology or terrain type. These patterns are then explored by examining the current vegetation and recent timber harvesting in relation to their occurrence in landslide potential classes, the product of a model that uses terrain type, vegetation, and landslides as variables. Landslide causality was not assigned and recent timber harvest activity has occurred in low percentages in most of the planning watersheds. The significance of the geologic characteristics in these tables is expressed as a relative rating and is not characterized numerically.

Table 31. Vegetation types associated with terrain types in the Mattole Basin.

Vegetative Condition in the Mattole Basin								
Feature/Function							Significance	Comments
Terrain Type	Vegetation Type							
	Conifer	Mixed	Hardwood	Grassland	Other	Total		
Hard	10%	68%	19%	3%	<1%	100%	The differences between the slope, soils, and stability of the geologic terrain results in a different mosaic of vegetation in each of these areas. The combination of the geologic and vegetative conditions between the terrain results in some differences in land use and sensitivity to impacts from land use.	Basin-wide, 64 % of the grassland vegetation type is present on soft terrain. Grazing practices should consider the susceptibility of the soft terrain to surface erosion. Timber harvesting impacts in soft terrain may be higher risk than the THP required estimated surface soil erosion hazard rating (EHR) worksheet may indicate.
Moderate	10%	66%	15%	8%	1%	100%		
Soft	5%	38%	16%	38%	3%	100%		
Quaternary	3%	26%	13%	33%	25%	100%		

Table 32. Riparian (within 150 feet of streams) vegetation types associated with terrain types in the Mattole Basin.

Riparian Vegetative Condition in the Mattole Basin									
Feature/Function								Significance	Comments
Terrain Type	Riparian Vegetation Type: Conifer	Mixed	Hardwood	Grassland	Barren	Other	Total		
Hard	15%	70%	13%	1%	1%	<1%	100 %	The differences between the slope, soils, and stability of the geologic terrain results in a different mosaic of vegetation in each of these areas. The combination of the geologic and vegetative conditions between the terrain results in some differences in land use and sensitivity to impacts from land use. The riparian vegetation in this zone is the primary source of large woody debris. The species and size of large woody debris provided to the stream system over time is at least partially dependent upon the inherent slope stability of the underlying terrain type.	Riparian vegetation is in tree-type vegetation at a proportionately higher percentage than the overall subbasin landscape. Vegetation removal impacts in riparian soft terrain should consider the heightened susceptibility of soft terrain to gullying. The large percentage of barren ground in the quaternary terrain type includes areas of expansive stream channel.
Moderate	12%	71%	13%	2%	1%	1%	100 %		
Soft	7%	55%	21%	14%	1%	2%	100 %		
Quaternary	4%	34%	15%	13%	27%	7%	100 %		

Table 33. Land use associated with terrain types in the Mattole Basin.

Land Use in the Mattole Basin						
Feature/Function					Significance	Comments
Terrain Type	Landuse Type: Public	Ag/Timber	Other	Total		
Hard	30%	49%	21%	100%	The Public category consists mostly of the King Range National Conservation Area managed by the Bureau of Land Management, other parcels managed by BLM, and State Parks. The Agriculture/Timber category includes virtually all the grassland shown on the CalVeg 2000 data layer, and parcels that contain TPZ and timber as part of their zoning designation. The Other category contains parcels zoned unclassified or forest recreation (Humboldt Co.), and forest lands (Mendocino Co.). The Other category often includes housing and contains many parcels 160 acres or less in size.	Historic logging occurred across all ownership types, leaving a legacy of young vegetation and dirt-surfaced roads. Public lands within the Mattole are reserved for recreation and conservation. The primary economic use of the natural resources on private land is grazing and timber harvesting. While grazing is widespread, only 5% of the watershed has been harvested since 1990. Many of the current owners simply live on their property and do not derive substantial economic benefits from the land. Despite this, many residents are interested in restoration work if funding and assistance is provided.
Moderate	13%	65%	22%	100%		
Soft	4%	83%	13%	100%		
Quaternary	10%	58%	32%	100%		

Table 34. Road mileage and density associated with terrain types in the Mattole Basin.

Roads in the Mattole Basin				
Feature/Function			Significance	Comments
Terrain Type	Miles (of road)	Road Density (miles per sq. mile)		
Hard	463	3.8	Roads crossings on steep slopes in hard and moderate terrain may increase the potential for debris slides while roads within the soft terrain may increase the potential for small earthflows, gullies, and erosion. The alluvium terrain type tends to be relatively flat, but proximity to watercourses may allow for direct delivery of sediment from the roads to the streams.	While current practices locate roads on less environmentally sensitive locations, typically gentle ground high on the hillslope, the presence of soft terrain in these areas should be considered. A large, but not quantified, portion of the road mileage was constructed for logging purposes between about 1945 and 1974. While many of these roads are no longer in use, others are used as residential and parcel access roads
Moderate	341	4.0		
Soft	305	4.1		
Quaternary	154	8.3		
Total	**1,263**	**4.2**		

Table 35. Data summary table for the Mattole Basin.

Factor	Mattole Basin	
Timber Harvest 1990 -2000[1]	**Acres**	**% Area**
Silviculture Category 1		
Tractor	**1,166**	**0.6%**
Cable	**1,578**	**0.8%**
Helicopter	**285**	**0.2%**
TOTAL	**3,029**	**1.6%**
Silviculture Category 2		
Tractor	**1,571**	**0.8%**
Cable	**483**	**0.3%**
Helicopter	**30**	**0.0%**
TOTAL	**2,083**	**1.1%**
Silviculture Category 3		
Tractor	**1,270**	**0.7%**
Cable	**510**	**0.3%**
Helicopter	**268**	**0.1%**
TOTAL	**2,049**	**1.1%**
TOTAL	**7,161**	**3.8%**
Other Land Uses		
Grazing	**23,332**	**12.3%**
Agriculture	**990**	**0.5%**
Development	**34**	**0.0%**
Timberland, No Recent Harvest	**140,910**	**74.3%**
TOTAL	**165,266**	**87.2%**
Roads		
Road Density (miles/sq. mile)	**4.2**	
Density of Road Crossings (#/stream mile)	**0.6**	
Roads within 200 feet of Stream (miles/stream mile)	**0.1**	

Silvicultural Category 1 includes even-aged regeneration prescriptions: clear-cut, rehabilitation, seed tree step, and shelter wood seed step prescriptions. Category 2 includes prescriptions that remove most of the largest trees: shelter wood prep step, shelter wood removal step, and alternative prescriptions. Category 3 includes prescriptions that leave large amounts of vegetation after harvest: selection, commercial thin, sanitation salvage, transition, and seed tree removal step prescriptions.

Table 36. Land use and vegetation type associated with historically active landslides in the Mattole Basin.

Historically Active Landslide Feature[1]	Mattole Basin	Woodland and Grassland[2]	THPs 1990 - 2000[5]	Timberland, No Recent Harvest[3]	Roads[4]	
	% of Area	% of Area	% of Area	% of Area	Length (miles)	% of Total Length
Earthflow	2.6%	1.7%	0.1%	0.7%	27.5	2.2%
Rock Slide	0.4%	0.2%	0.0%	0.2%	6.0	0.5%
Debris Slide	2.0%	0.2%	0.1%	1.6%	14.9	1.2%
Debris Flow	0.0%	0.0%	0.0%	0.0%	0.3	0.0%
All Features	**5.0%**	**2.2%**	**0.1%**	**2.6%**	**48.7**	**3.9%**

The area occupied by slides is almost evenly divided between the timberland and woodland/grassland categories even though the timberland acreage combined is four times larger. Earthflows are the most significant type of slide in the woodland/grassland while debris slides occupy the majority of the slide acreage in the timberland vegetation type. Recent THPs occupy 4% percent of the basin acreage and have a low percentage of the slide acreage in their boundaries.

1 This category includes only large polygon slides and does not include point slides.
2 Woodland and grassland includes areas mapped in 1998 as grassland and non-productive hardwood.
3 Area of timberlands that were not contained in a THP during the 1991 to 2000 period.
4 Roads layer is from the Information Center for the Environment (ICE) at UC Davis.
5 THP's are complete or active between the 1990 and 2000 timeframe.
Percent of area is based on the unit of analysis: Watershed, subbasin, or planning watershed.

Table 37. Land use and vegetation type associated with relative landslide potential in the Mattole Basin.

Relative Landslide Potential[1]	Mattole Basin	Woodland or Grassland[2]	THPs 1990 - 2000[5]	Timberland, No Recent Harvest[3]	Roads[4]	
	% of Area	% of Area	% of Area	% of Area	Length (miles)	% of Total Length
Very Low	4.4%	1.7%	0.1%	1.3%	82.4	6.7%
Low	11.8%	1.9%	0.7%	8.9%	185.9	15.0%
Moderate	34.3%	4.6%	1.4%	28.1%	455.5	36.8%
High	23.4%	6.0%	0.9%	16.2%	271.9	22.0%
Very High	26.2%	5.2%	0.7%	19.8%	239.4	19.4%
TOTAL	**100%**	**19%**	**4%**	**74%**	**1,235.1**	**100%**

Half of the Mattole Basin acreage is in the high and very high relative landslide potential categories. Recent THPs covered 4% of the basin and 40% of the harvest acres were in the two highest relative landslide potential classes. Since half of the basin is in the high and very high relative landslide potential classes well-distributed across the landscape, it is not surprising to find that THPs also contain a high percentage of acreage in these same categories. The Mattole Basin has about 1,235 miles of roads, with the proportion of road length in relative landslide potential categories similar to the percentage of total acres in each class, although there is a slight shift towards lower relative landslide potential classes.

1 Refer to Plate 2 and California Geological Survey Appendix A.
2 Woodland and grassland include areas mapped in 1998 as grassland and non-productive hardwood.
3 Area of timberlands that were not contained in a THP during the 1991 to 2000 period.
4 Roads layer is from the Information Center for the Environment (ICE) at UC Davis.
5 THP's are complete or active between the 1990 and 2000 timeframe.
Percent of area is based on the unit of analysis: Watershed, subbasin, or planning watershed.

Discussion

The Mattole Basin as a whole has had widespread grazing on its grasslands and limited timber harvesting since 1990. While Mattole timber harvest plans have incorporated a zero net sediment discharge analysis since about 1994, only 4% of the basin was harvested between 1990 and 2000, almost entirely by industrial timberland owners. Of the harvest acres in the high or very high relative landslide potential categories, about 40% was harvested by even-aged regeneration silvicultural systems and 40% was tractor logged. It should be noted that although these landslide potential categories are part of a classification system that is not equivalent to the THP potential surface erosion hazard rating (EHR), both quantify potential sediment movement, although by different processes. The current Forest Practice Rules do not have a methodology for characterizing relative landslide potential.

Other current land uses include recreation on public lands and residential occupation. The legacy of dirt-surfaced roads throughout the watershed provides a chronic source of sediment to the Mattole River. The large number of individual owners provides challenges in evaluating road condition and status. Future road relocation and transportation network efficiencies are also encumbered by the existing ownership patterns and road infrastructure. Since most of the landscape is outside current regulatory processes, the development of site-specific best management practices for grazing, road construction, and road use, especially on soft terrain, is recommended. Education and economic incentives for road improvements and livestock management provide the greatest opportunities for near-term benefits for fisheries.

Fluvial Geomorphology

Introduction

Fluvial geomorphic mapping of channel characteristics was conducted along blue line streams in the Mattole Basin to document channel characteristics that are indicative of excess sediment production, transport, and/or response (deposition); these features are referred to as negative mapped channel characteristics (NMCCs). The following CGS Integrated Analysis (IA) Tables present some of the findings of this investigation. To understand the distribution of these NMCC's we present: the predominant NMCC's identified; the relative distribution of these features between the bedrock terrains and the Quaternary units; the changes in amount and distribution of NMCC's observed between 1984 and 2000; and the relationship between areas of projected slope instability and portions of streams with evidence of excess sediment.

Table 38. Steam reach gradient in the Mattole Basin.

Stream Reach Gradient by Terrain as a Proportion of Total Blue Line Stream Length in the Mattole Basin					
Feature/Function				Significance	Comments
Terrain Type	Source (Slope >20%)	Transport (Slope 4-20%)	Response (Slope <4%)	The spatial distribution of source, transport, and response reaches governs the distribution of potential impacts and recovery times for the system. The areas of greatest susceptibility to pulses of sediment are transitions from the highest gradient reaches into a low gradient reach.	Practically all of the source and transport reaches are in the bedrock terrains. Response reaches are more common in the Quaternary alluvium. In the bedrock terrains, response reaches are typically found in the lower portions of the main tributaries to the Mattole River.
Hard	9%	15%	8%		
Moderate	7%	11%	6%		
Soft	7%	7%	4%		
Quaternary	<1%	3%	22%		
Total Basin	24%	36%	40%		

Table 39. Negative mapped channel characteristics in the Mattole Basin

Negative Mapped Channel Characteristics in the Mattole Basin						
Feature/Function					**Significance**	**Comments**
		From 1984 Photos	**From 2000 Photos**	**Change 1984 to 2000[4]**	The reduction in the total length of NMCC's over time qualitatively reflects the degree of improvements within the blue line streams. These NMCC's were chosen to be highlighted in these figures because in both photo years, the NMCC's observed were dominated by wide channels and, secondarily, by displaced riparian vegetation. Most of this observed improvement results from reductions in the proportion of streams affected by displaced riparian vegetation and wide channels.	Whereas significant reductions in the occurrence of wide channels mapped as a primary feature has occurred, many of wide channels observed as primary or secondary features in 1984 were still present in 2000.
Blue Line Streams where Wide Channel (wc) Observed		See Figure 34				
Blue Line Streams where Displaced Riparian Vegetation (dr) Observed		See Figure 35				Those portions of the fluvial system observed to be affected by displaced riparian vegetation, mapped as primary or secondary features in 1984 had recovered extensively by 2000.
% of all Blue Line Stream Segments in Basin affected by NMCC's	**Total**	36%	21%	-15%	These values identify how much of the streams have been affected by NMCC's. Decreases in the length of stream affected by NMCC's quantitatively represents the degree of improvement within blue line stream reaches.	The fluvial system in almost all of the bedrock reaches have experienced significant improvements between 1984 and 2000, but still remains impacted by NMCC's. The proportion of the Quaternary unit reaches affected by NMCC's have remained unchanged.
	Bedrock	40%	20%	-20%		
	Alluvium	23%	23%	0%		
Percentage of all NMCC's found within bedrock[1]		83%	72%	-12%	Changes in the distribution of NMCC's between 1984 and 2000 show different patterns in the bedrock and Quaternary unit reaches. Therefore, it is important to understand what portion of NMCC's occur within bedrock or Quaternary unit reaches.	The bedrock reaches have experienced significant reductions in NMCC's between 1984 and 2000, whereas the Quaternary reaches have shown no measurable improvement. When compared to the distribution of streams by terrain, NMCC's are disproportionably observed in the bedrock in 1984 and distributed evenly across the entire watershed in 2000. The values in the Change 1984 to 2000 column result from redistribution of relative percentages of NMCC's between bedrock and Quaternary unit reaches caused by the reduction in the total length of NMCC's observed in bedrock reaches. These values do not represent a significant increase in NMCC's within the Quaternary units.
Percentage of all NMCC's found within Quaternary Units[2]		17%	28%	+12%		
Percentage of all Blue Line Stream segments in bedrock that are: 1) adjacent to or within LPM Categories 4 and 5[3] and 2), affected by NMCC's		52%	26%	-26%	The magnitude of decrease in affected streams quantitatively represents the degree of improvement within bedrock stream reaches adjacent to unstable areas. Because the streams in the Quaternary units are commonly separated from the surrounding hillsides by alluvial terraces and floodplains, the NMCCs observed there do not directly result from input into the streams from landslides that occur on the surrounding hillsides. Therefore, NMCC's in alluvial areas have been interpreted as having been transported from upstream bedrock reaches. For this reason, the analysis of NMCC's vs. LPM 4 and 5 excludes the NMCC's identified in the Quaternary units and only describes the relationship between these two features as it applies to the bedrock reaches.	The fact that NMCC's are not ubiquitous in bedrock streams adjacent to or within LPM categories 4 and 5 indicates that although entire reaches of the streams have potentially unstable slopes above them, only a portion of those slopes have delivered or transported sediment to the streams. Whereas, between roughly one quarter (2000) to one half (1984) of all blue line streams in the bedrock terrains that are adjacent to or within LPM categories 4 and 5 are affected by NMCC's, there has been an about 26% decrease in the total length of blue line streams adjacent to or within those potentially unstable slopes and affected by NMCC's.

Negative Mapped Channel Characteristics in the Mattole Basin (Continued)					
Feature/Function				**Significance**	**Comments**
	From 1984 Photos	**From 2000 Photos**	**Change 1984 to 2000[4]**	Percentage reflects likelihood that the presence of NMCC's in bedrock are related to LPM categories 4 and 5 and that these unstable areas represent current and future potential sources of sediment to streams.	Virtually all of the total NMCC's observed in bedrock terrains were found on blue line streams adjacent to or within LPM category 4 and 5. Therefore, we interpret a clear relationship between areas of projected slope instability and portions of streams with negative sediment impacts, and that some portion of hillsides with high landslide potential are delivering sediment to the adjacent streams.
Percent of total NMCC length in bedrock, within 150 feet of LPM Categories 4 and 5[2]	99%	100%	+1%		

1 Include all areas identified as hard, moderate, or soft geomorphic terrain.
2 Areas where young (Quaternary) surficial units have been mapped covering bedrock; includes alluvium, as well as terrace deposits, active stream channel deposits, and other alluvial deposits.
3 Landslide Potential Map developed by CGS for the Mattole Basin; see California Geologic Report Appendix A and Plate 2.
4 Percentages are rounded to nearest 1%; sum of rounded values may not equal rounded totals or 100%.

Discussion

The results of our fluvial geomorphic mapping of channel characteristics that may indicate excess sediment accumulations (NMCC's) can be summarized as follows.

- Changes in the distribution of NMCC's between 1984 and 2000 show different patterns in the bedrock and Quaternary unit reaches.
- Channel conditions in bedrock streams have improved between 1984 and 2000.
- Channel conditions in the Quaternary unit reaches have remained unchanged between 1984 and 2000.
- Virtually all of the NMCC's in bedrock terrains were identified along portions of those streams that are near potentially unstable slopes and the total length of NMCC's in these areas has decreased between 1984 and 2000. Therefore, we conclude that portions, but not all, of the hillslopes in the high to very high landslide potential categories are delivering sediment to the adjacent streams.

Water Quality

Introduction

The following Water Quality Integrated Analysis table for the Mattole Basin is an attempt to compile and condense spatially and temporally varying data and information from all of the NCWAP subbasins into a more readily accessible format. The table headings are self-explanatory with the comment column used to briefly expand on the summary data and its significance affecting salmonids or other watershed processes. The seasonally derived maximum weekly average temperatures (MWATs) and maximum water temperature data have a consistent and reliable history of information gathering over time. Conclusions can be formulated about the relative conditions affecting salmonids and other aquatic species proximate to monitored locations. When the seasonal temperature results are viewed in conjunction with the single day, thermal imaging results, patterns of thermal distribution at the reach and watercourse scale become evident. Almost all of the sediment data were sporadically and inconsistently collected and analyzed, making it difficult to detect trends. The water chemistry and quality data in the mainstem Mattole at the USGS Petrolia gage were collected from 1973 through 1989, and are useful to extrapolate trends to the present. The Lower North Fork Mattole data, however, represents only two sampling events giving a quick snapshot of stream conditions. It becomes evident after reading the tables much information remains hidden, additional details can be more thoroughly explored in the NCRWQCB Appendix E and those of other participating NCWAP agencies.

Table 40. Mattole Basin summary water quality integrated analysis table

Feature/Function		Significance	Comments
Temperature			
MWATs (133 Thermograph Records for 77 stations)		Maximum weekly average temperature (MWAT) is the temperature range of 50-60°F considered fully suitable of the needs of several West Coast Salmonids.	Mostly unsuitable throughout subbasin but with a higher percentage of suitable locations in the Southern and Western Subbasins, and the headwater reach of the mainstem.
Suitable Records	**Unsuitable Records**		
27	106		
Maximum Temperatures (176 Thermograph Records for 71 Stations)		A maximum-peak temperature of 75°F is the maximum temperature that may be lethal to salmonids if cool water refugia is unavailable.	Mostly suitable throughout subbasin but this result is driven by the large number of suitable locations in the Southern and Western Subbasins. Refer to individual subbasins for specific results. There were insufficient thermograph sampling locations in the upstream reaches of the Northern and Eastern Subbasins however, one-day, thermal imaging (below) indicates these reaches may also have maximum temperatures suitable for salmonid survival.
Suitable Records	**Unsuitable Records**		
120	56		
Thermal Infrared Imaging Median Surface Temperature		Ability to assess surface water temperatures at the river-stream-reach level for a holistic picture of thermal distribution.	Basin wide median surface temperatures reflect subbasin results with cooler temperatures in the headwater-upstream reaches, gradually warming in a downstream direction. Except the Southern Subbasin, the above trend is symptomatic, and a reflection of fluvial geomorphology analyses disclosing, in a downstream direction, more sheltered narrow, and deeper inner gorges and canyons, that gradually widen to more open, disturbed floodplains, with little solar shelter. See below for data limitations of thermal imaging. Data limitations: 1) Assessments generally performed on a specific day and time, 2) not comparable to seasonally assessed MWATs or maximum temperatures, 3) unable to assess below water surface. Note: Thermal imaged median surface temperatures are derived from the minimum and maximum imaged surface temperatures scaled to a particular point in a sample cell (cell approximately = 317 feet x stream width). Cell minimum and maximum temperatures rarely varied more than 1-3 °F.
Subbasin	**Minimum/ Maximum (°F)**		
Estuary-Mainstem to Headwaters	58 / 80		
Northern	55 / 80		
Eastern	68 / 82		
Southern	(no thermal imaging)		
Western	56 / 74		

Feature/Function		Significance	Comments
MWATs (133 Thermograph Records for 77 stations)		Maximum weekly average temperature (MWAT) is the temperature range of 50-60°F considered fully suitable of the needs of several West Coast Salmonids.	Mostly unsuitable throughout subbasin but with a higher percentage of suitable locations in the Southern and Western Subbasins, and the headwater reach of the mainstem.
Suitable Records	**Unsuitable Records**		
27	106		
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Suitable Records	**Unsuitable Records**		
120	56		
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Subbasin	**Minimum/ Maximum (°F)**		
Estuary-Mainstem to Headwaters	58 / 80		
Northern	55 / 80		
Eastern	68 / 82		
Southern	(no thermal imaging)		
Western	56 / 74		
		Water Chemistry and Quality	
Subbasin	**Minimum / Maximum**		1973-1989 trend analyses and results for all three physical parameters are protective of the beneficial uses of water described in the North Coast Regional Water Board Basin Plan for the Mattole River. Limited, sporadic sampling results after 1989 are also protective of water quality goals and targets and presumed suitable throughout the basin.
pH (Standard units)		Beneficial pH ranges (~ph 6.5-8.5) controls/regulates chemical state of nutrients, such as CO_2, phosphates, ammonia, and some heavy metals (minimizes any possible toxic effects), etc.	
Estuary-Mainstem (1973-1989)	7.4 / 8.6		
Northern	8.3 / 8.9		
Dissolved Oxygen (mg/l)		By-product of plant photosynthesis/necessary for (life) respiration by aquatic plants and animals	
Estuary-Mainstem (1973-1989)	9.2 / 13.2		
Northern (2001)	8.9 / 9.3		
Conductivity (Micromhos)		Measure of ionic and dissolved constituents in aquatic systems; correlates well with salinity. Quantity/quality of dissolved solids-ions can determine abundance, variety, and distribution of plant/animals in aquatic environments. Osmoregulation efficiency largely dependent on salinity gradients. Estuary salinity essential to outmigrant smoltification.	
Estuary-Mainstem (1973-1989)	100 / 282		
Northern (2001)	255 / 281		

Feature/Function	Significance	Comments
Chemistry/Nutrients Chemical and nutrient sampling was inconsistently conducted from 1973-1989 and is limited spatially and temporally. Little, if any, data was available from 1989 to the present.	Quality and quantity of natural and introduced chemical and nutrient constituents in the aquatic environment can be toxic, beneficial, or neutral to organisms (whether terrestrial or aquatic), and their various life phases. Chemical composition, in part, influenced by rainfall, erosion and sedimentation (parent bedrock, overlying soils), solution, evaporation, and introduction of chemicals/nutrients through human and animal interactions.	Sample analysis results from 1973-1989 for various constituents were protective of the beneficial uses of water described in the North Coast Regional Water Board Basin Plan for the Mattole River. Limited sampling results after 1989 are also protective of water quality goals and targets.

References: Knopp, 1993; Mattole Salmon Group, 1996-200; PALCO, 2001; NCRWQCB Appendix E; Watershed Sciences, 2002

Discussion

In general, temperature conditions for salmonids in the Mattole Basin are unsuitable when MWATs are considered. However, maximum temperatures that may be lethal to salmonids are suitable at nearly twice the number of stations to those considered unsuitable. Though the thermal imaging was completed on a single day it represents temperature distributions over a thermal continuum. The thermal imaging reinforces point derived thermograph data that show cooler, surface water temperature in all of the Mattole Basin headwater reaches, gradually warming in a downstream direction. The sediment data in all of the subbasins varied widely but is inconclusive when attempting to extrapolate the limited results to long term trend analysis. For example, the Southern Subbasin has more sites with excessive sediment for the metrics sampled, but is also known to be the subbasin with some of the best fish habitat in the Mattole Basin. From 1973-1989, the mainstem at the USGS Petrolia Gage was suitable for all measured physical-chemical parameters and, even though very little recent information is available, probably continues to be so. The snapshot physical-chemical results for the NFK Mattole are inconclusive. Sufficient long-term physical-chemical data is unavailable for all of the other subbasins to attempt short or long-term predictions but, in all likelihood, are probably suitable.

Instream Habitat

Introduction

The products and effects of the watershed delivery processes examined in the geology, land use, fluvial geomorphology, and water quality Integrated Analyses tables are expressed in the stream habitats encountered by the organisms of the aquatic riparian community, including salmon and steelhead. Several key aspects of salmonid habitat in the Mattole Basin are presented in the CDFG Instream Habitat Integrated Analysis. Data in this discussion are not sorted into the geologic terrain types since the channel and stream conditions are not necessarily exclusively linked to their immediate surrounding terrain, but may in fact be both spatially and temporally distanced from the sites of the processes and disturbance events that have been blended together over time to create the channel and stream's present conditions. Instream habitat data presented here were compiled from CDFG stream inventories of 61 tributaries and the headwaters of the Mattole River from 1991 to 2002, published research conducted in the Mattole Estuary by HSU, the MRC, and MSG in the 1980s and 1990s, and fish passage barrier evaluation reports conducted under contract to CDFG from 1998-2000. Details of these reports are presented in the CDFG Appendix F.

Pool Quantity and Quality

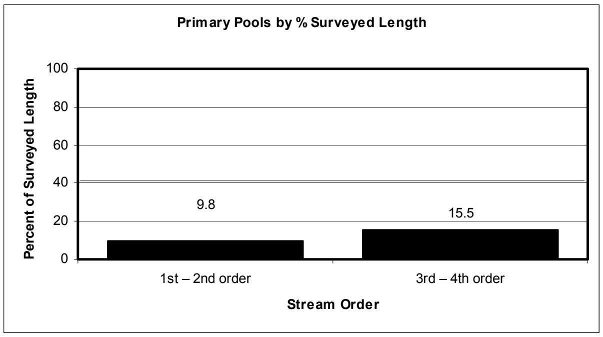


Figure 48. Primary pools in the Mattole Basin.

Pools greater than 2.5 feet deep in 1st and 2nd order streams and greater than 3 feet deep in 3rd and 4th order streams are considered primary pools.

Significance: Primary pools provide escape cover from high velocity flows, hiding areas from predators, and ambush sites for taking prey. Pools are also important juvenile rearing areas. Generally, a stream reach should have 30 – 55% of its length in primary pools to be suitable for salmonids.

Comments: The percent of primary pools by length in the Mattole Basin is generally below target values for salmonids, and appears to be less suitable in lower order streams than in higher order streams.

Spawning Gravel Quality

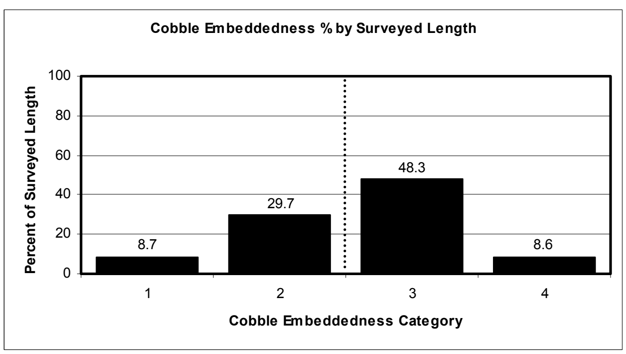


Figure 49. Cobble embeddedness in the Mattole Basin.

Cobble Embeddedness will not always sum to 100% because Category 5 (not suitable for spawning) is not included.

Significance: Salmonids cannot successfully reproduce when forced to spawn in streambeds with excessive silt, clays, and other fine sediment. Cobble embeddedness is the percentage of an average sized cobble piece at a pool tail out that is embedded in fine substrate. Category 1 is 0-25% embedded, category 2 is 26-50% embedded, category 3 is 51-75% embedded, and category 4 is 76-100% embedded. Cobble embeddedness categories 3 and 4 are not within the fully supported range for successful use by salmonids.

Comments: More than one half of the surveyed stream lengths within the Mattole Basin have cobble embeddedness in excess of 50% in categories 3 and 4, which does not meet spawning gravel target values for salmonids.

Shade Canopy

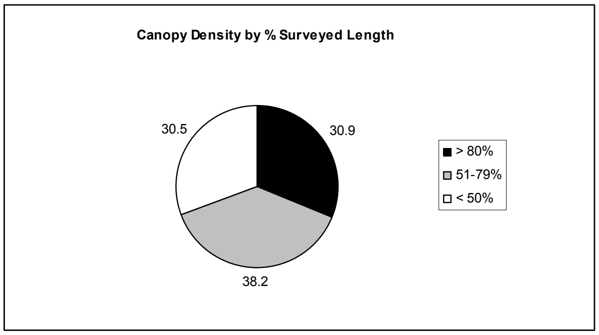


Figure 50. Canopy density in the Mattole Basin

Significance: Near-stream forest density and composition contribute to microclimate conditions that help regulate air temperature, which is an important factor in determining stream water temperature. Stream water temperature can be an important limiting factor of salmonids. Generally, canopy density less than 50% by survey length is below target values and greater than 85% fully meets target values.

Comments: More than one half of the surveyed stream lengths within the Mattole Basin have canopy densities greater than 50% and almost one third of the surveyed lengths have canopy densities greater than 80%. This is above the canopy density target values for salmonids

Fish Passage

Table 41. Salmonid habitat artificially obstructed for Fish Passage.*

Feature/Function		Significance	Comments
Type of Barrier	**% of Estimated Historic Coho Salmon Habitat Currently Inaccessible Due to Artificial Passage Barriers**	Free movement in well-connected streams allows salmonids to find food, escape from high water temperatures, escape from predation, and migrate to and from their stream of origin as juveniles and adults. Dry or intermittent channels can impede free passage for salmonids; temporary or permanent dams, poorly constructed road crossings, landslides, debris jams, or other natural and/or man-caused channel disturbances can also disrupt stream connectivity. Partial barriers exclude certain species and lifestages from portions of a watershed and temporary barriers delay salmonid movement beyond the barrier for some period of time. Total barriers exclude all species from portions of a watershed	The percent of estimated historic coho salmon habitat that is currently blocked by all artificial barriers in the Mattole Basin varies from 10.2-11.2%. More salmonid habitat is blocked by total fish passage barriers in the Mattole Basin than by partial and temporary barriers. The CDFG North Coast Watershed Improvement Program funded an improvement of Clear Creek in 2001 and Mill Creek (RM 5.5), Ravasoni Creek (East Anderson Creek), and Mill Creek (RM 2.8) in 2002.
All Barriers	10.2-11.2		
Partial and Temporary Barriers	4.3-6.4		
Total Barriers	9.1-9.5		

*(N=18 Culverts) in the Mattole Basin (1998-2000 Ross Taylor and Associates Inventories and Fish Passage Evaluations of Culverts within the Humboldt County and the Coastal Mendocino County Road Systems).

Table 42. Juvenile salmonid passage in the Mattole Basin (1991-2002 CDFG stream surveys, CDFG Appendix F).

Feature/Function		Significance	Comments
Juvenile Summer Passage:	**Juvenile Winter Refugia:**	Dry channel disrupts the ability of juvenile salmonids to move freely throughout stream systems.	Dry channel recorded in CDFG stream inventories in the Mattole Basin has the potential to disconnect tributaries from the mainstem Mattole River and disrupt the ability of juvenile salmonids to forage and escape predation. This condition is most common in streams in the Mattole headwaters in the Southern Subbasin, and in the Eastern Subbasin. Juvenile salmonids seek refuge from high winter flows, flood events, and cold temperatures in the winter. Intermittent side pools, back channels, and other areas of relatively still water that become flooded by high flows provide valuable winter refugia.
1.2 Miles of Surveyed Channel Dry	No Data		
0.9% of Surveyed Channel Dry			

Large Woody Debris

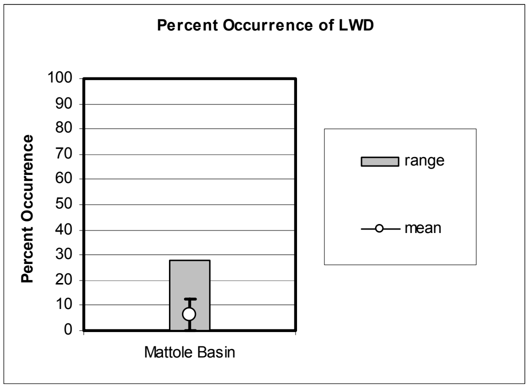


Figure 51. Large woody debris (LWD) in the Mattole Basin.

Error bars represent the standard deviation. The percentage of shelter provided by various structures (i.e. undercut banks, woody debris, root masses, terrestrial vegetation, aquatic vegetation, bubble curtains, boulders, or bedrock ledges) is described in CDFG surveys. The dominant shelter type is determined and then the percentage of a stream reach in which the dominant shelter type is provided by organic debris is calculated.

Significance: Large woody debris shapes channel morphology, helps a stream retain organic matter, and provides essential cover for salmonids. There are currently no target values established for the % occurrence of LWD.

Comments: The percent occurrence of LWD in a stream as calculated by CDFG in the Mattole Basin represents a measure of the amount of woody debris that was found in the wetted width of a stream channel during stream surveys that can be used by fish for cover as compared to other types of fish cover present. The average percent occurrence of LWD for the Mattole Basin is only 6.6%, as the dominant shelter type recorded in most stream reaches was boulders. This average percent occurrence of LWD is lower than that found in surveys in the Gualala River (average = 11.3 ± 13.6) and Redwood Creek (average = 8.9± 9.5) Basins, two basins for which CDFG has good records.

Discussion

Although instream habitat conditions for salmonids varied a great deal across the 304 square mile Mattole Basin, several generalities can be made. Canopy density was generally greater than 50% across the basin. Additionally, 0.9 miles of surveyed stream (less than 1% of surveyed stream channel) were dry and less than 5% of estimated historic coho habitat was inaccessible due to artificial passage barriers. However, across the Mattole Basin the percent of primary pools by survey length and cobble embeddedness values were both below target values found in CDFGs *California Salmonid Stream Habitat Restoration Manual* and calculated by the EMDS system. In two other North Coast California watersheds currently being assessed by the NCWAP, Redwood Creek near Orick and the Gualala River, have a higher percent occurrence of large woody debris than the Mattole Basin.

Draft Sediment Production EMDS

The draft sediment EMDS is currently under review. Preliminary results for the Mattole Basin are presented in the EMDS Appendix C.

Stream Reach Condition EMDS

The anadromous reach condition EMDS evaluates the conditions for salmonids in a stream reach based upon water temperature, riparian vegetation, stream flow, and in channel characteristics. Data used in the Reach EMDS come from CDFG Stream Inventories. Currently, data exist in the Mattole Basin to evaluate overall reach, canopy, in channel, pool quality, pool depth, pool shelter, and embeddedness conditions for salmonids. More details of how the EMDS functions are in the EMDS Appendix C. EMDS calculations and conclusions are pertinent only to surveyed streams and are based on conditions present at the time of individual survey.

EMDS stream reach scores were weighted by stream length to obtain overall scores for subbasins and the entire Mattole Basin. Weighted average reach conditions on surveyed streams in the Mattole Basin as evaluated by the EMDS are somewhat unsuitable for salmonids (Table 43). Suitable conditions exist for canopy in the Eastern, Southern, and Western Subbasins; and for pool quality and pool depth in the Southern Subbasin. Moderately unsuitable conditions exist for embeddedness in all four subbasins evaluated.

Table 43. EMDS anadromous reach condition model results for the Mattole Basin.

Subbasin	Reach	Water Temperature	Canopy	Stream Flow	In Channel	Pool Quality	Pool Depth	Pool Shelter	Embeddedness
Northern Subbasin	-	U	- -	U	-	- -	- -	- -	- -
Eastern Subbasin	-	U	+	U	-	- -	- -	- -	- -
Southern Subbasin	-	U	++	U	-	+	+	-	- -
Western Subbasin	-	U	+	U	-	-	-	-	- -
Mattole Basin	-	U	+	U	-	-	-	-	- -

Key:

+++	Fully Suitable	U	Undetermined
++	Moderately Suitable	+	Somewhat Suitable
-	Somewhat Unsuitable	- -	Moderately Unsuitable
- - -	Fully Unsuitable		

Analysis of Tributary Recommendations

In order to compare the occurrence of recommendations between the four subbasins in the Mattole Basin, the three top ranking recommendations for each tributary were compiled. Each tributary was originally assigned anywhere from zero to ten recommendations, which were ranked in order of importance. Complete tributary recommendations for each subbasin can be found in each of the five subbasin sections of this report.

The top three improvement recommendations in each tributary were summed for each subbasin (Table 44). In terms of the most frequently given recommendations in each subbasin, the Northern Subbasin had Bank, Canopy, and Pool recommendations for seven out of ten tributaries surveyed, the Eastern Subbasin had a Bank recommendation for 12 out of 18 tributaries surveyed, the Southern Subbasin had a Cover recommendation for 12 out of 14 tributaries surveyed, and the Western Subbasin had a Cover recommendations for 13 out of 17 tributaries surveyed.

Table 44. Occurrence of improvement recommendations in first three ranks in surveyed streams.

Subbasin	# of Surveyed Tributaries	# of Surveyed Stream Miles	Bank	Roads	Canopy	Temp	Pool	Cover	Spawning Gravel	LDA	Live-stock	Fish Passage
Northern	10	20.9	7	4	7	2	7	3	0	0	0	0
Eastern	18	34.9	12	7	9	6	9	8	1	2	0	0
Southern	14	25.7	10	5	0	0	11	12	1	5	0	1
Western	18	49.9	11	2	6	3	11	13	0	2	0	3
Mattole Basin	60	131.4	40	18	22	11	38	36	2	9	0	4

In order to further examine subbasin issues through the tributary recommendations given in CDFG stream surveys, the top three ranking recommendations for each tributary were collapsed into five different recommendation categories: Erosion/Sediment, Riparian/Water Temp, Instream Habitat, Gravel/Substrate, and Other (Table 45). When examining recommendation categories by number of tributaries, the most important Recommendation Category in the Northern and Eastern subbasins is Erosion/Sediment and in the Southern and Western subbasins is Instream Habitat, Table 46.

Table 45. How Improvement recommendations were collapsed into recommendation categories

Tributary Report Recommendations	Basin Wide Recommendation Category
Bank / Roads	Erosion/Sediment
Canopy / Temp	Riparian / Water Temp
Pool / Cover	Instream Habitat
Spawning Gravel / LDA	Gravel / Substrate
Livestock / Barrier	Other

Table 46. Distribution of basin-wide recommendation categories in the Mattole subbasins.

Subbasin	Erosion/Sediment	Riparian/Water Temperature	Instream Habitat	Gravel/Substrate	Other
Northern	11	9	10	0	0
Eastern	19	15	17	3	0
Southern	15	0	23	6	1
Western	13	9	24	2	3
Mattole Basin	54	31	74	11	4

However, comparing recommendation categories between subbasins could be confounded by the differences in the number of tributaries and the number of stream miles surveyed in each subbasin. Of the 59 tributaries and the Upper Mattole River surveyed in the Mattole Basin, 21 stream miles were in the Northern Subbasin, 35 in the Eastern Subbasin, 26 in the Southern Subbasin, and 50 in the Western Subbasin. Therefore, the percentage of stream miles in each subbasin assigned to the various recommendation categories was calculated for each subbasin. The percentage of the total stream length in each subbasin assigned to each subbasin recommendation category was then calculated to compare between subbasins.

Instream Habitat is the most important recommendation category in the Southern and Western subbasins, while Riparian/Water Temperature is most important in the Northern Subbasin and Erosion/Sediment is most important in the Eastern Subbasin (Figure 52). In the Mattole Basin as a whole, the most important recommendation category is Instream Habitat, followed by Erosion/Sediment, Riparian Water Temp, Gravel/Substrate, and Other. Therefore, the number one priority rankings remained the same for the Eastern, Southern, and Western subbasins, whether assessed by the number of tributaries or the percentage of stream miles. Additionally, the overall rankings of Recommendation Categories in the Mattole Basin as a whole remained the same in both analyses. However, the number one priority in the Northern Subbasin changed from Erosion/Sediment to Riparian/Water Temperature when assessed by percentage of stream miles rather than number of tributaries.

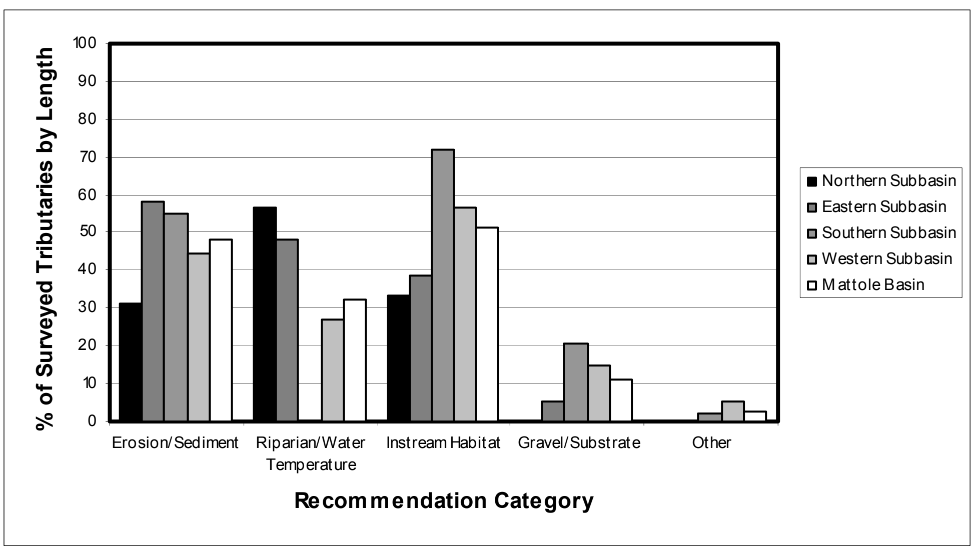


Figure 52. The Frequency of recommendation categories in Mattole Basin surveyed streams.

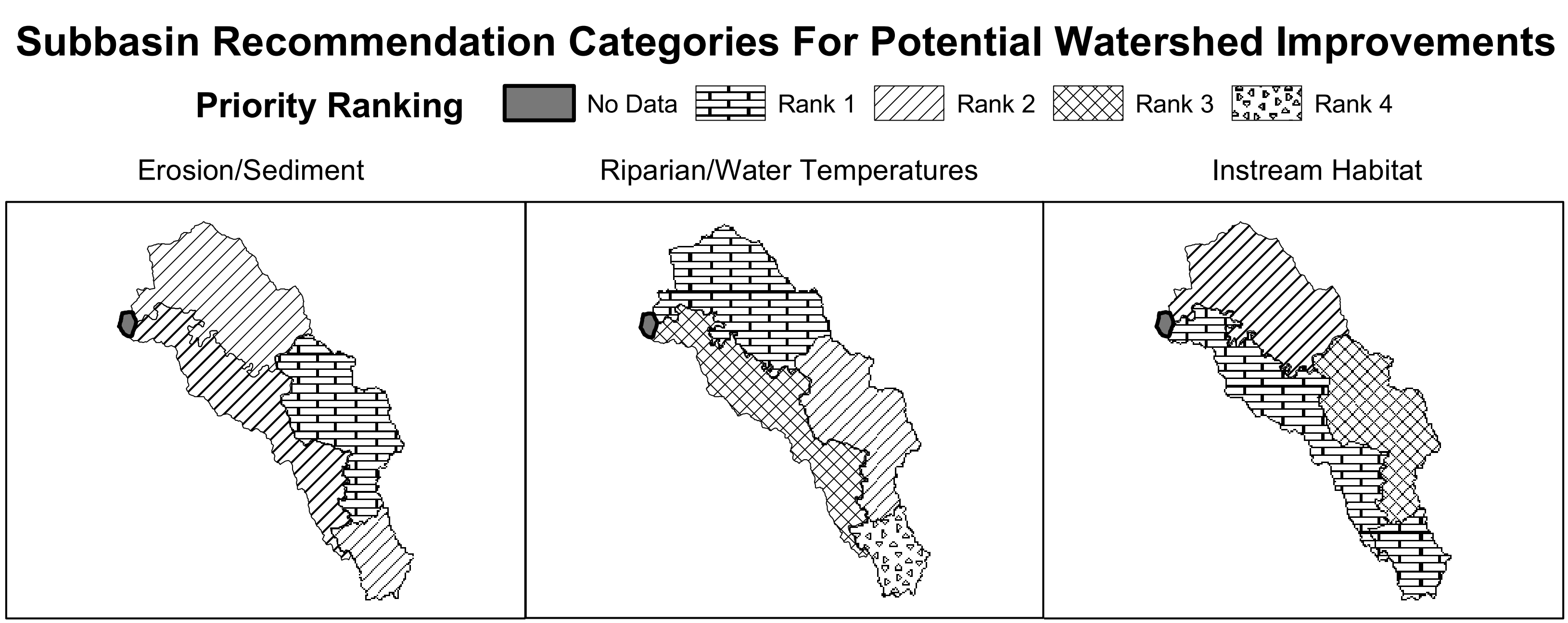
The high number of Instream Habitat, Erosion/Sediment, and Riparian/Water Temperature Recommendations across the Mattole Basin indicates that high priority should be given to restoration projects emphasizing pools, cover, sediment reduction, and riparian replanting.

Refugia Areas

The NCWAP interdisciplinary team identified and characterized refugia habitat in the Mattole Basin by using expert professional judgment and criteria developed for north coast watersheds. The criteria included measures of watershed and stream ecosystem processes, the presence and status of fishery resources, forestry and other land uses, land ownership, potential risk from sediment delivery, water quality, and other factors that may affect refugia productivity. The team also used results from information processed by NCWAP's EMDS at the stream reach and planning watershed/subbasin scales.

The most complete data available in the Mattole Basin were for tributaries surveyed by CDFG. However, many of these tributaries were still lacking data for some factors considered by the NCWAP team.

Salmonid habitat conditions in the Mattole Basin are generally best in the Southern and Western subbasins, mixed in the Eastern subbasin, and worst in the Estuary and Northern subbasins. The following refugia area rating table summarizes subbasin salmonid refugia conditions:



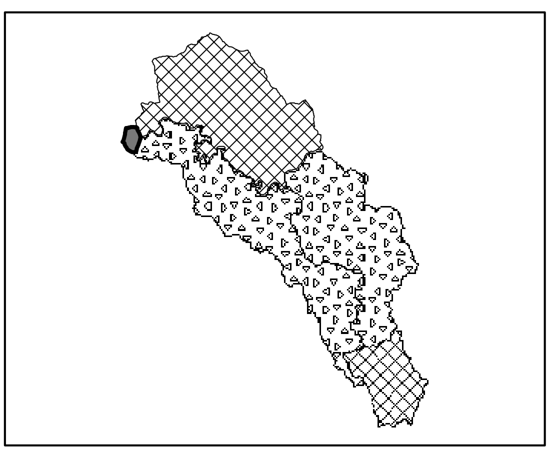


Table of Priorities

	E/S	R/T	IH	G/S
N	2	1	2	3
E	1	2	3	4
S	2	4	1	3
W	2	3	1	4

Figure 53. Prioritized recommendations by subbasin.

Table 47. Subbasin salmonid refugia area ratings in the Mattole Basin.

Subbasin	Refugia Categories:				Other Categories:		
	High Quality	High Potential	Medium Potential	Low Quality	Non-Anadromous	Critical Contributing Area/Function	Data Limited
Estuary Subbasin			X			X	X
Northern Subbasin			X				X
Eastern Subbasin			X				X
Southern Subbasin		X					X
Western Subbasin			X				X

*Ratings in this table are done on a sliding scale from best to worst. Subbasin refugia ratings are aggregated from their tributary ratings. See page 71 for a discussion of refugia criteria.

Mattole River Tributaries by Refugia Category:

High Quality Habitat, High Quality Refugia Tributaries:

Western Subbasin

Bear Creek (RM 42.8)

High Potential Refugia Tributaries:

Eastern Subbasin

Gilham Creek
Harrow Creek
Eubank Creek
McKee Creek
Painter Creek

Southern Subbasin

Bridge Creek
West Fork Bridge Creek
South Branch West Fork Bridge Creek
Vanauken Creek
Mill Creek (RM 56.2)
Upper Mattole River (> RM 56.2)
Baker Creek
Thompson Creek
Yew Creek
Lost Man Creek
Lost Man Creek Tributary

Western Subbasin

Mill Creek (RM 2.8)
North Fork Bear Creek
North Fork Bear Creek Tributary
South Fork Bear Creek
Big Finley Creek
South Fork Big Finley Creek

Medium Potential Refugia Tributaries:

Northern Subbasin

North Fork Mattole River
Sulphur Creek
Sulphur Creek Tributary #1
Sulphur Creek Tributary #2
Conklin Creek
McGinnis Creek
Oil Creek
Devils Creek
Rattlesnake Creek

Eastern Subbasin

Westlund Creek
Gilham Creek Tributary
Sholes Creek
Grindstone Creek
Little Grindstone Creek
Blue Slide Creek
Fire Creek
Box Canyon Creek
McKee Creek Tributary

Southern Subbasin

Anderson Creek
Stanley Creek
Helen Barnum Creek

Western Subbasin

Mill Creek (RM 2.8) Tributary #1
Mill Creek (RM 2.8) Tributary #2
Squaw Creek
Woods Creek
Honeydew Creek
Bear Trap Creek
East Fork Honeydew Creek
Upper East Fork Honeydew Creek
West Fork Honeydew Creek
Jewett Creek
Nooning Creek

Low Quality Habitat, Low Potential Refugia Tributaries:

Northern Subbasin	**Eastern Subbasin**
Green Ridge Creek	Dry Creek Middle Creek Fourmile Creek North Fork Fourmile Creek

<u>Other Related Refugia Component Categories:</u>

Potential Future Refugia (Non-anadromous)

None Identified

Critical Contributing Tributaries:

Northern Subbasin
North Fork Mattole River

Data Limited:

Individual streams were all missing data that would have provided a more complete data set for use in the refugia analysis. In all streams rated, this involved only one or two of the factors used in the rating process and did not prevent refugia determination from being estimated.

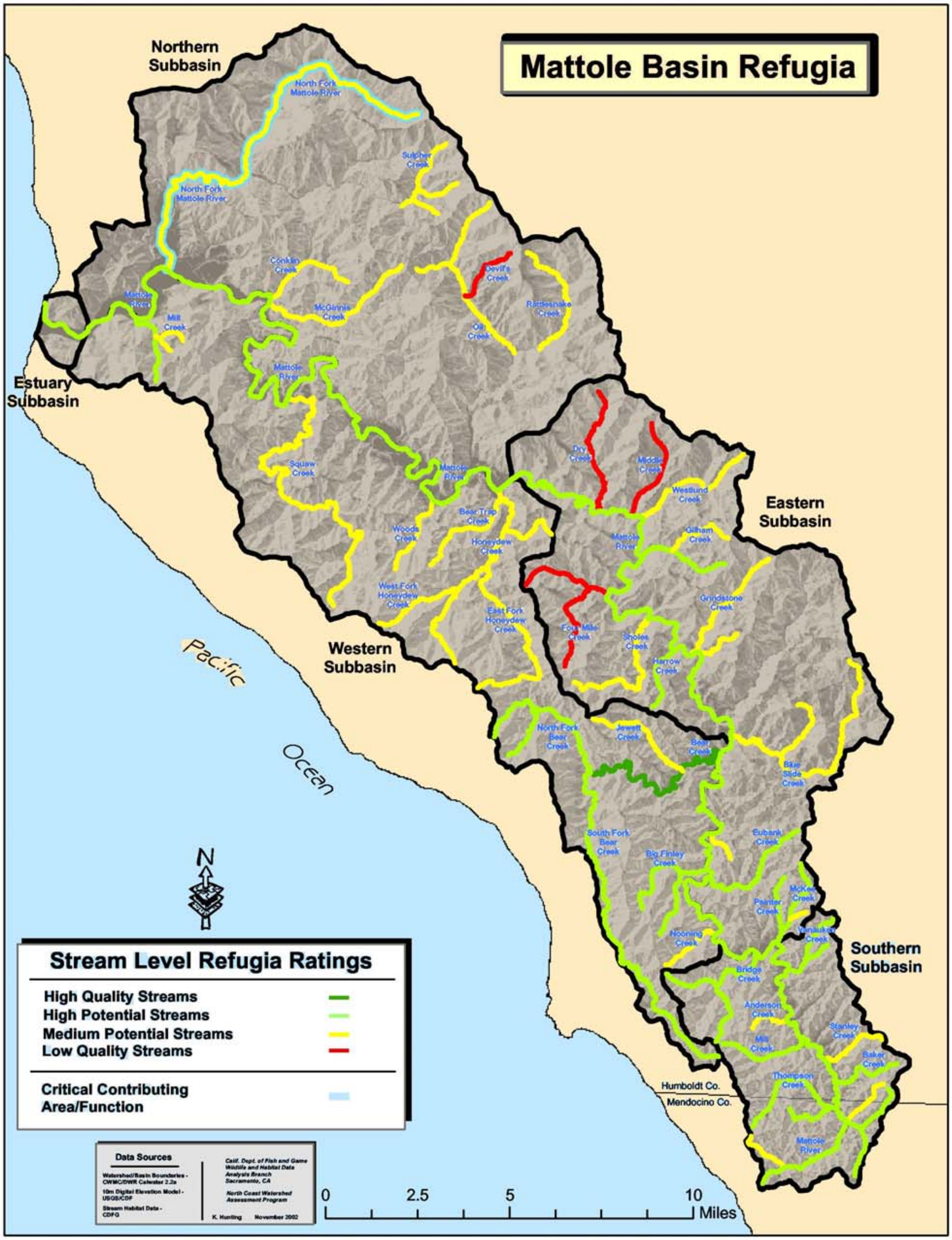


Figure 54. Refugia categories for Mattole Basin surveyed tributaries.

Responses to Assessment Questions

What are the history and trends of the sizes, distribution, and relative health and diversity of salmonid populations in the Mattole Basin?

Conclusions:

- Historical accounts and stream surveys conducted in the 1960s by CDFG indicate that the Mattole Basin historically supported relatively robust populations of Chinook salmon, coho salmon, and steelhead trout. Fishery surveys have been conducted on many tributaries throughout the Mattole Basin in the last ten years. These biological stream surveys indicate the presence of Chinook salmon and steelhead trout in all five Mattole subbasins and the presence of coho salmon in the Eastern, Southern, and Western Subbasins. Coho salmon also utilize the Estuary Subbasin on their migrations; however, in limited surveys conducted in the Northern Subbasin since the 1980s, coho salmon have not been detected. No studies have been conducted to estimate subbasin or tributary specific population levels of coho salmon or Chinook salmon. However, a nine-year intensive study of three tributaries within the Northern Subbasin indicated stable age classes of steelhead trout. Intensive studies of the Estuary Subbasin have shown depressed populations of over-summering Chinook salmon and steelhead trout, and no coho have been detected. Mattole Basin-wide population estimates indicate depressed meta-populations of Chinook and coho salmon. A metapopulation is a "regional (Mattole Basin) population consisting of semi-isolated local (stream/subbasin) populations" (Levins 1970).

Supporting Evidence:

- The United States Fish and Wildlife Service (USFWS) estimated existing populations of 2,000 Chinook salmon, 5,000 coho salmon and 12,000 steelhead and potential populations of 7,900 pairs of Chinook salmon, 10,000 pairs of coho salmon and 10,000 pairs of steelhead trout in the Mattole Basin in 1960 (USFWS 1960, CDFG Appendix F.
- CDFG conducted 65 stream surveys on Mattole River tributaries in the mid 1960s. CDFG continued to survey streams in the Mattole Basin in the 1970s and 1980s. Coho salmon and steelhead trout presence was documented in tributaries throughout the Mattole Basin. Coho salmon were detected in eleven tributaries, and steelhead trout were detected in 45 (CDFG Appendix F).
- Stream surveys throughout the 1970s, 1980s, and 1990s by CDFG, BLM, Coastal Headwaters Association, and the Redwood Sciences Laboratory continued to document the presence of steelhead trout throughout the Mattole Basin (CDFG Appendix F).
- Surveys also continued to document the presence of coho salmon in the Mattole Basin except for in the Northern Subbasin (CDFG Appendix F).
- Thirty-three of the 58 tributaries (and the upper Mattole River) surveyed by CDFG in the Mattole Basin from 1990-2000 included a biological survey. Steelhead trout were found in these 33 streams, but coho salmon were only found in eight. Coho salmon were not detected in the Northern Subbasin (CDFG Appendix F).
- Thirty-one tributaries in the Mattole Basin were also surveyed as a part of the CDFG 2001 Coho Inventory. Steelhead trout were found in these 31 streams, but coho salmon were only found in eleven streams. Coho salmon were not detected in the Northern Subbasin (CDFG Appendix F).
- Three tributaries in the Northern Subbasin were sampled intensively by CDFG for their salmonid populations from 1991 through 1999, Oil, Rattlesnake Creek, and Green Ridge creeks. Stable population structures of steelhead trout were found in these three streams, but coho salmon were not detected (CDFG Appendix F).
- Snorkel surveys in summers after 1987 have detected very low numbers of juvenile Chinook salmon in the estuary (MRC 1995, MSG 2000).
- Estimated populations of Chinook salmon or coho salmon in the entire Mattole Basin have not exceeded 1000 since the 1987-88 season. Mattole Basin Chinook salmon and coho salmon population estimates for the 1999-2000 season were 700 and 300, respectively (MSG 2000).

What are the current salmonid habitat conditions in the Mattole Basin? How do these conditions compare to desired conditions?

Conclusions:

- Erosion/Sediment
  - Instream sedimentation in several stream reaches throughout the basin may be approaching or exceeding levels considered unsuitable for salmonid populations. Currently, the estuary is very shallow and lacks channel complexity. Erosion/sediment reduction is the top recommendation category for the Eastern and Estuary subbasins;
- Riparian/Water Temperature
  - High summer water temperatures in many surveyed tributaries are deleterious to summer rearing salmonid populations in the Estuary, Northern, Eastern, and Western Subbasins. Riparian/water temperature improvements is the top recommendation category in the Northern Subbasin;
- Instream Habitat
  - In general, pool habitat, escape and ambush cover, and water depth are unsuitable for salmonids in many mainstem and tributary stream reaches in the Mattole Basin. In the Southern Subbasin summer flow is inadequate or non-existent in many reaches. Large woody debris recruitment potential is poor in the Northern, Eastern, and Western subbasins. Instream habitat improvement is the top recommendation category in the Southern and Western subbasins;
- Gravel/Substrate
  - Available data from sampled streams suggest that suitable, high quality spawning gravel for salmonids is limited in some streams in all subbasins;
- Refugia Areas
  - Salmonid habitat conditions in the Mattole Basin are generally best in the Southern and Western Subbasins, mixed in the Eastern Subbasin, and worst in the Estuary and Northern subbasins.

Supporting Evidence:

- Three of 61 tributaries (and the upper Mattole River) surveyed by CDFG in the Mattole Basin were found to have 40% or more of their survey lengths in pool habitat. These three tributaries were all in the Southern Subbasin. Ten surveyed tributaries were found to have 30 to 40% of the stream lengths surveyed in pool habitat. The Northern Subbasin had no streams with 30-40% of their survey length in pools. Forty percent or more of stream lengths in pool habitat is considered suitable on the North Coast. Additionally, 9.8% of first and second order surveyed streams and 15.5% of third and forth order surveyed streams in the Mattole Basin are composed of primary pools by survey length. The Southern and Western subbasins had the highest percentage of surveyed stream length in primary pools. Thirty to 55% of survey lengths composed of deep, complex, high quality primary pools is considered desirable. In addition, extensive studies of the Mattole estuary have determined that cooler, deeper pools are lacking (IA Tables, CDFG Appendix F).
- Three of 61 tributaries (and the upper Mattole River) surveyed by CDFG in the Mattole Basin were found to have a mean pool shelter rating exceeding 80. These three tributaries were all in the Southern Subbasin. This indicates that woody debris elements affecting scour are not present throughout the Mattole Basin. Thirty-five surveyed tributaries had shelter rating scores between 30 and 80. The Southern and Western subbasins had the most tributaries with mean pool shelter ratings above 30. Pool shelter ratings of 80 or more are considered suitable, and ratings less than 30 are unsuitable for contributing to shelter that supports salmonids. In addition, extensive studies of the Mattole estuary have determined that complex pools with cover are lacking (CDFG Appendix F).
- Boulders provided the primary form of shelter for salmonids in 40 of the 61 surveyed tributaries (and the upper Mattole River) in the Mattole Basin. The Southern Subbasin was the only subbasin in which boulders did not provide the primary form of shelter in surveyed tributaries; in fact, only two Southern Subbasin tributaries had boulders as the primary form of shelter (CDFG Appendix F).
- Removal of instream large woody debris under direction of CDFG occurred in about 71.5 stream miles in the Mattole Basin during the 1980s. A total of 56,960 cubic feet of wood was removed.

This is equivalent to 445 logs 2 feet x 40 feet. This activity likely had adverse local impacts on salmonid habitat conditions (CDFG Appendix F).

- Available data for two metrics indicate that sediment is impairing the cold water fisheries of a number of tributaries in the Mattole Basin. Reported values for pool filling (V*) calculated by the MSG during 2000 in Bridge Creek was 0.04. The values in seven other creeks, Mill, Conklin, Squaw, Westlund, Middle, and Honeydew Creeks, and the mainstem Mattole River, ranged from 0.22 to 0.27. Except for Bridge Creek, all are slightly higher than a target value for V* of 0.21 recommended in the Mattole River TMDL, Technical Support Document (Regional Water Board, 2002). Pebble counts (D50s) during 2001 collected by the Regional Water Board varied from 65 mm to 14mm, indicating low to high rates of sediment transport and deposition, respectively. The latter values indicate natural and/or land use activities may be introducing fine to medium sized sediment particles into local streams. A numeric target is not proposed for D50 in the Mattole River TMDL: Technical Support Document. Collectively (except for Bridge Creek), values for V* and D50 were borderline suitable to unsuitable for salmonids.
- During all analyzed sample years in the entire Mattole Basin, maximum weekly average temperatures (MWATs) were somewhat suitable to unsuitable on 106 out of 133 occasions at 77 sampling stations. Fully suitable MWATs for salmonids are from 50 °F to 60 °F. The Southern Subbasin was almost equally split, with 13 of 14 occasions at nine thermograph stations reporting suitable MWATs. All other Mattole subbasins had a majority of records with MWATs somewhat suitable to unsuitable for salmonids. Maximum temperatures for salmonid suitability were generally more favorable for salmonid survival with 68% of the records at 71 thermograph stations reporting temperatures under 75°F, the maximum temperature above which may be lethal to salmonids. At a total of 32 stations in the Estuary Subbasin and Mattole mainstem, had 36 suitable to 28 unsuitable maximum temperature records. The Northern Subbasin, with 11 of 15 unsuitable records, had the highest ratio of unsuitable to suitable temperatures. The Eastern Subbasin for 23 thermograph records at ten stations had 14 suitable to nine unsuitable maximum temperatures over 75°F. The Southern Subbasin, for 36 records at nine thermograph stations, had no unsuitable maximum temperatures, while the Western Subbasin had 30 suitable to eight unsuitable records.
- Twenty-six of 61 tributaries (and the Upper Mattole River) surveyed by CDFG in the Mattole Basin exceeded the recommended shade canopy density levels of 80% for North Coast streams. Only one tributary in the Northern Subbasin exceeded 80% canopy density. Additionally, 50 surveyed tributaries exceeded 50% shade canopy density levels. All surveyed tributaries in the Southern Subbasin and 16 out of 18 surveyed tributaries in both the Eastern and Western subbasins exceeded 50% canopy density levels. Shade canopy density below 50% is considered unsuitable (CDFG Appendix F).
- Twenty-three of 61 tributaries (and the upper Mattole River) surveyed by CDFG in the Mattole Basin were found to provide spawning reaches with favorable cobble embeddedness values in at least half of the stream reach lengths surveyed. Surveyed tributaries across all of the Mattole subbasins had poor cobble embeddedness values (CDFG Appendix F).
- Two tributaries out of 13, Honeydew Creek and Bridge Creek, had residual pool filling, known as V*, at levels below 0.30, a level considered low, and thus suitable salmonid habitat for this metric. The other 11 streams experienced low to moderate rates of pool filling. Only Honeydew Creek out of 14 sites had pebble counts, or D50s, ≥ 69 mm, a value considered well suited to most salmonid spawning gravel measured on an entire riffle (NCRWQCB Appendix E).
- CDFG has conducted an analysis of macroinvertebrate data collected by BLM and PALCO since 1994 on 17 tributary streams and two sites on the mainstem Mattole River. The results showed stream conditions ranged from fair to excellent. Baker Creek in the Southern Subbasin had good to excellent conditions (CDFG Appendix F).
- Out of 49 stream reaches examined for the presence of sensitive amphibian species, torrent salamanders found in eleven reaches and tailed frogs were found in 15 reaches. Neither torrent salamanders nor tailed frogs were detected in the Eastern Subbasin (Welsh et al. 2002).
- Artificial fish passage barriers block 10.2-11.2% of the estimated historic coho salmon habitat in the Mattole Basin. The greatest percentage of estimated historic coho habitat blocked in the Mattole

Basin is in the Southern Subbasin. Additionally, 0.9% of surveyed stream channel in the Mattole Basin was dry. The percentage of dry channel in surveyed tributaries was similar across all Mattole subbasins (IA Tables, CDFG Appendix F).

- The NCWAP analysis of tributary recommendations given in the Mattole Basin showed that the most important recommendation category was Instream Habitat, followed by Erosion/Sediment, Riparian/Water Temperature, Gravel/Substrate, and Other (Tributary Recommendation Analysis, pg.152).

What are the relationships of geologic, vegetative, and fluvial processes to natural events and land use history?

Conclusions:

- Geologic units within the basin can be grouped into one of three bedrock terrains (hard, moderate, and soft) and one for Quaternary alluvial units. Larger landslides are more prevalent in soft terrain and are typically earthflows, while smaller slides, typically debris slides, are more prevalent in hard and moderate terrains;
- Weak geologic materials, steep slopes, high rainfall, and strong earthquakes common to the basin result in high rates of natural landsliding and surface erosion, particularly in soft terrain. These natural processes can be exacerbated by human land use within the basin. About one half of the basin is considered to have a high to very high landslide potential;
- In general, the subbasins can be ranked in terms of relative impacts with geologically unstable areas linked to adverse stream effects. The Northern Subbasin has the largest proportion of geologically unstable (soft) terrain, which is linked to the highest amount of historically active landslides, gullies, and stream features indicative of excess sediment production, transport, and storage. The Southern Subbasin has the lowest proportion of geologically unstable terrain, historically active landslides, gullies, and stream features indicative of excess sediment production and transport. The Eastern and Western Subbasins are intermediate between these two extremes due to the variability in the proportion of soft terrain and steep slopes;
- Source and transport reaches of the blue line streams as depicted on NCWAP stream network maps, were identified primarily in bedrock terrains, while response (depositional) reaches were identified in the Quaternary (alluvial) unit reaches. Features indicative of excess sediment production, transport, and storage have decreased throughout most of the basin in the period between 1984 and 2000. The reduction in these features was greatest in the hard terrain. The distribution of these features in bedrock terrains suggests that portions of the areas interpreted as having a high to very high landslide potential are also the sources of sediment that has been delivered to streams;
- Human activities such as timberland conversion to grasslands and brush, grazing, timber harvest, and road construction and use, have interacted with natural geologic instability to increase sediment production above naturally high background levels. Historic timber harvesting and streamside road construction reduced riparian canopy and increased direct sediment inputs and water temperature. Overall, the current landscape is comprised of smaller diameter forest stands than in pre-European times. Decades of fire suppression have created dense forest stands and brush-lands leading to the designation of Mattole Basin population centers as high wildfire threat areas.

Supporting Evidence:

- The hard, moderate, soft and Quaternary unit terrains each comprises 40%, 28%, 25% and 7% respectively, of the watershed.
- Fifty five percent (by area) of the historically-active landslides, 46% of the dormant landslides, and 81% of the gullies mapped in the watershed occur in the soft terrain.
- Seventy-six percent of the small landslides, mostly debris slides, occur in the steep slopes of the hard and moderate terrains.
- Approximately 50% of the watershed has been interpreted as having a high to very high landslide potential.
- Over 90% of the source and transport reaches were identified along streams crossing bedrock.

- About 85% of the streams in the Quaternary units were mapped as response reaches.
- Thirty six percent (1984) and 21% (2000) of the total stream length were affected by features indicative of excess sediment production, transport, and storage.
- A 40% reduction in the total length of features indicative of excess sediment production, transport, and storage, as well as a 14% reduction in the proportion of streams affected by these features was observed between 1984 and 2000. This reduction in stream features was observed to have occurred primarily in the bedrock stream reaches.
- About 99% of features indicative of excess sediment production, transport, and storage in bedrock terrains were identified within areas interpreted as having a high to very high landslide potential (areas within LPM Category 4 and 5).

How has land use affected these natural processes?

Conclusions:

- Land use, including road construction and use, timber harvesting, and grazing, have added excess sediment to the fluvial system. Many of the effects from these activities are spatially and temporally removed from their upland sources. Excess sediment remains in the Mattole mainstem despite decades of low timber harvesting activity;
- Currently, roads are a major land use contributor of sediment (CDF, 2002). Large storms or other catastrophic events combined with poor road location and construction practices have the potential to deliver large and adverse amounts of sediment into stream systems;
- Water extraction for agriculture, road maintenance, and residential use has the direct effect of reducing the amount of available habitat for fish;
- Large woody debris recruitment potential is limited by the low percentage of near-stream forest stands containing trees in large diameter classes;
- Grazing is widespread on privately owned grasslands and has shifted to cattle since the enactment of predation protection measures. Stock impacts to streams are not widespread, but watercourse exclusionary fencing is limited.

Supporting Evidence:

- Many of these effects are spatially and temporally removed from their upland sources. Excess sediment remains in the mainstem of the Mattole despite decades of low timber harvesting activity. Grazing is widespread on privately owned grasslands and has shifted to cattle since the enactment of predation protection measures. Exclusionary fencing is limited. Currently, roads are a major land use contributor of sediment. Large storms or other catastrophic events combined with poor road location and construction practices have the potential to deliver large and adverse amounts of sediment into the stream systems.
- Water extraction for agriculture, road maintenance, and residential use has the direct effect of reducing the amount of available habitat for fish.

Based upon these conditions trends, and relationships, are there elements that could be considered to be limiting factors for salmon and steelhead production?

Conclusions:

Based on available information for the Mattole Basin, the NCWAP team believes that salmonid populations are currently being limited by:

- Impacted estuarine conditions;
- General basin-wide lack of habitat complexity;
- High instream sediment levels;
- High summer water temperatures;
- Reduced basin-wide coho and Chinook meta-populations.

What habitat improvement activities would most likely lead toward more desirable conditions in a timely, cost effective manner?

Recommendations:

Flow and Water Quality Improvement Activities:

- Discourage unnecessary and wasteful use of water during summer low flow periods to improve stream surface flows and fish habitat, especially in the Southern Subbasin;
- Increase the use of water storage and catchments systems that collect rainwater in the winter for use in the drier summer season;
- Support local efforts to educate landowners about water storage and catchments systems, and find ways to support and subsidize development of these systems;
- Support and expand ongoing local efforts that monitor summer water and air temperatures on a continuous 24-hour basis to detect long-range trends and short-term effects on the aquatic/riparian community;
- Support efforts to determine the role of sediment in the mainstem Mattole River in elevated estuarine water temperatures.

Erosion and Sediment Delivery Reduction Activities:

- Reduce sediment deposition to the estuary by supporting a basin-wide road and erosion assessment/control program such as the Mattole Restoration Council's *Good Roads, Clear Creeks* effort. Continue to conduct and implement road and erosion assessments such as the ongoing efforts in the Dry and Westlund planning watersheds in the Eastern Subbasin. Expand road assessment efforts because of the potential for further sediment delivery from active and abandoned roads, many of which are in close proximity to stream channels, especially in the Bridge and Thompson planning watersheds in the Southern Subbasin;
- Establish monitoring stations and train local personnel to track in-channel sediment and aggraded reaches throughout the basin and especially in the North Fork Mattole and the Upper North Fork Mattole rivers, Mattole Canyon, Blue Slide, Squaw, Honeydew, and Bear creeks;
- Consider the nature and extent of naturally occurring unstable geologic terrain, landslides and landslide potential (especially Categories 4 and 5, page 89) when planning potential projects in the subbasin;
- At stream bank erosion sites, encourage cooperative efforts to reduce sediment yield to streams. CGS mapping indicates eroding banks are not a significant basin wide issue, but may be of localized importance. They occur in isolated, relatively short reaches distributed throughout the Mattole Basin;
- Based on the high incidence of unstable slopes in the Northern Subbasin, any future sub-division development proposals should be based on an existing county-imposed forty acre minimum parcel sub-division ordinances;
- Encourage the use of appropriate Best Management Practices for all land use and development activities to minimize erosion and sediment delivery to streams. For example, low impact yarding systems should be used in timber harvest operations on steep and unstable slopes to reduce soil compaction, surface disturbance, and resultant sediment yield.

Riparian and Habitat Improvement Activities:

- Where current canopy is inadequate and site conditions, including geology, are appropriate, initiate tree planting and other vegetation management to hasten the development of denser and more extensive riparian canopy, especially in the Northern Subbasin;
- Landowners and managers in the Northern and Western subbasins should work to add more large organic debris and shelter structures to streams in order to improve channel structure, channel function, habitat complexity, and habitat diversity for salmonids;
- Ensure that stream reaches with high quality habitat in the Mattole Basin are protected from degradation. This is especially important in the Southern Subbasin. The best stream conditions as

evaluated by the stream reach EMDS were found in the South Fork of Vanauken Creek, Mill Creek - at Mattole river-mile 56.2 (RM 56.2), Stanley Creek, Thompson Creek, Yew Creek, and Lost Man Creek Tributary in the Southern Subbasin, and in Harrow Creek in the Eastern Subbasin. Refugia investigation criteria, which include biological parameters, indicated Bear Creek was the best stream evaluated in the Mattole Basin.

Supplemental Fish Rescue and Rearing Activities:

- Since 1982 a successful cooperative salmonid rearing facility in the Mattole Basin headwaters has been operated by the Mattole Salmon Group (MSG) and CDFG. They also operate a Chinook juvenile out-migrant rescue rearing program near the estuary, which released 2,400 coded-wire-tagged Chinook sub-yearlings in October 2002. These programs should be continued as needed to supplement wild populations while the improvements from long-term watershed and stream restoration efforts develop;
- Initiate a systematic program to monitor the effectiveness of fish rescue and rearing activities, and determine the need for the continuance of cooperative, supplemental fish rearing efforts;
- Update as scheduled the MSG/CDFG five-year plan that provides guidance to the cooperative rearing and rescue projects. Base the periodic plan updates on the findings of the effectiveness monitoring program and best available science.

Education, Research, and Monitoring Activities:

- Utilize Humboldt State University studies conducted in the early 1990s as baseline information to periodically monitor trends in estuarine conditions and fish production;
- Encourage ongoing stream inventories and fishery surveys of tributaries throughout the Mattole Basin, especially in the Northern Subbasin;
- In order to protect privacy while developing data, the possibility of training local landowners to survey their own streams and to conduct salmonid population status surveys throughout the basin would be advisable;
- Further study to investigate the affects to water quality from timberland herbicide use is recommended;
- Follow the procedures and guidelines outlined by NCRWQCB to protect water quality from ground applications of pesticides;
- Encourage appropriate chemical transportation and storage practices as well as early spill reporting and clean-up procedures;
- Conduct training as needed and desired to assist landowners, managers, consultants, and other interested parties in the construction and appropriate application of landslide occurrence and potential maps from GIS analysis

Subbasin Profiles and Synthesis

Mattole Estuary

Mattole Estuary, looking north from Prosper Ridge, King Range National Conservation Area.

Introduction

Estuaries are critical habitats for all anadromous salmonids. Estuaries provide the connection between freshwater and marine environments through which salmonids pass as juveniles during seaward migrations and as adults during spawning migrations. Estuaries are also recognized as valuable salmonid nursery areas because their ocean connection helps provide abundant food supplies, diverse habitat, and relative security from predators. Fish that utilize estuaries for an important part of their life cycle, such as salmonids, are referred to as estuarine-dependent.

During seaward migrations, all juvenile Chinook salmon, coho salmon, and steelhead utilize at least a brief estuarine residence while they undergo physiological adaptations to salt water and imprint on their natal stream. Juvenile salmonids may also extend their estuarine residency to utilize the sheltered, food rich environment for several months or a year before entering the ocean. Studies have revealed that juvenile salmonids utilizing estuaries for three months or more return to their natal stream at a higher rate than non-estuarine reared members of their cohort (Reimers 1973 , Nicholas and Hankin). Estuarine reared salmonids may be at an advantage because they enter the ocean at a larger size or during more favorable conditions. Entering the ocean at a larger size may be advantageous by allowing juvenile salmonids to avoid predation or increasing the amount of prey items that can be used for food.

Estuarine rearing is a strategy that adds diversity to juvenile salmonid life history patterns and increases the odds for survival of a species encountering a wide range of environmental conditions in both the freshwater and marine environments. Additionally, an extended estuarine residency may be especially beneficial for salmonids from rivers where low summer flows or warm water temperatures severely limit summer rearing habitat. Benefits are dependent upon the estuary retaining its connection with cool, nutrient laden seawater.

The Mattole estuary is a seasonal bar built estuary. It acts both as an estuary and as a lagoon throughout the course of the year. In the early summer of most years, a sand bar encroaches all the way across the mouth of the Mattole River to form a bay barrier and create a lagoon behind it. The formation of the bar is caused by a combination of sediment deposition from coastal longshore ocean currents, and decreased river flows. Lagoon formation typically occurs in late May or early June, although the mouth may remain open until mid or late June when adequate flows are present, as was the case in 1986. On the other hand, in extremely dry years, closure will take place earlier. The lagoon opens up again in the fall, usually in October, due to increased erosion of the sand bar from increased river flow and wave action (Busby et al. 1988).

The Mattole lagoon floods an area of approximately 7 acres with the deepest sections occurring in the main channel of the river. The size and depth of the lagoon fluctuate throughout the summer, with the lagoon shrinking towards the end of the summer due to decreased river flow, increased evaporation, and increased seepage through the sand bar. Annual variations in lagoon size occur due to scouring in some areas and sediment deposition on others. Although the extent of tidal influence in the lagoon has not been quantified, tides are thought to have a minimal effect on the water level of the lagoon. Before the lagoon closes, seawater intrusion is thought to extend only 984 feet above the mouth of the river. Shortly after lagoon closure, incoming river water and wind driven mixing cause the lagoon to become essentially freshwater. Intense and persistent winds cause vigorous mixing throughout the water column (Busby et al. 1988).

High levels of sediment transported from the upper watershed through periodic flooding has reduced the Mattole estuary volume and altered the physical and biologic function of the estuarine ecosystem and adjacent wetlands (MRC 1995). These impacts include elevated summer water temperatures. This present highly impacted state of the estuarine habitat is likely limiting the production of salmonids in the Mattole River. In fact, extensive studies, led by Humboldt State University from 1985-92, found that Chinook juveniles were suffering lethal impacts during summer rearing in the estuary (Young 1987, Busby et. al 1988). In response, the Mattole Salmon Group has initiated a springtime downstream migrant Chinook trapping and summer rearing program which has had limited success (CDFG Appendix F). Long-term watershed scale strategies to reduce sedimentation, provide habitat, and lower summer water temperatures are needed to improve the estuarine habitat, and these efforts will require private landowner and local stakeholders' cooperation.

The Mattole dune system is unique in that the aggressive and introduced European beachgrass, *Ammophila arenaria*, has not yet encroached on the Mattole dunes as it has on most coastal dunes north of San Francisco. The estuary is probably the most researched of all the Mattole subbasins in the watershed.

The NCWAP team's Estuary Subbasin results and analyses are presented in three basic sections. First, general information describing the subbasin is presented by different disciplines. Secondly, this information is integrated and presented to provide an overall picture of how different factors interact within the subbasin. Lastly, an overall assessment of the Estuary Subbasin is presented. The NCWAP team developed hypotheses, compiled supportive and contrary evidence, and used these six assessment questions to focus this assessment:

- What are the history and trends of the sizes, distribution, and relative health and diversity of salmonid populations within this subbasin?
- What are the current salmonid habitat conditions in this subbasin? How do these conditions compare to desired conditions?
- What are the relationships of geologic, vegetative, and fluvial processes to natural events and land use history?
- How has land use affected these natural processes?
- Based upon these conditions trends, and relationships, are there elements that could be considered to be limiting factors for salmon and steelhead production?
- What habitat improvement activities would most likely lead toward more desirable conditions in a timely, cost effective manner?

The assessment questions are answered at the end of this section.

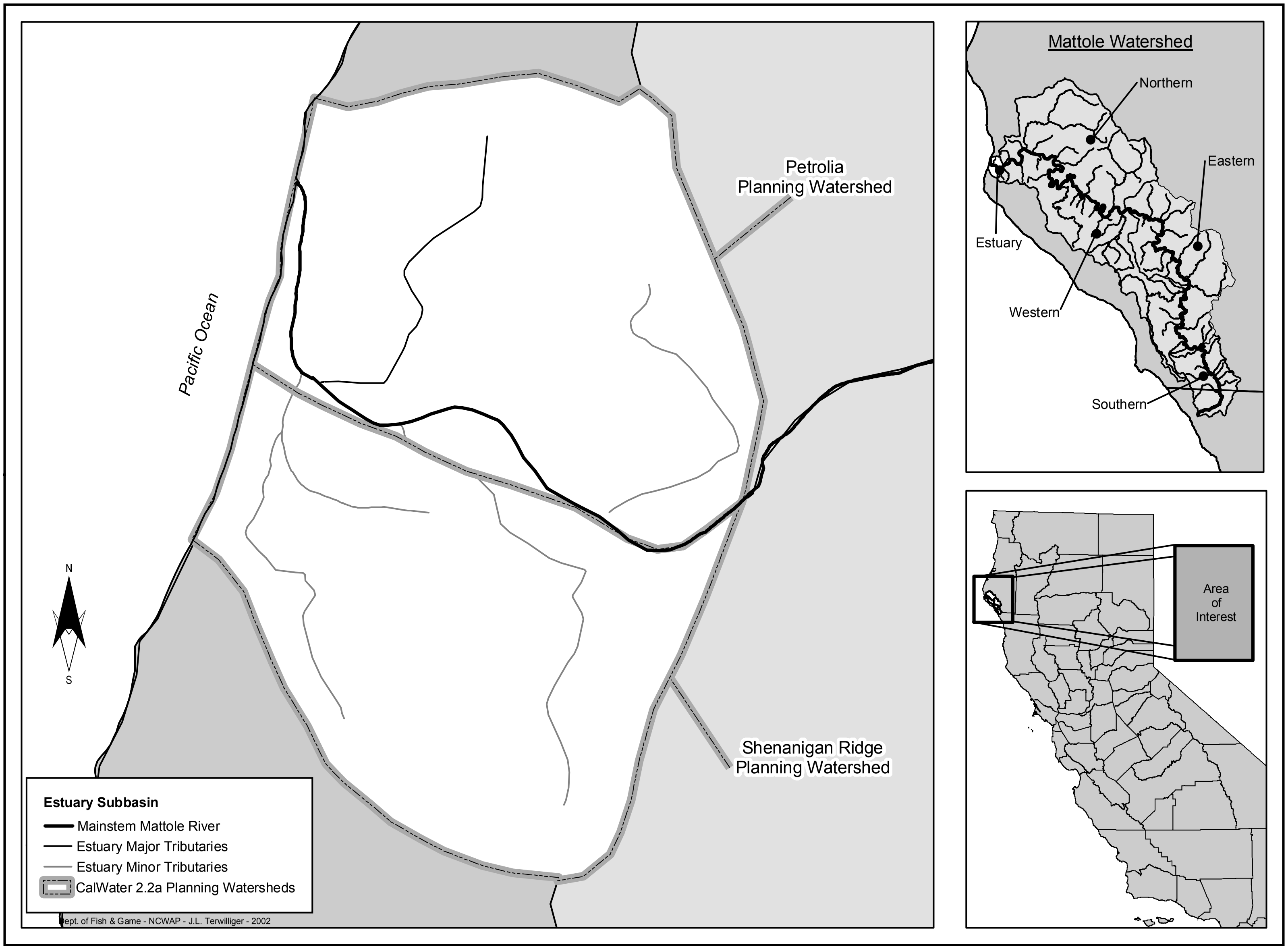


Figure 55. Mattole River Estuary Subbasin.

Climate

In the Estuary Subbasin, air temperatures average 55°F and ranges from 40° to 65°F. Rainfall in this area averages 60 inches per year. Summer fog is usually present here although fog is not a common climatic feature of the Mattole Basin.

Hydrology

The Estuary Subbasin contains small sections of the Petrolia and Shenanigan Ridge CalWater 2.2a Planning Watershed (Figure 6, previous page). There are no perennial tributaries in this subbasin.

Geology

The bedrock underlying the uplands above the estuary consists of the Franciscan Coastal terrane. In the Estuary Subbasin, the Franciscan is dominated by mélange with a far smaller area underlain by intact sandstone and argillite units. The strength of the mélange is variable, forming a soft to moderate topography of rolling hillsides, moderate slopes, and rounded crests. The small area overlooking the coast north of the Mattole River underlain by intact sandstone and argillite units forms a hard terrain with a greater proportion of steep slopes.

The estuary of the Mattole River divides this subbasin roughly in half, and occupies a wide active channel within a relatively wide valley. The active channel is underlain by Quaternary stream channel deposits whereas the balance of the valley floor is underlain by low river terraces. Much of the moderate terrain south of the Mattole River is underlain by a large, dormant landslide complex. A number of dormant rockslides overlay the locally steep slopes on the hard terrain north of the Mattole River. A portion of the hard terrain and the adjacent soft terrain is underlain by disrupted ground. A map showing the distribution of geologic units, landslides, and geomorphic features related to landsliding is presented on Plate 1 in the Geologic Report, Appendix A.

Vegetation

The vegetation of the Estuary Subbasin is very diverse. The Mattole Restoration Council's *Elements of Recovery* (1989), identifies nine distinct plant communities. Willows and red alder are found along past and present river channels. Lower floodplains contain grasses with scattered willows and coyote brush. Grasslands predominate on higher floodplains and hillslopes that have been cleared, cut, or grazed. Hillslope gullies, washes, and ravines contain coniferous/deciduous forest, mostly second and third growth coniferous forests with large stands of mature tanoak. Dune areas contain beach layia, a federally listed endangered plant species.

Land Use

Human habitation of the Estuary area goes back hundreds of years as evidenced by shell middens on the beach south of the Estuary. The native inhabitants hunted, fished, and made use of the diverse flora and fauna of the area. Euro-Americans arrived in the 1850s, bringing pasture and row crops to the river bottom flats, and sheep and cattle grazing to the surrounding hillsides. The largest land-use change occurred in 1970, with the creation of King Range National Conservation Area, managed by the Bureau of Land Management. Although limited grazing still occurs, BLM currently manages the estuary area for conservation and recreation. The BLM maintains a public campground and trailhead at the mouth of the river for the 25-mile Lost Coast Trail (gateway to the King Range National Conservation Area) from the Mattole River to Shelter Cove.

Fluvial Geomorphology

The Mattole estuary is characterized by a wide valley, with the lowest gradient and widest channel within the watershed. NMCCs were identified along 36% (1984) and 29% (2000) of the alluvial reach of the Mattole River (Table 54); no NMCCs were identified along bedrock reaches in this subbasin. When compared to other subbasins, the Estuary Subbasin had some of the lowest reduction in NMCCs as a percentage of all the blue-line streams, 6%. The system of gravel bars along the lower Mattole River has remained about constant between the years 1984 and 2000. Minor changes were observed chiefly with respect to the location and development of vegetated bars.

Between 1942 (Figure 56) and 1965 (Figure 57) the Mattole estuary was dramatically widened and large areas of vegetation were lost. However, compared to the 1965 photos, the 1984 (Figure 58) and 2000 (Figure 59) photos (WAC-84C, 21-165 and WAC-00-CA, 7-195) show (1) a progressive increase in vegetation along the south bank, (2) a decrease in the width of the active channel, (3) smaller areas of braided stream channel, and (4) a shift of the active channel to the north bank. In addition, at the dates the 1984 and 2000 photos where taken (May 6, 1984 and March 31, 2000) the mouth of the Mattole River was open. The white lines in the photos are common points of geographical reference between each photograph.

In summary, channel conditions across the subbasin have generally improved between 1984 and 2000, but the alluvial reaches remain impacted by sediment. Most of the improvement is seen as a reduction in the proportion of streams affected by lateral and mid-channel bars. The lack of NMCCs in nearby bedrock stream reaches within this subbasin suggests that excess sediment observed in the Quaternary units was transported from areas upstream of the subbasin.

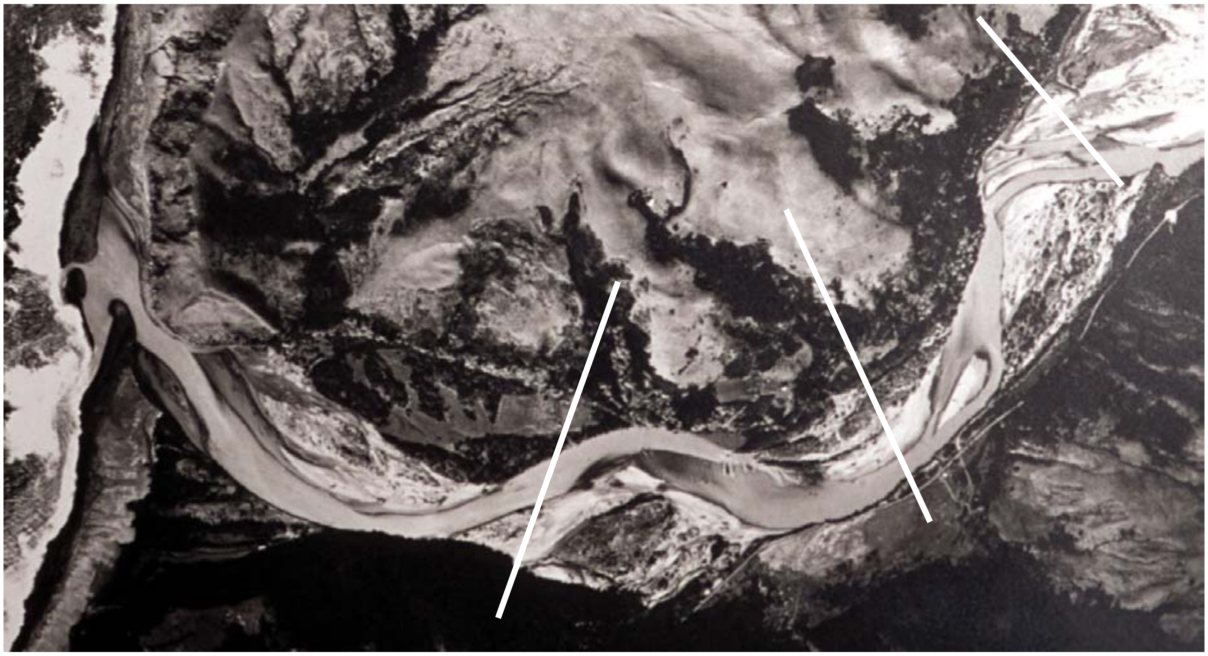


Figure 56. The Mattole River Estuary in 1942.

Riparian vegetation appears as dark patches and strips on the light gravel bar. The mouth was open when this photo was taken on February 15, 1942. Although the flow was not low, the wetted channel is narrow in some places. Photo provided by the Mattole Restoration Council. (Lines are for approximate reference locations).

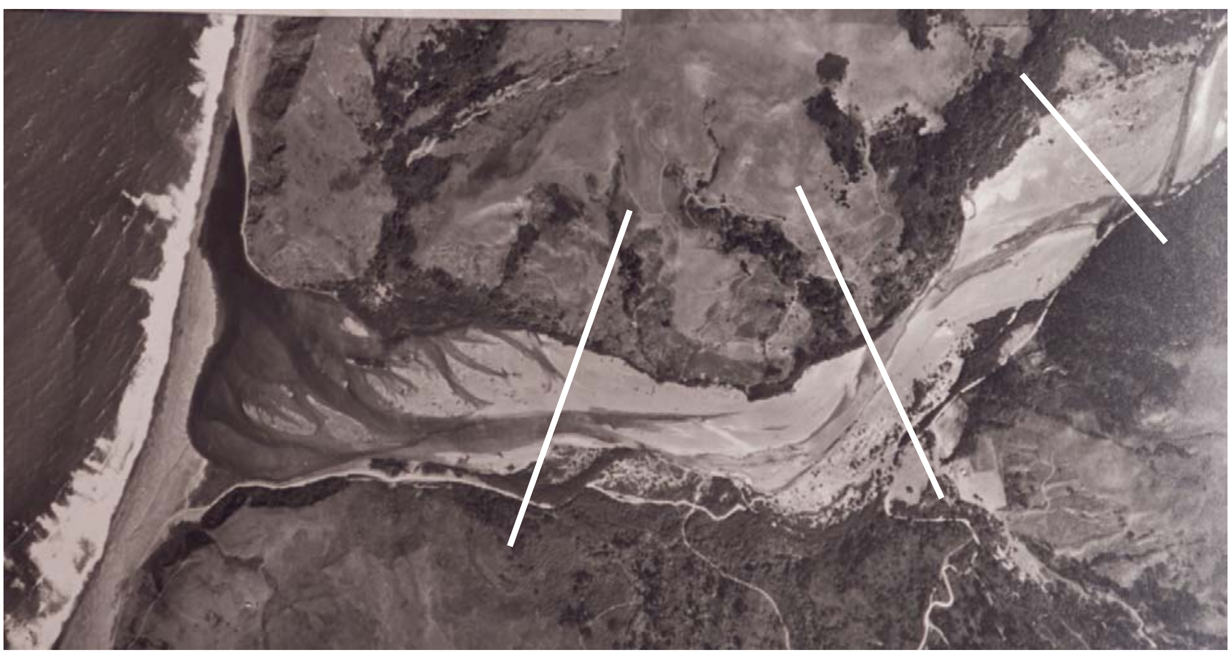


Figure 57. The Mattole River Estuary in 1965.

Riparian vegetation is rare along the wetted channel. At the time of this summer photo, the mouth was closed and some relative depths of the lagoon are evident. The wetted channel is wide and braided. Photo provided by the Mattole Restoration Council.

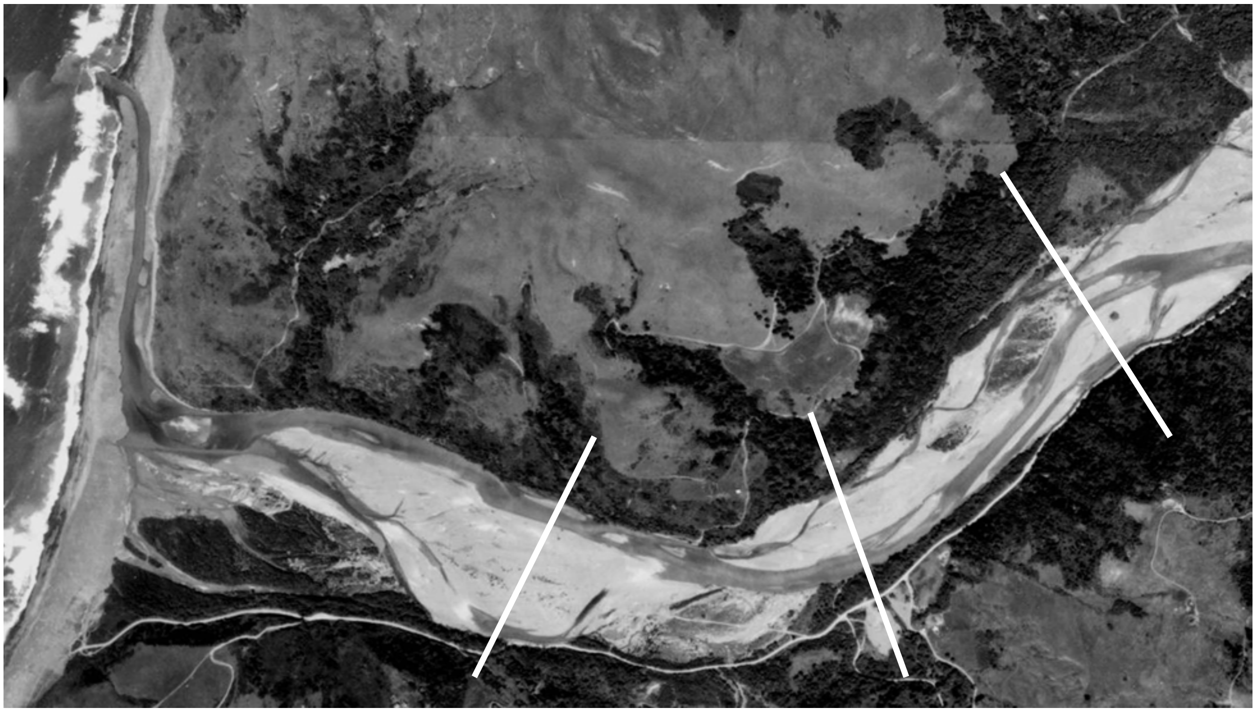


Figure 58. The Mattole River Estuary in 1984.

Riparian vegetation is evident in patches along the south side of the wetted channel. The mouth is open and is far to the north in this May 1984 photo. The wetted channel above the estuary is wide and braided. (Photo provided by CDF). (Lines are for approximate reference locations)

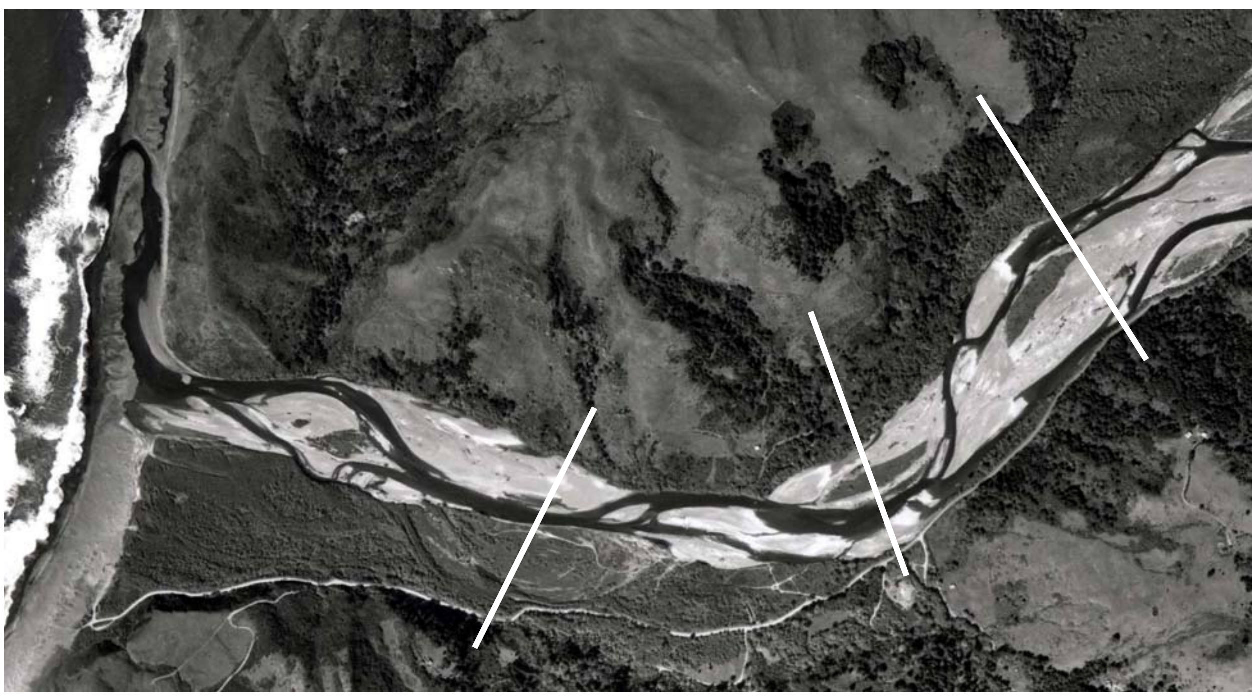


Figure 59. The Mattole River Estuary in 2000.

Riparian vegetation is well established along the south side of the estuary and continues upstream to Stansberry Creek. The mouth is open in this March 2000 photo. The wetted channel is narrower and has smaller braided areas. (Photo provided by CDF).

Aquatic/Riparian Conditions

Field observations conducted by Humboldt State University (HSU) students during the HSU study of the estuary from 1985-1992, and ongoing field observations indicate lack of pools, lack of instream structures for cover and lack of riparian canopy around the Estuary (Busby et. al 1988, MRC 1995). These factors contribute to elevated water temperatures. Additionally, lack of depth and escape cover for juveniles and adults contributes to possible natural-predator predation problems. There is not enough data to determine whether water chemistry is a limiting factor in the Estuary (NCRWQCB Appendix E).

Fish Habitat Relationship

The Estuary Subbasin was not evaluated with the EMDS; however, current habitat data for the Estuary were examined to determine the suitability for anadromous salmonids. Estuarine conditions are important for anadromous salmonids during their migrations and when Chinook salmon and steelhead trout over-summer in the estuary/lagoon. Juvenile Chinook salmon downstream migration is usually completed in June or the first week of July, and the only Chinook left in the Mattole Basin after this date are in the estuary/lagoon (Busby et al. 1988). Steelhead trout, on the other hand, exhibit both tributary and estuary rearing strategies in the Mattole Basin (Day 1996). Therefore, estuary/lagoon summer habitat conditions are important for steelhead trout, but *critical* for Chinook salmon populations.

Conditions in the Mattole estuary are a product of upstream natural processes and human land uses. Long term residents of the Mattole Basin and long time salmon sport fisherman of the Mattole remember that prior to the 1955 and 1964 floods, the lower Mattole River and the Mattole estuary had a narrower channel with a higher ratio of island floodplains to bars; larger and deeper pools (especially in the Estuary); much coarser substrate, both in the active channels and on bars; and higher densities of conifers and cottonwood trees on floodplains (Roscoe 1985 as quoted in MRC 1995, Lowry 2002, personal communication).

High sediment has likely contributed to pool filling and low canopy density has likely contributed to high summer water temperatures in the Estuary. Although summer water temperatures are currently documented to be higher than fully suitable EMDS values, there is not enough information over time to understand temperature trends or to allocate contributions by direct and indirect causes. Both high sediment levels and low canopy densities have also contributed to a lack of escape cover. Without escape cover, juvenile salmonids face a higher risk of predation from avian and aquatic predators. Therefore, sediment and temperature impacts to estuarine habitat and water quality are currently deleterious to summer rearing salmonid populations, particularly juvenile Chinook salmon.

Fish History and Status

All anadromous salmonids in the Mattole Basin must pass through the estuary when they go out to sea and when they return to spawn. Long time Mattole Basin residents remember excellent salmon fishing opportunities in the estuary when spawning fish were returning to the river. A much-anticipated annual event was the opening of the lagoon, usually in October. Local residents camped around the estuary and caught great numbers of salmon as the first runs migrated upstream (MRC 1995).

Both juvenile Chinook salmon and steelhead trout over-summer in the Mattole Estuary when the sand bar closes and a lagoon is formed. The juvenile Chinook salmon and steelhead trout utilizing the lagoon during the summer were studied extensively by HSU researchers from 1984 – 1992. The number of juvenile Chinook salmon in the lagoon declined throughout the summer (Busby et al. 1988, Young 1987), and all the Chinook appear to have died out by the end of the summer in 1988. Very few or no Chinook were captured in the lagoon from 1988 through 1992 (MRC 1995). Additionally, in years with higher numbers of Chinook salmon at the beginning of the summer, juveniles had slower growth rates and greater mortality throughout the summer when compared to years with smaller Chinook salmon populations at the start of the summer (Busby et al. 1988, Young 1987). Steelhead trout populations over summering in the lagoon fared better than Chinook salmon, with populations varying from year to year but not experiencing mass die-offs (Zedonis 1992, MRC 1995, Day 1996). Dive observations continue to document the presence of steelhead trout but not Chinook salmon (MSG 2000).

In response to the low juvenile Chinook salmon populations, the Mattole Salmon Group has conducted a rescue-rearing operation since 1994. The project traps down migrating Chinook juveniles at river mile 3.0, adjacent to summer rearing tanks at Mill Creek (RM 2.8), and releases them in the fall for out-migration.

More detailed summaries of fisheries research in the Mattole estuary are provided in the CDFG Appendix F.

Estuary Subbasin Issues

- Current sediment and temperature impacts are thought to be deleterious to summer rearing salmonid populations.
- Estuary pool habitat, escape and ambush cover, water depth, and substrate embeddedness are likely unsuitable for salmonids in the critical over summering life stage.
- The efficacy of the Mattole Salmon Group's Chinook rescue-rearing project has not been adequately determined.
- The Estuary upland slopes generally have a moderate to very high landslide potential.
- Since 1984, estuarine conditions have shown slight improvement from the deleterious impacts of floods and land use prior to 1965.
- Local residents consider sea lion and harbor seal predation of adult salmonids to be at least partially responsible for the decline in Mattole River fish stocks.

Estuary Integrated Analysis

The following tables provide a dynamic, spatial picture of watershed conditions for the freshwater lifestages salmon and steelhead. The tables' fields are organized to show the extent of watershed factors' conditions and their importance of function in the overall watershed dynamic. Finally a comment is presented on the impact or condition affected by the factor on the watershed, stream, or fishery. Especially at the tributary and subbasin levels, the dynamic, spatial nature of these processes provides a synthesis of the watershed conditions and indicates the quantity and quality of the freshwater habitat for salmon and steelhead.

Geology

Introduction

The potential for sediment production is strongly influenced by the underlying geology. The following IA tables compiled by CGS examine the influence of geology on sediment production by comparing the distribution of geomorphic terrains (hard, moderate, and soft bedrock terrains, and the separately grouped Quaternary surficial deposits) against the observation of landslides and geomorphic features related to mass wasting within the subbasin. The first table presents the proportions of the subbasin underlain by each of the terrains. The next table looks at hillside gradient within the subbasin. The distribution of historically active landslides, gullies, and inner gorges by terrain are then considered. Finally, the landslide potential map developed by CGS is examined with respect to the terrains.

Table 48. Geomorphic terrains as a proportion of the Estuary.

Proportion of Estuary Underlain by the Different Geomorphic Terrains				
Feature/Function			**Significance**	**Comments**
Terrain Type	**Proportion of Estuary Area**	**Terrain Area within Subbasin as a Proportion of Mattole Basin Area**	The geomorphic terrains represent groupings of geologic map units based on similarities in geology, geomorphic expression, and landslide occurrence. They provide a simplified division of the watershed useful in comparing the influence of bedrock geology to the distribution of other mapped features.	Whereas the terrains are proportionally more evenly distributed in the Estuary than other subbasins, because of the prevalence of gentle slopes, areas of historic slope instability and current gully erosion are rare within the subbasin.
Hard	18%	<1%		
Moderate	32%	<1%		
Soft	23%	<1%		
Quaternary[1]	27%	<1%		

1. Areas where young (Quaternary) surficial units have been mapped covering bedrock; includes alluvium, as well as terrace deposits, active stream channel deposits, and other alluvial deposits.

Table 49. Hillside Gradient in the Estuary.

Hillside Gradient in the Estuary							
Feature/Function						**Significance**	**Comments**
Proportion of Subbasin Area						Hillside slope is an important indicator of potential instability (steeper is generally less stable). The terrain type influences the degree to which hillside slope affects the slope stability.	Gradients on hillsides abound the Estuary are comparatively moderate. The Estuary has the smallest proportion of steep (>65% slope) slopes of all the subbasins.
Range in % slope							
0-10	**10-30**	**30-40**	**40-50**	**50-65**	**>65**		
24	26	21	15	9	5		

Table 50. Small historically-active landslides by terrain in the Estuary.

Distribution of Small Historically-Active Landslides by Geomorphic Terrain in the Estuary				
Feature/Function			**Significance**	**Comments**
Terrain Type	**Small Point Landslides[1] Mapped from year 1981[2], 1984, or 2000 Photographs**		The relative number of small point slides is used to evaluate which geomorphic terrains are more prone to small, localized slope failures.	Only a minor number of small slides have occurred in this subbasin; these failures consist of shallow debris slides associated with the limited steep slope areas in the watershed. These features are essentially a non-issue in this subbasin.
	Point Count	**Area[3] (acres)**		
Hard	2	<1		
Moderate	0	0		
Soft	0	0		
Quaternary	0	0		

1 Mapping was compiled at a 1:24,000 scale. Landslides smaller than approximately 100 feet in diameter were captured as points in the GIS database; larger features were captured as polygons.
2Landslides included from year 1981 photographs are from previous mapping by Spittler (1983 and 1984) covering limited portions of the Mattole Basin.
3 Based on assumed average area of 400 square meters (roughly 1/10th acre) for small landslides.

Table 51. All historically-active landslides by terrain in the Estuary.

Distribution of All Historically-Active Landslides by Terrain in the Estuary				
Feature/Function			**Significance**	**Comments**
Terrain Type	**Combined Area (acres) of All Historically-Active Landslides[1]**	**Proportion of Total Active Landslide Area within Subbasin**	The relative percentage of area covered by historically-active slides identifies which geomorphic terrains are most prone to relatively large-scale slope failures.	The area occupied by historically-active landslides in this subbasin is very limited and essential a non-factor with respect to current conditions in the Estuary. The historically-active landslides mapped in the subbasin consist of small debris slides.
Hard	<1	100%		
Moderate	0	0%		
Soft	0	0%		
Quaternary	0	0%		

[1] Includes small point and larger polygon features mapped from year 1981, 1984 and 2000 photos. Where landslides overlapped (i.e., the same or similar features mapped from more than one photo set) the area of overlap was counted only once. Small landslides captured as points in the GIS database were assumed to have an average area of 400 square meters (roughly 1/10th acre).

Table 52. Gullies and inner gorges by terrain in the Estuary.

Distribution of Gullies and Inner Gorges by Terrain in the Estuary				
Feature/Function			**Significance**	**Comments**
Terrain Type	**Proportion of Total Mapped Gully Lengths[1] in Subbasin**	**Proportion of Total Mapped Inner Gorge Lengths[1] in Subbasin**	Gullies and inner gorges are an important indicator of ongoing sources of sediment to the fluvial system.	These features are very limited and essentially a non-issue in this subbasin.
Hard	99%	9%		
Moderate	0%	0%		
Soft	>1%	91%		
Quaternary	0%	0%		

[1] Includes only those features mapped from year 2000 photographs.

Table 53. Landslide potential by terrain in the Estuary.

Distribution of Landslide Potential Categories by Terrain as a Proportion of the Estuary							
Feature/Function						Significance	Comments
Terrain Type	Landslide Potential Category[1]						
	1	2	3	4	5		
Hard	0.1%	2.7%	1.5%	10.8%	2.5%	Categories 4 and 5 represent the majority of unstable areas that are current or potential future sources of sediment.	Although historically-active landslides and gully erosion are relatively rare, a significant portion of the subbasin is in LPM Categories 4 and 5. The areas of ; LPM Categories 4 and 5 are largely associated with disrupted ground and soft terrain present on the hillsides in the northern portion of the subbasin, and with localized steep slopes on dormant landslides. Because of the subbasin's relatively small size, the area with LPM Categories 4 and 5 represent only a very limited potential sediment source area in the basin as a whole.
Moderate	0.3%	2.3%	25.4%	2.3%	1.8%		
Soft	0.2%	0.3%	5.5%	13.7%	3.3%		
Quaternary	23.2%	2.7%	1.2%	0.1%	0.0%		
Subbasin Total2	**23.8%**	**8.0%**	**33.6%**	**26.9%**	**7.6%**		

1 Categories represent ranges in estimated landslide potential, from very low (category 1) to very high (category 5); see Geologic Report, Plate 2.
2 Percentages are rounded to nearest 1/10 %; sum of rounded values may not equal 100%.

Discussion

The hillsides adjacent to the estuary do not appear to be significant contributors of sediment into the system. Historically active landslides and gully erosion are comparatively rare in this subbasin. However, due to the presence of dormant landslides, areas of disrupted ground, and locally steep slopes, about 34% of the Estuary Subbasin is considered to have a high to very high landslide potential (LPM categories 4 and 5).

Fluvial Geomorphology

Introduction

Fluvial geomorphic mapping of channel characteristics was conducted along blue line streams in the Mattole Basin to document channel characteristics that are indicative of excess sediment production, transport, and/or response (deposition); these features are referred to as negative mapped channel characteristics (NMCCs). The following CGS Integrated Analysis (IA) Tables present some of the findings of this investigation. To understand the distribution of these NMCC's we present: the predominant NMCC's identified; the relative distribution of these features between the bedrock terrains and the Quaternary units; the changes in amount and distribution of NMCC's observed between 1984 and 2000; and the relationship between areas of projected slope instability and portions of streams with evidence of excess sediment.

Table 54. Negative mapped channel characteristics in the Estuary

Negative Mapped Channel Characteristics in the Estuary Subbasin						
Feature/Function					**Significance**	**Comments**
		From 1984 Photos	**From 2000 Photos**	**%4 Change 1984 to 2000**	The reduction in the total length of NMCC's over time qualitatively reflects the degree of improvements within the blue line streams. These NMCC's were chosen to be highlighted in these figures because in both photo years, the NMCC's observed were dominated by wide channels and, secondarily, by displaced riparian vegetation. Most of this observed improvement results from reductions in the proportion of streams affected by displaced riparian vegetation and wide channels.	This feature was not observed in this subbasin.
Blue Line Streams where Wide Channel (wc) Observed		See Figure 32				
Blue Line Streams where Displaced Riparian Vegetation (dr) Observed		See Figure 33				This feature was not observed in this subbasin.
% of all Blue Line Stream Segments in Basin affected by NMCC's	Total	22%	18%	-4%	These values identify how much of the streams have been affected by NMCC's. Decreases in the length of stream affected by NMCC's quantitatively represents the degree of improvement within blue line stream reaches.	Only the Quaternary unit reaches of the fluvial system were identified as being affected by NMCC's. These reaches have experienced some improvements between 1984 and 2000, but still remains impacted by NMCC's
	Bedrock	0%	0%	0%		
	Alluvium	36%	29%	-6%		
Percentage of all Blue Line Stream segments in bedrock that are: 1) adjacent to or within LPM Categories 4 and 5[3] and 2), affected by NMCC's		0%	0%	0%	This category is a non-issue in this subbasin.	This category is a non-issue in this subbasin.
Percent of total NMCC length in bedrock, within 150 feet of LPM Categories 4 and 5[2]		0%	0%	0%	This category is a non-issue in this subbasin.	This category is a non-issue in this subbasin.

[1] Include all areas identified as hard, moderate, or soft geomorphic terrain.
[2] Areas where young (Quaternary) surficial units have been mapped covering bedrock; includes alluvium, as well as terrace deposits, active stream channel deposits, and other alluvial deposits.
[3] Landslide Potential Map developed by CGS for the Mattole Basin; see California Geologic Report, Appendix A) and Plate 2.
[4] Percentages are rounded to nearest 1%; sum of rounded values may not equal rounded totals or 100%.

Discussion

The results of our fluvial geomorphic mapping of channel characteristics that may indicate excess sediment accumulations (NMCC's) can be summarized as follows.

- In both 1984 and 2000, none of the blue line stream channels within bedrock reaches were observed to be affected by NMCC's.
- Channel conditions in the Quaternary unit reaches have generally improved between 1984 and 2000.
- In this subbasin, none of the NMCC's were identified in bedrock terrains along portions of the streams adjacent to or within areas designated as having high or very high landslide potential.

Water Quality

Introduction

Thermograph records that were regularly spaced temporally and physically are available for the mainstem from the estuary to the headwaters, permitting a representative view of temperature conditions for the entire reach. Thermal imaging was also conducted for the same reach from which median surface temperatures were calculated. Except for one D50 site located in the mainstem of the Southern Subbasin, and one V* site near the USGS Petrolia Gage, there is very little sediment data available. The MRC established and surveyed transects to map bottom profiles of the estuary in the early- to mid-1990s; there have been no additional efforts since then. Physical-chemical sampling took place at the USGS Petrolia Gage from 1973-1989. Humboldt State University students conducted additional physical-chemical monitoring in the estuary from the late1980s to approximately mid-1990.

Table 55. Estuary and mainstem water quality integrated analysis table

<table>
<tr><th colspan="2">Feature/Function</th><th>Significance</th><th>Comments</th></tr>
<tr><td colspan="4">Temperature</td></tr>
<tr><td colspan="2">MWATs (43 Thermograph Records for 32 Stations)</td><td rowspan="3">Maximum weekly average temperature (MWAT) is the temperature range of 50-60°F considered fully suitable of the needs of several West Coast salmonids.</td><td rowspan="3">Unsuitable throughout the estuary and the lower and mid-reaches of the mainstem Mattole River.</td></tr>
<tr><td>Suitable Records</td><td>Unsuitable Records</td></tr>
<tr><td>5</td><td>38</td></tr>
<tr><td colspan="2">Maximum Temperatures (64 Thermograph Records for 32 Stations)</td><td rowspan="3">A maximum-peak temperature of 75°F is the maximum temperature that may be lethal to salmonids if cool water refugium is unavailable.</td><td rowspan="3">Mostly suitable to moderately unsuitable throughout Estuary Subbasin and Mattole mainstem.</td></tr>
<tr><td>Suitable Records</td><td>Unsuitable Records</td></tr>
<tr><td>36</td><td>28</td></tr>
<tr><td colspan="2">Thermal Infrared Imaging Median Surface Temperature Estuary to headwaters</td><td rowspan="5">Ability to assess surface water temperatures at the river-stream-reach level for a holistic picture of thermal distribution.</td><td rowspan="5">The Mattole River from the estuary to the headwaters represents a temperature continuum that was artificially separated into the three reach categories to ascertain the minimum and maximum of thermally imaged median surface temperatures. In general, imaged median surface temperatures were cooler in the headwaters, warming to over 75°F in the mid-reach, and cooling at the estuary, probably due to cooler coastal climatic influences. See below for data limitations of thermal imaging.
Data limitations: 1) Assessments generally performed on a specific day and time, 2) not comparable to seasonally assessed MWAT or maximum temperatures, 3) unable to assess below water surface. Note: Thermal imaged median surface temperatures are derived from the minimum and maximum imaged surface temperatures scaled to a particular point in a sample cell (cell approximately = 317 feet x stream width). Cell minimum and maximum rarely varied more than 1-3 °F.</td></tr>
<tr><td>Reach</td><td>Median Surface Temperature (°F)</td></tr>
<tr><td>Estuary</td><td>71</td></tr>
<tr><td>Mid-Reach</td><td>80</td></tr>
<tr><td>Headwaters</td><td>58</td></tr>
</table>

Feature/Function		Significance	Comments
Sediment			
Tributary	**Date V***	V*: Measures the percent sediment filling of a streams pool, compared to the total pool volume. Lower V* values may indicate relatively low watershed disturbances. The V* ranges, below, derived from Knopp, 1993, are meant as reference markers and should not be construed as regulatory targets: V* ≤ 0.30 = low pool filling; correlates well with low upslope disturbance V* > 0.30 and ≤ 0.40 = moderate pool filling; correlates well with moderate upslope disturbance. V* > 0.40 = High (excessive) rates of pool filling; correlates well with high upslope disturbance	
Mainstem, mile 1.3	2001 0.31		V* of 0.31indicates moderate pool filling
Tributary	**Date D50 (mm)**	D50 means that 50 percent of the particles, measured in millimeters, on a riffle are smaller, and 50 percent are larger than the reported value. It is a simple and rapid stream assessment method that may help in determining if land use activities or natural land disturbances are introducing fine sediment into streams. In those Northern California basins with TMDLs where D50s are, or are considered for use as a numeric target, a mean D50 of > 69 mm, and minimum D50 > 37mm are desired future conditions over a specified time interval. Only the Garcia River TMDL has formally adopted these numeric targets and, for the Mattole River, are used as reference points only.	
Mainstem, River Mile 60.1	2001 34		D50 = 34 mm indicates transport and deposition of marginally small to medium sized particles on riffles
Sediment Transects		Stream transects, or cross sections, provide a bottom profile of the streambed at the time sampling takes place. Multiple year data sets can reveal whether a location is aggrading (accumulating sediment), degrading (losing stored sediment), undergoing channel shifts (changes within an established floodplain), or channel migration (changes beyond established floodplains).	
Estuary: Nine Transects	Surveyed: 1991, 1992, 1993, 1994		Showed mostly channel shifts within the established floodplain with one transect aggrading. Sediment volumes were not calculated.

Feature/Function		Significance	Comments
Water Chemistry and Quality			
Subbasin	**Minimum / Maximum**	Beneficial pH ranges (~ph 6.5-8.5) controls/regulates chemical state of nutrients such as CO2, phosphates, ammonia, and some heavy metals (minimizes any possible toxic effects), etc.	1976-1989 trend analyses and results for all three physical parameters are protective of the beneficial uses of water described in the North Coast Regional Water Board Basin Plan for the Mattole River. Limited, sporadic sampling results after 1989 are also protective of water quality goals and targets and presumed suitable throughout the basin.
pH (Standard units)			
Estuary-Mainstem (1973-1989)	7.4 / 8.6		
Dissolved Oxygen (mg/l)		By-product of plant photosynthesis/necessary for (life) respiration by aquatic plants and animals	
Estuary-Mainstem (1973-1989)	9.2 / 13.2		
Conductivity (Micromhos)		Measure of ionic and dissolved constituents in aquatic systems; correlates well with salinity. Quantity/quality of dissolved solids-ions can determine abundance, variety, and distribution of plant/animals in aquatic environments. Osmoregulation efficiency largely dependent on salinity gradients. Estuary salinity essential to outmigrant smoltification.	
Estuary-Mainstem (1973-1989)	100 / 282		
Chemistry/Nutrients		Quality and quantity of natural and introduced chemical and nutrient constituents in the aquatic environment can be toxic, beneficial, or neutral to organisms (whether terrestrial or aquatic), and their various life phases. Chemical composition, in part, influenced by rainfall, erosion and sedimentation (parent bedrock, overlying soils), solution, evaporation, and introduction of chemicals/nutrients through human and animal interactions.	Limited chemical sampling disclosed no North Coast Regional Water Board Basin Plan exceedences and is generally presumed suitable throughout the mainstem. Unable to detect long term trends during the limited time interval of sampling.
Inconsistent sampling from 1973-1989 with no deleterious results			

References: Knopp, 1993; Mattole Restoration Council; Mattole Salmon Group, 1996-2001, PALCO, 2001; NCRWQCB Appendix E; Watershed Sciences, 2000.

Discussion

MWATs in the mainstem Mattole River from the headwaters to the Pacific Ocean were unsuitable for salmonids for 38 of 43 available records, while maximum temperatures in the same reach had 36 of 64 records with conditions suitable for salmonids. Median surface temperatures in the same reach derived from thermal imaging mirrored thermograph records with generally more suitable conditions in headwater reaches, and also for 5-8 miles upstream from the river mouth. The two sites where sediment data is available are at opposite ends of the mainstem, and are not useable to detect sediment transport and deposition trends. However, survey results from nine transects completed by the MRC showed a wide, shallow, alluvial floodplain, mostly devoid of deep pools favored by salmonids during estuarine and lower river residency. Most channel changes at transects consisted of channel shifts within the existing floodplain, including aggradation at one transect; sediment volumes were not calculated. Physical-chemical information for the estuary-mainstem is more thoroughly discussed in the Mattole Basin Summary Water Quality Integrated Analysis Table. In the past the lower estuary was known to develop near anoxic conditions in deeper pools, as documented during 1987 when dissolved oxygen levels reached 2.8 mg/l (Busby, et al., 1988); present conditions are unknown. To summarize, though, the mainstem was suitable for all measured physical-chemical parameters, and probably continues to be so today, even though there are no data available with recent analyses.

Instream Habitat

Introduction

The products and effects of the watershed delivery processes examined in the geology, land use, fluvial geomorphology, and water quality Integrated Analyses tables are expressed in the stream habitats encountered by the organisms of the aquatic riparian community, including salmon and steelhead. Several key aspects of salmonid habitat in the Mattole Basin are presented in the CDFG Instream Habitat Integrated Analysis Table. Data in this table are not sorted into the geologic terrain types since the channel and stream conditions are not necessarily exclusively linked to their immediate surrounding terrain, but may in fact be both spatially and temporally distanced from the sites of the processes and disturbance events that have been blended together over time to create the channel and stream's present conditions. No data were collected in the Mattole estuary during CDFG stream inventories and fish passage barrier evaluation reports conducted under contract to CDFG because the CDFG *California Salmonid Stream Habitat Restoration Manual* methods are not suited to estuary assessments; however, a number of Masters theses of students at Humboldt State University (Young 1987, Busby 1991, Zedonis 1992, and Day 1996), a report on the natural resources of the Mattole estuary for the BLM (Busby et al. 1988), and a report by the Mattole Restoration Council (MRC 1995) examined salmonid habitat conditions in the estuary. Details of these reports are presented in the CDFG Appendix F.

*Table 56. Surveyed instream fish habitat.**

Feature/Function		Significance	Comments
Primary Pools**	No Data	Primary pools provide escape cover from high velocity flows, hiding areas from predators, and ambush sites for taking prey. Pools are also important juvenile rearing areas. Generally, a stream reach must have 30 – 55% of its length in primary pools to suitable for salmonids.	In the late 1980s, the Mattole Salmon Group obtained funding from CDFG to place bank protection and scouring structures in the estuary. The Mattole Restoration Council conducted investigations of the geomorphology of the Mattole estuary. Bathymetry studies revealed the dynamic quality of the estuary when gravel bars were observed to scour away and re-form. The depth of pools in the lower Mattole River was tracked from 1991 to 1994. There was an overall trend of pool aggradation in the study period, though pools adjacent to north bank scour structures did not aggrade.
Cobble Embeddedness	No Data	Salmonids cannot successfully reproduce when forced to spawn in streambeds with excessive silt, clays, and other fine sediment. Cobble embeddedness is the percentage of an average sized cobble piece at a pool tail out that is embedded in fine substrate. Category 1 is 0-25% embedded, category 2 is 26-50% embedded, 51-75% category 3 is embedded, and category 4 is 76-100% embedded. Cobble embeddedness categories 3 and 4 are not within the fully supported range for successful use by salmonids.	None of the salmonids present in the Mattole Basin use the estuary for spawning.
Canopy Density	No Data	Near-stream forest density and composition contribute to microclimate conditions that help regulate air temperature, which is an important factor in determining stream water temperature. Stream water temperature can be an important limiting factor of salmonids. Generally, canopy density less than 50% by survey length is below target values and greater than 85% fully meets target values.	In the late 1980s, the Mattole Salmon Group obtained funding from CDFG to re-vegetate areas of the estuary. In addition, the Mattole Restoration Council has initiated riparian planting programs throughout the basin since 1995.
Salmonid Habitat Artificially Obstructed for Fish Passage	No Data	Free movement in well-connected streams allows salmonids to find food, escape from high water temperatures, escape from predation, and migrate to and from their stream of origin as juveniles and adults. Dry or intermittent channels can impede free passage for salmonids; temporary or permanent dams, poorly constructed road crossings, landslides, debris jams, or other natural and/or man-caused channel disturbances can also disrupt stream connectivity.	

Feature/Function		Significance	Comments
Juvenile Summer Passage:	No Data	Dry channel disrupts the ability of juvenile salmonids to move freely throughout stream systems.	In late May or early June of most years, a sand bar encroaches all the way across the mouth of the Mattole River to form a bay barrier and create a lagoon. Both juvenile Chinook and steelhead trout over-summer in the estuary when the sand bar closes and a lagoon is formed. Juvenile Chinook salmon downstream migration is usually completed in June or the first week of July, and the only Chinook left in the Mattole Basin after this date are in the estuary/lagoon. Steelhead trout, on the other hand, exhibit both tributary and estuary rearing strategies in the Mattole Basin. Therefore, estuary/lagoon summer habitat conditions are important for steelhead trout, but critical for Chinook salmon populations. The lagoon usually opens up again in the fall.
Juvenile Winter Refugia:	No Data	Juvenile salmonids seek refuge from high winter flows, flood events, and cold temperatures in the winter. Intermittent side pools, back channels, and other areas of relatively still water that become flooded by high flows provide valuable winter refugia.	
Large Woody Debris (LWD)	No Data	Large woody debris shapes channel morphology, helps a stream retain organic matter, and provides essential cover for salmonids. There are currently no target values established for the % occurrence of LWD.	In the late 1980s, the Mattole Salmon Group obtained funding from CDFG to construct 24 floating structures in the estuary to provide shade and cover for juvenile salmon and steelhead trout.

* Pools greater than 2.5 feet deep in 1st and 2nd order streams and greater than 3 feet deep in 3rd and 4th order streams are considered primary pools.
**(N=0 Tributaries, 0 Reaches, 0 Miles) (Young 1987, Busby et al. 1988, Busby 1991, Zedonis 1992, MRC 1995, and Day 1996).

Discussion

Although CDFG stream inventory data were not available for the Estuary Subbasin, other studies provided information on instream habitat conditions for salmonids in the estuary. Research on the Mattole estuary has illustrated that high water temperatures and simplified habitat have created harsh conditions for juvenile salmonids during summer lagoon conditions. This poses serious problems for rearing Chinook salmon and steelhead trout that are essentially contained in the lagoon by a thermal plug of very low, warm river inflow, and the sandbar blocking the connection to the Pacific.

Draft Sediment Production EMDS

The draft sediment EMDS is currently under review. Preliminary results are presented in the EMDS Appendix F.

Stream Reach Condition EMDS

The stream reach EMDS was not used to evaluate the estuary.

Analysis of Tributary Recommendations

The small tributaries that flow into the Estuary Subbasin were not inventoried by CDFG survey crews. Therefore, no tributary recommendations exist for this subbasin. However, several recommendations for management and restoration of the estuary were given in the Mattole Restoration Council's 1995 Report, *Dynamics of Recovery*. These recommendations are not necessarily endorsed by NCWAP or any of its member agencies but are summarized in the CDFG Appendix F.

Refugia Areas

The NCWAP interdisciplinary team identified and characterized refugia habitat in the Estuary Subbasin by using expert professional judgment and criteria developed for north coast watersheds. The criteria included measures of watershed and stream ecosystem processes, the presence and status of fishery resources, forestry and other land uses, land ownership, potential risk from sediment delivery, water quality, and other factors that may affect refugia productivity. The team also used results from information processed by NCWAP's EMDS at the stream reach and planning watershed/subbasin scales.

The Estuary Subbasin serves as a point through which all of the Mattole Basin salmonids must pass when they go out to sea and when the return to spawn. This fact makes classifying the estuary into a refugia category difficult. Additionally, the Estuary Subbasin did not contain any tributaries surveyed by CDFG.

However, the NCWAP team was able to use the numerous studies of conditions in the estuary (Young 1987, Busby et al. 1988, Zedonis 1992, MRC 1995, Day 1996, MSG 2000) to make a refugia designation for the Estuary Subbasin.

Salmonid habitat conditions in the Estuary Subbasin are somewhat impaired due to warm summer water temperatures and are rated as medium potential refugia. The overall medium potential refugia rating is based on year round salmonid use and the diversity of the salmonid species assemblage. In addition, the estuary serves as a critical contributing area for Mattole Basin salmonids.

Assessment Focus Areas

__Working Hypothesis 1:__

The present state of estuarine habitat is limiting the successful production of salmonids, especially Chinook, in the Mattole River.

__Supporting Evidence:__

- Thermograph studies in the Mattole estuary from 1986 to 1992 found water temperatures in the upper lagoon to be above the 50-60°F optimal salmonid temperature range (MRC 1995, NCRWQCB Appendix E).
- Additional thermograph studies in the estuary in 1998, 1999, and 2000 showed that water temperatures were still above the 50-60°F optimal salmonid temperature range (NCRWQCB Appendix E).
- High temperatures in the estuary may have caused thermal trauma in juvenile Chinook salmon and be directly responsible for high mortality in late August 1984 and 1985. High temperatures probably limited juvenile Chinook salmon habitat and may have reduced food abundance (Young 1987).
- Optimum water temperatures for steelhead trout were exceeded more often in 1988 than in 1987. A reduction in steelhead trout yearling growth in the estuary was observed in 1988 (Zedonis 1992).
- Historic accounts indicate that the Mattole estuary was once much deeper and perhaps larger than it is now (Busby et al. 1988).
- Cooler, deep water habitats are not common in the estuary. Filling of the estuary with suspended and bed load sediments from upstream reduced the ability of the tidal prism to remove this material (Busby et al. 1988).
- The Mattole Restoration Council (MRC) found an overall trend in pool aggradation from 1991-1994 in the estuary (1995).
- Pools accounted for less than 1/6 of the channel length or area in 1991 habitat typing surveys in the estuary (MRC 1991).
- Nearly all pools in the estuary were main channel pools, which have less habitat value for salmonids than scour or backwater pools (MRC 1991, Flosi and Reynolds 1994).
- More than one half of the pool area surveyed had a cover value of 1 on a scale of 0-3. Cover values were also low for flatwater and riffles (MRC 1995).
- Throughout the lower Mattole River and estuary, many instream areas present relatively barren habitat for salmonids due to lack of cover or complexity (MRC 1995).
- In the late 1980s, the Mattole Salmon Group (MSG) obtained funding from CDFG to construct 24 floating structures in the estuary to provide shade and cover for juvenile salmonids (CDFG Appendix F).
- Additional seasonal shade and cover structures were proposed by the MRC in 1995.
- In years of early estuary closing, peak periods of zooplankton and drift abundance appear to lag behind peak abundances of juvenile Chinook salmon in the estuary, contributing to mortality, and suppressed growth (Busby 1991).
- Dissolved oxygen concentrations only went below the minimum acceptable level of 5.0 parts per million set by the United States Environmental Protection Agency on two nights. In both cases the

low oxygen concentration was limited to the bottom 1.6 feet of a single sampling station, and was thought to be caused by algae respiration and a lack of water mixing (Busby et al. 1988).

Contrary Evidence:

- Isolated pockets of colder water were found in the mainstem Mattole River immediately upstream from the estuary at five locations: at the mouths of Collins Gulch, Bear Creek (RM 1.0), Stansberry Creek, Titus Creek, and Mill Creek (RM 2.8) in 1991 (MRC 1995).
- Mill Creek (RM 2.8) never showed maximum weekly average water temperatures (MWAT) higher than 58°F in the years of record. Similarly, Stansberry Creek MWATs were in the 58°F in most sampling years (NCRWQCB Appendix E).
- Mill Creek (RM 2.8) has experienced summer flows anywhere from 2-3 cubic feet per second (cfs) to 10 cfs. This is higher than the discharge at nearby tributaries, and ranges from 13-66% of the flow of the mainstem Mattole River at the Petrolia gaging station (NCRWQCB Appendix E).
- Dissolved oxygen concentrations in the upper estuary ranged from 2.8 to 14.5 parts per million in 1987. Concentrations in the lower estuary ranged from 7.0 to 15.4 parts per million in 1986 and from 5.0 to 11.8 parts per million in 1987 (Busby et al. 1988).
- Data indicate that growth and survival of juvenile Chinook salmon in the estuary are density dependant (Busby et al. 1988).

Hypothesis 1 Evaluation:

Based upon the predominance of current supportive findings, the hypothesis is supported at this time.

Working Hypothesis 2:

Sea lion and harbor seal predation of adult salmonids are responsible for the decline in Mattole River fish stocks.

Supporting Evidence:

- For many years local residents have observed sea lion and harbor seal predation upon adult salmonids stocks in the estuary during fall spawning runs.
- Populations of seals and sea lions have been increasing since the passage of the Marine Mammal Protection Act in 1972 (DFG Marine Resource Report 2002). California sea lion populations in US waters have increased from around 25,000 in 1970 to over 150,000 in 1997 (Stewart 1997).

Contrary Evidence:

- Recent studies conducted at the mouth of the Klamath estuary estimated that seals and sea lions combined ate 2.3-2.6% of the fall Chinook salmon entering the Klamath estuary (Williamson 2002). A dietary analysis of California sea lions at the mouth of the Klamath found that lampreys were the main prey item and that 1-8% of diet samples included salmon (Bowlby 1981).Juvenile Chinook salmon populations dropped to zero in the Mattole estuary in August 1987 (Barnhart and Young 1985, Barnhart and Busby 1986, Busby et al. 1988).

Hypothesis 2 Evaluation:

Based upon the conflicting nature of supportive and contrary findings, the hypothesis is not supported at this time.

Working Hypothesis 3:

Anadromous salmonid populations in the estuary subbasin have declined since the 1950s.

Supporting Evidence:

- The Estuary Subbasin is used by Chinook salmon, coho salmon, and steelhead trout during outmigration to the ocean and return migrations for spawning. In addition, juvenile Chinook salmon and steelhead trout utilize the Mattole estuary for over summering. This over summering is critical for Chinook salmon, but less important for steelhead trout as steelhead also use tributary habitat for over summering (Busby et al. 1988, CDFG 2002).

- Juvenile Chinook salmon populations have been low in the Mattole estuary since August 1987 (Barnhart and Young 1985, Barnhart and Busby 1986, Busby et al. 1988, MRC 1995, MSG 2000).
- MSG instituted a juvenile Chinook salmon rescue-rearing program in 1993. MSG project personnel and volunteers net up to 6,000 naturally spawned downstream migrant salmonids each year and hold them in rearing ponds at Mill Creek. Volunteers rear fish until water temperatures drop and/or the lagoon opens to the sea with fall rains (CDFG Appendix F).
- Approximately 20,000 rescue-reared juvenile Chinook salmon have been released (MSG 2000).
- Estimated Chinook salmon populations in the Mattole Basin have increased from lows of 100 in 1990-1991 to 700 in 1999-2000 (MSG 2000).

Contrary Evidence:

No contrary evidence at this time.

Hypothesis 3 Evaluation:

Based upon current supportive and contrary findings for the streams surveyed, the hypothesis is supported.

Responses to Assessment Questions

What are the history and trends of the sizes, distribution, and relative health and diversity of salmonid populations within this subbasin?

Conclusions:

- Historical accounts indicate that the Estuary Subbasin supported populations of Chinook salmon, and steelhead trout throughout the summer months, in addition to being a vital transitional step on the seaward migration of juvenile salmonids and the returning spawning migration of adult salmonids. Biological studies were conducted in the estuary in the late 1980s and early 1990s by HSU researchers and the Mattole Restoration Council along with current population counts by the Mattole Salmon Group. These studies indicate that over-summering Chinook salmon and steelhead trout populations in the Estuary Subbasin are currently depressed;

What are the current salmonid habitat conditions in this subbasin? How do these conditions compare to desired conditions?

Conclusions:

- Instream sediment from both past land use and natural geologic processes upstream has been delivered to the estuary by large storm events, impacting the low gradient estuarine channel. Comparison of 1942 and 1965 photos indicates that the estuary widened, and areas of vegetation were lost during that time frame. However, the 1984 and 2000 aerial photos show some channel narrowing and vegetative improvement during this time period. Whereas dormant landslides, steep terrain and areas with high to very high landslide potential indicate that slopes in the subbasin are susceptible to landsliding and erosion, the bulk of excess instream sediment appears to have been transported from upstream sources;

What are the relationships of geologic, vegetative, and fluvial processes to natural events and land use history?

Conclusions:

- Soil disturbance associated with several agricultural and development activities have exacerbated the naturally high levels of sediment delivery to the Mattole River and its tributaries. In particular, vegetation removal and road construction during the post 1950 peak timber harvest period, coupled with the transport energy of the devastating floods of 1955 and 1964 have created extensive negative stream characteristics in the lower reaches of many large tributaries including mainstem Honeydew Creek. These negative impacts include displaced riparian vegetation; wide, aggraded channels; and very warm summertime water temperatures. These impacts have become resident in the Estuary Subbasin;

How has land use affected these natural processes?

Conclusions:

- The present state of estuarine habitat is limiting the successful production of salmonids, especially Chinook salmon. Based on known salmonid temperature suitability studies, current sediment, and temperature impacts in the estuary are thought to be deleterious to summer rearing salmonid populations. Results of habitat assessment conducted from 1988 through 1994 in the estuary by Humboldt State University, Mattole Restoration Council, and Mattole Salmon Group researchers identified a critical shortage of adequate pool habitat, water depth, substrate embeddedness, and escape and ambush cover. These are all necessary for survival of salmonids in the critical over-summering life stage;

Based upon these conditions trends, and relationships, are there elements that could be considered to be limiting factors for salmon and steelhead production?

Conclusions:

- Although lack of escape cover for fish increases the risk of predation by birds, mammals, etc., data from other river systems indicate that seal and sea lion predation is usually not limiting to salmonids. These data indicate pinnipeds are not likely to have a large impact on Mattole Basin salmonid runs.

What habitat improvement activities would most likely lead toward more desirable conditions in a timely, cost effective manner?

Key Recommendations:

- Continue to support the Mattole Salmon Group's Chinook juvenile rescue rearing and fish-tagging efforts, and incorporate a program to monitor effectiveness;
- Reduce sediment deposition to the estuary by supporting a basin-wide road and erosion assessment/control program such as the Mattole Restoration Council's Good Roads, Clear Creeks effort;
- Avoid potential sedimentation directly into the estuary from the estuary's upland slopes, which are predominantly mélange bedrock and dormant landslides. Encourage the use of appropriate Best Management Practices to achieve this objective;
- Consider the nature and extent of naturally occurring unstable geologic terrain, landslides and landslide potential (especially Categories 4 and 5, page 89) when planning potential projects in the subbasin;
- Maintain and enhance existing riparian cover. Use cost share programs and conservation easements as appropriate;
- Support ongoing local efforts that monitor summer water and air temperatures on a continuous 24-hour basis to detect long-range trends and short-term effects on the aquatic/riparian community;
- Support efforts to determine the role of the mainstem Mattole River in elevated estuarine water temperatures;
- Utilize Humboldt State University studies conducted in the early 1990s as baseline information to periodically monitor trends in estuarine conditions and fish production;
- Protect instream flows in Mill Creek (RM 2.8) and Stansberry Creek for thermal refugia;
- It would be informative to further study the degree to which the cool, summer base flow from Mill Creek (RM 2.8) could temper the warmer mainstem Mattole River waters and provide an area of cool water refugia. To do so, a summer low flow connection between Mill Creek and the river would have to be established through the Mattole's gravel floodplain.

Subbasin Conclusions

Salmon and steelhead habitat conditions in Estuary Subbasin are inhospitable during summer periods resulting from naturally occurring geologic processes and basin-wide land use. High sediment deposition levels, high summer water temperatures, shallow channels, and simplified salmonid habitat indicate that present estuary stream conditions are likely not fully supportive of salmonids during summer rearing periods.

However, historical accounts indicate that estuarine conditions were favorable for salmonid populations in the past. Accordingly, there are opportunities for improvements in conditions and a great need for improvements to support juvenile rearing needs. Water temperature monitoring, riparian canopy restoration, and adding LWD to improve channel complexity are examples of appropriate short term improvement activities that can be initiated directly in the estuary.

However, aquatic and channel conditions at the most downstream section of a river system are a response to watershed products transported from throughout the basin. Fine sediment and warm water are two watershed products most deleterious to the Mattole Estuary's fisheries. As such, long term improvements in the estuary must be produced by careful watershed stewardship throughout the Mattole Basin.

In general, the Mattole Basin is largely composed of a preponderance of naturally unstable and erosive terrain. In this fragile environment, land use project planning must include consideration of appropriate Best Management Practices (BMPs). These should be prescribed and followed during the course of any project to minimize erosion and sediment delivery and to prevent vegetation removal near streams. Many current landowners and managers are interested and motivated to eliminate watershed and stream impacts related to land use, and wish to accelerate a return to stable, beneficial conditions for salmonids. They are encouraged to do so, enlisting the aid and support of agency technology, experience, and funding opportunities.

Northern Mattole Subbasin

North Fork Mattole River agricultural land near Petrolia.

Introduction

The Northern Subbasin is located between the Estuary Subbasin and Honeydew Creek at River Mile 26.5 (RM 26.5) along the northeastern side of the Mattole mainstem. Eighteen perennial streams drain a watershed area of 98 square miles. Figure 60 shows Northern Subbasin tributaries and CalWater 2.2a Planning Watersheds. Elevations range from five feet at the estuary to approximately 2,500 feet in the headwaters of the tributaries.

The Northern Subbasin is largely managed for timber production and cattle ranching. The town of Petrolia is located in this subbasin at the confluence of the North Fork Mattole River and the Mattole River. Several back-to-land homesteads are located near Petrolia. Controversies concerning old-growth timber harvest issues are focused on Rainbow and Long ridges in this subbasin.

The NCWAP team's Northern Subbasin results and analyses are presented in three basic sections. First, general information describing the subbasin is presented by different disciplines. Secondly, this information is integrated and presented to provide an overall picture of how different factors interact within the subbasin. Lastly, an overall assessment of the Northern Subbasin is presented. The NCWAP team developed hypotheses, compiled supportive and contrary evidence, and used these six assessment questions to focus this assessment:

- What are the history and trends of the sizes, distribution, and relative health and diversity of salmonid populations within this subbasin?
- What are the current salmonid habitat conditions in this subbasin? How do these conditions compare to desired conditions?
- What are the relationships of geologic, vegetative, and fluvial processes to natural events and land use history?
- How has land use affected these natural processes?

- Based upon these conditions trends, and relationships, are there elements that could be considered to be limiting factors for salmon and steelhead production?
- What habitat improvement activities would most likely lead toward more desirable conditions in a timely, cost effective manner?

The assessment questions are answered at the end of this section.

Climate

The Northern Subbasin experiences the widest range of both temperature and precipitation in the Mattole Basin. Air temperatures range from below freezing in winter to over 100°F in summer. Temperatures near Petrolia are moderated year-round by the proximity of the ocean, while the inland areas experience the extremes. Annual rainfall averages range from 60 inches near Petrolia to 115 inches on the eastern ridgetops. Although most precipitation falls as rain, snow falls in the higher regions of the subbasin are not uncommon.

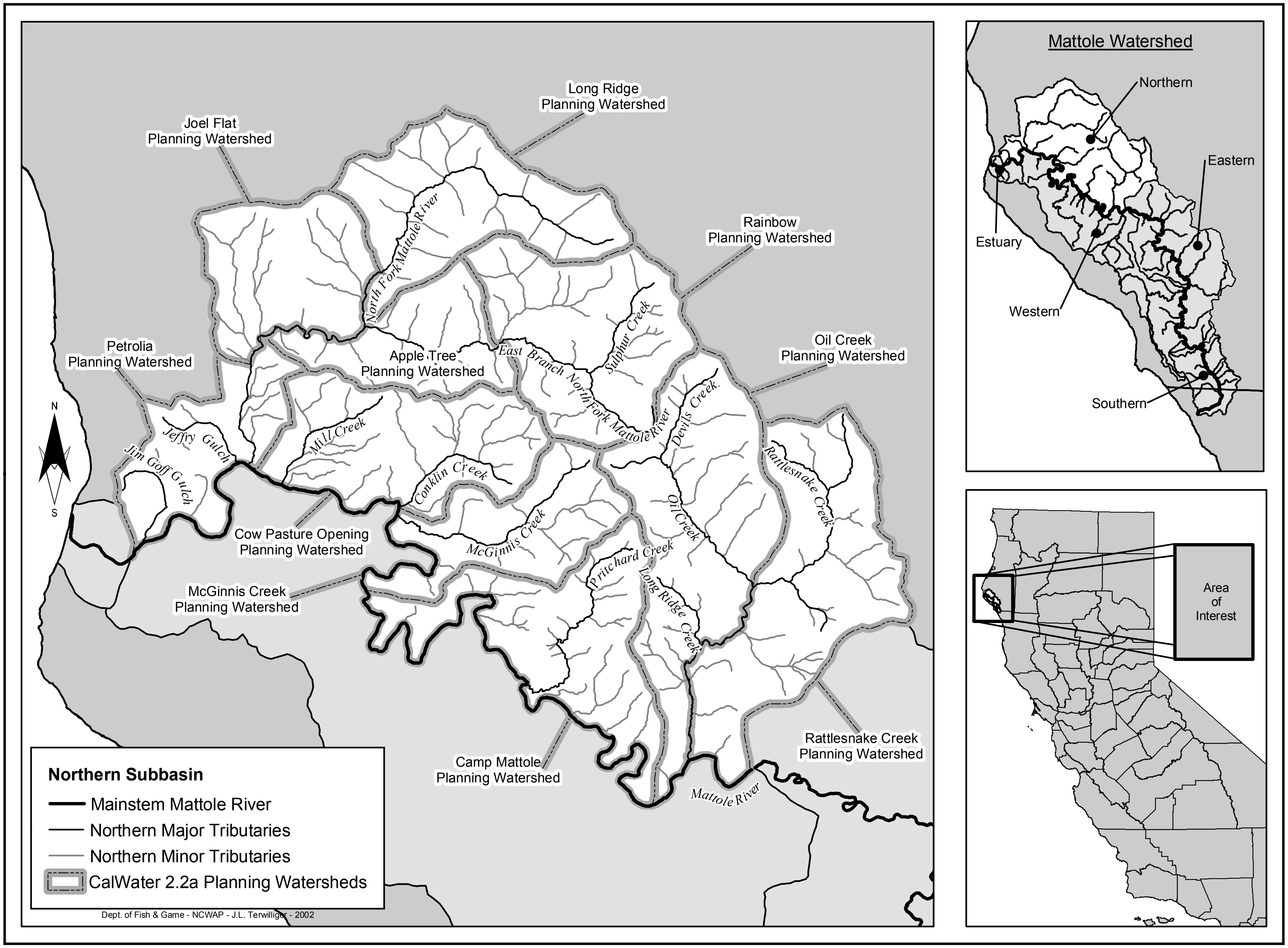


Figure 60. Mattole Northern Subbasin.

Hydrology

The Northern Subbasin is made up of nine complete CalWater Units and most of the Petrolia CalWater Unit (Figure 61). There are 69.6 perennial stream miles in 18 perennial tributaries in this subbasin (Table 57). Ten of these tributaries have been inventoried by CDFG. There were 17 reaches, totaling 20.9 miles in the inventory surveys. The inventories included channel and habitat typing, and biological sampling.

Table 57. Northern Subbasin with estimated anadromy.

Stream	CDFG Survey (Y/N)	Survey Length (miles)	Estimated Anadromous Habitat Length (miles)*	Reach	Channel Type
Jim Goff Gulch	N		0.7		
Jeffry Gulch	N				
North Fork Mattole River	Y		8.0		
	Y	2.6		1	C3
	Y	0.4		2	B3
East Branch North Fork Mattole River	N		0.9		
Sulphur Creek	Y	0.5		1	B4
Sulphur Creek Tributary #1	Y	0.1		1	C4
Sulphur Creek Tributary #2	Y	0.5		1	B4
Mill Creek (RM 5.5)	N		1.3		
Conklin Creek	Y	0.6	2.2	1	C4
McGinnis Creek	Y		3.1		
	Y	3.0		1	C4
	Y	0.7		2	B3
Thornton Creek	N				
Pritchett Creek	N				
Singley Creek	N				
Holman Creek	N				
Upper North Fork Mattole River	N		3.5		
Oil Creek	Y		3.3		
	Y	0.3		1	A1
	Y	2.5		2	B2
	Y	0.3		3	A2
Green Ridge Creek	Y	0.7	0.6	1	A2
Devils Creek	Y		0.8		
	Y	0.7		1	B2
	Y	0.7		2	A3
Rattlesnake Creek	Y		3.0		
	Y	0.5		1	B2
	Y	1.4		2	B1
	Y	2.4		3	A3

* Data from the Mattole Salmon Group.

In their inventory surveys, CDFG crews utilize a channel classification system developed by David Rosgen (1994) and described in the *California Salmonid Stream Habitat Restoration Manual*. Rosgen channel typing describes relatively long stream reaches using eight channel features: channel width, depth, velocity, discharge, channel slope, roughness of channel materials, sediment load and sediment size. There are eight general channel types in the Rosgen classification system.

In the Northern Subbasin, there were five type A channels, totaling 4.4 miles; eight type B channels, totaling 7.2 miles; and four type C channels, totaling 6.9 miles. Type A stream reaches are narrow, moderately deep, single thread channels. They are entrenched, high gradient reaches with step/pool sequences. Type A reaches flow through steep V- shaped valleys, do not have well-developed floodplains, and have few meanders. Type B stream reaches are wide, shallow, single thread channels. They are moderately entrenched, moderate to steep gradient reaches, which are riffle-dominated with step/pool sequences. Type B reaches flow through broader valleys than type A reaches, do not have well-developed floodplains, and have few meanders. Type C stream reaches are wide, shallow, single thread channels.

They are moderately entrenched, low gradient reaches with riffle/pool sequences. Type C reaches have well-developed floodplains, meanders, and point bars (Flosi, et al., 1998).

Geology

The Northern Subbasin (Figure 61) has the most structurally disrupted and least stable geology within the watershed. The bedrock underlying the Northern Subbasin is dominated by mélange (subunit co1) of the Franciscan Coastal terrane composed of scattered blocks of intact rock set within a matrix of pervasively sheared argillite and sandstone. This soft geologic material comprises 43% of the Northern Subbasin, as compared with 0 to 19% in the other major Mattole subbasins (Figure 24, pg.91). The mélange is generally too weak to support development of steep slopes. Accordingly, rolling hillsides, moderate slopes, and rounded crests have developed over much of this subbasin. Clayey residual soils tend to develop on the mélange that are subject to chronic down-slope movement through soil creep. Grassy vegetation generally develops in these areas of weathered mélange where conifer and hardwood trees have a difficult time becoming established on the clayey soil. These conditions are broadly reflected in the Northern Subbasin. Steep to very steep slopes are present in this subbasin as well, particularly along the northern and eastern boundaries. These slopes are formed in hard and moderate terrains, and trees are therefore more established in those areas.

An irregular drainage pattern lacking a preferred orientation and spacing has developed on the disrupted bedrock geology underlying the upper reaches of most streams in the Northern Subbasin. The mainstem Mattole and lower reaches of the Upper North Fork and North Fork meander within alluvial channels. Extensive terrace remnants of older alluvial deposits and strath surfaces extend over the broad valley bottoms above the active channel.

An abundance of historically active and dormant landslides of different types have been mapped in the subbasin, including large landslide complexes that impact entire hillsides covering many tens of acres. Over 32% of the subbasin area is underlain by historically active or dormant landslides, and approximately 8% of the subbasin is affected by historically-active landslides (Figure 25, pg.91) (Figure 28 of the Geologic Report). These landslides are predominantly found in the soft terrain. Historically active earthflows are particularly common here in comparison to their occurrence in the other subbasins. Accordingly, landslide potential is ranked highest in this subbasin, with approximately 61% of the area included in the high to very high potential categories. The delivery of sediment to streams through gully erosion and debris flows associated with larger historically active and dormant landslides is also prevalent in the subbasin. In the North Fork, the high rate of sediment input from erosion and mass wasting is reflected in the accumulation of debris and alluvial fans at the mouths of many tributary drainages. A map showing the distribution of geologic units, landslides, and geomorphic features is presented on Plate 1 in the Geologic Report, Appendix A.

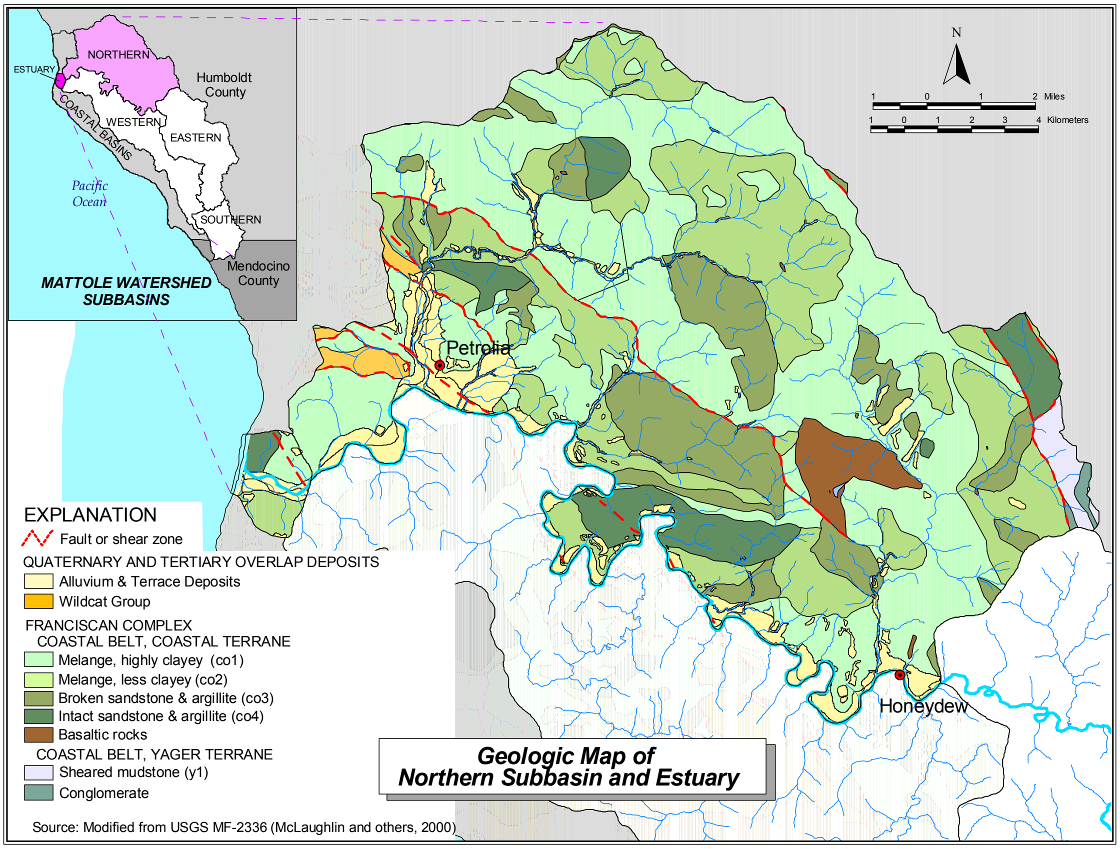


Figure 61. Geologic map of the Northern Subbasin.

Vegetation

Unless otherwise noted, the vegetation description in this section is based on manipulation of CalVeg 2000 data. This is vegetation data interpreted from satellite imagery by the United States Forest Service, Remote Sensing Lab. The minimum mapping size is 2.5 acres.

Occupying 31% of the Northern Subbasin, there is more grassland in this subbasin than in any of the others (Figure 62). Mixed hardwood and conifer forests cover 44% of the area, conifer forest 11%, and hardwood forest 12% for a total of 67% forested area. The largest contiguous old growth forest remaining in the entire watershed can be found in this subbasin. The current forested vegetation largely reflects the impacts of harvesting and wildfire. Two fires in 1990 covered 6,700 acres, mostly in the Oil Creek and Camp Mattole planning watersheds. Forty percent of the Northern Subbasin is in the 12 to 23.9 inch diameter breast height (dbh) size class. Only seven percent of the forest stands have average tree diameters greater than twenty-four inches. Some stands of old-growth Douglas fir forest are in private ownership, but not all stands greater than 24 inches dbh are old-growth forest and specific areas were not identified as old-growth stands within this report. Shrub, barren, agricultural lands, and urban classifications together cover the remaining 2% of the area.

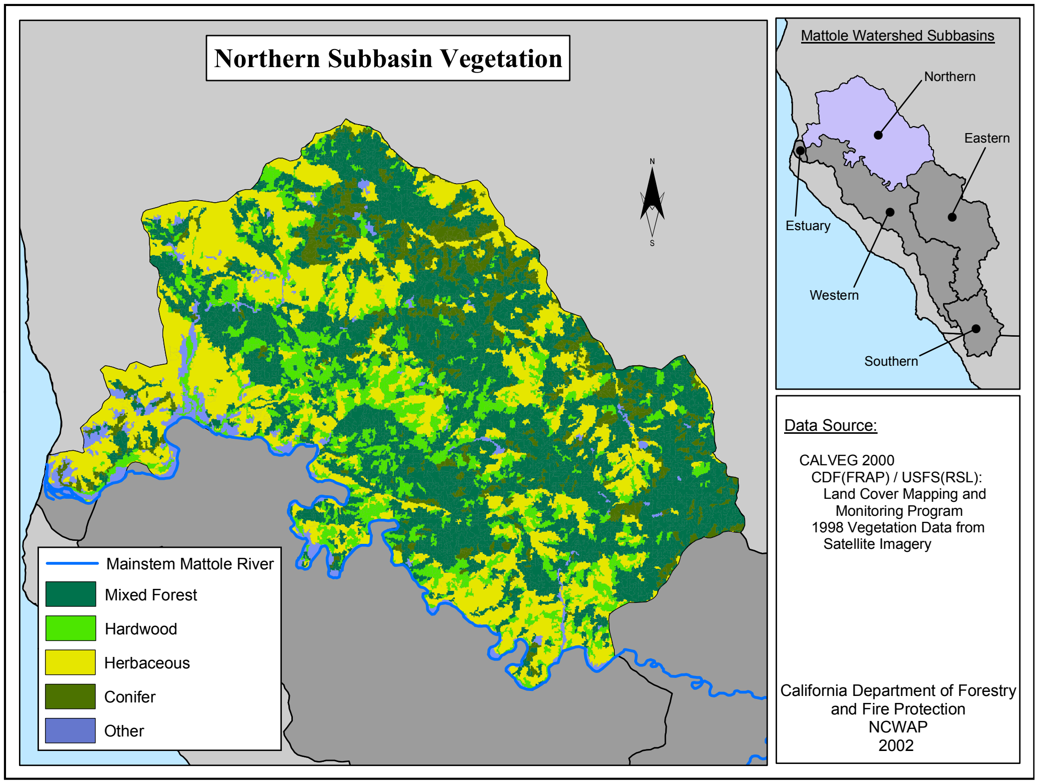


Figure 62. Vegetation pattern of the Northern Subbasin.

Land Use

Census 2000 data indicate that 200 people have their permanent residence in this subbasin, many of them in and surrounding the town of Petrolia. Grazing and timber management are the major land use activities. Grazing activity is primarily on non-irrigated natural grasslands. The 1941 aerial photographs show widespread indications of grazing, and written accounts make it clear that Petrolia and the surrounding grasslands have influenced the local landscape since settlement in the 1860s. This subbasin contains the largest blocks of land held in private ownership, including the Pacific Lumber Company (~18,000 acres) as the major industrial timberland owner (Figure 63). Timber harvesting since 1983 has occurred on a small percentage of the subbasin, almost entirely on industrial timberland.

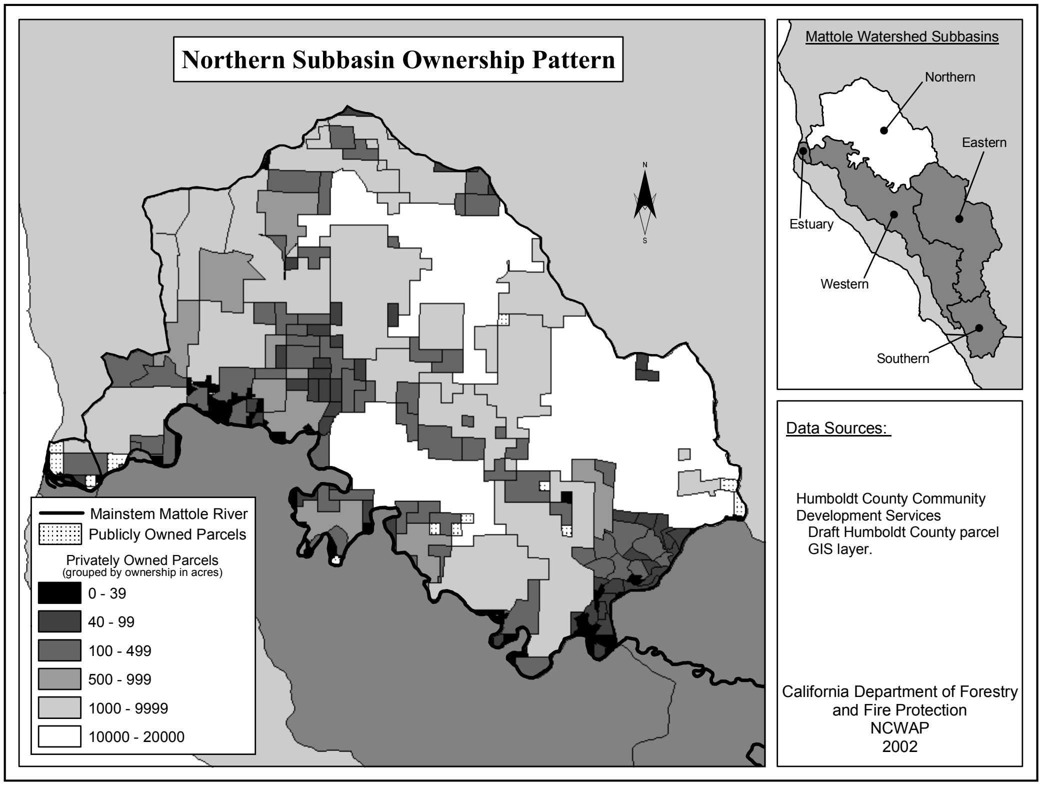


Figure 63. Ownership pattern of the Northern Subbasin.

Timber harvesting covered a substantial portion of the basin prior to the 1964 flood (

Table 58 and Figure 64). Aerial photograph analysis and 1952 aerial photographs, the main activity appeared to be maintenance of grassland and conversion of forestland to grassland. In many cases, grassland conversion was accomplished by use of fire, though in the aerial photographs standing dead trees were present while there was no indication of skid trails for harvesting. Later, as timber harvesting began, the primary method was tractor logging down to streamside road systems. The silviculture was a type of seed tree cut that often left brush and some conifer. Timber harvesting activity since 1983 has covered about 10% of the subbasin (Figure 65). One area of locally intensive harvest, in the Oil Creek planning watershed, was a sanitation/salvage harvest following the 1990 Rainbow wildfire. Since 1983, there is still a large percentage of tractor logging by area that has occurred. The silvicultural systems appear to be based on the uneven nature of the stands that were left after first entry and primarily consist of even-aged regeneration methods. About one-fifth of the total acres have had a commercial thin or selection treatment.

Table 58. Timber harvest history, Northern Mattole Subbasin.

TIMBER HARVEST HISTORY - NORTHERN SUBBASIN*				
	Total Harvested Acres	**Total Area Harvested (%)**	**Average Annual Harvest (ac)**	**Annual Harvest Rate (%)**
Harvested 1945 - 1961**	21,555	34%	1,268	2%
Harvested 1962 - 1974**	7,675	12	590	1
Harvested 1975 - 1983**	968	2	108	<1
Harvested 1984 - 1989	1,291	2	215	<1
Harvested 1990 - 1999	3,364	5	336	<1
Harvested 2000 - 2001	1,281	2	641	1
Not Harvested:				
Grasslands	19,479	31		
Brush and Hardwoods	8,194	13		

* Does not add to 100% due to data discrepancies, re-harvest areas, and uncut timber areas.

** CDF has not yet validated the accuracy of this data (obtained from MRC).

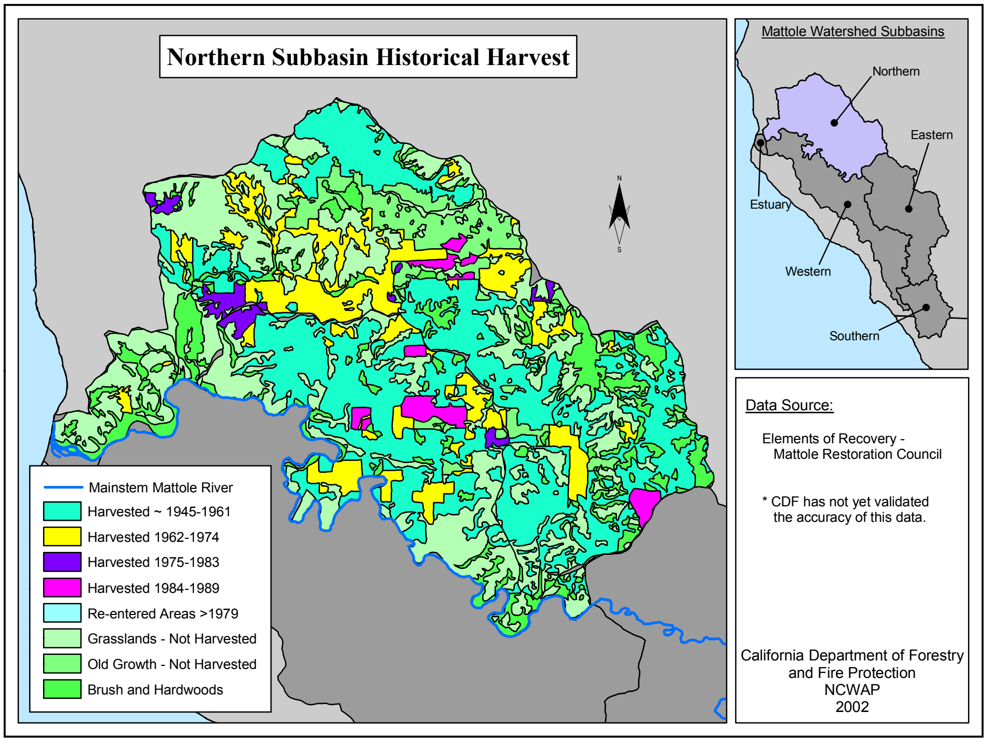


Figure 64. Timber harvest history for the Northern Subbasin.

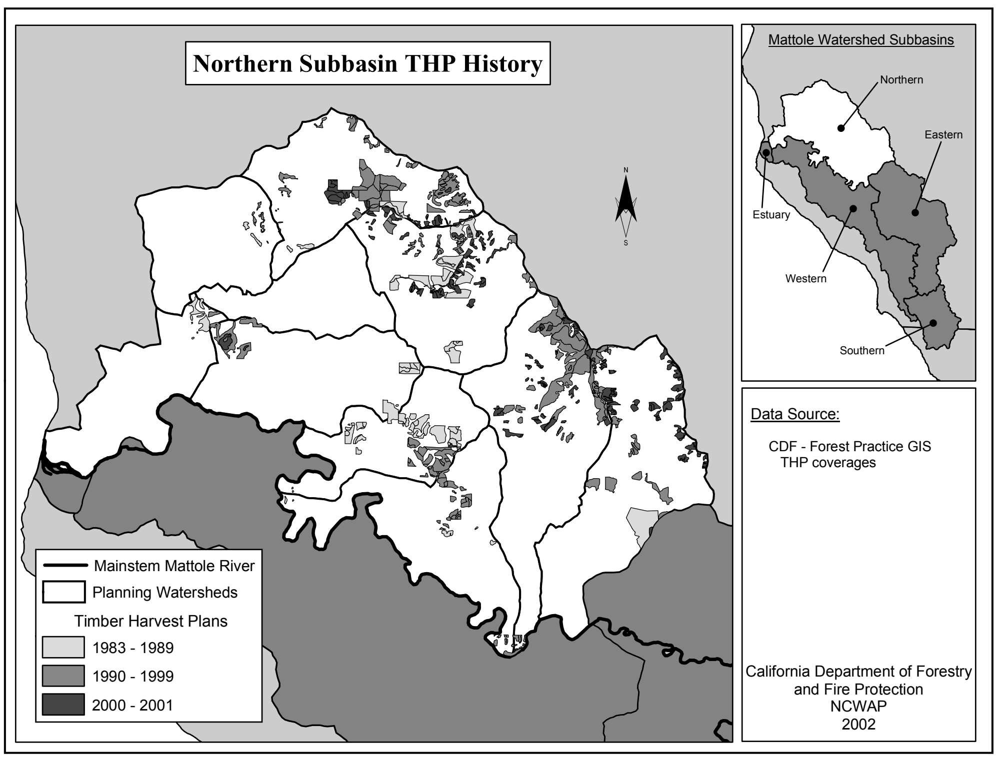


Figure 65. Timber harvesting plan history 1983-2001, Northern Subbasin.

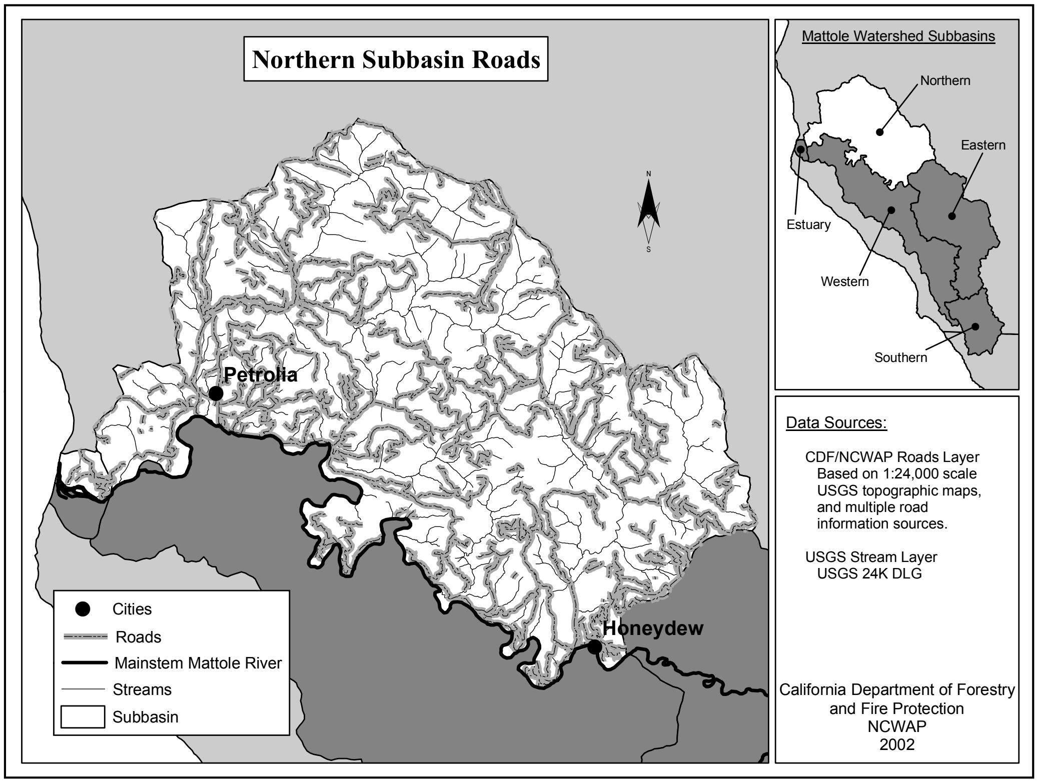


Figure 66. Northern Subbasin roads

Fluvial Geomorphology

The Northern Subbasin is characterized by the highest concentration of mapped gullies and length of Mapped Channel Characteristics (MCCs) in the study area. Table 59 and Table 60illustrate the range of these characteristics observed on 1984 and 2000 aerial photographs. The total length of MCCs decreased only slightly from 1984 to 2000. The cumulative length of gullies increased from 259,500 to 771,700 feet during the same period. Lateral-bar development ranged from low to high values within sub-reach lengths.

CGS Geologic Report-Table 12 illustrates changes in the individual Negative Mapped Channel Characteristics (NMCCs) between 1984 and 2000. There was a 7% decrease in the total length of NMCCs within the subbasin (CGS Geologic Report-Table 12), with most of the change coming from reduction in displaced riparian vegetation. Despite this, there was a 5% increase in NMCC length within the soft terrain during this time period. Just under half of all blue line streams that cross bedrock are adjacent to or within LPM categories 4 and 5 in this subbasin are also affected by NMCCs. Only a small improvement in this measure was observed between 1984 and 2000 (Table 76 and CGS Geologic Report Table 14).

A close examination of Table 60 reveals that six PWs (Joel Flat, Long Ridge, McGinnis Creek, Petrolia, Rainbow, and Rattlesnake Creek) have shown reductions (ranging from 5% to 25%) in the length of MCCs. Two PWs (Apple Tree and Camp Mattole) have remained about constant between 1984 and 2000, and two others, Cow Pasture Opening and Oil Creek, have shown significant increases (23% and 8%, respectively) in MCCs. The length of gullies has increased in all PWs between 1984 and 2000.

Table 59 documents the number of sites and summarizes the lengths of eroding bank features within the Northern Subbasin on the 2000 air photos. In general, streambank erosion has been observed within all of the planning watersheds within this subbasin. The number of eroding bank sites range from one in the Joel Flat PW to 12 in the Rattlesnake Creek PW. Approximately 8,200 feet of eroding bank has been mapped in the Rattlesnake Creek PW.

In summary, eight of the ten Planning Watersheds within the Northern Subbasin have remained relatively constant, or exhibited a slight reduction, in mapped channel characteristics and lateral-bar development between 1984 and 2000. However, the Cow Pasture Opening and Oil Creek PWs have demonstrated an increase in MCCs. All of the planning watersheds have exhibited an increase in the length of gullies during this same period. In addition, several large areas of on-going sediment deposition were observed along the North Fork Mattole River near Petrolia and Upper North Fork near Honeydew. These areas of deposition have been attributed to backwater effects with the mainstem of the Mattole River. Streambank erosion has been observed within all of the planning watersheds within the Northern Subbasin. These sites of streambank erosion are commonly associated with areas mapped as inner gorges or historically active landslides.

Table 59. Eroding stream bank lengths - Northern Subbasin.

2000 Photos				
Northern Subbasin Planning Watersheds[1]	**Number of Sites[2]**	**Maximum Length (feet) of Eroding Bank[3]**	**Total Length (feet) of Eroding Bank[4]**	**Eroding Bank (%)[5]**
Apple Tree	5	600	1,800	4
Camp Mattole	5	700	1,900	3
Cow Pasture Opening	2	500	700	<1
Joel Flat	1	400	400	1
Long Ridge	8	1,200	5,000	7
McGinnis Creek	7	1,600	3,600	5
Oil Creek	9	700	3,300	3
Petrolia	2	500	1,000	2
Rainbow	5	600	2,100	2
Rattlesnake Creek	12	2,900	8,200	9

1 See Figure 2 for location.
2 Number of sites mapped from air photos within PW.
3 Maximum length of a continuous section of eroding stream bank within PW.
4 Combined total length of all sections of eroding stream bank within PW.
5 Approximate percentage of eroding stream bank relative to total stream length within PW.

Table 60. Fluvial geomorphic features - Northern Subbasin.

	2000 Photos			1984 Photos		
Planning Watersheds[1]	**Length of Mapped Channel Characteristics[2] (feet)**	**Total Gully Length[3] (feet)**	**Lateral Bar Development[4]**	**Length of Mapped Channel Characteristics[2] (feet)**	**Total Gully Length[3] (feet)**	**Lateral Bar Development[4]**
Apple Tree	24,100	48,000	2-3	23,900	12,300	3-4
Camp Mattole	72,800	75,300	3-5	72,100	40,600	3-4
Cow Pasture Opening	30,600	50,500	1-2	24,900	11,600	2-3
Joel Flat	14,000	121,700	1-3	18,600	18,100	2-3
Long Ridge	37,000	96,600	4-5	48,900	51,000	4-5
McGinnis Creek	44,000	24,500	4-5	46,500	9,400	3-5
Oil Creek	73,900	123,000	4-5	68,600	48,100	4-5
Petrolia	34,500	74,100	3-5	39,000	25,400	4-5
Rainbow	63,000	87,200	4-5	69,000	27,500	4-5
Rattlesnake Creek	68,300	70,800	3-5	80,100	15,600	4-5
Northern Subbasin Totals	**462,200**	**771,700**		**491,600**	**259,500**	

1. See Figure 2 for location.
2 Features include negative and neutral characteristics including: wide channels, displaced riparian vegetation, point bars, distribution and lateral or mid-channel bars, channel bank erosion, and shallow landslides adjacent to channels.
3 Gullies include those that appear active, have little to no vegetation within the incised area, and are of sufficient size to be identified on aerial photos.
4 Lateral bars include mappable lateral, mid-channel bars and reflect sediment supply and storage. Rankings range from 1-5. Higher values suggest excess sediment.

Aquatic/Riparian Conditions

Unless otherwise noted, the vegetation description in this section is based on manipulation of CalVeg 2000 data. This is vegetation data interpreted from satellite imagery by the United States Forest Service, Remote Sensing Lab. The minimum mapping size is 2.5 acres.

Vegetation within 150 feet of the centerline of streams is 53% mixed conifer and hardwood forest, 17% hardwood, 10% conifer forest, 10% annual grassland and 7% barren while shrubs, water, agricultural and urban combined make up the remaining 3%. Riparian hardwood plant communities occupy only 2% of this near-stream area while hardwood dominated timber sites in this zone occupy 1.5% of the area. A large percentage of barren ground occurs primarily along the Mattole River and the lower reaches of the North Fork and Upper North Fork of the Mattole River. The area occupied by this single width zone is 12% of the total Northern Subbasin acreage.

Visual observation along the county roads adjacent to the Mattole River and the downstream reaches of the North Fork and the Upper North Fork indicates that the riparian area is often restricted and defined by the location of these roads. The grassland component is mainly adjacent to upslope grassland. In aerial photos it can be seen that while there are a tremendous number of springs originating near the ridgetops, some of which have definite channels and narrow riparian strips connecting to the stream systems, many tributaries in the grassland lack riparian vegetation. Hardwood dominated timber site is a classification that categorizes the area as a commercial timber site that has been converted to a vegetation type that no longer contains conifers.

Fish Habitat Relationship

Anadromous stream reach conditions in the Northern Subbasin were somewhat unsuitable as evaluated by the stream reach EMDS. The anadromous reach condition EMDS calculation is derived from water temperature, riparian vegetation, stream flow, and channel characteristics. More details are in the EMDS Appendix C. EMDS results are considered along with other assessment sources.

Data on water temperature and stream flow have not yet been incorporated into EMDS. However, water temperature data are presented in the NCRWQCB Appendix E and stream flow data are presented in the DWR Appendix D and in individual stream survey report summaries in the CDFG Appendix F. Stream temperatures were collected in the North Fork of the Mattole River, Conklin Creek, and the Upper North Fork of the Mattole River. Average high temperatures in Green Ridge Creek in 1991 and Oil Creek during 1991, 1993, and 1994 exceeded the critical peak lethal temperature threshold of 75°F established for salmonid survival. Green Ridge Creek and Oil Creek are in the Oil Creek CalWater Unit. The North Fork Mattole River, Conklin Creek, and the Upper North Fork Mattole River are not supportive of the cold beneficial use of water for salmonid habitat.

Stream attributes that were evaluated by the anadromous stream reach EMDS included canopy cover, embeddedness, percent pools, pool depth, and pool shelter. These attributes were collected in ten streams in the Northern Subbasin by CDFG (see the CDFG Appendix F for stream survey report summaries).

Stream attributes tend to vary with stream size. For example, larger streams generally have more open canopy and deeper pools than small streams. This is partially a function of stream channels and greater stream energy due to high discharge flow during storms. Surveyed streams in the Northern Subbasin ranged in drainage area from 1.15 to 36.5 square miles (Figure 67).

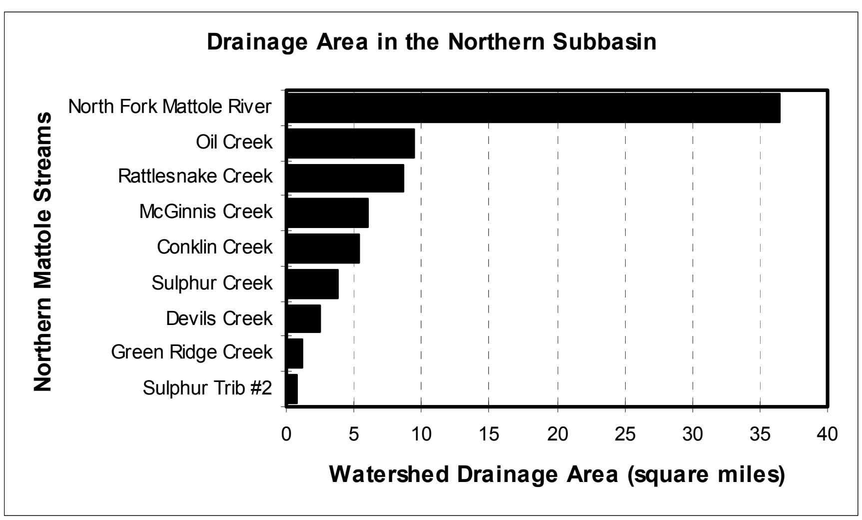


Figure 67. Drainage area of stream surveyed by CDFG in the Northern Subbasin.

Canopy cover, and relative canopy cover by coniferous versus deciduous trees were measured at each habitat unit during CDFG stream surveys. Near stream forest density and composition contribute to microclimate conditions that help regulate air temperature, which is an important factor in determining stream water temperature. Furthermore, canopy levels provide an indication of the potential present and future recruitment of large woody debris to the stream channel, as well as the insulating capacity of the stream and riparian areas during winter.

In general, the percentage of stream canopy cover decreases as drainage area and channel width increase. Deviations from this trend in canopy may indicate streams with more suitable or unsuitable canopy relative to other streams of that subbasin. As described in the EMDS response curves, total canopy (sum of conifer and deciduous canopy) exceeding 85% is considered fully suitable, and total canopy less than 50% is less than unsuitable for contributing to cool water temperatures that support salmonids. The surveyed stream reaches of the Northern Subbasin show percent canopy levels that are rated by the EMDS as somewhat unsuitable or worse for maintaining water temperature to support anadromous salmonid production (Figure 68). Sulphur Creek and its tributary have the highest canopy cover values of Northern Subbasin surveyed tributaries.

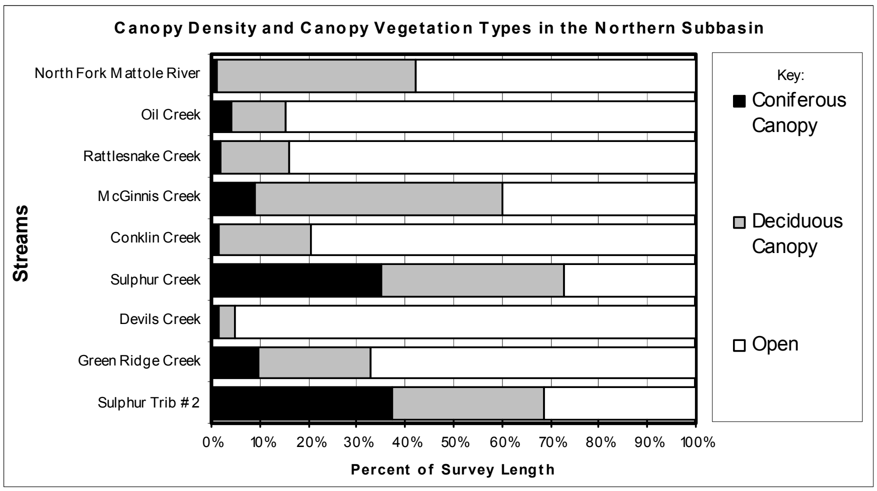


Figure 68. The relative percentage of coniferous, deciduous, and open canopy covering surveyed streams, Northern Subbasin

Averages are weighted by unit length to give the most accurate representation of the percent of a stream under each type of canopy. Streams are listed in descending order by drainage area (largest at the top). As described in the EMDS response curves, total canopy (sum of conifer and deciduous canopy) exceeding 85% is considered fully suitable, and total canopy less than 50% is considered to be fully unsuitable for contributing to cool water temperatures that support salmonids.

Cobble embeddedness was measured at each pool tail crest during CDFG stream surveys. Cobble embeddedness is the percentage of an average sized cobble piece at a pool tail out that is embedded in fine substrate. Category 1 is 0-25% embedded; Category 2 is 26-50% embedded; Category 3 is 51-75% embedded; Category 4 is 76-100% embedded, and Category 5 is unsuitable for spawning due to factors other than embeddedness (e.g. logs, rocks). Cobble embedded deeper than 51% is not within the fully supported range for successful use by salmonids. The EMDS Reach Model considers cobble embeddedness greater than 50% to be somewhat unsuitable and 100% to be fully unsuitable for the survival of salmonid eggs and embryos. Embeddedness values in the Northern Subbasin represent conditions that are moderately unsuitable or unsuitable for successful salmonid egg and embryo development with the exception of Sulphur Creek (somewhat suitable), its tributary (somewhat unsuitable), and the North Fork Mattole River. However, Figure 69 illustrates how stream reaches rated as overall unsuitable may actually have some suitable spawning gravel sites distributed through the stream reach.

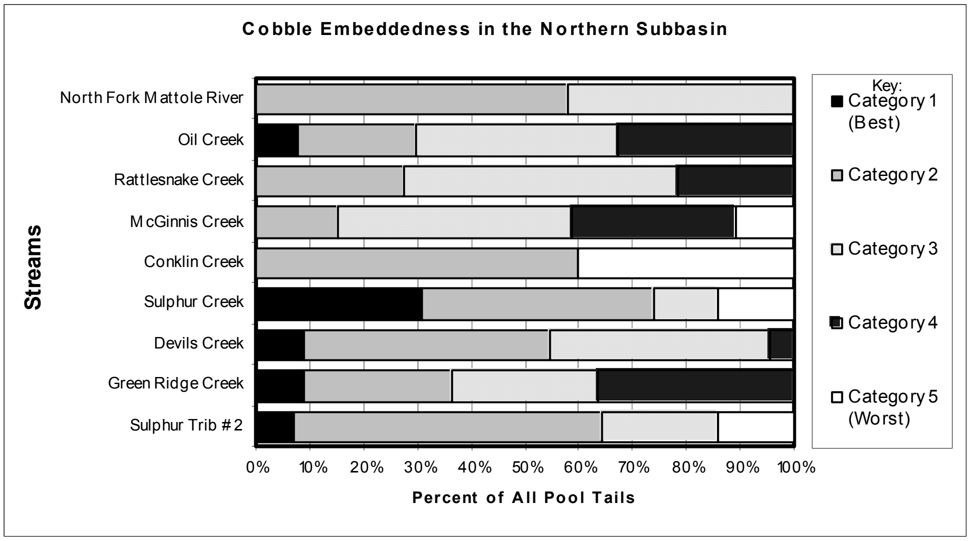


Figure 69. Cobble embeddedness categories as measured at pool tail crests in surveyed streams, Northern Subbasin

Cobble embeddedness is the % of an average-sized cobble piece at a pool tail out that is embedded in fine substrate: Category 1 = 0-25% embedded, Category 2 = 26-50% embedded, Category 3 = 51-75% embedded, Category 4 = 76-100%, and Category 5 = unsuitable for spawning due to factors other than embeddedness (e.g. log, rocks). Substrate embeddedness Categories 3, 4, and 5 are considered by EMDS to be somewhat unsuitable to fully unsuitable for the survival of salmonid eggs and embryos. Streams are listed in descending order by drainage area (largest at the top).

Pool, flatwater, and riffle habitat units observed were measured, described, and recorded during CDFG stream surveys. During their freshwater life history, salmonids require access to all of these types of habitat. EMDS does not evaluate the ratio of these habitat types, but a balanced proportion is desirable. All of the surveyed Northern Subbasin streams have less than 20% pool habitat by length (Figure 70). This is well below the range considered fully suitable as described below. Dry units were also measured, and obviously indicate poor conditions for fish.

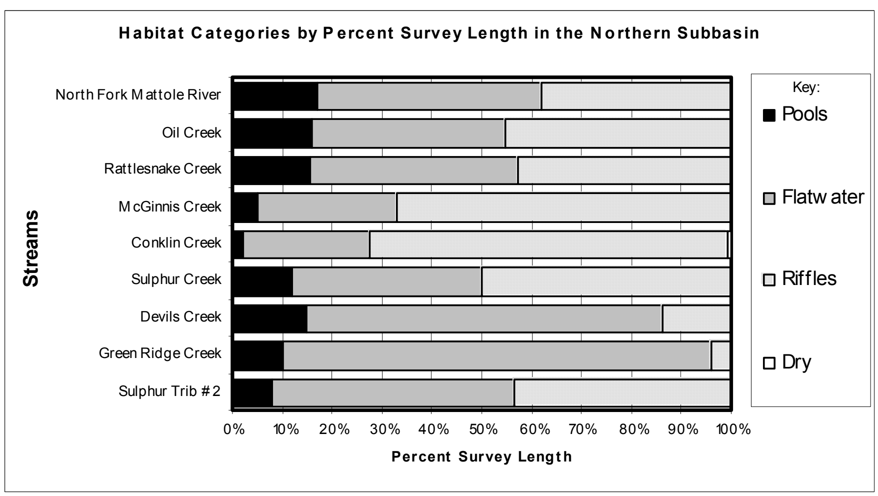


Figure 70. Percentage of pool habitat, flatwater habitat, riffle habitat, and dewatered channel by surveyed length, Northern Subbasin.

EMDS does not evaluate the ratio of these habitat types, but a balanced proportion is desirable. Streams are listed in descending order by drainage area (largest at the top).

Pool depths were measured during CDFG surveys. The amount of primary pool habitat of sufficient depth to be fully suitable for anadromous salmonids is considered in the EMDS Reach Model. Primary pools are determined by a range of pool depths, depending on the order (size) of the stream. Generally, a reach must have 30 – 55% of its length in primary pools for its stream class to be in the suitable ranges (EMDS, page 54). Usually, larger streams have deeper pools. Deviations from the expected trend in pool depth may indicate streams with more suitable or unsuitable pool depth conditions relative to other streams of that subbasin. North Fork Mattole River has the most pool habitat with maximum depth greater than 3 feet, but this measures less than 10% of total pool length (Figure 71). The EMDS rates pool quality in all Northern Subbasin streams as moderately unsuitable or unsuitable for supporting anadromous fish populations.

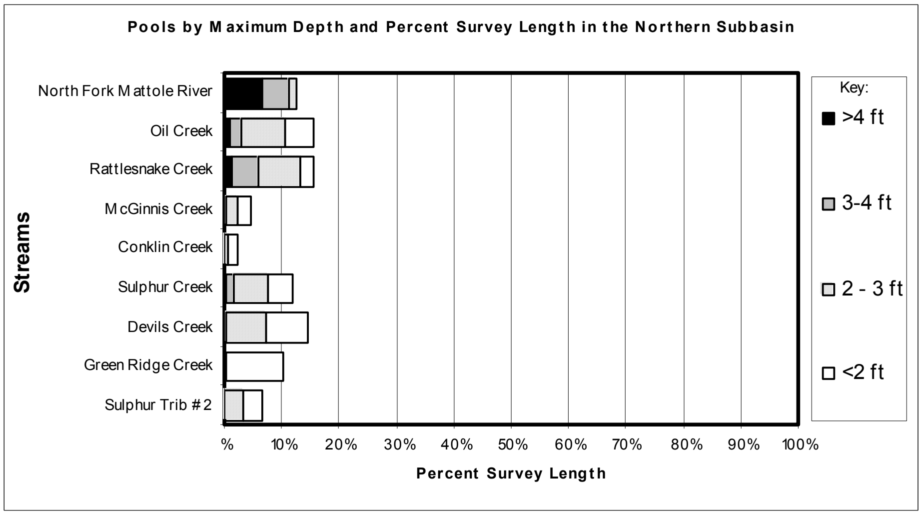


Figure 71. Percent length of a survey composed of deeper, high quality pools.

Values sum to the length of percent pool habitat in Figure 70. As described in the EMDS response curves, a stream must have 30-55% of its length in primary pools to provide stream conditions that are fully suitable for salmonids. Streams with <20 % or >90% of their length in primary pools provide conditions that are fully unsuitable for salmonids. Streams are listed in descending order by drainage area (largest at the top).

Pool shelter was measured during CDFG surveys. Pool shelter rating illustrates relative pool complexity, another component of pool quality. Ratings range from 0-300. The Stream Reach EMDS model evaluates pool shelter to be fully unsuitable if less than a rating of 30. The range from 100 to 300 is fully suitable. Pool shelter ratings in the Northern Subbasin, according to the EMDS stream reach model, range from somewhat unsuitable to unsuitable (Figure 72).

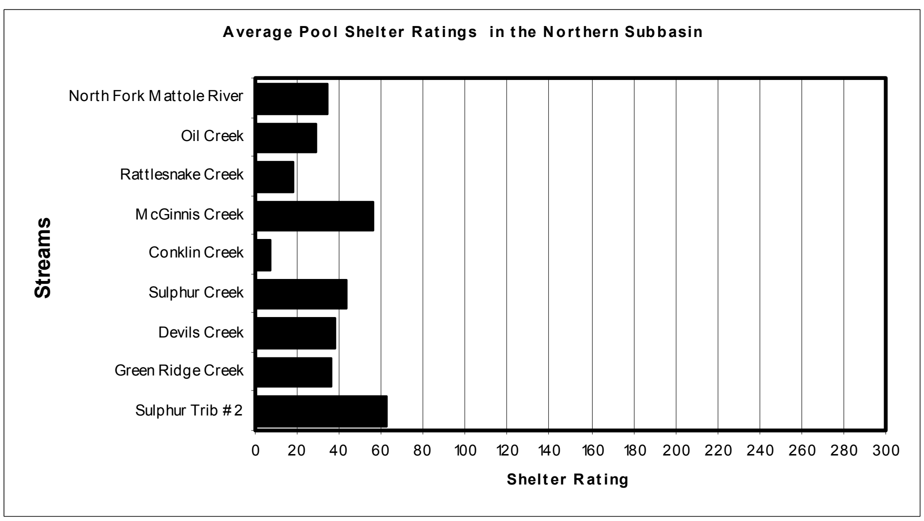


Figure 72. Average pool shelter ratings from CDFG stream surveys, Eastern Subbasin.

As described in the EMDS response curves, average pool shelter ratings exceeding 80 are considered fully suitable and average pool shelter ratings less than 30% are fully unsuitable for contributing to shelter that supports salmonids. Streams are listed in descending order by drainage area (largest at the top).

In terms of the fish habitat relationship present in the Northern Subbasin, it appears that habitat is somewhat unsuitable for salmonids. Additionally, data on fish passage barriers and water temperature (two important parameters considered by our assessment but not currently included in the EMDS analysis) show that there is one temporary salmonid barrier and several streams that exceed temperatures suitable for salmonids in this subbasin. Although, coho salmon have not been detected in the Northern Subbasin in recent studies, steelhead trout are found and have relatively dense, multi-year class rearing populations in the upper tributary reaches of the Upper North Fork Mattole River. This occurs in spite of unsuitable summer water temperatures, due, it seems, to a plentitude of cold springs, seeps, and small tributaries that provide thermal refugia.

Fish Passage Barriers

Stream Crossings

Two stream crossings were surveyed in the Northern Subbasin as a part of the Humboldt County culvert inventory and fish passage evaluation conducted by Ross Taylor and Associates (2000). Conklin Creek Road and Chambers Road both have culverts on Mill Creek (RM 5.5). The culvert on Conklin Creek Road was found to be a temporary salmonid barrier while the culvert on Chambers Road was not found to be a salmonid barrier (Table 61). Priority ranking of 67 culverts in Humboldt County for treatment to provide unimpeded salmonid passage to spawning and rearing habitat placed the culvert on Conklin Creek Road at rank 17 and the culvert on Chambers Road at rank 36. Criteria for priority ranking included salmonid species diversity, extent of barrier present, and culvert risk of failure, current culvert condition, salmonid habitat quantity, salmonid habitat quality, and a total salmonid habitat score. The culvert on Conklin Creek Road was replaced with a bridge in October, 2002 and is no longer a barrier (G. Flosi, personal communication).

Table 61. Culverts surveyed for barrier status in the Northern Subbasin

Stream Name	Road Name	Priority Rank	Barrier Status	Upstream Habitat	Treatment
Mill Creek (RM 5.5) (1)	Conklin Creek Road	17	Temporary barrier. A steep gradient and excessive under sizing creates a temporary velocity barrier for adults, which is probably a total barrier to juveniles. Additionally, railroad rails probably contribute to passage problems – the rails break up the slope in steps, yet there is no depth for fish to leap out of when ascending. Woody debris pinned across the culvert also increases velocity and turbulence at inlet. An October, 2002 CDFG Humboldt Co. project has installed a bridge at this site and it is no longer a barrier.	Approximately 2.7 miles of fair salmonid habitat.	Improved in 2002
Mill Creek (RM 5.5) (2)	Chamber s Road	36	Not a barrier. The culvert is set below grade with natural channel bottom. Even at low flow there is a backwatering of the downstream end of the culvert.	Approximately 2.0 miles of fair salmonid habitat.	None proposed at this time

Dry Channel

A main component of CDFG Stream Inventory Surveys is habitat typing, in which the amount and location of pools, flatwater, riffles, and dry channels are recorded. Although the habitat typing survey only records the dry channels present at the point in time when the survey was conducted, this measure of dry channel can give an indication of summer passage barriers to juvenile salmonids. Dry channel conditions in the Mattole Basin generally become established from late July through early September. Therefore, CDFG stream surveys conducted outside this period are less likely to encounter dry channels.

Dry channels disrupt the ability of juvenile salmonids to move freely throughout stream systems. Juvenile salmonids need well-connected streams to allow free movement to find food, escape from high water temperatures, escape from predation, and migrate out of their stream of origin. The amount of dry channels reported in surveyed stream reaches in the Northern Subbasin is less than 0.1% of the total length of stream surveyed. All of the dry channel was found at the mouth of Conklin Creek (Table 62 and Figure 73). Dry channel at the mouth of a tributary disconnects that tributary from the mainstem Mattole River, which can disrupt the ability of juvenile salmonids to access tributary thermal refugia in the summer.

Table 62. Dry channel recorded in CDFG stream surveys in the Northern Subbasin.

Stream	Survey Period	# of Dry Units	Dry Unit Length (ft)	% of Survey in Dry Channel
North Fork Mattole River	July	0	0	0
Sulphur Creek	June	0	0	0
Sulphur Creek Tributary #1	August	0	0	0
Sulphur Creek Tributary #2	July	0	0	0
Conklin Creek	August	1	22	0.7
McGinnis Creek	July-August	0	0	0
Oil Creek	August	0	0	0
Green Ridge Creek	September	0	0	0
Devils Creek	August	0	0	0
Rattlesnake Creek	August	0	0	0

Figure 73. Mapped dry channels in the Northern Subbasin.

Fish History and Status

Historically, the Northern Subbasin supported runs of Chinook salmon, coho salmon, and steelhead trout. Interviews with local residents indicate that Chinook salmon and coho salmon were found in the North Fork Mattole River, Mill Creek (RM 5.5), Conklin Creek, and possibly in Jim Goff Gulch and McGinnis Creek (Coastal Headwaters Association 1982). The CDFG stream surveys in the 1960s found steelhead trout in eleven streams, unidentified salmonids in Pritchett Creek, and coho salmon in Mill Creek (RM 5.5) and Devils Creek. High densities of steelhead trout were estimated for the East Branch of the North Fork Mattole River (500 per 100 feet of stream) and Mill Creek (RM 5.5) (300 per 100 feet of stream) in June, 1966.

A study of Mattole Basin salmonids conducted in July and August, 1972 (Brown, 1973b) examined two sites on the North Fork of the Mattole River. The first site was 0.5 miles downstream of the Mattole Road Bridge and the second site was 1.5 miles above the mouth. Steelhead trout were found at densities of 122 and 250 per 100 feet of stream, respectively.

BLM, Coastal Headwaters Association, and CDFG stream surveys have continued to document the presence of steelhead trout in most streams in the Northern Subbasin. A BLM survey of the North Fork Mattole River in September, 1977 found many juvenile steelhead trout. Coastal Headwaters Association surveys in 1981 and 1982 found steelhead trout in Jim Goff Gulch, the North Fork Mattole River, Mill Creek (RM 5.5), Conklin Creek, McGinnis Creek, and the Upper North Fork Mattole River. CDFG surveys found steelhead trout in McGinnis Creek and Pritchett Creek in the 1980s and Conklin Creek, Oil Creek, and Rattlesnake Creek in the 1990s. Additionally, CDFG electrofishing data from 1992-1995 in Oil Creek, Green Ridge Creek, and Rattlesnake Creek indicated stable multi-year class populations of juvenile steelhead trout.

Although unidentified salmonids were found in the East Branch of the North Fork Mattole River in July 1982 that could have been coho salmon, coho were not detected in the Northern Subbasin by the 2001 CDFG Coho Inventory, 1990s CDFG stream surveys, other CDFG electrofishing efforts, or a 1997-99 Redwood Sciences Laboratory study of juvenile coho salmon distributions in relation to water temperatures in the Mattole Basin (Welsh et al. 2001). More detailed summaries of stream surveys and fisheries studies in the Northern Subbasin are provided in the CDFG Appendix F.

Northern Subbasin Issues

From the various discipline's assessments and constituent input, the following issues were developed for the Northern Subbasin.

- The preponderance of unstable hillslope conditions in the subbasin results from the widespread areal distribution of soft terrain and steep slopes.
- There is a lack of stream survey information for many streams in this subbasin.
- High summer water temperatures in surveyed streams are deleterious to summer rearing salmonid populations in this subbasin.
- Instream sedimentation in several stream reaches in this subbasin may be approaching or exceeding levels considered unsuitable for salmonid populations.
- In general, Northern Subbasin pool habitat, escape and ambush cover, water depth, and substrate embeddedness are unsuitable for salmonids.
- Large woody debris recruitment potential is very poor overall, and may be exacerbated by land use practices.
- Landsliding related to existing roads, both active and abandoned, is a probable contributor of instream sediment.
- Currently, there is no road assessment program in this subbasin.
- Subdivision development within this subbasin could potentially exacerbate erosion and landslides to a greater degree than elsewhere in the Mattole Basin.
- Fish population information is limited due in part to private property access issues.
- Although coho salmon were once known to be in this subbasin, they have not been detected in recent CDFG and Redwood Science Laboratory studies.
- There is a lack of available data on pH, dissolved oxygen, nutrients, and other water chemistry parameters.

Northern Subbasin Integrated Analysis

The following tables provide a dynamic, spatial picture of watershed conditions for the freshwater lifestages salmon and steelhead. The tables' fields are organized to show the extent of watershed factors' conditions and their importance of function in the overall watershed dynamic. Finally a comment is presented on the impact or condition affected by the factor on the watershed, stream, or fishery. Especially at the tributary and subbasin levels, the dynamic, spatial nature of these processes provides a synthesis of the watershed conditions and indicates the quantity and quality of the freshwater habitat for salmon and steelhead.

Geology

Introduction

The potential for sediment production is strongly influenced by underlying geology. The following IA tables compiled by CGS examine the influence of geology on sediment production by comparing the distribution of geomorphic terrains (hard, moderate, and soft bedrock terrains, and the separately grouped Quaternary surficial deposits) against the observation of landslides and geomorphic features related to mass wasting within the subbasin. The first table presents the proportions of the subbasin underlain by each of the terrains. The next table looks at hillside gradient within the subbasin. The distribution of historically active landslides, gullies, and inner gorges by terrain are then considered. Finally, the landslide potential map developed by CGS is examined with respect to the terrains.

Table 63. Geomorphic terrains as a proportion of the Northern Subbasin.

Feature/Function			Significance	Comments
Terrain Type	**Proportion of Subbasin Area**	**Terrain Area within Subbasin as a Proportion of Mattole Basin Area**	The geomorphic terrains represent groupings of geologic map units based on similarities in geology, geomorphic expression, and landslide occurrence. They provide a simplified division of the watershed useful in comparing the influence of bedrock geology to the distribution of other mapped features.	The majority (approximately 58%) of soft terrain in the Mattole Basin is found within the subbasin. Soft terrain, with its associated higher levels of active landsliding and gully erosion, accounts for about half of the bedrock area of this subbasin.
Hard	20%	6%		
Moderate	29%	10%		
Soft	43%	14%		
Quaternary[1]	8%	3%		

[1] Areas where young (Quaternary) surficial units have been mapped covering bedrock; includes alluvium, as well as terrace deposits, active stream channel deposits, and other alluvial deposits.

Table 64. Hillside gradient in the Northern Subbasin.

Feature/Function						Significance	Comments
Proportion of Subbasin Area						Hillside slope is an important indicator of potential instability (steeper is generally less stable). The terrain type influences the degree to which hillside slope affects the slope stability.	Typically, the steeper slopes reflect the presence of hard and moderate terrain while the less steep slopes reflect the presence of soft terrain.
Range in % slope							
0-10	**10-30**	**30-40**	**40-50**	**50-65**	**>65**		
7	17	18	20	21	17		

Table 65. Small historically-active landslides by terrain in the Northern Subbasin.

Feature/Function			Significance	Comments
Terrain Type	**Small Point Landslides1 Mapped from year 19812, 1984, or 2000 Photographs**		The relative number of small point slides is used to evaluate which geomorphic terrains are more prone to small, localized slope failures.	The distribution of small landslides in this subbasin reflects the distribution of terrains across the subbasin. The majority of small failures consist of shallow debris slides associated with steep slopes. However, a significant proportion of the small failures in soft terrain are earthflows.
	Point Count	**Area[3] (acres)**		
Hard	562	56		
Moderate	766	76		
Soft	903	89		
Quaternary	10	1		

[1] Mapping was compiled at a 1:24,000 scale. Landslides smaller than approximately 100 feet in diameter were captured as points in the GIS database; larger features were captured as polygons.

[2] Landslides included from year 1981 photographs are from previous mapping by Spittler (1983 and 1984) covering limited portions of the Mattole Basin.

[3] Based on assumed average area of 400 square meters (roughly 1/10th acre) for small landslides.

Table 66. All historically-active landslides by terrain in the Northern Subbasin.

Feature/Function			Significance	Comments
Terrain Type	**Combined Area (acres) of All Historically-Active Landslides1**	**Proportion of Total Active Landslide Area within Subbasin**	The relative percentage of area covered by historically-active slides identifies which geomorphic terrains are most prone to relatively large-scale slope failures.	More than half (approximately 51%) of the total area occupied by landslides in the Mattole Basin is found in the Northern Subbasin. Within the Northern Subbasin, the majority of landslides are located in soft terrain.
Hard	587	11%		
Moderate	1,157	22%		
Soft	3,420	66%		
Quaternary	24	<1%		

[1] Includes small point and larger polygon features mapped from year 1981, 1984 and 2000 photos. Where landslides overlapped (i.e., the same or similar features mapped from more than one photo set) the area of overlap was counted only once. Small landslides captured as points in the GIS database were assumed to have an average area of 400 square meters (roughly 1/10th acre).

Table 67. Gullies and inner gorges by terrain in the Northern Subbasin.

Feature/Function			Significance	Comments
Terrain Type	**Proportion of Total Mapped Gully Lengths[1] in Subbasin**	**Proportion of Total Mapped Inner Gorge Lengths[1] in Subbasin**	Gullies and inner gorges are an important indicator of ongoing sources of sediment to the fluvial system.	The large majority of gully lengths observed in the Northern Subbasin are located in soft terrain; gully erosion from soft terrain areas is a significant, on-going contributor of sediment. Inner gorges are more equally prevalent in each terrain; inner gorges act as sediment source areas primarily through debris sliding.
Hard	3%	29%		
Moderate	9%	34%		
Soft	84%	34%		
Quaternary	4%	3%		

[1] Includes only those features mapped from year 2000 photographs

Table 68. Landslide potential by terrain in the Northern Subbasin.

Feature/Function						Significance	Comments
Terrain Type	**Landslide Potential Category[1]**					Categories 4 and 5 represent the majority of unstable areas that are current or potential future sources of sediment.	Well over half of this subbasin is categorized as having a high or very high landslide potential. Soft terrain is disproportionably represented in LPM Categories 4 and 5 because of the unit's inherent instability. Hard and moderate terrain in LPM Categories 4 and 5 are largely associated with steep slopes.
	1	**2**	**3**	**4**	**5**		
Hard	0.1%	2.0%	7.8%	3.0%	6.7%		
Moderate	0.2%	1.9%	12.8%	6.9%	7.4%		
Soft	0.1%	0.4%	6.2%	19.0%	17.5%		
Quaternary	5.4%	1.9%	0.4%	0.1%	0.3%		
Subbasin Total[2]	5.8%	6.2%	27.2%	29.0%	31.9%		

[1] Categories represent ranges in estimated landslide potential, from very low (category 1) to very high (category 5); see Geologic Report, Plate 2.

[2] Percentages are rounded to nearest 1/10 %; sum of rounded values may not equal rounded totals or 100%.

Discussion

The Northern Subbasin has the most structurally disrupted and least stable geology in the Mattole Basin. Approximately 58% of the soft terrain in the watershed is found within the Northern Subbasin. Correspondingly, more than half of the total area occupied by historically active landslides within the watershed is located in the Northern Subbasin. In addition, more than half (approximately 65%) of the total mapped gully lengths in the watershed are located in the Northern Subbasin.

Vegetation and Land Use

Introduction

CDF NCWAP developed a number of tables that are intended to help identify and highlight how current patterns of vegetation and land use are expressed in relation to the geology of the watershed. First, vegetation and land use are related to the underlying bedrock geology or terrain type. These patterns are then explored by examining the current vegetation and recent timber harvesting in relation to their occurrence in landslide potential classes, the product of a model that uses terrain type, vegetation, and landslides as variables. Landslide causality was not assigned and recent timber harvest activity has occurred in low percentages in most of the planning watersheds. The significance of the geologic characteristics in these tables is expressed as a relative rating and is not characterized numerically.

Table 69. Vegetation types associated with terrain types in the Northern Subbasin.

Vegetative Condition in the Northern Subbasin								
Feature/Function							**Significance**	**Comments**
Terrain Type	**Vegetation Type**						The differences between the slope, soils, and stability of the geologic terrain results in a different mosaic of vegetation in each of these areas. The combination of the geologic and vegetative conditions between the terrains results in some differences in land use and sensitivity to impacts from land use.	Conifer and mixed hardwood/conifer occupy 40% of the soft terrain while grassland occupies 43%. Timber harvesting impacts in soft terrain may be higher than the THP required estimated surface soil erosion hazard rating (EHR) worksheet may indicate.
	Conifer	**Mixed**	**Hardwood**	**Grassland**	**Other**	**Total**		
Hard	9%	62%	18%	10%	1%	100%		
Moderate	12%	59%	13%	15%	1%	100%		
Soft	7%	33%	14%	43%	3%	100%		
Quaternary	2%	14%	15%	43%	26%	100%		

Table 70. Riparian vegetation (within 150 feet of streams) types associated with terrain types in the Northern Subbasin.

Riparian Vegetative Condition in the Northern Subbasin									
Feature/Function								**Significance**	**Comments**
Terrain Type	**Riparian Vegetation Type**							The differences between the slope, soils, and stability of the geologic terrain results in a different mosaic of vegetation in each of these areas. The combination of the geologic and vegetative conditions between the terrain results in some differences in land use and sensitivity to impacts from land use. The riparian vegetation in this zone is the primary source of large woody debris. The species and size of large woody debris provided to the stream system over time is at least partially dependent upon the inherent slope stability of the underlying terrain type.	Riparian vegetation is in tree-type vegetation at a proportionately higher percentage than the overall subbasin landscape. Vegetation removal impacts in riparian soft terrain should consider the heightened susceptibility of soft terrain to gullying. The large percentage of barren ground in the quaternary terrain type includes areas of expansive stream channel.
	Conifer	**Mixed**	**Hardwood**	**Grassland**	**Barren**	**Other**	**Total**		
Hard	13%	70%	13%	2%	1%	1%	100%		
Moderate	16%	66%	13%	3%	1%	1%	100%		
Soft	9%	53%	21%	14%	1%	2%	100%		
Quaternary	3%	20%	18%	22%	28%	9%	100%		

Table 71. Landuse types associated with terrain types in the Northern Subbasin.

Landuse in the Northern Subbasin						
Feature/Function					Significance	Comments
Terrain Type	Landuse Type					
	Public	Ag/Timber	Other	Total		
Hard	3%	97%	1%	100%	Lands are held primarily for natural resource economic activity in the Northern Subbasin and the majority of roads are privately owned. Reducing the amount of additional adverse sediment in the streams from land use will require a combination of education, economic incentive, and regulatory action.	Recent timber harvesting in this subbasin is conducted almost exclusively by Pacific Lumber Co., whose current plans are conducted within the guidelines of an approved Habitat Conservation Plan. A comparison of the CGS landslide potential methodology and Pacific Lumber's existing geologic work could be incorporated into their scheduled Watershed Analysis or the adaptive management process.
Moderate	1%	95%	4%	100%		
Soft	1%	96%	3%	100%		
Quaternary	4%	65%	31%	100%		

Table 72. Road mileage and density associated with terrain types in the Northern Subbasin.

Roads in the Northern Subbasin				
Feature/Function			Significance	Comments
Terrain Type	Miles (of road)	Road Density (miles per sq. mile)	Roads crossings on steep slopes in hard and moderate terrain may increase the potential for debris slides while roads within the soft terrain may increase the potential for small earthflows, gullies, and erosion. The alluvium terrain type tends to be relatively flat, but proximity to watercourses may allow for direct delivery of sediment from the roads to the streams.	While current practices locate roads on less environmentally sensitive locations, typically gentle ground high on the hillslope, the presence of soft terrain in these areas should be considered. Roads in soft terrain require construction and maintenance standards that recognize the inherent instability of this terrain type.
Hard	54	2.7		
Moderate	94	3.3		
Soft	150	3.5		
Quaternary	58	6.8		
Total	**356**	**3.5**		

Table 73. Data summary table for the Northern Subbasin.

Factor	Northern Subbasin	
Timber Harvest 1990 -2000	**acres**	**% area**
Silviculture Category 1		
Tractor	**380**	**0.6%**
Cable	**445**	**0.7%**
Helicopter	**253**	**0.4%**
TOTAL	**1,078**	**1.7%**
Silviculture Category 2		
Tractor	**614**	**1.0%**
Cable	**171**	**0.3%**
Helicopter	**6**	**0.0%**
TOTAL	**791**	**1.2%**
Silviculture Category 3		
Tractor	**606**	**1.0%**
Cable	**434**	**0.7%**
Helicopter	**172**	**0.3%**
TOTAL	**1,211**	**1.9%**
TOTAL	**3,080**	**4.9%**
Other Land Uses	**acres**	**% area**
Grazing	**16,282**	**25.6%**
Agriculture	**364**	**0.6%**
Development	**21**	**0.0%**
Timberland, No Recent Harvest	**34,835**	**54.9%**
TOTAL	**51,501**	**81.1%**
Roads		
Road Density (miles/sq. mile)	**3.4**	
Density of Road Crossings (#/stream mile)	**0.6**	
Roads within 200 feet of Stream (miles/stream mile)	**0.1**	
Silvicultural Category 1 includes even-aged regeneration prescriptions: clear-cut, rehabilitation, seed tree step, and shelter wood seed step prescriptions. Category 2 includes prescriptions that remove most of the largest trees: shelter wood prep step, shelter wood removal step, and alternative prescriptions. Category 3 includes prescriptions that leave large amounts of vegetation after harvest: selection, commercial thin, sanitation salvage, transition, and seed tree removal step prescriptions.		

Table 74. Land use and vegetation type associated with historically active landslides in the Northern Subbasin.

Historically Active Landslide Feature[1]	Northern Subbasin	Woodland and Grassland[2]	THPs 1990 - 2000[5]	Timberland, No Recent Harvest[3]	Roads[4]	
	% of Area	**% of Area**	**% of Area**	**% of Area**	**Length (miles)**	**% of Total Length**
Earthflow	4.3%	2.6%	0.2%	1.4%	14.9	4.4%
Rock Slide	1.0%	0.6%	0.0%	0.2%	4.2	1.2%
Debris Slide	2.4%	0.3%	0.1%	1.9%	4.6	1.3%
Debris Flow	0.1%	0.0%	0.0%	0.1%	0.3	0.1%
All Features	**7.8%**	**3.7%**	**0.3%**	**3.6%**	**24.0**	**7.0%**
The area occupied by slides is almost evenly divided between the timberland and woodland/grassland categories even though woodland/grassland acreage is a third smaller. Earthflows occupy roughly three quarters of the slide acreage in the woodland/grassland type, while debris slides occupy slightly more than half the slide acreage in the timberland type, almost all of which has had harvest activity prior to the last ten years. Recent THPs occupy 5% percent of the subbasin acreage and within this small area, 5.7% is in slide areas as compared to 6.4% slide area for the timberland type as a whole. Seven percent of the road length intersects historically active slides, a percentage almost equal to the slide acreage percentage.						

1 This category includes only large polygon slides and does not include point slides.
2 Woodland and grassland includes areas mapped in 1998 as grassland and non-productive hardwood.
3 Area of timberland that were not contained in a THP during the 1991 to 2000 period.
4 Roads layer is from the Information Center for the Environment (ICE) at UC Davis.
5 THP's are complete or active between the 1990 and 2000 timeframe.
Percent of area is based on the unit of analysis: Watershed, subbasin, or planning watershed.

Table 75. Land use and vegetation type associated with relative landslide potential in the Northern Mattole Subbasin.

Relative Landslide Potential[1]	Northern Subbasin	Woodland or Grassland[2]	THPs 1990 - 2000[5]	Timberland, No Recent Harvest[3]	Roads[4]	
	% of Area	% of Area	% of Area	% of Area	Length (miles)	% of Total Length
Very Low	5.8%	3.2%	0.1%	0.7%	34.0	9.9%
Low	6.2%	2.8%	0.4%	2.8%	29.5	8.6%
Moderate	27.2%	8.2%	1.2%	17.2%	91.9	26.9%
High	29.0%	12.2%	1.6%	14.7%	98.7	28.9%
Very High	31.9%	10.3%	1.4%	19.3%	87.5	25.6%
TOTAL	**100%**	**35%**	**5%**	**55%**	**342**	**100%**
Recent THPs in 1991-2000 covered 5%of the subbasin and 60% of the harvest acres were in the two highest relative landslide potential classes. Since the majority of the subbasin is in the high and very high relative landslide potential classes well-distributed across the landscape, it is not surprising to find that THPs also contain a high percentage of acreage in these same categories. The subbasin has about 342 miles of roads, with the proportion of road length in relative landslide potential categories similar to the percentage of total acres in each class, although there is a slight shift towards lower relative landslide potential classes.						

1 Refer to Plate 2 and California Geological Survey Report.
2 Woodland and grassland include areas mapped in 1998 as grassland and non-productive hardwood.
3 Area of timberland that were not contained in a THP during the 1991 to 2000 period.
4 Roads layer is from the Information Center for the Environment (ICE) at UC Davis.
5 THP's are complete or active between the 1990 and 2000 timeframe.
Percent of area is based on the unit of analysis: Watershed, subbasin, or planning watershed.

Discussion

The Northern Subbasin contains over half the soft terrain found in the Mattole Basin. In addition, the Northern Subbasin contains the largest percentage of acreage (61%) in the two highest relative landslide potential categories. It also contains the largest percentage of land area in both historically active (8%) and dormant landslide features (25%). The high number of existing landslides and the large percentage of the subbasin in high landslide potential classes suggest that land use practices should have careful site-specific evaluation in order to avoid land use accelerated sedimentation in the streams. While Mattole timber harvesting plans have incorporated a zero net sediment discharge analysis since about 1994, only five percent of the Northern Subbasin was harvested between 1990 and 2000. However, of the harvest acres in the high or very high relative landslide potential classes, one third were harvested by even-aged regeneration silvicultural systems and almost half was tractor logged. It should be noted that although these landslide potential categories are part of a different classification system that is not equivalent to the THP potential surface erosion hazard rating (EHR), both quantify potential sediment movement, although by different processes. The current Forest Practice Rules do not have a methodology for characterizing relative landslide potential. The Pacific Lumber HCP requires road reconstruction and maintenance standards on HCP lands beyond current State regulatory requirements. Other activities, including grazing and most road use and maintenance for grazing and residential access, are often outside the current regulatory process. Education and economic incentives for road improvements and livestock management provide the greatest opportunities for near-term benefits for fisheries.

Fluvial Geomorphology

Introduction

Fluvial geomorphic mapping of channel characteristics was conducted along blue line streams in the Mattole Basin to document channel characteristics that are indicative of excess sediment production, transport, and/or response (deposition); these features are referred to as negative mapped channel characteristics (NMCCs). The following CGS Integrated Analysis Tables (IA) present some of the findings of this investigation. To understand the distribution of these NMCC's we present: the predominant NMCC's identified; the relative distribution of these features between the bedrock terrains and the Quaternary units; the changes in amount and distribution of NMCC's observed between 1984 and 2000; and the relationship between areas of projected slope instability and portions of streams with evidence of excess sediment.

Table 76. Negative mapped channel characteristics in the Northern Subbasin.

Negative Mapped Channel Characteristics in the Northern Subbasin						
Feature/Function					**Significance**	**Comments**
		From 1984 Photos	**From 2000 Photos**	**%[4] Change 1984 to 2000**	The reduction in the total length of NMCC's over time quantitatively reflects the degree of improvements within the blue line streams. These NMCC's were chosen to be highlighted in these figures because in both photo years, the NMCC's observed were dominated by wide channels and, secondarily, by displaced riparian vegetation. Most of this observed improvement results from reductions in the proportion of streams affected by displaced riparian vegetation and wide channels.	Improvement in the occurrence of wide channels observed as primary or secondary features in this subbasin appears minor compared to other subbasins in the watershed in general. The majority of these features observed in 1984 remained in 2000.
Blue Line Streams where Wide Channel (wc) Observed		See Figure 34				
Blue Line Streams where Displaced Riparian Vegetation (dr) Observed		See Figure 35				That portion of the fluvial system observed to be affected by displaced riparian vegetation in 1984 has recovered extensively by 2000.
% of all Blue Line Stream Segments in Basin affected by NMCC's	**Total**	39%	36%	-3%	These values identify how much of the streams have been affected by NMCCs. A decrease in the length of streams affected by NMCCs quantitatively represents the degree of improvement within blue line stream reaches.	The fluvial system in this subbasin has experienced the smallest improvement of the subbasins between 1984 and 2000, and still remains impacted by NMCC's.
	Bedrock	37%	34%	-3%		
	Alluvium	48%	45%	-3%		

Negative Mapped Channel Characteristics in the Northern Subbasin (Continued)					
Feature/Function				Significance	Comments
	From 1984 Photos	From 2000 Photos	Percent[4] Change 1984 to 2000	The magnitude of decrease in affected streams quantitatively represents the degree of improvement within bedrock stream reaches adjacent to unstable areas. Because the streams in the Quaternary units are commonly separated from the surrounding hillsides by alluvial terraces and floodplains, the NMCCs observed there do not directly result from input into the streams from landslides that occur on the surrounding hillsides. Therefore, NMCC's in alluvial areas have been interpreted as having been transported from upstream bedrock reaches. For this reason, the analysis of NMCC's vs. LPM 4 and 5 excludes the NMCCs identified in the Quaternary units and only describes the relationship between these two features as it applies to the bedrock reaches.	The fact that NMCC's are not ubiquitous in bedrock streams adjacent to or within LPM categories 4 and 5 indicates that although entire reaches of the streams have potentially unstable slopes above them, only a portion of those slopes have delivered or transported sediment to the streams. Just under half of all blue line streams in bedrock are adjacent to or within LPM categories 4 and 5 are affected by NMCC's, with only a small improvement between 1984 and 2000.
Percentage of all Blue Line Stream segments in bedrock that are: 1) adjacent to or within LPM Categories 4 and 5[3] and 2), affected by NMCC's	46%	42%	-4%		
Percent of total NMCC length in bedrock, within 150 feet of LPM Categories 4 and 5[2]	100%	100%	0%	Percentage reflects likelihood that the presence of NMCC's in bedrock are related to LPM categories 4 and 5 and that these unstable areas represent current and future potential sources of sediment to streams.	Virtually the entire total NMCC's observed in bedrock terrains were found on blue line streams adjacent to or within LPM category 4 and 5. Therefore, we interpret a clear relationship between areas of projected slope instability and portions of streams with negative sediment impacts, and that some portion of hillsides with high landslide potential are delivering sediment to the adjacent streams.

[1] Include all areas identified as hard, moderate, or soft geomorphic terrain.
[2] Areas where young (Quaternary) surficial units have been mapped covering bedrock; includes alluvium, as well as terrace deposits, active stream channel deposits, and other alluvial deposits.
[3] Landslide Potential Map developed by CGS for the Mattole Basin; see geologic report in California Geological Survey Report, Appendix A and Plate 2.
[4] Percentages are rounded to nearest 1%; sum of rounded values may not equal rounded totals or 100%.

Discussion

The results of our fluvial geomorphic mapping of channel characteristics that may indicate excess sediment accumulations (NMCC's) can be summarized as follows:

- Channel conditions across the subbasin have experienced the smallest improvement of any of the subbasins between 1984 and 2000.

- Change in NMCC's between 1984 and 2000 show a similar patterns in the bedrock and Quaternary unit reaches.
- Virtually all of the NMCCs in bedrock terrains were identified along portions of the streams near potentially unstable slopes and the total length of NMCCs in these areas has not changed significantly between 1984 and 2000. Therefore, we conclude that portions, but not all, of the hillslopes in the high to very high landslide potential categories are delivering sediment to the adjacent streams.

Water Quality

Introduction

There was very little water quality information available for the Northern Subbasin, especially temperature. Except for two stations, located between nine and eleven miles upstream in the Lower North Fork Mattole, and one site 4.5 miles upstream in the Upper North Fork Mattole, water temperature data were gathered within 0.5 mile of the mouth of sampled watercourses. Thermal imaging was conducted from the mouth to the upstream reaches of both of the latter watercourses, continuing into some upstream reaches of their major tributaries, providing a continuous snapshot of median surface temperature distributions. Except for sediment sampling conducted by the CDFG (CDFG Appendix F) only one sampling event, V*, was conducted by the Mattole Salmon Group and is included in the table below. Physical-chemical information, except for two sampling events by the Regional Water Board, was not available for streams in the subbasin.

Table 77. Northern subbasin water quality integrated analysis table.

<table>
<tr><th colspan="2">Feature/Function</th><th>Significance</th><th>Comments</th></tr>
<tr><td colspan="4">Temperature</td></tr>
<tr><td colspan="2">MWATs (9 Thermograph Records for 5 Stations)</td><td rowspan="3">Maximum weekly average temperature (MWAT) is the temperature range of 50-60°F considered fully suitable of the needs of several West Coast salmonids.</td><td rowspan="3">Although unsuitable throughout the subbasin this conclusion is based on only nine sampling points located mostly in the mid- to lower reaches of subbasin tributaries.</td></tr>
<tr><td>Suitable Records</td><td>Unsuitable Records</td></tr>
<tr><td>0</td><td>9</td></tr>
<tr><td colspan="2">Maximum Temperatures (15 Thermograph Records for 6 Stations)</td><td rowspan="3">A maximum-peak temperature of 75°F may be lethal to salmonids if cool water refugia are unavailable.</td><td rowspan="3">Generally unsuitable throughout subbasin. Of the four locations with suitable maximum temperatures, only one was in an upstream reach (Sulphur Creek). These same stations had unsuitable temperature during seven of eleven seasons.</td></tr>
<tr><td>Suitable Records</td><td>Unsuitable Records</td></tr>
<tr><td>4</td><td>11</td></tr>
<tr><td colspan="2">Thermal Infrared Imaging Median Surface Temperature</td><td rowspan="7">Ability to assess surface water temperatures at the river-stream-reach level for a holistic picture of thermal distribution.</td><td rowspan="7">Except Rattlesnake Creek, median surface temperatures in the lower reaches on the date and time of imaged tributaries were unsuitable for salmonids. Suitable temperatures were recorded in their upper reaches. See below for data limitations of thermal imaging.
Data limitations: 1) Assessments generally performed on a specific day and time, 2) not comparable to seasonally assessed MWAT or maximum temperatures, 3) unable to assess below water surface. Note: Thermal imaged median surface temperatures are derived from the minimum and maximum imaged surface temperatures scaled to a particular point in a sample cell (cell approximately = 317 feet x stream width). Cell minimum and maximum rarely varied more than 1-3 °F</td></tr>
<tr><td>Tributary</td><td>Minimum/ Maximum (°F)</td></tr>
<tr><td>Lower North Fork Mattole</td><td>55 / 77</td></tr>
<tr><td>East Branch Lower North Fork Mattole</td><td>60 / 75</td></tr>
<tr><td>Upper North Fork Mattole</td><td>66 / 80</td></tr>
<tr><td>Oil Creek</td><td>62 / 77</td></tr>
<tr><td>Rattlesnake Creek</td><td>55 / 71</td></tr>
</table>

Feature/Function		Significance	Comments
Sediment			
Tributary	**Date V***	V*: Measures the percent sediment filling of a streams pool, compared to the total pool volume. Lower V* values may indicate relatively low watershed disturbances. The V* ranges, below, derived from Knopp, 1993, are meant as reference markers and should not be construed as regulatory targets: V* ≤ 0.30 = low pool filling; correlates well with low upslope disturbance V* > 0.30 and ≤ 0.40 = moderate pool filling; correlates well with moderate upslope disturbance V* > 0.40 = High (excessive) rates of pool filling; correlates well with high upslope disturbance	V* = 0.27 indicates moderate pool filling.
Conklin Creek	2000 0.27		
Water Chemistry and Quality			
Lower North Fork Mattole River			Lower North Fork Mattole Sampling was performed during two temporally isolated sampling events. The pH of 8.9 exceeded the Basin Plan by 0.4 standard units. All other constituents were protective of the beneficial uses of water. Additional, long-term monitoring would be necessary to develop trends.
pH (Standard Units)		Beneficial pH ranges (~ph 6.5-8.5) controls/regulates chemical state of nutrients, such as CO_2, phosphates, ammonia, and some heavy metals (minimizes any possible toxic effects), etc.	
Minimum	**Maximum**		
8.3	8.9		
Dissolved Oxygen (mg/l)		By-product of plant photosynthesis, necessary for (life) respiration by aquatic plants and animals	
Minimum	**Maximum**		
8.9	9.3		
Conductivity (Micromhos)		Measure of ionic and dissolved constituents in aquatic systems; correlates well with salinity. Quantity/quality of dissolved solids-ions can determine abundance, variety, and distribution of plant/animals in aquatic environments. Osmoregulation efficiency largely dependent on salinity gradients. Estuary salinity essential to outmigrant smoltification.	
Minimum	**Maximum**		
255	281		
Chemistry/Nutrients		Quality and quantity of natural and introduced chemical and nutrient constituents in the aquatic environment, can be toxic, beneficial, or neutral to organisms (whether terrestrial or aquatic), and their various life phases. Chemical composition, in part, influenced by rainfall, erosion and sedimentation (parent bedrock, overlying soils), solution, evaporation, and introduction of chemicals/nutrients through human and animal interactions.	There has been no consistent chemical sampling, but generally presumed suitable throughout the subbasin.
No chemical/nutrient data available for subbasin			

References: Knopp, 1993; Mattole Salmon Group, 1996-200; PALCO, 2001; NCRWQCB Appendix E; Watershed Sciences, 2002.

Discussion

As shown above, all nine MWAT, and eleven of the fifteen reported maximum temperature sites were considered unsuitable for salmonids. The locations of all of the unsuitable maximum temperature locations coincided with the same stream mile locations above 75°F derived from thermal imaging. Due to the seasonally averaged MWATs derived from instream thermographs versus the one-day, peak median surface temperatures of thermal imaging, the two metrics are not comparable. Interestingly, as expected, the thermal imaged areas showing the highest median surface temperatures also coincided with the CGS's fluvial geomorphic and CDF's vegetation mapping analysis depicting these same areas with more open, near-channel locations due to widened floodplains, and adjacent upland areas with mostly herbaceous vegetative plant cover, respectively. Sediment conditions in Northern Subbasin tributaries are inconclusive if based on just the single V* = 0.27 in Conklin Creek. The two, single day, physical-chemical sampling events conducted by the NCRWQCB are also inadequate to paint a complete picture of those conditions in the Northern Subbasin.

Instream Habitat

Introduction

The products and effects of the watershed delivery processes examined in the geology, land use, fluvial geomorphology, and water quality Integrated Analyses tables are expressed in the stream habitats encountered by the organisms of the aquatic riparian community, including salmon and steelhead. Several key aspects of salmonid habitat in the Mattole Basin are presented in the CDFG Instream Habitat Integrated Analysis. Data in this discussion are not sorted into the geologic terrain types since the channel and stream conditions are not necessarily exclusively linked to their immediate surrounding terrain, but may in fact be both spatially and temporally distanced from the sites of the processes and disturbance events that have been blended together over time to create the channel and stream's present conditions. Instream habitat data presented here were compiled from CDFG stream inventories of ten tributaries from 1991 to 2002, published research conducted in the Mattole estuary by HSU, the MRC, and MSG in the 1980s and 1990s, and fish passage barrier evaluation reports conducted under contract to CDFG from 1998-2000. Details of these reports are presented in the CDFG Appendix F.

Pool Quantity and Quality

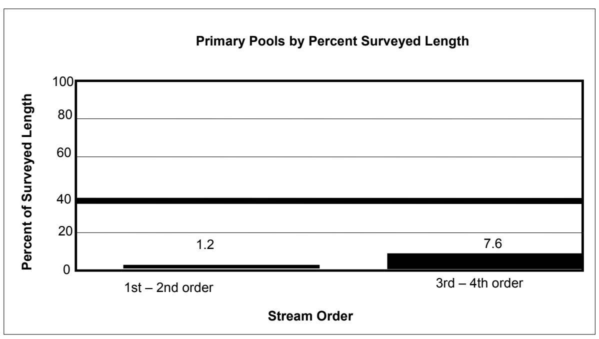


Figure 74. Primary pools in the Northern Subbasin.

Pools greater than 2.5 feet deep in 1st and 2nd order streams and greater than 3 feet deep in 3rd and 4th order streams are considered primary pools.

Significance: Primary pools provide escape cover from high velocity flows, hiding areas from predators, and ambush sites for taking prey. Pools are also important juvenile rearing areas. Generally, a stream reach should have 30 – 55% of its length in primary pools to be suitable for salmonids.

Comments: The percent of primary pools by length in the Northern Subbasin is generally below target values for salmonids, and appears to be very low throughout this subbasin. This subbasin has the lowest percent of primary pools in first and second order streams surveyed of any of the Mattole subbasins.

Spawning Gravel Quality

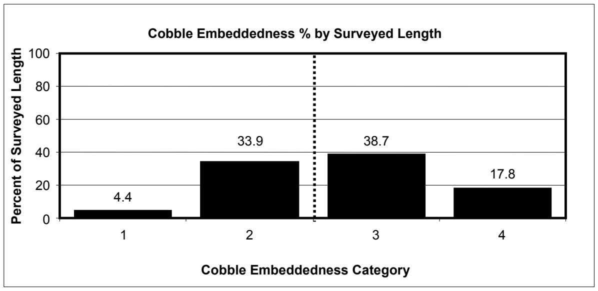


Figure 75. Cobble embeddedness in the Northern Subbasin.

Cobble Embeddedness will not always sum to 100% because Category 5 (not suitable for spawning) is not included.

Significance: Salmonids cannot successfully reproduce when forced to spawn in streambeds with excessive silt, clays, and other fine sediment. Cobble embeddedness is the percentage of an average sized cobble piece at a pool tail out that is embedded in fine substrate. Category 1 is 0-25% embedded, category 2 is 26-50% embedded, category 3 is 51-75% embedded, and category 4 is 76-100% embedded. Cobble embeddedness categories 3 and 4 are not within the fully supported range for successful use by salmonids.

Comments: More than one half of the surveyed stream lengths within the Northern Subbasin have cobble embeddedness in excess of 50% in categories 3 and 4, which does not meet spawning gravel target values for salmonids.

Shade Canopy

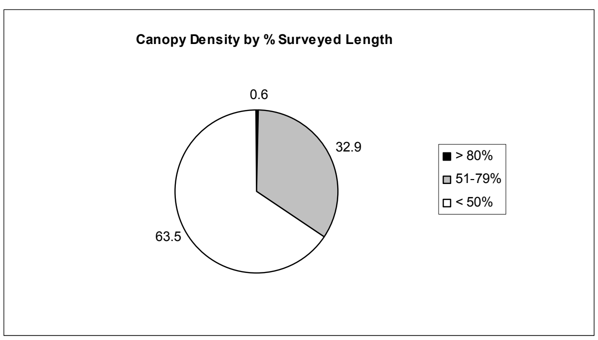


Figure 76. Canopy density in the Northern Subbasin 80 % is the target

Significance: Near-stream forest density and composition contribute to microclimate conditions that help regulate air temperature, which is an important factor in determining stream water temperature. Stream water temperature can be an important limiting factor of salmonids. Generally, canopy density less than 50% by survey length is below target values and greater than 85% is fully meets target values.

Comments: Less than one half of the surveyed stream lengths within the Northern Subbasin have canopy densities greater than 50% and less than 1% of the surveyed lengths have canopy densities greater than 80%. This is below the canopy density target values for salmonids. This subbasin has the lowest percent canopy density in surveyed streams of any of the Mattole subbasins.

Fish Passage

*Table 78. Salmonid habitat artificially obstructed for fish passage.**

Feature/Function		Significance	Comments
Type of Barrier	% of Estimated Historic Coho Salmon Habitat Currently Inaccessible Due to Artificial Passage Barriers	Free movement in well-connected streams allows salmonids to find food, escape from high water temperatures, escape from predation, and migrate to and from their stream of origin as juveniles and adults. Dry or intermittent channels can impede free passage for salmonids; temporary or permanent dams, poorly constructed road crossings, landslides, debris jams, or other natural and/or man-caused channel disturbances can also disrupt stream connectivity. Partial barriers exclude certain species and lifestages from portions of a watershed and temporary barriers delay salmonid movement beyond the barrier for some period of time. Total barriers exclude all species from portions of a watershed	Artificial barriers currently block 5.7% of the estimated historic coho salmon habitat in the Northern Subbasin. This entire habitat is blocked by partial and temporary artificial fish passage barriers, and no habitat is blocked by total barriers. The CDFG North Coast Watershed Improvement Program funded an improvement of Mill Creek (RM 5.5) in 2002.
All Barriers	5.7		
Partial and Temporary Barriers	5.7		
Total Barriers	0.0		

*(N=2 Culverts) in the Northern Subbasin (1998-2000 Ross Taylor and Associates Inventories and Fish Passage Evaluations of Culverts within the Humboldt County and the Coastal Mendocino County Road Systems).

*Table 79. Juvenile salmonid passage in the Northern Subbasin.**

Feature/Function		Significance	Comments
Juvenile Summer Passage:	Juvenile Winter Refugia:	Dry channel disrupts the ability of juvenile salmonids to move freely throughout stream systems.	The amount of dry channel reported in surveyed stream reaches in the Northern Subbasin is less than 0.1% of the length of stream surveyed. However, the dry channel that was recorded disconnects Conklin Creek from the mainstem Mattole River. Juvenile salmonids seek refuge from high winter flows, flood events, and cold temperatures in the winter. Intermittent side pools, back channels, and other areas of relatively still water that become flooded by high flows provide valuable winter refugia.
<0.1 Miles of Surveyed Channel Dry	No Data		
<0.1% of Surveyed Channel Dry			

*(1991-2002 CDFG Stream Surveys, CDFG Appendix F).

Large Woody Debris

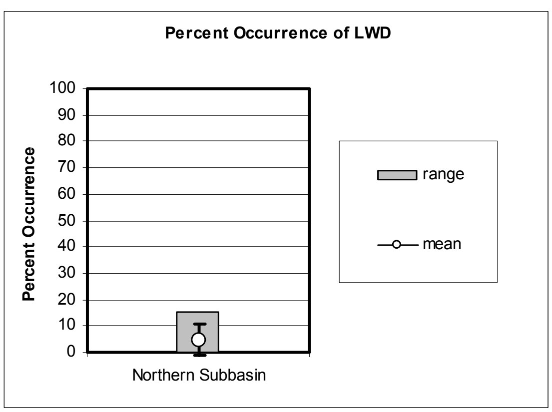


Figure 77. Large woody debris (LWD) in the Northern Subbasin.

Error bars represent the standard deviation. The percentage of shelter provided by various structures (i.e. undercut banks, woody debris, root masses, terrestrial vegetation, aquatic vegetation, bubble curtains, boulders, or bedrock ledges) is described in CDFG surveys. The dominant shelter type is determined and then the percentage of a stream reach in which the dominant shelter type is provided by organic debris is calculated.

Significance: Large woody debris shapes channel morphology, helps a stream retain organic matter, and provides essential cover for salmonids. There are currently no target values established for the % occurrence of LWD.

Comments: A 4.8 average percent occurrence of large woody debris is low compared to the range of values recorded throughout the entire Mattole Basin, which is 0 to 28. Additionally, boulders were found to provide the primary form of shelter for salmonids in six of the seven surveyed streams.

Discussion

Although instream habitat conditions for salmonids varied across the Northern Subbasin, several generalities can be made. Instream habitat conditions were generally poor within this subbasin at the time of CDFG surveys. The percentage of primary pools by survey length in first and second order streams was the least suitable for salmonids of any of the Mattole subbasins. The canopy density by survey length was the least suitable for salmonids of any of the Mattole subbasins. The estimated historic coho habitat inaccessible due to artificial passage barriers was 5.7%. Additionally, embeddedness values were generally less than target values as found in CDFGs *California Salmonid Stream Habitat Restoration Manual* and calculated by the EMDS, and the percent occurrence of large woody debris for escape and ambush cover was in the lower range of values recorded in the Mattole Basin. However, dry channel occurred in less than 0.1% of the surveyed stream length in the Northern Subbasin, thus forage and refuge passage for juveniles were not considered to be significant problems.

Draft Sediment Production EMDS

The draft sediment EMDS is currently under review. Preliminary results are presented in the EMDS Appendix C.

Stream Reach Condition EMDS

The anadromous reach condition EMDS evaluates the conditions for salmonids in a stream reach based upon water temperature, riparian vegetation, stream flow, and in channel characteristics. Data used in the Reach EMDS come from CDFG stream inventories. Currently, data exist in the Mattole Basin to evaluate overall reach, canopy, in channel, pool quality, pool depth, pool shelter, and embeddedness conditions for salmonids. More details of how the EMDS system calculates habitat variables can be found in the EMDS Appendix C. EMDS calculations and conclusions are pertinent only to surveyed streams and are based on conditions present at the time of individual survey.

EMDS stream reach scores were weighted by stream length to obtain overall scores for tributaries and the entire Northern Subbasin. Weighted average reach conditions on surveyed streams in the Northern Subbasin were evaluated by the EMDS as somewhat unsuitable for salmonids (Table 80). Suitable conditions exist for canopy in Sulphur Creek and Sulphur Creek Tributary #1; and for embeddedness in Sulphur Creek. Unsuitable conditions exist for reach, in channel, and pool shelter in all tributaries evaluated.

Table 80. EMDS anadromous reach condition model results for the Northern Subbasin.

Stream	Reach	Water Temperature	Canopy	Stream Flow	In Channel	Pool Quality	Pool Depth	Pool Shelter	Embeddedness
Northern Subbasin	**-**	**U**	**- -**	**U**	**-**	**- -**	**- -**	**- -**	**- -**
Sulphur Creek	-	U	+	U	-	- -	- - -	- -	+
Sulphur Creek Tributary #1	-	U	+++	U	-	- - -	- - -	- - -	U
Sulphur Creek Tributary #2	-	U	-	U	-	- -	- - -	-	-
Conklin Creek	-	U	- - -	U	-	- - -	- - -	- - -	U
Oil Creek	-	U	- - -	U	-	- -	- -	- - -	- - -
Green Ridge Creek	-	U	- - -	U	-	- - -	- - -	- - -	- -
Devils Creek	-	U	- - -	U	-	U	U	- - -	- - -
Rattlesnake Creek	-	U	- - -	U	-	- - -	- - -	- - -	- - -

Key:
+++ Fully Suitable
++ Moderately Suitable
+ Somewhat Suitable
U Undetermined
- Somewhat Unsuitable
- - Moderately Unsuitable
- - - Fully Unsuitable

Analysis of Tributary Recommendations

CDFG inventoried 20.9 miles on ten tributaries in the Northern Subbasin. A CDFG biologist selected and ranked recommendations for each of the inventoried streams, based upon the results of these standard

CDFG habitat inventories (Table 81). More details about the tributary recommendation process are given in the Mattole Synthesis Section of the Watershed Profile.

Table 81. Ranked tributary recommendations summary in the Northern Subbasin based on CDFG stream inventories.

Stream	Number of Surveyed Stream Miles	Bank	Roads	Canopy	Temp	Pool	Cover	Spawning Gravel	LDA	Livestock	Fish Passage
North Fork Mattole River	3.0	1	2	3	4	6	5				
Sulphur Creek	1.4	1	2	5		3	4				
Sulphur Creek Tributary #1	0.1	2	3	6		1	5	4			
Sulphur Creek Tributary #2	0.5	3	4	5		1	2				
Conklin Creek	0.6	3	4	2	1	5	6				
McGinnis Creek	5.9	1	2	3	4	5	6				
Oil Creek	3.1	2		1	4	3	5		6		
Green Ridge Creek	0.7	4		2		1	3				
Devils Creek	1.4	4		2		1	3				
Rattlesnake Creek	4.2	5		1	2	3	4				

Bank = stream banks are failing and yielding fine sediment into the stream; Roads = fine sediment is entering the stream from the road system; Canopy = shade canopy is below target values; Temp = summer water temperatures seem to be above optimum for salmon and steelhead; Pool = pools are below target values in quantity and/or quality; Cover = escape cover is below target values; Spawning Gravel = spawning gravel is deficient in quality and/or quantity; LDA = large debris accumulations are retaining large amounts of gravel and could need modification; Livestock = there is evidence that stock is impacting the stream or riparian area and exclusion should be considered; Fish Passage = there are barriers to fish migration in the stream.

In order to further examine Northern Subbasin issues through the tributary recommendations given in CDFG stream surveys, the top three ranking recommendations for each tributary were collapsed into five different recommendation categories: Erosion/Sediment, Riparian/Water Temp, Instream Habitat, Gravel/Substrate, and Other (Table 82). When examining recommendation categories by number of tributaries, the most important recommendation category in the Northern Subbasin is Erosion/Sediment.

Table 82. Top three ranking recommendation categories by number of tributaries in the Northern Subbasin.

North Subbasin Target Issue	Related Table Categories	Count
Erosion / Sediment	Bank / Roads	11
Riparian / Water Temp	Canopy / Temp	9
Instream Habitat	Pool / Cover	10
Gravel / Substrate	Spawning Gravel / LDA	0
Other	Livestock / Barrier	0

However, comparing recommendation categories in the Northern Subbasin by number of tributaries could be confounded by the differences in the number of stream miles surveyed on each tributary. Therefore, the number of stream miles in each subbasin assigned to various recommendation categories was calculated (Figure 78). When examining recommendation categories by number of stream miles, the most important recommendation categories in the Northern Subbasin are Riparian/Water Temp, Instream Habitat, and Erosion/Sediment. These comprise the top tier of recommended improvement activity focus areas.

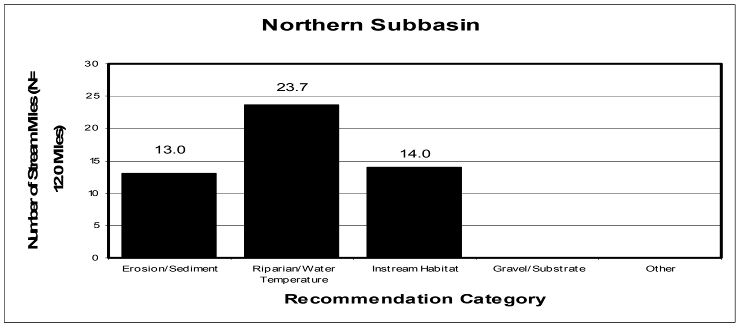


Figure 78. Recommendation categories by stream miles in the Northern Subbasin.

The high number of Riparian/Water Temperature, Instream Habitat, and Erosion/Sediment Recommendations across the Northern Subbasin indicates that high priority should be given to restoration projects emphasizing riparian replanting, pools, cover, and sediment reduction.

Refugia Areas

The NCWAP interdisciplinary team identified and characterized refugia habitat in the Northern Subbasin by using expert professional judgment and criteria developed for north coast watersheds. The criteria included measures of watershed and stream ecosystem processes, the presence and status of fishery resources, forestry and other land uses, land ownership, potential risk from sediment delivery, water quality, and other factors that may affect refugia productivity. The team also used results from information processed by NCWAP's EMDS at the stream reach and planning watershed/subbasin scales.

The most complete data available in the Northern Subbasin were for tributaries surveyed by CDFG. However, many of these tributaries were still lacking data for some factors considered by the NCWAP team.

Salmonid habitat conditions in the Northern Subbasin on surveyed streams are generally rated as medium potential refugia. Sulphur Creek Tributary #1 and Rattlesnake Creek provide the best salmonid habitat in this subbasin, while Green Ridge Creek is the only surveyed tributary to provide low quality refugia. Additionally, the North Fork Mattole River serves as a critical contributing area. The following refugia area rating table summarizes subbasin salmonid refugia conditions:

Table 83. Tributary salmonid refugia area ratings in the Northern Subbasin.

Stream	Refugia Categories*:				Other Categories:		
	High Quality	**High Potential**	**Medium Potential**	**Low Quality**	**Non-Anadromous**	**Critical Contributing Area/Function**	**Data Limited**
North Fork Mattole River			X			X	X
Sulphur Creek			X				X
Sulphur Creek Tributary #1			X				X
Sulphur Creek Tributary #2			X				X
Conklin Creek			X				X
McGinnis Creek			X				X
Oil Creek			X				X
Green Ridge Creek				X			X
Devils Creek			X				X
Rattlesnake Creek			X				
Subbasin Rating			X				

**Ratings in this table are done on a sliding scale from best to worst. See page 71 for a discussion of refugia criteria.*

Assessment Focus Areas

The foregoing analysis and conclusions are a result of the following working hypotheses, which are based upon subbasin issues.

Working Hypothesis 1:

Watershed and stream conditions are the least supportive of salmonids in the Mattole Basin.

Supporting Evidence:

- Sampled summer stream temperatures exceeded levels fully suitable for salmonids in Green Ridge, Oil, and Conklin creeks, Upper North Fork Mattole River, and North Fork Mattole River. Thermal infrared surface temperature imaging during 2001, though only for one day, corroborates excessively elevated maximum temperatures in the preceding tributaries. (NCRWQCB Appendix E).
- Air photo analysis indicates that timber harvest activities prior to 1973 reduced canopy closure near streams (CDF Appendix F).
- Only one of ten tributaries surveyed by CDFG in this subbasin exceeded the recommended shade canopy density levels of 80% for North Coast streams. Additionally, only four tributaries exceeded 50% shade canopy density levels. Shade canopy density below 50% is considered unsuitable (CDFG Appendix F).
- None of the ten tributaries surveyed by CDFG in this subbasin were found to have 30% or more of the survey lengths in pool habitat. Forty percent or more of stream lengths in pool habitat is considered suitable on the North Coast. Additionally, only 1.2% of first and second order surveyed streams and 7.6% of third and forth order surveyed streams in this subbasin are composed of primary pools by survey length. Thirty to 55% of survey lengths composed of deep, complex, high quality primary pools is considered desirable (IA Tables, CDFG Appendix F).
- None of the ten tributaries surveyed by CDFG in this subbasin was found to have a mean pool shelter rating exceeding 80. Six tributaries had shelter rating scores between 30 and 80. This indicates that woody debris elements affecting scour are not present. Pool shelter ratings of 80 or more are considered suitable, and ratings less than 30 are unsuitable for contributing to shelter that supports salmonids (CDFG Appendix F).
- Boulders provided the primary form of shelter for salmonids in nine of the ten surveyed streams in this subbasin. Small woody debris provided the primary form of shelter for salmonids in Conklin Creek (CDFG Appendix F).
- Existing riparian vegetation in much of this subbasin is small in diameter size class, which is not expected to contribute large woody debris in significant quantities in the near future (CDF Appendix F).
- Air photo analysis and field observations indicate that the lower reaches of the larger tributaries to the Mattole mainstem in this subbasin are highly aggraded with fine sediment (CGS; CDF).
- Surveys on Oil and Green Ridge creeks showed that McNeil sediment samples were slightly above acceptable threshold levels for optimum salmonid egg and embryo incubation (Hopelain et al. 1997).
- Several areas of on-going high sediment deposition were observed along the North Fork Mattole River near Petrolia and Upper North Fork Mattole River near Honeydew. These areas of deposition have been attributed to backwater effects with the mainstem Mattole River. Backwater effects occur where the stage versus discharge relationship is controlled by the geometry downstream of the area of interest (e.g., a high riffle controls conditions in the upstream pool at low flow). However, in the case of the North Fork Mattole River at Petrolia and the Upper North Fork Mattole River at Honeydew, we conclude from our observations that the backwater effects mapped at these locations are controlled by a hydrologic point of constraint caused by the mainstem Mattole at high flows (CGS, 2002).
- Review of photographs from the early 1900s combined with anecdotal statements indicates that the North Fork Mattole River near Petrolia has been an area of episodic sediment accumulation since the early 1900s. (CGS, 2002).

- Local residents have observed loss of surface stream flow during the summer in the lower reaches of major tributaries in this subbasin.
- Five of ten tributaries surveyed by CDFG in this subbasin were found to provide spawning reaches with favorable cobble embeddedness values in at least half of the stream reaches (CDFG Appendix F).
- Out of eleven stream reaches examined for the presence of sensitive amphibian species, torrent salamanders were not found in any reaches and tailed frogs were found in four reaches, on the Lower North Fork Mattole River, Alwardt Creek, and Sulphur Creek (Welsh et al. 2002).
- There is a lack of available data on pH, dissolved oxygen, nutrients, and other water chemistry parameters (NCRWQCB Appendix E).
- Artificial fish passage barriers block 5.7% of the estimated historic coho salmon habitat in this subbasin. Additionally, less than 0.1% of surveyed stream channel in this subbasin was dry (IA Tables, CDFG Appendix F). These fish passage barriers are being addressed in 2002.
- The NCWAP analysis of tributary recommendations given in the Northern Subbasin showed that the most important recommendation category was Riparian/Water Temperature, followed by Instream habitat improvements and Erosion/Sediment.

Contrary Evidence:

- Only 30% of the blue line streams in the Northern Subbasin have been inventoried by CDFG following the methods presented in the *California Salmonid Stream Habitat Restoration Manual*, therefore, the sampled stream reaches cannot be used as a representation of the whole subbasin.
- Surveyed streams were found to contain cold springs, seeps, and small tributaries that provide thermal refugia when high summer temperatures approach lethal limits (CDFG stream inventory reports for Oil Creek, Rattlesnake Creek, Green Ridge Creek, Devil's Creek, and Sulphur Creek). In addition to the aforementioned streams, helicopter over flights during 2001 using thermal infrared surface temperature imaging also showed numerous side-channels, seeps, and springs in the North Fork and Upper North Fork Mattole Rivers, East Branch of the North Fork Mattole River, and Fox Camp Creek that may provide cold water salmonid refugia (NCRWQCB Appendix E).
- CDFG has conducted analyses on macroinvertebrate data collected by BLM since 1996 on one subbasin stream, Conklin Creek, and PALCO lands since 1994 on seven subbasin streams. Results show stream conditions were fair to good, good, or undetermined (CDFG Appendix F).
- Surveys on Rattlesnake Creek showed that McNeil sediment samples were slightly below acceptable threshold levels for optimum salmonid egg and embryo incubation (Hopelain et al. 1997).
- V* calculated for Conklin Creek from data collected in 2000 with a single sample indicates a low to moderate supply of sediment from upslope-upstream sources (NCRWQCB Appendix E).

Hypothesis 1 Evaluation

Based upon the predominance of current supportive findings for the streams surveyed, the hypothesis is supported at this time.

Working Hypothesis 2:

Summer stream temperatures in surveyed subbasin tributaries are not within the range of temperatures that are fully suitable for healthy anadromous salmonid populations.

Supporting Evidence:

- Summer stream temperatures exceeded levels fully suitable for salmonids in Green Ridge, Oil, and Conklin creeks, and Upper and Lower North Forks of the Mattole River. Thermal infrared surface temperature imaging during 2001, though only for one day, corroborates excessively elevated maximum temperatures in the preceding tributaries. (NCRWQCB Appendix E).
- Air photo analysis indicates that timber harvest activities prior to 1973 reduced canopy closure near streams (CDF Appendix F).
- Only one of ten tributaries surveyed by CDFG in this subbasin exceeded the recommended shade canopy density levels of 80% for North Coast streams. Additionally, only four tributaries exceeded

50% shade canopy density levels. Shade canopy density below 50% is considered unsuitable (CDFG Appendix F).

Contrary Evidence:

- Surveyed streams were found to contain cold springs, seeps, and small tributaries that provide thermal refugia when high summer temperatures approach lethal limits (CDFG stream inventory reports for Oil Creek, Rattlesnake Creek, Green Ridge Creek, Devil's Creek, and Sulphur Creek). In addition to the aforementioned streams, helicopter over flights during 2001 using thermal infrared surface temperature imaging also showed numerous side-channels, seeps, and springs in the North Fork and Upper North Fork Mattole Rivers, East Branch of the North Fork Mattole River, and Fox Camp Creek that may provide cold water salmonid refugia (NCRWQCB Appendix E).

Hypothesis 2 Evaluation:

Based upon current supportive and contrary findings and the lack of field survey data, the hypothesis needs further investigation.

Working Hypothesis 3:

Aggradation from fine sediment in some stream channels of this subbasin has reduced channel diversity needed to provide suitable conditions for anadromous salmonid populations and has compromised salmonid health.

Supporting Evidence:

- Air photo analysis and field observations indicate that the lower reaches of the larger tributaries to the Mattole River in this subbasin are highly aggraded with fine sediment (CGS; CDF).
- V* calculated for Conklin Creek from data collected in 2000 indicates a low to moderate supply of sediment from upslope-upstream sources (NCRWQCB Appendix E).
- Surveys on Oil and Green Ridge creeks showed that McNeil sediment samples were slightly above acceptable threshold levels for optimum salmonid egg and embryo incubation (Hopelain et al. 1997).
- Several areas of on-going high sediment deposition were observed along the North Fork Mattole River near Petrolia and Upper North Fork Mattole River near Honeydew. These areas of deposition have been attributed to backwater effects with the mainstem Mattole. Backwater effects occur where the stage versus discharge relationship is controlled by the geometry downstream of the area of interest (e.g., a high riffle controls conditions in the upstream pool at low flow). However, in the case of the Lower North Fork at Petrolia and the Upper North Fork at Honeydew, we conclude from our observations that the backwater effects mapped at these locations are controlled by a hydrologic point of constraint caused by the mainstem Mattole at high flows (CGS, 2002).
- About 43% of this subbasin is underlain by soft terrain, the highest proportion of any subbasin.
- Over 50% of all the total area occupied by historically active landslides and about 65% of the total length of gullies identified within the entire Mattole basin was observed to be within the Northern Subbasin.
- About 61% of the subbasin is interpreted as having a high or very high landslide potential, the highest proportion of any subbasin.
- Thirty nine percent (1984) and 36% (2000) of the total stream length were affected by features indicative of excess sediment production, transport, and storage.
- A 7% reduction in the total length of features indicative of excess sediment production, transport, and storage, as well as a 3% reduction in the proportion of streams affected by these features was observed between 1984 and 2000. This is the lowest reduction in stream features observed within the Mattole watershed
- Landsliding related to existing roads, both active and abandoned, is a probable contributor of instream sediment.
- Currently, there is no road assessment program in this subbasin.

Contrary Evidence:

- Review of photographs from the early 1900s combined with anecdotal statements indicates that the Lower North Fork of the Mattole River near Petrolia has been an area of episodic sediment accumulation since the early 1900s. (CGS, 2002).
- Surveys on Rattlesnake Creek showed that McNeil sediment samples were slightly below acceptable threshold levels for optimum salmonid egg and embryo incubation (Hopelain et al. 1997).

Hypothesis 3 Evaluation:

Based upon current supportive and contrary findings, the hypothesis is supported.

Working Hypothesis 4:

A lack of large woody debris in some stream reaches of this subbasin has reduced channel diversity needed to provide suitable habitat conditions for anadromous salmonid populations.

Supporting Evidence:

- None of the ten tributaries surveyed by CDFG in this subbasin was found to have a mean pool shelter rating exceeding 80. Six tributaries had shelter rating scores between 30 and 80. This indicates that woody debris elements affecting scour are not present. Pool shelter ratings of 80 or more are considered suitable, and ratings less than 30 are unsuitable for contributing to shelter that supports salmonids (CDFG Appendix F).
- Boulders provided the primary form of shelter for salmonids in nine of the ten surveyed streams in this subbasin. Small woody debris provided the primary form of shelter for salmonids in Conklin Creek (CDFG Appendix F).
- Existing riparian vegetation in much of this subbasin is small in diameter size class, which is not expected to contribute large woody debris in significant quantities in the near future (CDF Appendix B).
- Large woody debris recruitment potential may be exacerbated by land use practices.

Contrary Evidence:

No contrary evidence at this time.

Hypothesis 4 Evaluation:

Based upon current supportive and contrary findings for the streams surveyed, the hypothesis is supported.

Working Hypothesis 5:

Anadromous salmonid populations in the Northern Subbasin have declined since the 1950s.

Supporting Evidence:

- Interviews with local residents indicate that Chinook salmon and coho salmon were found in the North Fork Mattole River, Mill Creek (RM 5.5), and Conklin Creek, and possibly in Jim Goff Gulch and McGinnis Creek and that steelhead trout were found throughout the Northern Subbasin (CDFG Appendix F).
- Coho salmon were detected in two of the 13 tributaries surveyed in the Northern Subbasin by CDFG in the 1960s, Mill Creek (RM 5.5), and Devil's Creek. 1960s surveys also detected steelhead trout in eleven tributaries (CDFG Appendix F).
- Stream surveys throughout the 1970s, 1980s, and 1990s by CDFG, BLM, Coastal Headwaters Association, and the Redwood Sciences Laboratory continued to document the presence of steelhead trout throughout the Northern Subbasin, but coho salmon were no longer detected (CDFG Appendix F).
- Only three of the eight tributaries surveyed by CDFG in the Northern Subbasin from 1990-2000, Conklin Creek, Oil Creek and Rattlesnake Creek, included a biological survey. Steelhead trout were found in these three streams, but coho salmon were not (CDFG Appendix F).

- Three tributaries in this subbasin were also surveyed as a part of the CDFG 2001 Coho Inventory, McGinnis Creek, the Upper North Fork of the Mattole River, and Oil Creek. Steelhead trout were found in these three streams, but coho salmon were not (CDFG Appendix F).
- Three tributaries in this subbasin were sampled intensively by CDFG for their salmonid populations from 1991 through 1999, Oil Creek, Rattlesnake Creek, and Green Ridge Creek. Stable population structures of steelhead trout were found in these three streams, but coho salmon were not detected (CDFG Appendix F).
- Estimated populations of Chinook salmon or coho salmon in the entire Mattole Basin have not exceeded 1000 since the 1987-88 season. Mattole Basin Chinook salmon and coho salmon population estimates for the 1999-2000 season were 700 and 300, respectively (MSG 2000).

Contrary Evidence:

No contrary evidence at this time.

Hypothesis 5 Evaluation:

Based upon current supportive and contrary findings for the streams surveyed, the hypothesis is supported.

Responses to Assessment Questions

What are the history and trends of the sizes, distribution, and relative health and diversity of salmonid populations within this subbasin?

- Historical accounts and stream surveys conducted in the 1960s by CDFG indicate that the Northern Subbasin supported populations of Chinook salmon, coho salmon, and steelhead trout. Fishery surveys have been conducted on very few tributaries in the Northern Subbasin in the last ten years. Therefore, current fish population information is poor. However, existing recent biological stream surveys indicate the presence of healthy steelhead trout populations but an absence of coho salmon. Mattole Basin-wide data indicate a depressed population of Chinook salmon, which likely indicates a depressed number of Chinook salmon spawners in the Northern Subbasin;

What are the current salmonid habitat conditions in this subbasin? How do these conditions compare to desired conditions?

- Erosion/Sediment
  - Instream sedimentation in several stream reaches in this subbasin may be approaching or exceeding levels considered unsuitable for salmonid populations. Macroinvertebrate data indicate fair to good, or good conditions. However, amphibians sensitive to fine sediment were absent from most stream reaches surveyed in this subbasin;
- Riparian/Water Temperature
  - High summer water temperatures in surveyed streams are deleterious to summer rearing salmonid populations in this subbasin;
- Instream Habitat
  - In general, Northern Subbasin pool habitat, escape and ambush cover, water depth, and substrate embeddedness are unsuitable for salmonids. Large woody debris recruitment potential is very poor overall;
- Gravel Substrate
  - Available data from sampled streams suggest that suitable amounts and distribution of high quality spawning gravel for salmonids is lacking in this subbasin;
- There is a lack of stream survey and water chemistry information for much of the Northern Subbasin;

What are the relationships of geologic, vegetative, and fluvial processes to natural events and land use history?

- This subbasin has the most structurally disrupted and least stable geology in the basin, with approximately 43% of the area underlain by soft terrain. Correspondingly, more than half of the total area occupied by historically-active landslides and gully lengths mapped in the basin are located in the Northern Subbasin. Due to the prevalence of soft terrain with its associated high level of active landslides and gully erosion, it appears that comparatively high rates of natural sedimentation are to be expected in this subbasin;
- Stream channels in this subbasin have the greatest total length of features indicative of excess sediment production, transport and storage within the basin, with the smallest reduction in these features observed between 1984 and 2000;
- Grasslands are extensive in the Northern Subbasin, occupying 31% of the area. Grasslands are commonly associated with soft terrain. As a result of past timber harvest and conversion activities, 40% of the Northern Subbasin is occupied by small diameter (twelve to twenty-four inches diameter at breast height) forest stands. Only 7% is in forest stands greater than twenty-four inches. The most significant vegetation change in recent years was the result of two 1990 wildfires burning 10% of the subbasin, primarily in the Oil Creek and Camp Mattole planning watersheds;

How has land use affected these natural processes?

- Over 99% of this subbasin is privately owned and is managed for timber production and grazing. Current timber harvesting is concentrated on industrial timberland subject to both the California Forest Practice Rules and a Habitat Conservation Plan. Existing road location and densities primarily reflects construction related to timber harvest access since the 1940s;

Based upon these conditions trends, and relationships, are there elements that could be considered to be limiting factors for salmon and steelhead production?

- Based on information available for the Northern Subbasin, the NCWAP team believes that salmonid populations are currently being limited by high water temperatures, high sediment levels, and reduced habitat complexity in the subbasin.

What habitat improvement activities would most likely lead toward more desirable conditions in a timely, cost effective manner?

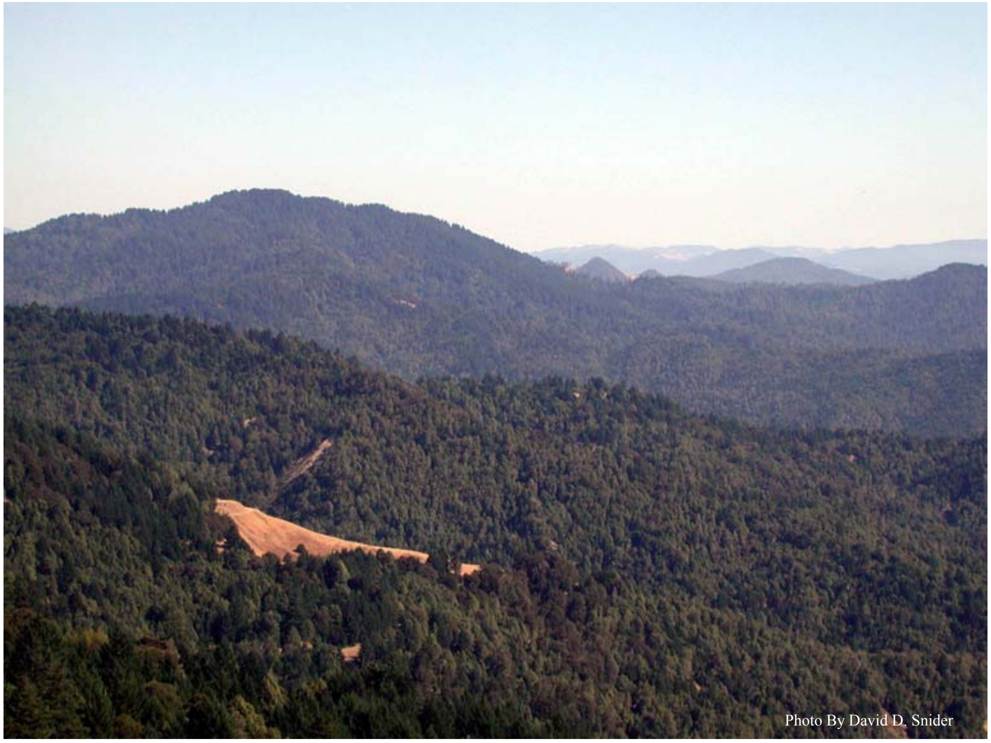
- Encourage more stream inventories and fishery surveys of tributaries within this subbasin;
- In order to protect privacy while developing data, the possibility of training local landowners to survey their own streams and conduct salmonid population status surveys should be developed;
- Several years of monitoring summer water and air temperatures to detect trends using continuous, 24 hour monitoring thermographs should be done. Continue temperature monitoring efforts in the North Fork Mattole River, Sulphur Creek, and the Upper North Fork Mattole River, and expand efforts into other subbasin tributaries. Study the role of seeps and springs as cold water refugia in Oil and Rattlesnake creeks;
- Where current canopy is inadequate and site conditions, including geology, are appropriate, initiate tree planting and other vegetation management to hasten the development of denser and more extensive riparian canopy. Low canopy density measurements were found in Conklin, Oil, Green Ridge, Devils, and Rattlesnake creeks;
- Maintain and enhance existing riparian cover. Use cost share programs and conservation easements as appropriate;
- Landowners and managers in this subbasin should be encouraged to add more large organic debris and shelter structures in order to improve channel structure, channel function, habitat complexity, and habitat diversity for salmonids. Pool shelter has the lowest suitability for salmonids in Sulphur Creek Tributary #1, Conklin, and Green Ridge creeks;

- Establish monitoring stations and train local personnel to track in-channel sediment and aggraded reaches throughout the subbasin and especially in the lower reaches of the North Fork Mattole River and the Upper North Fork Mattole River;
- Consider the nature and extent of naturally occurring unstable geologic terrain, landslides and landslide potential (especially Categories 4 and 5, page 89) when planning potential projects in the subbasin;
- Encourage the use of appropriate Best Management Practices for all land use and development activities to minimize erosion and sediment delivery to streams. For example, low impact yarding systems should be used in timber harvest operations on steep and unstable slopes to reduce soil compaction, surface disturbance, and resultant sediment yield;
- Based on the high incidence of unstable slopes in this subbasin, any future sub-division development proposals should be based on existing county-imposed forty acre minimum parcel sub-division ordinances;
- At stream bank erosion sites, encourage cooperative efforts to reduce sediment yield to streams. CDFG stream surveys indicated Sulphur Creek, Sulphur Creek Tributaries 1 and 2, Conklin Creek, Oil Creek, and the lower reaches of the North Fork Mattole River have bank stabilization activities as a top tier tributary improvement recommendation. Rattlesnake, McGinnis, Green Ridge, and Devils creeks also have eroding banks mapped by CGS. These could be of localized importance to reduce stream fine sediment levels;
- Continue efforts such as road erosion proofing, improvements, and decommissioning throughout the basin to reduce sediment delivery to the Mattole River and its tributaries. CDFG stream surveys indicated Sulphur Creek and Sulphur Creek Tributary #1 have road sediment inventory and control as a top tier tributary improvement recommendation.

Subbasin Conclusions

The Northern Subbasin appears to be the most impacted of the Mattole subbasins, due to naturally occurring geologic processes and land use. High channel sedimentation levels, high summer water temperatures, simplified salmonid habitat, and a lack of high quality spawning gravels indicate that present stream conditions may not be fully supportive of salmonids in many stream reaches in this subbasin. However, historical accounts indicate that stream conditions were favorable for salmonid populations in the past. Accordingly, there are abundant opportunities for improvements in watershed stream conditions and a great need to restore areas of stream refugia. Surveys by landowners, water temperature monitoring, riparian canopy restoration, improvements to channel complexity such as additional LWD are examples of such opportunities. The preponderance of naturally unstable and erosive terrain should be considered before project implementation and appropriate BMPs should be followed to minimize erosion and sediment delivery to streams. Current landowners and managers interested and motivated to eliminate impacts related to land use and accelerate a return to the stable, beneficial conditions for salmonids are encouraged to do so, enlisting the aid and support of agency technology, experience, and funding opportunities.

Eastern Mattole Subbasin



Looking southeast to Gilham Butte

Introduction

The Eastern Subbasin is located between Honeydew Creek, at river mile 26.5 (RM 26.5) and Bridge Creek (RM 52.1) along the eastern side of Wilder Ridge, at Whitethorn Junction, for a distance of about 25.6 river miles (Figure 79). Fifteen perennial streams drain a watershed area of 79 square miles. Elevations range from 344 feet at Honeydew Creek to approximately 2,300 feet in the headwaters of the tributaries.

The NCWAP team's Eastern Subbasin results and analyses are presented in three basic sections. First, general information describing the subbasin is presented by different disciplines. Secondly, this information is integrated and presented to provide an overall picture of how different factors interact within the subbasin. Lastly, an overall assessment of the Eastern Subbasin is presented. The NCWAP team developed hypotheses, compiled supportive and contrary evidence, and used these six assessment questions to focus this assessment:

- What are the history and trends of the sizes, distribution, and relative health and diversity of salmonid populations within this subbasin?
- What are the current salmonid habitat conditions in this subbasin? How do these conditions compare to desired conditions?
- What are the relationships of geologic, vegetative, and fluvial processes to natural events and land use history?
- How has land use affected these natural processes?
- Based upon these conditions trends, and relationships, are there elements that could be considered to be limiting factors for salmon and steelhead production?
- What habitat improvement activities would most likely lead toward more desirable conditions in a timely, cost effective manner?

The assessment questions are answered at the end of this section.

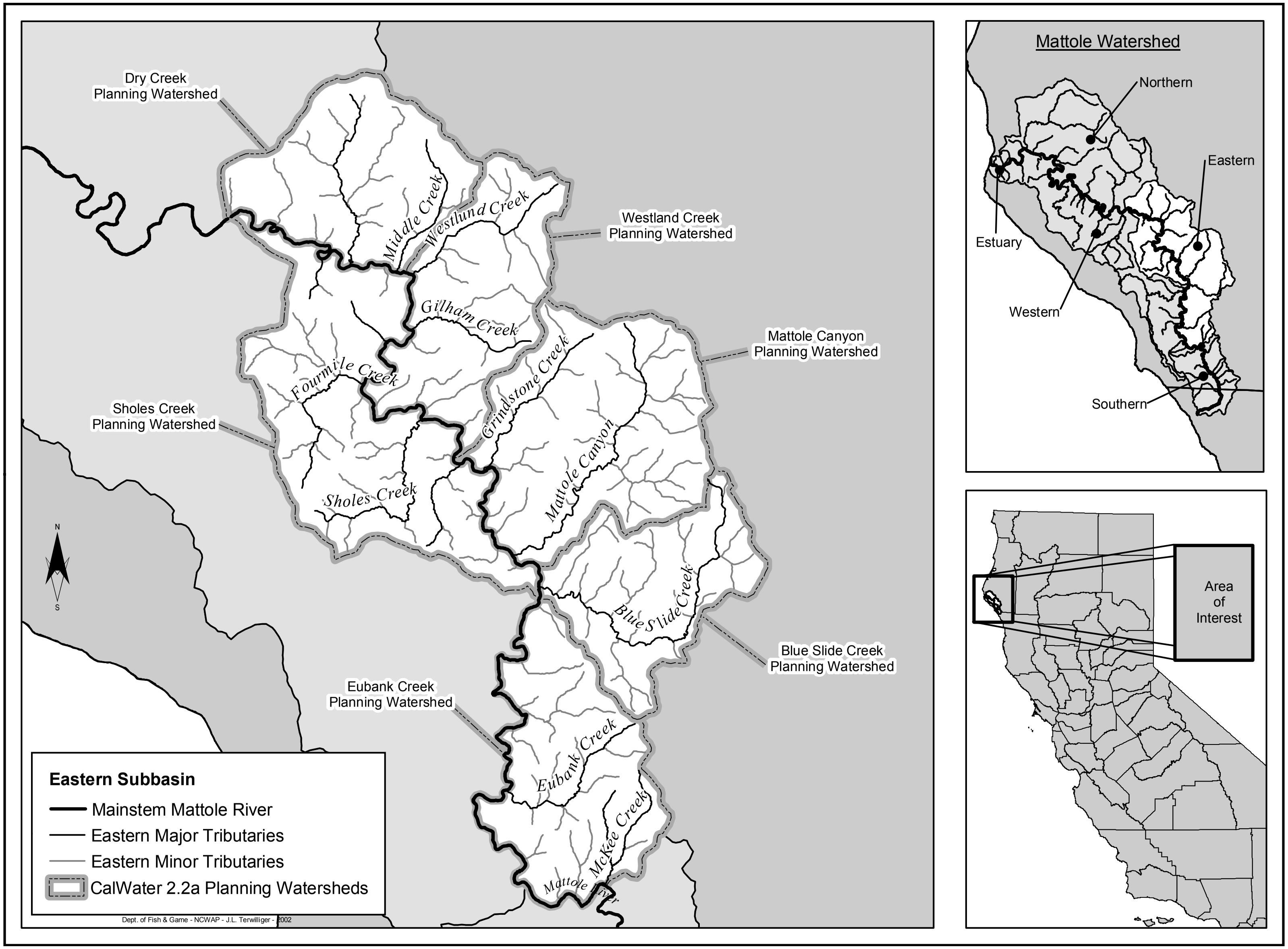


Figure 79. Mattole Eastern Subbasin.

Climate

The Eastern Subbasin has the highest yearly rainfall averages, ranging from 85 inches near Thorn Junction to 115 inches in the hills east of Honeydew. Temperatures are typical of other inland areas of California with sub-freezing winter temperatures and above 100°F summer temperatures.

Hydrology

The Eastern Subbasin is made up of six complete CalWater Units (Figure 79). There are 54.0 perennial stream miles in 15 perennial tributaries in this subbasin (Table 84). Eighteen of these tributaries have been inventoried by CDFG. There were 26 reaches, totaling 34.9 miles in the inventory surveys. The inventories included channel and habitat typing, and biological sampling.

Table 84. Streams with estimated anadromy in the Eastern Subbasin.

Stream	CDFG Survey (Y/N)	CDFG Survey Length (miles)	Estimated Anadromous Habitat Length (miles)*	Reach	Channel Type
Dry Creek	Y	1.6	3.0	1	F4
Middle Creek	Y	1.4	2.1	1	B4
Westlund Creek	Y		3.1		
	Y	2.3		1	B4
	Y	0.9		2	A4
Gilham Creek	Y	1.9		1	B4
	Y	0.7		2	A3
Gilham Creek Tributary	Y	0.6		1	B4
Duncan Creek	N				
Four Mile Creek	Y		3.1		
	Y	0.5		1	C4
	Y	0.7		2	A4
North Fork Four Mile Creek	Y				
	Y	0.5		1	C4
	Y	0.7		2	A4
Sholes Creek	Y	4.0	2.0	1	B4
Harrow Creek	Y	0.2	0.2	1	B3
Little Grindstone Creek	Y	0.6		1	B4
Grindstone Creek	Y	2.6	0.3	1	B4
Mattole Canyon	N		6.0		
Blue Slide Creek	Y	6.3	7.0	1	F4
Fire Creek	Y	2.0		1	F4
Deer Lick Creek	N				
Box Canyon Creek	Y				
	Y	0.2		1	F4
	Y	0.2		2	B4
	Y	0.2		3	B2
Eubank Creek	Y		3.2		
	Y	3.0		1	B1
	Y	0.3		2	B4
Sinkyone Creek	N				
McKee Creek	Y		2.1		
	Y	0.7		1	B3
	Y	1.5		2	F4
McKee Creek Tributary #1	Y	0.1		1	
Painter Creek	Y	0.3	1.1	1	F4

* Data from the Mattole Salmon Group.

In their inventory surveys, CDFG crews utilize a chin el classification system developed by David Rosgen (1994) and described in the *California Salmonid Stream Habitat Restoration Manual*. Rosgen channel typing describes relatively long stream reaches using eight channel features: channel width, depth, velocity, discharge, channel slope, roughness of channel materials, sediment load and sediment size. There are eight general channel types in the Rosgen classification system.

In the Eastern Subbasin, there were four type A channels, totaling 3.0 miles; twelve type B channels, totaling 17.8 miles; two type C channels, totaling 1.0 miles; and six type F channels, totaling 11.9 miles. Type A stream reaches are narrow, moderately deep, single thread channels. They are entrenched, high gradient reaches with step/pool sequences. Type A reaches flow through steep V- shaped valleys, do not have well-developed floodplains, and have few meanders. Type B stream reaches are wide, shallow, single thread channels. They are moderately entrenched, moderate to steep gradient reaches, which are riffle-dominated with step/pool sequences. Type B reaches flow through broader valleys than type A reaches, do not have well-developed floodplains, and have few meanders. Type C stream reaches are wide, shallow, single thread channels. They are moderately entrenched, low gradient reaches with riffle/pool sequences. Type C reaches have well-developed floodplains, meanders, and point bars. Type F stream reaches are wide, shallow, single thread channels. They are deeply entrenched, low gradient reaches and often have high rates of bank erosion. Type F reaches flow through low-relief valleys and gorges, are typically working to create new floodplains, and have frequent meanders (Flosi, et al., 1998).

Geology

This subbasin encompasses the widest range of bedrock types and structure in the Mattole Basin, including portions of the Coastal terrane, Yager terrane, and Central belt mélange, along with the fault zones that form the boundaries between the terranes. Correspondingly, relative slope stability and geomorphology vary widely within the subbasin. In general, the bedrock may be described as relatively intact and stable material that is locally interrupted by northwest-trending zones of sheared mélange and faulting where the rock is much weaker and susceptible to weathering. As with other areas in the watershed, soft terrain consisting of grassland areas impacted by earthflows, soil creep, and gully erosion tend to develop in the mélange matrix and fault zones. These conditions are found along a broad shear zone that extends to the southeast from Honeydew, along Pringle Ridge and on across the Mattole River near Duncan Creek. Similar conditions are found in the upper reaches of Mattole Canyon Creek and Blue Slide Creek where several fault zones and Central belt mélange are present. Steep forested slopes locally impacted by historically active debris slides and occasional large, deep-seated, dormant landslides are more typical in the moderate to hard terrain in the subbasin. Terrain distribution for the entire Mattole Basin is shown on Figure 24). Overall, approximately 24% of the Eastern Subbasin is occupied by mapped landslides, and approximately 6% of the subbasin is occupied by historically-active landslides (Figure 25). A map showing the distribution of geologic units, landslides, and geomorphic features is presented on Plate 1 in the Geologic Report, Appendix A.

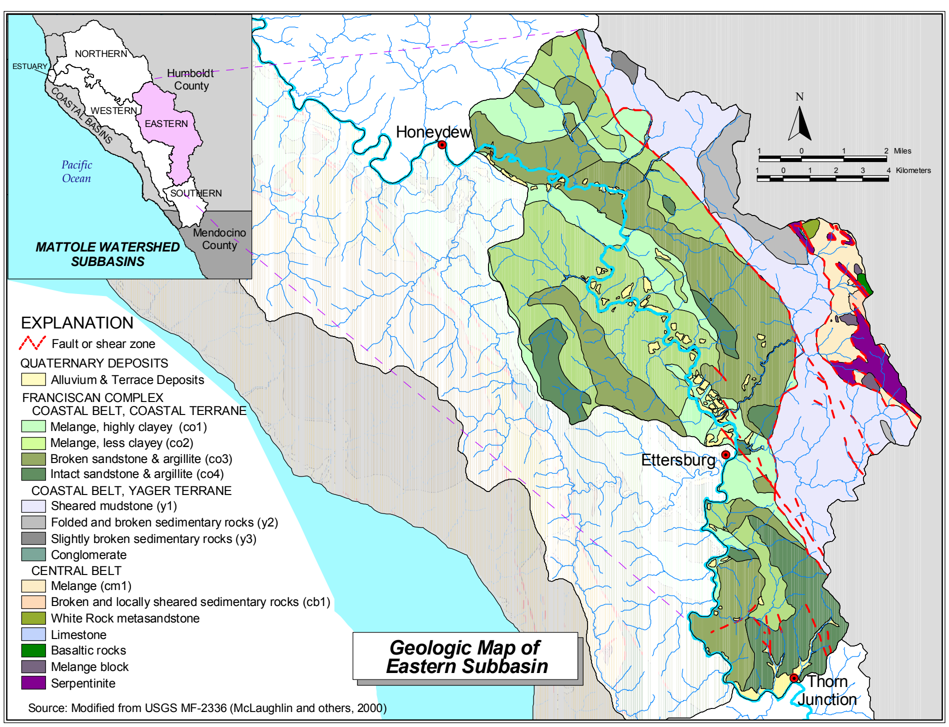


Figure 80. Geology of the Eastern Subbasin.

Vegetation

Unless otherwise noted, the vegetation description in this section is based on manipulation of CalVeg 2000 data. This is vegetation data interpreted from satellite imagery by the United States Forest Service, Remote Sensing Lab. The minimum mapping size is 2.5 acres.

Mixed hardwood and conifer forests cover 64% of the area, conifer forest 9%, and hardwood forest 16% for a total of 89% forested area (Figure 81). Grassland occupies 11% of the subbasin. Shrub, barren, agricultural lands, and urban classifications together cover the remaining 2% of the area. Fifty-six percent of the Eastern Subbasin is in the 12 to 23.9 inch diameter breast height (dbh) size class. Twenty-one percent is in a diameter size class greater than 24 inches dbh.

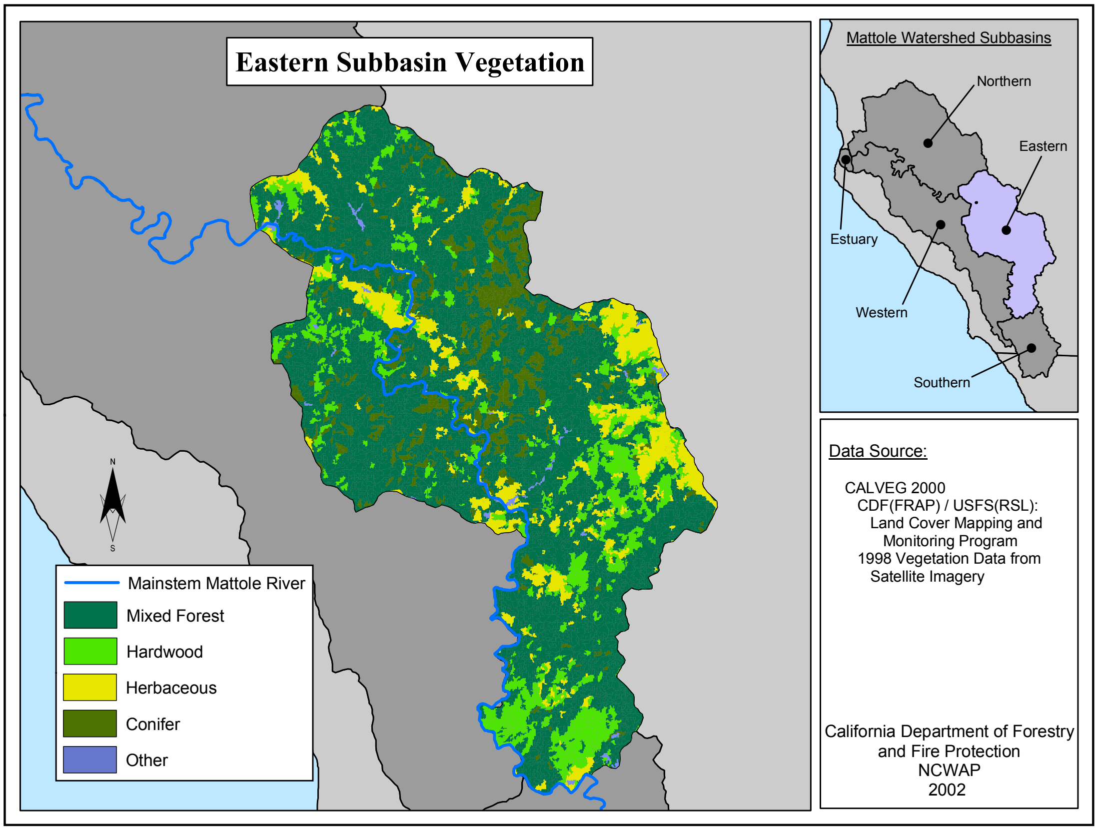


Figure 81. Vegetation of the Eastern Subbasin.

Land Use

The watershed is largely subdivided into back-to-land homesteads, Figure 82. About a third of the area is managed for timber production and cattle ranching. The town of Honeydew is located at the downstream end of this subbasin near the confluence of Honeydew Creek and the Mattole River. The hamlets of Ettersburg and Thorn Junction are also located in this subbasin. Controversy over timber harvest issues has occurred in the past, focusing on stands near Gilham Butte. There is some citizen interest to establish a wildlife and forestland corridor linking lands in the South Fork Eel River to Humboldt Redwood State Park, through the Gilham Butte protected lands and across the basin to the King Range National Recreation Area in the Western Subbasin. The track of this corridor would bisect the middle of this subbasin as well as the largest remaining ranch, thus a large portion of the subbasin would, for the most part, be unavailable for sub-division. It has been suggested that a conservation easement might be negotiated with the ranch ownership to provide the corridor and allow the traditional land use to continue.

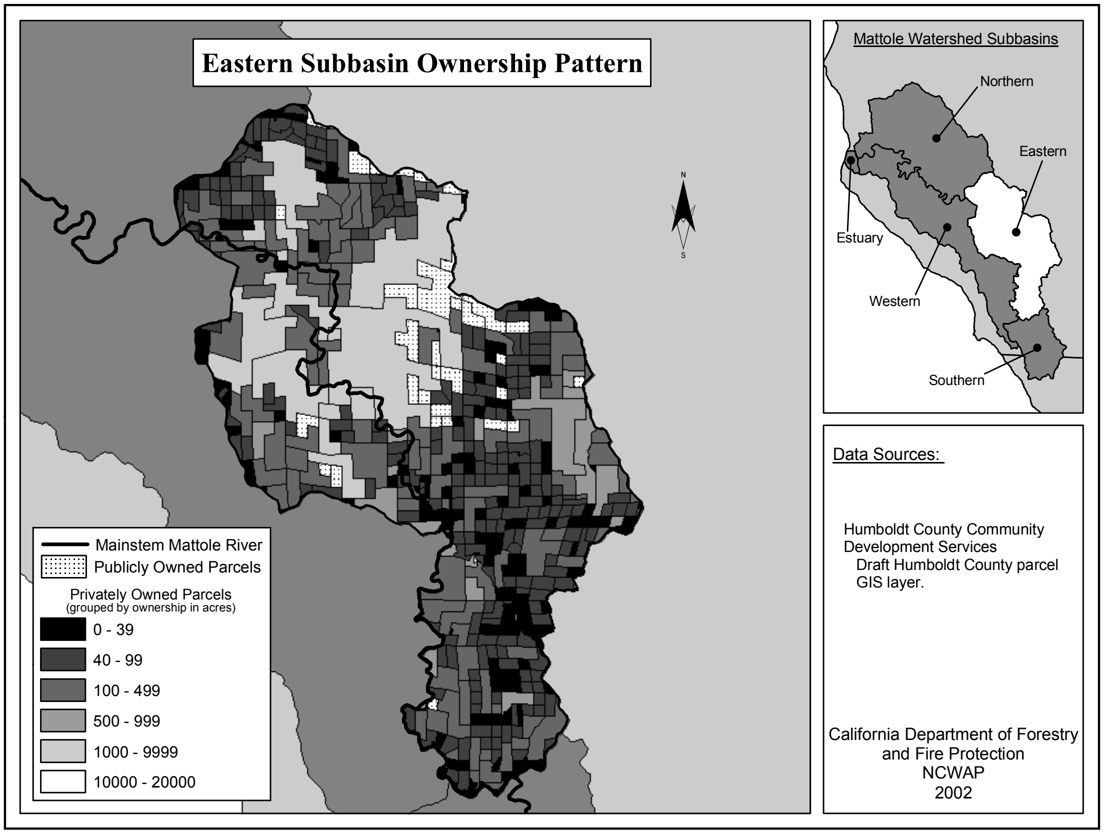


Figure 82. Ownership pattern of the Eastern Subbasin.

Timber harvesting covered a substantial portion of the basin prior to the 1964 flood (Figure 83, Table 85). Aerial photograph analysis of 1941 and 1952 aerial photographs show the main activity appeared to be maintenance of grassland and conversion of forestland to grassland. In many cases, grassland conversion was accomplished by use of fire, though in the aerial photographs standing dead trees were present while there was no indication of skid trails for harvesting. Later, as timber harvesting occurred, the logging method was tractor logging down to streamside road systems. The silviculture was a type of seed tree cut that often left brush and some conifer. Timber harvesting activity since 1983 (Figure 84) has covered about 5% of the subbasin. There have been no timber harvesting plans filed in the smaller parcel sizes that are now rural subdivisions. Almost all of the acreage harvested utilized an even-aged silvicultural method, including the shelterwood removal step. About 80% of the harvested area was tractor logged.

Table 85. Timber harvest history, Eastern Mattole Subbasin.

TIMBER HARVEST HISTORY - EASTERN SUBBASIN*				
	Total Harvested Acres	Total Area Harvested (%)	Average Annual Harvest (ac)	Annual Harvest Rate (%)
Harvested ~1945 - 1961**	21,431	42%	1,261	2%
Harvested 1962 - 1974**	7,639	15	588	1
Harvested 1975 - 1983**	3,288	7	365	<1
Harvested 1984 - 1989	554	1	92	<1
Harvested 1990 - 1999	2,010	4	201	<1
Harvested 2000 - 2001	47	<1	24	<1
Not Harvested:				
Grasslands	6,223	12		
Brush and Hardwoods	9,260	18		

* Does not add to 100% due to data discrepancies, re-harvest areas, and uncut timber areas.

** CDF has not yet validated the accuracy of this data (obtained from MRC).

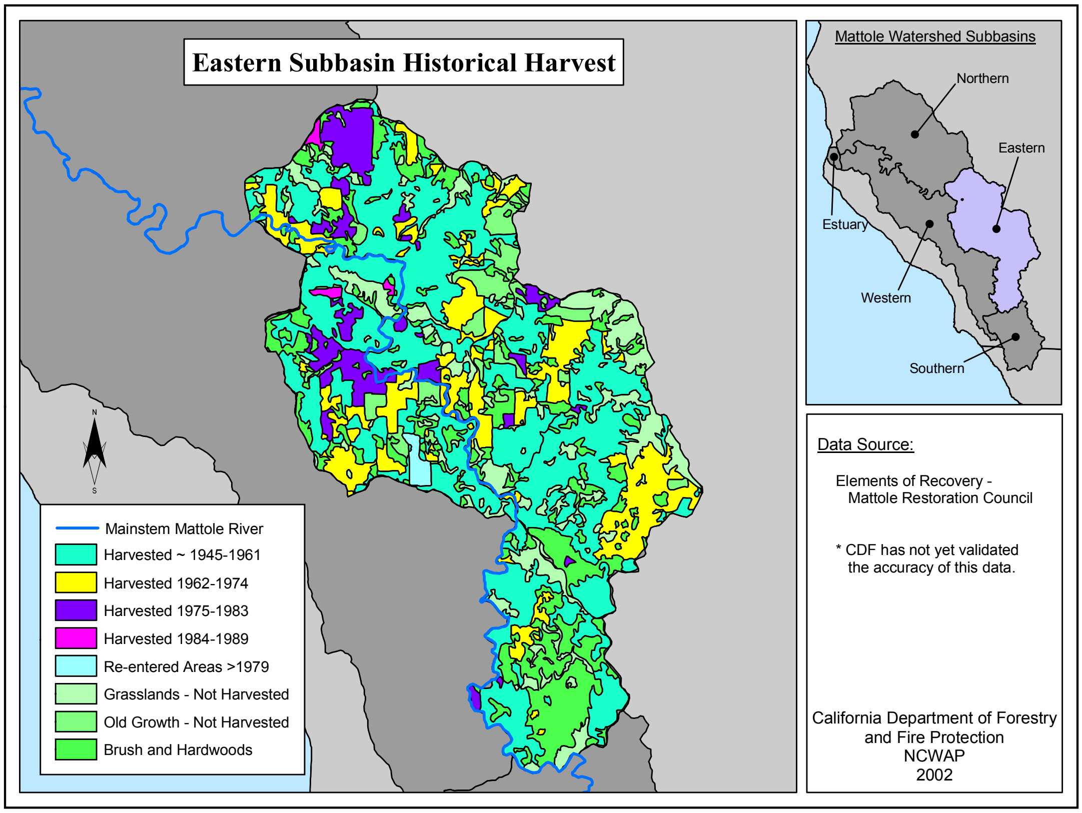


Figure 83. Timber harvest history for the Eastern Subbasin

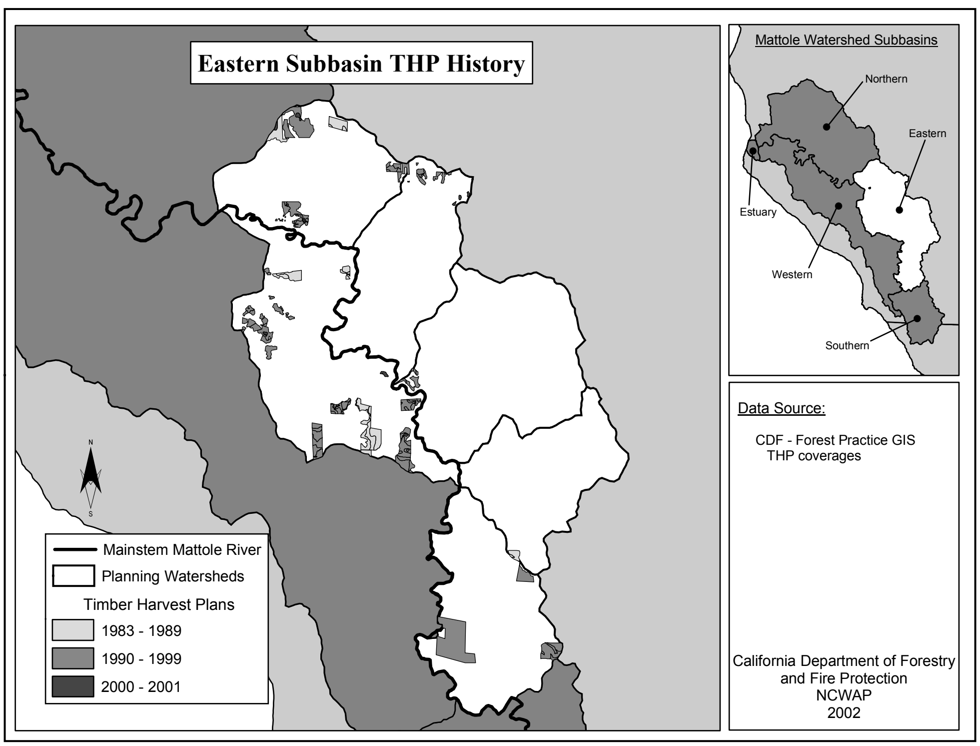


Figure 84. Timber harvesting plans history 1983-2001, Eastern Subbasin.

The Eastern Subbasin contains an extensive and largely unsurfaced road system to service the rural sub-divisions in the subbasin (Figure 85). These roads are used year-round by residents, further elevating the already high production rates of fine sediment into the stream network. This condition is deleterious to stream habitat for salmonids. These impacts, especially in the depositional, lower reaches of the tributaries, adversely affects summer juvenile rearing and creates less than ideal spawning conditions for adult salmonids.

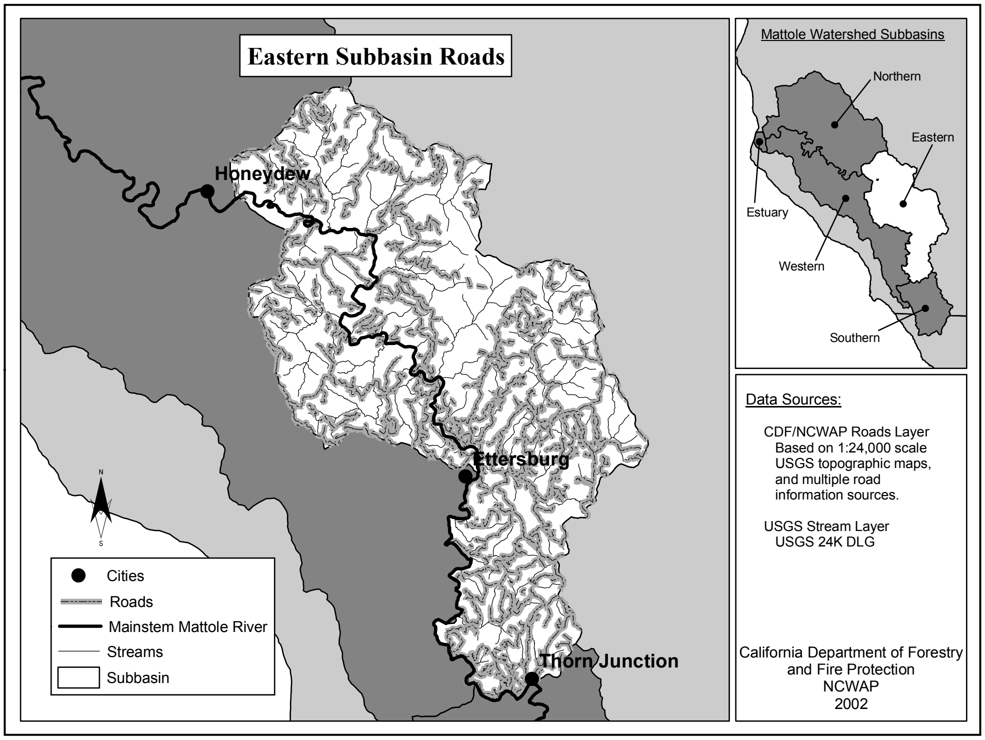


Figure 85. Eastern Subbasin road system.

Fluvial Geomorphology

The Eastern Subbasin shows the largest reduction in the length of mapped channel characteristics between 1984 and 2000 as well as the largest reduction (27%) in blue-line stream length occupied by negative mapped channel characteristics (NMCCs) (CGS Geologic Report-Table 12). Table 86 and Table 87 illustrate the range in MCCs, gullies, and lateral-bar development from the 1984 and 2000 aerial photographs. Comparing the two photo sets it can be seen that every PW within the Eastern Subbasin has shown a significant decrease in MCCs. The most noteworthy example is illustrated in the Sholes Creek PW, where the length of MCCs decreased by 68,200 feet from 1984 to 2000. Two PWs, Blue Slide and Sholes Creeks, have demonstrated a dramatic reduction in lateral-bar development, which suggests a decrease in excess sediment.

There has been a dramatic reduction in the length of wide channels, and a two-fold decrease in the length of displaced riparian vegetation in this subbasin (Table 86 and Table 87.). However, there has been a doubling of the length of gullies within the Eastern Subbasin (Table 86). Significant improvement was observed between 1984 and 2000 in the proportion of blue line streams in bedrock and adjacent to or within LPM 4 and 5 that were affected by NMCC's. In 1984, about 70% of such stream reaches were affected by NMCCs while in 2000 about 20% were affected (CGS Geologic Report Table 14). Considering the low concentration of NMCC's in the upstream Southern Subbasin and the increase in NMCC's in the alluvial reaches of this subbasin, it appears that sediment is being produced internally or from the adjacent Western Subbasin.

A sizeable area of sediment deposition was observed along Dry Creek immediately upstream from a large slide. This area of deposition has been attributed to this large persistent slide acting as a point of hydrologic constraint. The mouth of Mattole Canyon has also been a long-term area of sediment accumulation. This can be attributed to weak rocks and numerous landslides up- canyon, and a reduction of stream gradient near the area of deposition.

Table 87 documents the number of sites and summarizes the lengths of eroding-bank features within the Eastern Subbasin. Stream-bank erosion has been observed in all but one of the planning watersheds of this subbasin. The number of eroding-bank sites range from one in the Mattole Canyon PW to 10 in the Sholes Creek PW. Approximately 12,100 feet of eroding bank has been mapped in the Sholes Creek PW.

In summary, observations from the 2000 air photos shows that every PW within the Eastern Subbasin has shown a significant decrease in mapped channel characteristics since 1984, with all but one PW showing a significant increase in the length of gullies. Stream-bank erosion has been observed within all but one of the planning watersheds within the Eastern Subbasin. The majority of eroding stream banks within this subbasin are within the Sholes Creek and Dry Creek PWs. There has been a dramatic decrease in the length of wide channels from 1984 to 2000, and a decrease in the length of displaced riparian vegetation (Figure 34 and Figure 35).

Table 86. Fluvial geomorphic features - Eastern Subbasin

	2000 Photos			1984 Photos		
Planning Watersheds1	**Length of Mapped Channel Characteristics2 (feet)**	**Total Gully Length3 (feet)**	**Lateral Bar Development4**	**Length of Mapped Channel Characteristics2 (feet)**	**Total Gully Length3 (feet)**	**Lateral Bar Development4**
Blue Slide Creek	2,200	33,800	1	55,300	11,500	3-5
Dry Creek	46,800	17,400	2-4	65,500	2,100	3-5
Eubank Creek	13,400	22,400	1	56,600	27,500	1
Mattole Canyon	44,700	78,500	3-4	87,900	33,600	3-5
Sholes Creek	60,400	42,500	3-4	128,600	22,600	3-5
Westland Creek	26,200	35,100	3	59,500	8,100	3-5
Eastern Subbasin Totals	193,700	229,800		453,400	105,400	

1 See Figure 2 for locations.
2 Features include negative and neutral characteristics including: wide channels, displaced riparian vegetation, point bars, distribution and lateral or mid-channel bars, channel bank erosion, shallow landslides adjacent to channels.
3 Gullies include those that appear active, have little to no vegetation within the incised area, and are of sufficient size to be identified on aerial photos.
4 Lateral bars include mappable lateral, mid-channel bars and reflect sediment supply and storage. Rankings range from 1-5. Higher values suggest excess sediment.

Table 87. Eroding stream bank lengths - Eastern Subbasin.

2000 Photos				
Eastern Subbasin Planning Watersheds1	**Number of Sites2**	**Maximum Length (feet) of Eroding Bank3**	**Total Length (feet) of Eroding Bank4**	**Eroding Bank (%)5**
Blue Slide Creek	0	N.O.	N.O.	N.A.
Dry Creek	7	1,800	4,500	5
Eubank Creek	3	500	900	1
Mattole Canyon	1	300	300	<1
Sholes Creek	10	3,700	12,100	9
Westland Creek	3	800	1,600	2

1 See Figure 2 for locations.
2 Number of sites mapped from air photos within PW.
3 Maximum length of a continuous section of eroding stream bank within PW.
4 Combined total length of all sections of eroding stream bank within PW.
5 Approximate percentage of eroding stream bank relative to total stream length within PW.
N.O.– Not Observed.
N.A. – Not Applicable.

Aquatic/Riparian Conditions

Unless otherwise noted, the vegetation description in this section is based on manipulation of CalVeg 2000 data. This is vegetation data interpreted from satellite imagery by the United States Forest Service, Remote Sensing Lab. The minimum mapping size is 2.5 acres.

Vegetation within 150 feet of the centerline of streams is 70% mixed conifer and hardwood forest, 11% hardwood, 9% conifer forest, 4% annual grassland and 5% barren while shrubs, water, agricultural and urban combined make up the remaining 1%. The large percentage of barren occurs primarily along the Mattole River downstream of the confluence of Mattole Canyon and the Mattole River, the downstream portion of Mattole Canyon and in Dry Creek. Trees in the 12 to 23.5 inch diameter size class cover 58% of the riparian area. The area occupied by this single-width zone is 13% of the total Eastern Subbasin acreage.

Fish Habitat Relationship

Anadromous stream reach conditions in the Eastern Subbasin were somewhat unsuitable as evaluated by the stream reach EMDS. The anadromous reach condition EMDS is composed of water temperature, riparian vegetation, stream flow, and in channel characteristics. More details of the EMDS are in the EMDS Appendix C.

Data on water temperature and stream flow have not yet been incorporated into EMDS. However, water temperature data are presented in the NCRWQCB Appendix E) and stream flow data are presented in the DWR Appendix C and in individual stream survey report summaries in the CDFG Appendix E. Temperature records were available for Westlund, Mattole Canyon, Blue Slide Creek, and Eubank Creeks. All MWATs for these four tributaries from 1996-2001 were above the 50-60° F range for optimal coho growth, except Eubank Creek at 59.7° F during 2001.

Stream attributes that were evaluated by the anadromous stream reach EMDS included canopy cover, embeddedness, percent pools, pool depth, and pool shelter. These attributes were collected in 16 streams in the Eastern Subbasin by CDFG (see CDFG Appendix F) for stream survey report summaries).

Stream attributes tend to vary with stream size. For example, larger streams generally have more open canopy and deeper pools than small streams. This is partially a function of wider stream channels and greater stream energy due to higher discharge during storms. Surveyed streams in the Eastern Subbasin ranged in drainage area from 0.6 to 9.9 square miles (Figure 86).

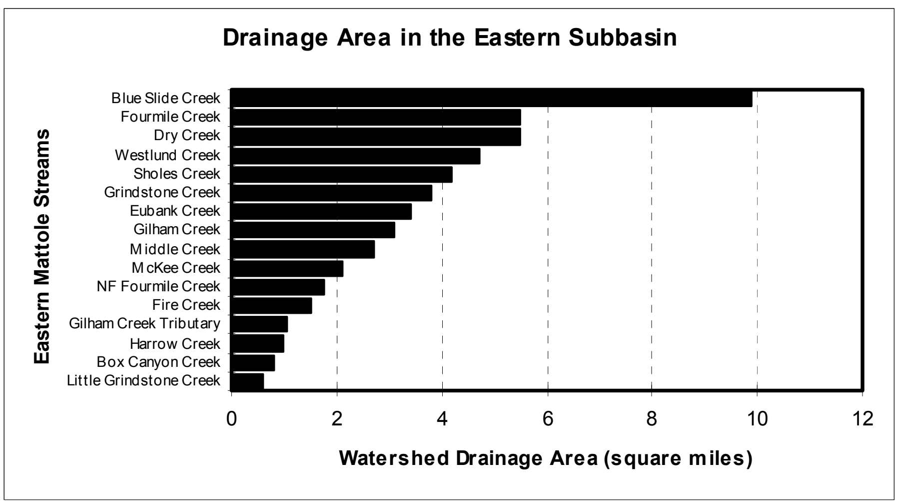


Figure 86. Drainage area of stream surveyed by CDFG in Eastern Subbasin.

Canopy density, and relative canopy density by coniferous versus deciduous trees were measured at each habitat unit during CDFG stream surveys. Near-stream forest density and composition contribute to microclimate conditions that help regulate air temperature, which is an important factor in determining stream water temperature. Furthermore, canopy levels provide an indication of the potential present and future recruitment of large woody debris to the stream channel, as well as the insulating capacity of the stream and riparian areas during winter.

In general, the percentage of stream canopy density increases as drainage area and therefore, channel width, decrease. Deviations from this trend in canopy may indicate streams with more suitable or unsuitable canopy relative to other streams of that subbasin. As described by the EMDS response curves, total canopy (sum of conifer and deciduous canopy) exceeding 85% is considered fully suitable, and total canopy less than 50% is fully unsuitable for contributing to cool water temperatures that support salmonids. The surveyed streams of the Eastern Subbasin show a wide range of percent canopy levels (46%-99% total canopy) that vary in their EMDS rating from fully suitable to fully unsuitable (Figure 87). Existing canopy is strongly dominated by deciduous trees in this subbasin.

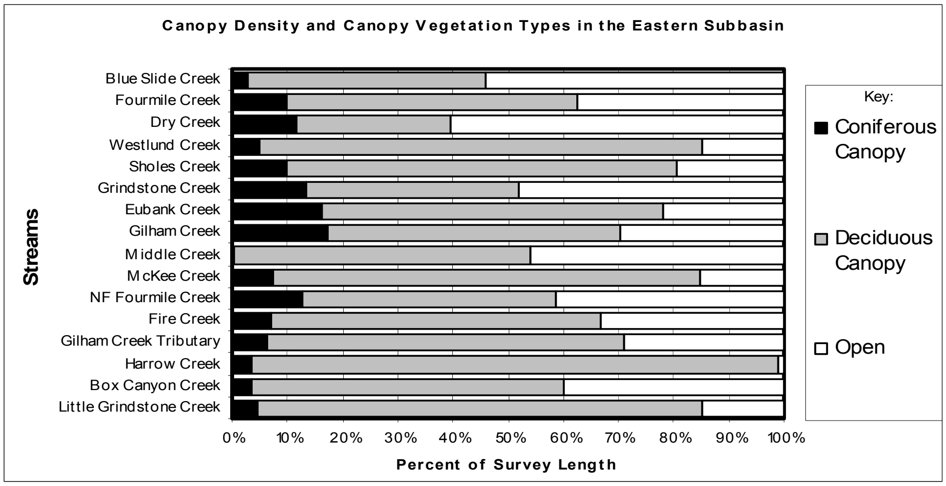


Figure 87. Relative percentage of coniferous, deciduous, and open canopy covering surveyed streams, Eastern Subbasin.

Averages are weighted by unit length to give the most accurate representation of the percent of a stream under each type of canopy. Streams are listed in descending order by drainage area (largest at the top). As described in the EMDS response curves, total canopy (sum of conifer and deciduous canopy) exceeding 85% is considered fully suitable, and total canopy less than 50% is fully unsuitable for contributing to cool water temperatures that support salmonids.

Cobble embeddedness was measured at each pool tail crest during CDFG stream surveys. Cobble embeddedness is the percentage of an average sized cobble piece at a pool tail out that is embedded in fine substrate. Category 1 is 0-25% embedded, Category 2 is 26-50% embedded, Category 3 is 51-75% embedded, Category 4 is 76-100% embedded, and Category 5 is unsuitable for spawning due to factors other than embeddedness. Cobble embedded deeper than 51% is not within the fully supported range for successful use by salmonids. The EMDS Reach Model considers cobble embeddedness greater than 50% to be somewhat unsuitable and 100% to be fully unsuitable for the survival of salmonid eggs and embryos. Embeddedness values in the Eastern Subbasin are somewhat unsuitable or worse for the survival of developing salmonid eggs and embryos (Figure 88). However, Figure 88 also illustrates how stream reaches rated as unsuitable overall may actually have some suitable spawning gravel sites distributed through the stream reach.

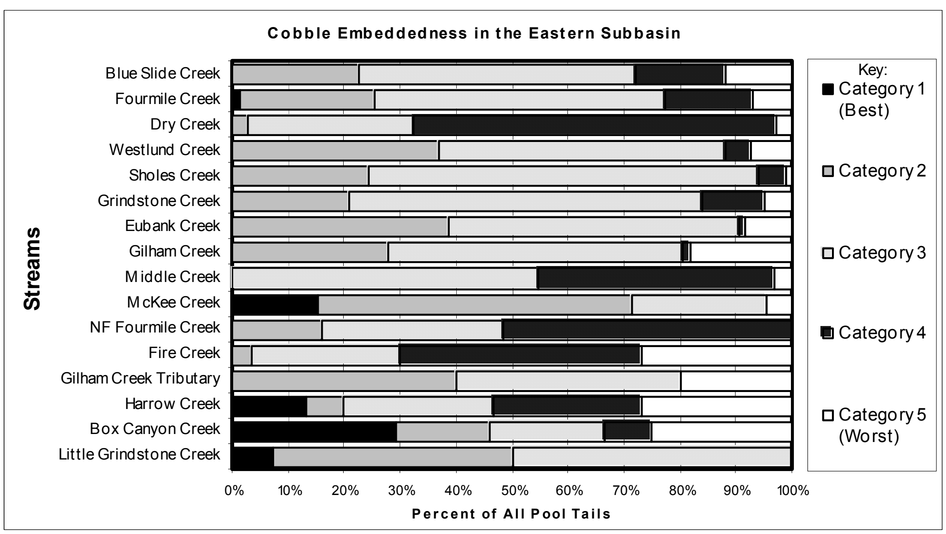


Figure 88. Cobble embeddedness categories as measured at every pool tail crest in surveyed streams, Eastern Subbasin.

Cobble embeddedness is the % of an average-sized cobble piece at a pool tail out that is embedded in fine substrate: Category 1 = 0-25% embedded, Category 2 = 26-50% embedded, Category 3 = 51-75% embedded, Category 4 = 76-100%, and Category 5 = unsuitable for spawning due to factors other than embeddedness (e.g. log, rocks). Substrate embeddedness Categories 3, 4, and 5 are considered by EMDS to be somewhat unsuitable to fully unsuitable for the survival of salmonid eggs and embryos. Streams are listed in descending order by drainage area (largest at the top).

Pool, flatwater, and riffle habitat units observed were measured, described, and recorded during CDFG stream surveys. During their life history, salmonids require access to all of these types of habitat. EMDS does not evaluate the ratio of these habitat types, but a balanced proportion is desirable. Most surveyed

Eastern Subbasin tributaries have less than 20% pool habitat by length indicating unsuitable conditions for salmonid rearing and holding (Figure 89). This is well below the range considered fully suitable as described below. Eubank Creek has the most pool habitat (33%). Dry units were also measured, and obviously indicate poor conditions for fish.

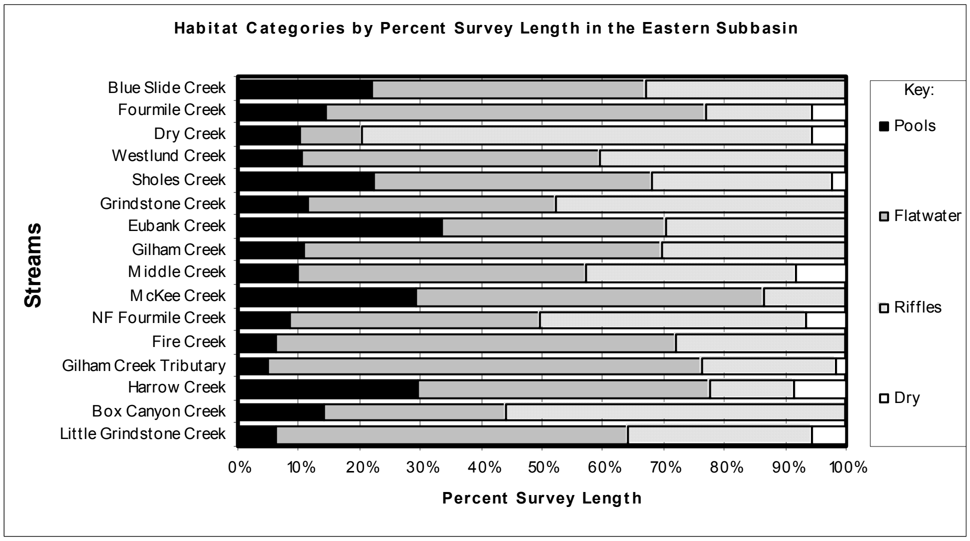


Figure 89. Percentage of pool habitat, flatwater habitat, riffle habitat, and dewatered channel by survey length, Eastern Subbasin.

EMDS does not evaluate the ratio of these habitat types, but a balanced proportion is desirable. Streams are listed in descending order by drainage area (largest at the top).

Pool depths were measured during CDFG surveys. The amount of primary pool habitat of sufficient depth to be fully suitable for anadromous salmonids is considered in the EMDS Reach Model. Primary pools are determined by a range of pool depths, depending on the order (size) of the stream. Generally, a reach must have 30 – 55% of its length in primary pools for its stream class to be in the suitable ranges. Generally, larger streams have deeper pools. Deviations from the expected trend in pool depth may indicate streams with more suitable or unsuitable pool depth conditions relative to other streams of that subbasin. Eubank Creek has the highest frequency of deeper pools (Figure 90), but other streams are unsuitable with respect to pool depth.

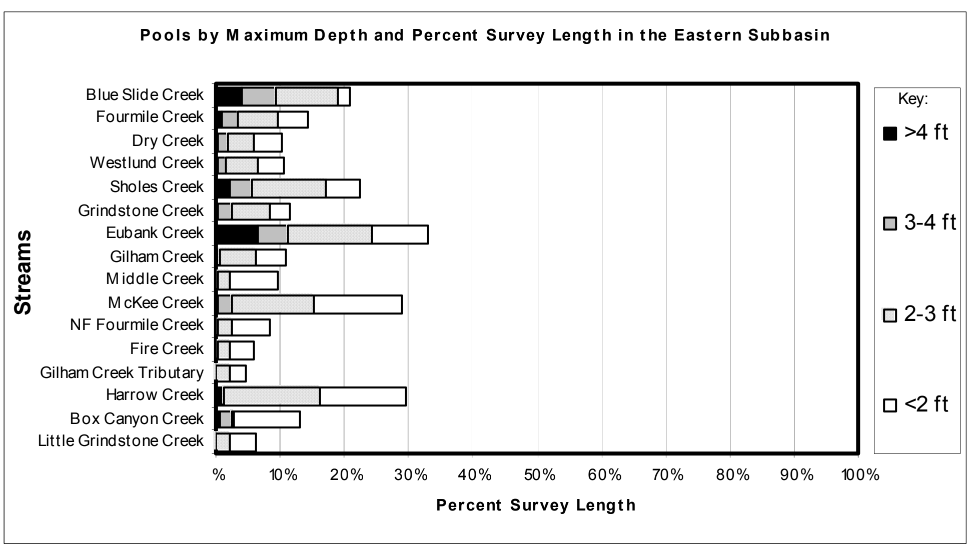


Figure 90. Percent length of a survey composed of deeper, high quality pools, Eastern Subbasin

Values sum to the length of percent pool habitat in Figure 89. As described in the EMDS response curves, a stream must have 30-55% of its length in primary pools to provide stream conditions that are fully suitable for salmonids. Streams with <20 % or >90% of their length in primary pools provide conditions that are fully unsuitable for salmonids. Streams are listed in descending order by drainage area (largest at the top).

Pool shelter was measured during CDFG surveys. Pool shelter rating illustrates relative pool complexity, another component of pool quality. Ratings range from 0-300. The Stream Reach EMDS model evaluates pool shelter to be fully unsuitable if less than a rating of 30. The range from 100 to 300 is fully suitable. Pool shelter ratings in Eastern Subbasin tributaries are among the lowest in the Mattole Basin and offer unsuitable pool habitat complexity and cover for anadromous fish (Figure 91).

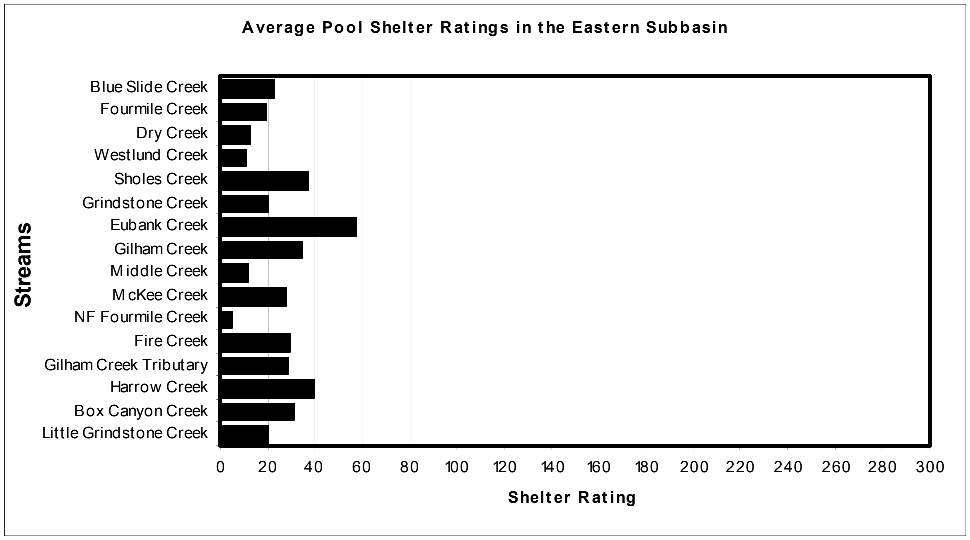


Figure 91. Average pool shelter ratings from CDFG stream surveys, Eastern Subbasin..

As described in the EMDS response curves, average pool shelter ratings exceeding 80 are considered fully suitable and average pool shelter ratings less than 30% are fully unsuitable for contributing to shelter that supports salmonids. Streams are listed in descending order by drainage area (largest at the top).

In terms of the fish habitat relationship present in the Eastern Subbasin, it appears that habitat ranges from somewhat suitable to somewhat unsuitable for salmonids as evaluated by EMDS. Additionally, data on fish passage barriers and water temperature (two important parameters considered by our assessment but not currently included in the EMDS analysis) shows that there is one partial and temporary salmonid barrier and several streams that exceed temperatures suitable for salmonids in this subbasin. However, refugia from poor habitat conditions and suitable conditions for canopy density have allowed coho salmon to persist in four studied streams and steelhead trout to persist in eight surveyed streams.

Fish Passage Barriers

Stream Crossings

One stream crossing was surveyed in the Eastern Subbasin as a part of the Humboldt County culvert inventory and fish passage evaluation conducted by Ross Taylor and Associates (2000). Shelter Cove Road has a culvert on Painter Creek. This culvert was found to be a partial and temporary salmonid barrier (Table 88). Priority ranking of 67 culverts in Humboldt County for treatment to provide unimpeded salmonid passage to spawning and rearing habitat placed the culvert on Shelter Cove Road at rank 10. Criteria for priority ranking included salmonid species diversity, extent of barrier present, culvert risk of failure, current culvert condition, salmonid habitat quantity, salmonid habitat quality, and a total salmonid habitat score. No improvement of the culvert on Painter Creek is currently proposed (G. Flosi, personal communication).

Table 88. Culverts surveyed for barrier status in the Eastern Subbasin.

Stream Name	Road Name	Priority Rank	Barrier Status	Upstream Habitat	Treatment
Painter Creek	Shelter Cove Road	10	Temporary and partial barrier. The culvert is a partial and temporary barrier for adults and a total barrier to juveniles. An excessive jump (3-5 ft) is required to enter the culvert. The concrete divider reduces the target size of the outflow that fish must jump into for entry.	1.1 miles of good to fair salmonid habitat.	None proposed at this time

Dry Channels

CDFG stream inventories were conducted for 34.9 miles on 26 reaches of 18 tributaries in the Eastern Subbasin. A main component of CDFG Stream Inventory Surveys is habitat typing, in which the amount and location of pools, flatwater, riffles, and dry channel is recorded. Although the habitat typing survey only records the dry channel present at the point in time when the survey was conducted, this measure of dry channel can give an indication of summer passage barriers to juvenile salmonids. Dry channel conditions in the Mattole Basin generally become established from late July through early September. Therefore, CDFG stream surveys conducted outside this period are less likely to encounter dry channel.

Dry channel disrupts the ability of juvenile salmonids to move freely throughout stream systems. Juvenile salmonids need well-connected streams to allow free movement to find food, escape from high water temperatures, escape from predation, and migrate out of their stream of origin. The amount of dry channel reported in surveyed stream reaches in the Eastern Subbasin is 2.3% of the total length of streams surveyed. This dry channel was found in eight streams (and Figure 92). Dry habitat units occurred near the mouth of four tributaries, in the middle reaches of four tributaries, and at the upper limit of anadromy in six tributaries. Dry channel at the mouth of a tributary disconnects that tributary from the mainstem Mattole River, which can disrupt the ability of juvenile salmonids to access tributary thermal refugia in the summer. Dry channel in the middle reaches of a stream disrupts the ability of juvenile salmonids to forage and escape predation. Lastly, dry channel in the upper reaches of a stream indicates the end of anadromy.

Table 89. Dry channel recorded in CDFG stream surveys in the Eastern Subbasin.

Stream	Survey Period	# of Dry Units	Dry Unit Length (ft)	% of Survey Dry Channel
Dry Creek	September	1	480	5.6
Middle Creek	September	5	614	8.2
Westlund Creek	September	0	0	0
Gilham Creek	August	0	0	0
Gilham Creek Tributary #1	August	3	49	1.6
Fourmile Creek	August-September	5	1199	7.7
North Fork Fourmile Creek	August	5	404	6.5
Sholes Creek	September	8	476	2.2
Harrow Creek	September	3	105	8.6
Little Grindstone Creek	September	6	164	5.5
Grindstone Creek	August-September	0	0	0
Blue Slide Creek	July	0	0	0
Fire Creek	July-August	0	0	0
Box Canyon Creek	July	0	0	0
Eubank Creek	July	0	0	0
McKee Creek	July	0	0	0
McKee Creek Tributary #1	July	0	0	0
Painter Creek	July	1	50	3.1

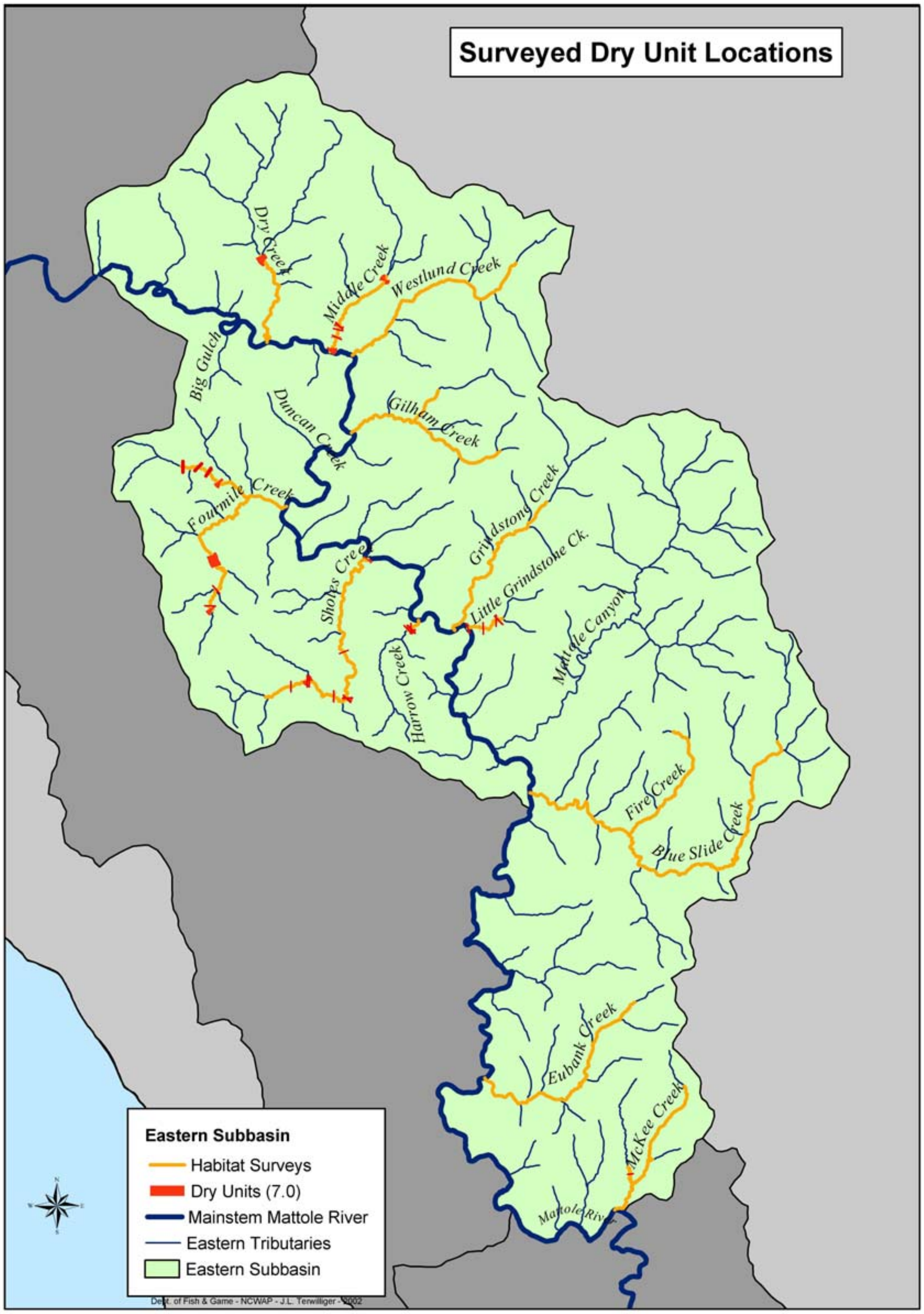


Figure 92. Mapped dry channels in the Eastern Subbasin.

Fish History and Status

Historically, the Eastern Subbasin supported runs of Chinook salmon, coho salmon, and steelhead trout. Interviews with local residents describe Eubanks Creek as the finest salmon stream in the area (Coastal Headwaters Association 1982). CDFG stream surveys in the 1960s found steelhead trout in five streams, unidentified salmonids in eight streams, and coho salmon in Westlund Creek and Harrow Creek. High densities of steelhead trout were estimated for McKee Creek (300 per 100 feet of stream) in August 1966.

A study of Mattole Basin salmonids conducted in July and August 1972 (Brown, 1973b) examined two streams in the Eastern Subbasin, Mattole Canyon Creek and McKee Creek. One coho salmon was found in Mattole Canyon Creek. Steelhead trout were found at densities of 608 per 100 feet of stream in Mattole Canyon Creek, 67 per 100 feet of stream in McKee Creek 1.0 mile above its mouth, and 209 per 100 feet of stream in McKee Creek near its mouth.

BLM, Coastal Headwaters Association, and CDFG stream surveys have continued to document the presence of steelhead trout in most streams in the Eastern Subbasin over time. BLM surveys of Dry Creek and Sholes Creek in 1977 found many juvenile steelhead trout. Coastal Headwaters Association surveys in 1981 and 1982 found steelhead trout in Dry Creek, Eubanks Creek, Sinkyone Creek, McKee Creek, and Painter Creek. CDFG surveys found steelhead trout in Four Mile Creek in the 1980s and Middle Creek, Westlund Creek, Gilham Creek, Four Mile Creek, Harrow Creek, Grindstone Creek, Blue Slide Creek, Box Canyon Creek, Eubanks Creek, and McKee Creek in the 1990s.

Unidentified salmonid adults were found in McKee Creek and Painter Creek in January 1985 by CDFG. These could have been Chinook or coho salmon. Although coho salmon were only detected in one 1990s CDFG stream survey in this subbasin, Box Canyon Creek, they were found by a Redwood Sciences Lab study in Eubanks Creek in 1995. However, a 1997-99 Redwood Sciences Laboratory study of juvenile coho salmon distributions in relation to water temperatures in the Mattole Basin (Welsh et al. 2001) did not find coho salmon in Eubanks Creek, Westlund Creek, Mattole Canyon Creek, or Blue Slide Creek. The 2001 CDFG Coho Inventory also found coho salmon in Four Mile Creek, Sholes Creek, and Grindstone Creek. More detailed summaries of stream surveys and fisheries studies in the Eastern Subbasin are provided in the CDFG Appendix F).

Eastern Subbasin Issues

- In general, a high incidence of shallow pools, a lack of cover, and a lack of large woody debris have contributed to a simplification of instream salmonid habitat.
- Available data from sampled streams suggests that high summer temperatures are deleterious to summer rearing salmonid populations in the lower depositional reaches of most streams in this subbasin.
- Inadequate maintenance and storm-proofing of existing roads, both active and abandoned, are causing large amounts of sediment to be contributed to local stream systems.
- Sub-division development in this subbasin has caused numerous impacts to stream systems.
- Possible toxic chemical spills near streams from illegal drug operations would be problematic for stream water quality.
- Fish population information is limited due to access issues for surveys.
- In April 2000, a serious diesel spill occurred directly into a subbasin tributary. Petroleum spills represent a chemical threat to favorable stream conditions.

Eastern Subbasin Integrated Analysis

The following tables provide a dynamic, spatial picture of watershed conditions for the freshwater lifestages salmon and steelhead. The tables' fields are organized to show the extent of watershed factors' conditions and their importance of function in the overall watershed dynamic. Finally a comment is presented on the impact or condition affected by the factor on the watershed, stream, or fishery. Especially at the tributary and subbasin levels, the dynamic, spatial nature of these processes provides a synthesis of the watershed conditions and indicates the quantity and quality of the freshwater habitat for salmon and steelhead.

Geology

Introduction

The potential for sediment production is strongly influenced by the underlying geology. The following IA tables compiled by CGS examine the influence of geology on sediment production by comparing the distribution of geomorphic terrains (hard, moderate, and soft bedrock terrains, and the separately grouped Quaternary surficial deposits) against the observation of landslides and geomorphic features related to mass wasting within the subbasin. The first table presents the proportions of the subbasin underlain by each of the terrains. The next table looks at hillside gradient within the subbasin. The distribution of historically active landslides, gullies, and inner gorges by terrain are then considered. Finally, the landslide potential map developed by CGS is examined with respect to the terrains.

Table 90. Geomorphic terrains as a proportion of the Eastern Subbasin.

Proportion of Eastern Subbasin Basin Underlain by the Different Geomorphic Terrains				
Feature/Function			**Significance**	**Comments**
Terrain Type	**Proportion of Subbasin Area**	**Terrain Area within Subbasin as a Proportion of Mattole Basin Area**	The geomorphic terrains represent groupings of geologic map units based on similarities in geology, geomorphic expression, and landslide occurrence. They provide a simplified division of the watershed useful in comparing the influence of bedrock geology to the distribution of other mapped features.	This subbasin has the largest proportion of moderate terrain in the watershed. Soft terrain, with its associated higher levels of active landsliding and gully erosion, accounts for less than one fifth of the Eastern Subbasin area. Hard terrain with its steep slopes, debris slides and inner gorges contributes to the high degree of slope instability in the subbasin.
Hard	37%	10%		
Moderate	42%	11%		
Soft	17%	5%		
Quaternary[1]	4%	1%		

1 Areas where young (Quaternary) surficial units have been mapped covering bedrock; includes alluvium, as well as terrace deposits, active stream channel deposits, and other alluvial deposits.

Table 91. Hillside gradient in the Eastern Subbasin.

Hillside Gradient in the Eastern Subbasin							
Feature/Function						**Significance**	**Comments**
Proportion of Subbasin Area						Hillside slope is an important indicator of potential instability (steeper is generally less stable). The terrain type influences the degree to which hillside slope affects the slope stability.	Typically, the steeper slopes reflect the presence of hard and moderate terrain while the less steep slopes reflect the presence of soft terrain.
Range in % slope							
0-10	**10-30**	**30-40**	**40-50**	**50-65**	**>65**		
4	22	22	21	19	12		

Table 92. Small historically-active landslides by terrain in the Eastern Subbasin.

Distribution of Small Historically-Active Landslides by Geomorphic Terrain in the Eastern Subbasin				
Feature/Function			**Significance**	**Comments**
Terrain Type	**Small Point Landslides[1] Mapped from year 1981[2], 1984, or 2000 Photographs**		The relative number of small point slides is used to evaluate which geomorphic terrains are more prone to small, localized slope failures.	The large majority of small landslides in this subbasin occur in the hard and moderate terrain and consist primarily of shallow debris slides associated with steep slopes.
	Point Count	**Area[3] (acres)**		
Hard	656	65		
Moderate	605	60		
Soft	147	15		
Quaternary	15	1		

1 Mapping was compiled at a 1:24,000 scale. Landslides smaller than approximately 100 feet in diameter were captured as points in the GIS database; larger features were captured as polygons.
2Landslides included from year 1981 photographs are from previous mapping by Spittler (1983 and 1984) covering limited portions of the Mattole Basin.
3 Based on assumed average area of 400 square meters (roughly 1/10th acre) for small landslides.

Table 93. All historically-active landslides by terrain in the Eastern Subbasin.

Distribution of All Historically-Active Landslides by Terrain in the Eastern Subbasin				
Feature/Function			Significance	Comments
Terrain Type	Combined Area (acres) of All Historically-Active Landslides[1]	Proportion of Total Active Landslide Area within Subbasin	The relative percentage of area covered by historically-active slides identifies which geomorphic terrains are most prone to relatively large-scale slope failures.	Approximately 34% of the total area occupied by historically-active landslides in the Mattole Basin is found in the Eastern Subbasin, second only to the Northern Subbasin. Soft terrain, despite underlying less than a fifth of the subbasin, contains nearly half the total landslide area in the Eastern Subbasin.
Hard	773	22%		
Moderate	1,032	30%		
Soft	1,622	47%		
Quaternary	35	1%		

1 Includes small point and larger polygon features mapped from year 1981, 1984 and 2000 photos. Where landslides overlapped (i.e., the same or similar features mapped from more than one photo set) the area of overlap was counted only once. Small landslides captured as points in the GIS database were assumed to have an average area of 400 square meters (roughly 1/10th acre).

Table 94. Gullies and inner gorges by terrain in the Eastern Subbasin.

Distribution of Gullies and Inner Gorges by Terrain in the Eastern Subbasin				
Feature/Function			Significance	Comments
Terrain Type	Proportion of Total Mapped Gully Lengths[1] in Subbasin	Proportion of Total Mapped Inner Gorge Lengths[1] in Subbasin	Gullies and inner gorges are an important indicator of ongoing sources of sediment to the fluvial system.	The large majority of mapped gully lengths in the Eastern Subbasin are located in soft terrain, despite soft terrain underlying only a small proportion (17%) of the subbasin. Gully erosion is a significant, on-going contributor of sediment from soft terrain areas in the subbasin. Inner gorges are considerably more prevalent in hard, and to a lesser degree, moderate terrains; inner gorges act as sediment source areas primarily through debris sliding.
Hard	6%	51%		
Moderate	14%	38%		
Soft	78%	9%		
Quaternary	2%	2%		

1 Includes only those features mapped from year 2000 photographs.

Table 95. Landslide potential by terrain in the Eastern Subbasin.

Distribution of Landslide Potential Categories by Terrain as a Proportion of the Eastern Subbasin Area							
Feature/Function						Significance	Comments
Terrain Type	Landslide Potential Category[1]					Categories 4 and 5 represent the majority of unstable areas that are current or potential future sources of sediment.	The limited area of soft terrain is disproportionably represented in categories 4 and 5 because of this unit's inherent instability. Hard and moderate terrain both underlay a significantly larger proportion of area in the subbasin, yet do not include appreciably higher percentages of the subbasin in categories 4 and 5.
	1	2	3	4	5		
Hard	0.2%	8.8%	13.4%	6.3%	8.4%		
Moderate	0.5%	6.1%	21.6%	7.9%	6.2%		
Soft	0.0%	0.5%	3.6%	7.2%	5.8%		
Quaternary	1.3%	1.4%	0.4%	0.1%	0.3%		
Subbasin Total[2]	2.0%	16.8%	39.0%	21.5%	20.7%		

1 Categories represent ranges in estimated landslide potential, from very low (category 1) to very high (category 5); see Geologic Report, Plate 2.
2 Percentages are rounded to nearest 1/10 %; sum of rounded values may not equal 100%.

Discussion

The Eastern Subbasin is second only to the Northern Subbasin in area occupied by historically active landslides and total gully lengths. Again, landslides and gullies are concentrated in areas of soft terrain. Although soft terrain underlies only 17% of the subbasin, nearly half of the area of active landsides and three-fourths of the total gully lengths within the subbasin are found in soft terrain.

Vegetation and Land Use

Introduction

CDF NCWAP developed a number of tables that are intended to help identify and highlight how current patterns of vegetation and land use are expressed in relation to the geology of the watershed. First, vegetation and land use types are related to the underlying bedrock geology or terrain type. These patterns are then explored by examining the current vegetation and recent timber harvesting in relation to their occurrence in landslide potential classes, the product of a model that uses terrain type, vegetation, and landslides as variables. Landslide causality was not assigned and recent timber harvest activity has occurred in low percentages in most of the planning watersheds. The significance of the geologic characteristics in these tables is expressed as a relative rating and is not characterized numerically.

Table 96. Vegetation types associated with terrain types in the Eastern Subbasin.

Vegetative Condition in the Eastern Subbasin								
Feature/Function							Significance	Comments
Terrain Type	Vegetation Type							
	Conifer	Mixed	Hardwood	Grassland	Other	Total		
Hard	12%	72%	14%	2%	<1%	100%	The differences between the slope, soils, and stability of the geologic terrain results in a different mosaic of vegetation in each of these areas. The combination of the geologic and vegetative conditions between the terrain results in some differences in land use and sensitivity to impacts from land use.	While grassland is strongly associated with the soft and quaternary terrain types, the majority of acreage in this terrain type is in tree dominated vegetation. Timber harvesting impacts in soft terrain may be higher than the THP required estimated surface soil erosion hazard rating (EHR) worksheet may indicate.
Moderate	8%	73%	13%	5%	1%	100%		
Soft	4%	45%	14%	36%	1%	100%		
Quaternary	6%	42%	6%	26%	20%	100%		

Table 97. Riparian vegetation (within 150 feet of streams) types associated with terrain types in the Eastern Subbasin.

Riparian Vegetative Condition in the Eastern Subbasin									
Feature/Function								Significance	Comments
Terrain Type	Riparian Vegetation Type								
	Conifer	Mixed	Hardwood	Grassland	Barren	Other	Total		
Hard	14%	72%	11%	1%	2%	<1%	100%	The differences between the slope, soils, and stability of the geologic terrain results in a different mosaic of vegetation in each of these areas. The combination of the geologic and vegetative conditions between the terrain results in some differences in land use and sensitivity to impacts from land use. The riparian vegetation in this zone is the primary source of large woody debris. The species and size of large woody debris provided to the stream system over time is at least partially dependent upon the inherent slope stability of the underlying terrain type.	Riparian vegetation is in tree-type vegetation at a proportionately higher percentage than the overall subbasin landscape. Vegetation removal impacts in riparian soft terrain should consider the heightened susceptibility of soft terrain to gullying. The large percentage of barren ground in the quaternary terrain type includes areas of expansive stream channel.
Moderate	7%	80%	10%	2%	1%	<1%	100%		
Soft	3%	58%	23%	14%	2%	<1%	100%		
Quaternary	7%	41%	3%	8%	40%	1%	100%		

Table 98. Land use associated with terrain types in the Eastern Subbasin.

Land Use in the Eastern Subbasin						
Feature/Function					Significance	Comments
Terrain Type	Landuse Type					
	Public	Ag/Timber	Other	Total		
Hard	10%	49%	41%	100%	Eighty-four percent of the subbasin is about evenly divided between lands zoned for agriculture and timber and the "other" category of land use parcels. The other category often includes housing and contains many parcels 160 acres or less in size.	Historic logging occurred across all ownership types, leaving a legacy of young vegetation and dirt-surfaced roads. Many of the current owners simply live on their property and do not derive substantial economic benefits from the land. Despite this, many residents are interested in restoration work if funding and assistance is provided. The Mattole Restoration Council, a local watershed group, is an active participant and coordinator of restoration projects, such as the Good Roads, Clear Creeks Program and the Mattole River & Range Partnership.
Moderate	4%	54%	42%	100%		
Soft	1%	55%	44%	100%		
Quaternary	1%	58%	41%	100%		

Table 99. Road mileage and density associated with terrain types in the Eastern Subbasin.

Roads in the Eastern Subbasin				
Feature/Function			Significance	Comments
Terrain Type	**Miles (of road)**	**Road Density (miles per sq. mile)**	Roads crossings on steep slopes in hard and moderate terrain may increase the potential for debris slides while roads within the soft terrain may increase the potential for small earthflows, gullies, and erosion. The alluvium terrain type tends to be relatively flat, but proximity to watercourses may allow for direct delivery of sediment from the roads to the streams.	While current practices locate roads on less environmentally sensitive locations, typically gentle ground high on the hillslope, the presence of soft terrain in these areas should be considered. Roads in soft terrain require construction and maintenance standards that recognize the inherent instability of this terrain type.
Hard	104	3.5		
Moderate	147	4.3		
Soft	61	4.4		
Quaternary	17	7.5		
Total	**329**	**4.1**		

Table 100. Data summary table for the Eastern Subbasin.

Factor	Eastern Subbasin	
Timber Harvest 1990 -2000¹	**acres**	**% area**
Silviculture Category 1		
Tractor	352	0.7%
Cable	305	0.6%
Helicopter	7	0.0%
TOTAL	664	1.3%
Silviculture Category 2		
Tractor	555	1.1%
Cable	74	0.1%
Helicopter	0	0.0%
TOTAL	629	1.2%
Silviculture Category 3		
Tractor	461	0.9%
Cable	46	0.1%
Helicopter	35	0.1%
TOTAL	543	1.1%
TOTAL	1,836	3.6%
Other Land Uses		
Grazing	2,971	5.9%
Agriculture	16	0.0%
Development	10	0.0%
Timberland, No Recent Harvest	42,276	83.3%
TOTAL	45,273	89.2%
Roads		
Road Density (miles/sq. mile)	4.1	
Density of Road Crossings (#/stream mile)	0.4	
Roads within 200 feet of Stream (miles/stream mile)	0.1	
Silvicultural Category 1 includes even-aged regeneration prescriptions: clear-cut, rehabilitation, seed tree step, and shelter wood seed step prescriptions. Category 2 includes prescriptions that remove most of the largest trees: shelter wood prep step, shelter wood removal step, and alternative prescriptions. Category 3 includes prescriptions that leave large amounts of vegetation after harvest: selection, commercial thin, sanitation salvage, transition, and seed tree removal step prescriptions.		

Table 101. Land use and vegetation type associated with historically active landslides in the Eastern Subbasin.

Historically Active Landslide Feature1	Eastern Subbasin	Woodland and Grassland2	THPs 1990 - 20005	Timberland, No Recent Harvest3	Roads4	
	% of Area	% of Area	% of Area	% of Area	Length (miles)	% of Total Length
Earthflow	3.4%	2.6%	0.0%	0.7%	10.0	3.1%
Rock Slide	0.2%	0.0%	0.0%	0.2%	0.7	0.2%
Debris Slide	2.9%	0.1%	0.1%	2.6%	5.6	1.7%
Debris Flow	0.0%			0.0%		
All Features	**6.5%**	**2.8%**	**0.1%**	**3.4%**	**16.3**	**5.0%**
Twenty-three percent of the acres in the woodland/grassland category are occupied by historically active landslide features, dominated by earthflows (95%) while the timberland categories have debris slides mapped as the dominant landslide feature (76%). Recent THPs occupy 4% of the subbasin acreage and within this small area, 2.7% is in slide areas as compared to 4% slide area for the timberland vegetation type as a whole. Five percent of road length intersects historically active slides, a percentage almost equal to the slide acreage percentage.						

1 This category includes only large polygon slides and does not include point slides.
2 Woodland and grassland includes areas mapped in 1998 as grassland and non-productive hardwood.
3 Area of timberlands that were not contained in a THP during the 1991 to 2000 period.
4 Roads layer is from the Information Center for the Environment (ICE) at UC Davis.
5 THP's are complete or active between the 1990 and 2000 timeframe.
Empty cells denote zero.
Percent of area is based on the unit of analysis: Watershed, subbasin, or planning watershed.

Table 102. Land use and vegetation type associated with relative landslide potential in the Eastern Mattole Subbasin.

Relative Landslide Potential1	Eastern Subbasin	Woodland or Grassland2	THPs 1990 - 20005	Timberland, No Recent Harvest3	Roads4	
	% of Area	% of Area	% of Area	% of Area	Length (miles)	% of Total Length
Very Low	2.0%	0.6%	0.0%	1.0%	10.3	3.2%
Low	16.8%	1.8%	0.8%	13.9%	63.1	19.5%
Moderate	39.0%	2.6%	1.4%	34.7%	134.6	41.6%
High	21.5%	3.0%	0.8%	17.6%	64.9	20.1%
Very High	20.7%	3.9%	0.5%	15.9%	50.1	15.5%
TOTAL	**100%**	**12%**	**4%**	**83%**	**323.0**	**100%**
Recent THPs in 1991-2000 covered 4% of the subbasin and 35% of the harvest acres were in the two highest relative landslide potential classes. Since the majority of the subbasin is in the high and very high relative landslide potential classes well-distributed across the landscape, it is not surprising to find that THPs also contain a high percentage of acreage in these same categories. The subbasin has about 323 miles of roads, with the proportion of road length in relative landslide potential categories similar to the percentage of total acres in each class, although there is a slight shift towards lower relative landslide potential classes.						

1 Refer to Plate 2 and California Geological Survey appendix.
2 Woodland and grassland include areas mapped in 1998 as grassland and non-productive hardwood.
3 Area of timberlands that were not contained in a THP during the 1991 to 2000 period.
4 Roads layer is from the Information Center for the Environment (ICE) at UC Davis.
5 THP's are complete or active between the 1990 and 2000 timeframe.
Percent of area is based on the unit of analysis: Watershed, subbasin, or planning watershed.

Discussion

The Eastern Subbasin contains almost one quarter of the soft terrain found in the Mattole Basin, similar to the amount found in the Western Subbasin. In addition, the Eastern Subbasin contains the second lowest percentage of acreage (42%) in the two highest relative landslide potential categories. It also contains the second largest percentage of land area in both historically active (7%) and dormant landslide features (19%). The high number of existing landslides and the large percentage of the subbasin in high landslide potential classes suggest that land use practices should have careful site-specific evaluation in order to avoid land use accelerated sedimentation in the streams. While Mattole timber harvesting plans have incorporated a zero net sediment discharge analysis since about 1994, less than four percent of the Eastern Subbasin was harvested between 1990 and 2000. However, of the harvest acres in the high or very high relative landslide potential classes, one third was harvested by even-aged regeneration silvicultural systems and three quarters was tractor logged. It should be noted that although these landslide potential categories are part of a different classification system that is not equivalent to the THP potential surface erosion hazard rating (EHR), both quantify potential sediment movement, although by different processes. The current Forest Practice Rules do not have a methodology for characterizing relative landslide potential. Other activities, including grazing and most road use and maintenance for grazing and residential access, are often outside the current regulatory process. Education and economic incentives for road improvements and livestock management provide the greatest opportunities for near-term benefits for fisheries.

Fluvial Geomorphology

Introduction

Fluvial geomorphic mapping of channel characteristics was conducted along blue line streams in the Mattole Basin to document channel characteristics that are indicative of excess sediment production, transport, and/or response (deposition); these features are referred to as negative mapped channel characteristics (NMCCs). The following CGS Integrated Analysis (IA) Tables present some of the findings of this investigation. To understand the distribution of these NMCC's we present: the predominant NMCC's identified; the relative distribution of these features between the bedrock terrains and the Quaternary units; the changes in amount and distribution of NMCC's observed between 1984 and 2000; and the relationship between areas of projected slope instability and portions of streams with evidence of excess sediment.

Table 103. Negative mapped channel characteristics in the Eastern Subbasin.

Negative Mapped Channel Characteristics in the Eastern Subbasin						
Feature/Function					**Significance**	**Comments**
		From 1984 Photos	**From 2000 Photos**	**%4 Change 1984 to 2000**	The reduction in the total length of NMCC's over time qualitatively reflects the degree of improvements within the blue line streams. These NMCC's were chosen to be highlighted in these figures because in both photo years, the NMCC's observed were dominated by wide channels and, secondarily, by displaced riparian vegetation. Most of this observed improvement results from reductions in the proportion of streams affected by displaced riparian vegetation and wide channels.	That portion of the fluvial system observed to be affected by wide channel in 1984 has recovered extensively by 2000.
Blue Line Streams where Wide Channel (wc) Observed		See Figure 34				
Blue Line Streams where Displaced Riparian Vegetation (dr) Observed		See Figure 35				That portion of the fluvial system observed to be affected by displaced riparian vegetation in 1984 has recovered extensively by 2000.
% of the all Blue Line Stream Segments in Basin affected by NMCC's	Total	42%	14%	-27%	These values identify how much of the streams have been affected by NMCC's. Decreases in the length of stream affected by NMCC's quantitatively represent the degree of improvement within blue line stream reaches.	The fluvial system in the bedrock reaches have experienced the largest reduction in the total length of NMCCs as well as in the subbasin total proportion of blue line stream length occupied by NMCCs between 1984 and 2000, but still remains impacted by NMCCs. Alluvial reaches, however, have experienced a slight increase in NMCCs
	Bedrock	47%	13%	-34%		
	Alluvium	20%	22%	+2%		

Negative Mapped Channel Characteristics in the Eastern Subbasin (Continued)					
Feature/Function				**Significance**	**Comments**
	From 1984 Photos	**From 2000 Photos**	**%4 Change 1984 to 2000**		
Percentage of all Blue Line Stream segments in bedrock that are: 1) adjacent to or within LPM Categories 4 and 5[3] and 2), affected by NMCC's	70%	19%	-52%	The magnitude of decrease in affected streams quantitatively represents the degree of improvement within bedrock stream reaches adjacent to unstable areas. Because the streams in the Quaternary units are commonly separated from the surrounding hillsides by alluvial terraces and floodplains, the NMCCs observed there do not directly result from input into the streams from landslides that occur on the surrounding hillsides. Therefore, NMCC's in alluvial areas have been interpreted as having been transported from upstream bedrock reaches. For this reason, the analysis of NMCC's vs. LPM 4 and 5 excludes the NMCC's identified in the Quaternary units and only describes the relationship between these two features as it applies to the bedrock reaches.	The fact that NMCC's are not ubiquitous in bedrock streams adjacent to or within LPM categories 4 and 5 indicates that although entire reaches of the streams have potentially unstable slopes above them, only a portion of those slopes have delivered or transported sediment to the streams. The length of blue line streams affected by NMCC's has decreased by about 50% between 1984 and 2000.
Percent of total NMCC length in bedrock, within 150 feet of LPM Categories 4 and 5[2]	98%	100%	+2%	Percentage reflects likelihood that the presence of NMCC's in bedrock are related to LPM categories 4 and 5 and that these unstable areas represent current and future potential sources of sediment to streams.	Virtually all of the total NMCC's observed in bedrock terrains were found on blue line streams adjacent to or within LPM category 4 and 5. Therefore, we interpret a clear relationship between areas of projected slope instability and portions of streams with negative sediment impacts, and that some portion of hillsides with high landslide potential are delivering sediment to the adjacent streams.

1 Include all areas identified as hard, moderate or soft geomorphic terrain.
2 Areas where young (Quaternary) surficial units have been mapped covering bedrock; includes alluvium, as well as terrace deposits, active stream channel deposits, and other alluvial deposits.
3 Landslide Potential Map developed by CGS for the Mattole Basin; see California Geologic Report, Appendix A and Plate 2.
4 Percentages are rounded to nearest 1%; sum of rounded values may not equal rounded totals or 100%.

Discussion

The results of our fluvial geomorphic mapping of channel characteristics that may indicate excess sediment accumulations (NMCC's) can be summarized as follows.

- Changes in the distribution of NMCC's between 1984 and 2000 show different patterns in the bedrock and Quaternary unit reaches.
- Channel conditions in the bedrock streams have generally improved between 1984 and 2000.
- Channel conditions in the Quaternary unit reaches have degraded slightly between 1984 and 2000. Considering the low concentration of NMCC's in the Southern Subbasin, it appears sediment is being transported to these reaches from upstream sources inside this subbasin or from the adjacent Western Subbasin.
- Virtually all of the NMCC's in bedrock terrains were identified along portions of the streams that are near potentially unstable slopes and the total length of NMCC's in these areas has decreased between 1984 and 2000. Therefore, we conclude that portions, but not all, of the hillslopes in the high to very high landslide potential categories are delivering sediment to the adjacent streams.

Water Quality

Introduction

For many of the major, anadromous streams in the Eastern Subbasin, temperature information had the most complete record of water quality information available. Only one stream, Mattole Canyon Creek, was monitored with thermographs at an upstream location; all other streams were sampled at their confluences with the mainstem. Thermal imaging was conducted from the mouth to the upstream reaches of Mattole Canyon Creek, providing a continuous stream–length snapshot of median surface temperature distributions. Limited sediment sampling by the MSG was completed for V* in Middle and Westlund Creeks in 2000; no other sediment information was found during record searches of the subbasin. Except for Blue Slide Creek, there was no consistent, long-term physical-chemical information reported for the Eastern Subbasin. Blue Slide Creek has in the past, and continues to have chemical and water quality sampling conducted on a quarterly basis to monitor any effects an unauthorized diesel fuel release may have to the watercourse.

Table 104. Eastern Subbasin water quality integrated analysis table

Feature/Function		Significance	Comments
Temperature			
MWATs (17 Thermograph Records for 9 stations)		Maximum weekly average temperature (MWAT) is the temperature range of 50-60°F considered fully suitable of the needs of several West Coast Salmonids.	Unsuitable throughout subbasin
Suitable Records	Unsuitable Records		
1	16		
Maximum Temperatures (23 Thermograph Records for 10 Stations)		A maximum-peak temperature of 75°F is the maximum temperature that may be lethal to salmonids if cool water refugia is unavailable.	Mostly suitable throughout much of subbasin
Suitable Records	**Unsuitable Records**		
14	9		
Thermal Infrared Imaging Median Surface Temperature		Ability to assess surface water temperatures at the river-stream-reach level for a holistic picture of thermal distribution.	Mattole Canyon Creek had suitable median temperatures in upstream reaches and unsuitable temperatures in lower reaches on the day of the thermal imaging fly-over. See below for data limitations of thermal imaging. Data limitations: 1) Assessments generally performed on a specific day and time, 2) not comparable to seasonally assessed MWAT or maximum temperatures, 3) unable to assess below water surface. Note: Thermal imaged median surface temperatures are derived from the minimum and maximum imaged surface temperatures scaled to a particular point in a sample cell (cell approximately = 317 feet x stream width). Cell minimum and maximum rarely varied more than 1-3 °F
Tributary	**Minimum/ Maximum (°F)**		
Mattole Canyon Creek	68/ 82		
Sediment			
Tributary	**Date V***	V* measures the percent sediment filling of a streams pool, compared to the total pool volume. Pools with lower V* values are thought to provide suitable salmonid habitat and may also indicate relatively low watershed disturbances. The V* ranges, below, derived from Knopp, 1993, are meant as reference markers and should not be construed as regulatory targets: V* ≤ 0.30 = low pool filling; correlates well with low upslope disturbance V* > 0.30 and ≤ 0.40 = moderate pool filling; correlates well with moderate upslope disturbance V* > 0.40 = High (excessive)rates of pool filling; correlates well with high upslope disturbance	
Middle Creek	2001 0.25		V* = 0.25 indicates moderate pool filling

Feature/Function		Significance	Comments
Sediment			
Westlund Creek	2001 0.25		V* = 0.25 indicates moderate pool filling.
Water Chemistry and Quality			
pH/Dissolved Oxygen/Conductivity: No data available		All three physical parameters maintain metabolic balances for bio-chemical reactions, respiration-photosynthesis, osmoregulation, etc., that determine habitat suitability for salmonids and all other aquatic flora and fauna.	There has been no consistent sampling for these physical water quality parameters but they are generally presumed suitable throughout the subbasin.
Chemistry/Nutrients Blue Slide Creek: Diesel fuel release to surface and groundwater in 2000		Mild contamination of diesel fuel and its breakdown products, such as benzene, can impart taste and odor impairments to ground and surface water. Higher concentrations in drinking water supplies and aquatic systems dependent on surface and ground water sources can result in toxicity via human ingestion, and possible death to aquatic life unable to escape.	Non detectable levels during 2002 in Blue Slide Creek

References: Knopp, 1993; Mattole Salmon Group, 1996-200;, PALCO, 2001; NCRWQCB D Appendix E; Watershed Sciences, 2002

Discussion

As the table shows, all of the MWAT records except one were unsuitable during all record years; however, many of those records/stations were suitable if maximum temperatures are considered. Interestingly, seven of the nine unsuitable temperature records were in only two watercourses: Mattole Canyon Creek with five records and Blue Slide Creek with two. During the day of thermal, and simultaneous video imaging, the lower reaches of both watercourses had open, unsheltered channels with low water flows, and median surface temperatures above 75°F. Thermograph data largely agrees with the snapshot, same day thermal imaging temperatures. V* sediment sampling took place in only Middle and Westlund Creeks, indicating moderate pool filling. Additional, long term monitoring in a number of different streams is needed to more fully assess the subbasin's sediment characteristics. The only physical-chemical sampling and monitoring is related to a diesel fuel release to Blue Slide Creek with non-detectable results from ongoing chemical sampling and analysis.

Instream Habitat

Introduction

The products and effects of the watershed delivery processes examined in the geology, land use, fluvial geomorphology, and water quality Integrated Analyses tables are expressed in the stream habitats encountered by the organisms of the aquatic riparian community, including salmon and steelhead. Several key aspects of salmonid habitat in the Mattole Basin are presented in the CDFG Instream Habitat Integrated Analysis. Data in this discussion are not sorted into the geologic terrain types since the channel and stream conditions are not necessarily exclusively linked to their immediate surrounding terrain, but may in fact be both spatially and temporally distanced from the sites of the processes and disturbance events that have been blended together over time to create the channel and stream's present conditions. Instream habitat data presented here were compiled from CDFG stream inventories of 18 tributaries from 1991 to 2002, published research conducted in the Mattole estuary by HSU, the MRC, and MSG in the 1980s and 1990s, and fish passage barrier evaluation reports conducted under contract to CDFG from 1998-2000. Details of these reports are presented in the CDFG Appendix F.

Pool Quantity and Quality

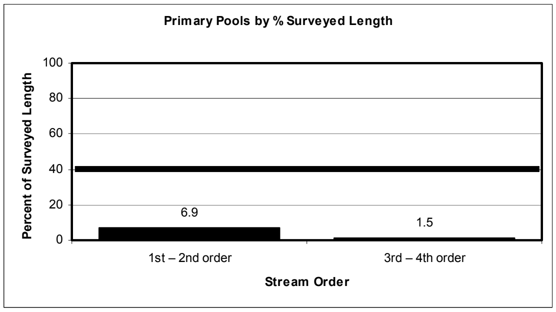


Figure 93. Primary pools in the Eastern Subbasin

Pools greater than 2.5 feet deep in 1st and 2nd order streams and greater than 3 feet deep in 3rd and 4th order streams are considered primary pools.

Significance: Primary pools provide escape cover from high velocity flows, hiding areas from predators, and ambush sites for taking prey. Pools are also important juvenile rearing areas. Generally, a stream reach should have 30 – 55% of its length in primary pools to be suitable for salmonids.

Comments: The percent of primary pools by length in the Eastern Subbasin is generally below target values for salmonids, and appears to be less suitable in higher order streams than in lower order streams. This subbasin has the lowest percent of primary pools in third order streams surveyed of any of the Mattole subbasins.

Spawning Gravel Quality

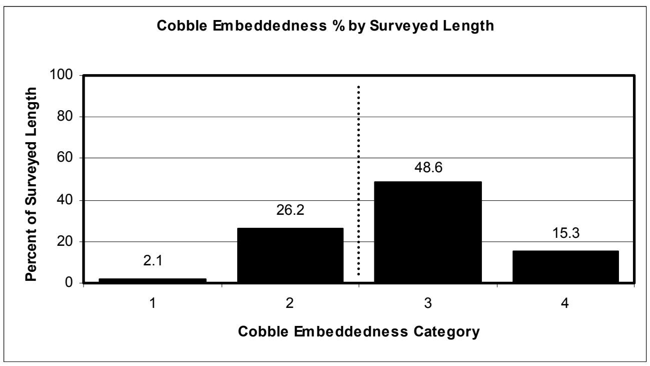


Figure 94. Cobble embeddedness in the Eastern Subbasin

Cobble Embeddedness will not always sum to 100% because Category 5 (not suitable for spawning) is not included.

Significance: Salmonids cannot successfully reproduce when forced to spawn in streambeds with excessive silt, clays, and other fine sediment. Cobble embeddedness is the percentage of an average sized cobble piece at a pool tail out that is embedded in fine substrate. Category 1 is 0-25% embedded, category 2 is 26-50% embedded, category 3 is 51-75% embedded, and category 4 is 76-100% embedded. Cobble embeddedness categories 3 and 4 are not within the fully supported range for successful use by salmonids.

Comments: More than one half of the surveyed stream lengths within the Eastern Subbasin have cobble embeddedness in excess of 50% in categories 3 and 4, which does not meet spawning gravel target values for salmonids. This subbasin has the highest percent of unsuitable cobble embeddedness values in surveyed streams of the Mattole subbasins.

Shade Canopy

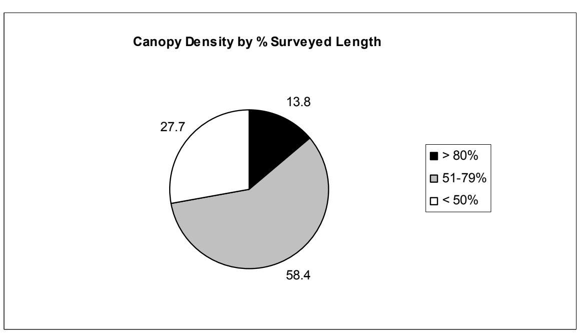


Figure 95. Canopy density in the Eastern Subbasin.

Significance: Near-stream forest density and composition contribute to microclimate conditions that help regulate air temperature, which is an important factor in determining stream water temperature. Stream water temperature can be an important limiting factor of salmonids. Generally, canopy density less than 50% by survey length is below target values and greater than 85% is fully meets target values.

Comments: More than one half of the surveyed stream lengths within the Eastern Subbasin have canopy densities greater than 50% and over 13% of the surveyed lengths have canopy densities greater than 80%. This is above the canopy density target values for salmonids.

Fish Passage

*Table 105. Salmonid habitat artificially obstructed for Fish Passage.**

Feature/Function		Significance	Comments
Type of Barrier	% of Estimated Historic Coho Salmon Habitat Currently Inaccessible Due to Artificial Passage Barriers	Free movement in well-connected streams allows salmonids to find food, escape from high water temperatures, escape from predation, and migrate to and from their stream of origin as juveniles and adults. Dry or intermittent channels can impede free passage for salmonids; temporary or permanent dams, poorly constructed road crossings, landslides, debris jams, or other natural and/or man-caused channel disturbances can also disrupt stream connectivity.	Artificial barriers currently block 2.4% of the estimated historic coho salmon habitat in the Eastern Subbasin. This is the lowest percentage of estimated historic coho salmon habitat blocked by artificial barriers in any of the Mattole subbasins. All of this habitat is blocked by partial, temporary, and total artificial fish passage barriers. The CDFG North Coast Watershed Improvement Program did not fund any improvement of culverts in this subbasin in 2001 or 2002.
All Barriers	2.4		
Partial and Temporary Barriers	2.4	Partial barriers exclude certain species and lifestages from portions of a watershed and temporary barriers delay salmonid movement beyond the barrier for some period of time.	
Total Barriers	2.4	Total barriers exclude all species from portions of a watershed	

*(N=1 Culvert) in the Eastern Subbasin (1998-2000 Ross Taylor and Associates Inventories and Fish Passage Evaluations of Culverts within the Humboldt County and the Coastal Mendocino County Road Systems).

*Table 106. Juvenile salmonid passage in the Eastern Subbasin.**

Feature/Function		Significance	Comments
Juvenile Summer Passage:	Juvenile Winter Refugia:	Dry channel disrupts the ability of juvenile salmonids to move freely throughout stream systems.	The Eastern Subbasin has the highest percentage of dry channel in surveyed stream reaches of the Mattole subbasins. Dry channel recorded in this subbasin has the potential to disconnect tributaries from the mainstem Mattole River and disrupt the ability of juvenile salmonids to forage and escape predation in Little Grindstone, Harrow, Sholes, and Middle Creeks. Juvenile salmonids seek refuge from high winter flows, flood events, and cold temperatures in the winter. Intermittent side pools, back channels, and other areas of relatively still water that become flooded by high flows provide valuable winter refugia.
0.7 Miles of Surveyed Channel Dry	**No Data**		
1.9% of Surveyed Channel Dry			

*(1991-2002 CDFG Stream Surveys, CDFG Appendix F).

Large Woody Debris

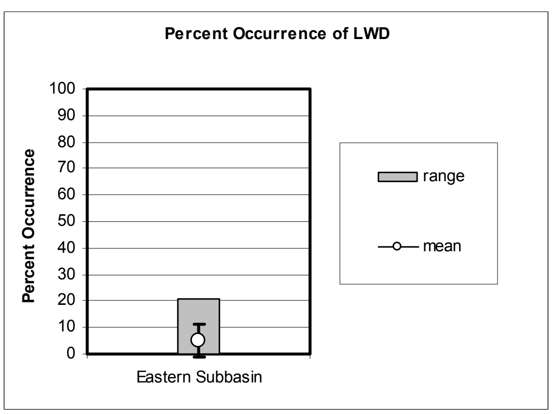


Figure 96. Large woody debris (LWD) in the Eastern Subbasin

Error bars represent the standard deviation. The percentage of shelter provided by various structures (i.e. undercut banks, woody debris, root masses, terrestrial vegetation, aquatic vegetation, bubble curtains, boulders, or bedrock ledges) is described in CDFG surveys. The dominant shelter type is determined and then the percentage of a stream reach in which the dominant shelter type is provided by organic debris is calculated.

Significance: Large woody debris shapes channel morphology, helps a stream retain organic matter, and provides essential cover for salmonids. There are currently no target values established for the % occurrence of LWD.

Comments: A 4.8 average percent occurrence of large woody debris is low compared to the range of values recorded throughout the entire Mattole Basin, which is 0 to 28. Additionally, boulders were found to provide the primary form of shelter for salmonids in twelve of the fourteen surveyed streams, and bedrock ledges provided the primary form of shelter for salmonids in two additional stream reaches.

Discussion

Although instream habitat conditions for salmonids varied across the Eastern Subbasin, several generalities can be made. Instream habitat conditions were generally poor within this subbasin at the time of CDFG surveys. Cobble embeddedness values, the length of surveyed dry channel, and the percentage of surveyed channel dry were the least suitable for salmonids of any of the Mattole subbasins. Additionally, the percent of primary pools by length was generally less than target values as found in CDFGs California Salmonid Stream Habitat Restoration Manual and calculated by the EMDS. The percent occurrence of large woody debris was in the lower range of values recorded in the Mattole Basin. However, canopy density was generally greater than 50% and the Eastern Subbasin had the lowest percentage of estimated historic coho habitat blocked by artificial barriers in the Mattole Basin.

Draft Sediment Production EMDS

The draft sediment EMDS is currently under review. Preliminary results are presented in the EMDS Appendix C.

Stream Reach Condition EMDS

The anadromous reach condition EMDS evaluates the conditions for salmonids in a stream reach based upon water temperature, riparian vegetation, stream flow, and in channel characteristics. Data used in the Reach EMDS come from CDFG Stream Inventories. Currently, data exist in the Mattole Basin to evaluate overall reach, canopy, in channel, pool quality, pool depth, pool shelter, and embeddedness conditions for salmonids. More details of how the EMDS functions are in the EMDS Appendix C. EMDS calculations and conclusions are pertinent only to surveyed streams and are based on conditions present at the time of individual survey.

EMDS stream reach scores were weighted by stream length to obtain overall scores for tributaries and the entire Eastern Subbasin. Weighted average reach conditions on surveyed streams in the Eastern Subbasin as evaluated by the EMDS are somewhat unsuitable for salmonids (Table 107). Suitable conditions exist for reach, in channel, pool quality, and pool depth in Harrow Creek; for canopy in ten tributaries; and for embeddedness in Painter Creek. Unsuitable conditions exist for pool shelter in all tributaries evaluated.

Table 107. EMDS anadromous reach condition model results for the Eastern Subbasin.

Stream	Reach	Water Temperature	Canopy	Stream Flow	In Channel	Pool Quality	Pool Depth	Pool Shelter	Embeddedness
Eastern Subbasin	**-**	**U**	**+**	**U**	**-**	**- -**	**- -**	**- -**	**- -**
Dry Creek	-	U	- - -	U	-	- - -	- - -	- - -	- - -
Middle Creek	-	U	- -	U	-	- - -	- - -	- - -	- - -
Westlund Creek	-	U	++	U	-	- - -	- - -	- - -	- -
Gilham Creek	-	U	+	U	-	- -	- - -	- -	- -
Gilham Creek Tributary	-	U	+	U	-	- - -	- - -	- - -	- -
Fourmile Creek	-	U	- -	U	-	- - -	- - -	- - -	- -
North Fork Fourmile Creek	-	U	- -	U	-	- - -	- - -	- - -	- - -
Sholes Creek	-	U	++	U	-	- -	- - -	- -	- - -
Harrow Creek	+	U	+++	U	+	+	+++	- -	- -
Grindstone Creek	-	U	- -	U	-	- - -	- - -	- - -	- - -
Little Grindstone Creek	-	U	+++	U	-	- - -	- - -	- - -	- -
Fire Creek	-	U	-	U	-	- -	- - -	- -	- - -
Eubanks Creek	-	U	++	U	-	-	-	-	- -
McKee Creek	-	U	++	U	-	- -	- -	- -	-
McKee Creek Tributary	-	U	++	U	-	- - -	- - -	- - -	-
Painter Creek	-	U	+	U	-	- - -	- - -	- - -	+

Key: +++ Fully Suitable ++ Moderately Suitable + Somewhat Suitable
U Undetermined - Somewhat Unsuitable - - Moderately Unsuitable
- - - Fully Unsuitable

Analysis of Tributary Recommendations

CDFG inventoried 34.9 miles on 18 tributaries in the Eastern Subbasin. In Table 108, a CDFG biologist selected and ranked recommendations for each of the inventoried streams, based upon the results of these standard CDFG habitat inventories. More details about the tributary recommendation process are given in the Mattole Synthesis Section of the Watershed Profile.

Table 108. Ranked tributary recommendations summary in the Eastern Subbasin based on CDFG stream inventories.

Stream	# of Surveyed Stream Miles	Bank	Roads	Canopy	Temp	Pool	Cover	Spawning Gravel	LDA	Livestock	Fish Passage
Dry Creek	1.6	4	6	2	1	3	5				
Middle Creek	1.4	1	2	3	6	5	4				
Westlund Creek	3.2	1	2		5	3	4		6		
Gilham Creek	1.9	1	2	7		5	3	4	6		8
Gilham Creek Tributary #1	0.6	1	2	6		4	3	5			
Fourmile Creek	2.9	4	5	3	2	1	6		7		
North Fork Fourmile Creek	1.2	3	4	2	1	5	6	7			
Sholes Creek	4.0	2	3	6	7	4	1		5		
Harrow Creek	0.2	3	4	7		6	5	1	2		
Little Grindstone Creek	0.6	3	4	6		1	2		5		
Grindstone Creek	2.6	3	6	2	1	4	5		7		
Blue Slide Creek	6.3	4	3	1	2	5	6				
Fire Creek	2.0	4	3	5	1	2	6		7		
Box Canyon Creek	0.5		5	1		2	3				4
Eubank Creek	3.3	3			5	4	2		1		
McKee Creek	2.2	3	4			1	2				
Tributary to McKee Creek	0.1	2		3		1					
Painter Creek	0.3			3		1	2				

Temp = summer water temperatures seem to be above optimum for salmon and steelhead; Pool = pools are below target values in quantity and/or quality; Cover = escape cover is below target values; Bank = stream banks are failing and yielding fine sediment into the stream; Roads = fine sediment is entering the stream from the road system; Canopy = shade canopy is below target values; Spawning Gravel = spawning gravel is deficient in quality and/or quantity; LDA = large debris accumulations are retaining large amounts of gravel and could need modification; Livestock = there is evidence that stock is impacting the stream or riparian area and exclusion should be considered; Fish Passage = there are barriers to fish migration in the stream.

In order to further examine Eastern Subbasin issues through the tributary recommendations given in CDFG stream surveys, the top three ranking recommendations for each tributary were collapsed into five different recommendation categories: Erosion/Sediment, Riparian/Water Temp, Instream Habitat, Gravel/Substrate, and Other (Table 109). When examining recommendation categories by number of tributaries, the most important recommendation category in the Eastern Subbasin is Erosion/Sediment.

Table 109. Top three ranking recommendation categories by number of tributaries in the Eastern Subbasin.

East Subbasin Target Issue:	Related Table Categories:	Count:
Erosion / Sediment	Bank / Roads	19
Riparian / Water Temp	Canopy / Temp	15
Instream Habitat	Pool / Cover	17
Gravel / Substrate	Spawning Gravel / LDA	3
Other	Livestock / Barrier	0

However, comparing recommendation categories in the Eastern Subbasin by number of tributaries could be confounded by the differences in the number stream miles surveyed on each tributary. Therefore, the number of stream miles in each subbasin assigned to the various recommendation categories was calculated (Figure 97). When examining recommendation categories by number of stream miles, the most important recommendation categories in the Eastern Subbasin are Erosion/Sediment, Riparian/Water Temp, and Instream Habitat.

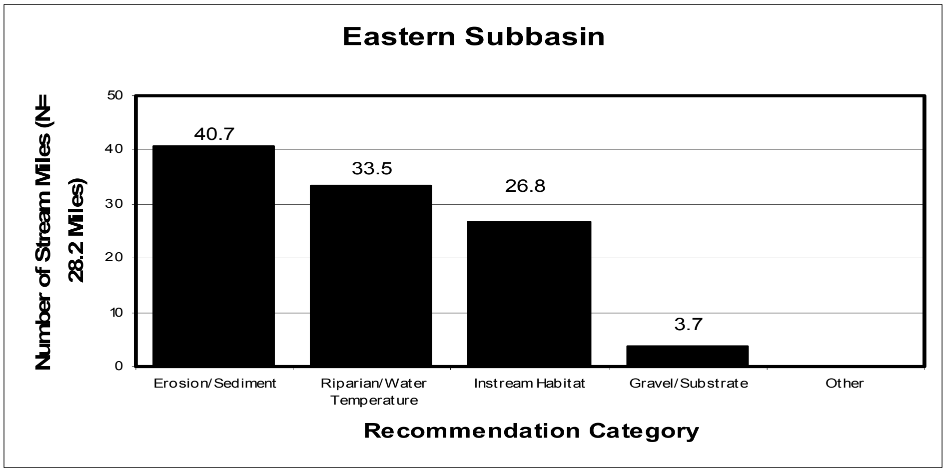


Figure 97. Recommendation categories by stream miles in the Eastern Subbasin.

The high number of Erosion/Sediment, Riparian/Water Temp, and Instream Habitat Recommendations across the Eastern Subbasin indicates that high priority should be given to restoration projects emphasizing sediment reduction, riparian replanting, pools, and cover.

Refugia Areas

The NCWAP interdisciplinary team identified and characterized refugia habitat in the Eastern Subbasin by using expert professional judgment and criteria developed for north coast watersheds. The criteria included measures of watershed and stream ecosystem processes, the presence and status of fishery resources, forestry and other land uses, land ownership, potential risk from sediment delivery, water quality, and other factors that may affect refugia productivity. The team also used results from information processed by NCWAP's EMDS at the stream reach and planning watershed/subbasin scales.

The most complete data available in the Eastern Subbasin were for tributaries surveyed by CDFG. However, many of these tributaries were still lacking data for some factors considered by the NCWAP team.

Salmonid habitat conditions in the Eastern Subbasin on surveyed streams are generally rated as medium potential refugia. Gilham, Harrow, Eubank, McKee, and Painter creeks provide the high potential refugia in this subbasin, while Dry, Middle, and Fourmile creeks and the North Fork of Fourmile Creek provide low quality refugia. The following refugia area rating table summarizes subbasin salmonid refugia conditions:

Table 110. Tributary salmonid refugia area ratings in the Eastern Subbasin.

Stream	Refugia Categories*:				Other Categories:		
	High Quality	High Potential	Medium Potential	Low Quality	Non-Anadromous	Critical Contributing Area/Function	Data Limited
Dry Creek				X			
Middle Creek				X			
Westlund Creek			X				X
Gilham Creek		X					X
Gilham Creek Tributary			X				X
Fourmile Creek				X			X
North Fork Fourmile Creek				X			X
Sholes Creek			X				X
Harrow Creek		X					X
Grindstone Creek			X				X
Little Grindstone Creek			X				X
Blue Slide Creek			X				X
Fire Creek			X				X
Box Canyon Creek			X				X
Eubank Creek		X					X
McKee Creek		X					X
McKee Creek Tributary			X				X
Painter Creek		X					X
Subbasin Rating			X				

*Ratings in this table are done on a sliding scale from best to worst. See page 71 for a discussion of refugia criteria.

Assessment Focus Areas

Working Hypothesis 1:

Salmonid habitat conditions in the Eastern Subbasin are simplified and are not fully supportive of salmonids.

Supporting Evidence:

- Air photos and field observations show that the Mattole River bordering the Eastern Subbasin downstream of Honeydew Creek is highly aggraded with sediment. (CGS, 2002).
- Based on samples taken from 1996-2001, all maximum weekly average temperatures (MWATs) for Westlund Creek, Mattole Canyon Creek, Blue Slide Creek, and Eubanks Creek were above the 50-60ºF range considered suitable for coho growth in the EMDS analysis (except Eubanks Creek in 2001). Maximum temperatures over 75 °F, a level considered lethal to most salmonid stocks, were also exceeded in Dry Creek, Mattole Canyon Creek, and Blue 'Slide Creek for most sample years. A single day thermal infrared surface temperature analysis also showed excessively high temperatures in the lower reaches of Mattole Canyon Creek (NCRWQCB Appendix E).
- Low canopy density levels appear to result from riparian cover depletion associated with land use, and stream widening due to high sediment inputs, especially during the 1955 and 1964 flood events (CDF Appendix B).
- Seven of 18 tributaries surveyed by CDFG in this subbasin exceeded recommended shade canopy density levels of 80% for North Coast streams. Additionally, 16 tributaries exceeded 50% shade canopy density levels. Shade canopy density below 50% is considered unsuitable (CDFG Appendix F).

- None of 18 tributaries surveyed by CDFG in this subbasin were found to have 40% or more of the survey lengths in pool habitat, and only two of surveyed tributaries were found to have 30 to 40% of the stream lengths surveyed in pool habitat. Forty percent or more of stream lengths in pool habitat is considered suitable on the North Coast. Additionally, only 6.9% of first and second order surveyed streams and 1.5% of third and forth order surveyed streams in this subbasin are composed of primary pools by survey length. Thirty to 55% of survey lengths composed of deep, complex, high quality primary pools is considered desirable (IA Tables, CDFG Appendix F).
- None of 18 tributaries surveyed by CDFG in this subbasin was found to have a mean pool shelter rating exceeding 80. Five surveyed tributaries were found to have shelter rating scores between 30 and 80. This indicates that the woody debris elements affecting scour are not present. Pool shelter ratings of 80 or more are considered suitable, and ratings less than 30 are unsuitable for contributing to shelter that supports salmonids (CDFG Appendix F).
- Boulders provided the primary form of shelter for salmonids in 15 of the 18 surveyed streams in this subbasin. Bedrock ledges provided the primary form of shelter for salmonids in two stream reaches, in McKee Creek and Painter Creek; undercut banks provided the primary form of shelter in one stream reach, in McKee Creek Tributary; and small woody debris provided the primary form of shelter in one stream reach, in McKee Creek (CDFG Appendix F).
- Removal of instream large woody debris under direction of CDFG occurred in about 1.6 stream miles in this subbasin during the 1980s. A total of 1024 cubic feet of wood was removed. This is equivalent to 8 logs 2 feet x 40 feet (CDFG Appendix F).
- Only four of 18 tributaries surveyed by CDFG in this subbasin were found to provide spawning reaches with favorable cobble embeddedness values in at least half of the stream reaches (CDFG Appendix F).
- An estimated 2,000 gallon diesel spill in Blue Slide Creek was reported in April 2000 to the NCRWQCB and is currently undergoing remediation and monitoring by the Board (NCRWQCB Appendix E).
- Out of six stream reaches examined for the presence of sensitive amphibian species, torrent salamanders, and tailed frogs were not found in any reaches (Welsh et al. 2002).
- There is a lack of available data on pH, dissolved oxygen, nutrients, and other water chemistry parameters (NCRWQCB Appendix E).
- Artificial fish passage barriers block 2.4% of the estimated historic coho salmon habitat in this subbasin. Additionally, 1.9% of surveyed stream channel in this subbasin was dry (IA Tables, CDFG Appendix F).
- The NCWAP analysis of tributary recommendations given in the Eastern Subbasin showed that the most important recommendation category was Erosion/Sediment, followed by Riparian/Water Temperature, Instream Habitat, and Gravel/Substrate (Tributary Recommendation Analysis pg xx).

Contrary Evidence:

There is no contrary evidence at this time.

Hypothesis 1 Evaluation:

Based upon current supportive and contrary findings, the hypothesis is supported.

Working Hypothesis 2:

Summer stream temperatures in many subbasin tributaries are not within the range of temperatures that are fully suitable for healthy anadromous salmonid populations.

Supporting Evidence:

- Based on samples taken from 1996-2001, all maximum weekly average temperatures (MWATs) for Westlund Creek, Mattole Canyon Creek, Blue Slide Creek, and Eubanks Creek were above the 50-60ºF range considered suitable for coho growth in the EMDS analysis (except Eubanks Creek in 2001). Maximum temperatures over 75 °F, a level considered lethal to most salmonid stocks, were also exceeded in Dry Creek, Mattole Canyon Creek and Blue 'Slide Creek for most sample years. A single day thermal infrared surface temperature analysis also showed excessively high temperatures in the lower reaches of Mattole Canyon Creek (NCRWQCB Appendix E).

- Low canopy density levels appear to result from riparian cover depletion associated with land use, and stream widening due to high sediment inputs, especially during the 1955 and 1964 flood events (CDF Appendix B).
- Seven of 18 tributaries surveyed by CDFG in this subbasin exceeded recommended shade canopy density levels of 80% for North Coast streams. Additionally, 16 tributaries exceeded 50% shade canopy density levels. Shade canopy density below 50% is considered unsuitable (CDFG Appendix F).

Contrary Evidence:

No contrary evidence at this time.

Hypothesis 2 Evaluation:

Based upon current supportive findings, the hypothesis is supported.

Working Hypothesis 3:

Aggradation from fine sediment in some stream channels of this subbasin has reduced channel diversity needed to provide suitable conditions for anadromous salmonid populations and has compromised salmonid health.

Supporting Evidence:

- Air photos and field observations show that the Mattole River bordering the Eastern Subbasin downstream of Honeydew Creek is highly aggraded with sediment. (CGS, 2002).

Contrary Evidence:

No contrary evidence at this time.

Hypothesis 3 Evaluation:

Based upon current supportive findings, the hypothesis is supported.

Working Hypothesis 4:

Toxic chemical spills have had an adverse effect on salmonid habitat conditions.

Supporting Evidence:

- An estimated 2,000 gallon diesel spill in Blue Slide Creek was reported in April 2000 to the North Coast Regional Water Quality Control Board and is currently undergoing remediation and monitoring by the Board (NCRWQCB Appendix E).

Contrary Evidence:

There is no contrary evidence at this time.

Hypothesis 4 Evaluation:

Based upon current supportive findings, the hypothesis is supported.

Working Hypothesis 5:

A lack of large woody debris in some stream reaches of this subbasin has reduced channel diversity needed to provide suitable habitat conditions for anadromous salmonid populations.

Supporting Evidence:

- None of 18 tributaries surveyed by CDFG in this subbasin was found to have a mean pool shelter rating exceeding 80. Five surveyed tributaries were found to have shelter rating scores between 30 and 80. This indicates that the woody debris elements affecting scour are not present. Pool shelter ratings of 80 or more are considered suitable, and ratings less than 30 are unsuitable for contributing to shelter that supports salmonids (CDFG Appendix F).
- Boulders provided the primary form of shelter for salmonids in 15 of the 18 surveyed streams in this subbasin. Bedrock ledges provided the primary form of shelter for salmonids in two stream reaches, in McKee Creek and Painter Creek; undercut banks provided the primary form of shelter in one stream

reach, in McKee Creek Tributary; and small woody debris provided the primary form of shelter in one stream reach, in McKee Creek (CDFG Appendix F).

- Removal of instream large woody debris under direction of CDFG occurred in about 1.6 stream miles in this subbasin during the 1980s. A total of 1024 cubic feet of wood was removed. This is equivalent to 8 logs 2 feet x 40 feet (CDFG Appendix F).

Contrary Evidence:

No contrary evidence at this time.

Hypothesis 5 Evaluation:

Based upon current supportive and contrary findings, the hypothesis is supported.

Working Hypothesis 6:

Anadromous salmonid populations in the eastern subbasin have declined since the 1950s.

Supporting Evidence:

- Interviews with local residents indicate that the Eastern Subbasin historically supported Chinook salmon, coho salmon, and steelhead trout and that Eubank Creek was described as the finest salmon stream in the area (CDFG Appendix F).
- Coho salmon were detected in two of the 14 tributaries surveyed in the Eastern Subbasin by CDFG in the 1960s, Westlund Creek and Harrow Creek. 1960s surveys also detected steelhead trout in five tributaries (CDFG Appendix F).
- Coho salmon were detected in Mattole Canyon Creek and steelhead trout were detected in Mattole Canyon Creek and McKee Creek in 1972 by a study of the standing salmonid stock (CDFG Appendix F).
- Stream surveys throughout the 1970s, 1980s, and 1990s by CDFG, BLM, Coastal Headwaters Association, and the Redwood Sciences Laboratory continued to document the presence of steelhead trout throughout the Eastern Subbasin (CDFG Appendix F).
- Coho salmon were detected by a Redwood Sciences Laboratory study in Eubanks Creek in 1995 (CDFG Appendix F).
- Ten of the eighteen tributaries surveyed by CDFG in the Eastern Subbasin from 1990-2000 included a biological survey. Steelhead trout were found in these ten streams, but coho salmon were only found in Box Canyon Creek (CDFG Appendix F).
- Ten tributaries in this subbasin were also surveyed as a part of the CDFG 2001 Coho Inventory. Steelhead trout were found in these ten streams, but coho salmon were only found in Fourmile Creek, Sholes Creek, and Grindstone Creek (CDFG Appendix F).
- Estimated populations of Chinook salmon or coho salmon in the entire Mattole Basin have not exceeded 1000 since the 1987-88 season. Mattole Basin Chinook salmon and coho salmon population estimates for the 1999-2000 season were 700 and 300, respectively (MSG 2000).

Contrary Evidence:

There is no contrary evidence at this time.

Hypothesis 6 Evaluation:

Based upon current supportive and contrary findings for the streams surveyed, the hypothesis is supported.

Responses to Assessment Questions

What are the history and trends of the sizes, distribution, and relative health and diversity of salmonid populations within this subbasin?

- No studies have examined the size or health of salmonid populations in the Eastern Subbasin. However, historical accounts and stream surveys conducted in the 1960s by CDFG indicate that the Eastern Subbasin supported populations of Chinook salmon, coho salmon, and steelhead trout. Recent biological stream surveys indicate the presence of steelhead trout throughout the Eastern Subbasin and coho salmon in a few tributaries. Low salmonid populations throughout the Mattole Basin indicate that salmonid populations in the Eastern Subbasin are likely to be depressed at this time;

What are the current salmonid habitat conditions in this subbasin? How do these conditions compare to desired conditions?

- Erosion/Sediment
    - Instream sedimentation in several stream reaches in this subbasin may be approaching or exceeding levels considered unsuitable for salmonid populations. Macroinvertebrates were not sampled in this subbasin. Amphibian sensitive to fine sediment were absent from all stream reaches surveyed in this subbasin;
- Riparian/Water Temperature
    - Available data from sampled streams suggest that high summer temperatures are deleterious to summer rearing salmonid populations in the lower depositional reaches of most streams in this subbasin;
- Instream Habitat
    - In general, a high incidence of shallow pools, a lack of cover, and a lack of large woody debris have contributed to a simplification of instream salmonid habitat.
- Gravel Substrate
    - Available data from sampled streams suggest that suitable amounts and distribution of high quality spawning gravel for salmonids is lacking in this subbasin;
- Gilham, Harrow, Eubank, McKee, and Painter creeks are considered good refugia.

What are the relationships of geologic, vegetative, and fluvial processes to natural events and land use history?

- Geologic conditions in this subbasin are the most variable in the basin. Areas of relatively intact and stable geologic units are locally interrupted by areas of highly disrupted and unstable soft terrain. These are accompanied by active landslides, gully erosion and, in proximal stream channels, features indicative of excess sediment production, transport and storage in the streams;
- Although stream conditions in bedrock reaches suggest that in 1984 this subbasin had the second highest level of impact within the basin, these conditions have improved dramatically in the period between 1984 and 2000. Considering the low degree of impact by features indicative of excess sediment production, transport and storage observed in the adjacent upstream Southern Subbasin, it appears that the stream features observed in the Eastern Subbasin must be derived either internally within the subbasin or from the adjacent Western Subbasin;
- As a result of past timber harvest and conversion activities, 56% of the Eastern Subbasin is populated with small diameter forest stands (twelve to twenty-four inches diameter at breast height). Twenty-one percent is in forest stands greater than twenty-four inches. Grasslands occupy 11% of the area;

How has land use affected these natural processes?

- In April 2000, a serious diesel spill occurred directly into a subbasin tributary. Petroleum spills represent a chemical threat to favorable stream conditions and should be eliminated using all means available;
- Over 94% of this subbasin is privately owned, much of it was sub-divided after extensive timber harvesting. Currently, there is a low level of timber harvest activity;
- Existing road densities and locations reflect construction for timber harvest access since the 1940s. Many of these roads are now used to access homes or parcels;

Based upon these conditions trends, and relationships, are there elements that could be considered to be limiting factors for salmon and steelhead production?

- Based on information available for the Eastern Subbasin, the NCWAP team believes that salmonid populations are currently being limited by high sediment levels, high water temperatures, reduced habitat complexity, and embedded spawning gravels in some tributaries of the Eastern Subbasin. Harrow Creek has very good salmonid habitat; Westlund, Gilham, Gilham Creek Tributary, Sholes, Little Grindstone, Harrow, Eubank, McKee, McKee Creek Tributary, and Painter creeks have good canopy density; and Painter Creek has good cobble embeddedness.

What habitat improvement activities would most likely lead toward more desirable conditions in a timely, cost effective manner?

- Establish monitoring stations and train local personnel to track in-channel sediment and aggraded reaches throughout the subbasin and especially in Mattole Canyon and Blue Slide creeks;
- At stream bank erosion sites, encourage cooperative efforts to reduce sediment yield to streams. CDFG stream surveys indicate Middle, Westlund, Gilham, Gilham Creek Tributary, North Fork Fourmile, Sholes, Harrow, Little Grindstone, Grindstone, Eubank, and McKee creeks, and the Tributary to McKee Creek have bank stabilization activities as a top tier tributary improvement recommendation. These could be of localized importance to reduce stream fine sediment levels;
- Continue to conduct and implement road and erosion assessments such as the ongoing efforts in the Dry and Westlund planning watersheds. Initiate road improvements and erosion proofing throughout the subbasin to reduce sediment delivery. Middle, Westlund, Gilham, Gilham Creek Tributary, Sholes, Blue Slide, and Fire creeks had road sediment inventory and control as one of their top tier tributary improvement activity recommendations;
- Several years of monitoring summer water and air temperatures to detect trends using continuous, 24 hour monitoring thermographs should be done. Continue temperature monitoring efforts in Dry, Middle, Westlund, Sholes, Mattole Canyon, Blue Slide, Eubank, Gilham, and Grindstone creeks. Start temperature monitoring in Little Grindstone, Fire, and Box Canyon creeks;
- Where current canopy is inadequate and site conditions, including geology, are appropriate, use tree planting and other vegetation management techniques to hasten the development of denser and more extensive riparian canopy. Canopy density has the lowest suitability for salmonids in Dry and Blue Slide creeks;
- Landowners and managers in the this subbasin should work to add more large organic debris and shelter structures in order to improve channel structure, channel function, habitat complexity, and habitat diversity for salmonids. Pool shelter has the lowest suitability for salmonids in Dry, Middle, Westlund, Gilham Creek Tributary, Fourmile, North Fork Fourmile, Grindstone, Little Grindstone, Blue Slide, McKee Creek Tributary, and Painter creeks;
- Consider the nature and extent of naturally occurring unstable geologic terrain, landslides and landslide potential (especially Categories 4 and 5, page 89) when planning potential projects in the subbasin;
- Encourage the use of appropriate Best Management Practices for all land use and development to minimize erosion and sediment delivery to streams;
- Encourage appropriate chemical transportation and storage practices, early spill reporting, and clean-up procedures.
- Ensure that high quality habitat within this subbasin is protected from degradation. The highest stream reach conditions as evaluated by the stream reach EMDS and refugia analysis were found in the Gilham, Harrow, Eubank, McKee, and Painter Creeks.

Subbasin Conclusions

The Eastern Subbasin appears to be variably impacted by high sediment levels, high water temperature, reduced habitat complexity, and embedded spawning gravels in some tributaries. The variability of impacts is largely the result of the natural variability of stability and erodability of the geologic terrains in the subbasin. Present stream conditions in some tributaries are less then target values beneficial to salmonids. However, historical accounts indicate that stream conditions were favorable for salmonid in the past and certain habitat factors remain favorable in some of the tributaries. Accordingly, there are opportunities for improvements in watershed stream conditions and a need to restore areas of stream refugia. Examples of recommendations to improve habitat include road improvements and erosion proofing, mitigation of stream bank erosion, monitoring stream and air temperatures, tree planting to improve riparian canopy, and increase channel complexity. The natural variability of stability and erodability of the geologic terrains should be considered before project implementation and appropriate BMPs should be followed to minimize erosion and sediment delivery to streams. Current landowners and managers interested and motivated to eliminate impacts related to land use and accelerate a return to the stable, beneficial conditions for salmonid are encouraged to do so, enlisting the aid and support of agency technology, experience, and funding opportunities.

Southern Mattole Subbasin

Redwoods in the Southern Subbasin near Whitethorn

Introduction

The Southern Subbasin (Figure 98) is located south of Bridge Creek (RM 52.1) and McKee Creek (RM 52.8), both near Thorn Junction, and continues upstream to the Mattole's headwaters near Four Corners (RM 61.5), a distance along the Mattole mainstem of about 9.4 river miles (Figure 98). Twenty-six perennial streams drain a watershed area of 28 square miles. Elevations range from 930 feet at Bridge Creek to approximately 1,500 feet in the headwaters of the tributaries.

The NCWAP team's Southern Subbasin results and analyses are presented in three basic sections. First, general information describing the subbasin is presented by different disciplines. Secondly, this information is integrated and presented to provide an overall picture of how different factors interact within the subbasin. Lastly, an overall assessment of the Southern Subbasin is presented. The NCWAP team developed hypotheses, compiled supportive and contrary evidence, and used these six assessment questions to focus this assessment:

- What are the history and trends of the sizes, distribution, and relative health and diversity of salmonid populations within this subbasin?
- What are the current salmonid habitat conditions in this subbasin? How do these conditions compare to desired conditions?
- What are the relationships of geologic, vegetative, and fluvial processes to natural events and land use history?
- How has land use affected these natural processes?
- Based upon these conditions trends, and relationships, are there elements that could be considered to be limiting factors for salmon and steelhead production?
- What habitat improvement activities would most likely lead toward more desirable conditions in a timely, cost effective manner?

The assessment questions are answered at the end of this section.

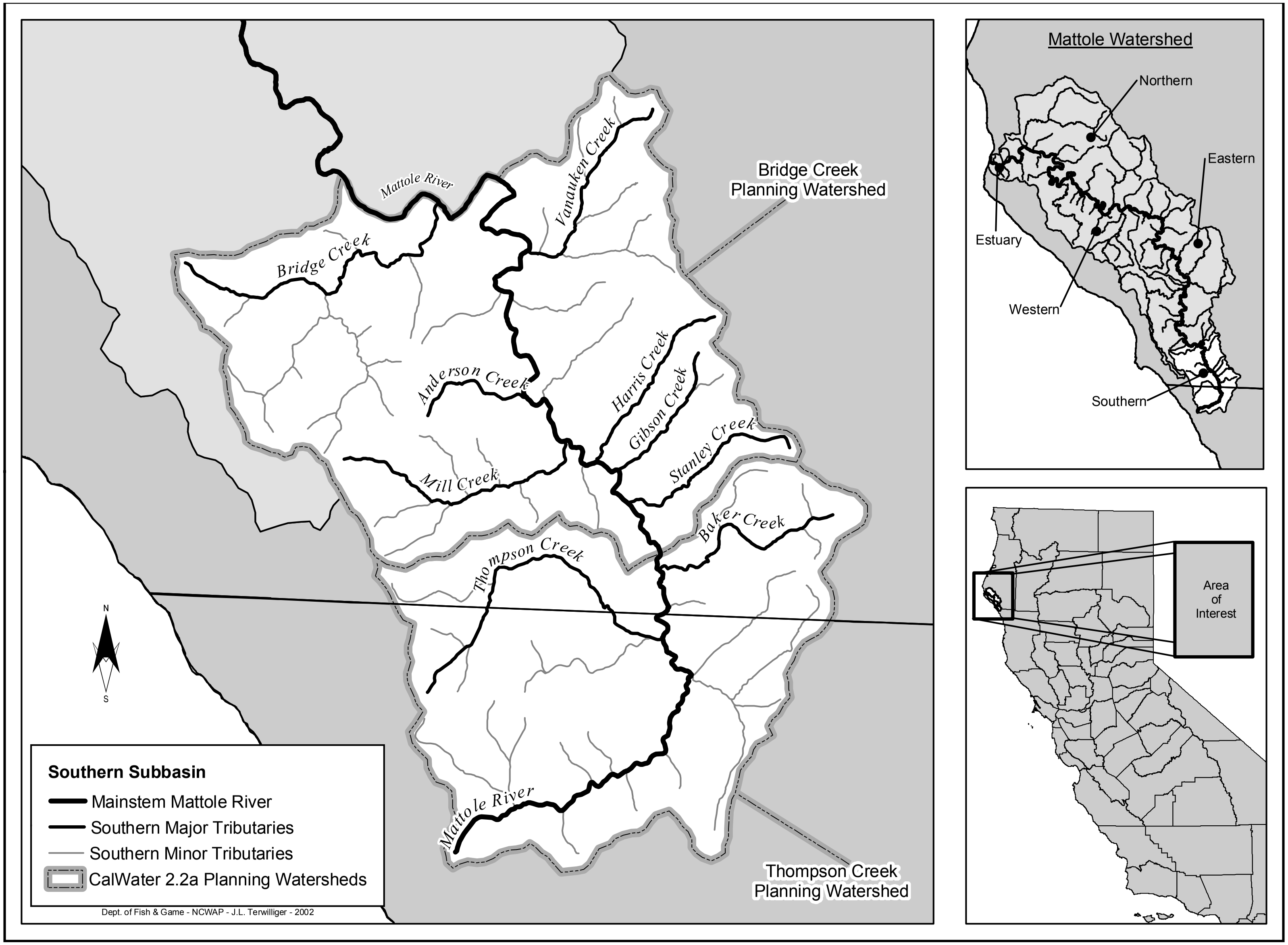


Figure 98. Mattole Southern Subbasin

Climate

The Southern Subbasin temperature and yearly precipitation totals are influenced by the King Range that lies immediately west of the area. Temperatures reflect the inland location ranging from sub-freezing to above 100° F but generally stay between 55° and 85°F. Annual rainfall totals average between 70 and 85 inches.

Hydrology

There are 23.5 perennial stream miles in 26 perennial tributaries in this subbasin (Table 111). Fourteen of these tributaries have been inventoried by CDFG. There were 21 reaches, totaling 25.7 miles in the inventory surveys. The inventories included channel and habitat typing, and biological sampling.

Table 111. Streams with estimated anadromy in the Southern Subbasin.

Stream	CDFG Survey (Y/N)	CDFG Survey Length (miles)	Estimated Anadromous Habitat Length (miles)*	Reach	Channel Type
Bridge Creek	Y		2.8		
	Y	3.1			
	Y	0.7		1	F4
	Y	0.5		2	
	Y	1.9		3	F4
West Fork of Bridge Creek (Robinson Creek)	Y		1.5		
	Y	0.9		1	B4
	Y	0.5		2	C4
South Branch of the West Fork of Bridge Creek	Y	1.4	1.0	1	F4
Vanauken Creek	Y		1.1		
	Y	1.4		1	F4
	Y	0.1		2	G4
South Fork Vanauken Creek	Y	0.1			
Anderson Creek	Y	0.9	0.1	1	B3
Ravasoni Creek	N		0.0		
Mill Creek (RM 56.2)	Y	0.2	2.3	1	F4
Harris Creek	N		0.8		
Gibson Creek	N		1.0		
Upper Mattole River	Y	6.7	7.0	1	F3
Stanley Creek	Y	1.0	1.0	1	F4
Baker Creek	Y	2.2	1.7	1	F4
Thompson Creek	Y		3.2		
	Y	1.6		1	B1
	Y	1.7		2	F1
Yew Creek	Y	0.7	1.3	1	B4
Helen Barnum Creek	Y	0.9	0.6	1	E4
Lost Man Creek	Y	1.2	0.5	1	E4
Lost Man Creek Tributary	Y	1.2		1	E4
Big Alder Creek	N				
Pipe Creek	N				
Dream Stream	N				
Arcanum Creek	N				
Big Jackson Creek	N				
Phillips Creek	N		0.1		
McNasty Creek	N		1.0		
Ancestor Creek	N		0.3		

* Data from the Mattole Salmon Group.

In their inventory surveys, CDFG crews utilize a channel classification system developed by David Rosgen (1994) and described in the *California Salmonid Stream Habitat Restoration Manual*. Rosgen channel typing describes relatively long stream reaches using eight channel features: channel width, depth, velocity, discharge, channel slope, roughness of channel materials, sediment load and sediment size. There are eight general channel types in the Rosgen classification system.

In the Southern Subbasin, there were four type B channels, totaling 4.1 miles; three type E channels, totaling 3.3 miles; nine type F channels, totaling 17.2 miles; and one type G channel, totaling 0.1 miles. Type B stream reaches are wide, shallow, single thread channels. They are moderately entrenched, moderate to steep gradient reaches, which are riffle-dominated with step/pool sequences. Type B reaches flow through broader valleys than type A reaches, do not have well-developed floodplains, and have few meanders. Type E stream reaches are narrow, deep, single thread channels. They are slightly entrenched, low gradient reaches with consistent riffle/pool sequences. Type E reaches flow through wide alluvial valleys and have frequent meanders. Type F stream reaches are wide, shallow, single thread channels. They are deeply entrenched, low gradient reaches and often have high rates of bank erosion. Type F reaches flow through low-relief valleys and gorges, are typically working to create new floodplains, and have frequent meanders. Type G or gully stream reaches are similar to F types but are narrow and deep. With few exceptions, type G reach types possess high rates of bank erosion as they try to widen into a type F channel. Type G reach types are found in a variety of landforms, including meadows, developed areas, and newly established channels within relic channels (Flosi, et al., 1998).

Geology

The geologic conditions in the Southern Subbasin (Figure 99) are the most uniform and stable in the Mattole Basin study area. The subbasin is underlain by Franciscan Coastal terrane rocks that are generally less broken and, therefore, more resistant to erosion and slope instability in comparison to bedrock in the other subbasins. This condition has resulted in a large preponderance of hard terrain throughout the subbasin. Overall relief is the lowest of the subbasins; however, the relatively stable condition of the bedrock has led to the formation of sharp-crested topography dissected by more straight, well-incised sidehill drainages with steep, heavily forested slopes. In the lower reaches of the larger tributaries and along the mainstem Mattole, streams are confined to narrow channels incised below broader valley bottoms formed by bedrock strath terraces with a thin mantle of alluvium. Drainage orientations generally follow, or are perpendicular to, the dominant northwest-trending structural fabric of the bedrock in the area.

The more intact condition of the bedrock is reflected in the presence of comparatively few deep-seated landslides in the southern subbasin. Only 2% of the Southern Subbasin is affected by mapped landslides, compared with 17% to 32% in other subbasins in the study area (Figure 25). Seven to ten of the 32 dormant landslides observed from air photos are associated with a narrow, northwest-trending fault zone in the southeastern corner of the watershed. Most of the very limited historically-active mass wasting activity is in the form of small debris slides. Accordingly, the Southern Subbasin has the lowest landslide potential of the subbasins, with about half the subbasin classified as moderate potential, and approximately 24% in the high to very high potential categories (Figure 24).

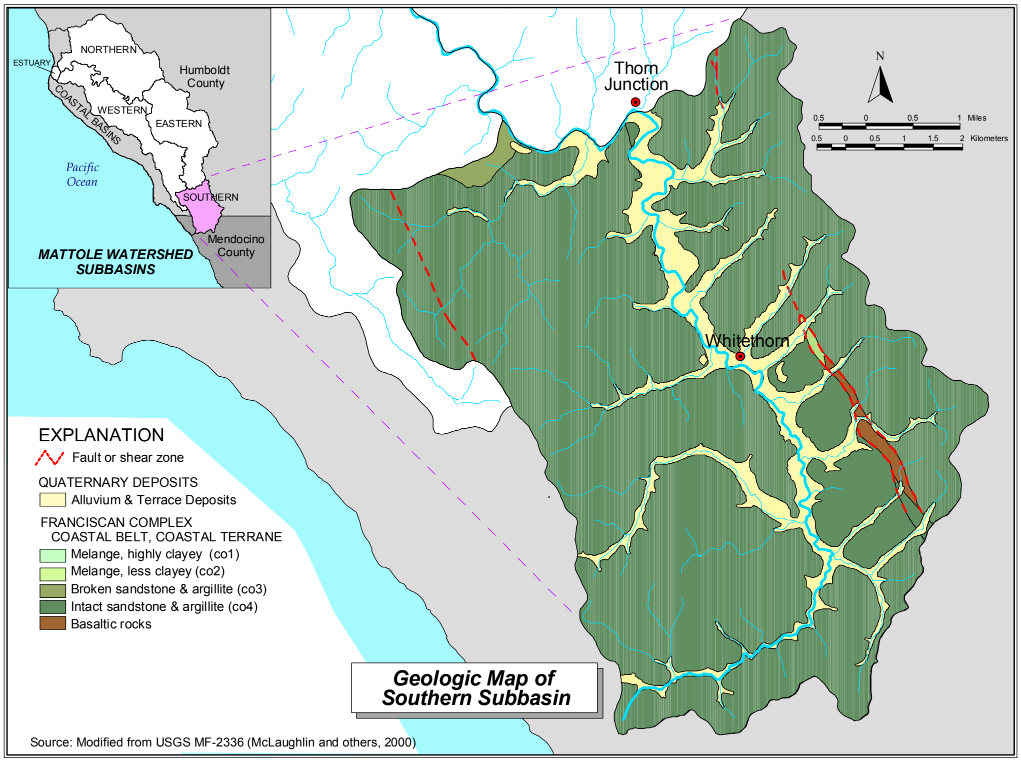


Figure 99. Geologic map of the Southern Subbasin.

Vegetation

Unless otherwise noted, the vegetation description in this section is based on manipulation of CalVeg 2000 data. This is vegetation data interpreted from satellite imagery by the United States Forest Service, Remote Sensing Lab. The minimum mapping size is 2.5 acres.

Mixed hardwood and conifer forests cover 70% of the area, conifer forest 4%, and hardwood forest 23% for a total of 95% forested area (Figure 100). Approximately 13% of the area contains a redwood component along the lower elevations near watercourses. Grassland occupies 4% of the subbasin. Shrub, barren, agricultural lands, and urban classifications together cover less than 1% of the area. Sixty-three percent of the Southern Subbasin is in the 12 to 23.9 inch diameter breast height (dbh) size class. Twenty-two percent is in a diameter size class greater than 24 inches dbh.

Land Use

The watershed is largely subdivided into small parcels and is the most densely populated subbasin of the Mattole (Figure 101). The town of Whitethorn is located in the middle of this subbasin near the confluence of Mill Creek (RM 56.2) and the Mattole River. The human population has contributed to reduced summer flows in some of the tributaries and the mainstem itself above Baker Creek due to domestic and agricultural water consumption. About half of the watershed is managed for timber production (Figure 102, Table 112, Figure 103) and is unique to the Mattole Basin as a redwood production zone. Controversy over timber harvest issues have occurred in the past, focused on stands near what is now the 4,700-acre Sanctuary Forest. Today much of the land in contention has been sold or traded into public ownership as ecological reserves. There is interest from some local citizens to expand the size of the reserves.

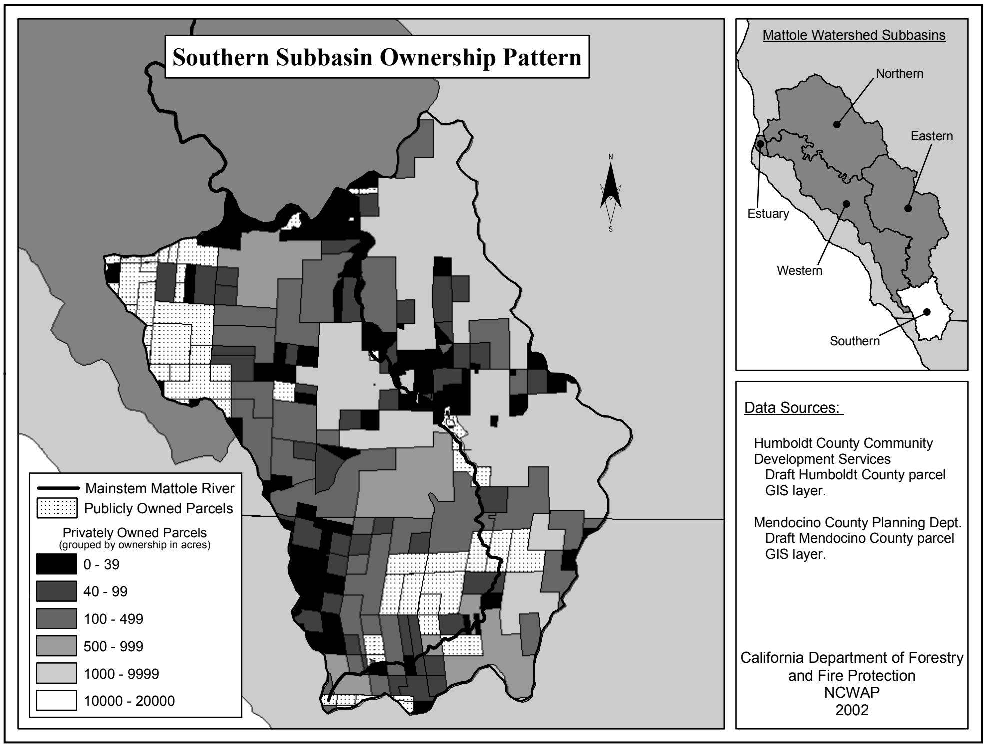


Figure 100. Vegetation of the Southern Subbasin.

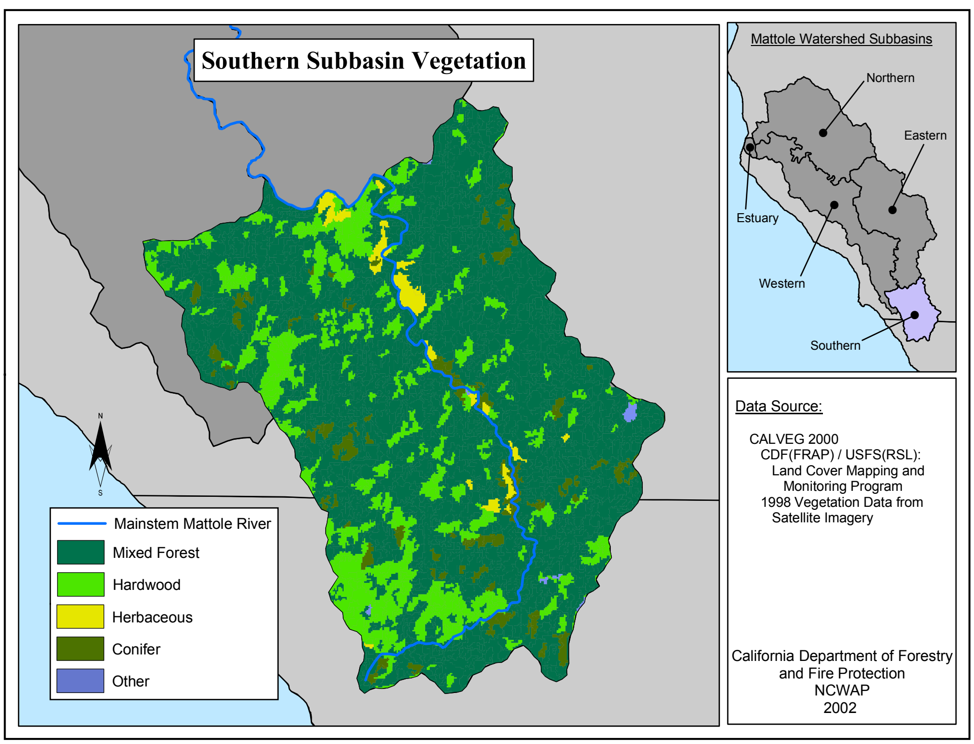


Figure 101. Ownership pattern of the Southern Subbasin.

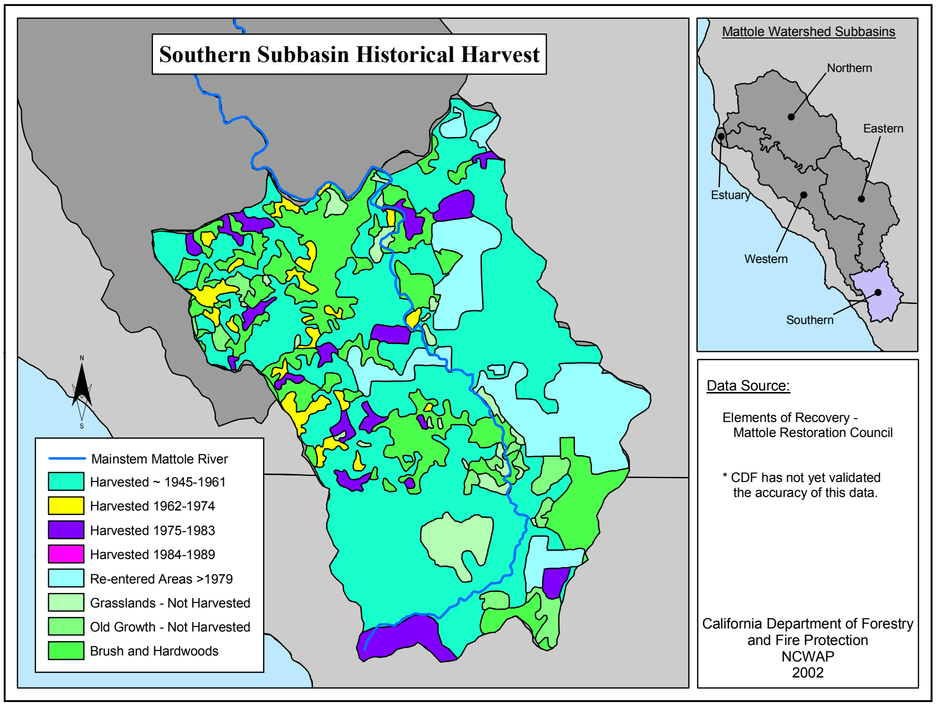


Figure 102. Timber harvest history of the Southern Subbasin.

Table 112. Timber harvest history, Southern Subbasin.

TIMBER HARVEST HISTORY - SOUTHERN SUBBASIN*				
	Total Harvested Acres	**Total Area Harvested (%)**	**Average Annual Harvest (ac)**	**Annual Harvest Rate (%)**
Harvested ~1945 - 1961**	8,875	50%	522	3%
Harvested 1962 - 1974**	546	3	42	<1
Harvested 1975 - 1983**	1,333	8	148	<1
Harvested 1984 - 1989	1,519	9	253	1
Harvested 1990 - 1999	2,299	13	230	1
Harvested 2000 - 2001	394	2	197	1
Not Harvested:				
Grasslands	714	4		
Brush and Hardwoods	3,402	19		

* Does not add to 100% due to data discrepancies, re-harvest areas, and uncut timber areas.

** CDF has not yet validated the accuracy of this data (obtained from MRC).

Timber harvesting covered a substantial portion of the basin prior to the 1964 flood. The logging method was tractor logging down to streamside road systems. The silviculture was a type of seed tree cut that often left brush and some conifer. Timber harvesting activity since 1983 has covered about 21% of the subbasin, the highest level of harvesting in the Mattole Basin. Both planning watersheds have had harvesting concentrated on the east side of the Mattole River. The silvicultural systems appear to be based on the uneven nature of the stands that were left after the first entries and primarily consist of even-aged regeneration methods, often using a rehabilitation or alternative prescription. Since 1983, cable systems account for half of the logging operations used.

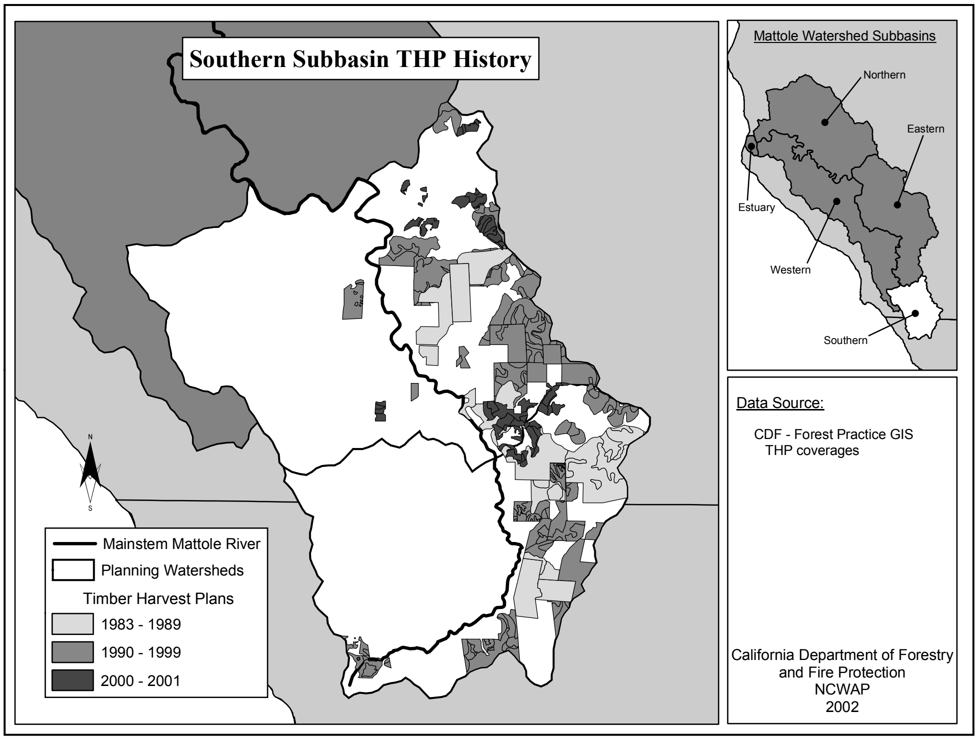


Figure 103. Timber harvest plans (THPs) of the Southern Subbasin.

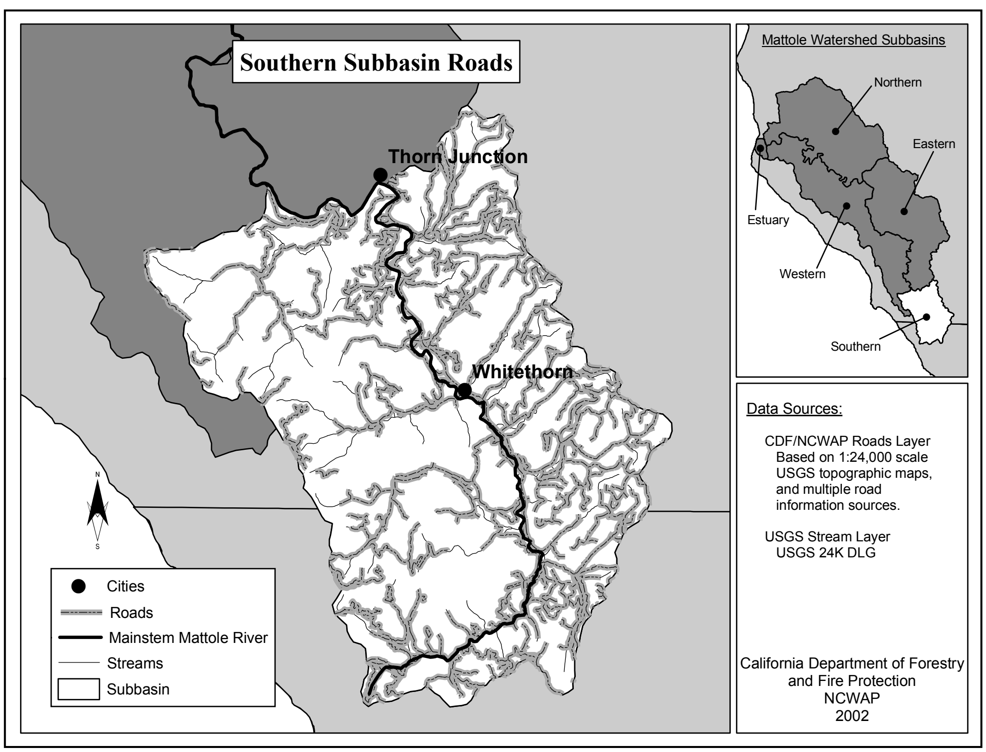


Figure 104. Southern Subbasin roads.

Fluvial Geomorphology

The fluvial geomorphology of the Southern Subbasin is characterized by the lowest concentration of mapped channel characteristics, no observed gullies, and low to intermediate values for lateral-bar development. Table 113 illustrates the range of these features observed on the 1984 and 2000 aerial photographs. Subbasin-wide values for NMCCs decreased from 20% of total stream length in 1984 to 2% in 2000 (CGS Geologic Report-Table 12). Table 113 and Table 114 show the change in NMCCs is primarily due to a dramatic decrease in the total length of wide channels and a smaller but still significant decrease in displaced riparian vegetation during that time period. Significant improvement was observed between 1984 and 2000 in the proportion of blue line streams in bedrock and adjacent to or within LPM 4 and 5 that were affected by NMCCs. In 1984, about 64% of such stream reaches were affected by NMCCs, while in 2000 about 7% were affected (Table 113). Gullies were not observed in the aerial photos, and lateral-bar development values are uniformly low within sub reach lengths (Table 113).

The Thompson Creek PW has low values for all MCCs, and has shown a 91% decrease in length of MCCs from 1984 to 2000 (Table 113). The Bridge Creek PW has shown an 87% decrease in MCCs during this same period, with no change in lateral-bar development. Stream-bank erosion in the Southern Subbasin appears negligible (Table 114).

Table 113. Fluvial geomorphic features – Southern Subbasin.

	2000 Photos			1984 Photos		
Planning Watersheds1	**Length of Mapped Channel Characteristics2 (feet)**	**Total Gully Length3 (feet)**	**Lateral Bar Development4**	**Length of Mapped Channel Characteristics2 (feet)**	**Total Gully Length3 (feet)**	**Lateral Bar Development4**
Bridge Creek	7400	N.O.	1	58,900	N.O.	1
Thompson Creek	1400	N.O.	1	15,800	N.O.	1
Southern Subbasin Totals	8800			74,700		
Bridge Creek	7,400	N.O.	1	58,900	N.O.	1
Thompson Creek	1,400	N.O.	1	15,800	N.O.	1
Southern Subbasin Totals	8,800			74,700		

1 See Figure 2 for locations.
2 Features include negative and neutral characteristics including: wide channels, displaced riparian vegetation, point bars, distribution and lateral or mid-channel bars, channel bank erosion, shallow landslides adjacent to channels.
3 Gullies include those that appear active, have little to no vegetation within the incised area, and are of sufficient size to be identified on aerial photos.
4 Lateral bars include mappable lateral, mid-channel bars and reflect sediment supply and storage. Rankings range from 1-5. Higher values suggest excess sediment.
N.O. – Not Observed.

Table 114. Eroding stream bank lengths - Southern Subbasin.

2000 Photos				
Southern Subbasin Planning Watersheds1	**Number of Sites2**	**Maximum Length (feet) of Eroding Bank3**	**Total Length (feet) of Eroding Bank4**	**Eroding Bank (%)5**
Bridge Creek	N.O.	N.O.	N.O.	N.A.
Thompson Creek	N.O.	N.O.	N.O.	N.A.

1 See Figure 2 for locations.
2 Number of sites mapped from air photos within PW.
3 Maximum length of a continuous section of eroding stream bank within PW.
4 Combined total length of all sections of eroding stream bank within PW.
5 Approximate percentage of eroding stream bank relative to total stream length within PW.
N.O. - Not Observed. N.A. – Not Applicable

Aquatic/Riparian Conditions

Unless otherwise noted, the vegetation description in this section is based on manipulation of CalVeg 2000 data. This is vegetation data interpreted from satellite imagery by the United States Forest Service, Remote Sensing Lab. The minimum mapping size is 2.5 acres.

Vegetation within 150 feet of the centerline of streams is 79% mixed conifer and hardwood forest, 12% hardwood, and 7% conifer forest, while annual grassland, shrubs and barren combined make up the remaining 2%. The Mattole River is at its headwaters here and is narrow enough to receive full shade across its width from riparian vegetation. Trees in the 12 to 24.5 inch diameter size class cover 66% of the riparian area. The area occupied by this single-width zone is 14% of the total Southern Subbasin acreage.

Fish Habitat Relationship

Anadromous stream reach conditions in the Southern Subbasin were somewhat unsuitable as evaluated by the stream reach EMDS. The anadromous reach condition EMDS is composed of water temperature, riparian vegetation, stream flow, and in channel characteristics. More details are in the EMDS Appendix C.

Data on water temperature and stream flow have not yet been incorporated into EMDS. However, water temperature data are presented in the NCRWQCB Appendix E and stream flow data are presented in the DWR Appendix D and in individual stream survey report summaries in the CDFG Appendix F. Temperatures were collected in Bridge Creek and Vanauken Creek, and Baker Creek, Yew Creek, Thompson Creek, Helen Barnum Creek, Lost Man Creek, Dream Stream, and Ancestor Creek. The lower temperatures in Bridge Creek, Vanauken Creek, Baker Creek, Yew Creek, Thompson Creek, Helen Barnum Creek, Lost Man Creek, Dream Stream, and Ancestor Creek are within the 50-60° F range suitable for coho salmon viability, although a number of the MWATs are right at the upper temperature threshold of 60° F.

Stream attributes that were evaluated by the anadromous stream reach EMDS included canopy cover, embeddedness, percent pools, pool depth, and pool shelter. These attributes were collected in 12 streams in the Southern Subbasin by CDFG (see the CDFG Appendix F) for stream survey report summaries).

Stream attributes tend to vary with stream size. For example, larger streams generally have more open canopy and deeper pools than small streams. This is partially a function of wider stream channels and greater stream energy due to higher discharge during storms. Surveyed streams in the Southern Subbasin ranged in drainage area from 0.7 to 12.8 square miles (Figure 105).

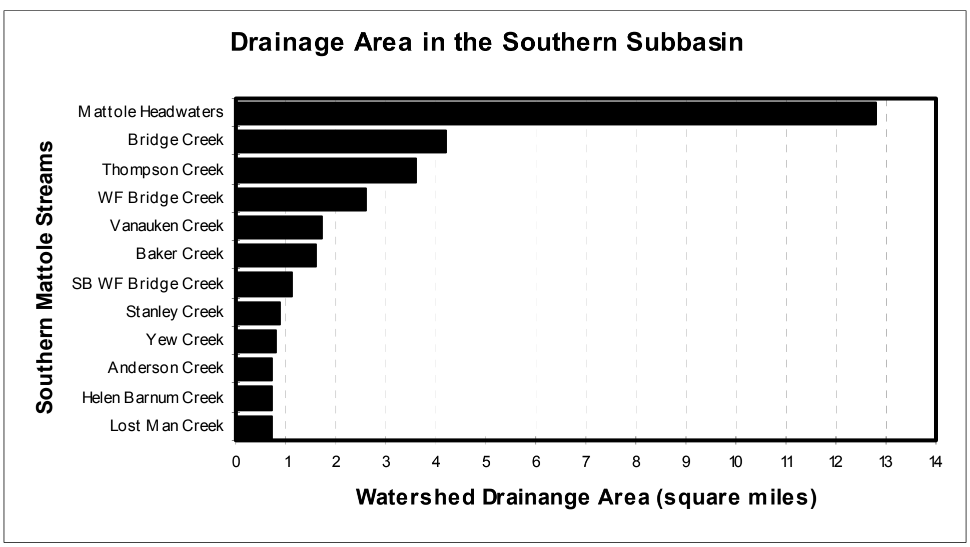


Figure 105. Drainage area of stream surveyed by CDFG in the Southern Subbasin.

Canopy cover, and relative canopy cover by coniferous versus deciduous trees were measured at each habitat unit during CDFG stream surveys. Near-stream forest density and composition contribute to microclimate conditions that help regulate air temperature, which is an important factor in determining stream water temperature. Furthermore, canopy levels provide an indication of the potential present and future recruitment of large woody debris to the stream channel, as well as the insulating capacity of the stream and riparian areas during winter.

In general, the percentage of stream canopy cover increases as drainage area, and therefore channel width, decrease. Deviations from this trend in canopy may indicate streams with more suitable or unsuitable canopy relative to other streams of that subbasin. As described in the EMDS response curves, total canopy (sum of conifer and deciduous canopy) exceeding 85% is considered fully suitable, and total canopy less than 50% is fully unsuitable for contributing to cool water temperatures that support salmonids. The surveyed streams of the Southern Subbasin show percent canopy levels that are rated by the EMDS as fully suitable to somewhat unsuitable for maintaining cool water temperatures yet are generally the highest among the subbasins (Figure 106). Percent conifer canopy levels vary from 5% to 31%.

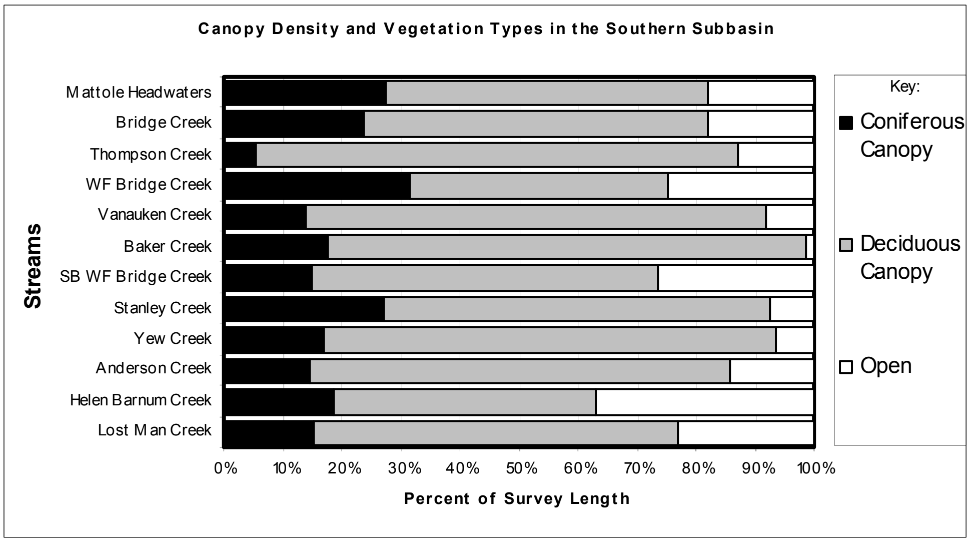


Figure 106. The relative percentage of coniferous, deciduous, and open canopy covering surveyed streams, Southern Subbasin.

Averages are weighted by unit length to give the most accurate representation of the percent of a stream under each type of canopy. Streams are listed in descending order by drainage area (largest at the top). As described in the EMDS response curves, total canopy (sum of conifer and deciduous canopy) exceeding 85% is considered fully suitable, and total canopy less than 50% is fully unsuitable for contributing to cool water temperatures that support salmonids.

Cobble embeddedness was measured at each pool tail crest during CDFG stream surveys. Cobble embeddedness is the percentage of an average sized cobble piece at a pool tail out that is embedded in fine substrate. Category 1 is 0-25% embedded, Category 2 is 26-50% embedded, Category 3 is 51-75% embedded, Category 4 is 76-100% embedded, and Category 5 is unsuitable for spawning due to factors other than embeddedness. Cobble embedded deeper than 51% is not within the fully supported range for successful use by salmonids. The EMDS Reach Model considers cobble embeddedness greater than 50% to be somewhat unsuitable and 100% to be fully unsuitable for the survival of salmonid eggs and embryos. Embeddedness values in the Southern Subbasin yield EMDS ratings that vary from somewhat suitable to fully unsuitable for the survival of developing salmonid eggs and embryos (Figure 107). However, Figure 107 also illustrates how stream reaches rated as unsuitable overall may actually have some suitable spawning gravel sites distributed through the stream reach.

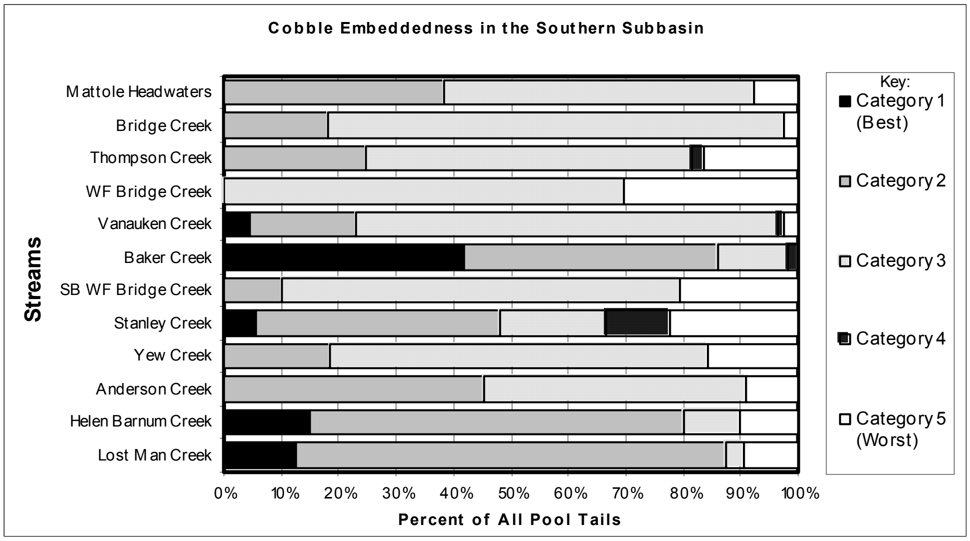


Figure 107. Cobble embeddedness categories as measured at every pool tail crest in surveyed streams, Southern Subbasin.

Cobble embeddedness is the % of an average-sized cobble piece at a pool tail out that is embedded in fine substrate: Category 1 = 0-25% embedded, Category 2 = 26-50% embedded, Category 3 = 51-75% embedded, Category 4 = 76-100%, and Category 5 = unsuitable for spawning due to factors other than embeddedness (e.g. log, rocks). Substrate embeddedness Categories 3, 4, and 5 are considered by EMDS to be somewhat unsuitable to fully unsuitable for the survival of salmonid eggs and embryos. Streams are listed in descending order by drainage area (largest at the top).

Pool, flatwater, and riffle habitat units observed were measured, described, and recorded during CDFG stream surveys. During their life history, salmonids require access to all of these types of habitat. EMDS does not evaluate the ratio of these habitat types, but a balanced proportion is desirable. Most surveyed Southern Subbasin tributaries have 20%-30% pool habitat by length, but five streams have less than 20% pool habitat and five have greater than 30% pools (Figure 108). Dry units were also measured, and obviously indicate poor conditions for fish.

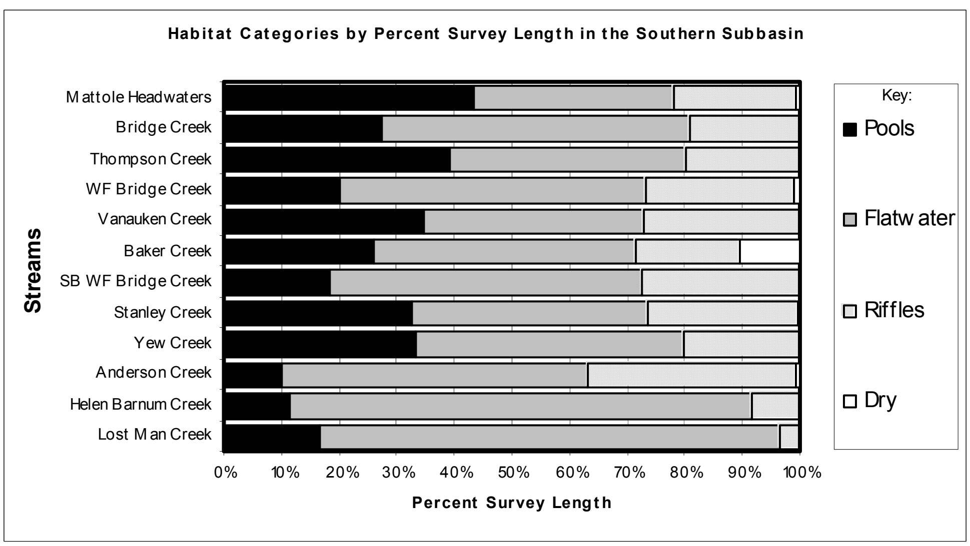


Figure 108. The percentage of pool habitat, flatwater habitat, riffle habitat, and dewatered channel by survey length, Southern Subbasin.

EMDS does not evaluate the ratio of these habitat types, but a balanced proportion is desirable. Streams are listed in descending order by drainage area (largest at the top).

Pool depths were measured during CDFG surveys. The amount of primary pool habitat of sufficient depth to be fully suitable for anadromous salmonids is considered in the EMDS Reach Model. Primary pools are determined by a range of pool depths, depending on the order (size) of the stream. Generally, a reach must have 30 – 55% of its length in primary pools for its stream class to be in the suitable ranges. Generally, larger streams have deeper pools. Deviations from the expected trend in pool depth may indicate streams with more suitable or unsuitable pool depth conditions relative to other streams of that subbasin. Most pools in Southern Subbasin streams are relatively shallow, but the Mattole Headwaters and Stanley Creek stand out as streams with relatively abundant deep pools for their size (Figure 109). The EMDS Reach Model rates several streams as fully suitable and others as fully unsuitable with regard to pool habitat.

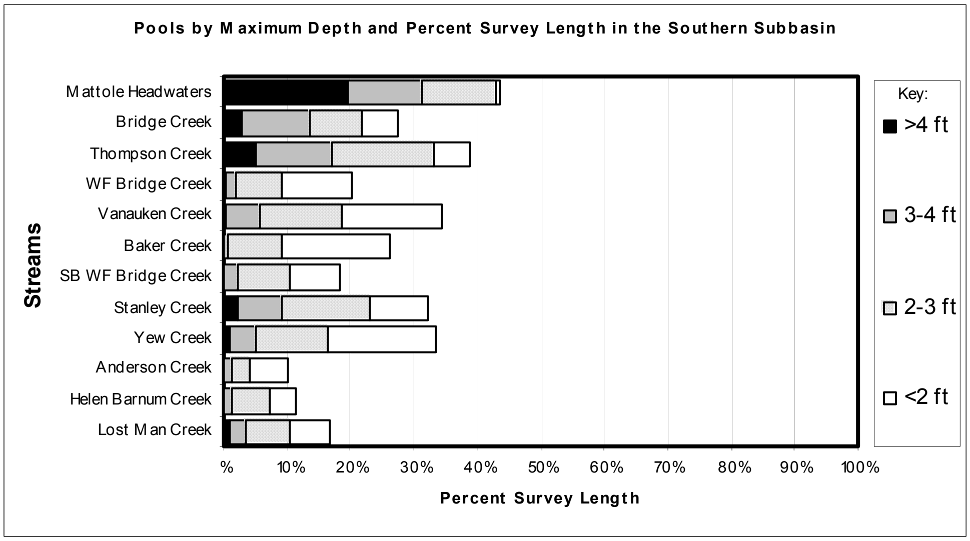


Figure 109. Percent length of a survey composed of deeper, high quality pools, Southern Subbasin.

Values sum to the length of percent pool habitat in Figure 108. As described in the EMDS response curves, a stream must have 30-55% of its length in primary pools to provide stream conditions that are fully suitable for salmonids. Streams with <20 % or >90% of their length in primary pools provide conditions that are fully unsuitable for salmonids. Streams are listed in descending order by drainage area (largest at the top).

Pool shelter was measured during CDFG surveys. Pool shelter rating illustrates relative pool complexity, another component of pool quality. Ratings range from 0-300. The Stream Reach EMDS model evaluates pool shelter to be fully unsuitable if less than a rating of 30. The range from 100 to 300 is fully suitable. Pool shelter ratings in the Southern Subbasin are among the highest in the Mattole Basin, but only the Mattole Headwaters scored above 80 to suggest fully suitable pool habitat complexity and cover (Figure 110).

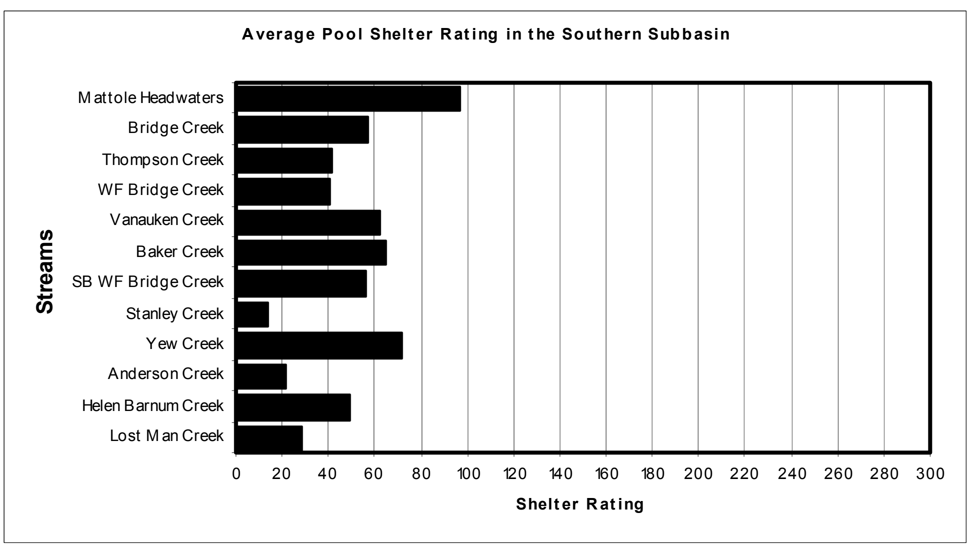


Figure 110. Average pool shelter ratings from CDFG stream surveys, Southern Subbasin.

As described in the EMDS response curves, average pool shelter ratings exceeding 80 are considered fully suitable and average pool shelter ratings less than 30% are fully unsuitable for contributing to shelter that supports salmonids. Streams are listed in descending order by drainage area (largest at the top).

In terms of the fish habitat relationship present in the Southern Subbasin, it appears that habitat ranges from somewhat suitable to somewhat unsuitable for salmonids as evaluated by EMDS. Additionally, data on fish passage barriers and water temperature (two important parameters considered by our assessment but not currently included in the EMDS analysis) shows that there is one temporary and partial salmonid barrier, three partial salmonid barriers, and one total salmonid barrier, and that water temperatures in monitored streams are suitable for salmonids in this subbasin. These suitable summer water temperatures for summer rearing habitat and suitable conditions for canopy cover and cobble embeddedness have helped make the Southern Subbasin one of the most important spawning and rearing areas for salmonids in the Mattole Basin. Recent studies have found coho salmon in seven studied streams and steelhead trout in nine surveyed streams. However, excessive water extraction compromises the quality of late summer salmonid rearing habitat.

Fish Passage Barriers

Stream Crossings

Six stream crossings were surveyed in the Southern Subbasin as a part of the Humboldt and Mendocino County culvert inventories and fish passage evaluations conducted by Ross Taylor and Associates (2000, 2001). Briceland Road has a culvert on Ancestor Creek, and Whitethorn Road has culverts on Baker Creek, Gibson Creek, Harris Creek, Ravasoni Creek (East Anderson Creek), and Stanley Creek. The culvert on Ancestor Creek was found to be a total salmonid barrier and the culverts on Gibson Creek, Harris Creek and Stanley Creek were found to be partial salmonid barriers (Table 115, Taylor, 2000; G. Flosi, personal communication). The culvert on Ravasoni Creek (East Anderson Creek) was found to be a temporary and partial salmonid barrier while the culvert on Baker Creek was not found to be a salmonid barrier. In fact, the culvert in Baker Creek was thought to be the best road crossing observed in Humboldt County in the course of the inventory.

Priority ranking of 26 culverts in Mendocino County for treatment to provide unimpeded salmonid passage to spawning and rearing habitat placed the culvert on Ancestor Creek at rank 3. In a similar list of priority rankings for 67 culverts in Humboldt County, rankings of culverts in the Southern Subbasin ranged from 15 for Stanley Creek to 43 for Baker Creek. Criteria for priority ranking included salmonid species diversity, extent of barrier present, risk of culvert failure, current culvert condition, salmonid habitat quantity, salmonid habitat quality, and a total salmonid habitat score. The culvert on Ravasoni Creek (East Anderson Creek) was improved in 2002, while the culverts on Gibson Creek and Stanley Creek were proposed but are not funded at this time for improvement (G. Flosi, personal communication).

Dry Channel

CDFG stream inventories were conducted for 25.7 miles on 21 reaches of 15 tributaries in the Southern Subbasin. A main component of CDFG Stream Inventory Surveys is habitat typing, in which the amount and location of pools, flatwater, riffles, and dry channel is recorded. Although the habitat typing survey only records the dry channel present at the point in time when the survey was conducted, this measure of dry channel can give an indication of summer passage barriers to juvenile salmonids. Dry channel conditions in the Mattole Basin generally become established from late July through early September. Therefore, CDFG stream surveys conducted outside this period are less likely to encounter dry channel.

Dry channel disrupts the ability of juvenile salmonids to move freely throughout stream systems. Juvenile salmonids need well-connected streams to allow free movement to find food, escape from high water temperatures, escape from predation, and migrate out of their stream of origin. The amount of dry channel reported in surveyed stream reaches in the Southern Subbasin is 1.2% of the total length of streams surveyed. Dry channel was found in four streams (Table 116, Figure 113). Dry habitat units occurred in the middle reaches of two tributaries, and at the upper limit of anadromy in three tributaries. Dry channel in the middle reaches of a stream disrupts the ability of juvenile salmonids to forage and escape predation while dry channel in the upper reaches of a stream indicates the end of anadromy.

Table 115. Culverts surveyed for barrier status in the Southern Subbasin.

Stream Name	Road Name	Priority Rank	Barrier Status	Upstream Habitat	Treatment
Ancestor Creek	Briceland Road	3	Total barrier. A barrier for adult coho and steelhead and all age classes of juveniles.	2.0 miles of good salmonid habitat.	Funded and scheduled for improvement in 2003
Baker Creek	Whitethorn Road	43	Not a barrier. Short of a bridge this was the BEST crossing observed in Humboldt County.	Approximately 1.6 miles of good salmonid habitat.	None proposed at this time
Gibson Creek	Whitethorn Road	19	Partial barrier. The culvert is nearly a complete barrier for adults and a complete barrier to juveniles. An excessive jump (4.9 ft at low flow) is required to enter culvert. Velocities are also excessive due to steep slope and length of pipe.	1.0 to 1.7 miles of potential salmonid habitat.	Proposed but not funded for improvement
Harris Creek	Whitethorn Road	40	Partial barrier. The culvert is not a barrier for adults and a partial barrier to juveniles. For juveniles, an excessive jump is required to enter the culvert.	0.75 to 1.75 miles of potential salmonid habitat.	None proposed at this time
Ravasoni Creek (East Anderson Creek)	Whitethorn Road	20	Temporary and partial barrier. The culvert is a temporary barrier for adults (20-40% passable for coho and 60-80% passable for steelhead) and a total barrier to juveniles. An excessive jump is required to enter the culvert, even for adults. Excessive velocity is caused by steep slope (at inlet, steeper slope along first 20 ft).	1.1 miles of potential salmonid habitat.	Improved in 2002
Stanley Creek	Whitethorn Road	15	Partial barrier. The culvert is probably not a barrier for adults, but a complete barrier to juveniles. For juveniles, an excessive jump is required to enter culvert. Leakage through rusted bottom may be harmful to out-migrating juveniles. Steelhead observed above the culvert, however, coho were only seen below the culvert.	Approximately 1.7 miles of potential salmonid habitat.	Proposed but not funded for improvement

Table 116. Dry channel recorded in stream surveys in the Southern Subbasin.

Stream	Survey Period	# of Dry Units	Dry Unit Length (ft)	% of Survey Dry Channel
Unnamed Tributary to the Mattole River	September	0	0	0
Bridge Creek	June-July	0	0	0
West Fork Bridge Creek	June	1	80	1
South Branch of the West Fork of Bridge Creek	June	0	0	0
Vanauken Creek	June	0	0	0
South Fork Vanauken Creek	June	0	0	0
Anderson Creek	September	3	42	0.8
Mill Creek (RM 56.2)	July	0	0	0
Upper Mattole River	August-September	0	0	0
Stanley Creek	June	1	25	0.5
Baker Creek	August	16	1250	10.6
Thompson Creek	June	0	0	0
Yew Creek	June	0	0	0
Helen Barnum Creek	June	0	0	0
Lost Man Creek	June-July	0	0	0
Lost Man Creek Tributary #1	June-July	0	0	0

In addition to stream inventory data on dry channel, interviews with local residents, newspaper articles, and observations by NCRWQCB, the National Marine Fisheries Service (NMFS), and CDFG have shown that de-watering can be a problem in the Southern Subbasin (Figure 111, Figure 112). An October 2002 article in the southern Humboldt County newspaper The Independent, reports that the Mattole River was reduced to a bare gravel bar with scattered, disconnected pools for 3,000 feet at Shadowbrook Bridge downstream of Whitethorn. Some long-term local residents claimed that Mattole River water levels were the lowest they had ever seen. Causes of the de-watering were attributed to a combination of drought and water use, especially for agricultural operations by Mattole Basin residents.

Figure 111. The Mattole River at Thorn Junction on September 18, 2002.

Figure 112. The Mattole River Headwaters near Mill Creek (RM 56.2) on September 18, 2002.

Figure 113. Mapped dry channels in the Southern Subbasin.

Fish History and Status

Historically, the Southern Subbasin supported runs of Chinook salmon, coho salmon, and steelhead trout. Interviews with local residents indicate that Vanauken Creek and Baker Creek were important salmon producing streams (Coastal Headwaters Association 1982). CDFG stream surveys in the 1960s found steelhead trout in five streams, unidentified salmonids in two streams, and coho salmon in Mill Creek (RM 56.2). Moderate densities of steelhead trout were estimated for Baker Creek (100 per 100 feet of stream) in August 1966.

A study of Mattole Basin salmonids conducted in July and August 1972 (Brown, 1973b) examined five streams and seven stations on the mainstem Mattole River in the Southern Subbasin. Coho salmon were found in Harris Creek, Baker Creek, Thompson Creek, and the Mattole River one mile upstream from Baker Creek. Steelhead trout densities of over 100 fish per 100 feet of stream were found in Vanauken

Creek, the Mattole River 100 yards downstream from Bridge Creek, and the Mattole River 0.5 miles upstream from Thompson Creek.

BLM, Coastal Headwaters Association, MSG, and CDFG stream surveys have continued to document the presence of steelhead trout in most streams in the Southern Subbasin. A BLM survey of Anderson Creek in 1977 found juvenile steelhead trout. Coastal Headwaters Association surveys in 1981 and 1982 found steelhead trout in Bridge Creek, Mill Creek (RM 56.2), Harris Creek, Gibson Creek, Stanley Creek, Baker Creek, and Thompson Creek. MSG carcass surveys found steelhead trout in Thompson Creek in December 2000 and January 2001. CDFG surveys found steelhead trout in Bridge Creek, Vanauken Creek, and Baker Creek in the 1980s and nine streams in the 1990s.

Unidentified salmonids were found in Bridge Creek in July 1972 and Baker Creek in July 1977 by BLM. These could have been coho salmon. In addition, coho salmon were detected in Bridge Creek, Anderson Creek, Thompson Creek, Yew Creek, and Stanley Creek in 1990s CDFG stream surveys and in Yew Creek in 1995 by the Redwood Sciences Lab. MSG carcass surveys found coho salmon in Baker Creek, Thompson Creek, Danny's Creek, and Yew Creek in the late 1990s and early 2000s. CDFG electrofishing in the 1990s also found coho salmon in Baker Creek, Thompson Creek, and Yew Creek. A 1997-99 Redwood Sciences Laboratory study of juvenile coho salmon distributions in relation to water temperatures in the Mattole Basin (Welsh et al. 2001) found coho salmon in Baker Creek, Lost Man Creek, the headwaters of the Mattole River, Yew Creek, Thompson Creek, and Bridge Creek. The 2001 CDFG Coho Inventory found coho salmon in Mill Creek (RM 56.2), Baker Creek, Thompson Creek, Yew Creek, and the upper mainstem Mattole River.

This subbasin has the highest fish productivity in the Mattole Basin. The Mattole Salmon Group has operated cooperative hatcheries with the CDFG since 1981 in the Mattole Basin, and much of that effort has been located in the Southern Subbasin. The Mattole Salmon Group traps native Chinook and coho, and has released 338,000 Chinook salmon and 52,550 coho salmon fingerlings and yearlings during the period of operation. More detailed summaries of stream surveys and fisheries studies in the Southern Subbasin are provided in the CDFG Appendix F.

Southern Subbasin Issues

- Human land use in this subbasin is impacting the best remaining fish habitat in the Mattole Basin; the most severe current impacts is from water extraction.
- Continuing inputs of fine sediment remain a problem in this subbasin.
- The use of herbicides on industrial timberlands is of concern for both human health and water quality reasons.
- The likelihood of catastrophic fire, based upon high fuel load and relatively dense human habitation, is high in this subbasin.
- The lack of road related erosion assessments and treatments are of concern in this subbasin.
- There is little of available data on pH, dissolved oxygen, nutrients, and other water chemistry parameters.

Southern Subbasin Integrated Analysis

The following tables provide a dynamic, spatial picture of watershed conditions for the freshwater lifestages salmon and steelhead. The tables' fields are organized to show the extent of watershed factors' conditions and their importance of function in the overall watershed dynamic. Finally a comment is presented on the impact or condition affected by the factor on the watershed, stream, or fishery. Especially at the tributary and subbasin levels, the dynamic, spatial nature of these processes provides a synthesis of the watershed conditions and indicates the quantity and quality of the freshwater habitat for salmon and steelhead.

Geology

Introduction

The potential for sediment production is strongly influenced by the underlying geology. The following IA tables compiled by CGS examine the influence of geology on sediment production by comparing the distribution of geomorphic terrains (hard, moderate, and soft bedrock terrains, and the separately grouped Quaternary surficial deposits) against the observation of landslides and geomorphic features related to mass wasting within the subbasin. The first table presents the proportions of the subbasin underlain by each of the terrains. The next table looks at hillside gradient within the subbasin. The distribution of historically active landslides, gullies, and inner gorges by terrain are then considered. Finally, the landslide potential map developed by CGS is examined with respect to the terrains.

Table 117. Geomorphic terrains as a proportion of the Southern Subbasin.

Proportion of Southern Subbasin Basin Underlain by the Different Geomorphic Terrains				
Feature/Function			Significance	Comments
Terrain Type	Proportion of Subbasin Area	Terrain Area within Subbasin as a Proportion of Mattole Basin Area	The geomorphic terrains represent groupings of geologic map units based on similarities in geology, geomorphic expression, and landslide occurrence. They provide a simplified division of the watershed useful in comparing the influence of bedrock geology to the distribution of other mapped features.	Hillside areas in this subbasin are underlain almost entirely by hard terrain. Debris sliding on steep slopes and along inner gorges is the predominant mechanism of recent slope instability in the subbasin.
Hard	86%	8%		
Moderate	1%	<1%		
Soft	0%	0%		
Quaternary[1]	13%	1%		

1 Areas where young (Quaternary) surficial units have been mapped covering bedrock; includes alluvium, as well as terrace deposits, active stream channel deposits, and other alluvial deposits.

Table 118. Hillside gradient in the Southern Subbasin.

Hillside Gradient in the Southern Subbasin							
Feature/Function						Significance	Comments
Proportion of Subbasin Area						Hillside slope is an important indicator of potential instability (steeper is generally less stable). The terrain type influences the degree to which hillside slope affects the slope stability.	The majority of the subbasin is underlain by moderately steep to very steep slopes. However, more stable hard terrain is present in almost all hillside areas of this subbasin.
Range in % slope							
0-10	10-30	30-40	40-50	50-65	>65		
7	18	15	19	24	17		

Table 119. Small historically-active landslides by terrain in the Southern Subbasin.

Distribution of Small Historically-Active Landslides by Geomorphic Terrain in the Southern Subbasin				
Feature/Function			Significance	Comments
Terrain Type	Small Point Landslides1 Mapped from year 19812, 1984, or 2000 Photographs		The relative number of small point slides is used to evaluate which geomorphic terrains are more prone to small, localized slope failures.	Nearly all point slides in this subbasin have occurred in hard terrain. The density of point slides is roughly half that found in the other subbasins, excluding the estuary.
	Point Count	**Area3 (acres)**		
Hard	**269**	**27**		
Moderate	**3**	**<1**		
Soft	**0**	**0**		
Quaternary	**3**	**<1**		

1 Mapping was compiled at a 1:24,000 scale. Landslides smaller than approximately 100 feet in diameter were captured as points in the GIS database; larger features were captured as polygons.
2Landslides included from year 1981 photographs are from previous mapping by Spittler (1983 and 1984) covering limited portions of the Mattole Basin.
3 Based on assumed average area of 400 square meters (roughly 1/10th acre) for small landslides.

Table 120. All historically-active landslides by terrain in the Southern Subbasin.

Distribution of All Historically-Active Landslides by Terrain in the Southern Subbasin				
Feature/Function			Significance	Comments
Terrain Type	Combined Area (acres) of All Historically-Active Landslides1	Proportion of Total Active Landslide Area within Subbasin	The relative percentage of area covered by historically-active slides identifies which geomorphic terrains are most prone to relatively large-scale slope failures.	Larger, historically-active landslides are relatively rare in this subbasin, accounting for less than 1% of the total area occupied by active landslide in the Mattole Basin.
Hard	50	94%		
Moderate	2	4%		
Soft	0	0%		
Quaternary	1	2%		
1 Includes small point and larger polygon features mapped from year 1981, 1984 and 2000 photos. Where landslides overlapped (i.e., the same or similar features mapped from more than one photo set) the area of overlap was counted only once. Small landslides captured as points in the GIS database were assumed to have an average area of 400 square meters (roughly 1/10th acre).				

Table 121. Gullies and inner gorges by terrain in the Southern Subbasin.

Distribution of Gullies and Inner Gorges by Terrain in the Southern Subbasin				
Feature/Function			Significance	Comments
Terrain Type	Proportion of Total Mapped Gully Lengths[1] in Subbasin	Proportion of Total Mapped Inner Gorge Lengths[1] in Subbasin	Gullies and inner gorges are an important indicator of ongoing sources of sediment to the fluvial system.	Gullies were not observed in this subbasin, presumably because of the lack of soft terrain. Inner gorges are present at levels proportional to the subbasin's areal extant of hard terrain when compared against areas of hard terrain throughout the watershed.
Hard	0%	98%		
Moderate	0%	<1%		
Soft	0%	0%		
Quaternary	0%	2%		
1 Includes only those features mapped from year 2000 photographs.				

Table 122. Landslide potential by terrain in the Southern Subbasin area.

Distribution of Landslide Potential Categories by Terrain as a proportion of the Southern Subbasin Area							
Feature/Function						Significance	Comments
Terrain Type	Landslide Potential Category1					Categories 4 and 5 represent the majority of unstable areas that are current or potential future sources of sediment.	Because of the relatively small size of the subbasin and prevalence of hard terrain, the Southern Subbasin has the lowest proportion of area in LPM Category 4 and 5 of all the Mattole subbasins. Portions of the subbasin that lie within the designated unstable.
	1	2	3	4	5		
Hard	0.6%	17.5%	44.7%	9.6%	13.9%		
Moderate	0.0%	0.1%	0.5%	0.1%	0.1%		
Soft	0.0%	0.0%	0.0%	0.0%	0.0%		
Quaternary	5.1%	5.9%	1.6%	0.1%	0.3%		
Subbasin Total2	5.7%	23.5%	46.8%	9.8%	14.3%		
1 Categories represent ranges in estimated landslide potential, from very low (category 1) to very high (category 5); see Geologic Report, Plate 2. 2 Percentages are rounded to nearest 1/10 %; sum of rounded values may not equal 100%.							

Discussion

The Southern Subbasin has the most uniform and stable geologic conditions in the watershed with nearly all hillside areas underlain by hard terrain. Correspondingly, the Southern Subbasin has the lowest density of landslides and no mapped gullies. Nearly all of the historically active landslides mapped in the subbasin are small debris slides on steep slopes and along inner gorges.

Vegetation and Land Use

Introduction

CDF NCWAP developed a number of tables that are intended to help identify and highlight how current patterns of vegetation and land use are expressed in relation to the geology of the watershed. First, vegetation and land use are related to the underlying bedrock geology or terrain type. These patterns are then explored by examining the current vegetation and recent timber harvesting in relation to their occurrence in landslide potential classes, the product of a model that uses terrain type, vegetation, and landslides as variables. Landslide causality was not assigned and recent timber harvest activity has occurred in low percentages in most of the planning watersheds. The significance of the geologic characteristics in these tables is expressed as a relative rating and is not characterized numerically.

Table 123. Vegetation types associated with terrain types in the Southern Subbasin.

Vegetative Condition in the Southern Subbasin								
Feature/Function							Significance	Comments
Terrain Type	Vegetation Type						The differences between the slope, soils, and stability of the geologic terrain results in a different mosaic of vegetation in each of these areas. The combination of the geologic and vegetative conditions between the terrain results in some differences in land use and sensitivity to impacts from land use.	Unlike the other subbasins, there is no soft terrain in the Southern Subbasin. Tree type vegetation predominates and this subbasin includes the redwood forest type, primarily along the streams and lower slopes. Potential timber harvesting impacts may be highest in inner gorges and steep slopes.
	Conifer	Mixed	Hardwood	Grassland	Other	Total		
Hard	4%	76%	19%	1%	<1%	100%		
Moderate	4%	91%	2%	3%	0%	100%		
Soft	0%	0%	0%	0%	0%	100%		
Quaternary	7%	69%	6%	18%	<10%	100%		

Table 124. Riparian vegetation (within 150 feet of streams) types associated with terrain types in the Southern Subbasin.

Riparian Vegetative Condition in the Southern Subbasin									
Feature/Function								Significance	Comments
Terrain Type	Riparian Vegetation Type							The differences between the slope, soils, and stability of the geologic terrain results in a different mosaic of vegetation in each of these areas. The combination of the geologic and vegetative conditions between the terrain results in some differences in land use and sensitivity to impacts from land use. The riparian vegetation in this zone is the primary source of large woody debris. The species and size of large woody debris provided to the stream system over time is at least partially dependent upon the inherent slope stability of the underlying terrain type.	This subbasin has the highest percentage of tree vegetation in the riparian zone of any of the subbasins. However, the Southern Subbasin also has the greatest amount of roads within 200 feet of the streams of the basin, potentially reducing the effectiveness of the riparian zone in recruiting and retaining large woody debris.
	Conifer	Mixed	Hardwood	Grassland	Barren	Other	Total		
Hard	7%	78%	14%	1%	<1%	<1%	100%		
Moderate	5%	90%	0%	5%	0%	0%	100%		
Soft	0%	0%	0%	0%	0%	0%	100%		
Quaternary	7%	83%	7%	3%	0%	<1%	100%		

Table 125. Land use associated with terrain types in the Southern Subbasin.

Land Use in the Southern Subbasin						
Feature/Function					Significance	Comments
Terrain Type	Landuse Type					
	Public	Ag/Timber	Other	Total		
Hard	65%	26%	9%	100%	Public land, primarily State Parks, occupy about 16% of the Southern Subbasin. Eighty-four percent of the subbasin is about evenly divided between lands zoned for agriculture and timber and the other category of land use parcels. The other category often includes housing and contains many parcels 160 acres or less in size.	Historic logging occurred across all ownership types, leaving a legacy of young vegetation and dirt-surfaced roads. Timber harvesting is the primary economic use of the natural resources since the limited amount of grassland acreage does not provide for large scale livestock production. Many of the current owners simply live on their property and do not derive substantial economic benefits from the land. Despite this, many residents are interested in restoration work if funding and assistance is provided. Sanctuary Forest, Inc., a local non-profit land trust organization, is an active participant and coordinator of restoration projects.
Moderate	43%	43%	14%	100%		
Soft	12%	74%	14%	100%		
Quaternary	10%	58%	32%	100%		

Table 126. Road mileage and density associated with terrain types in the Southern Subbasin.

Roads in the Southern Subbasin				
Feature/Function			Significance	Comments
Terrain Type	Miles (of road)	Road Density (miles per sq. mile)	Roads crossings on steep slopes in hard and moderate terrain may increase the potential for debris slides while roads within the soft terrain may increase the potential for small earthflows, gullies, and erosion. The alluvium terrain type tends to be relatively flat, but proximity to watercourses may allow for direct delivery of sediment from the roads to the streams.	While current practices locate roads on less environmentally sensitive locations, typically gentle ground high on the hillslope, the presence of soft terrain in these areas should be considered. A large, but not quantified portion of the road mileage was constructed for logging purposes between about 1945 and 1974. While many of these roads are no longer in use, others are used as residential access roads. Road managers should be aware that debris slides are the primary slide type in this subbasin.
Hard	144	5.6		
Moderate	2	9.0		
Soft	0	0.0		
Quaternary	33	16.5		
Total	144	5.6		

Table 127. Data summary table for the Southern Subbasin.

Factor	Southern Subbasin	
Timber Harvest 1990 -2000¹	**Acres**	**% Area**
Silviculture Category 1		
Tractor	**435**	**2.5%**
Cable	**827**	**4.7%**
Helicopter	**0**	**0.0%**
TOTAL	**1,262**	**7.2%**
Silviculture Category 2		
Tractor	**395**	**2.2%**
Cable	**237**	**1.3%**
Helicopter	**0**	**0.0%**
TOTAL	**633**	**3.6%**
Silviculture Category 3		
Tractor	**149**	**0.8%**
Cable	**31**	**0.2%**
Helicopter	**0**	**0.0%**
TOTAL	**180**	**1.0%**
TOTAL	**2,075**	**11.8%**
Other Land Uses	**Acres**	**% Area**
Grazing	**56**	**0.3%**
Agriculture	**0**	**0.0%**
Development	**0**	**0.0%**
Timberland, No Recent Harvest	**15,201**	**86.4%**
TOTAL	**15,257**	**86.7%**
Roads		
Road Density (miles/sq. mile)	**6.4**	
Density of Road Crossings (#/stream mile)	**1.9**	
Roads within 200 feet of Stream (miles/stream mile)	**0.4**	
Silvicultural Category 1 includes even-aged regeneration prescriptions: clear-cut, rehabilitation, seed tree step, and shelter wood seed step prescriptions. Category 2 includes prescriptions that remove most of the largest trees: shelter wood prep step, shelter wood removal step, and alternative prescriptions. Category 3 includes prescriptions that leave large amounts of vegetation after harvest: selection, commercial thin, sanitation salvage, transition, and seed tree removal step prescriptions.		

Table 128. Land use and vegetation type associated with historically active landslides in the Southern Subbasin.

Historically Active Landslide Feature1	Southern Subbasin	Woodland and Grassland2	THPs 1990 - 20005	Timberland, No Recent Harvest3	Roads4	
	% of Area	**% of Area**	**% of Area**	**% of Area**	**Length (miles)**	**% of Total Length**
Earthflow	0.0%					
Rock Slide	0.0%					
Debris Slide	0.1%	0.0%	0.0%	0.1%	0.3	0.2%
Debris Flow	0.0%		0.0%			
All Features	**0.1%**	**0.0%**	**0.0%**	**0.1%**	**0.3**	**0.2%**
Historically active slides within the Southern Subbasin total about 0.1% of the acreage. All are debris slides. This is the lowest percentage of slide area in the Mattole watershed. Because of this low percentage, when Southern Subbasin point slides are included, the percentage doubles to two tenths of one percent. All of the point slides are also debris slides.						

1 This category includes only large polygon slides and does not include point slides.
2 Woodland and grassland includes areas mapped in 1998 as grassland and non-productive hardwood.
3 Area of timberlands that were not contained in a THP during the 1991 to 2000 period.
4 Roads layer is from the Information Center for the Environment (ICE) at UC Davis.
5 THP's are complete or active between the 1990 and 2000 timeframe.
Empty cells denote zero.
Percent of area is based on the unit of analysis: Watershed, subbasin, or planning watershed.

Table 129. Land use and vegetation type associated with relative landslide potential in the Southern Subbasin.

Relative Landslide Potential1	Southern Subbasin	Woodland or Grassland2	THPs 1990 - 20005	Timberland, No Recent Harvest3	Roads4	
	% of Area	% of Area	% of Area	% of Area	Length (miles)	% of Total Length
Very Low	5.7%	1.0%	0.5%	4.2%	14.4	8.1%
Low	23.5%	0.7%	3.7%	18.9%	44.6	25.2%
Moderate	46.8%	0.0%	5.6%	41.0%	84.2	47.6%
High	9.8%	0.0%	1.1%	8.6%	13.5	7.6%
Very High	14.3%	0.0%	0.9%	13.4%	19.9	11.2%
TOTAL	**100%**	**2%**	**12%**	**86%**	**176.6**	**100%**
In the Southern Subbasin, 2% of the area is in the woodland/ grassland vegetation type. None of the acreage for this category is found in the two highest relative landslide potential categories. Recent THPs in 1991-2000 covered 12% of the subbasin and only 1.9% of the harvest acres were in the two highest relative landslide potential categories. About 86% of the subbasin is characterized as timberland with no recent harvest. Twenty-two percent of this area is concentrated in the two highest relative landslide potential classes. The subbasin has about 177 miles of roads, with the proportion of road length in relative landslide potential categories similar to the percentage of total acres in each class, although there is a slight shift towards lower relative landslide potential classes.						

1 Refer to Plate 2 and California Geological Survey appendix.
2 Woodland and grassland include areas mapped in 1998 as grassland and non-productive hardwood.
3 Area of timberlands that were not contained in a THP during the 1991 to 2000 period.
4 Roads layer is from the Information Center for the Environment (ICE) at UC Davis.
5 THP's are complete or active between the 1990 and 2000 timeframe.
Percent of area is based on the unit of analysis: Watershed, subbasin, or planning watershed.

Discussion

The Southern Subbasin consists almost entirely of hard terrain and the amount of unstable and potentially land is significantly less when compared to the other subbasins. It contains the lowest percentage of acreage (24%) in the two highest relative landslide potential categories, in historically active landslides (<1%), and in dormant landslide features (2%). Total THP activity between 1990 and 2000 occupied about 12% of the Southern Subbasin. Seventeen percent of the harvested acres were in the high and very high relative landslide potential categories, of these acres, about 60% were harvested in Category 1 even-aged regeneration silvicultural systems, and 47% were tractor logged. Of the harvest acres in the high or very high relative landslide potential classes, about sixty percent were harvested using even-aged regeneration silvicultural systems and forty-seven percent were tractor logged. Since about 1994, THP plan submitters have implemented the zero net discharge requirement for timber harvesting plans in the Mattole watershed, mostly by improving roads owned by the THP landowner. This subbasin has a large number of road stream crossings, roads near streams, and overall number of miles of road per square mile of area. These roads, many accessing residential areas, are often outside the current regulatory process and most likely provide a chronic source of sediment to the Mattole River. Education and economic incentives for road improvements provide the greatest opportunities for near-term benefits for fisheries.

Fluvial Geomorphology

Introduction

Fluvial geomorphic mapping of channel characteristics was conducted along blue line streams in the Mattole Basin to document channel characteristics that are indicative of excess sediment production, transport, and/or response (deposition); these features are referred to as negative mapped channel characteristics (NMCCs). The following CGS Integrated Analysis (IA) Tables present some of the findings of this investigation. To understand the distribution of these NMCC's we present: the predominant NMCC's identified; the relative distribution of these features between the bedrock terrains and the Quaternary units; the changes in amount and distribution of NMCC's observed between 1984 and 2000; and the relationship between areas of projected slope instability and portions of streams with evidence of excess sediment.

Table 130. Negative mapped channel characteristics in the Southern Subbasin.

Negative Mapped Channel Characteristics in the Southern Subbasin						
Feature/Function					**Significance**	**Comments**
		From 1984 Photos	**From 2000 Photos**	**%4 Change 1984 to 2000**	The reduction in the total length of NMCC's over time qualitatively reflects the degree of improvements within the blue line streams. These NMCC's were chosen to be highlighted in these figures because in both photo years, the NMCC's observed were dominated by wide channels and, secondarily, by displaced riparian vegetation. Most of this observed improvement results from reductions in the proportion of streams affected by displaced riparian vegetation and wide channels.	Significant reductions in the occurrence of wide channels mapped as a primary or secondary features has occurred from 1984 to 2000.
Blue Line Streams where Wide Channel (wc) Observed		See Figure 34**Error! Reference source not found.**				
Blue Line Streams where Displaced Riparian Vegetation (dr) Observed		See Figure 35**Error! Reference source not found.**				Those portions of the fluvial system observed to be affected by displaced riparian vegetation, mapped as primary or secondary features in 1984 had recovered extensively by 2000.
% of the all Blue Line Stream Segments in Basin affected by NMCC's	**Total**	20%	2%	-18%	These values identify how much of the streams have been affected by NMCC's. Decreases in the length of stream affected by NMCC's quantitatively represent the degree of improvement within blue line stream reaches.	The fluvial system in the bedrock terrains has experienced significant improvements between 1984 and 2000, but still remains minimally impacted by NMCC's. Some minor improvements in NMCC's in the alluvial areas was observed..
	Bedrock	45%	5%	-40%		
	Alluvium	1%	<1%	<1%		
Percentage of all Blue Line Stream segments in bedrock that are adjacent to or within LPM Categories 4 and 53, and affected by NMCC's		64%	7%	-57%	The magnitude of decrease in affected streams quantitatively represents the degree of improvement within bedrock stream reaches adjacent to unstable areas. Because the streams in the Quaternary units are commonly separated from the surrounding hillsides by alluvial terraces and floodplains, the NMCCs observed there do not directly result from input into the streams from landslides that occur on the surrounding hillsides. Therefore, NMCC's in alluvial areas have been interpreted as having been transported from upstream bedrock reaches. For this reason, the analysis of NMCC's vs. LPM 4 and 5 excludes the NMCC's identified in the Quaternary units and only describes the relationship between these two features as it applies to the bedrock reaches.	The percentage of blue line streams in this subbasin affected by NMCC's has decreased significantly and the residual level of impact by NMCC's is relatively low.

Negative Mapped Channel Characteristics in the Southern Subbasin (Continued)					
Feature/Function				Significance	Comments
	From 1984 Photos	From 2000 Photos	%[4] Change 1984 to 2000		
Percent of total NMCC length in bedrock, within 150 feet of LPM Categories 4 and 5[2]	98%	100%	+2%	Percentage reflects likelihood that the presence of NMCC's in bedrock are related to LPM categories 4 and 5 and that these unstable areas represent current and future potential sources of sediment to streams.	Virtually all of the total NMCC's observed in bedrock terrains were found on blue line streams adjacent to or within LPM categories 4 and 5. Therefore, we interpret a clear relationship between areas of projected slope instability and portions of streams with negative sediment impacts, and that some portion of hillsides with high landslide potential are delivering sediment to the adjacent streams.

1 Include all areas identified as hard, moderate or soft geomorphic terrain.
2 Areas where young (Quaternary) surficial units have been mapped covering bedrock; includes alluvium, as well as terrace deposits, active stream channel deposits, and other alluvial deposits.
3 Landslide Potential Map developed by CGS for the Mattole Basin; see California Geologic Survey Report, Appendix A and Plate 2.
4 Percentages are rounded to nearest 1%; sum of rounded values may not equal rounded totals or 100%.

Discussion

The results of our fluvial geomorphic mapping of channel characteristics that may indicate excess sediment accumulations (NMCC's) can be summarized as follows.

- Changes in the distribution of NMCC's between 1984 and 2000 show different patterns in the bedrock and Quaternary unit reaches.
- Channel conditions in bedrock streams have generally improved between 1984 and 2000.
- In both 1984 and 2000, only small portions of the blue line stream channels within Quaternary units were observed to be affected by NMCC's, and this portion has decreased between 1984 and 2000.
- Virtually all of the NMCC's in bedrock terrains were identified along portions of the streams that are near potentially unstable slopes and the total length of NMCC's in these areas has decreased between 1984 and 2000. Therefore, we conclude that portions, but not all, of the hillslopes in the high to very high landslide potential categories are delivering sediment to the adjacent streams.

Water Quality

Introduction

There is a fairly complete record of water quality information, mostly temperature, for the Southern Subbasin due largely, in part, to more widespread accessibility to subbasin watercourses. For example, thermograph data is largely represented for the subbasin and many of its streams. Thermal imaging did take place in the headwater reaches of the subbasin but are discussed in the Estuary-Mainstem Subbasin. Sediment records were available for both V* and D50 (pebble counts) in a number of watercourses. Except for a single day sampling event conducted by the Regional Water Board in the Mattole mainstem upstream from McKee Creek during October, 2002, there appeared to be no other physical-chemical data available in this subbasin.

Table 131. Southern Subbasin water quality integrated analysis table.

Feature/Function		Significance	Comments
Sediment			
Tributary	**Date V***	V* measures the percent sediment filling of a streams pool, compared to the total pool volume. Pools with lower V* values are thought to provide suitable salmonid habitat and may also indicate relatively low watershed disturbances. The V* ranges, below, derived from Knopp, 1993, are meant as reference markers and should not be construed as regulatory targets: V* ≤ 0.30 = low pool filling; correlates well with low upslope disturbance V* > 0.30 and ≤ 0.40 = moderate pool filling; correlates well with moderate upslope disturbance V* > 0.40 = High (excessive) rates of pool filling; correlates well with high upslope disturbance	
Baker Creek	1992 0.51		V* = 0.51indicates excessive pool filling with fine sediment.
Bridge Creek	2001 0.04		V* = 0.04indicates little, if any, pool filling with fine sediment.
Mill Creek	1992 0.24		V* = 0.24indicates excessive pool filling with fine sediment.
Yew Creek	1992 0.45		Indicates excessive pool filling with fine sediment.
Tributary	**Date D50 (mm)**	D50 means that 50 percent of the particles, measured in millimeters, on a riffle are smaller, and 50 percent are larger than the reported value. It is a simple and rapid stream assessment method that may help in determining if land use activities or natural land disturbances are introducing fine sediment into streams. In those Northern California basins with TMDLs where D50s are, or are considered for use as a numeric target, a mean D50 of > 69 mm, and minimum D50 > 37mm are desired future conditions over a specified time interval. Only the Garcia River TMDL has formally adopted these numeric targets and, for the Mattole River, are used as reference points only.	
Ancestor Creek	16		
Baker Creek	2001 / 1992 23 / 29		Both multi-year results indicates transport and deposition of very small particles on riffles
Bridge Creek	2001 65		D50 of 65 mm indicates medium surface particle size transport and deposition.
Helen Barnum Creek	2001 14		D50 = 14 mm indicates transport and deposition of very small particles on riffles
Lost River Creek	2001 16		D50 = 16 mm indicates transport and deposition of very small particles on riffles
Mill Creek	2001 52		D50 = 52 mm indicates transport and deposition of medium sized particles on riffles
Thompson Creek	2001 37		D50 = 37 mm indicates transport and deposition of marginally small to medium sized particles on riffles
Vanauken Creek	2001 26		D50 = 26 mm indicates transport and deposition of small particles on riffles
Yew Creek	2001 / 1992 39 / 47		Both D50 values indicates transport and deposition of medium sized particles on riffles

Feature/Function	Significance	Comments
Water Chemistry and Quality		
pH/Dissolved Oxygen/Conductivity: No data available	Measure of ionic and dissolved constituents in aquatic systems; correlates well with salinity. Quantity/quality of dissolved solids-ions can determine abundance, variety, and distribution of plant/animals in aquatic environments. Osmoregulation efficiency largely dependent on salinity gradients. Estuary salinity essential to outmigrant smoltification.	
Chemistry/Nutrients No data available	Quality and quantity of natural and introduced chemical and nutrient constituents in the aquatic environment, can be toxic, beneficial, or neutral to organisms (whether terrestrial or aquatic), and their various life phases. Chemical composition, in part, influenced by rainfall, erosion and sedimentation (parent bedrock, overlying soils), solution, evaporation, and introduction of chemicals/nutrients through human and animal interactions.	

References: Knopp, 1993; Mattole Salmon Group, 1996-200; PALCO, 2001; NCRWQCB Appendix E; Watershed Sciences, 2002.

Discussion

Collectively, temperature data show that the Southern Subbasin is mostly suitable for both MWATs and maximum temperature standards. MWATs show more ambiguity for conditions suitable to salmonids than do maximum temperatures records, where all of the streams and their associated records are fully suitable. Temperature results largely reflect overall habitat and geological conditions documented by CDFG and CGS, whose results generally show more sheltered streams located in narrow valleys and canyons, respectively, which provide a greater degree of solar protection to subbasin streams. Both V* and D50 results for all sampled years have mixed results. As shown, Bridge Creek in 2000 had a V* = 0.04, reflective of almost no fine sediment deposits in its pools. In contrast, both Baker and Yew Creeks during 1992 had pools that were approximately half filled with fine sediment. D50 results largely agreed with V* data in the same streams where both types of sampling took place with sites having higher V* (more pool filling) also with lower D50 values, indicative of smaller particle size transport and deposition.

There was no long term trend monitoring of physical-chemical data available for the Southern Subbasin. However, a single day sampling event on October 29, 2002, by the NCRWQCB, assisted by the CDFG, and the MSG at eleven sample points along the Mattole mainstem in the Southern Subbasin found dissolved oxygen levels at ten points that were below 7.5 mg/l, the lower threshold considered protective of salmonids in the Basin Plan. One location had a dissolved oxygen result that was 0.2 mg/l, a level that could be considered anoxic. Of the eleven sampling points only one had a dissolved oxygen level over 7.5 mg/l. During the sampling event, which took place from McKee Creek to the headwaters, the Mattole mainstem was mostly a series of disconnected pools with little or no surface flow between them. There is anecdotal information that unauthorized water withdrawals are dewatering area streams to the detriment of instream biological habitat, but it could not be determined if that was the situation on October 29, 2002.

Instream Habitat

Introduction

The products and effects of the watershed delivery processes examined in the geology, land use, fluvial geomorphology, and water quality Integrated Analyses tables are expressed in the stream habitats encountered by the organisms of the aquatic riparian community, including salmon and steelhead. Several key aspects of salmonid habitat in the Mattole Basin are presented in the CDFG Instream Habitat Integrated Analysis. Data in this discussion are not sorted into the geologic terrain types since the channel and stream conditions are not necessarily exclusively linked to their immediate surrounding terrain, but may in fact be both spatially and temporally distanced from the sites of the processes and disturbance events that have been blended together over time to create the channel and stream's present conditions. Instream habitat data presented here were compiled from CDFG stream inventories of 15 tributaries and the headwaters of the Mattole River from 1991 to 2002, published research conducted in the Mattole estuary by HSU, the MRC, and MSG in the 1980s and 1990s, and fish passage barrier evaluation reports conducted under contract to CDFG from 1998-2000. Details of these reports are presented in the CDFG Appendix F.

Pool Quantity and Quality

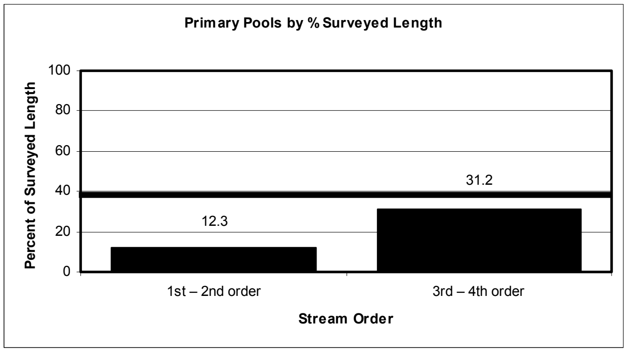


Figure 114. Primary pools in the Southern Subbasin

Pools greater than 2.5 feet deep in 1st and 2nd order streams and greater than 3 feet deep in 3rd and 4th order streams are considered primary pools.

Significance: Primary pools provide escape cover from high velocity flows, hiding areas from predators, and ambush sites for taking prey. Pools are also important juvenile rearing areas. Generally, a stream reach should have 30 – 55% of its length in primary pools to be suitable for salmonids.

Comments: The percent of primary pools by length in the Southern Subbasin is generally below target values for salmonids in lower order streams and appears to be suitable in higher order streams. This subbasin has the highest percent of primary pools in surveyed streams of any of the Mattole subbasins.

Spawning Gravel Quality

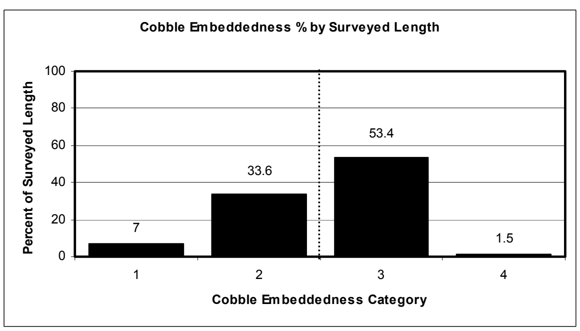


Figure 115. Cobble embeddedness in the Southern Subbasin

Cobble Embeddedness will not always sum to 100% because Category 5 (not suitable for spawning) is not included.

Significance: Salmonids cannot successfully reproduce when forced to spawn in streambeds with excessive silt, clays, and other fine sediment. Cobble embeddedness is the percentage of an average sized cobble piece at a pool tail out that is embedded in fine substrate. Category 1 is 0-25% embedded, category 2 is 26-50% embedded, category 3 is 51-75% embedded, and category 4 is 76-100% embedded. Cobble embeddedness categories 3 and 4 are not within the fully supported range for successful use by salmonids.

Comments: More than one half of the surveyed stream lengths within the Southern Subbasin have cobble embeddedness in excess of 50% in categories 3 and 4, which does not meet spawning gravel target values for salmonids.

Shade Canopy

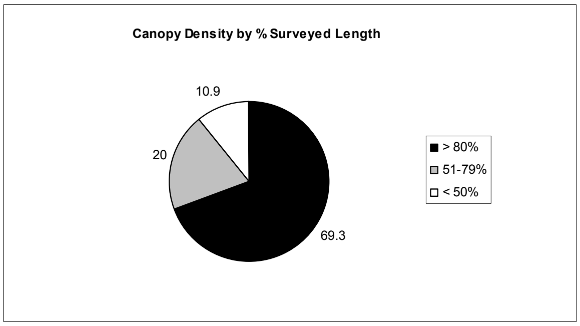


Figure 116. Canopy density in the Southern Subbasin.

Significance: Near-stream forest density and composition contribute to microclimate conditions that help regulate air temperature, which is an important factor in determining stream water temperature. Stream water temperature can be an important limiting factor of salmonids. Generally, canopy density less than 50% by survey length is below target values and greater than 85% fully meets target values.

Comments: More than one half of the surveyed stream lengths within the Southern Subbasin have canopy densities greater than 50% and almost 70% of the surveyed lengths have canopy densities greater than 80%. This is above the canopy density target values for salmonids. This subbasin has the highest percent canopy density in surveyed streams of any of the Mattole subbasins.

Fish Passage

*Table 132. Salmonid habitat artificially obstructed for fish passage.**

Feature/Function		Significance	Comments
Type of Barrier	**% of Estimated Historic Coho Salmon Habitat Currently Inaccessible Due to Artificial Passage Barriers**	Free movement in well-connected streams allows salmonids to find food, escape from high water temperatures, escape from predation, and migrate to and from their stream of origin as juveniles and adults. Dry or intermittent channels can impede free passage for salmonids; temporary or permanent dams, poorly constructed road crossings, landslides, debris jams, or other natural and/or man-caused channel disturbances can also disrupt stream connectivity. Partial barriers exclude certain species and lifestages from portions of a watershed and temporary barriers delay salmonid movement beyond the barrier for some period of time. Total barriers exclude all species from portions of a watershed	Artificial barriers currently block 28.8-36.3% of the estimated historic coho salmon habitat in the Southern Subbasin. This is the highest percentage of estimated historic coho salmon habitat blocked by artificial barriers in any of the Mattole subbasins. Total barriers block more habitat than partial and temporary barriers in this subbasin. The CDFG North Coast Watershed Improvement Program funded an improvement of Ravasoni Creek (East Anderson Creek) in 2002.
All Barriers	28.8-36.3		
Partial and Temporary Barriers	7.7 – 15.2		
Total Barriers	25.5 – 28.6		

**(N=6 Culverts) in the Southern Subbasin (1998-2000 Ross Taylor and Associates Inventories and Fish Passage Evaluations of Culverts within the Humboldt County and the Coastal Mendocino County Road Systems).*

*Table 133. Juvenile salmonid passage in the Southern Subbasin.**

Feature/Function		Significance	Comments
Juvenile Summer Passage:	**Juvenile Winter Refugia:**	Dry channel disrupts the ability of juvenile salmonids to move freely throughout stream systems.	Dry channel recorded in the Southern Subbasin during stream surveys has the potential to disrupt the ability of juvenile salmonids to forage and escape predation in Anderson Creek and Baker Creek. Juvenile salmonids seek refuge from high winter flows, flood events, and cold temperatures in the winter. Intermittent side pools, back channels, and other areas of relatively still water that become flooded by high flows provide valuable winter refugia.
0.3 Miles of Surveyed Channel Dry	No Data		
1.2% of Surveyed Channel Dry			

*(1991-2002 CDFG Stream Surveys, CDFG Appendix F)

Large Woody Debris

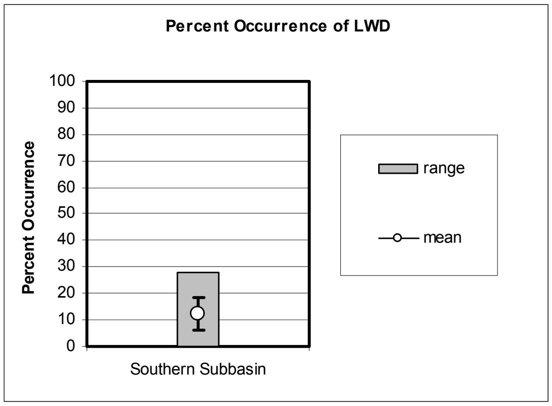


Figure 117. . Large woody debris (LWD) in the Southern Subbasin.

Error bars represent the standard deviation. The percentage of shelter provided by various structures (i.e. undercut banks, woody debris, root masses, terrestrial vegetation, aquatic vegetation, bubble curtains, boulders, or bedrock ledges) is described in CDFG surveys. The dominant shelter type is determined and then the percentage of a stream reach in which the dominant shelter type is provided by organic debris is calculated.

Significance: Large woody debris shapes channel morphology, helps a stream retain organic matter, and provides essential cover for salmonids. There are currently no target values established for the % occurrence of LWD.

Comments: This subbasin has the highest average percent occurrence of large woody debris in surveyed streams of any of the Mattole subbasins.

Discussion

Although instream habitat conditions for salmonids varied across the Southern Subbasin, several generalities can be made. Instream habitat conditions were generally good within this subbasin at the time of CDFG surveys. The percentage of primary pools by survey length, canopy density, and the percent occurrence of large woody debris were the most suitable for salmonids of any of the Mattole subbasins. However, embeddedness values were generally below target values as found in CDFGs California Salmonid Stream Habitat Restoration Manual and calculated by the EMDS. In addition, dry channel occurred in 0.3 miles of surveyed stream (1.2% of the surveyed stream length) and the Southern Subbasin had the highest percentage of estimated historic coho habitat bloc/ked by artificial barriers in the Mattole Basin.

Draft Sediment Production EMDS

The draft sediment EMDS is currently under review. Preliminary results are presented in the EMDS Appendix C.

Stream Reach Condition EMDS

The anadromous reach condition EMDS evaluates the conditions for salmonids in a stream reach based upon water temperature, riparian vegetation, stream flow, and in channel characteristics. Data used in the Reach EMDS come from CDFG Stream Inventories. Currently, data exist in the Mattole Basin to evaluate overall reach, canopy, in channel, pool quality, pool depth, pool shelter, and embeddedness conditions for salmonids. More details of how the EMDS functions are in the EMDS Appendix C. EMDS calculations and conclusions are pertinent only to surveyed streams and are based on conditions present at the time of individual survey.

EMDS stream reach scores were weighted by stream length to obtain overall scores for tributaries and the entire Southern Subbasin. Weighted average reach conditions on surveyed streams in the Southern Subbasin as evaluated by the EMDS are somewhat unsuitable for salmonids (Table 134). Suitable conditions exist for reach in seven tributaries; for canopy in every tributary evaluated except for Helen Barnum Creek; for in channel in four tributaries; for pool quality in eight tributaries; for pool depth in eight tributaries; for pool shelter in four tributaries, and for embeddedness in four tributaries.

Table 134. EMDS anadromous reach condition model results for the Southern Subbasin.

Stream	Reach	Water Temperature	Canopy	Stream Flow	In Channel	Pool Quality	Pool Depth	Pool Shelter	Embeddedness
Southern Subbasin	-	U	++	U	-	+	+	-	- -
Unnamed Tributary to Mattole River	-	U	+++	U	-	+	- -	+++	- - -
Bridge Creek	-	U	++	U	-	-	U	-	- -
West Fork Bridge Creek	-	U	++	U	-	- -	- -	- -	- - -
South Branch West Fork Bridge Creek	-	U	+	U	-	- -	- - -	-	- - -
Vanauken Creek	-	U	++	U	-	- -	- -	-	- -
South Fork Vanauken Creek	+	U	+++	U	+	++	+++	+	- - -
Anderson Creek	-	U	+++	U	-	- - -	- - -	- - -	- - -
Mill Creek (Thorn Junction)	+	U	+++	U	+	+	+++	-	-
Upper Mattole River	+	U	++	U	+	+++	+++	+++	- -
Stanley Creek	+	U	+++	U	U	U	+++	- - -	-
Baker Creek	-	U	+++	U	-	-	- - -	+	+
Thompson Creek	+	U	++	U	-	+	+++	- -	- -
Yew Creek	+	U	+++	U	-	+	+++	-	- - -
Helen Barnum Creek	-	U	-	U	-	- -	- - -	-	+
Lost Man Creek	-	U	++	U	-	- -	- - -	- -	+
Lost Man Creek Tributary	+	U	++	U	+	+	+++	- -	+

Key: +++ Fully Suitable ++ Moderately Suitable + Somewhat Suitable
U Undetermined - Somewhat Unsuitable - - Moderately Unsuitable
- - - Fully Unsuitable

Analysis of Tributary Recommendations

CDFG inventoried 25.7 miles on 14 tributaries and the Upper Mattole River in the Southern Subbasin. In Table 135, a CDFG biologist selected and ranked recommendations for each of the inventoried streams, based upon the results of these standard CDFG habitat inventories. More details about the tributary recommendation process are given in the Mattole Synthesis Section of the Watershed Profile.

Table 135. Ranked tributary recommendations summary in the Southern Subbasin based on CDFG stream inventories.

Stream	# of Surveyed Stream Miles	Bank	Roads	Canopy	Temp	Pool	Cover	Spawning Gravel	LDA	Livestock	Fish Passage
Bridge Creek	3.1	3	4			1	2				
West Fork Bridge Creek	1.4	3	4			1	2		5		
South Branch West Fork Bridge Creek	1.4	4	5	6	7	2	3		1		
Vanauken Creek	1.4	2	4			1			3		5
South Fork Vanauken Creek	0.1	1	2				3				
Anderson Creek	0.9	3				1	2				
Mill Creek (RM 56.2)	0.2	3	4			2	1				
Upper Mattole River	6.7	1	2			3					
Stanley Creek	1.0	2	3			4	1		6		5
Baker Creek	2.2	5	4			1	2	3			
Thompson Creek	3.3	3	4				2		1		
Yew Creek	0.7	2	3				1				

Stream	# of Surveyed Stream Miles	Bank	Roads	Canopy	Temp	Pool	Cover	Spawning Gravel	LDA	Livestock	Fish Passage
Helen Barnum Creek	0.9		3			1	2				
Lost Man Creek	1.2		4			2			3		1
Lost Man Creek Tributary #1	1.2		4			2	1		3		

Temp = summer water temperatures seem to be above optimum for salmon and steelhead; Pool = pools are below target values in quantity and/or quality; Cover = escape cover is below target values; Bank = stream banks are failing and yielding fine sediment into the stream; Roads = fine sediment is entering the stream from the road system; Canopy = shade canopy is below target values; Spawning Gravel = spawning gravel is deficient in quality and/or quantity; LDA = large debris accumulations are retaining large amounts of gravel and could need modification; Livestock = there is evidence that stock is impacting the stream or riparian area and exclusion should be considered; Fish Passage = there are barriers to fish migration in the stream.

In order to further examine Southern Subbasin issues through the tributary recommendations given in CDFG stream surveys, the top three ranking recommendations for each tributary were collapsed into five different recommendation categories: Erosion/Sediment, Riparian/Water Temp, Instream Habitat, Gravel/Substrate, and Other (Table 136). When examining recommendation categories by number of tributaries, the most important recommendation category in the Southern Subbasin is Instream Habitat.

Table 136. Top three ranking recommendation categories by number of tributaries in the Southern Subbasin.

South Subbasin Target Issue:	Related Table Categories:	Count:
Erosion / Sediment	Bank / Roads	15
Riparian / Water Temp	Canopy / Temp	0
Instream Habitat	Pool / Cover	23
Gravel / Substrate	Spawning Gravel / LDA	6
Other	Livestock / Barrier	1

However, comparing recommendation categories in the Southern Subbasin by number of tributaries could be confounded by the differences in the number stream miles surveyed on each tributary. Therefore, the number of stream miles in each subbasin assigned to the various recommendation categories was calculated (Figure 118). When examining recommendation categories by number of stream miles, the most important recommendation categories in the Southern Subbasin are Instream Habitat, Erosion/Sediment, and Gravel/Substrate.

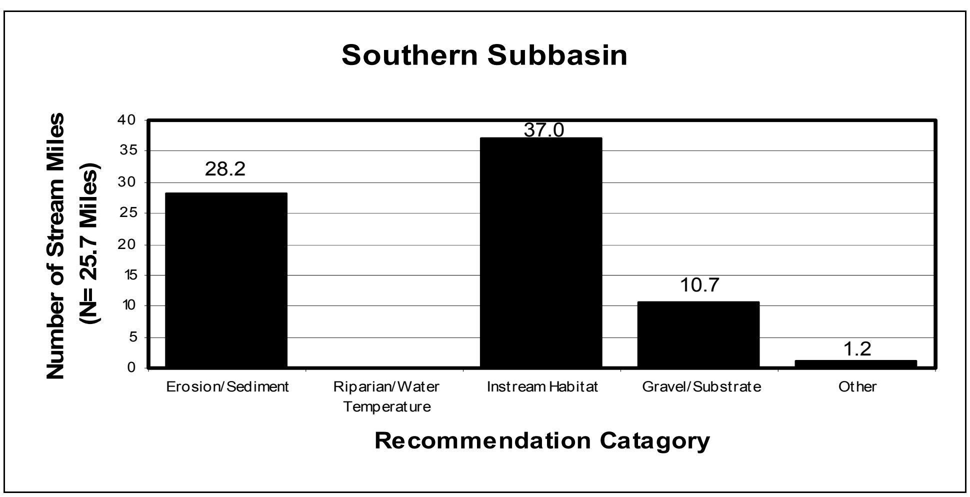


Figure 118. Recommendation categories by stream miles in the Southern Subbasin.

The high number of Instream Habitat, Erosion/Sediment, and Gravel/Substrate Recommendations across the Southern Subbasin indicates that high priority should be given to restoration projects emphasizing pools, cover, and sediment reduction.

Refugia Areas

The NCWAP interdisciplinary team identified and characterized refugia habitat in the Southern Subbasin by using expert professional judgment and criteria developed for north coast watersheds. The criteria included measures of watershed and stream ecosystem processes, the presence and status of fishery resources, forestry and other land uses, land ownership, potential risk from sediment delivery, water quality, and other factors that may affect refugia productivity. The team also used results from information processed by NCWAP's EMDS at the stream reach and planning watershed/subbasin scales.

The most complete data available in the Southern Subbasin were for tributaries surveyed by CDFG. However, many of these tributaries were still lacking data for some factors considered by the NCWAP team.

Salmonid habitat conditions in the Southern Subbasin on surveyed streams are generally rated as high potential refugia. Most creeks provide the high potential refugia in this subbasin, while Anderson, Stanley, and Helen Barnum creeks provide medium quality refugia. In nearly all streams in this subbasin, a lack of stream flow during dry summer and fall periods lowers refugia ratings. The following refugia area rating table summarizes subbasin salmonid refugia conditions.

Table 137. Tributary salmonid refugia area ratings in the Southern Subbasin.

Stream	Refugia Categories*:				Other Categories:		
	High Quality	High Potential	Medium Potential	Low Quality	Non-Anadromous	Critical Contributing Area/Function	Data Limited
Bridge Creek		X					X
West Fork Bridge Creek		X					X
South Branch West Fork Bridge Creek		X					X
Vanauken Creek		X					X
South Fork Vanauken Creek		X					X
Anderson Creek			X				X
Mill Creek (RM 56.2)		X					X
Upper Mattole River		X					X
Stanley Creek			X				X
Baker Creek		X					X
Thompson Creek		X					X
Yew Creek		X					X
Helen Barnum Creek			X				X
Lost Man Creek		X					X
Lost Man Creek Tributary		X					X
Subbasin Rating		X					

*Ratings in this table are done on a sliding scale from best to worst. See page 71 for a discussion of refugia criteria.

Assessment Focus Areas

<u>Working Hypothesis 1:</u>

Watershed and stream conditions are the most supportive of salmonids in the Mattole Basin.

<u>Supporting Evidence:</u>

- The percent occurrence of large organic debris in surveyed Southern Subbasin streams is much higher than in the other Mattole subbasins. Thirteen stream reaches have amounts of large organic debris greater than the amount found in 75% of all surveyed stream reaches in the entire Mattole Basin (IA Tables, CDFG Appendix F).
- V-Star (V*) was 0.04 in Bridge Creek in 2000, which is exceptionally low and may indicate low sediment production due to few, if any, upslope disturbances or rapid sediment transport through well armored pools that may experience high rates of scour during storms (NCRWQCB Appendix E).
- During 2001, median particle sizes, or D50s, in eight of nine tributaries, were in the medium to small size range considered favorable for salmonids. Bridge Creek was the exception with medium to large surface particles deposited on riffles (NCRWQCB Appendix E).
- CDFG has conducted analyses on macroinvertebrate data collected by BLM since 1996 on four subbasin streams and two sections of the Mattole River; and PALCO in 1994 on one subbasin

stream, Baker Creek. Results show stream conditions were either fair to good, good, or good to excellent (CDFG Appendix F).

- Eleven of 15 tributaries (and the upper Mattole River) surveyed by CDFG in this subbasin exceeded the recommended shade canopy density levels of 80% for North Coast streams. Additionally, all surveyed tributaries exceeded 50% shade canopy density. Shade canopy density below 50% in considered unsuitable (CDFG Appendix F).
- In general, MWATs in the Southern Subbasin are grouped in the high 50º F to low 60º F range. This is within the range suitable for salmonids. Maximum temperatures were below 75 °F, the upper limit that may be lethal to most salmonids, in all Southern Subbasin tributaries (NCRWQCB Appendix E).
- There is a lack of available data on pH, dissolved oxygen, nutrients, and other water chemistry parameters. A single day sampling event during October, 2002 showed dissolved oxygen at or below stress levels for salmonids in seven out of nine pools tested in the upper 10.5 miles of the Mattole mainstem (NCRWQCB Appendix E).

Contrary Evidence:

- During the dry summer months, the mainstem Mattole River channel in this subbasin has either intermittent flow or is dewatered above the confluence with Mill Creek (RM 56.2). During 2002 the mainstem above McKee Creek was a series of disconnected pools—(See NCRWQCB Appendix E).
- Three of 15 tributaries (and the upper Mattole River) surveyed by CDFG in this subbasin were found to have 40% or more of the survey lengths in pool habitat. Five surveyed tributaries were found to have 30 to 40 percent of their stream lengths surveyed in pool habitat. Forty percent or more of stream lengths in pool habitat is considered suitable on the North Coast. Additionally, 12.3% of first and second order surveyed streams and 31.2% of third and forth order surveyed streams in this subbasin are composed of primary pools by survey length. Thirty to 55% of survey lengths composed of deep, complex, high quality primary pools is considered desirable (IA Tables, CDFG Appendix F).
- The upper Mattole River was found to have a mean pool shelter rating exceeding 80; however, none of the 15 tributaries surveyed by CDFG in this subbasin was found to exceed a score of 80. Eleven surveyed tributaries were found to have shelter rating scores between 30 and 80. Pool shelter ratings of 80 or more are considered suitable, and ratings less than 30 are unsuitable for contributing to shelter that supports salmonids (CDFG Appendix F).
- Removal of instream large woody debris under direction of CDFG occurred in about 21 stream miles in this subbasin during the 1980s. A total of 36,800 cubic feet of wood was removed. This is equivalent to 294 logs 2 feet x 40 feet. This activity likely had adverse local impacts on salmonid habitat conditions (CDFG Appendix F).
- Five of 15 tributaries (and the upper Mattole River) surveyed by CDFG in this subbasin were found to provide spawning reaches with favorable cobble embeddedness values in at least half of the stream reaches. Two tributaries were found to provide no spawning reaches with favorable cobble embeddedness values, the West Fork of Bridge Creek and the South Fork of Vanauken Creek (CDFG Appendix F).
- Out of 15 stream reaches examined for the presence of sensitive amphibian species, torrent salamanders found in three reaches, on a tributary to Bridge Creek, Pipe Creek, and Ancestor Creek; and tailed frogs were found in three reaches, on a tributary to Yew Creek and Yew Creek (Welsh et al. 2002).
- Artificial fish passage barriers block 28.8-36.3% of the estimated historic coho salmon habitat in this subbasin. A complete barrier to juvenile salmonids exists on Stanley Creek where it is crossed by Whitethorn Road. This culvert is currently proposed but not funded for improvement. Additionally, 1.2% of surveyed stream channel in this subbasin was dry (Taylor 2000, G. Flosi, personal communication, IA Tables, CDFG Appendix F).
- The NCWAP analysis of tributary recommendations given in the Southern Subbasin showed that the most important recommendation category was Instream Habitat, followed by Erosion/Sediment, Gravel/Substrate, and Other (Tributary Recommendation Analysis pg xx).

Hypothesis 1 Evaluation:

Based upon current supportive and contrary findings, the hypothesis is supported.

Working Hypothesis 2:

Some reaches of streams in the subbasin are not fully suitable for salmonids due to stream flow reductions related to human diversion.

Supporting Evidence:

- During the dry summer months, the mainstem Mattole River channel in this subbasin has either intermittent flow or is dewatered above the confluence with Mill Creek (RM 56.2). During 2002 the mainstem above McKee Creek was a series of disconnected pools—(See NCRWQCB Appendix E).

Contrary Evidence:

There is no contrary evidence at this time.

Hypothesis 2 Evaluation:

Based upon current supportive findings, the hypothesis is supported.

Working Hypothesis 3:

Runoff from herbicide applications and fertilizers used on timberlands has had an adverse effect on salmonids.

Supporting Evidence:

- Timber operations often apply herbicides such as atrazine (Aatrex), glyphosate (Accord and Roundup), triclopyr (Garlon 3A, Garlon 4), sulfometruron methyl (Oust), hexazinone, imazapyr, or 2,4- D to suppress botanical growth after a timber harvest (PALCO 1999).
- Glyphosate is moderately toxic to coho salmon at 42 and 32 mg/L respectively (PALCO 1999). It is unlikely that glyphosate will affect aquatic organisms at the concentrations found in the environment after use at the recommended rates (PALCO 1999).
- A recent study of the effects of atrazine on frogs has shown that this herbicide disrupts the sexual development of frogs at concentrations 30 times lower than levels allowed by the Environmental Protection Agency (EPA) (Hayes et al. 2002).
- Sulfometuron methyl is considered slightly toxic to freshwater fish (PALCO 1999).
- Garlon 4 is slightly toxic to salmonids of the Pacific Northwest at a concentration of 1.4 mg/L (PALCO 1999).
- Hexazinone is slightly toxic to fish and other freshwater organisms and has a low bioaccumulation factor in fish (PALCO 1999).
- 2,4- D is considered highly toxic to fish and other aquatic life (PALCO 1999).
- Herbicides are commonly mixed with diesel fuel for dilution before being spayed on harvested areas (PALCO 1999). Exposure to diesel fuel could result in potential toxicity to some forms of aquatic life (NPS 1997).

Contrary Evidence:

- The impacts of these herbicide applications have not been quantified in this subbasin.
- The effects of these herbicides on Mattole Basin salmon have not been studied.
- It is unlikely that glyphosate will affect aquatic organisms at the concentrations found in the environment after use at the recommended rates (PALCO 1999).
- Atrazine is only slightly toxic to fish and other stream life. An ecological risk assessment panel determined that atrazine does not pose a significant risk to the aquatic environment (PALCO 1999).
- Typical applications of Garlon 4 lead to streamwater concentrations of 0.62 mg/L (PALCO 1999).
- Imazapyr is considered to have slight to no toxic effects on fish or wildlife (PALCO 1999).

Hypothesis 3 Evaluation:

Based upon current supportive and contrary findings and the lack of data, the hypothesis needs further investigation.

Working Hypothesis 4:

There is a high risk of catastrophic fire in the Southern Subbasin.

Supporting Evidence:

- There is high fuel load and relatively dense human habitation in this subbasin.

Contrary Evidence:

No contrary evidence at this time.

Hypothesis 4 Evaluation:

Based upon current supportive findings and the lack data, the hypothesis needs further investigation.

Working Hypothesis 5:

Anadromous salmonid populations in the southern subbasin have declined since the 1950s.

Supporting Evidence:

- Interviews with local residents indicate that the Southern Subbasin historically supported Chinook salmon, coho salmon, and steelhead trout and that Vanauken Creek and Baker Creek were important salmon producing streams (CDFG Appendix F).
- Coho salmon were detected in one of the eight tributaries surveyed in the Southern Subbasin by CDFG in the 1960s, Mill Creek (RM 56.2). 1960s surveys also detected steelhead trout in five tributaries (CDFG Appendix F).
- Coho salmon were detected in Harris Creek, Baker Creek, Thompson Creek, and the mainstem Mattole River; and steelhead trout were detected in Vanauken Creek, Mill Creek (RM 56.2), Harris Creek, Baker Creek, Thompson Creek, and the mainstem Mattole River in 1972 by a study of the standing salmonid stock (CDFG Appendix F).
- Stream surveys throughout the 1970s, 1980s, and 1990s by CDFG, BLM, Coastal Headwaters Association, and the Redwood Sciences Laboratory continued to document the presence of steelhead trout throughout the Southern Subbasin (CDFG Appendix F).
- Coho salmon were detected by a Redwood Sciences Laboratory study in Baker Creek, Lost Man Creek, the headwaters of the Mattole River, Yew Creek, Thompson Creek, and Bridge Creek from 1997-1999 (CDFG Appendix F).
- Ten of the 14 tributaries surveyed by CDFG in the Southern Subbasin from 1990-2000 included a biological survey. Steelhead trout were found in these ten streams, and coho salmon were found in Bridge Creek, Anderson Creek, Thompson Creek, Yew Creek, and Stanley Creek (CDFG Appendix F).
- Seven tributaries in this subbasin were also surveyed as a part of the CDFG 2001 Coho Inventory. Steelhead trout were found in these seven streams, but coho salmon were only found in Mill Creek (RM 56.2), Baker Creek, Thompson Creek, Yew Creek, and the upper mainstem Mattole River (CDFG Appendix F).
- Estimated populations of Chinook salmon or coho salmon in the entire Mattole Basin have not exceeded 1000 since the 1987-88 season. Mattole Basin Chinook salmon and coho salmon population estimates for the 1999-2000 season were 700 and 300, respectively (MSG 2000).

Contrary Evidence:

No contrary evidence at this time.

Hypothesis 5 Evaluation:

Based upon current supportive and contrary findings for the streams surveyed, the hypothesis is supported.

Responses to Assessment Questions

What are the history and trends of the sizes, distribution, and relative health and diversity of salmonid populations within this subbasin?

- No systematic, scientific studies have examined the size or health of salmonid populations in the Southern Subbasin. However, historical accounts and stream surveys conducted in the 1960s by CDFG indicate that the Southern Subbasin supported populations of Chinook salmon, coho salmon, and steelhead trout. Recent biological stream surveys indicate the presence of steelhead trout and coho salmon throughout the Southern Subbasin. This subbasin supports coho salmon in more tributaries than the other Mattole subbasins. Low salmonid populations throughout the Mattole Basin indicate that salmonid populations in the Southern Subbasin are also likely to be depressed at this time;

What are the current salmonid habitat conditions in this subbasin? How do these conditions compare to desired conditions?

- Dewatered stream channels are a serious problem during summer low flow periods in the mainstem Mattole River and select reaches of many tributaries;
- Erosion/Sediment
  - As indicated by the Potential Stream Sediment Production EMDS, potential fine sediment delivery to streams due to road runoff is high in the Southern Subbasin. Although there are few roads on unstable slopes, there are many roads positioned low on hill slopes and many road crossings of streams throughout the Bridge Creek and Thompson Creek Planning Watersheds. The types and variety of macroinvertebrates indicate fair to good, good, or good to excellent instream conditions. Additionally, amphibians sensitive to fine sediment were present in several stream reaches surveyed in this subbasin;
- Riparian/Water Temperature
  - Available data suggest that summer water temperatures support rearing juvenile salmonid populations in most reaches of most streams with summer flow in this subbasin;
- Instream Habitat
  - Based upon 26 miles of surveyed stream habitat in the past 10 years, the Southern Subbasin is considered to contain some of the best salmonid habitat in the Mattole Basin. The utility of this good habitat for salmonids is compromised because of summer de-watering of the upper mainstem reach and many subbasin tributaries;
- Gravel Substrate
  - Available data from sampled streams suggest that suitable amounts and distribution of high quality spawning gravel for salmonids is lacking in some subbasin stream reaches;

Most creeks in this subbasin are considered good refugia;

What are the relationships of geologic, vegetative, and fluvial processes to natural events and land use history?

- The geologic conditions in the Southern Subbasin are the most uniform and stable in the Mattole Basin. Nearly all the hillside areas are underlain by hard terrain. Correspondingly, this subbasin has the lowest density of mapped landslides, and stream channels within the Mattole Basin, and is the least impacted by features indicative of excess sediment production, transport and storage in the basin;
- Redwood stands occur in this subbasin because of favorable conditions, including summer fog. As a result of past timber harvest and conversion activities, over 60% of the Southern Subbasin is occupied by small diameter (twelve to twenty-four inches diameter at breast height) forest stands. Another 22% is in forest stands greater than twenty-four inches. Industrial timberlands on the eastern side of the subbasin have been intensively managed in the past decade and are characterized by young, even-aged conifer stands;

How has land use affected these natural processes?

- This is the most densely populated area in the Mattole Basin. Many of the landowners have conservation easements as a part of Sanctuary Forest. Roads, abandoned after early timber harvest activities, are being upgraded and stormproofed by landowners. Many of these roads are now used as residential and parcel access roads and are located near streams.

Based upon these conditions trends, and relationships, are there elements that could be considered to be limiting factors for salmon and steelhead production?

- Based on the information available for the Southern Subbasin, the NCWAP believes that salmonid populations are currently being limited by low summer stream flows, reduced habitat complexity, high sediment levels, embedded spawning gravels, and artificial passage barriers.

What habitat improvement activities would most likely lead toward more desirable conditions in a timely, cost effective manner?

- Encourage reducing the unnecessary and wasteful use of water to improve summer stream surface flows and fish habitat;
- Increase the use of water storage and catchment systems that collect rainwater in the winter for use in the drier summer season;
- Support local efforts to educate landowners about water storage and catchment systems, and to find ways to subsidize development of these systems;
- Ensure that this high quality habitat is protected from degradation. The highest stream reach conditions as evaluated by the stream reach EMDS and refugia analysis were found in the Bridge, West Fork Bridge, South Fork West Fork Bridge, South Fork of Vanauken, Mill (RM 56.2), Stanley, Baker, Thompson, Yew, and Lost Man creeks, the Upper Mattole River, and Lost Man Creek Tributary;
- Improve the culvert on Stanley Creek that is blocking juvenile salmonids from accessing high quality rearing habitat;
- Establish monitoring stations and train local personnel to track in-channel sediment and aggraded reaches throughout the subbasin and especially in Bridge and Thompson creeks;
- Consider the nature and extent of naturally occurring unstable geologic terrain, landslides and landslide potential (especially Categories 4 and 5, page 89) when planning potential projects in the subbasin;
- Encourage the use of appropriate Best Management Practices for all land use and development activities to minimize erosion and sediment delivery to streams. For example, low impact yarding systems should be used in timber harvest operations on steep and unstable slopes to reduce soil compaction, surface disturbance, and resultant sediment yield;
- Expand road assessment efforts because of the potential for further sediment delivery from active and abandoned roads, many of which are in close proximity to stream channels;
- Continue efforts such as road improvements, and decommissioning throughout this subbasin to reduce sediment delivery to the Mattole River and its tributaries. CDFG stream surveys indicated South Fork Vanauken Creek, the Upper Mattole River, Stanley Creek, Thompson Creek, and Yew Creek have road sediment inventory and control as a top tier tributary recommendation. In 2002, road erosion assessments and road erosion control projects were underway in the upper Mattole Basin;
- Further study of timberland herbicide use is recommended;
- Follow the procedures and guidelines outlined by NCRWQCB to protect water quality from ground applications of pesticides;
- A cooperative salmonid rearing facility exists in the headwaters, operated since 1982 by the Mattole Salmon Group. This operation has been successful and should be continued on an as needed basis in order to supplement wild populations of Chinook salmon;

- Initiate a training program for local landowners to survey their own streams and monitor salmonid populations. This will provide important data and protect privacy;
- Monitor summer water and air temperatures to detect trends using continuous 24 hour monitoring thermographs. Continue temperature monitoring efforts in Bridge, Vanauken, Baker, Yew, Thompson, Helen Barnum, Lost Man, Dream Stream, and Ancestor creeks, and expand efforts into other subbasin tributaries.

Subbasin Conclusions

Historical accounts indicate that the Southern Subbasin has supported healthy populations of Chinook salmon, coho salmon, and steelhead trout. More current surveys indicate that it continues to have the highest fish productivity in the Mattole Basin. The natural geological conditions in the subbasin are comparatively stable and stream channels within the subbasin appear to be the least impacted by features indicative of excess sediment production, transport, and storage. However, it appears that salmonid populations are currently being limited by low summer stream flows, reduced habitat complexity, high sediment levels, embedded spawning gravels, and artificial fish passage barriers. This subbasin is the most heavily populated are of the subbasin, and dewatering of streams is considered a serious problem. The subbasin has a comparatively dense network of roads located near streams and road crossings that provide potential sources of fine sediment input to streams. Residents, landowners, and land managers can help maintain and improve stream habitat through becoming educated in methods to reduce water use, remove fish passage barriers, and mitigate road related sedimentation, and may enlist the aid and support of agency technology, experience, and funding in accomplishing these goals.

Western Mattole Subbasin

Western Subbasin near Ettersburg.

Introduction

The Western Subbasin is located between Bear Creek in the estuary (RM 0.3) and the headwaters of the South Fork of Bear Creek (RM 50) along the western side of the Mattole mainstem and Wilder Ridge for a distance of about 60 miles (Figure 119). Elevations range from 20 feet at the estuary to approximately 2800 feet in the headwaters of the tributaries in the King Range. Kings Peak, at 4088 feet, is the highest point in the Mattole Basin.

The NCWAP team's Western Subbasin results and analyses are presented in three basic sections. First, general information describing the subbasin is presented by different disciplines. Secondly, this information is integrated and presented to provide an overall picture of how different factors interact within the subbasin. Lastly, an overall assessment of the Western Subbasin is presented. The NCWAP team developed hypotheses, compiled supportive and contrary evidence, and used these six assessment questions to focus this assessment:

- What are the history and trends of the sizes, distribution, and relative health and diversity of salmonid populations within this subbasin?
- What are the current salmonid habitat conditions in this subbasin? How do these conditions compare to desired conditions?
- What are the relationships of geologic, vegetative, and fluvial processes to natural events and land use history?
- How has land use affected these natural processes?
- Based upon these conditions trends, and relationships, are there elements that could be considered to be limiting factors for salmon and steelhead production?
- What habitat improvement activities would most likely lead toward more desirable conditions in a timely, cost effective manner?

The assessment questions are answered at the end of this section.

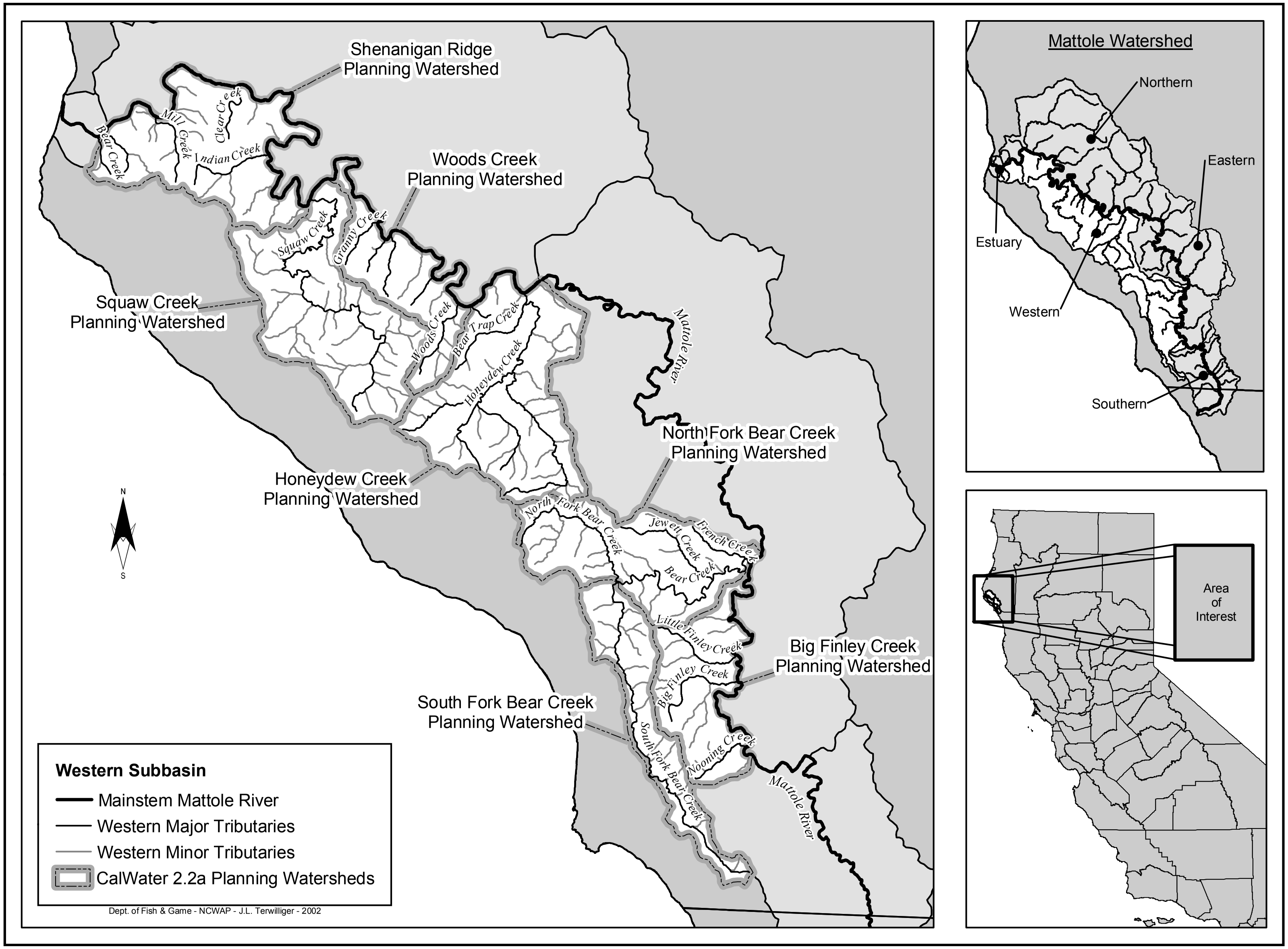


Figure 119. Mattole Western Subbasin.

Climate

The Western Subbasin is greatly influenced by the King Range, which is its western boundary. Temperatures have a wide range because the mountains cut off the moderating effect produced by marine air. Precipitation totals vary from 70 to 100 inches annually. Annual rainfall averages are highest in the center of this subbasin because the greatest orographic effect occurs here due to the presence of the King Ranges' tallest peaks.

Hydrology

The Western Subbasin is made up of six complete CalWater Units and most of the Shenanigan Ridge CalWater Unit (Figure 119). There are 85.8 perennial stream miles in 33 perennial tributaries in this subbasin (Table 138). Eighteen of these tributaries have been inventoried by CDFG. There were 33 reaches, totaling 49.9 miles in the inventory surveys. The inventories included channel and habitat typing, and biological sampling.

Table 138. Streams with estimated anadromy in the Western Subbasin.

Stream	CDFG Survey (Y/N)	CDFG Survey Length (miles)	Estimated Anadromous Habitat Length (miles)*	Reach	Channel Type
Bear Creek	N		0.3		
Stansberry Creek	N		0.5		
Mill Creek (RM 2.8)	Y	1.1	1.4	1	B2
Mill Creek (RM 2.8) Tributary 1	Y	0.2		1	A2
Mill Creek (RM 2.8) Tributary 2	Y	0.1		1	A2
Clear Creek	N		0.7		
Indian Creek	N		1.2		
Wild Turkey Creek	N		0.1		
Green Fir Creek	N				
Squaw Creek	Y	4.1	12.7	1	F3
Granny Creek	N				
Cook Gulch	N				
Saunders Creek	N		0.4		
Hadley Creek	N				
Kendall Gulch	N				
Woods Creek	Y		1.5		
	Y	1.2		1	F4
	Y	0.7		2	B4
Bundle Prairie Creek	N				
Honeydew Creek	Y		5.9		
	Y	1.4		1	F4
	Y	0.9		2	F4
	Y	1.1		3	F3
	Y	0.7		4	A2
Bear Trap Creek	Y		0.1		
	Y	2.9		1	F3
	Y	1.7		2	F2
	Y	1.6		3	B2
	Y	1.1		4	F2
High Prairie Creek	N		0.6		
East Fork Honeydew Creek	Y	2.9	6.0	1	F2
Upper East Fork Honeydew Creek	Y	1.0	0.0	1	F2
West Fork Honeydew Creek	Y	0.7	0.2	1	B2
Bear Creek	Y		6.5		

Stream	CDFG Survey (Y/N)	CDFG Survey Length (miles)	Estimated Anadromous Habitat Length (miles)*	Reach	Channel Type
	Y	1.4		1	B2
	Y	0.3		2	A2
French Creek	N		0.4		
Jewett Creek	Y	2.7	2.4	1	F4
North Fork Bear Creek	Y		4.3		
	Y	2.5		1	B4
	Y	0.9		2	A3
North Fork Bear Creek Tributary	Y	1.4		1	B2
	Y	0.3		2	A2
South Fork Bear Creek	Y		10.7		
	Y	1.9		1	B2
	Y	4.6		2	F3
	Y	5.3		3	B3
	Y	0.3		4	F4
Little Finley Creek	N				
Big Finley Creek	Y		0.1		
	Y	1.3		1	B4
	Y	0.3		2	A2
South Fork Big Finley Creek	Y	1.3		1	B3
Nooning Creek	Y		1.5		
	Y	0.1		1	F3
	Y	1.4		2	B2

* Data from the Mattole Salmon Group.

In their inventory surveys, CDFG crews utilize a channel classification system developed by David Rosgen (1994) and described in the *California Salmonid Stream Habitat Restoration Manual*. Rosgen channel typing describes relatively long stream reaches using eight channel features: channel width, depth, velocity, discharge, channel slope, roughness of channel materials, sediment load and sediment size. There are eight general channel types in the Rosgen classification system.

In the Western Subbasin, there were seven type A channels, totaling 2.8 miles; twelve type B channels, totaling 20.6 miles; and 13 type F channels, totaling 25.7 miles. Type A stream reaches are narrow, moderately deep, single thread channels. They are entrenched, high gradient reaches with step/pool sequences. Type A reaches flow through steep V- shaped valleys, do not have well-developed floodplains, and have few meanders. Type B stream reaches are wide, shallow, single thread channels. They are moderately entrenched, moderate to steep gradient reaches, which are riffle-dominated with step/pool sequences. Type B reaches flow through broader valleys than type A reaches, do not have well-developed floodplains, and have few meanders. Type F stream reaches are wide, shallow, single thread channels. They are deeply entrenched, low gradient reaches and often have high rates of bank erosion. Type F reaches flow through low-relief valleys and gorges, are typically working to create new floodplains, and have frequent meanders (Flosi, et al., 1998).

Geology

The south and central portions of the Western Subbasin straddle the boundary between the King Range terrane on the west and the Coastal terrane to the east. The lower portion of both the North Fork and South Fork of Bear Creek are subsequent streams that follow the zone of faulting and shearing associated with the structural suture between the two terranes, the King Range thrust fault. To the west, the dramatic relief and steep slopes of the King Range are a reflection of the hard terrain, resulting from the relatively intact and stable bedrock underlying the middle of the mountain range coupled with rapid, ongoing regional uplift.

Overall, approximately 17% of the subbasin is underlain by historically active or dormant landslides, a lower proportion than any subbasin except the Southern Subbasin (Figure 120). The relatively few deep-seated landslides mapped along the eastern flanks of the King Range appear to be dormant. Abundant debris slide slopes have been mapped in this area, along with a moderate number of historically active debris slide scars concentrated adjacent to drainages. Historically active debris slides are common along the portions of Bear Creek that lie along the King Range thrust fault. West of Honeydew and in the middle reaches of Squaw Creek, bedrock is pervasively disrupted along the broad, west-trending Cooskie shear zone that forms the northern boundary of the King Range terrane. Large deep-seated landslides, historically active earthflows, and gully erosion on grass-covered highlands have been mapped in association with soft terrain in this area of the subbasin. Similar conditions are found in soft terrain in the lower portion of Honeydew Creek. A map showing the distribution of geologic units, landslides, and geomorphic features related to landsliding is presented on Plate 1 of the Geologic Report, Appendix A.

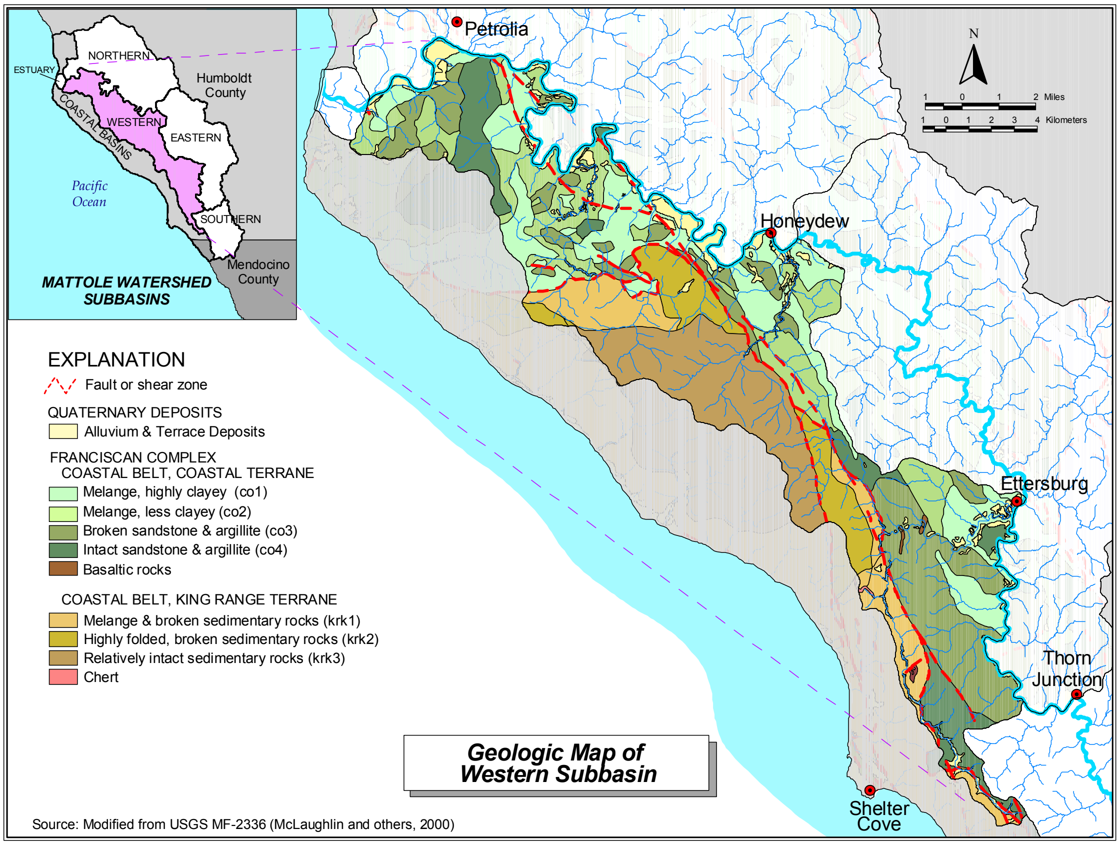


Figure 120. Geologic map of the Western Subbasin.

Vegetation

Unless otherwise noted, the vegetation description in this section is based on manipulation of CalVeg 2000 data. This is vegetation data interpreted from satellite imagery by the United States Forest Service, Remote Sensing Lab. The minimum mapping size is 2.5 acres.

Mixed hardwood and conifer forests cover 55% of the area, conifer forest 7%, and hardwood forest 25% for a total of 87% forested area (Figure 121). Grassland occupies 10% of the subbasin. Shrub, barren, agricultural lands, and urban classifications together cover the remaining 3% of the area. The forested vegetation reflects the impacts of harvesting. Fifty-Eight percent of the Western Subbasin is in the 12 to 23.9 inch diameter breast height (dbh) size class. Twenty percent is in a diameter size class greater than 24 inches dbh.

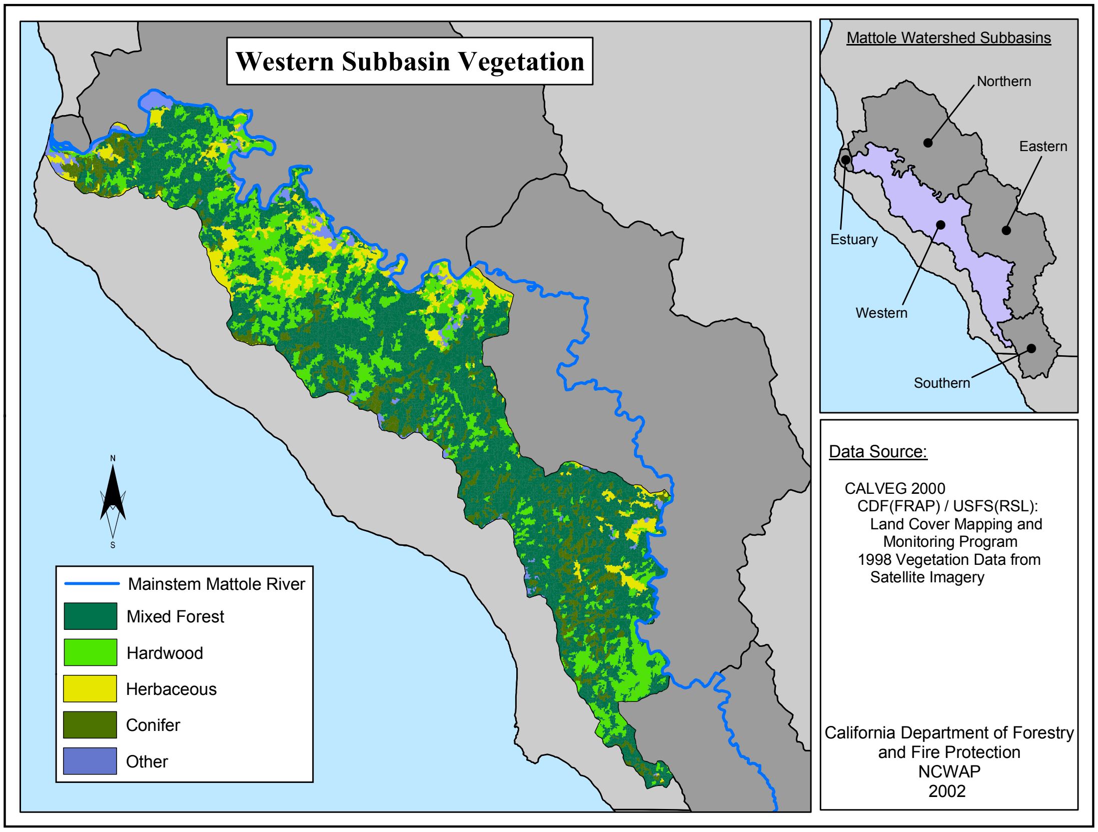


Figure 121. Vegetation of the Western Subbasin.

Land Use

The subbasin is largely in public ownership managed by the Bureau of Land Management (BLM) as part of the King Range National Conservation Area (KRNCA) (Figure 122). The area has a relatively small amount of subdivision. The major land use activity on privately owned land is ranching and some timber management. Controversy over BLM management and public access to the resources of the KRNCA, both supportive and critical, are ongoing issues. Timber harvest issues have occurred in the past, focused on stands in Honeydew Creek, but most timber is now managed for late seral reserve (Figure 123, Figure 124, and Table 139). The 220-acre Mill Creek (RM 2.8) Forest, the last old-growth Douglas fir and tan oak forest in the lower Mattole Basin, is located in the lowest downstream part of this subbasin. Timber harvest activity was extensive prior to 1961 and steadily decreased as a proportion of land area since.

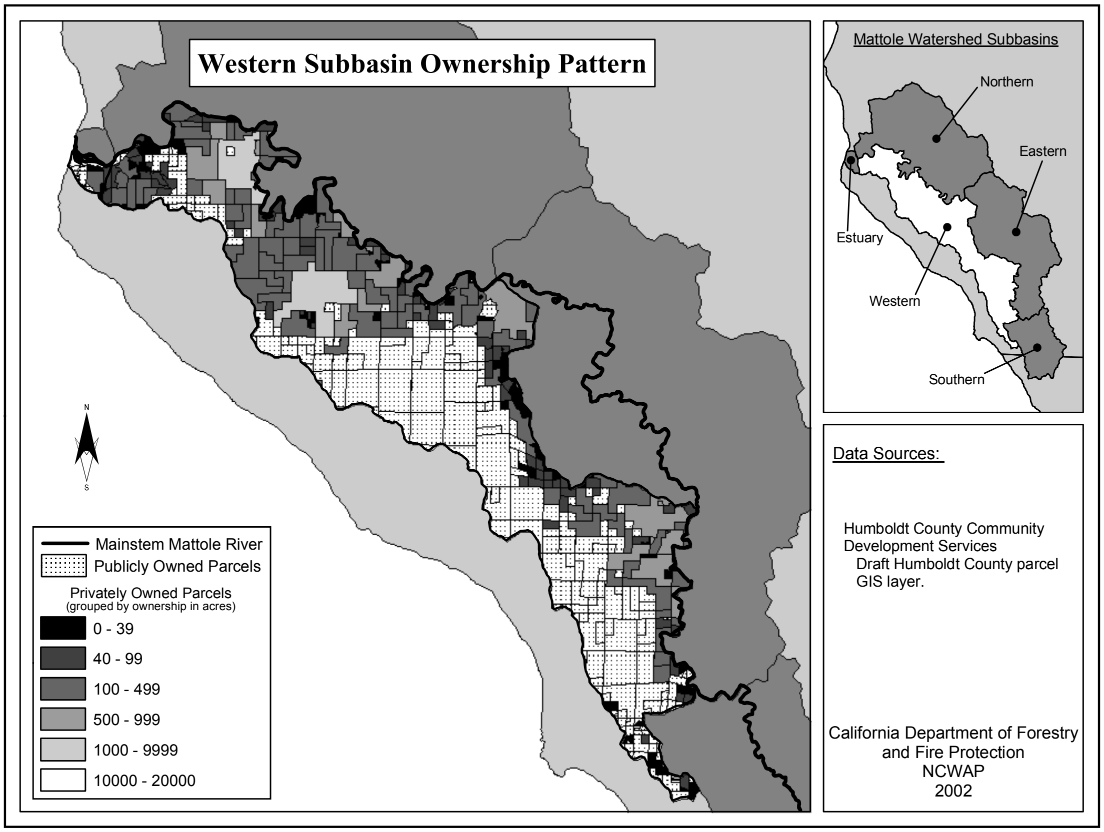


Figure 122. Ownership pattern of the Western Subbasin.

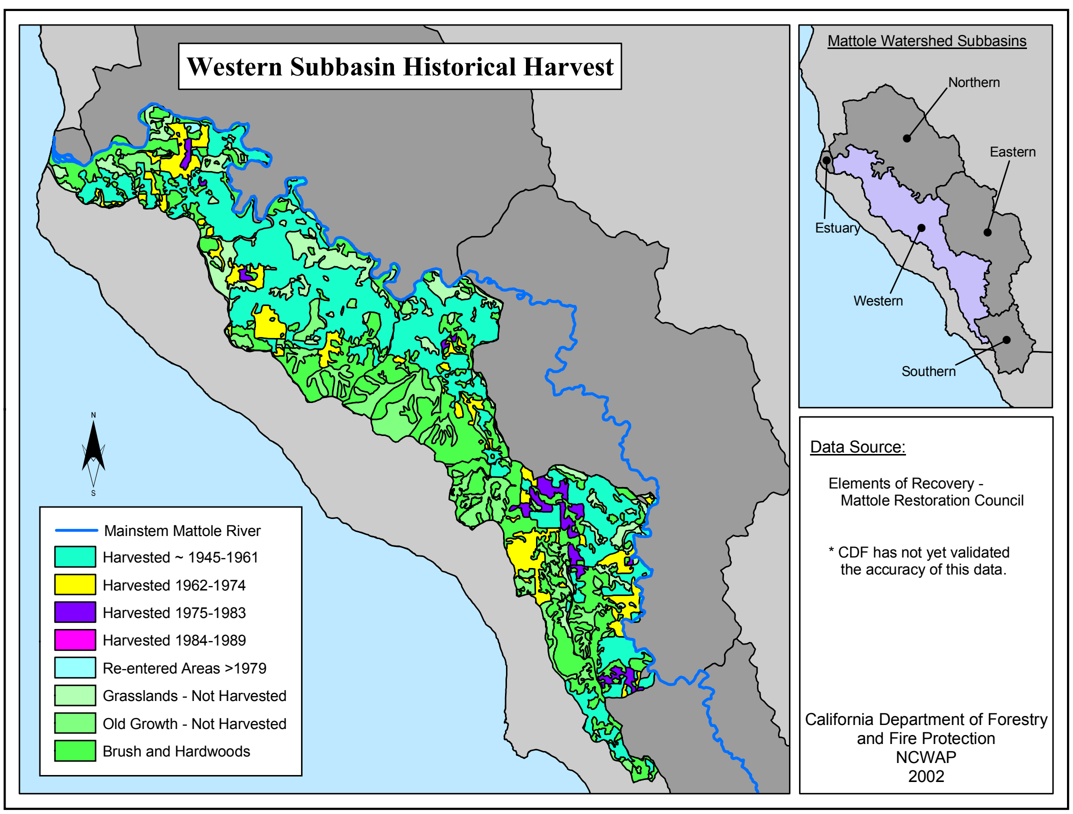


Figure 123. Timber harvest history for the Western Subbasin.

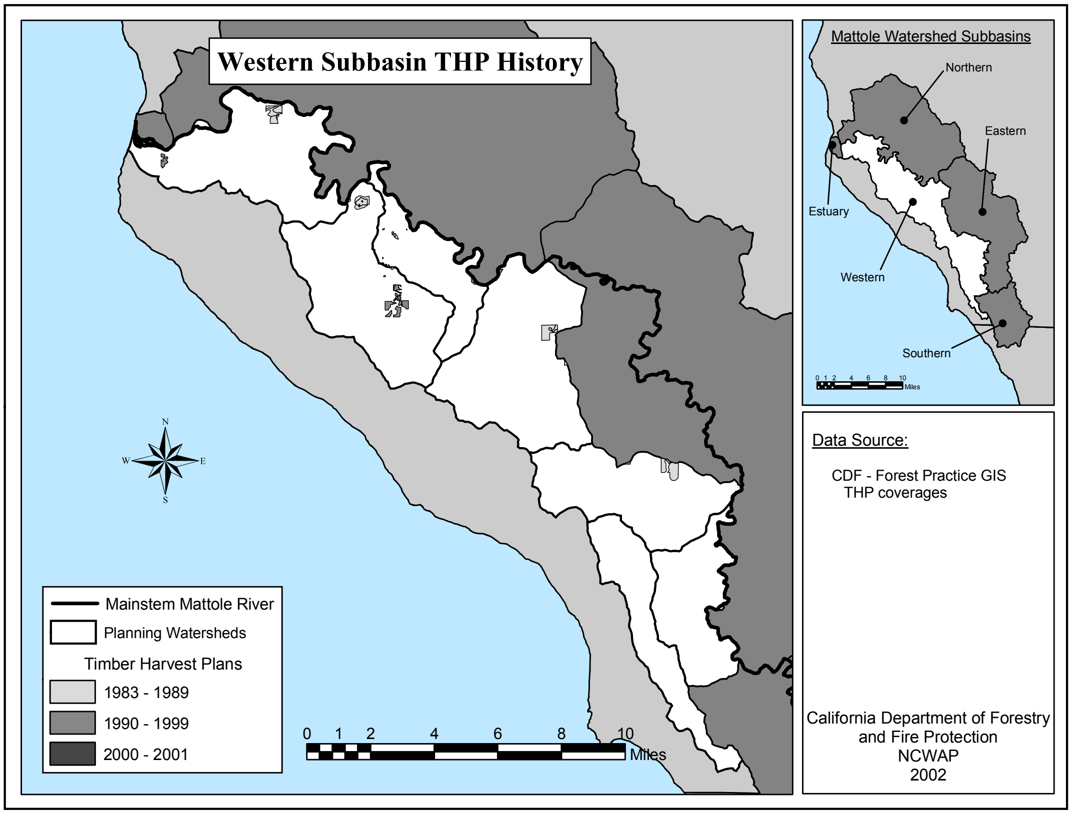


Figure 124. Timber harvesting plans 1983-2001, Western Subbasin

Table 139. Timber harvest history, Western Mattole Subbasin.

TIMBER HARVEST HISTORY - WESTERN SUBBASIN*				
	Total Harvested Acres	**Total Area Harvested (%)**	**Average Annual Harvest (ac)**	**Annual Harvest Rate (%)**
Harvested ~1945 - 1961**	20,544	36%	1,208	2%
Harvested 1962 - 1974**	5,222	9	402	<1
Harvested 1975 - 1983**	1,584	3	176	<1
Harvested 1984 - 1989	536	1	60	<1
Harvested 1990 - 1999	228	<1	23	<1
Harvested 2000 - 2001	87	<1	44	<1
Not Harvested:				
Grasslands	6,353	11		
Brush and Hardwoods	17,560	30		

* Does not add to 100% due to data discrepancies, re-harvest areas, and uncut timber areas.
** CDF has not yet validated the accuracy of this data (obtained from MRC).

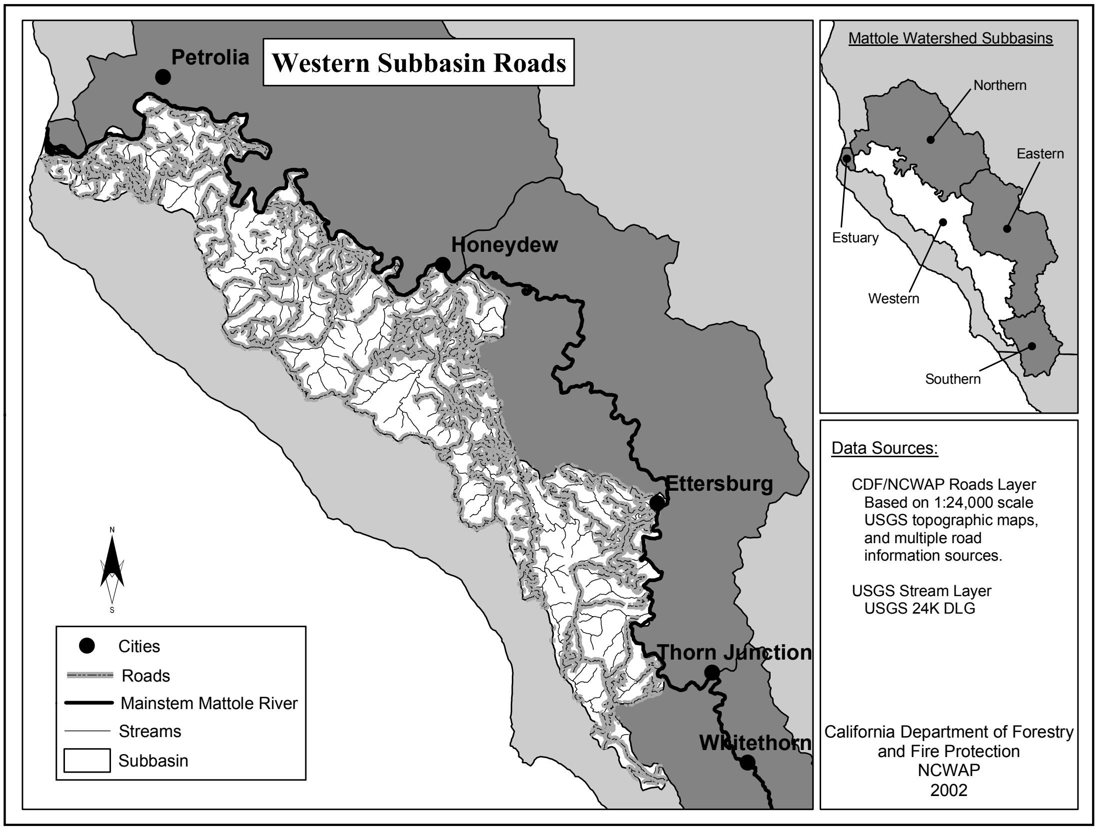


Figure 125. Western Subbasin roads.

Fluvial Geomorphology

The fluvial geomorphology of the Western Subbasin is characterized by a highly variable concentration of mapped channel characteristics, the lowest increase in the number of gullies among the subbasins, and a wide-ranging pattern of lateral-bar development (Table 140). Comparison of the 2000 and 1984 air photos reveals that six of the seven PWs within the Western Subbasin have shown a significant decrease in MCCs. Wide channels and displaced riparian vegetation decreased dramatically (see Figure 34 and Figure 35). Similar to other subbasins, the length of gullies about doubled across the subbasin between 1984 and 2000. Two PWs, Big Finley and Squaw Creeks, have shown notable decreases in lateral-bar development (Table 140), which suggest decreases in excess sediment in those PWs.

Significant improvement was observed between 1984 and 2000 in the proportion of blue line streams in bedrock and adjacent to or within LPM 4 and 5 that were affected by NMCCs. In 1984, fewer than 50% of such streams reaches were affected by NMCCs, while in 2000 about 20% were affected (CGS Geologic Report Table 14). Considering the low concentration of NMCCs in the upstream Southern Subbasin and the increase in sediment in the alluvial reaches, it appears that sediment is being produced internally or from the adjacent Eastern Subbasin.

The Western Subbasin displays a trend similar to the Eastern Subbasin in the significant decrease in MCCs between 1984 and 2000. The exception to this trend is found in the Shenanigan Ridge PW, in which mapped channel characteristics have increased approximately 36% since 1984 (Table 140). Areas with a high percentage of MCCs in 1984 include portions of the Honeydew Creek, Big Finley Creek, Squaw Creek, and North Fork Bear Creek PWs. These PWs showed decreases in MCC lengths of between 34% and 76% between 1984 and 2000 (Table 140).

Table 141 documents the number of sites and summarizes the lengths of eroding-bank features within the Western Subbasin. Stream-bank erosion has been observed in all but one of the planning watersheds of this subbasin. The number of eroding-bank sites range from two in the Shenanigan Ridge PW to 11 in the Honeydew Creek PW. The Squaw Creek PW has been mapped with the greatest total length of eroding banks, approximately 5700 feet.

Table 140. Fluvial geomorphic features - Western Subbasin.

	2000 Photos			1984 Photos		
Planning Watersheds1	**Length of Mapped Channel Characteristics2 (feet)**	**Total Gully Length3 (feet)**	**Lateral Bar Development4**	**Length of Mapped Channel Characteristics2 (feet)**	**Total Gully Length3 (feet)**	**Lateral Bar Development4**
Bear Creek, North Fork	24,700	28,000	2-3	57,300	8,000	3-4
Bear Creek, South Fork	8,400	8,500	1-2	24,000	4,100	2-3
Big Finely Creek	14,800	15,000	1-2	62,000	8,700	3-4
Honeydew Creek	48,600	38,200	3	74,000	17,200	3-4
Shenanigan Ridge	67,000	5,200	2-3	49,300	6,300	1-2
Squaw Creek	47,900	61,600	2	100,100	42,600	3-4
Woods Creek	32,600	24,200	2-3	54,000	4,800	3
Western Subbasin Totals	**244,000**	**180,700**		**420,700**	**91,800**	

1 See Figure 2 for locations.
2 Features include negative and neutral characteristics including: wide channels, displaced riparian vegetation, point bars, distribution and lateral or mid-channel bars, channel bank erosion, shallow landslides adjacent to channels.
3 Gullies include those that appear active, have little to no vegetation within the incised area, and are of sufficient size to be identified on aerial photos.
4 Lateral bars include mappable lateral, mid-channel bars and reflect sediment supply and storage. Rankings range from 1-5. Higher values suggest excess sediment

Table 141. Eroding stream bank lengths - Western Subbasin.

2000 Photos				
Western Subbasin Planning Watersheds1	**Number of Sites2**	**Maximum Length (feet) of Eroding Bank3**	**Total Length (feet) of Eroding Bank4**	**Eroding Bank (%)5**
Bear Creek, No. Fork	6	700	2,700	2
Bear Creek, So. Fork	N.O.	N.O.	N.O.	N.O.
Big Finely Creek	3	800	1,500	2
Honeydew Creek	11	600	4,100	2
Shenanigan Ridge	2	300	600	<1
Squaw Creek	10	1,700	5,700	3
Woods Creek	4	1,400	3,500	8

1 See Figure 2 for locations.
2 Number of sites mapped from air photos within PW.
3 Maximum length of a continuous section of eroding stream bank within PW.
4 Combined total length of all sections of eroding stream bank within PW.
5 Approximate percentage of eroding stream bank relative to total stream length within PW.
N.O.- Not Observed

Aquatic/Riparian Conditions

Unless otherwise noted, the vegetation description in this section is based on manipulation of CalVeg 2000 data. This is vegetation data interpreted from satellite imagery by the United States Forest Service, Remote Sensing Lab. The minimum mapping size is 2.5 acres.

Vegetation within 150 feet of the centerline of streams is 58% mixed conifer and hardwood forest, 16% hardwood, and 15% conifer forest. One percent of the forest type is riparian hardwood while another 1% is hardwood occupied commercial timberland site. The barren classification makes up 5 % of the riparian area, all of it adjacent to the Mattole River. Annual grassland is 3% of the area, while shrubs, water, and agricultural lands comprise the remaining 2%. Trees in the twelve to 23.5 inch diameter size class cover 66% of the riparian. The area occupied by this single-width zone is 13% of the total Western Subbasin acreage.

Fish Habitat Relationship

Anadromous stream reach conditions in the Western Subbasin were somewhat unsuitable as evaluated by the stream reach EMDS. The anadromous reach condition EMDS is composed of water temperature, riparian vegetation, stream flow, and in channel characteristics. More details of the EMDS are in the EMDS Appendix C).

Data on water temperature and stream flow have not yet been incorporated into EMDS. However, water temperature data is presented in the NCRWQCB Appendix E and stream flow data is presented in the DWR Appendix D and in individual stream survey report summaries in the CDFG Appendix F. Temperature records were available for Mill Creek (RM 2.8) and Stansberry Creek; Squaw Creek; Honeydew Creek, the Lower SF Honeydew Creek, WF Honeydew Creek, and the Upper EF Honeydew Creek; Bear Creek, NF Bear Creek, and the LNF Bear Creek; SF Bear Creek in the South Fork Bear Creek CalWater Unit; and Big Finley Creek and Nooning Creek. Except for Mill Creek (RM 2.8) during 1996, 1999, and 2001, Stansberry Creek during 1999 and the borderline ± 60 °F in the Lower North Fork Bear Creek during 1996 and 2001, and Big Finley Creek in 1999 all Western Subbasin tributaries sampled had temperatures that exceeded the fully supportive 50 - 60°F MWAT range considered suitable for optimal salmonid survival from 1996-2001.

Stream attributes that were evaluated by the anadromous stream reach EMDS included canopy cover, embeddedness, percent pools, pool depth, and pool shelter. These attributes were collected in 18 streams in the Western Subbasin by CDFG (see CDFG Appendix F) for stream survey report summaries).

Stream attributes tend to vary with stream size. For example, larger streams generally have more open canopy and deeper pools than small streams. This is partially a function of wider stream channels and greater stream energy due to higher discharge during storms. Surveyed streams in the Western Subbasin ranged in drainage area from 0.3 to 21.7 square miles (Figure 126).

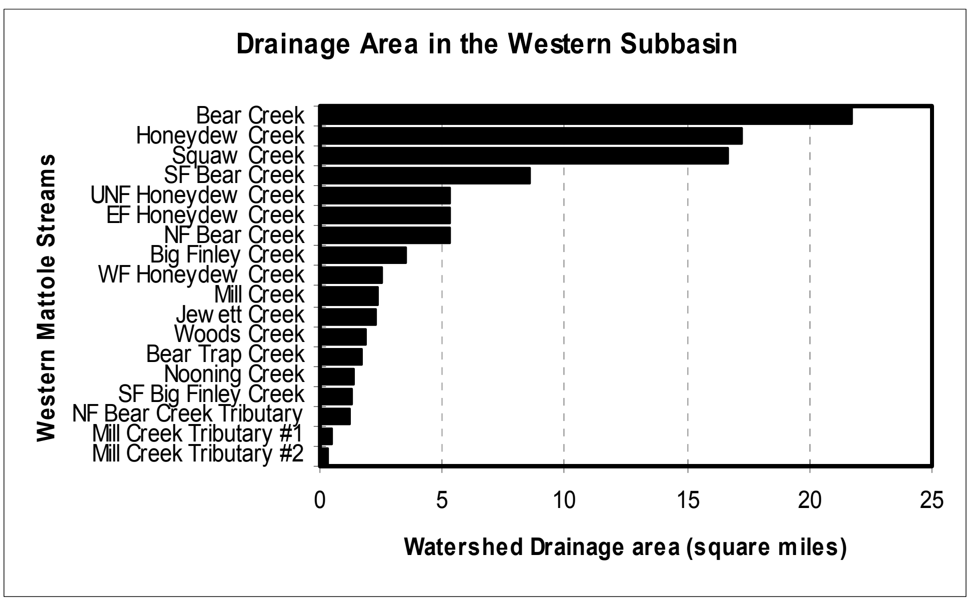


Figure 126. Drainage area of stream surveyed by CDFG in the Western Subbasin.

Canopy density, and relative canopy density by coniferous versus deciduous trees were measured at each habitat unit during CDFG stream surveys. Near-stream forest density and composition contribute to microclimate conditions that help regulate air temperature, which is an important factor in determining stream water temperature. Furthermore, canopy levels provide an indication of the potential present and future recruitment of large woody debris to the stream channel, as well as the insulating capacity of the stream and riparian areas during winter.

In general, the percentage of stream canopy density increases as drainage area, and therefore channel width, decrease. Deviations from this trend in canopy may indicate streams with more suitable or unsuitable canopy relative to other streams of that subbasin. As described in the EMDS response curves, total canopy (sum of conifer and deciduous canopy) exceeding 85% is considered fully suitable, and total canopy less than 50% is fully unsuitable for contributing to cool water temperatures that support salmonids. The surveyed streams of the Western Subbasin show percent canopy levels (45%-90% total canopy) that vary in their EMDS rating from completely unsuitable to completely suitable (Figure 127). Canopy conditions generally trend with stream size, but the South Fork Bear Creek, Mill Creek (RM 2.8), and Nooning Creek have exceptionally high total canopy cover, while a tributary to Bear Creek, and Bear Trap Creek have exceptionally low total canopy cover. Deciduous trees in this subbasin dominate existing canopy.

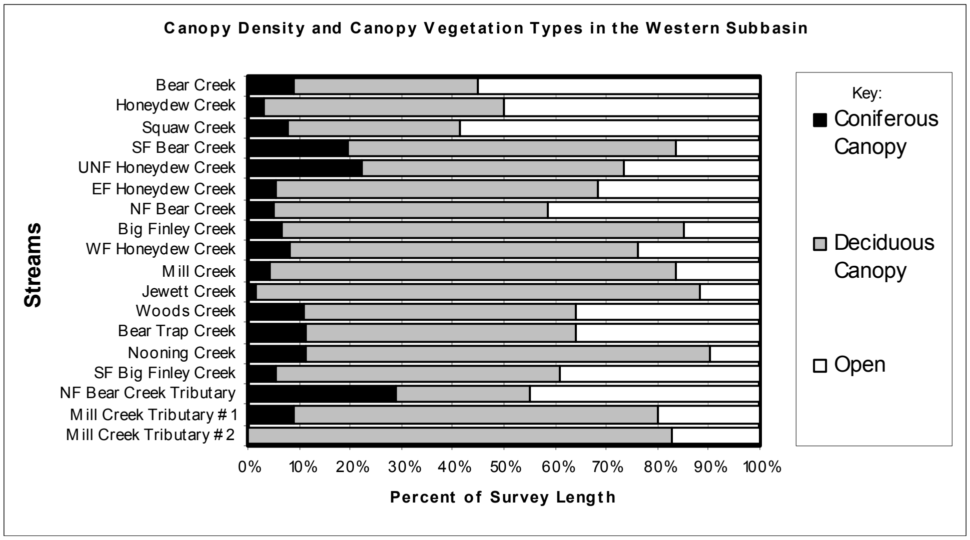


Figure 127. The Relative percentage of coniferous, deciduous, and open canopy covering surveyed streams, Western Subbasin.

Averages are weighted by unit length to give the most accurate representation of the percent of a stream under each type of canopy. Streams are listed in descending order by drainage area (largest at the top). As described in the EMDS response curves, total canopy (sum of conifer and deciduous canopy) exceeding 85% is considered fully suitable, and total canopy less than 50% is fully unsuitable for contributing to cool water temperatures that support salmonids.

Cobble embeddedness was measured at each pool tail crest during CDFG stream surveys. Cobble embeddedness is the percentage of an average sized cobble piece at a pool tail out that is embedded in fine substrate. Category 1 is 0-25% embedded, Category 2 is 26-50% embedded, Category is 3 51-75% is embedded, Category 4 is 76-100% embedded, and Category 5 is unsuitable for spawning due to factors other than embeddedness. Cobble embedded deeper that 51% is not within the fully supported range for successful use by salmonids. The EMDS Reach Model considers cobble embeddedness greater than 50% to be somewhat unsuitable and 100% to be fully unsuitable for the survival of salmonid eggs and embryos. Embeddedness values in the Western Subbasin are somewhat unsuitable or worse for the survival of developing salmonid eggs and embryos with the exception of Bear Creek and its tributaries where somewhat suitable conditions do exist (Figure 128). Figure 128 also illustrates how stream reaches rated as unsuitable overall may actually have some suitable spawning gravel sites distributed through the stream reach.

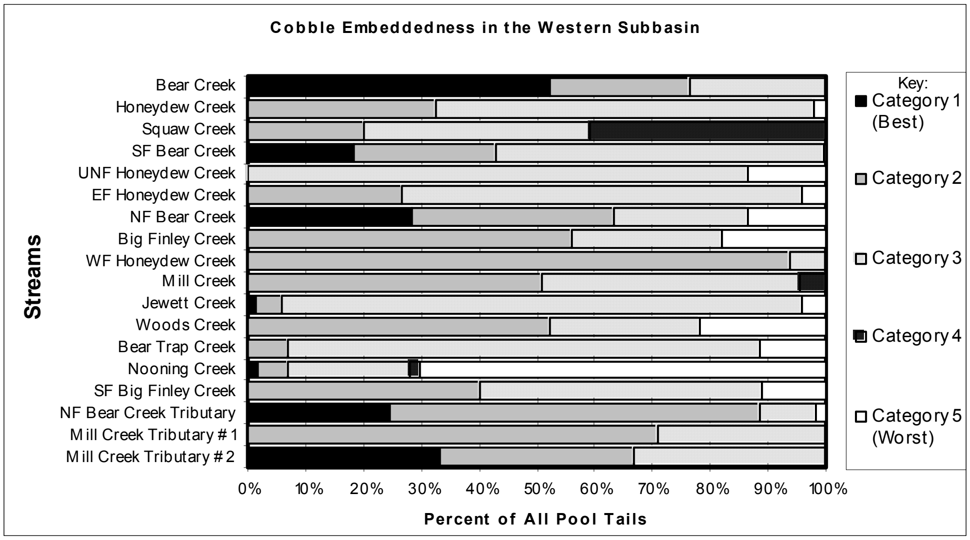


Figure 128. Cobble embeddedness categories as measured at every pool tail crest in surveyed streams, Western Subbasin.

Cobble embeddedness is the % of an average- sized cobble piece at a pool tail out that is embedded in fine substrate: Category 1 = 0-25% embedded, Category 2 = 26-50% embedded, Category 3 = 51-75% embedded, Category 4 = 76-100%, and Category 5 = unsuitable for spawning due to factors other than embeddedness (e.g. log, rocks). Substrate embeddedness Categories 3, 4, and 5 are considered by EMDS to be somewhat unsuitable to fully unsuitable for the survival of salmonid eggs and embryos. Streams are listed in descending order by drainage area (largest at the top).

Pool, flatwater, and riffle habitat units observed were measured, described, and recorded during CDFG stream surveys. During their life history, salmonids require access to all of these types of habitat. EMDS does not evaluate the ratio of these habitat types, but a balanced proportion is desirable. Most surveyed Western Subbasin streams have less than 20% pool habitat by length (Figure 129). This is well below the range considered fully suitable as described below. Dry units were also measured, and obviously indicate poor conditions for fish.

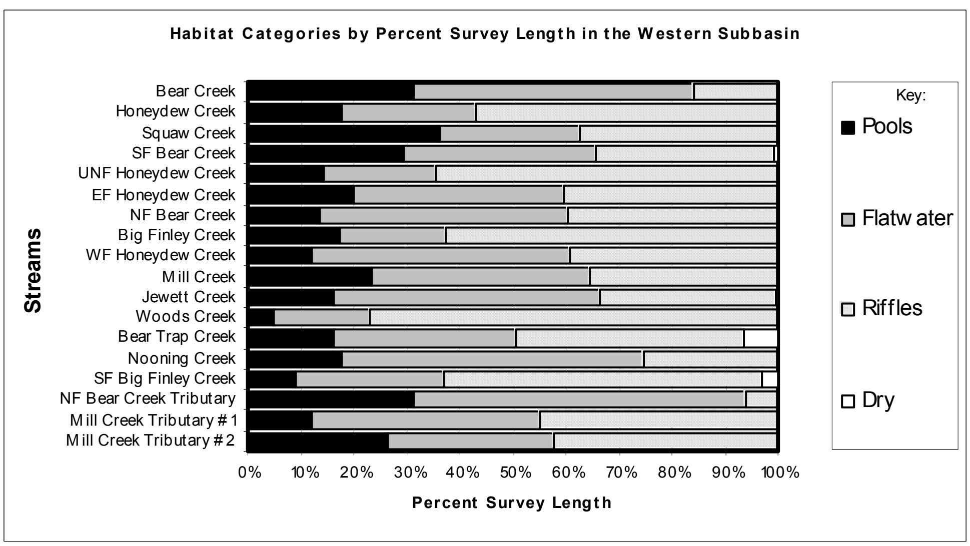


Figure 129. The percentage of pool habitat, flatwater habitat, riffle habitat, and dewatered channel by survey length, Western Subbasin.

EMDS does not evaluate the ratio of these habitat types, but a balanced proportion is desirable. Streams are listed in descending order by drainage area (largest at the top).

Pool depths were measured during CDFG surveys. The amount of primary pool habitat of sufficient depth to be fully suitable for anadromous salmonids is considered in the EMDS Reach Model. Primary pools are determined by a range of pool depths, depending on the order (size) of the stream. Generally, a reach must have 30 – 55% of its length in primary pools for its stream class to be in the suitable ranges. Generally, larger streams have deeper pools. Deviations from the expected trend in pool depth may indicate streams with more suitable or unsuitable pool depth conditions relative to other streams of that subbasin. The frequency of deeper pools in the Western Subbasin (Figure 130) yields EMDS ratings that vary from fully suitable to fully unsuitable. Pool depth is generally higher than for any other Mattole subbasin.

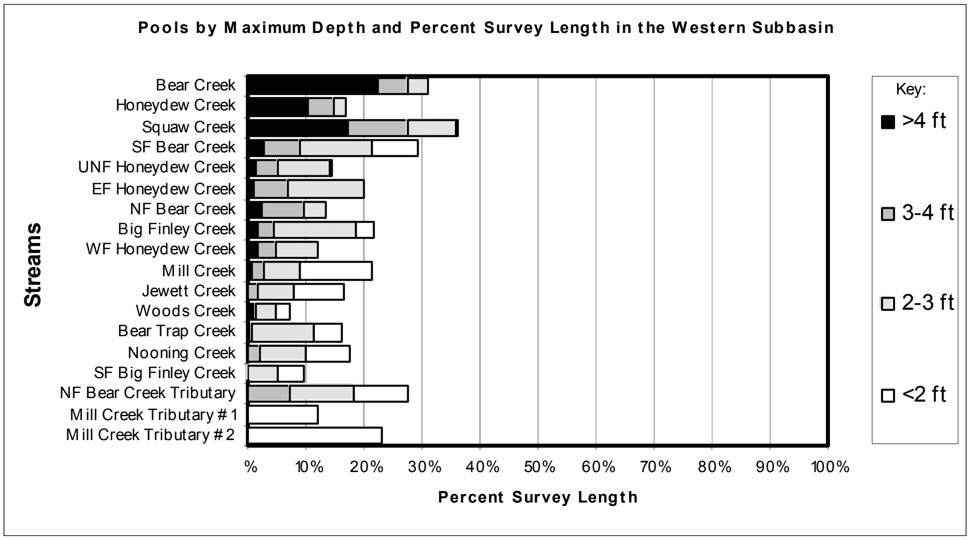


Figure 130. Percent length of a survey composed of deeper, high quality pools, Western Subbasin.

Values sum to the length of percent pool habitat in Figure 129. As described in the EMDS response curves, a stream must have 30-55% of its length in primary pools to provide stream conditions that are fully suitable for salmonids. Streams with <20 % or >90% of their length in primary pools provide conditions that are fully unsuitable for salmonids. Streams are listed in descending order by drainage area (largest at the top).

Pool shelter was measured during CDFG surveys. Pool shelter rating illustrates relative pool complexity, another component of pool quality. Ratings range from 0-300. The Stream Reach EMDS model evaluates pool shelter to be fully unsuitable if less than a rating of 30. The range from 100 to 300 is fully suitable. Pool shelter ratings in the Western Subbasin yield EMDS ratings that vary from fully suitable to fully unsuitable (Figure 131).

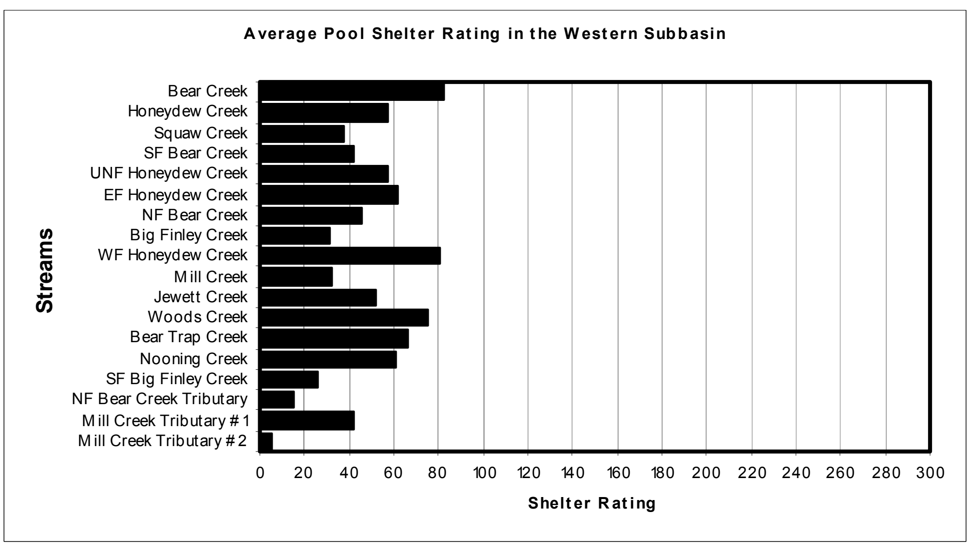


Figure 131. Average pool shelter ratings from CDFG stream surveys, Western Subbasin

As described in the EMDS response curves, average pool shelter ratings exceeding 80 are considered fully suitable and average pool shelter ratings less than 30% are fully unsuitable for contributing to shelter that supports salmonids. Streams are listed in descending order by drainage area (largest at the top).

In terms of the fish habitat relationship present in the Western Subbasin, it appears that habitat is somewhat unsuitable for salmonids as evaluated by EMDS. Additionally, data on fish passage barriers and water temperature (two important parameters considered by our assessment but not currently included in the

EMDS analysis) shows that there are two temporary and partial barriers, two partial salmonid barriers, five total salmonid barriers, and that several streams exceed temperatures suitable for salmonids in this subbasin. However, refugia from poor habitat conditions and suitable conditions for canopy density have allowed coho salmon to persist in six studied streams and steelhead trout to persist in nine surveyed streams.

Fish Passage Barriers

Stream Crossings

Nine stream crossings were surveyed in the Western Subbasin as a part of the Humboldt County culvert inventory and fish passage evaluation conducted by Ross Taylor and Associates (2000). Lighthouse Road near Petrolia has culverts on Bear Creek (RM 1.0), Mill Creek (RM 2.8), Stansberry Creek, and Titus Creek; the Mattole Road between Petrolia and Honeydew has culverts on Clear Creek, Granny Creek, Indian Creek and Saunders Creek; and Wilder Ridge Road has a culvert on High Prairie Creek. The culverts on Bear Creek, Clear Creek, High Prairie Creek, Stansberry Creek, and Titus Creek were found to be total salmonid barriers and the culverts on Indian Creek and Saunders Creek were found to be partial salmonid barriers (Table 142);*(Taylor, 2000; G. Flosi, Personal Communication).* The culverts on Granny Creek and Mill Creek (RM 2.8) were found to be temporary and partial salmonid barriers. In a list of priority rankings of 67 culverts in Humboldt County for treatment to provide unimpeded salmonid passage to spawning and rearing habitat, rankings of culverts in the Western Subbasin ranged from five for Stansberry Creek to 64 for Granny Creek. Criteria for priority ranking included salmonid species diversity, extent of barrier present, and risk of culvert failure, current culvert condition, salmonid habitat quantity, salmonid habitat quality, and a total salmonid habitat score. The culvert on Mill Creek (RM 2.8) is scheduled for improvements in 2002, the culvert on Clear Creek was improved in 2001, the culvert on Stansberry Creek was proposed and scheduled for improvement in 2001 but funding ran out, and the culvert on Saunders Creek is currently proposed for improvement (G. Flosi, personal communication).

Table 142. Culverts surveyed for barrier status in the Western Subbasin.

Stream Name	Road Name	Priority Rank	Barrier Status	Upstream Habitat	Treatment
Bear Creek	Lighthouse Road	15	Total barrier. Excessive under sizing probably creates a velocity barrier.	0.3 miles of potential salmonid habitat.	Proposed but not funded
Clear Creek	Mattole Road	7	Total barrier. An extremely steep gradient creates a total velocity barrier. Parallel steel tracks probably contribute to passage problems by increasing velocities, as they have minimal roughness, and interfering with a fish's swimming motion.	0.7 miles of good salmonid habitat.	Improved in 2001
Granny Creek	Mattole Road	64	Temporary and partial barrier. This culvert is a partial/temporary barrier for adult steelhead (only 20% passable) and a complete barrier for adult coho and all juveniles. Water levels are too shallow at low flows, and excessive velocities exist at higher flows. Both excessive slope and the long length of the culvert cause passage problems.	0.7 miles of poor salmonid habitat.	None proposed at this time
High Prairie Creek	Wilder Ridge Road	50	Total barrier. The culvert is a complete barrier for all adults and juveniles. Water levels are too shallow at low flows, and excessive velocities exist at higher flows. Both excessive slope and a smooth floor cause passage problems. The baffles are poorly installed, and flow is turbulent and fast during even moderate runoff. The outlet pool is not deep enough for salmonids to jump into the culvert.	1.4 miles of poor salmonid habitat.	None proposed at this time
Indian Creek	Mattole Road	13	Partial barrier. Partial barrier for adults, nearly complete barrier for juveniles. Water levels are too shallow at low flows, and excessive velocities exist at higher flows. Direct observation of juveniles suggests that the entry jump and flow velocities were problems.	1.2 miles of good salmonid habitat.	Proposed but not funded
Mill Creek (RM 2.8)	Lighthouse Road	20	Temporary and partial barrier. A temporary barrier for adults. Excessive velocities at higher migration flows exist. A barrier for juveniles. An excessive jump is required to enter the culvert and velocities appear excessive even with baffles.	1.35 miles of good salmonid habitat.	Improved in 2002
Saunders Creek	Mattole Road	16	Partial barrier. Partial barrier for adult steelhead (only 24% passable) and a complete barrier for adult coho and all juveniles. Water levels are too shallow at low flows and excessive velocities exist at higher flows. Both excessive slope and a smooth floor cause passage problems. Juveniles were observed failing to swim even several feet up the culvert due to velocity. Measured velocities were 10-12 ft per second during a low-moderate winter migration flow.	0.7 miles of fair salmonid habitat.	Proposed but not funded
Stansberry Creek	Lighthouse Road	5	Total barrier. An excessive jump is required to enter the culvert, while there is a lack of depth to execute such a jump. A steep gradient and excessive under sizing creates a velocity barrier.	0.7 miles of potential salmonid habitat.	Proposed but not funded
Titus Creek	Lighthouse Road	46	Total barrier. Steep gradient, length and excessive under sizing create a velocity barrier.	0.4 miles of poor salmonid habitat.	None proposed

Dry Channel

CDFG stream inventories were conducted for 49.9 miles on 33 reaches of 18 tributaries in the Western Subbasin. A main component of CDFG Stream Inventory Surveys is habitat typing, in which the amount and location of pools, flatwater, riffles, and dry channel is recorded. Although the habitat typing survey only records the dry channel present at the point in time when the survey was conducted, this measure of dry channel can give an indication of summer passage barriers to juvenile salmonids. Dry channel conditions in the Mattole Basin generally become established from late July through early September. Therefore, CDFG stream surveys conducted outside this period are less likely to encounter dry channel.

Dry channel disrupts the ability of juvenile salmonids to move freely throughout stream systems. Juvenile salmonids need well-connected streams to allow free movement to find food, escape from high water temperatures, escape from predation, and migrate out of their stream of origin. The amount of dry channel reported in surveyed stream reaches in the Western Subbasin is 0.04% of the total length of streams surveyed. Dry channel was found in three streams (Table 143, Figure 132). Dry habitat units occurred near the mouth of Bear Trap Creek and the South Fork of Big Finley Creek, in the middle reaches of Jewett Creek, and at the upper limit of anadromy in the South Fork of Bear Creek. Dry channel at the mouth of a tributary disconnects that tributary from the mainstem Mattole River, which can disrupt the ability of juvenile salmonids to access tributary thermal refugia in the summer. Dry channel in the middle reaches of a stream disrupts the ability of juvenile salmonids to forage and escape predation. Lastly, dry channel in the upper reaches of a stream indicates the end of anadromy.

Table 143. Dry channels recorded in CDFG stream surveys in the Western Subbasin.

Stream	Survey Period	# of Dry Units	Dry Unit Length (ft)	% of Survey Dry Channel
Mill Creek (R.M. 2.8)	July	0	0	0
Mill Creek (R.M. 2.8) Tributary #1	July	0	0	0
Mill Creek (R.M. 2.8) Tributary #2	July	0	0	0
Squaw Creek	September	0	0	0
Woods Creek	June	0	0	0
Honeydew Creek	July	0	0	0
Bear Trap Creek	July-August	1	638	6.5
Upper North Fork Honeydew Creek	July	0	0	0
East Fork Honeydew Creek	August	0	0	0
West Fork Honeydew Creek	July	0	0	0
Bear Creek	September	0	0	0
Jewett Creek	July	1	30	0.2
North Fork Bear Creek	July	0	0	0
North Fork Bear Creek Tributary #1	July	0	0	0
South Fork Bear Creek	June-July	1	400	0.6
Big Finley Creek	September	0	0	0
South Fork of Big Finley Creek	October	1	202	3.0
Nooning Creek	June	0	0	0

Fish History and Status

Historically, the Western Subbasin supported runs of Chinook salmon, coho salmon, and steelhead trout. Interviews with local residents indicate that coho salmon and steelhead trout have been found in the Bear Creek (RM 1.0), Stansberry Creek, Clear Creek, Indian Creek, Squaw Creek, and Woods Creek; and Chinook salmon have been found in Stansberry Creek, Indian Creek, Squaw Creek, and Woods Creek (Coastal Headwaters Association 1982). CDFG stream surveys before 1970 found steelhead trout in 15 streams, unidentified salmonids in six streams, and coho salmon in Mill Creek (RM 2.8), Clear Creek, Woods Creek, Bear Trap Creek, and Bear Creek. High densities of steelhead trout were estimated by CDFG for the South Fork of Bear Creek and Indian Creek (200-300 per 100 feet of stream) in 1966.

A study of Mattole Basin salmonids conducted in July and August 1972 (Brown, 1973b) examined Squaw Creek near its mouth. The steelhead trout density was 74 fish per 100 feet of stream.

Figure 132. Mapped dry channels of the Western Subbasin.

BLM, Coastal Headwaters Association, MSG, and CDFG stream surveys have continued to document the presence of steelhead trout in most streams in the Western Subbasin over time. BLM surveys in the 1970s and early 1980s found juvenile steelhead trout in seven streams. Coastal Headwaters Association surveys in 1981 and 1982 found steelhead trout in ten streams. MSG carcass surveys found steelhead trout in Mill Creek (RM 2.8), Honeydew Creek, Bear Creek, and the South Fork of Bear Creek in the late 1990s. CDFG surveys found steelhead trout in Squaw Creek, Bear Trap Creek, the East Fork of Honeydew Creek, and Jewett Creek in the 1980s and ten streams in the 1990s.

Unidentified salmonids were found in Indian Creek, Squaw Creek, the Upper East Fork of Honeydew Creek, Jewett Creek, and Nooning Creek by CDFG in the 1980s. These could have been Chinook or coho salmon. In addition, coho salmon were detected in Mill Creek (RM 2.8) and Bear Creek in the 1990s by CDFG stream surveys and in Big Finley Creek in 1995 by the Redwood Sciences Lab. MSG carcass surveys found coho salmon in Bear Creek and the South Fork of Bear Creek in the late 1990s and early 2000s. CDFG electrofishing in the 1990s also found coho salmon in Mill Creek (RM 2.8), the North Fork of Bear Creek, and the South Fork of Bear Creek. A 1997-99 Redwood Sciences Laboratory study of juvenile coho salmon distributions in relation to water temperatures in the Mattole Basin (Welsh et al. 2001) found coho salmon in Big Finley Creek and the South Fork of Bear Creek. The 2001 CDFG Coho Inventory found coho salmon in Mill Creek (RM 2.8), Woods Creek, and Honeydew Creek. More detailed summaries of stream surveys and fisheries studies in the Western Subbasin are provided in the CDFG Appendix F.

Western Subbasin Issues

- Instream habitat diversity and complexity, based on available survey data (i.e. pool depths, cover, and large woody debris) may be adequate for salmonid production. Based on current surveys, instream habitat appears to be recovering.
- Available data from sampled streams suggests that high summer temperatures are deleterious to summer rearing salmonid populations in some streams in this subbasin.
- Instream sediment throughout this subbasin may be approaching or exceeding levels considered unsuitable for salmonid populations.
- Although, the rural road system is not as extensive as in the other subbasins, there is concern that inadequate maintenance and storm-proofing of existing roads, both active and abandoned, are causing large amounts of sediment to be contributed to local stream systems.
- Large woody debris recruitment potential is poor in this subbasin.

Western Subbasin Integrated Analysis

The following tables provide a dynamic, spatial picture of watershed conditions for the freshwater lifestages salmon and steelhead. The tables' fields are organized to show the extent of watershed factors' conditions and their importance of function in the overall watershed dynamic. Finally a comment is presented on the impact or condition affected by the factor on the watershed, stream, or fishery. Especially at the tributary and subbasin levels, the dynamic, spatial nature of these processes provides a synthesis of the watershed conditions and indicates the quantity and quality of the freshwater habitat for salmon and steelhead.

Geology

Introduction

The potential for sediment production is strongly influenced by the underlying geology. The following IA tables compiled by CGS examine the influence of geology on sediment production by comparing the distribution of geomorphic terrains (hard, moderate, and soft bedrock terrains, and the separately grouped Quaternary surficial deposits) against the observation of landslides and geomorphic features related to mass wasting within the subbasin. The first table presents the proportions of the subbasin underlain by each of the terrains. The next table looks at hillside gradient within the subbasin. The distribution of historically active landslides, gullies, and inner gorges by terrain are then considered. Finally, the landslide potential map developed by CGS is examined with respect to the terrains.

Table 144. Geomorphic terrains as a proportion of the Western Subbasin.

Proportion of Western Subbasin Basin Underlain by the Different Geomorphic Terrains				
Feature/Function			**Significance**	**Comments**
Terrain Type	**Proportion of Subbasin Area**	**Terrain Area within Subbasin as a Proportion of Mattole Basin Area**	The geomorphic terrains represent groupings of geologic map units based on similarities in geology, geomorphic expression, and landslide occurrence. They provide a simplified division of the watershed useful in comparing the influence of bedrock geology to the distribution of other mapped features.	This subbasin is second only to the Southern Subbasin in the proportion of hard terrain and, because of its larger size, actual includes more area of hard terrain than any other subbasin. The limited area of soft terrain are concentrated along the Cooskie shear zone in the northern portion of the subbasin.
Hard	50%	15%		
Moderate	24%	7%		
Soft	19%	6%		
Quaternary[1]	7%	2%		
1 Areas where young (Quaternary) surficial units have been mapped covering bedrock; includes alluvium, as well as terrace deposits, active stream channel deposits, and other alluvial deposits.				

Table 145. Hillside gradient in the Western Subbasin.

Hillside Gradient in the Western Subbasin							
Feature/Function						**Significance**	**Comments**
Proportion of Subbasin Area						Hillside slope is an important indicator of potential instability (steeper is generally less stable). The terrain type influences the degree to which hillside slope affects the slope stability.	This subbasin ranks first within the Mattole Basin for the highest percentage of moderately steep to very steep slopes areas. Typically, the steeper slopes reflect the presence of hard and moderate terrain while the less steep slopes reflect the presence of soft terrain.
Range in % slope							
0-10	**10-30**	**30-40**	**40-50**	**50-65**	**>65**		
5	14	15	18	25	23		

Table 146. Small historically-active landslides by terrain in the Western Subbasin.

Distribution of Small Historically-Active Landslides by Geomorphic Terrain in the Western Subbasin				
Feature/Function			Significance	Comments
Terrain Type	Small Point Landslides1 Mapped from year 19812, 1984, or 2000 Photographs		The relative number of small point slides is used to evaluate which geomorphic terrains are more prone to small, localized slope failures.	The majority of small failures occur in the hard terrain and consist primarily of shallow debris slides associated with steep slopes. However, the larger number of point slides in the hard and moderate terrain is somewhat a reflection of the greater areal extant of these terrains within the subbasin.
	Point Count	Area3 (acres)		
Hard	866	86		
Moderate	526	52		
Soft	296	29		
Quaternary	13	1		

1 Mapping was compiled at a 1:24,000 scale. Landslides smaller than approximately 100 feet in diameter were captured as points in the GIS database; larger features were captured as polygons.
2Landslides included from year 1981 photographs are from previous mapping by Spittler (1983 and 1984) covering limited portions of the Mattole Basin.
3 Based on assumed average area of 400 square meters (roughly 1/10th acre) for small landslides.

Table 147. All historically-active landslides by terrain in the Western Subbasin.

Distribution of All Historically-Active Landslides by Terrain in the Western Subbasin				
Feature/Function			Significance	Comments
Terrain Type	Combined Area (acres) of All Historically-Active Landslides1	Proportion of Total Active Landslide Area within Subbasin	The relative percentage of area covered by historically-active slides identifies which geomorphic terrains are most prone to relatively large-scale slope failures.	Only about 14% of the total area occupied by active landslides in the Mattole Basin are found in the Western Subbasin. Soft terrain forms less than a fifth of the subbasin, yet contains more than a third of the total landslide area within the subbasin.
Hard	511	36%		
Moderate	362	25%		
Soft	544	38%		
Quaternary	9	1%		

1 Includes small point and larger polygon features mapped from year 1981, 1984 and 2000 photos. Where landslides overlapped (i.e., the same or similar features mapped from more than one photo set) the area of overlap was counted only once. Small landslides captured as points in the GIS database were assumed to have an average area of 400 square meters (roughly 1/10th acre).

Table 148. Gullies and inner gorges by terrain in the Western Subbasin.

Distribution of Gullies and Inner Gorges by Terrain in the Western Subbasin				
Feature/Function			Significance	Comments
Terrain Type	Proportion of Total Mapped Gully Lengths1 in Subbasin	Proportion of Total Mapped Inner Gorge Lengths1 in Subbasin	Gullies and inner gorges are an important indicator of ongoing sources of sediment to the fluvial system.	Soft terrain forms less than a fifth of the Western Subbasin, yet the large majority of mapped gully lengths in the subbasin are located in soft terrain; gully erosion is a significant, on-going contributor of sediment from soft terrain areas. Because inner gorges are found preferentially in hard terrain, and to a lesser degree moderate terrain, the distribution of inner gorges reflects the greater areal extant of hard and moderate terrains within the subbasin. Inner gorges act as sediment source areas primarily through debris sliding.
Hard	12%	59%		
Moderate	11%	26%		
Soft	75%	13%		
Quaternary	2%	2%		

[1] Includes only those features mapped from year 2000 photographs.

Table 149. Landslide potential by terrain in the Western Subbasin area.

Distribution of Landslide Potential Categories by Terrain as a Proportion of the Western Subbasin Area							
Feature/Function						Significance	Comments
Terrain Type	Landslide Potential Category1						
	1	2	3	4	5		
Hard	0.2%	6.1%	17.5%	8.5%	17.9%	Categories 4 and 5 represent the majority of unstable areas that are current or potential future sources of sediment.	Hard and moderate terrains are similarly represented in LPM Categories 4 and 5 relative to their areal extant within the subbasin; in comparison, soft terrain is proportionally over represented relative to its areal extent. The presence of steep to very steep slopes over nearly half of the subbasin contributes to the large proportion of unstable areas.
Moderate	0.2%	1.5%	11.7%	5.4%	5.3%		
Soft	0.1%	0.4%	4.2%	9.0%	5.2%		
Quaternary	4.0%	2.0%	0.6%	0.1%	0.2%		
Subbasin Total2	**4.5%**	**10.0%**	**34.0%**	**23.0%**	**28.6%**		

1 Categories represent ranges in estimated landslide potential, from very low (category 1) to very high (category 5); see Geologic Report, Plate 2.
2 Percentages are rounded to nearest 1/10 %; sum of rounded values may not equal 100%.

Discussion

Encompassing the dramatic relief of the King Range, the Western Subbasin has the highest proportion of steep to very steep slopes (areas exceeding 50% gradient) in the Mattole Basin. Despite this, the Western Subbasin is comparatively stable with only a small proportion (about 14%) of the total area occupied by historically active landslides within the Mattole Basin being found here. Most of the steeper slope areas are located in the half of the subbasin underlain by hard terrain, where landsliding typically occurs in the form of small debris slides. More than one third of the area occupied by larger landslides, as well as 75% of the gully lengths within the subbasin, are concentrated in the 19% of the subbasin underlain by soft terrain.

Vegetation and Land Use

Introduction

CDF NCWAP developed a number of tables that are intended to help identify and highlight how current patterns of vegetation and land use are expressed in relation to the geology of the watershed. First, vegetation and land use are related to the underlying bedrock geology or terrain type. These patterns are then explored by examining the current vegetation and recent timber harvesting in relation to their occurrence in landslide potential classes, the product of a model that uses terrain type, vegetation, and landslides as variables. Landslide causality was not assigned and recent timber harvest activity has occurred in low percentages in most of the planning watersheds. The significance of the geologic characteristics in these tables is expressed as a relative rating and is not characterized numerically.

Table 150. Vegetation types associated with terrain types in the Western Subbasin.

Vegetative Condition in the Western Subbasin								
Feature/Function							Significance	Comments
Terrain Type	Vegetation Type							
	Conifer	Mixed	Hardwood	Grassland	Other	Total		
Hard	12%	63%	22%	2%	1%	100%	The differences between the slope, soils, and stability of the geologic terrain results in a different mosaic of vegetation in each of these areas. The combination of the geologic and vegetative conditions between the terrain results in some differences in land use and sensitivity to impacts from land use.	While grassland is strongly associated with the soft and quaternary terrain types, the majority of acreage is in tree dominated vegetation. Timber harvesting impacts in soft terrain may be higher than the THP required estimated surface soil erosion hazard rating (EHR) worksheet may indicate.
Moderate	10%	63%	21%	4%	2%	100%		
Soft	5%	43%	21%	27%	4%	100%		
Quaternary	2%	21%	16%	26%	35%	100%		

Table 151. Riparian vegetation (within 150 feet of streams) types associated with terrain types in the Western Subbasin.

Riparian Vegetative Condition in the Western Subbasin									
Feature/Function								Significance	Comments
Terrain Type	Riparian Vegetation Type								
	Conifer	Mixed	Hardwood	Grassland	Barren	Other	Total		
Hard	21%	64%	14%	1%	<1%	<1%	100%	The differences between the slope, soils, and stability of the geologic terrain results in a different mosaic of vegetation in each of these areas. The combination of the geologic and vegetative conditions between the terrain results in some differences in land use and sensitivity to impacts from land use. The riparian vegetation in this zone is the primary source of large woody debris. The species and size of large woody debris provided to the stream system over time is at least partially dependent upon the inherent slope stability of the underlying terrain type.	Riparian vegetation is in tree-type vegetation at a proportionately higher percentage than the overall subbasin landscape. Vegetation removal impacts in riparian soft terrain should considered the heightened susceptibility of soft terrain to gullying. The large percentage of barren ground in the quaternary terrain type includes areas of expansive stream channel.
Moderate	15%	65%	17%	1%	<1%	2%	100%		
Soft	6%	58%	20%	11%	1%	4%	100%		
Quaternary	3%	25%	20%	8%	32%	12%	100%		

Table 152. Land use associated with terrain types in the Western Subbasin..

Land Use in the Western Subbasin						
Feature/Function					Significance	Comments
Terrain Type	Landuse Type					
	Public	Ag/Timber	Other	Total		
Hard	65%	26%	9%	100%	About half of the Western Subbasin is in public ownership. Most of the soft terrain type is privately owned and in an agriculture or timber land use designation. The other category often includes housing and contains many parcels 160 acres or less in size. The town of Honeydew is within the western subbasin.	Historic logging occurred across all ownership types, leaving a legacy of young vegetation and dirt-surfaced roads. The Bureau of Land Management currently administers the King Range National Conservation Area, about 50% of the subbasin acreage, as a Late Successional reserve. Residents are interested in restoration work if funding and assistance is provided. The Mattole Restoration Council, a local watershed group, is an active participant and coordinator of restoration projects in this subbasin, with several projects including the Good Roads, Clear Creeks Program, and Mattole River and Range Partnership.
Moderate	43%	43%	14%	100%		
Soft	12%	74%	14%	100%		
Quaternary	10%	58%	32%	100%		

Table 153. Road mileage and density associated with terrain types in the Western Subbasin.

Roads in the Western Subbasin				
Feature/Function			Significance	Comments
Terrain Type	Miles (of road)	Road Density (miles per sq. mile)	Roads crossings on steep slopes in hard and moderate terrain may increase the potential for debris slides while roads within the soft terrain may increase the potential for small earthflows, gullies, and erosion. The alluvium terrain type tends to be relatively flat, but proximity to watercourses may allow for direct delivery of sediment from the roads to the streams.	While current practices locate roads on less environmentally sensitive locations, typically gentle ground high on the hillslope, the presence of soft terrain in these areas should be considered. Roads in soft terrain require construction and maintenance standards that recognize the inherent instability of this terrain type.
Hard	162	3.5		
Moderate	98	4.3		
Soft	94	5.5		
Quaternary	46	7.9		
Total	**400**	**4.4**		

Table 154. Data summary table for the Western Subbasin..

Factor	Western Subbasin	
Timber Harvest 1990 -2000¹	**acres**	**% area**
Silviculture Category 1		
Tractor	0	0.0%
Cable	0	0.0%
Helicopter	24	0.0%
TOTAL	24	0.0%
Silviculture Category 2		
Tractor	6	0.0%
Cable	0	0.0%
Helicopter	24	0.0%
TOTAL	30	0.1%
Silviculture Category 3		
Tractor	54	0.1%
Cable	0	0.0%
Helicopter	61	0.1%
TOTAL	115	0.2%
TOTAL	**170**	**0.3%**
Other Land Uses	acres	% area
Grazing	4,023	7.0%
Agriculture	611	1.1%
Development	3	0.0%
Timberland, No Recent Harvest	48,598	84.1%
TOTAL	**53,235**	**92.2%**
Roads		
Road Density (miles/sq. mile)	4.4	
Density of Road Crossings (#/stream mile)	0.6	
Roads within 200 feet of Stream (miles/stream mile)	0.1	

Silvicultural Category 1 includes even-aged regeneration prescriptions: clear-cut, rehabilitation, seed tree step, and shelter wood seed step prescriptions. Category 2 includes prescriptions that remove most of the largest trees: shelter wood prep step, shelter wood removal step, and alternative prescriptions. Category 3 includes prescriptions that leave large amounts of vegetation after harvest: selection, commercial thin, sanitation salvage, transition, and seed tree removal step prescriptions.

Table 155. Land use and vegetation type associated with historically active landslides in the Western Subbasin.

Historically Active Landslide Feature1	Western Subbasin	Woodland and Grassland2	THPs 1990 - 20005	Timberland, No Recent Harvest3	Roads4	
	% of Area	% of Area	% of Area	% of Area	Length (miles)	% of Total Length
Earthflow	0.7%	0.4%		0.2%	2.6	0.7%
Rock Slide	0.2%	0.0%	0.0%	0.2%	1.1	0.3%
Debris Slide	1.3%	0.1%		1.0%	4.4	1.1%
Debris Flow	0.0%			0.0%	0.0	0.0%
All Features	**2.2%**	**0.6%**	**0.0%**	**1.4%**	**8.1**	**2.1%**

A larger percentage (4.7%) of the woodland/grassland vegetation type is occupied by slides than the timberland type (1.7%). Within the woodland/grassland category, earthflows are the dominant landslide feature while debris slides occupy 71% of the slide acreage in the timberland type, almost all of which has had harvest activity prior to the last ten years. Recent THPs occupy 0.3% percent of the subbasin acreage. The road length by percent that intersects historically active slides is the same as the proportion of landslide acres across the subbasin.

1 This category includes only large polygon slides and does not include point slides.
2 Woodland and grassland includes areas mapped in 1998 as grassland and non-productive hardwood.
3 Area of timberlands that were not contained in a THP during the 1991 to 2000 period.
4 Roads layer is from the Information Center for the Environment (ICE) at UC Davis.
5 THP's are complete or active between the 1990 and 2000 timeframe.
Empty cells denote zero.
Percent of area is based on the unit of analysis: Watershed, subbasin, or planning watershed.

Table 156. Land use and vegetation type associated with relative landslide potential in the Western Mattole Subbasin.

Relative Landslide Potential1	Western Subbasin	Woodland or Grassland2	THPs 1990 - 20005	Timberland, No Recent Harvest3	Roads4	
	% of Area	% of Area	% of Area	% of Area	Length (miles)	% of Total Length
Very Low	4.5%	1.4%	0.0%	1.3%	23.7	6.0%
Low	10.0%	1.5%	0.0%	8.1%	48.7	12.4%
Moderate	34.0%	3.6%	0.1%	30.2%	144.8	36.8%
High	23.0%	3.5%	0.1%	19.0%	94.8	24.1%
Very High	28.6%	2.5%	0.0%	25.6%	81.9	20.8%
TOTAL	**100%**	**12%**	**0%**	**84%**	**393.9**	**100%**
In the Western Subbasin, 12% of the area is in the woodland/ grassland vegetation type. Half of the acreage for this category is found in the two highest relative landslide potential categories. About 84% of the subbasin is characterized as timberland with no recent harvest and almost half of this area is concentrated in the two highest relative landslide potential classes. The subbasin has about 393 miles of roads, with the proportion of road length in relative landslide potential categories similar to the percentage of total acres in each class, although there is a slight shift towards lower relative landslide potential classes.						

1 Refer to Plate 2 and California Geological Survey appendix.
2 Woodland and grassland include areas mapped in 1998 as grassland and non-productive hardwood.
3 Area of timberlands that were not contained in a THP during the 1991 to 2000 period.
4 Roads layer is from the Information Center for the Environment (ICE) at UC Davis.
5 THP's are complete or active between the 1990 and 2000 timeframe.
Percent of area is based on the unit of analysis: Watershed, subbasin, or planning watershed.

Discussion

The Western Subbasin contains about one quarter of the soft terrain found in the Mattole Basin, similar to the amount found in the Eastern Subbasin. In addition, the Western Subbasin contains the second highest percentage of acreage (51%) in the two highest relative landslide potential categories. It also contains the second lowest percentage of land area in both historically active (2%) and dormant landslide features (16%). The large percentage of the subbasin in high landslide potential classes suggests that land use practices should have careful site-specific evaluation in order to avoid land use accelerated sedimentation in the streams. The large block of reserved public land (BLM, King Range) allows for the possibility of monitoring the progression of stream recovery in the absence of additional timber harvesting and grazing in some streams in the Mattole Basin. A joint monitoring agreement between State and Federal agencies would further the scientific basis for government action in regulation and restoration programs. Timber harvesting has occurred on less than 1%, or approximately 57 acres/year, of the subbasin since 1990, while grazing continues on private grasslands. Current land use activities, including grazing and most road use and maintenance for grazing and residential access, are often outside the current regulatory process. Education and economic incentives for road improvements and livestock management provide the greatest opportunities for near-term benefits for fisheries.

Fluvial Geomorphology

Introduction

Fluvial geomorphic mapping of channel characteristics was conducted along blue line streams in the Mattole Basin to document channel characteristics that are indicative of excess sediment production, transport, and/or response (deposition); these features are referred to as negative mapped channel characteristics (NMCCs). The following CGS Integrated Analysis (IA) Tables present some of the findings of this investigation. To understand the distribution of these NMCC's we present: the predominant NMCC's identified; the relative distribution of these features between the bedrock terrains and the Quaternary units; the changes in amount and distribution of NMCC's observed between 1984 and 2000; and the relationship between areas of projected slope instability and portions of streams with evidence of excess sediment.

Table 157. Negative mapped channel characteristics in the Western Subbasin.

Negative Mapped Channel Characteristics in the Western Subbasin						
Feature/Function					**Significance**	**Comments**
		From 1984 Photos	**From 2000 Photos**	**%4 Change 1984 to 2000**	The reduction in the total length of NMCC's over time qualitatively reflects the degree of improvements within the blue line streams. These NMCC's were chosen to be highlighted in these figures because in both photo years, the NMCC's observed were dominated by wide channels and, secondarily, by displaced riparian vegetation. Most of this observed improvement results from reductions in the proportion of streams affected by displaced riparian vegetation and wide channels.	That portion of the fluvial system observed to be affected by wide channel in 1984 has recovered extensively by 2000.
Blue Line Streams where Wide Channel (wc) Observed		See Figure 34				
Blue Line Streams where Displaced Riparian Vegetation (dr) Observed		See Figure 35				That portion of the fluvial system observed to be affected by displaced riparian vegetation in 1984 has practically disappeared by 2000.
% of the all Blue Line Stream Segments in Basin affected by NMCC's	**Total**	33%	16%	-16%	These values identify how much of the streams have been affected by NMCC's. Decreases in the length of stream affected by NMCC's quantitatively represent the degree of improvement within blue line stream reaches.	The fluvial system in bedrock terrains has experienced significant improvements between 1984 and 2000, but still remains impacted by NMCC's. Alluvial units within this subbasin have experienced an increase in the length of blue line streams affected by NMCC's.
	Bedrock	37%	15%	-22%		
	Alluvium	19%	20%	+2%		

Negative Mapped Channel Characteristics in the Western Subbasin (Continued)					
Feature/Function				**Significance**	**Comments**
	From 1984 Photos	**From 2000 Photos**	**%4 Change 1984 to 2000**	The magnitude of decrease in affected streams quantitatively represents the degree of improvement within bedrock stream reaches adjacent to unstable areas. Because the streams in the Quaternary units are commonly separated from the surrounding hillsides by alluvial terraces and floodplains, the NMCCs observed there do not directly result from input into the streams from landslides that occur on the surrounding hillsides. Therefore, NMCC's in alluvial areas have been interpreted as having been transported from upstream bedrock reaches. For this reason, the analysis of NMCC's vs. LPM 4 and 5 excludes the NMCC's identified in the Quaternary units and only describes the relationship between these two features as it applies to the bedrock reaches.	The fact that NMCC's are not ubiquitous in bedrock streams adjacent to or within LPM categories 4 and 5 indicates that although entire reaches of the streams have potentially unstable slopes above them, only a portion of those slopes have delivered or transported sediment to the streams. There has been a significant decrease in blue line streams within LPM categories 4 and 5 affected by NMCC's.
Percentage of all Blue Line Stream segments in bedrock that are: 1) adjacent to or within LPM Categories 4 and 53 and 2), affected by NMCC's	44%	18%	-26%		
Percent of total NMCC length in bedrock, within 150 feet of LPM Categories 4 and 52	100%	100%	0%	Percentage reflects likelihood that the presence of NMCC's in bedrock are related to LPM categories 4 and 5 and that these unstable areas represent current and future potential sources of sediment to streams.	Virtually all of the total NMCC's observed in bedrock terrains were found on blue line streams adjacent to or within LPM category 4 and 5. Therefore, we interpret a clear relationship between areas of projected slope instability and portions of streams with negative sediment impacts, and that some portion of hillsides with high landslide potential are delivering sediment to the adjacent streams.

1 Include all areas identified as hard, moderate or soft geomorphic terrain.
2 Areas where young (Quaternary) surficial units have been mapped covering bedrock; includes alluvium, as well as terrace deposits, active stream channel deposits, and other alluvial deposits.
3 Landslide Potential Map developed by CGS for the Mattole Basin; see California Geological Survey Report, Appendix A and Plate 2.
4 Percentages are rounded to nearest 1%; sum of rounded values may not equal rounded totals or 100%.

Discussion

The results of our fluvial geomorphic mapping of channel characteristics that may indicate excess sediment accumulations (NMCC's) can be summarized as follows.

- Changes in the distribution of NMCC's between 1984 and 2000 show different patterns in the bedrock and Quaternary unit reaches.
- Channel conditions in bedrock streams have generally improved between 1984 and 2000.
- Channel conditions in the Quaternary unit reaches have degraded between 1984 and 2000. Considering the low concentration of NMCC's in the Southern Subbasin, it appears sediment is being transported to these reaches from upstream sources inside this subbasin or from the adjacent Eastern Subbasin.
- Virtually all of the NMCC's in bedrock terrains were identified along portions of the streams that are near potentially unstable slopes and the total length of NMCC's in these areas has decreased between 1984 and 2000. Therefore, we conclude that portions, but not all, of the hillslopes in the high to very high landslide potential categories are delivering sediment to the adjacent streams.

Water Quality

Introduction

The Western Subbasin has a more complete record of water quality information due largely to better accessibility to area watercourses in part because of BLMs extensive land ownership in the subbasin. Thermograph data is fairly representative and widespread although, except for Honeydew and Bear Creeks, much of the data was gathered near the confluences of sampled streams with the Mattole mainstem. Thermal imaging took place in three streams, Bear, Honeydew, and Squaw Creeks. Sediment records were available for both V* and D50 (pebble counts) in a number of watercourses. The only physical-chemical information available was for nutrient and fecal coliform sampling conducted by the BLM in the South Fork Bear Creek.

Table 158. Western Subbasin water quality integrated analysis table

Feature/Function		**Significance**	**Comments**
		Temperature	
MWATs (37 Thermograph Records for 22 Stations)		Maximum weekly average temperature (MWAT) is the temperature range of 50-60°F considered fully suitable of the needs of several West Coast Salmonids.	Unsuitable throughout subbasin
Suitable Records	**Unsuitable Records**		
8	29		
Maximum Temperatures (38 Thermograph Records for 14 Stations)		A maximum-peak temperature of 75°F is the maximum temperature that may be lethal to salmonids if cool water refugia is unavailable.	Mostly suitable throughout subbasin
Suitable Records	**Unsuitable Records**		
30	8		
Thermal Infrared Imaging Median Surface Temperature		Ability to assess surface water temperatures at the river-stream-reach level for a holistic picture of thermal distribution.	On the date and time of imaging median surface temperatures in the three sampled streams were in general agreement with thermograph data that showed they were mostly suitable for salmonids. See below for data limitations of thermal imaging. Data limitations: 1) Assessments generally performed on a specific day and time, 2) not comparable to seasonally assessed MWAT or maximum temperatures, 3) unable to assess below water surface. Note: Thermal imaged median surface temperatures are derived from the minimum and maximum imaged surface temperatures scaled to a particular point in a sample cell (cell approximately = 317 feet x stream width). Cell minimum and maximum rarely varied more than 1-3 °F
Tributary	**Minimum/ Maximum (°F)**		
Bear Creek	60/ 70		
Honeydew Creek	58 / 71		
Squaw Creek	56 / 73		
		Sediment	
Tributary	**Date V***	V* measures the percent sediment filling of a streams pool, compared to the total pool volume. Pools with lower V* values are thought to provide suitable salmonid habitat and may also indicate relatively low watershed disturbances. The V* ranges, below, derived from Knopp, 1993, are meant as reference markers and should not be construed as regulatory targets: V* ≤ 0.30 = low pool filling; correlates well with low upslope disturbance V* > 0.30 and ≤ 0.40 = moderate pool filling; correlates well with moderate upslope disturbance V* > 0.40 = High (excessive) rates of pool filling; correlates well with high upslope disturbance	

Feature/Function		Significance	Comments
NFK Bear Creek	1992 0.25		V* = 0.25 indicates moderate pool filling.
WFK Honeydew Creek	2001/ 1992 0.22 / 0.10		Both V* results are indicative of low pool filling with fine sediment and may indicate little watershed disturbance and/or efficient hydraulic sediment transport. Note: Both multi-year data sets were derived from two spatially isolated field sites and are not comparable.
Mill Creek	2001 0.26		V* = 0.26 indicates moderate pool filling with fine sediment.
Squaw Creek	2001 0.24		V* = 0.24 indicates moderate pool filling
Tributary	**Date D50 (mm)**	D50 means that 50 percent of the particles, measured in millimeters, on a riffle are smaller, and 50 percent are larger than the reported value. It is a simple and rapid stream assessment method that may help in determining if land use activities or natural land disturbances are introducing fine sediment into streams. In those Northern California basins with TMDLs where D50s are, or are considered for use as a numeric target, a mean D50 of > 69 mm, and minimum D50 > 37mm are desired future conditions over a specified time interval. Only the Garcia River TMDL has formally adopted these numeric targets and, for the Mattole River, are used as reference points only.	
NFK Bear Creek	1992 62 mm		D50 of 62 mm indicates medium surface particle size transport and deposition on riffles
WFK Honeydew Creek	1992 106 mm		D50 of 106 mm indicates transport and deposition of large to very large particles on riffles.
Water Chemistry and Quality			
pH/Dissolved Oxygen/Conductivity: No data available		Measure of ionic and dissolved constituents in aquatic systems; correlates well with salinity. Quantity/quality of dissolved solids-ions can determine abundance, variety, and distribution of plant/animals in aquatic environments. Osmoregulation efficiency largely dependent on salinity gradients. Estuary salinity essential to outmigrant smoltification.	
Chemistry/Nutrients		Quality and quantity of natural and introduced chemical and nutrient constituents in the aquatic environment, can be toxic, beneficial, or neutral to organisms (whether terrestrial or aquatic), and their various life phases. Chemical composition, in part, influenced by rainfall, erosion and sedimentation (parent bedrock, overlying soils), solution, evaporation, and introduction of chemicals/nutrients through human and animal interactions.	
SFK Bear Creek Fecal coliform sampling in 1995 was non-detectable		Fecal coliform sampling and analysis can indicate the presence/absence of human and animal wastes in surface and groundwater from nearby sewage facilities, livestock, wild animals, etc.	Public concerns prompted BLM to conduct fecal coliform sampling at campgrounds adjacent SFK Bear Creek. Lab results were below minimum health standards and not a threat to human health and or water quality

References: Knopp, 1993; Mattole Salmon Group, 1996-2000, PALCO, 2001; NCRWQCB Appendix E; Watershed Sciences, 2002.

Discussion

The MWAT and maximum temperature records had diametrically opposed results with unsuitable MWATs in approximately 78% of available records while 79% of the records available were suitable for salmonids. In general, the more suitable locations, as expected, and also seen in other subbasins, are in the upstream reaches of streams where this information is available. Thermal imaging in the subbasin's three largest streams, Bear, Honeydew, and Squaw Creeks, corroborates the trend of improving temperature for salmonids as you proceed from their confluences with the Mattole River to headwater reaches. Sediment information is spotty with only two disconnected periods of data available. V* data for the streams reaches sampled had low to moderate rates of pool filling; D50 counts indicate transport and deposition of medium to large particle sizes on those riffles sampled. Trends are difficult to detect because sediment sampling took place first in 1992, then there was an 8-year period where monitoring was not conducted again until 2000 and 2001. The sediment locations for all years were also in different reaches of the same streams adding to the difficulty of detecting monitoring trends. Physical-chemical data were available for nutrient and fecal coliform sampling that was conducted by the BLM in the SFK Honeydew Creek adjacent to restrooms at agency campground; results were non-detectable for all constituents. There were no other water quality data available.

Instream Habitat

Introduction

The products and effects of the watershed delivery processes examined in the geology, land use, fluvial geomorphology, and water quality Integrated Analyses tables are expressed in the stream habitats encountered by the organisms of the aquatic riparian community, including salmon and steelhead. Several key aspects of salmonid habitat in the Mattole Basin are presented in the CDFG Instream Habitat Integrated Analysis. Data in this discussion are not sorted into the geologic terrain types since the channel and stream conditions are not necessarily exclusively linked to their immediate surrounding terrain, but may in fact be both spatially and temporally distanced from the sites of the processes and disturbance events that have been blended together over time to create the channel and stream's present conditions. Instream habitat data presented here were compiled from CDFG stream inventories of 18 tributaries from 1991 to 2002, published research conducted in the Mattole estuary by HSU, the MRC, and MSG in the 1980s and 1990s, and fish passage barrier evaluation reports conducted under contract to CDFG from 1998-2000. Details of these reports are presented in the CDFG Appendix F.

Pool Quantity and Quality

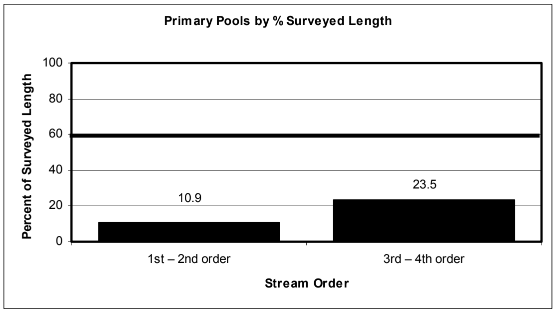


Figure 133. Primary pools in the Western Subbasin.

Pools greater than 2.5 feet deep in 1st and 2nd order streams and greater than 3 feet deep in 3rd and 4th order streams are considered primary pools.

Significance: Primary pools provide escape cover from high velocity flows, hiding areas from predators, and ambush sites for taking prey. Pools are also important juvenile rearing areas. Generally, a stream reach should have 30 – 55% of its length in primary pools to be suitable for salmonids.

Comments: The percent of primary pools by length in the Western Subbasin is generally below target values for salmonids, and appears to be less suitable in lower order streams than in higher order streams.

Spawning Gravel Quality

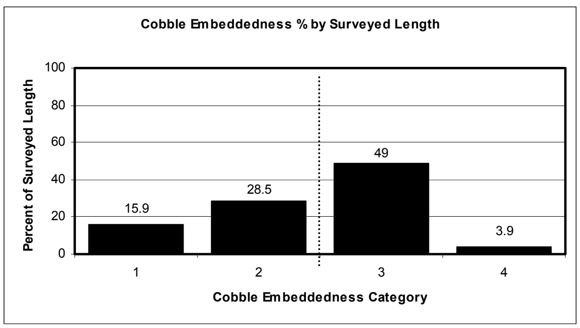


Figure 134. Cobble embeddedness in the Western Subbasin.

Cobble Embeddedness will not always sum to 100% because Category 5 (not suitable for spawning) is not included.

Significance: Salmonids cannot successfully reproduce when forced to spawn in streambeds with excessive silt, clays, and other fine sediment. Cobble embeddedness is the percentage of an average sized cobble piece at a pool tail out that is embedded in fine substrate. Category 1 is 0-25% embedded, category 2 is 26-50% embedded, category 3 is 51-75% embedded, and category 4 is 76-100% embedded. Cobble embeddedness categories 3 and 4 are not within the fully supported range for successful use by salmonids.

Comments: More than one half of the surveyed stream lengths within the Western Subbasin have cobble embeddedness in excess of 50% in categories 3 and 4, which does not meet spawning gravel target values for salmonids

Shade Canopy

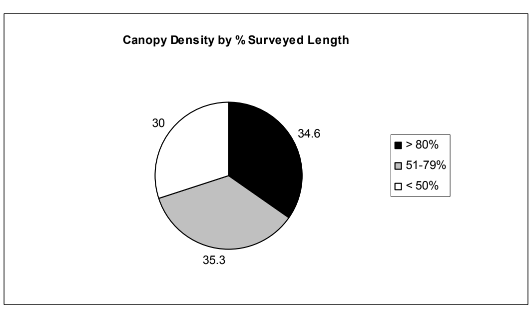


Figure 135. Canopy density in the Western Subbasin.

Significance: Near-stream forest density and composition contribute to microclimate conditions that help regulate air temperature, which is an important factor in determining stream water temperature. Stream water temperature can be an important limiting factor of salmonids. Generally, canopy density less than 50% by survey length is below target values and greater than 85% fully meets target values.

Comments: More than one half of the surveyed stream lengths within the Western Subbasin have canopy densities greater than 50% and more than one third of the surveyed lengths have canopy densities greater than 80%. This is above the canopy density target values for salmonids.

Fish Passage

*Table 159. Salmonid habitat artificially obstructed for fish passage.**

Feature/Function		Significance	Comments
Type of Barrier	**% of Estimated Historic Coho Salmon Habitat Currently Inaccessible Due to Artificial Passage Barriers**	Free movement in well-connected streams allows salmonids to find food, escape from high water temperatures, escape from predation, and migrate to and from their stream of origin as juveniles and adults. Dry or intermittent channels can impede free passage for salmonids; temporary or permanent dams, poorly constructed road crossings, landslides, debris jams, or other natural and/or man-caused channel disturbances can also disrupt stream connectivity. Partial barriers exclude certain species and lifestages from portions of a watershed and temporary barriers delay salmonid movement beyond the barrier for some period of time. Total barriers exclude all species from portions of a watershed	Artificial barriers currently block 12.9% of the estimated historic coho salmon habitat in the Western Subbasin. Total barriers block more habitat than partial and temporary barriers in this subbasin. The CDFG North Coast Watershed Improvement Program funded an improvement of Clear Creek in 2001 and Mill Creek (RM 2.8) in 2002.
All Barriers	12.9		
Partial and Temporary Barriers	6.8		
Total Barriers	10.8		

*(N=9 Culverts) in the Western Subbasin (1998-2000 Ross Taylor and Associates Inventories and Fish Passage Evaluations of Culverts within the Humboldt County and the Coastal Mendocino County Road Systems).

*Table 160. Juvenile salmonid passage in the Western Subbasin.**

Feature/Function		Significance	Comments
Juvenile Summer Passage:	Juvenile Winter Refugia:	Dry channel disrupts the ability of juvenile salmonids to move freely throughout stream systems.	Dry channel recorded in the Western Subbasin during stream surveys has the potential to disconnect Bear Trap Creek from the mainstem Mattole River and to disrupt the ability of juvenile salmonids to forage and escape predation in Jewett Creek. Juvenile salmonids seek refuge from high winter flows, flood events, and cold temperatures in the winter. Intermittent side pools, back channels, and other areas of relatively still water that become flooded by high flows provide valuable winter refugia.
0.2 Miles of Surveyed Channel Dry	No Data		
0.5% of Surveyed Channel Dry			

*(1991-2002 CDFG Stream Surveys, CDFG Appendix F).

Large Woody Debris

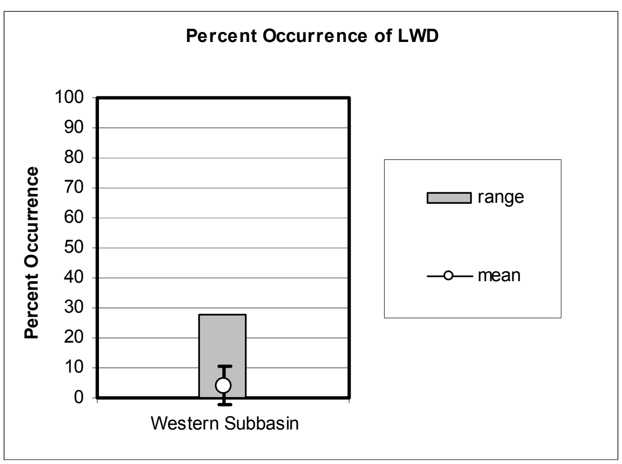


Figure 136. Large woody debris (LWD) in the Western Subbasin.

Error bars represent the standard deviation. The percentage of shelter provided by various structures (i.e. undercut banks, woody debris, root masses, terrestrial vegetation, aquatic vegetation, bubble curtains, boulders, or bedrock ledges) is described in CDFG surveys. The dominant shelter type is determined and then the percentage of a stream reach in which the dominant shelter type is provided by organic debris is calculated.

Significance: Large woody debris shapes channel morphology, helps a stream retain organic matter, and provides essential cover for salmonids. There are currently no target values established for the % occurrence of LWD.

Comments: This subbasin has the lowest average percent occurrence of large woody debris in surveyed streams of any of the Mattole subbasins. Additionally, boulders were found to provide the primary form of shelter for salmonids in ten of the thirteen surveyed streams, while bedrock ledges and bubble curtains provided the primary form of shelter for salmonids in two streams.

Discussion

Although instream habitat conditions for salmonids varied across the Western Subbasin, several generalities can be made. Instream habitat conditions were generally poor within this subbasin at the time of CDFG surveys. The percent occurrence of large woody debris was the least suitable for salmonids of any of the Mattole subbasins. Additionally, the percentage of primary pools by survey length and embeddedness values were generally below target values as found in CDFGs California Salmonid Stream Habitat Restoration Manual and calculated by the EMDS. The estimated historic coho habitat inaccessible due to artificial passage barriers was high relative to other Mattole subbasins. However, canopy density was generally greater than 50% and dry channel occurred in 0.2 miles of surveyed stream (0.5% of the surveyed stream length), thus forage and refuge passage for juveniles were not considered to be significant problems in the Western Subbasin.

Draft Sediment Production EMDS

The draft sediment EMDS is currently under review. Preliminary results are presented in the EMDS Appendix C.

Stream Reach Condition EMDS

The anadromous reach condition EMDS evaluates the conditions for salmonids in a stream reach based upon water temperature, riparian vegetation, stream flow, and in channel characteristics. Data used in the Reach EMDS come from CDFG Stream Inventories. Currently, data exist in the Mattole Basin to evaluate overall reach, canopy, in channel, pool quality, pool depth, pool shelter, and embeddedness conditions for salmonids. More details of how the EMDS functions are in the EMDS Appendix C EMDS calculations and conclusions are pertinent only to surveyed streams and are based on conditions present at the time of individual survey.

EMDS stream reach scores were weighted by stream length to obtain overall scores for tributaries and the entire Western Subbasin. Weighted average reach conditions on surveyed streams in the Western Subbasin as evaluated by the EMDS are somewhat unsuitable for salmonids (Table 161). Suitable conditions exist for reach in seven tributaries; for canopy in eight tributaries; for in channel and pool quality in Bear Creek; for pool depth in three tributaries; for pool shelter in four tributaries, and for embeddedness in three tributaries. Unsuitable conditions exist for reach in all tributaries evaluated.

Table 161. EMDS anadromous reach condition model results for the Western Subbasin

Stream	Reach	Water Temperature	Canopy	Stream Flow	In Channel	Pool Quality	Pool Depth	Pool Shelter	Embeddedness
Western Subbasin	**-**	**U**	**+**	**U**	**-**	**-**	**-**	**-**	**- -**
Mill Creek	-	U	++	U	-	- -	- - -	- -	- -
Squaw Creek	-	U	- - -	U	-	-	++	- -	- - -
Honeydew Creek	-	U	-	U	-	-	- -	-	- -
Bear Trap Creek	-	U	-	U	-	-	-	+	- - -
East Fork Honeydew Creek	-	U	+	U	-	-	- - -	+	- -
Upper East Fork Honeydew Creek	-	U	+	U	-	- -	- - -	-	- - -
West Fork Honeydew Creek	-	U	+	U	-	-	- - -	++	-
Bear Creek	-	U	- - -	U	+	++	++	++	+
Jewett Creek	-	U	+++	U	-	- -	- - -	- -	- - -
North Fork Bear Creek	-	U	- -	U	-	-	U	- -	+
North Fork Bear Creek Tributary	-	U	- -	U	-	-	+	- -	+
South Fork Bear Creek	-	U	++	U	-	- -	-	- -	-
Nooning Creek	-	U	++	U	-	- -	- - -	-	- -

Key:

+++	Fully Suitable	U	Undetermined
++	Moderately Suitable	-	Somewhat Unsuitable
+	Somewhat Suitable	- -	Moderately Unsuitable
		- - -	Fully Unsuitable

Analysis of Tributary Recommendations

CDFG inventoried 49.9 miles on 18 tributaries in the Western Subbasin. In Table 162, a CDFG biologist selected and ranked recommendations for each of the inventoried streams, based upon the results of these standard CDFG habitat inventories. More details about the tributary recommendation process are given in the Mattole Synthesis Section of the Watershed Profile.

Table 162. Ranked Tributary Recommendations Summary in the Western Subbasin based on CDFG Stream Inventories.

Stream	# of Surveyed Stream Miles	Bank	Roads	Canopy	Temp	Pool	Cover	Spawning Gravel	LDA	Livestock	Fish Passage
Mill Creek (RM 2.8)	1.1	4	3			2	1				
Mill Creek Tributary #1	0.2			2			1				
Mill Creek Tributary #2	0.03			1			2				
Squaw Creek	4.1	3	4	2	1		5				
Woods Creek	1.9	3	4	5		1	2		6		7
Honeydew Creek	4.4	3		5	4	1	2				
Bear Trap Creek	1.9	1	2	6	5	3	4				
Upper North Fork Honeydew Creek	1.0	3		5	4	1	2				6
East Fork Honeydew Creek	2.9	2	5	4	3	1	6				
West Fork Honeydew Creek	0.7	4		5		2	3				1
Bear Creek	7.2	2		1		3	4				
Jewett Creek	2.7	1				4	5		3	2	
North Fork Bear Creek	3.4	5		2	1	6	3		4		
North Fork Bear Creek Tributary #1	1.8	5		2		4	3				1
South Fork Bear Creek	12.0	2				4	1		3		
Big Finley Creek	1.6	3				1	2				
South Fork of Big Finley Creek	1.3					2	1				
Nooning Creek	1.5	1			5	3	2		4		

Temp = summer water temperatures seem to be above optimum for salmon and steelhead; Pool = pools are below target values in quantity and/or quality; Cover = escape cover is below target values; Bank = stream banks are failing and yielding fine sediment into the stream; Roads = fine sediment is entering the stream from the road system; Canopy = shade canopy is below target values; Spawning Gravel = spawning gravel is deficient in quality and/or quantity; LDA = large debris accumulations are retaining large amounts of gravel and could need modification; Livestock = there is evidence that stock is impacting the stream or riparian area and exclusion should be considered; Fish Passage = there are barriers to fish migration in the stream.

In order to further examine Western Subbasin issues through the tributary recommendations given in CDFG stream surveys, the top three ranking recommendations for each tributary were collapsed into five different recommendation categories: Erosion/Sediment, Riparian/Water Temp, Instream Habitat, Gravel/Substrate, and Other (Table 163). When examining recommendation categories by number of tributaries, the most important recommendation category in the Western Subbasin is Instream Habitat.

Table 163. Three ranking recommendation categories by number of tributaries in the Western Subbasin.

West Subbasin Target Issue:	Related Table Categories:	Count:
Erosion / Sediment	Bank / Roads	13
Riparian / Water Temp	Canopy / Temp	9
Instream Habitat	Pool / Cover	24
Gravel / Substrate	Spawning Gravel / LDA	2
Other	Livestock / Barrier	3

However, comparing recommendation categories in the Western Subbasin by number of tributaries could be confounded by the differences in the number of stream miles surveyed on each tributary. Therefore, the number of stream miles in each subbasin assigned to the various recommendation categories was calculated (Figure 137). When examining recommendation categories by number of stream miles, the most important recommendation categories in the Western Subbasin are Instream Habitat, Erosion/Sediment, and Riparian/Water Temperature.

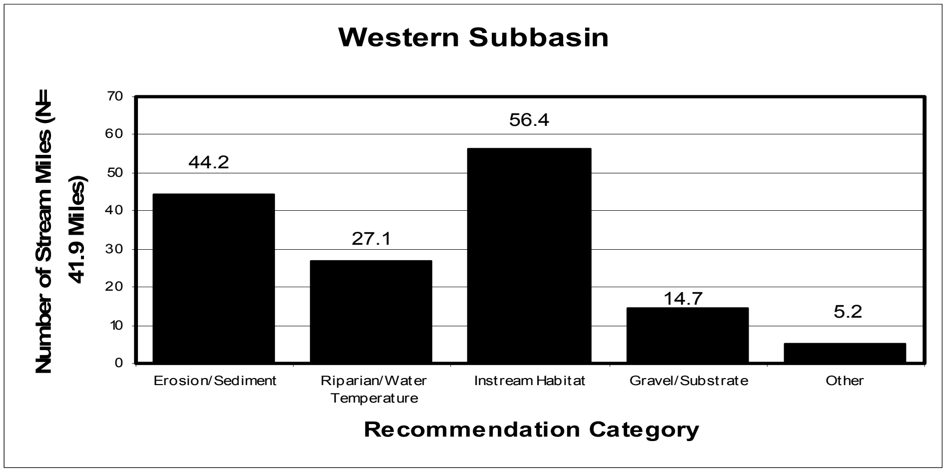


Figure 137. Recommendation categories by stream miles in the Western Subbasin.

The high number of Instream Habitat, Erosion/Sediment Riparian/Water, and Temp Recommendations across the Western Subbasin indicates that high priority should be given to restoration projects emphasizing pools, cover, sediment reduction, and riparian replanting.

Refugia Areas

The NCWAP interdisciplinary team identified and characterized refugia habitat in the Western Subbasin by using expert professional judgment and criteria developed for north coast watersheds. The criteria included measures of watershed and stream ecosystem processes, the presence and status of fishery resources, forestry and other land uses, land ownership, potential risk from sediment delivery, water quality, and other factors that may affect refugia productivity. The team also used results from information processed by NCWAP's EMDS at the stream reach and planning watershed/subbasin scales.

The most complete data available in the Western Subbasin were for tributaries surveyed by CDFG. However, many of these tributaries were still lacking data for some factors considered by the NCWAP team.

Salmonid habitat conditions in the Western Subbasin on surveyed streams are generally rated as medium potential refugia. Bear Creek is the only creek in the Mattole Basin determined to provide high quality refugia. Mill (RM 2.8), North Fork Bear, South Fork Bear, Big Finley, and South Fork Big Finley creeks, and the tributary to North Fork Bear Creek provide high potential refugia in this subbasin, while the remaining surveyed tributaries provide medium quality refugia. The following refugia area rating table summarizes subbasin salmonid refugia conditions:

Table 164. Tributary salmonid refugia area ratings in the Western Subbasin.

Stream	Refugia Categories*:				Other Categories:		
	High Quality	**High Potential**	**Medium Potential**	**Low Quality**	**Non-Anadromous**	**Critical Contributing Area/Function**	**Data Limited**
Mill Creek (RM 2.8)		X					X
Mill Creek (RM 2.8) Tributary #1			X				X
Mill Creek (RM 2.8) Tributary #2			X				X
Squaw Creek			X				X
Woods Creek			X				X
Honeydew Creek			X				X
Bear Trap Creek			X				X
East Fork Honeydew Creek			X				X
Upper East Fork Honeydew Creek			X				X
West Fork Honeydew Creek			X				X
Bear Creek	X						X
Jewett Creek			X				X
North Fork Bear Creek		X					X
North Fork Bear Creek Tributary		X					X
South Fork Bear Creek		X					
Big Finley Creek		X					X
South Fork of Big Finley Creek		X					X
Nooning Creek			X				X
Subbasin Rating			X				

*Ratings in this table are done on a sliding scale from best to worst. See page 71 for a discussion of refugia criteria.

Assessment Focus Areas

Working Hypothesis 1:

Salmonid habitat conditions in the Western Subbasin are adequate for salmonids.

Supporting Evidence:

- V* of 0.26 for Mill Creek, 0.24 for Squaw Creek and 0.22 for Honeydew Creek in 2000 indicating low to moderate residual pool filling (NCRWQCB Appendix E).
- Physical and chemical water quality data was unavailable in the Western Subbasin for pH, DO, and nutrient levels. Limited nutrient sampling during 1993 in South Fork Honeydew Creek showed normal nutrient levels (NCRWQCB Appendix E).
- CDFG has conducted an analysis of macroinvertebrate data collected by BLM since 1996 on five tributary streams. The results showed stream conditions were good.

Contrary Evidence:

- None of 18 tributaries surveyed by CDFG in this subbasin were found to have 40% or more of their survey lengths in pool habitat. Three surveyed tributaries were found to have 30 to 40% of the stream lengths surveyed in pool habitat. Forty percent or more of stream lengths in pool habitat is considered suitable on the North Coast. Additionally, 10.9% of first and second order surveyed streams and 23.5% of third and forth order surveyed streams in this subbasin are composed of primary pools by survey length. Thirty to 55% of survey lengths composed of deep, complex, high quality primary pools is considered desirable (IA Tables, CDFG Appendix F).

- CDFG surveys of Honeydew Creek, Squaw Creek, and Bear Creek found less than 40% of their lower reaches by length were composed of pools, indicating a lack of pool habitat (CDFG Appendix F).
- Two of 18 tributaries surveyed by CDFG in this subbasin were found to have a mean pool shelter rating exceeding 80. This indicates that woody debris elements affecting scour are not present. Thirteen surveyed tributaries had shelter rating scores between 30 and 80. Pool shelter ratings of 80 or more are considered suitable, and ratings less than 30 are unsuitable for contributing to shelter that supports salmonids (CDFG Appendix F).
- Boulders provided the primary form of shelter for salmonids in 14 of the 18 surveyed streams in this subbasin, while bedrock ledges, whitewater, and bubble curtains provided the primary form of shelter for salmonids in three streams and one stream had a mixture of boulders, terrestrial vegetation, and small woody debris as primary shelter (CDFG Appendix F).
- Field observations indicate that amounts of instream large woody debris in the mainstem Mattole River and its tributaries in the Western Subbasin are low
- Historic timber harvest throughout the Western Subbasin tributaries frequently removed large conifer vegetation down to the stream bank, severely reducing the available recruitment supply of large woody debris (CDF Appendix B).
- Removal of instream large woody debris under direction of CDFG occurred in about 49 stream miles in this subbasin during the 1980s. A total of 19,136 cubic feet of wood was removed. This is equivalent to 153 logs 2 feet x 40 feet. This activity likely had adverse local impacts on salmonid habitat conditions (CDFG Appendix F).
- Riparian vegetation is in size classes that are not expected to contribute large woody debris in significant quantities in the near future (CDF Appendix B).
- Large woody debris recruitment is expected to improve over time as a result of the BLM management policies within the King Range National Conservation Area (CDF Appendix B).
- Based on limited sampling, instream conditions indicate moderate sediment levels. The limited data available suggests that there is a degradation of habitat due to instream sediment accumulation in the lower gradient reaches of the larger tributaries (CGS).
- Air photos and field observations show that the Mattole River bordering the Western Subbasin downstream of Honeydew Creek is highly aggraded with sediment (CGS).
- Air photos after the 1955 and 1964 floods indicate significant changes in the stream channel in the Western Subbasin (CGS).
- Seven of 18 tributaries surveyed by CDFG in this subbasin exceeded the recommended shade canopy density levels of 80% for North Coast streams. Additionally, 16 surveyed tributaries exceeded 50% shade canopy density levels. Shade canopy density below 50% is considered unsuitable (CDFG Appendix F).
- Historic timber harvest has reduced canopy closure in near stream areas (CDF Appendix B).
- Summer maximum high temperatures exceed the suitable range for salmonid rearing in the lower reaches of Bear, Squaw, and Honeydew creeks. Maximum temperatures are within fully suitable conditions in upstream reaches of larger and smaller tributaries sampled (NCRWQCB Appendix E).
- During nearly all available sample years MWATs exceeded the fully suitable range of 50-60°F in all Western Subbasin streams except Mill Creek-Mile 2.8, Clear Creek, Big Finley Creek, and Nooning Creek (NCRWQCB Appendix E).
- Nine of 18 tributaries surveyed by CDFG in this subbasin were found to provide spawning reaches with favorable cobble embeddedness values in at least half of the stream reach lengths surveyed (CDFG Appendix F).
- Out of 17 stream reaches examined for the presence of sensitive amphibian species, torrent salamanders were found in seven reaches and tailed frogs were found in seven reaches (Welsh et al. 2002).

- Artificial fish passage barriers block 12.9% of the estimated historic coho salmon habitat in this subbasin. Additionally, 0.3% of surveyed stream channel in this subbasin was dry (IA Tables, CDFG Appendix F).
- The NCWAP analysis of tributary recommendations given in the Western Subbasin showed that the most important recommendation category was Instream Habitat, followed by Erosion/Sediment, Riparian/Water Temperature, Gravel/Substrate, and Other.

Hypothesis 1 Evaluation:

Based upon current supportive and contrary findings, the hypothesis is not supported. Although several stream reaches are in good condition, there are others that have improvement potential.

Working Hypothesis 2:

Summer stream temperatures in some subbasin tributaries are not within the range of temperatures that provide suitable conditions for healthy anadromous salmonid populations.

Supporting Evidence:

- Summer maximum high temperatures exceed the suitable range for salmonid rearing in the lower reaches of Bear, Squaw, and Honeydew creeks. Maximum temperatures are within fully suitable conditions in upstream reaches of larger and smaller tributaries sampled (NCRWQCB Appendix E).
- During nearly all available sample years MWATs exceeded the fully suitable range of 50-60°F in all Western Subbasin streams except Mill Creek-Mile 2.8, Clear Creek, Big Finley Creek and Nooning Creek (NCRWQCB Appendix E).
- Seven of 18 tributaries surveyed by CDFG in this subbasin exceeded the recommended shade canopy density levels of 80% for North Coast streams. Additionally, 16 surveyed tributaries exceeded 50% shade canopy density levels. Shade canopy density below 50% is considered unsuitable (CDFG Appendix F).
- Historic timber harvest has reduced canopy closure in near stream areas (CDF Appendix B).

Contrary Evidence:

No contrary evidence at this time.

Hypothesis 2 Evaluation:

Based upon current supportive and contrary findings, the hypothesis is supported.

Working Hypothesis 3:

Aggradation from fine sediment in some stream channels of this subbasin has reduced channel diversity needed to provide suitable conditions for anadromous salmonid populations and has compromised salmonid health.

Supporting Evidence:

- Based on limited sampling, instream conditions indicate moderate sediment levels. The limited data available suggests that there is a degradation of habitat due to instream sediment accumulation in the lower gradient reaches of the larger tributaries (CGS).
- Air photos and field observations show that the Mattole River bordering the Western Subbasin downstream of Honeydew Creek is highly aggraded with sediment (CGS).
- Air photos after the 1955 and 1964 floods indicate significant changes in the stream channel in the Western Subbasin (CGS).

Contrary Evidence:

- V* of 0.26 for Mill Creek, 0.24 for Squaw Creek and 0.22 for Honeydew Creek in 2000 indicating low to moderate residual pool filling (NCRWQCB Appendix E).

Hypothesis 3 Evaluation:

Based upon current supportive and contrary findings, the hypothesis is supported.

Working Hypothesis 4:

A lack of large woody debris in some stream reaches of this subbasin has reduced channel diversity needed to provide suitable conditions for anadromous salmonid populations and has compromised salmonid health.

Supporting Evidence:

- Two of 18 tributaries surveyed by CDFG in this subbasin were found to have a mean pool shelter rating exceeding 80. This indicates that woody debris elements affecting scour are not present. Thirteen surveyed tributaries had shelter rating scores between 30 and 80. Pool shelter ratings of 80 or more are considered suitable, and ratings less than 30 are unsuitable for contributing to shelter that supports salmonids (CDFG Appendix F).
- Boulders provided the primary form of shelter for salmonids in 14 of the 18 surveyed streams in this subbasin, while bedrock ledges, whitewater, and bubble curtains provided the primary form of shelter for salmonids in three streams and one stream had a mixture of boulders, terrestrial vegetation, and small woody debris as primary shelter (CDFG Appendix F)
- Field observations indicate that amounts of instream large woody debris in the mainstem Mattole River and its tributaries in the Western Subbasin are low.
- Historic timber harvest throughout the Western Subbasin tributaries frequently removed large conifer vegetation down to the stream bank, severely reducing the available recruitment supply of large woody debris (CDF Appendix B).
- Removal of instream large woody debris under direction of CDFG occurred in about 49 stream miles in this subbasin during the 1980s. A total of 19,136 cubic feet of wood was removed. This is equivalent to 153 logs 2 feet x 40 feet. This activity likely had adverse local impacts on salmonid habitat conditions (CDFG Appendix F).
- Riparian vegetation is in size classes that are not expected to contribute large woody debris in significant quantities in the near future (CDF Appendix B).

Contrary Evidence:

- Large woody debris recruitment is expected to improve over time as a result of the BLM management policies within the King Range National Conservation Area (CDF Appendix B).

Hypothesis 4 Evaluation:

Based upon current supportive and contrary findings, the hypothesis is supported at this time.

Working Hypothesis 5:

Anadromous salmonid populations in the Western Subbasin have declined since the 1950s.

Supporting Evidence:

- Interviews with local residents indicate that the Western Subbasin historically supported Chinook salmon, coho salmon, and steelhead trout; and that coho salmon and steelhead trout have been found in the Lower Bear Creek, Stansberry Creek, Clear Creek, Indian Creek, Squaw Creek, and Woods Creek; and Chinook salmon have been found in Stansberry Creek, Indian Creek, Squaw Creek, and Woods Creek (CDFG Appendix F).
- Coho salmon were detected in five of the 24 tributaries surveyed in the Western Subbasin by CDFG in the 1960s, Mill Creek (RM 2.8), Clear Creek, Woods Creek, Bear Trap Creek, and Bear Creek. 1960s surveys also detected steelhead trout in 15 tributaries (CDFG Appendix F).
- Stream surveys throughout the 1970s, 1980s, and 1990s by CDFG, BLM, Coastal Headwaters Association, and the Redwood Sciences Laboratory continued to document the presence of steelhead trout throughout the Western Subbasin (CDFG Appendix F).
- Coho salmon were detected by Redwood Sciences Laboratory studies in Big Finley Creek and the South Fork of Bear Creek in the late 1990s (CDFG Appendix F).

- Ten of the 18 tributaries surveyed by CDFG in the Western Subbasin from 1990-2000 included a biological survey. Steelhead trout were found in these ten streams, and coho salmon were found in Mill Creek (RM 2.8) and Bear Creek (CDFG Appendix F).
- Eleven tributaries in this subbasin were also surveyed as a part of the CDFG 2001 Coho Inventory. Steelhead trout were found in these eleven streams, but coho salmon were only found in Mill Creek (RM 2.8), Woods Creek, and Honeydew Creek (CDFG Appendix F).
- Three salmon rearing facilities are located within this subbasin and have been operated by the Mattole Salmon Group since the mid 1980s (MSG 2000).
- Estimated populations of Chinook salmon or coho salmon in the entire Mattole Basin have not exceeded 1000 since the 1987-88 season. Mattole Basin Chinook salmon and coho salmon population estimates for the 1999-2000 season were 700 and 300, respectively (MSG 2000).

Contrary Evidence:

No contrary evidence at this time.

Hypothesis 5 Evaluation:

Based upon current supportive and contrary findings for the streams surveyed, the hypothesis is supported.

Responses to Assessment Questions

What are the history and trends of the sizes, distribution, and relative health and diversity of salmonid populations within this subbasin?

- No systematic, scientific studies have examined the size or health of salmonid populations in the Western Subbasin. However, historical accounts and stream surveys conducted in the 1960s by CDFG indicate that the subbasin supported populations of Chinook salmon, coho salmon, and steelhead trout. Recent biological stream surveys indicate the presence of steelhead trout throughout the subbasin and coho salmon in a few tributaries. Low salmonid populations throughout the Mattole Basin indicate that salmonid populations in the Western Subbasin are also likely to be depressed at this time. However, populations have a good chance to recover due to public land stewardship that is actively engaged in improving watershed and stream conditions. In addition, salmonid rearing activities within the subbasin are working to supplement native stocks as habitat conditions improve.

What are the current salmonid habitat conditions in this subbasin? How do these conditions compare to desired conditions?

- Erosion/Sediment
  - Instream sediment in several stream reaches in this subbasin may be approaching or exceeding levels considered unsuitable for salmonid populations. Macroinvertebrates data indicate good conditions. Additionally, amphibians sensitive to fine sediment were present in most stream reaches surveyed in this subbasin;
- Riparian Water Temperature
  - Available data suggest high summer temperatures are deleterious to summer rearing salmonid populations in some streams in this subbasin; in others it is good;
- Instream Habitat
  - In-stream habitat diversity and complexity, based on available survey data (i.e. pool depths, cover, and large woody debris) may be adequate for salmonid production. Additionally, recent surveys indicate instream habitat appears to be improving. Large woody debris recruitment potential is poor in this subbasin;
- Gravel Substrate
  - Available data from sampled streams suggest that suitable amounts and distribution of high quality spawning gravel for salmonids is lacking in some reaches in this subbasin;

- The upper reaches of Bear, Mill (RM 2.8), North Fork Bear, South Fork Bear, Big Finley, and South Fork Big Finley creeks, and the tributary to North Fork Bear Creek, are considered good refugia, and this will continue due to BLM and cooperative private land owners and current management policies in key headwater reaches. In fact, Bear Creek was the only creek in the Mattole Basin determined to provide high quality refugia.

What are the relationships of geologic, vegetative, and fluvial processes to natural events and land use history?

- Although the Western Subbasin encompasses the dramatic relief of the King Range, with the highest proportion of steep slopes in the basin, approximately half of the subbasin is underlain by hard terrain and it is second only to the Southern Subbasin in terms of stable areas. Slope instability is focused primarily in the abundant areas with steep to very steep slopes and the limited area of soft terrain;
- Based on features indicative of excess sediment production, transport and storage, the pattern of impacts to stream conditions is similar to that observed in the Eastern Subbasin, and is highly variable throughout the subbasin. Considering the low degree of impact by features indicative of excess sediment production, transport and storage observed in the adjacent upstream Southern Subbasin, it appears that the stream features observed in the Western Subbasin must be derived either internally within the subbasin or from the adjacent Eastern Subbasin;
- As a result of past timber harvest and conversion activities, almost 60% of the Western Subbasin is occupied by small diameter (twelve to twenty-four inches diameter at breast height) forest stands. Another 20% is in forest stands greater than twenty-four inches.

How has land use affected these natural processes?

- Forty square miles, or nearly half of this subbasin are in public ownership managed by the Bureau of Land Management as part of the King Range National Conservation Area, designated as late seral reserve. Timber harvesting has occurred on less than one percent of the area in the last ten years and has been at low levels for decades. Privately owned acres carrying grassland are grazed while smaller, residential parcels are concentrated along the main county roads. Old roads, many abandoned, are common across the landscape.

Based upon these conditions trends, and relationships, are there elements that could be considered to be limiting factors for salmon and steelhead production?

- Based on information available for this subbasin, the NCWAP team believes that salmonid populations are currently being limited by reduced habitat complexity, high sediment levels, high water temperatures, and embedded spawning gravels.

What habitat improvement activities would most likely lead toward more desirable conditions in a timely, cost effective manner?

- Based upon the latest science on placement of large woody debris in stream channels, managers in the Western Subbasin should work to improve channel structure and function for salmonids. Pool shelter has the lowest suitability for salmonids in Mill Creek (RM 2.8) Tributary #1 and South Fork Big Finley Creek;
- Establish monitoring stations and train local personnel to track in-channel sediment and aggraded reaches throughout the subbasin and especially in the lower reaches of major tributaries and Squaw, Honeydew, Finley, Big Finley, Woods and Bear creeks;
- Continue efforts such as road improvements and decommissioning throughout the basin to reduce sediment delivery to the Mattole River and its tributaries. Road inventories have been completed for much of this planning basin, and it is recommended that this effort be continued until a complete inventory is compiled. CDFG stream surveys indicated Mill Creek (RM 2.8) and Bear Trap Creek have road sediment inventory and control as a top tier tributary improvement recommendation;

- Monitor summer water and air temperatures to detect trends using continuous 24 hour monitoring thermographs. Continue temperature monitoring efforts in Stansberry, Mill (RM 2.8) Clear, Squaw, Woods, Honeydew, Bear, North Fork Bear, South Fork Bear, Little Finley, Big Finley, and Nooning creeks, and expand efforts into other subbasin tributaries;
- Ensure that near stream forest projects retain and recruit high canopy densities in riparian areas to reduce solar radiation and moderate air temperatures;
- Where current canopy is inadequate and site conditions, including geology, are appropriate, use tree planting and other vegetation management techniques to hasten the development of denser and more extensive riparian canopy. Canopy density has the lowest suitability for salmonids in Squaw Creek. Use cost share programs and conservation easements as appropriate;
- The three cooperative salmon rearing facilities in this subbasin should be continued as needed to supplement wild populations while the improvements from long-term watershed and stream restoration efforts develop;
- Initiate a systematic program to monitor the effectiveness of these fish rescue and rearing activities, and determine the need for the continuance of cooperative, supplemental fish rearing efforts on an ongoing, adaptive basis using the best available science;
- The nature and extent of naturally occurring unstable geologic terrain, landslides and landslide potential (especially Categories 4 and 5, page 89) must be considered when planning potential projects in the subbasin;
- Encourage the use of appropriate Best Management Practices for all land use and development to minimize erosion and sediment delivery to streams;
- In order to protect privacy on private lands in this subbasin while developing data, the possibility of training local landowners to survey streams and conduct salmonid population status surveys is advisable;
- Ensure that high quality habitat within this subbasin is protected from degradation. The highest stream reach condition as evaluated by the stream reach EMDS and refugia analysis were found in Bear, Mill (RM 2.8), North Fork Bear, South Fork Bear, Big Finley, and South Fork Big Finley creeks and the tributary to North Fork Bear Creek.

Subbasin Conclusions

Although having some of the steepest slopes in the Mattole Basin, the Western Subbasin is underlain by predominately hard terrain and is second only to the Southern Subbasin in terms of stable areas. Conversely, there is a preponderance of instream and near-stream features impacting subbasin streams that are very similar to the Eastern Subbasin. High sedimentation level, high summer water temperatures, and a lack of suitable spawning gravel may be limiting salmonid populations in many streams. Available data suggest instream habitat complexity may be adequate or recovering but that LWD recruitment potential from riparian sources is limited. However, historical accounts indicate that salmonid populations and stream complexity were much more favorable in the past. The continuation of present salmonid rearing activities to supplement wild populations is further encouraged. The management by BLM of publicly owned lands in the King Range National Conservation Area, particularly in the headwater reaches of larger streams such as Honeydew, Bear, and Squaw creeks as late seral reserve, should help further the recover process in this subbasin. The enlistment of cooperative landowners in key headwater reaches to further implement beneficial land use practices will also assist watershed recovery efforts. Conditions beneficial to salmonids may be further enhanced in this subbasin through encouraging all motivated subbasin landowners to use good land stewardship practices and enlisting the aid and support of agency technology, experience, and funding opportunities is encouraged.

Mattole Basin in the Regional Context

Introduction

Within the context of the North Coast, the Mattole River basin is unique in many ways. The basin receives some of the highest annual rainfall in California. This region also experiences a very high level of seismic activity. Bedrock underlying much of the basin has been tectonically broken and sheared making it relatively weak, easily weathered, and inherently susceptible to landsliding and erosion. The unstable bedrock and soil conditions combined with heavy rainfall, high regional uplift rates, and very active seismicity produce widespread naturally occurring landsliding with associated large volumes of sediment delivered to streams.

The total Mattole Basin resident population for the year 2000 census was approximately 1,200 people. Both Honeydew and Petrolia are two hours driving time south of Eureka, the closest urbanized area. This remoteness has made local residents self-sufficient, independent, and adaptive. Additionally, many local residents have a strong sense of place. Both historic and current land uses are based upon agriculture and forestry. Specific land uses today are centered on relatively small, private non-industrial timber management, cattle and sheep ranching activities, and other agricultural pursuits like orchards, pasture, and field crops.

Fishery resources of the Mattole Basin include fall-run Chinook salmon, coho salmon, summer-run steelhead trout, and winter-run steelhead trout. The salmon and steelhead trout have been traditionally important as food and recreation resources to local residents and visitors.

Based upon commonality of watershed attributes, four subbasins can be distinguished within the context of the Mattole Basin. For the purpose of watershed assessment, these study areas were named the Northern, Eastern, Southern, and Western subbasins. These are in addition to the Estuary, which is a product of the upstream subbasins, but is itself unique. In general, each of the five is somewhat unique from the others, but each has distinguishing attributes that are generally common within the several CalWater 2.2a Planning Watersheds (PWs) contained within the subbasin. The subbasin is a useful assessment scale upon which to conduct analyses of findings, form conclusions, and suggest improvement recommendations.

Summary of Subbasin Conditions and Recommendations

Based on NCWAP's six assessment questions, salmonid habitat in the Mattole Basin was found to have medium to high potential to serve as refugia for salmon and steelhead trout (Table 165).

Table 165. Subbasin Salmonid Refugia Area Ratings in the Mattole Basin.

Subbasin	Refugia Categories:				Other Categories:		
	High Quality	High Potential	Medium Potential	Low Quality	Non-Anadromous	Critical Contributing Area/Function	Data Limited
Estuary Subbasin			X			X	X
Northern Subbasin			X				X
Eastern Subbasin			X				X
Southern Subbasin		X					X
Western Subbasin			X				X

Salmonid Populations

The NCWAP assessment of salmonid populations found that:

- The Mattole Basin historically supported relatively robust populations of Chinook salmon, coho salmon, and steelhead trout;
- Recent biological stream surveys indicate the presence of Chinook salmon and steelhead trout in all five Mattole subbasins and the presence of coho salmon in the Eastern, Southern, and Western subbasins;
- No studies have been conducted to estimate subbasin or tributary specific population abundance levels of coho salmon or Chinook salmon; however, a nine-year intensive study of three tributaries within the Northern Subbasin indicated stable age classes of steelhead trout;
- Intensive studies of the Estuary Subbasin have shown depressed populations and poor survival of over-summering Chinook salmon and steelhead trout, and no coho have been detected;
- Mattole basin-wide population estimates indicate depressed meta-populations of Chinook and coho salmon.

Salmonid Habitat

- Instream sedimentation in several stream reaches throughout the basin may be approaching or exceeding levels considered suitable for salmonid populations. Currently, the estuary is very shallow and lacks channel complexity. Conditions in the estuary are thought to be deleterious to salmon and steelhead trout at this time. Erosion/sediment reduction is the top recommendation category for the Eastern and Estuary subbasins;
- High summer water temperatures in many surveyed tributaries are deleterious to summer rearing salmonid populations in the Estuary, Northern, Eastern, and Western subbasins. Riparian/water temperature improvements is the top recommendation category in the Northern Subbasin;
- In general, pool habitat, escape and ambush cover, and water depth are unsuitable for salmonids in many mainstem and tributary stream reaches in the Mattole Basin. In the Southern Subbasin summer flow is inadequate or non-existent in many reaches. Large woody debris recruitment potential is poor in the Northern, Eastern, and Western Subbasins. Instream habitat improvement is the top recommendation category in the Southern and Western subbasins;
- Available data from sampled streams suggest that suitable, high quality spawning gravel for salmonids is limited in some streams in all subbasins;
- Salmonid habitat conditions in the Mattole Basin are generally best in the Southern and Western subbasins, mixed in the Eastern subbasin, and most impacted in the Estuary and Northern subbasins.

Table 166. Summary of Mattole Subbasins Stream and Watershed Conditions and Recommended Action.

	Estuary Subbasin	**Northern Subbasin**	**Eastern Subbasin**	**Southern Subbasin**	**Western Subbasin**
Identified Conditions					
In-Stream Sediment	**-/R**	**-/R**	**-**	**-/R**	**-**
Water Temperature	-	-	~	+	~
Pools	-	-	-	~	-
Flow	+	~	~	-	~
Escape Cover	-	-	-	-	-
Fish Passage Barriers	+	~	~	~	~
Natural Sediment Sources	-	-	~	+	+
Management-Related Sediment Sources	-	-	+	-	+

Recommended Improvement Activity Focus Areas					
Flow				X	
Erosion/Sediment		X	X	X	X
Riparian/Water Temperature	X	X	X		X
Instream Habitat	X	X	X	X	X
Gravel/Substrate			X	X	X
Fish Passage Barriers				X	X

+ Condition is favorable for anadromous salmonids
- Condition is not favorable for anadromous salmonids
~ Condition is mixed or indeterminate for anadromous salmonids
R Trend indicates improved conditions 1984-2000
X Recommended improvement activity focus areas

Geology

The NCWAP assessment of geology found that:

- Geologic units within the basin can be grouped into one of three bedrock terrains (hard, moderate, and soft) and one for Quaternary alluvial units. Larger landslides are more prevalent in soft terrain and are typically earthflows, while smaller slides, typically debris slides, are more prevalent in hard and moderate terrains;
- Weak geologic materials, steep slopes, high rainfall, and strong earthquakes common to the basin result in high rates of natural landsliding and surface erosion, particularly in soft terrain. These natural processes can be exacerbated by human land use within the basin. About one half of the basin is considered to have a high to very high landslide potential;
- In general, the subbasins can be ranked in terms of relative impacts with geologically unstable areas linked to adverse stream effects. The Northern Subbasin has the largest proportion of geologically unstable (soft) terrain, which is linked to the highest amount of historically active landslides, gullies, and stream features indicative of excess sediment production, transport and storage. The Southern Subbasin has the lowest proportion of geologically unstable terrain, historically active landslides, gullies, and stream features indicative of excess sediment production and transport. The Eastern and Western subbasins are intermediate between these two extremes due to the variability in the proportion of soft terrain and steep slopes;
- Source and transport reaches of the blue line streams as depicted on NCWAP stream network maps, were identified primarily in bedrock terrains, while response (depositional) reaches were identified in the Quaternary (alluvial) unit reaches. Features indicative of excess sediment production, transport and storage have decreased throughout most of the basin in the period between 1984 and 2000. The reduction in these features was greatest in the hard terrain. The distribution of these features in bedrock terrains suggests that portions of the areas interpreted as having a high to very high landslide potential are also the sources of sediment that has been delivered to streams;
- Human activities such as timberland conversion to grasslands and brush, grazing, timber harvest, and road construction and use, have interacted with natural geologic instability to increase sediment production far above naturally high background levels.

Vegetation

The NCWAP assessment of vegetation found that:

- Historic timber harvesting and streamside road construction reduced riparian canopy and increased direct sediment inputs and water temperature. Overall, the current landscape is comprised of smaller diameter forest stands than in pre-European times;
- There has been little timber harvesting in the Mattole Basin in the last decade, and it is not likely under current management that intense timber harvest will occur;

- Remaining stands in late seral reserve are fragmented in the basin, and found largely on the public land in the Western and Eastern subbasins;
- A considerable part of the Southern Subbasin is now in State Park or Sanctuary Forest management, and no commercial harvest is planned in the subbasin;
- Large woody debris recruitment potential is currently limited by the low percentage of near-stream forest stands containing trees in large diameter classes, but the situation should improve with the current forest management scenario;
- Decades of fire suppression have created dense forest stands and brush-lands leading to the designation of Mattole Basin population centers as high wildfire threat areas.

Land Use Impacts

The NCWAP assessment of land use found that:

- Land use, including road construction and use, timber harvesting, and grazing, has added excess sediment to the fluvial system. Many of the effects from these activities are spatially and temporally removed from their upland sources. Excess sediment remains in the Mattole mainstem despite decades of low timber harvesting activity;
- Currently, roads are a major land use contributor of sediment (CDF, 2002). Large storms or other catastrophic events combined with poor road location and construction practices have the potential to deliver large and adverse amounts of sediment into stream systems;
- Water extraction for agriculture, road maintenance, and residential use has the direct effect of reducing the amount of available habitat for fish;
- Grazing is widespread on privately owned grasslands and has shifted to cattle since the enactment of predation protection measures. Stock impacts to streams are not common or widespread, but watercourse exclusionary fencing is limited.

Limiting Factors Analysis Conclusions

Based on available information for the Mattole Basin, the NCWAP team believes that salmonid populations in general are currently being affected by:

- Impacted estuarine conditions;
- General lack of habitat complexity in many stream reaches;
- High instream sediment levels;
- High summer water temperatures;
- Inadequate flows during summer low flow periods;
- Reduced basin-wide coho and Chinook meta-populations.

Recommendations:

***Flow and Water Quality Improvement Activities**:*

- Discourage unnecessary and wasteful use of water during summer low flow periods to improve stream surface flows and fish habitat, especially in the Southern Subbasin;
- Increase the use of water storage and catchments systems that collect rainwater in the winter for use in the drier summer season;
- Support local efforts to educate landowners about water storage and catchments systems, and find ways to support and subsidize development of these systems;
- Support and expand ongoing local efforts that monitor summer water and air temperatures on a continuous 24-hour basis to detect long-range trends and short-term effects on the aquatic/riparian community;
- Support the Mattole Salmon Group's efforts to determine the role of sediment in the mainstem Mattole River in elevated estuarine water temperatures.

***Erosion and Sediment Delivery Reduction Activities**:*

- Reduce sediment deposition to the estuary by supporting a basin-wide road and erosion assessment/control program such as the Mattole Restoration Council's Good Roads, Clear Creeks effort. Continue to conduct and implement road and erosion assessments such as the on-going efforts in the Dry and Westlund planning watersheds in the Eastern Subbasin. Expand road assessment efforts because of the potential for further sediment delivery from active and abandoned roads, many of which are in close proximity to stream channels in the Bridge and Thompson planning watersheds in the Southern Subbasin;
- Establish monitoring stations and train local personnel to track in-channel sediment and aggraded reaches throughout the basin and especially in the North Fork Mattole and the Upper North Fork Mattole rivers, Mattole Canyon, Blue Slide, Squaw, Honeydew, and Bear creeks;
- Consider the nature and extent of naturally occurring unstable geologic terrain, landslides and landslide potential (especially Categories 4 and 5) when planning potential projects in the subbasin;
- At stream bank erosion sites, encourage cooperative efforts to reduce sediment yield to streams. CGS mapping indicates eroding banks are not a significant basin wide issue, but may be of localized importance. They occur in isolated, relatively short reaches distributed throughout the Mattole Basin;
- Based on the high incidence of unstable slopes in the Northern Subbasin, any future sub-division development proposals should be based on an existing county-imposed forty acre minimum parcel sub-division ordinances;
- Encourage the use of appropriate Best Management Practices for all land use and development activities to minimize erosion and sediment delivery to streams. For example, low impact yarding systems should be used in timber harvest operations on steep and unstable slopes to reduce soil compaction, surface disturbance, and resultant sediment yield.

***Riparian and Habitat Improvement Activities**:*

- Where current canopy is inadequate and site conditions, including geology, are appropriate, initiate tree planting and other vegetation management to hasten the development of denser and more extensive riparian canopy, especially in the Northern Subbasin;
- Landowners and managers in the Northern and Western subbasins should work to add more large organic debris and shelter structures to streams in order to improve channel structure, channel function, habitat complexity, and habitat diversity for salmonids;
- Ensure that stream reaches with high quality habitat in the Mattole Basin are protected from degradation. This is especially important in the Southern Subbasin. The best stream conditions as evaluated by the stream reach EMDS were found in the South Fork of Vanauken Creek, Mill Creek - at Mattole river-mile 56.2 (RM 56.2), Stanley Creek, Thompson Creek, Yew Creek, and Lost Man Creek Tributary in the Southern Subbasin, and in Harrow Creek in the Eastern Subbasin. Refugia investigation criteria, which include biological parameters, indicated Bear Creek was the best stream evaluated in the Mattole Basin.

***Supplemental Fish Rescue and Rearing Activities**:*

- Since 1982 a successful cooperative salmonid rearing facility in the Mattole headwaters has been operated by the Mattole Salmon Group (MSG) and CDFG. They also operate a Chinook juvenile out-migrant rescue rearing program near the estuary, which released 2,400 coded-wire-tagged Chinook sub-yearlings in October 2002. These programs should be continued as needed to supplement wild populations while the improvements from long-term watershed and stream restoration efforts develop;
- Initiate a systematic program to monitor the effectiveness of fish rescue and rearing activities, and determine the need for the continuance of cooperative, supplemental fish rearing efforts;
- Update as scheduled the MSG / CDFG five-year plan that provides guidance to the cooperative rearing and rescue projects. Base the periodic plan updates on the findings of the effectiveness monitoring program and best available science.
- Education, Research and Monitoring Activities:

- Utilize Humboldt State University studies conducted in the early 1990s as baseline information to periodically monitor trends in estuarine conditions and fish production;
- Encourage ongoing stream inventories and fishery surveys of tributaries throughout the Mattole Basin, especially in the Northern Subbasin;
- In order to protect privacy while developing data, the possibility of training local landowners to survey their own streams and to conduct salmonid population status surveys throughout the basin would be advisable;
- Further study to investigate the affects to water quality from timberland herbicide use is recommended;
- Follow the procedures and guidelines outlined by NCRWQCB to protect water quality from ground applications of pesticides;
- Encourage appropriate chemical transportation and storage practices as well as early spill reporting and clean-up procedures;
- Conduct training as needed and desired to assist landowners, managers, consultants, and other interested parties in the construction and appropriate application of landslide occurrence and potential maps from GIS analysis.

Propensity for Improvement

Advantages

The Mattole Basin has several advantages for planning and implementing successful salmonid habitat improvement activities that include:

- An active restoration community made up of many highly skilled and experienced individuals. This community includes the comprehensive Mattole River and Range Partnership. The Partnership is composed of several natural resources agencies, Mattole landowners, and watershed groups like the Mattole Salmon Group and the Mattole Restoration Council. This broad base provides a common forum for different points of view and interests concerning the watershed and fisheries within the basin;
- Skilled fundraisers who are capable of recruiting funds from a myriad of grant programs. Currently, a major grant was secured by members of the Partnership from the Coastal Conservancy for a multi-year general watershed improvement program which includes various activities ranging from education to stream work;
- A skilled workforce with a core of experienced workers. This group of community based technicians provides a resource for ensuring successful projects and building future technical capacity in the basin. The logical long range product of this component is better watershed stewardship on a landscape scale;
- An expanding group of cooperative landowners that includes both public and private landowners from all subbasins in the Mattole. The effect of this growing cooperative land-base is the ability to choose locations for projects where the best result can be achieved in the shortest period of time. This accelerates the overall effectiveness of the watershed improvement program. The current Good Roads, Clear Creeks program is an example of this advantage;
- Several watersheds and streams are now well into recovery and should respond well to continued stewardship and improvement treatments.
- This NCWAP assessment containing findings, conclusions, and recommendations for improvement opportunities. This report provides focus from the basin scale, through the subbasin scale and down to the level of specific tributary assessments. With this tool to focus project design efforts, local landowners and restoration groups can pursue the mutual development of site specific improvement projects on an adaptive basis;
- A core population of Chinook salmon, coho salmon, and steelhead trout as well as summer steelhead unique to the Mattole River system. Although depressed from historic levels there remain local stocks that can take advantage of improved conditions. Over time, barring overwhelming outside

impacts, the stocks should grow in response to watershed efforts. Currently, efforts by the Cooperative Hatchbox and Rescue Rearing Program are augmenting these core populations.

Challenges

The Mattole Basin also has some challenges confronting efforts to improve watershed and fish habitat conditions, and increase anadromous fish populations:

- Not all landowners are interested in salmonid habitat improvement efforts. Without a watershed wide cooperative land-base, treatment options are limited. In some cases this can remove some key areas from consideration of project development;
- High natural erosion rates will always be a part of the Mattole landscape. These high background erosion thresholds makes the need to reduce human induced erosion rates to as close to zero as possible an imperative;
- Summer and early fall water resources are very limited in some very important parts of the basin, particularly the Southern Subbasin. The very good instream habitat conditions in that subbasin are of no use to fish without water in the streams. As human water use intensifies, the loss of critical fish stocks will continue and compromise other fishery improvement efforts.
- The risk of pollutant spills also becomes problematic with increases in near stream residential and agricultural development and occupation.
- Even if needed watershed improvement efforts succeed in reducing sediment yield to basin streams, the estuary will be slow respond. The scale of the problem and the nature of low gradient, depositional reaches to move sediment slowly cause this situation. Therefore, containing the erosion that exceeds natural background levels will affect estuarine habitat improvements only over a very long period of time. That means basin wide sediment reduction efforts will have to be sustained with a great deal of patience for a very long time, in fact, in perpetuity. Meanwhile, salmonid stocks impacted by the harsh estuarine conditions will have to be protected and perhaps rescued until conditions improve. Fish rescue is a very difficult and risky task and can be problematic itself.
- Chinook and coho salmon and summer steelhead meta-populations are currently reduced to levels that could impact the amount of needed straying of colonizing fish into improved or expanded habitat conditions. Without a high degree of habitat seeding from strays, meta-population increases are compromised and the desired response to improvement efforts are slowed, successes masked, and evaluation difficult.

Conclusion

The likelihood that any North Coast basin will react in a responsive manner to management improvements and restoration efforts is a function of existing watershed conditions. In addition, the status of processes influencing watershed conditions will affect the success of watershed improvement activities. A good knowledge base of these current watershed conditions and processes is essential for successful watershed improvement. Acquiring this knowledge requires property access. Access is also needed to design, implement, monitor, and evaluate suitable improvement projects. This systematic process is dependent upon the cooperative attitude of resource agencies, watershed groups and individuals, and landowners and managers.

The Mattole NCWAP assessment has considered a great deal of available information regarding watershed conditions and processes in the Mattole Basin. This long assessment and analysis has identified problems and made recommendations to address these problems while considering the advantages and challenges of conducting watershed improvement programs in the Mattole Basin.

After considering these problems, recommendations, advantages and challenges, the Mattole Basin appears to be a very good candidate for a successful long term programmatic watershed improvement effort. According to the current NCWAP refugia analysis, the Mattole Basin has medium to high potential to become a high quality refugia habitat basin. Reaching this goal is dependent upon the formation of a well organized and thoughtful improvement program founded on a broad based community commitment to active watershed stewardship. The energy and opportunity appears to be present here, and well underway in many parts of the basin. If these efforts are pursued vigorously and patiently, one day the Mattole could once again be known as “clear waters” and be home to both a healthy fishery resource and a healthy watershed-based community in a uniquely diverse and beautiful area.

Limitations of this Assessment

This watershed assessment provides useful and valuable information and represents a considerable effort of the involved agencies, contractors, and public. It was limited in duration, scope, detail, and analysis level due to constraints in budget, time, access, and overall resources. Where data are limited, hypotheses were developed to test or improve our understanding of watershed processes. Specific limitations are presented below to put the assessment in context.

- Point or more local data, e.g., individual stream reaches, were described in relation to those smaller geographical areas. As descriptions and inferences are drawn from those data to a more regional, watershed scale, the certainty associated with those conclusions and inferences is reduced.
- The CGS’s landslide and geomorphic analyses were limited to aerial photo interpretation from varying sets of photos and limited verification. Limited aerial photo coverage does not bracket temporal distribution of important watershed events, which may not be evident in photos taken years after the fact.
- Imagery from 1965 was only partly reviewed. Due to access, time, budget, and staffing constraints, field checking of interpretations did not occur.
- The geologic analysis did not identify erosion sources beyond mass wasting and gullying, such as surface erosion or erosion induced by human activities.
- At the analysis scale of 1:24,000, the detection of geologic features smaller than 100 feet in greatest diameter is poor.
- Localized point source channel aggradation and meandering flows observed shortly after the 1964 storms were not systematically compared sequentially through time to detail evolving stream channel morphology.
- The CGS’s channel classification was done based on channel gradients taken from a Digital Elevation Model. This model was based on imperfect topographic data. Most of the basin topography is mapped at a contour interval of 80 feet, which is too coarse to adequately interpret the gradient of individual reaches. No field stream gradient surveys were done for this assessment, due to time and budget constraints.
- The CGS analysis of fluvial and hillslope conditions has not been completed. Collected data are not completely converted into a digital format needed for spatial analysis. This includes the CGS's Landslide Potential Map, fluvial geomorphic characteristics, and spatial data from NCRWQCB, CDFG, DWR, and CDF. The CGS has not reviewed all documents referenced in this report.
- There was only time to compare broad contrasts between land use impacts and habitat conditions.
- The NCRWQCBs water chemistry analysis was limited to available USEPA StoRet data for the period 1973 to 1988 at one location, and samples obtained by the NCRWQCB at four locations for two sampling events in 2001. The sampling frequency was scattered and discontinuous and did not allow for much detailed temporal analysis.
- Data on pesticide occurrences in surface water were not available from StoRet, private interests, nor collected in the NCRWQCB sampling of 2001.
- The temperature range used for proposed fully suitable of 50-60° F was developed as an average of the needs of several cold water fish species and life stages, including Chinook and coho salmon, and steelhead and cutthroat trout. As such, the range does not represent the slight variance of fully acceptable ranges for particular species.
- In-channel data and some temperature data were provided as summary statistics (medians, means, and maxima), limiting the ability to factor variability into the analysis, and not allowing for independent checks on the data quality. As such, the analyses and subsequent assessment are limited in scope.

- Temperature data analysis did not include probability of exceedance from cumulative distribution plots, nor hours of exceedance of a threshold. This analysis was limited by not having raw data for all sites, obtaining raw data late in the analysis, and data interface problems.
- The NCRWQCB did not have acceptably useful turbidity or suspended solids data, though they are considered crucial to watershed analysis. The absence of useful data and any analysis of suspended loads and turbidity are limitations in this assessment. These data sets exist, but were for one surface sampling location only and were not used in the 2002 assessment.
- Analysis of temperature information is without knowledge of the extent of a thermal reach upstream of the continuous data logger.
- Historic timber harvesting data are compiled from previous work performed by the Mattole Restoration Council. The CDF has not yet validated the accuracy of this data.
- Although the CDFG has surveyed just over 130 miles of anadromous reaches in the Mattole Basin, there are a few, most importantly Mattole Canyon Creek and unsurveyed reaches of the North Fork Mattole River, which could possibly identify opportunities for local improvements for fish. Extensive stream surveys will strengthen the stewardship effort.
- Most CDFG surveys used for this NCWAP stream reach assessment were conducted in 1996. A few surveys are more recent, while three are nearly ten years old. Although most channel characteristics remain relatively constant, components like habitat complexity and riparian shade canopy can change fairly quickly. Current surveys would contribute to data relevance and help track change to the streams in a timelier manner.
- The EMDS model used is preliminary; not all components of the model are currently in use due to data and modeling issues (i.e., stream temperature, fish passage, stream flow); not all data layers used in the model have yet been fully subjected to quality control review; scientist and practitioner peer review of the model is planned but not yet completed.

NOTES:

Appendices

Glossary

AGGRADATION: The geologic process in which stream beds, floodplains, and the bottoms of other water bodies are raised in elevation by the deposition of material eroded and transported from other areas. It is the opposite of degradation.

ALEVIN: The life stage of salmonids that occurs after eggs have hatched but before young emerge from the gravel nests where they have incubated. Alevin still have yolk sacs attached to provide them with nutrition within the nest.

ALLUVIUM: A general term for all deposits resulting directly or indirectly from the sediment transport of streams, thus including the sediments laid down in riverbeds, floodplains, lakes, fans and estuaries. ALLUVIAL *adj.*

ANADROMOUS: Fish that leave freshwater and migrate to the ocean to mature then return to freshwater to spawn. Salmon, steelhead and shad are examples.

ANTHROPOGENIC: Caused by humans.

ARCINFO: ESRI (Environmental Systems Research Institute) proprietary software, which provides a complete GIS data creation, update, query, mapping, and analysis system.

AERIAL: Having to do with or done by aircraft. Aerial photographs are taken from aircraft equipped with cameras.

ATHABASKAN: A group of related North American Indian languages including the Apachean languages, languages of Alaska, northwest Canada, and coastal Oregon and California. The Athabaskan languages formerly spoken in the northern third of Mendocino and the southern half of Humboldt counties in northwestern California fall into three broad groups of closely related dialects: Hupa-Chilula, Mattole-Bear River, and Eel River (including Cahto and the Kuneste (from koneest'ee', person) dialects: Lassik, Nongatl, Sinkyone, Wailaki).

BANKFULL DISCHARGE: The discharge corresponding to the stage at which the floodplain of a particular stream reach begins to be flooded; the point at which bank overflow begins.

BANKFULL WIDTH: The width of the channel at the point at which overbank flooding begins.

BASIN: see watershed.

BED SUBSTRATE: The materials composing the bottom of a stream.

BENTHIC: The collection of organisms living on or in sea, river or lake bottoms.

BOULDER: Stream substrate particle larger than 10 inches (256 millimeters) in diameter.

CALWATER: A set of standardized watershed boundaries for California nested into larger previously standardized watersheds and meeting standardized delineation criteria.

CANOPY: The overhead branches and leaves of streamside vegetation.

CANOPY COVER: The vegetation that projects over the stream.

CANOPY DENSITY: The percentage of the stream covered by the canopy of plants, sometimes expressed by species.

CENTROID: The center of water mass of a flowing stream at any location. This location usually correlates well with the thalweg, or deepest portion of the stream. Sampling in the centroid is intended to provide a reasonably representative sample of the main stream.

CHANNEL: A natural or artificial waterway of perceptible extent that periodically or continuously contains moving water. It has a definite bed and banks, which serve to confine the water.

COAST RANGE: A string of mountain ranges along the Pacific Coast of North America from Southeastern Alaska to lower California.

COBBLE: Stream substrate particles between 2.5 and 10 inches (64 and 256 millimeters) in diameter.

COLLUVIUM: A general term for loose deposits of soil and rock moved by gravity; e.g. talus.

CONIFEROUS: Any of various mostly needle-leaved or scale-leaved, chiefly evergreen, cone-bearing gymnospermous trees or shrubs such as pines, spruces, and firs.

CONSUMPTIVE USE OF WATER: Occurs when water is taken from a stream and not returned.

COVER: Anything that provides protection from predators or ameliorates adverse conditions of streamflow and/or seasonal changes in metabolic costs. May be instream cover, turbulence, and/or overhead cover, and may be for the purpose of escape, feeding, hiding, or resting.

DEBRIS: Material scattered about or accumulated by either natural processes or human influences.

DEBRIS JAM: Log jam. Accumulation of logs and other organic debris.

DEBRIS LOADING: The quantity of debris located within a specific reach of stream channel, due to natural processes or human activities.

DECIDUOUS: A plant (usually a tree or shrub) that sheds its leaves at the end of the growing season.

DEGRADATION: The geologic process in which stream beds and floodplains are lowered in elevation by the removal of material. It is the opposite of aggradation.

DEMOGRAPHY: The study of the characteristics of populations, such as size, growth, density, distribution, and vital statistics.

DEPOSITION: The settlement or accumulation of material out of the water column and onto the streambed. Occurs when the energy of flowing water is unable to support the load of suspended sediment.

DEPTH: The vertical distance from the water surface to the streambed.

DISCHARGE: Volume of water flowing in a given stream at a given place and within a given period of time, usually expressed as cubic meters per second (m^3/sec), or cubic feet per second (cfs).

DISSOLVED OXYGEN (DO): The concentration of oxygen dissolved in water, expressed in mg/l or as percent saturation, where saturation is the maximum amount of oxygen that can theoretically be dissolved in water at a given altitude and temperature.

DIVERSION: A temporal removal of surface flow from the channel.

ECOTONE: A transition area between two distinct habitats that contains species from each area, as well as organisms unique to it.

EMBEDDEDNESS: The degree that larger particles (boulders, rubble, or gravel) are surrounded or covered by fine sediment. Usually measured in classes according to percentage of coverage of larger particles by fine sediments.

ECOLOGICAL MANAGEMENT DECISION SUPPORT (EMDS): An application framework for knowledge-based decision support of ecological landscape analysis at any geographic scale.

EMBRYO: An organism in its early stages of development, especially before it has reached a distinctively recognizable form.

ENDANGERED SPECIES: Any species which is in danger of extinction throughout all or a significant portion of its range other than a species of the Class Insecta determined by the Secretary to constitute a pest whose protection under the provisions of this Act would present an overwhelming and overriding risk to man.

EROSION: The group of natural processes, including weathering, dissolution, abrasion, corrosion, and transportation, by which material is worn away from the earth's surface. EROSIONAL *adj.*

ESTUARY: A water passage where the tide meets a river current.

EXTIRPATION: To destroy totally; exterminate.

EXTINCTION: The death of an entire species.

FILL: a) the localized deposition of material eroded and transported from other areas, resulting in a change in the bed elevation. This is the opposite of scour; b) the deliberate placement of (generally) inorganic materials in a stream, usually along the bank.

FINE SEDIMENT: The fine-grained particles in stream banks and substrate. Those are defined by diameter, varying downward from 0.24 inch (6 millimeters).

FISH HABITAT: The aquatic environment and the immediately surrounding terrestrial environment that, combined, afford the necessary biological and physical support systems required by fish species during various life history stages.

FLATWATERS: In relation to a stream, low velocity pool or run habitat.

FLOOD: Any flow that exceeds the bankfull capacity of a stream or channel and flows out of the floodplain; greater than bankfull discharge.

FLOODPLAIN: The area bordering a stream over which water spreads when the stream overflows its banks at flood stages.

FLOW: a) the movement of a stream of water and/or other mobile substances from place to place; b) the movement of water, and the moving water itself; c) the volume of water passing a given point per unit of time. Discharge.

FLUVIAL: Relating to or produced by a river or the action of a river. Situated in or near a river or stream.

FRESHETS: A sudden rise or overflowing of a small stream as a result of heavy rains or rapidly melting snow.

FRY: Small fish, especially young, recently hatched fish.

GENETIC DRIFT: The random change of the occurrence of a particular gene in a population.

GEOGRAPHIC INFORMATION SYSTEM (GIS): A computer system for capturing, storing, checking, integrating, manipulating, analyzing, and displaying data related to positions on the Earth's surface. Typically, a GIS is used for handling maps of one kind or another. These might be represented as several different layers where each layer holds data about a particular kind of feature (e.g. roads). Each feature is linked to a position on the graphical image of a map.

GEOMORPHOLOGY: The study of surface forms on the earth and the processes by which these develop.

GRADIENT: The slope of a streambed or hillside. For streams, gradient is quantified as the vertical distance of descent over the horizontal distance the stream travels.

GRAVEL: Substrate particle size between 0.08 and 2.5 inches (2 and 64 millimeters) in diameter.

GRILSE: see jack.

GULLY: A deep ditch or channel cut in the earth by running water after a prolonged downpour.

HABITAT: The place where a population lives and its surroundings, both living and nonliving; includes the provision of life requirements such as food and shelter.

HABITAT CONSERVATION PLAN: A document that describes how an agency or landowner will manage their activities to reduce effects on vulnerable species. An HCP discusses the applicant's proposed activities and describes the steps that will be taken to avoid, minimize, or mitigate the take of species that are covered by the plan.

HABITAT TYPE: A land or aquatic unit, consisting of an aggregation of habitats having equivalent structure, function, and responses to disturbance.

HATCH BOX: An apparatus in which environmental conditions, such as temperature and sediment, can be controlled, used for hatching eggs artificially.

HETEROZYGOSITY: The presence of different alleles at one or more loci on homologous chromosomes.

HIERARCHY: A series of ordered groupings of people or things within a system.

HYDROGRAPH: A graph showing, for a given point on a stream, the discharge, stage, velocity, or other property of water with respect to time.

HYDROLOGY: The science of water, its properties, phenomena, and distribution over the earth's surface.

HYDROGRAPHIC UNIT: A watershed designation at the level below Hydrologic Region and above Hydrologic Sub-Area.

HYPOTHESIS: A tentative explanation for an observation, phenomenon, or scientific problem that can be tested by further investigation.

INBREEDING: The breeding of related individuals within an isolated or a closed group of organisms.

INBREEDING DEPRESSION: The exposure of individuals in a population to the effects of deleterious recessive genes through matings between close relatives.

INCUBATION: Maintaining something at the most favorable temperature for its development.

INSTREAM COVER: Areas of shelter in a stream channel that provide aquatic organisms protection from predators or competitors and/or a place in which to rest and conserve energy due to a reduction in the force of the current.

INTERMITTENT STREAM: A stream in contact with the ground water table that flows only at certain times of the year when the ground water table is high and/or when it receives water from springs or from some surface source such as melting snow in mountainous areas. It ceases to flow above the streambed when losses from evaporation or seepage exceed the available stream flow. Seasonal.

JACK: An immature male salmonid (usually two-year old) that returns to freshwater to spawn. Also known as grilse.

KNOWLEDGE BASE: An organized body of knowledge that provides a formal logical specification for the interpretation of information.

LAGOON: A shallow body of water, especially one separated from a sea by sandbars or coral reefs.

LIMITING FACTOR: Environmental factor that limits the growth or activities of an organism or that restricts the size of a population or its geographical range.

LARGE WOODY DEBRIS (LWD): A large piece of relatively stable woody material having a diameter greater than 12 inches (30 centimeters) and a length greater than 6 feet (2 meters) that intrudes into the stream channel. Large organic debris.

MACROINVERTEBRATE: An invertebrate animal (animal without a backbone) large enough to be seen without magnification.

MAINSTEM: The principal, largest, or dominating stream or channel of any given area or drainage system.

MELANGE: A mappable body of rock that includes fragments and blocks of all sizes, both exotic and native, embedded in a fragmented and generally sheared matrix.

MIGRATION: The periodic passage from one region to another for feeding or breeding.

NETWEAVER: A knowledge-based development system. A meta database that provides a specification for interpreting information.

NUTRIENT: A nourishing substance; food. The term *nutrient* is loosely used to describe a compound that is necessary for metabolism.

ONCORHYNCHUS: A genus of the family salmonidae (salmons and trouts). They are named for their hooked (onco) nose (rhynchus).

ORGANIC DEBRIS: Debris consisting of plant or animal material.

ORTHOPHOTOQUADS: A combined aerial photo and planimetric quad map (with no indication of contour) without image displacements and distortions.

PERMANENT STREAM: A stream that flows continuously throughout the year. Perennial.

pH: A measure of the hydrogen ion activity in a solution, expressed as the negative $\log_{10}$ of hydrogen ion concentration on a scale of 0 (highly acidic) to 14 (highly basic) with a pH of 7 being neutral.

PLATE TECTONICS: A theory in which the earth's crust is divided into mobile plates which are in constant motion causing earthquake faults, volcanic eruptions, and uplift of mountain ranges.

PHOTOGRAMMETRY: The process of making maps or scale drawings from photographs, especially aerial photographs.

PRODUCTIVITY: a) Rate of new tissue formation or energy utilization by one or more organisms; b) Capacity or ability of an environmental unit to produce organic material; c) The ability of a population to recruit new members by reproduction.

REDD: A spawning nest made by a fish, especially a salmon or trout.

REFERENCE CONDITIONS: Minimally impaired conditions that provide an estimate of natural variability in biological condition and habitat quality.

RIFFLE: A shallow area extending across a streambed, over which water rushes quickly and is broken into waves by obstructions under the water.

RILL: An erosion channel that typically forms where rainfall and surface runoff is concentrated on slopes. If the channel is larger than one square foot in size, it is called a gully.

RIPARIAN: Pertaining to anything connected with or immediately adjacent to the banks of a stream or other body of water.

RIPARIAN AREA: The area between a stream or other body of water and the adjacent upland identified by soil characteristics and distinctive vegetation. It includes wetlands and those portions of floodplains and valley bottoms that support riparian vegetation.

RIPARIAN VEGETATION: Vegetation growing on or near the banks of a stream or other body of water on soils that exhibit some wetness characteristics during some portion of the growing season.

RUBBLE: Stream substrate particles between 2.5 and 10 inches (64 and 256 millimeters) in diameter.

SALMONID: Fish of the family *Salmonidae*, including salmon, trout, chars, whitefish, ciscoes, and graylings.

SCOUR: The localized removal of material from the stream bed by flowing water. This is the opposite of fill.

SEDIMENT: Fragmented material that originates from weathering of rocks and decomposition of organic material that is transported by, suspended in, and eventually deposited by water or air, or is accumulated in beds by other natural phenomena.

SERAL STAGES: The series of relatively transitory plant communities that develop during ecological succession from bare ground to the climax stage.

SHEAR: A deformation resulting from stresses that cause contiguous parts of a body to slide relatively to each other in a direction parallel to their plane of contact.

SHEAR STRAIN: A measure of the amount by which parallel lines have been sheared past one another by deformation.

SHEAR ZONE: A tabular zone of rock that has been crushed and breciated by many parallel fractures due to shear strain.

SILVICULTURE: The care and cultivation of forest trees; forestry.

SMOLT: Juvenile salmonid one or more years old that has undergone physiological changes to cope with a marine environment, the seaward migration stage of an anadromous salmonid.

SMOLTIFICATION: The physiological change adapting young anadromous salmonids for survival in saltwater.

SPAWNING: To produce or deposit eggs.

STADIA RODS: Graduated rods observed through a telescopic instrument while surveying to determine distances and elevation.

STAGE: The elevation of a water surface above or below an established datum or reference.

STRATH: a) An extensive terrace-like remnant of a broad valley floor that has undergone dissection; b) a broad valley floor representing a local base level, usually covered by a veneer of alluvium.

STREAM: (includes creeks and rivers): A body of water that flows at least periodically or intermittently through a bed or channel having banks and supports fish or other aquatic life. This includes watercourses having a surface or subsurface flow that supports or has supported riparian vegetation.

STREAM BANK: The portion of the channel cross section that restricts lateral movement of water at normal water levels. The bank often has a gradient steeper than 45 degrees and exhibits a distinct break in slope from the stream bottom. An obvious change in substrate may be a reliable delineation of the bank.

STREAM CLASSIFICATION: Various systems of grouping or identifying streams possessing similar features according to geomorphic structure (e.g. gradient, water source, spring, and creek), associated biota (e.g. trout zone) or other characteristics.

STREAM CORRIDOR: A stream corridor is usually defined by geomorphic formation, with the corridor occupying the continuous low profile of the valley. The corridor contains a perennial, intermittent, or ephemeral stream and adjacent vegetative fringe.

STREAM REACH: A section of a stream between two points.

SUBSTRATE: The material (silt, sand, gravel, cobble, etc.) that forms a stream or lakebed.

SUBWATERSHED: One of the smaller watersheds that combine to form a larger watershed.

TAKE: to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct.

TERRACE: A former floodplain underlain by sediment deposited by a stream when the stream was flowing at a higher level; typically forming a relatively level bench along a valley side adjacent to a recent floodplain.

TERRAIN: A tract or region of the earth's surface considered as a physical feature, an ecological environment, or a site of some planned activity of man.

TERRANE: A term applied to a rock or group of rocks and to the area in which they crop out. The term is used in a general sense and does not imply a specific rock unit.

THALWEG: The line connecting the lowest or deepest points along a streambed.

THREATENED SPECIES: Any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

TOPOGRAPHY: The general configuration of a land surface, including its relief and the position of its natural and man-made features.

TOPOLOGY: The analytical, detailed study of minor landforms, requiring fairly large scales of mapping.

TRIBUTARY: A stream feeding, joining, or flowing into a larger stream. Feeder stream, side stream.

UNDERCUT BANK: A bank that has had its base cut away by the water action along man-made and natural overhangs in the stream.

VELOCITY: The time rate of motion; the distance traveled divided by the time required to travel that distance.

V*: Measures of percent sediment filling of a stream pool with deposits such as silt, sand, and gravel compared to the total volume.

WATER RIGHT: The right to draw water from a particular source, such as a lake, irrigation canal, or stream. Often used in the plural.

WATERSHED ASSESSMENT: An interdisciplinary process of information collection and analysis that characterizes current watershed conditions at a course scale.

WATERSHED: Total land area draining to any point in a stream, as measured on a map, aerial photograph or other horizontal plane. Also called catchment area, watershed, and basin.

WATERSHED MANAGEMENT AREA (WMA): In the context of the North Coast Regional Water Quality Control Board's Watershed Management Initiative, this represents a grouping of smaller watersheds into a larger area for identifying and addressing water quality problems, e.g., the Humboldt WMA includes all watersheds draining to the ocean or bays north of the Eel River to and including Redwood Creek.

WEIR: A barrier constructed across a stream to divert fish into a trap.

WETLAND: An area subjected to periodic inundation, usually with soil and vegetative characteristics that separate it from adjoining non-inundated areas.

WILDLIFE CORRIDOR: Linear spaces that connect the various areas of an animal's habitat, links between feeding, watering, resting, and breeding places.

List of Abbreviations

BLM	Bureau of Land Management
CalEPA	California Environmental Protection Agency
Caltrans	California Department of Transportation
CCD	Census County Division
CDF	California Department of Forestry and Fire Protection
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
CFS	Cubic Feet per Second
DAU	Detailed Analysis Unit
CDFG	California Department of Fish and Game
DOC/CGS	California Department of Conservation-California Geological Survey
DWR	California Department of Water Resources
EMDS	Ecological Management Decision Support
EPA	Environmental Protection Agency
EPIC	Environmental Protection Information Center
ESA	Federal Endangered Species Act
ESU	Evolutionarily Significant Units
FPA	Z'Berg-Nejedly Forest Practice Act
FPR	California Forest Practice Rules
GIS	Geographic Information System
HA	Hydrologic Area
HCP	Habitat Conservation Plan
HR	North Coast Hydrologic Region
HSA	Hydrologic Sub-area
HU	Hydrologic Unit
IFR	Institute for Fisheries Resources
KRIS	Klamath Resource Information System
KRNCA	King Range National Conservation Area
LFA	Limiting Factor Analysis
LWD	Large Woody Debris
MOU	Memorandum of Understanding
MRC	Mattole Restoration Council
MSG	Mattole Salmon Group
MTJ	Mendocino Triple Junction
MWAT	Maximum Weekly Average Temperature
NCRWQCB	North Coast Regional Water Quality Control Board
NCWAP	North Coast Watershed Assessment Program
NEPA	National Environmental Policy Act
NPDES	National Pollution Discharge Elimination System
NMFS	National Marine Fisheries Service
PALCO	Pacific Lumber Company
PSA	Planning Sub Area
PWS	Planning Watershed
RM	River Mile
SPEWS	Super Planning Watershed
SRP	Scientific Review Panel
SWRCB	California State Water Resources Control Board
TMDL	Total Maximum Daily Load
TPZ	Timber Production Zone
USFS	United States Forest Service
USGS	United States Geologic Survey
WMA	Watershed Management Area
WQO	Water Quality Objectives

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Aerial Photographs (CGS)

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___, dated 8-29-65, Flight 65-CVL-18FF: Photo numbers 6-21, 29-40, 46-58, 99-106, 114-117, and 154-156; black and white digital images scanned from photo positives, vertical, scale 1:20,000.

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___, dated 8-31-65, Flight 65-CVL-21FF, Photo numbers 128-140; black and white digital images scanned from photo positives, vertical, scale 1:20,000.

___, dated 1-21-53, Flight AXL-29K, numbers 15 and 16, black and white, vertical, scale 1:20,000.

___, dated 1-15-53, Flight AXL-28K, numbers 182 and 183, black and white, vertical, scale 1:20,000

United States Department of Defense, dated 10-29-41, Flight 41-HUM-CVL-1B: Photo numbers 53-69 and 73-93; black and white digital images scanned from photo positives, vertical, scale 1:20,000.

___, dated 10-29-41, Flight 41-HUM-CVL-2B, Photo numbers 22-27: black and white digital images scanned from photo positives, vertical, scale 1:20,000.

___, dated 10-30-41, Flight 41-HUM-CVL-1B: Photo numbers 199-212 and 215-231: black and white digital images scanned from photo positives, vertical, scale 1:20,000.

___, dated 10-30-41, Flight 41-HUM-CVL-2B: Photo numbers 77-83 and 110-128; black and white digital images scanned from photo positives, vertical, scale 1:20,000.

___, dated 2-15-42, Flight 42-HUM-CVL-9B: Photos numbers 1-13 and 56-66: black and white digital images scanned from photo positives, vertical, scale 1:20,000.

___, dated 2-16-42, Flight 42-HUM-CVL-9B: Photo numbers 177-198; black and white digital images scanned from photo positives, vertical, scale 1:20,000.

___, dated 2-19-42, Flight 42-HUM-CVL-10B, Photo numbers 1-18 and 45-54, black and white digital images scanned from photo positives, vertical, scale 1:20,000.

WAC Corporation, dated 5-6-84, Flight WAC-84C: Roll 21, Frames 42-54, 95-109, 131-142, 161-169, 185-193, and 203-217; Roll 24, Frames 64-78 and 160-171; and Roll 25, Frames 75-85; black and white, vertical, scale 1:31,680.

___, dated 3-31-00, Flight WAC-00-CA: Roll 4, Frames 1-15, 83-96, 164-167, and 173-175; Roll 6, Frames 1-21, and 95-113; Roll 7, Frames 1-15, 48-63, 88-104, 135-148, 165-177, 191-201, and 213-219; and Roll 9, Frames 176-191, black and white, vert.

___, dated 4-1-00, Flight WAC-00-CA: Role 10, Frames 64-67, 70-75, and 77-81; black and white, vertical, scale 1:24,000.

NCWAP Spatial Data Availability, Catalog, Standards and Analyses

Data Availability

GIS spatial data used and developed by the NCWAP is available to the public through the internet on the NCWAP website: www.ncwatershed.ca.gov. Please navigate to the California Geospatial Information Library under other links.

Data Catalog

Mattole River Watershed, NCWAP DATA CATALOG					
Name	**Source**	**Description**	**Data Quality**	**Metadata**	**Analytical Use in NCWAP**
Ma10mdem	CDF	Clip of 10 m Digital Elevation Model	Created from original USGS contours. Contains horizontal and vertical errors.	Yes	Base for creation of stream gradient and true surface area data.
ma10hlshd	CDF	Shaded relief (hillshade) created from 10 m Digital Elevation Model	See above	Yes	Primarily display.
Ma_cw22	CWMC	Clip of watershed boundaries from CalWater 2.2a	High quality	Yes	Base geographic boundary file for analyses.
Ma_subbasins	CWMC	Clip of watershed boundary including sub-basin and planning watershed boundaries	High quality	Yes	Base geographic boundary file for analyses.
Ma_veg2002	CDF FRAP	Clip of mosaic of vegetation data comprised primarily of Calveg data.	Photo-interpreted. Contains spatial and typing errors. Validation by FRAP in process	Yes	To determine extent of vegetation types within each planning watershed
Matt_allv00x	CGS	Alluvium mapped from 2000 aerial photographs	Mapped to 1:24,000 scale. Dependent upon canopy cover.	No	Stream channel determination
Matt_gulf00x Matt_gulf84x	CGS	Gullies within fluvial features mapped from 2000 and 1984 aerial photographs	Mapped to 1:24,000 scale. Dependent upon canopy cover.	No	Various analyses including relative degree of surface erosion and landslides.
Matt_sfl00x Matt_sfl84x	CGS	Stream features lines including riparian, bars, etc. recorded from 2000 and 1984 photographs	Mapped to 1:24,000 scale. Dependent upon canopy cover.	No	Various analyses including sediment delivery and stream change detection.
Matt_sfpo00x Matt_sfpo84x	CGS	Stream features polygons including riparian, bars, etc. recorded from 2000 and 1984 photographs	Mapped to 1:24,000 scale. Dependent upon canopy cover.	No	Various analyses including sediment delivery and stream change detection.
Matt_act00x, matt_act84x	CGS	Active landslides mapped from 1984 and 2000 aerial photographs	Mapped to 1:24,000 scale. Dependent upon canopy cover.	No	Spatial relationships between active landslides and land use, roads, and streams.
Matt_dor00x, matt_dor84x	CGS	Dormant landslides mapped from 1984 and 2000 aerial photographs	Mapped to 1:24,000 scale. Dependent upon canopy cover.	No	Spatial relationships between dormant landslides and land use, roads, and streams.
Matt_csax, matt_csdx	CGS	Composite slides; active and dormant.	Mapped to 1:24,000 scale. Dependent upon canopy cover.	No	Spatial relationships between composite landslides and land use, roads, and streams.
Matt_pts00x, matt_pts84x, matt_pts65x	CGS	Point slides (landslides < 150m in diameter or across)	Mapped to 1:24,000 scale. Dependent upon canopy cover.	No	Spatial relationships between point slides and roads and proximity to streams.
Matt_linoox, matt_lin84x	CGS	Linear slide features (mapped as points if <150m long)	Mapped to 1:24,000 scale. Dependent upon canopy cover.	No	Spatial relationships between linear slides and roads and proximity to streams.
Matt_gupx, matt_gulx	CGS	Linear and polygon gully features	Mapped to 1:24,000 scale. Dependent upon canopy	No	Spatial relationships between gullies and roads and

Mattole River Watershed, NCWAP DATA CATALOG					
Name	**Source**	**Description**	**Data Quality**	**Metadata**	**Analytical Use in NCWAP**
			cover.		proximity to streams.
Matt_dssx	CGS	Debris slide slopes	Mapped to 1:24,000 scale. Dependent upon canopy cover.	No	Various analyses including stream delivery and landslides.
Matt_isx	CGS	Irregular slopes	Mapped to 1:24,000 scale. Dependent upon canopy cover.	No	Limited analytical use.
Matt_igx	CGS	Inner gorge features	Mapped to 1:24,000 scale. Dependent upon canopy cover.	No	Spatial relationships between gorges and proximity to streams.
Matt_rlsp	CGS	Relative landslide potential. Derivative coverage based on a weighted model using landslide, geomorphology, fluvial, and geology features	Complete coverage at 1:24,000 scale	No	Primary geological analysis coverage.
Ma_fire_pers	CDF	Fire history	Maximum extent fire history polygons	No	Limited analytical use.
ma_habunit	DFG	Unit-level in-stream habitat data	Extensive data set. Contains spatial, typing, and data range errors.	Yes	Data collected opportunistically. Not valid for basin or planning watershed level analyses.
ma_habreach	DFG	Reach-level in-stream habitat data	Extensive data set. Contains spatial, typing, and data range errors. Summarized from unit-level data.	Yes	Data collected opportunistically. Not valid for basin or planning watershed level analyses.
Ma_cdf24khydro	CDF	1:24,000 scale routed hydrography	Incomplete at 1:24,000 scale. Digitized from 1:24,000 USGS quadrangle maps. Contains naming and routing errors.	Yes	Base coverage for routing in-stream habitat data. Used with geology and geomorphology data for proximity and sediment delivery analysis.
Ma_lakeclip	DWR	Clip of statewide lake coverage	Created at 1:24,000 scale	Yes	Limited analysis use – primarily cartographic
Ma_500kstrm	DWR	Clip of 1:500,000 statewide stream and river coverage	Created at 1:500,000 scale	Yes	Limited analysis use – primarily cartographic
St_mattole	CDF	Stream gradients for 1:24,000 hydrography	Derivative data created from original DEM contour intervals and routed hydrography	No	Used in conjunction with in-stream habitat data for fish distribution.
Ma_pubparcel	CDF	Land ownership for public land parcels in Mattole watershed	Unknown	No	Used informally in land use analysis
Ma_privparcel	CDF	Land ownership for private land parcels in Mattole watershed	Unknown	No	Used informally in land use analysis
thpxx	CDF	Timber harvest coverages for 1977 through 2001	Created from 1:24,000 USGS quadrangle maps. Maximum extent polygons. Highly attributed.	No	Base coverage for comparing landslides, roads, and other features to stream proximity.
Ma_roads	CDF	Major and minor roads.	Created from 1:24,000 USGS quad maps. Some field verification.	Yes	Limited utility due to incomplete nature of data. Base coverage for comparing landslides, THP's, and other features to stream proximity.
Creel census data	DFG	Creel and fisherman survey data for the Mattole river 1973	Not digital. Quality unknown	No	Fish distribution.
Water temperature data	DFG	Mattole river water temperatures. 1972.	Not digital. Quality unknown	No	Used in conjunction with in-stream habitat data.
Stream habitat	DFG	Numerous stream habitat surveys of	Not digital. Quality	No	Comparison with current in-

Mattole River Watershed, NCWAP DATA CATALOG					
Name	**Source**	**Description**	**Data Quality**	**Metadata**	**Analytical Use in NCWAP**
surveys		major Mattole River tributaries conducted during 1938 and 1985.	unknown		stream habitat surveys.
Stream fish inventories	DFG	Stream fish inventory data for Mattole river, north fork Mattole river, squaw, mill, Thompson, baker, and bridge creeks.	Not digital. Quality unknown	No	Comparison with current in-stream habitat surveys.
Stream flow data	DFG	Stream flow data for the Mattole river, 1976.	Not digital. Quality unknown	No	Comparison with current in-stream habitat surveys.
Historic photos	Froland	Historic photographs of the Honeydew slide. 1983	Not digital. Quality unknown	No	Historic geological information
Erosion data	MSG	Aerial photo interpretation of erosion in the Mattole river basin	Not digital. Quality unknown	No	Historic geological information
In-stream habitat data	DFG	In-stream habitat data for yew, barnum and dream stream creeks.	Not digital. Quality unknown	No	Comparison with current in-stream habitat conditions
Fisheries data	DWR	Unspecified fisheries data, north coast basins. 1962.	Not digital. Quality unknown	No	Comparison with other fish population data.
Erosion and sedimentation data	MRC	Sediment source and erosion data for the Mattole watershed. 1989.	n/a	n/a	Historic geological information
Fish distribution data	MSG	Migrant trapping data for the Mattole river 1996-1999	n/a	n/a	Comparison with other fish population data.
Spawning ground data	MSG	Spawning ground surveys for the Mattole river, 1998-2001.	n/a	n/a	Historical land use.
Meteorological, temperature, and discharge data	Noble	Meteorological, temperature, and discharge data for the Mattole river, 1983	n/a	n/a	Comparison with current physical data.
Fish distribution data	DFG	Fish stocking, spawning, and salmonid release records for the Mattole river. 1985-1990	n/a	n/a	Historical land use.
In-stream habitat data	DFG	In-stream habitat data Eubanks creek. 1982 and 1987.	Not digital. Quality unknown	No	Comparison with current in-stream habitat conditions
Flow and discharge data	USGS	Historic monthly Mattole river discharge data. 1993	Not digital. Quality unknown.	no	Comparison with current in-stream habitat surveys.
Aquatic invertebrate data	BLM	Aquatic invertebrate monitoring data. Location unknown. 1997-2000.	Not digital. Quality unknown.	no	Comparison with current in-stream habitat surveys.
Historic map	Brown and Wolfe	1:24,000 scale fault map of western Mattole watershed. 1972.	Not digital. Quality unknown	No	Historic geological information
Watershed mapping data	CGS	Various digital products for base watershed mapping.	http://www.consrv.ca.gov/dmg/ws/index.htm	Yes	Various.
Standard quadrangle maps	USGS	Complete set of 7.5 minute USGS quadrangle maps covering the Mattole River watershed.	Created in 1952 and many updated in 1983	Yes	Base data and information for land use, geology, hydrography, and other data mapping.
Geological and landslide feature maps	USGS	Complete set of 7.5 minute USGS landslide feature maps covering the Mattole River watershed.	Created in 1952 and many updated in 1983	Yes	Base data and information for land use, geology, hydrography, and other data mapping.
Geological field survey data	USGS	Misc. field survey information related to the Mattole watershed	http://geopubs.wr.usgs.gov/map-mf/mf2336	Yes	Geology and geomorphology data creation.
Aerial photographs	USDA	Flight 65-CVL-8FF: Photo numbers 7-29 and 33-48; black and white digital images scanned from photo positives, vertical, scale 1:20,000. 1965	Unknown quality	n/a	Base data and information for land use, geology, hydrography, and other data mapping.
Aerial photographs	USDA	Flight 65-CVL-10FF: Photo numbers 1-16, 28-45, 48-64, 80-98, 126-135, 138-141, and 156-158; black and white	Unknown quality	n/a	Base data and information for land use, geology, hydrography, and other data

Mattole River Watershed, NCWAP DATA CATALOG					
Name	**Source**	**Description**	**Data Quality**	**Metadata**	**Analytical Use in NCWAP**
		digital images scanned from photo positives, vertical, scale 1:20,000. 1965			mapping.
Aerial photographs	USDA	Flight 65-CVL-18FF: Photo numbers 6-21, 29-40, 46-58, 99-106, 114-117, and 154-156; black and white digital images scanned from photo positives, vertical, scale 1:20,000. 1965	Unknown quality	n/a	Base data and information for land use, geology, hydrography, and other data mapping.
Aerial photographs	USDA	Flight 65-CVL-20FF: Photo numbers 190-203; black and white digital images scanned from photo positives, vertical, scale 1:20,000. 1965	Unknown quality	n/a	Base data and information for land use, geology, hydrography, and other data mapping.
Aerial photographs	USDA	Flight 65-CVL-21FF, Photo numbers 128-140; black and white digital images scanned from photo positives, vertical, scale 1:20,000. 1965	Unknown quality	n/a	Base data and information for land use, geology, hydrography, and other data mapping.
Aerial photographs	DOD	Flight 41-HUM-CVL-1B: Photo numbers 53-69 and 73-93; black and white digital images scanned from photo positives, vertical, scale 1:20,000. 1941	Unknown quality	n/a	Base data and information for land use, geology, hydrography, and other data mapping.
Aerial photographs	DOD	1:18,500 scale. Flight line 24; Frames 27-38, 121-132; Flight line 25; Frames 9-11; Flight line 32; Frames 95-100. 1984	Unknown quality	n/a	Base data and information for land use, geology, hydrography, and other data mapping.
Aerial photographs	DOD	Flight 41-HUM-CVL-2B, Photo numbers 22-27: black and white digital images scanned from photo positives, vertical, scale 1:20,000. 1941	Unknown quality	n/a	Base data and information for land use, geology, hydrography, and other data mapping.
Aerial photographs	DOD	Flight 41-HUM-CVL-1B: Photo numbers 199-212 and 215-231: black and white digital images scanned from photo positives, vertical, scale 1:20,000. 1941	Unknown quality	n/a	Base data and information for land use, geology, hydrography, and other data mapping.
Aerial photographs	DOD	Flight 41-HUM-CVL-2B: Photo numbers 77-83 and 110-128; black and white digital images scanned from photo positives, vertical, scale 1:20,000. 1941.	Unknown quality	n/a	Base data and information for land use, geology, hydrography, and other data mapping.
Aerial photographs	DOD	Flight 42-HUM-CVL-9B: Photos numbers 1-13 and 56-66: black and white digital images scanned from photo positives, vertical, scale 1:20,000. 1942	Unknown quality	n/a	Base data and information for land use, geology, hydrography, and other data mapping.
Aerial photographs	DOD	Flight 42-HUM-CVL-9B: Photo numbers 177-198; black and white digital images scanned from photo positives, vertical, scale 1:20,000. 1942.	Unknown quality	n/a	Base data and information for land use, geology, hydrography, and other data mapping.
Aerial photographs	DOD	Flight 42-HUM-CVL-10B, Photo numbers 1-18 and 45-54, black and white digital images scanned from photo positives, vertical, scale 1:20,000. 1942	Unknown quality	n/a	Base data and information for land use, geology, hydrography, and other data mapping.
Aerial photographs	WAC Corp.	Flight WAC-84C: Roll 21, Frames 42-54, 95-109, 131-142, 161-169, 185-193, and 203-217; Roll 24, Frames 64-78 and 160-171; and Roll 25, Frames 75-85; black and white, vertical, scale	Unknown quality	n/a	Base data and information for land use, geology, hydrography, and other data mapping.

Mattole River Watershed, NCWAP DATA CATALOG					
Name	**Source**	**Description**	**Data Quality**	**Metadata**	**Analytical Use in NCWAP**
		1:31,680. 1984.			
Aerial photographs	WAC Corp.	Flight WAC-00-CA: Roll 4, Frames 1-15, 83-96, 164-167, and 173-175; Roll 6, Frames 1-21, and 95-113; Roll 7, Frames 1-15, 48-63, 88-104, 135-148, 165-177, 191-201, and 213-219; and Roll 9, Frames 176-191, black and white, vertical, scale 1:24,000. 2000.	Unknown quality	n/a	Base data and information for land use, geology, hydrography, and other data mapping.
Aerial photographs	WAC Corp.	Flight WAC-00-CA: Role 10, Frames 64-67, 70-75, and 77-81; black and white, vertical, scale 1:24,000.	Unknown quality	n/a	Base data and information for land use, geology, hydrography, and other data mapping.

Source abbreviations
CDF – California Department of Forestry and Fire Protection
CGS – Department of Conservation, California Geological Survey
CWMC – California Watershed Mapping Committee
DFG – California Department of Fish and Game
DOD – Department of Defense
DWR – California Department of Water Resources
FRAP – Forest Resource Assessment Program
MRC – Mattole Restoration Council
MSG - Mattole Salmon Group
NCRWQCB – North Coast Regional Water Quality Control Board
RNSP – Redwood National and State Parks
SSRRCD – Sotoyome-Santa Rosa Resource Conservation District
Teale – Stephen P. Teale data center, State of California
USDA – United States Department of Agriculture
USGS – United States Geological Survey

Spatial and Geographic Information Systems (GIS) Data Standards and Analyses

The NCWAP collected or created thousands of data records for synthesis and analysis purposes and most of these data were either created in a spatial context or converted to a spatial format. Effective use of these data between the five partner departments required establishing standards for data format, storage, management and dissemination. Early in the assessment process, we held a series of meetings designed to gain consensus on a common format for the often widely disparate data systems within each department. Our objective was to establish standards which could be easily used by each department, that were most useful and powerful for selected analysis, and would be most compatible with standards used by potential private and public sector stakeholders.

As a result, we agreed that spatial data used in NCWAP and base information disseminated to the public through the program would be in the following format (See data catalog for a complete description of data sources and scale):

Data form: standard database format usually associated with a GIS shapefile© (ESRI) or coverage. Data were organized by watershed and distributed among watershed synthesis teams. Electronic images were retained in their current format.

Spatial Data Projection: spatial data were projected from their native format to both Teale albers, North American Datum (NAD) 1927 and Universal Transverse Mercator (UTM), Zone 10, NAD 1983. Both formats were used in data analysis and synthesis.

Scale: most data were created and analyzed at 1:24000 scale to 1) match the minimum analysis scale for planning watersheds, and 2) coincide with base information (e.g., stream networks) on USGS quadrangle maps (used as Digital Raster Graphics [DRG]).

Data Sources: data were obtained from a variety of sources including spatial data libraries with partner departments or were created by manually digitizing from 1:24000 DRG.

The metadata available for each spatial data set contain a complete description of how data were collected and attributed for use in NCWAP. Spatial data sets that formed the foundation of most analysis included the 1:24000 hydrography and the 10 meter scale Digital Elevation Models (DEM). Hydrography data were created by manually digitizing from a series of 1:24000 DRG then attributing with direction, routing, and distance information using a dynamic segmentation process (see http://arconline.esri.com/arconline/whitepapers/ao_/ArcGIS8.1.pdf for more information). The resulting routed hydrography allowed for precise alignment and display of stream habitat data and other information along the stream network. The DEM was created from base contour data obtained form the USGS for the entire NCWAP region.

Source spatial data were often clipped to watershed, planning watershed, and subbasin units prior to use in analysis. Analysis often included creation of summary tables, tabulating areas, intersecting data based on selected attributes, or creation of derivative data based on analytical criteria. For more information regarding the approach to analysis and basis for selected analytical methods, see the integrated analyses section.