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.

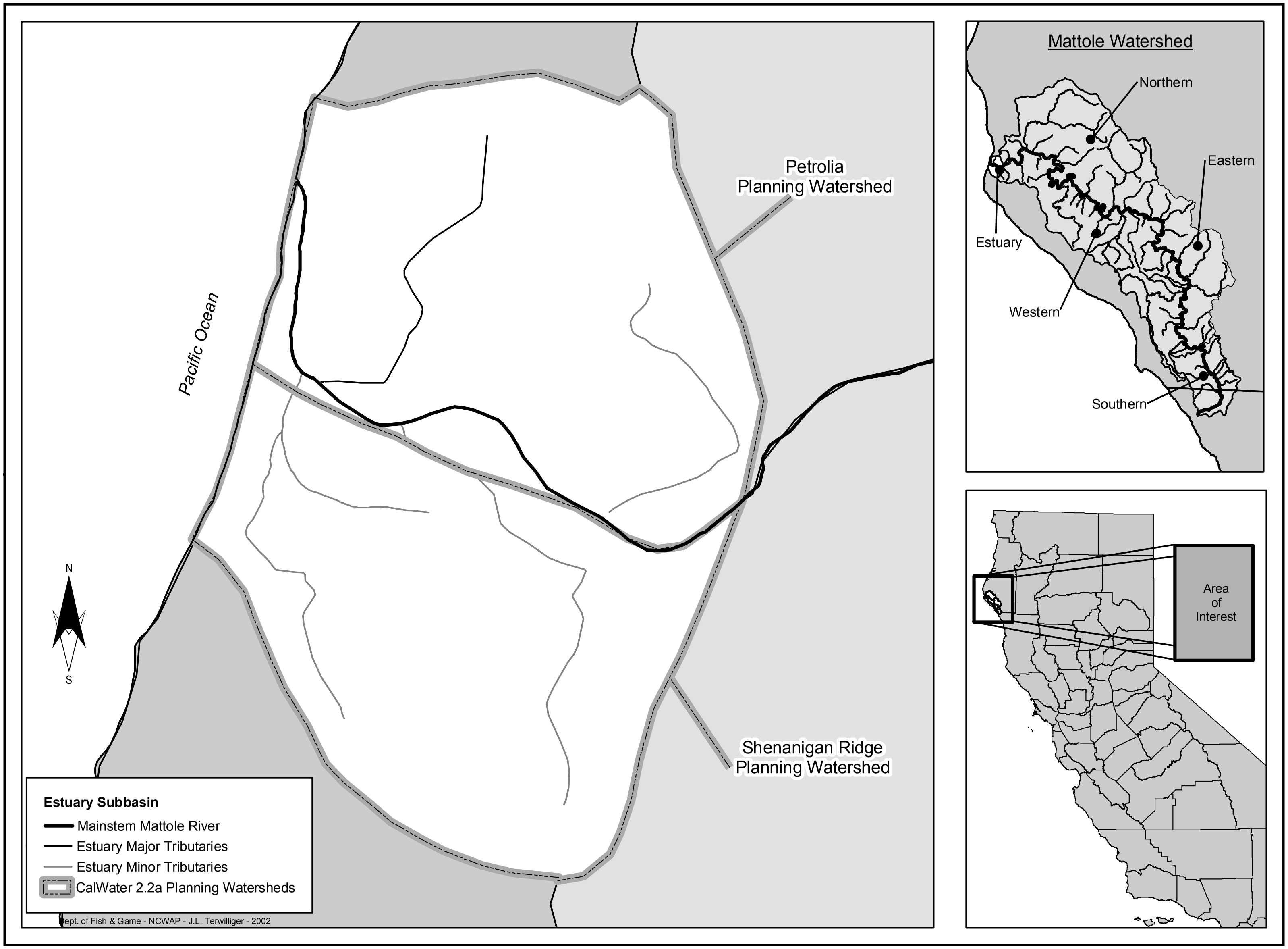

Figure 55. Mattole River Estuary Subbasin.

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.

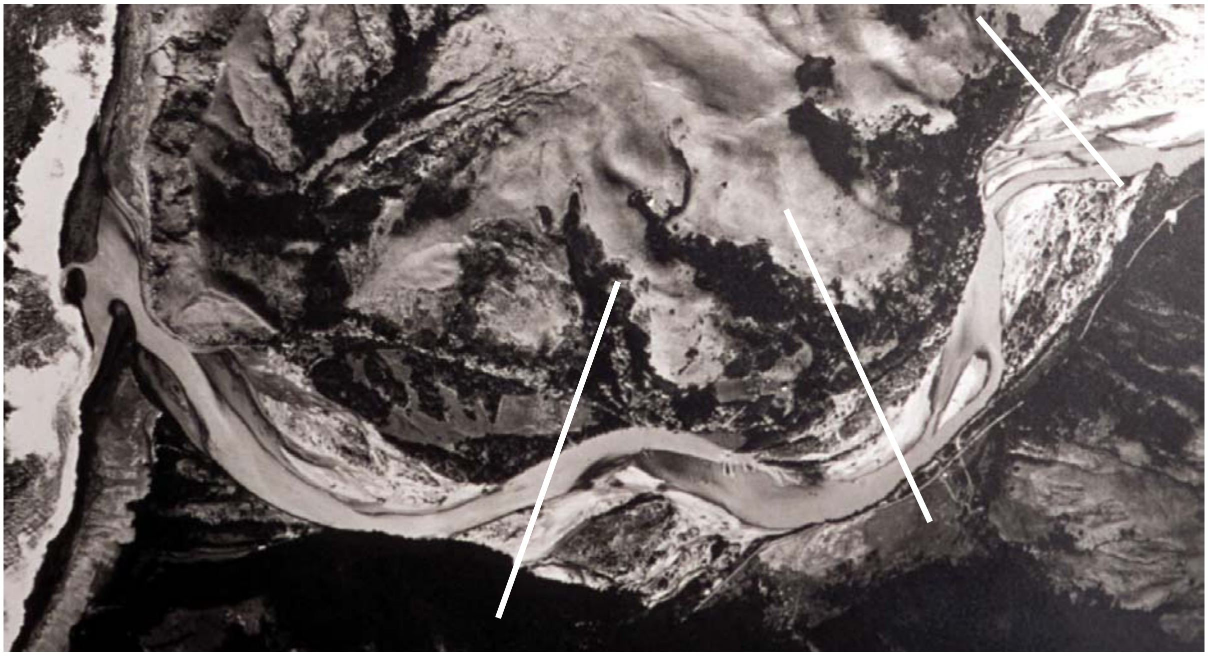

Figure 56. The Mattole River Estuary in 1942.

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).

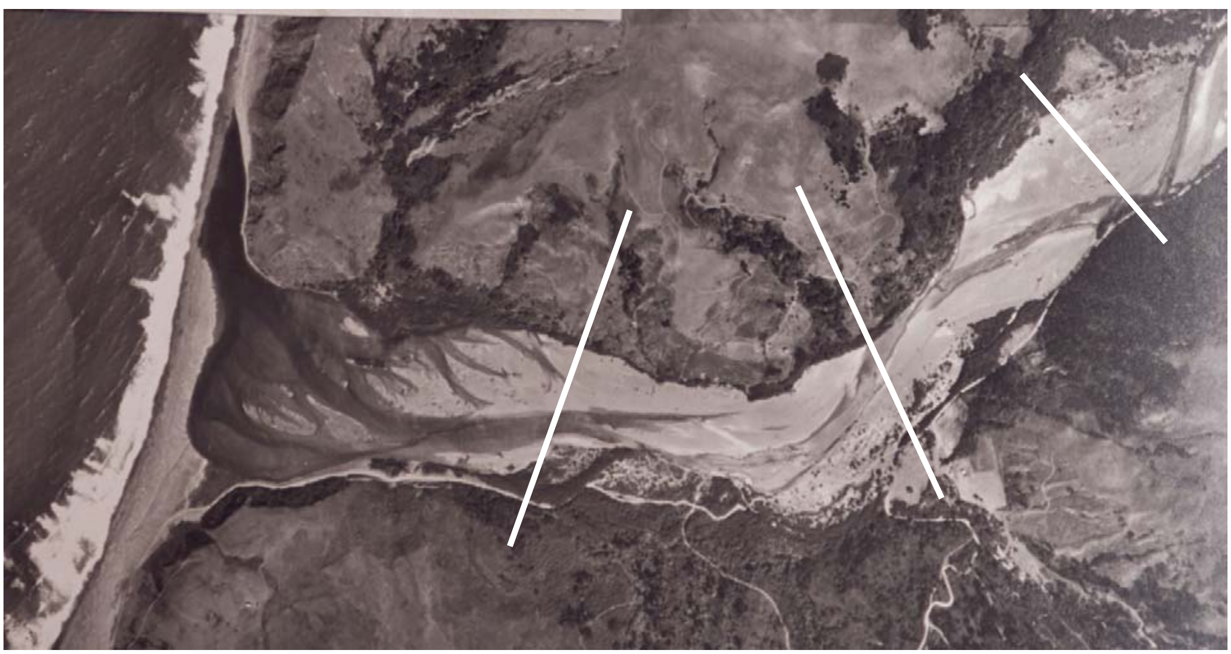

Figure 57. The Mattole River Estuary in 1965.

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.

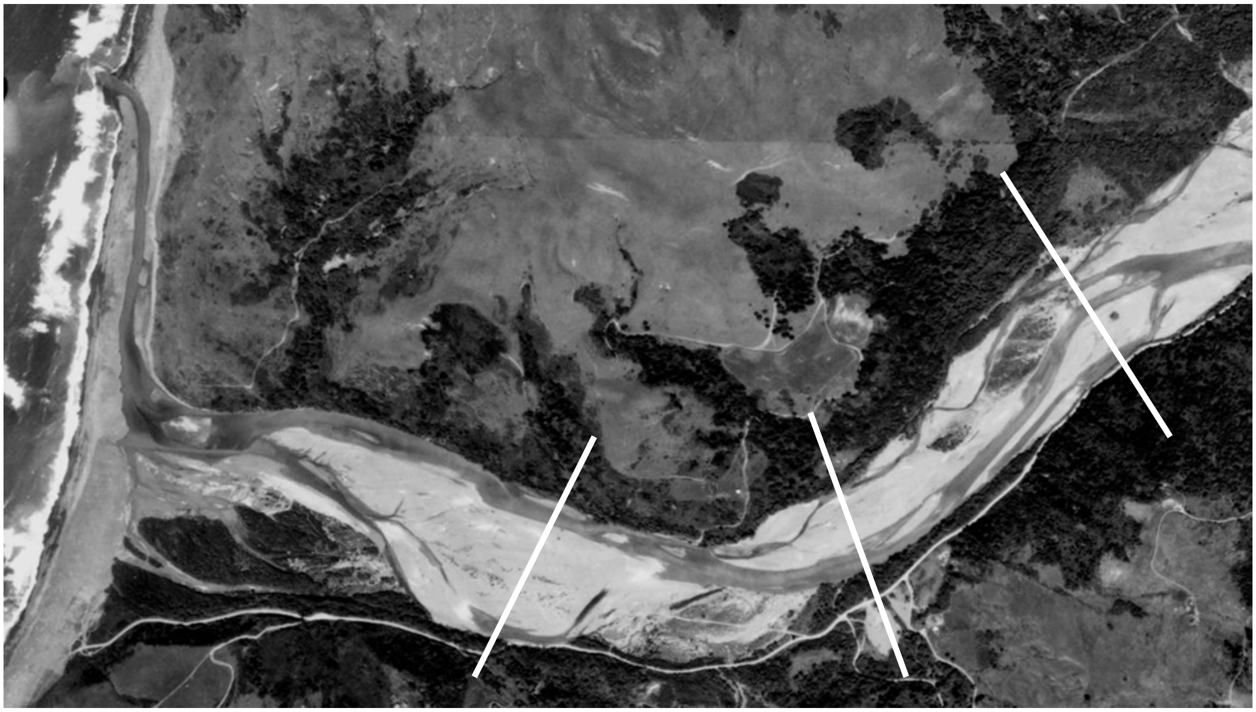

Figure 58. The Mattole River Estuary in 1984.

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)

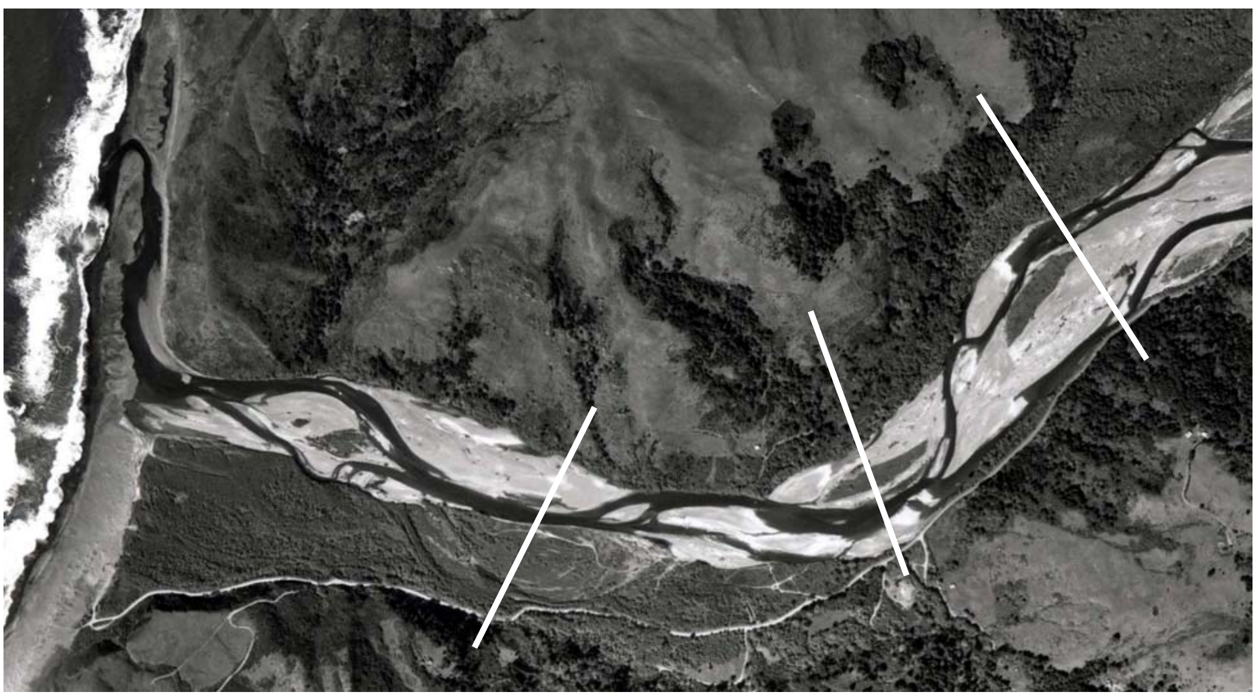

Figure 59. The Mattole River Estuary in 2000.

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			
	Point Count	Area[3] (acres)		
Hard	2	<1	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.
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		
Hard	<1	100%	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.
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		
Hard	99%	9%	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.
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.	
Blue Line Streams where Wide Channel (wc) Observed		See Figure 32				This feature was not observed in this subbasin.
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.

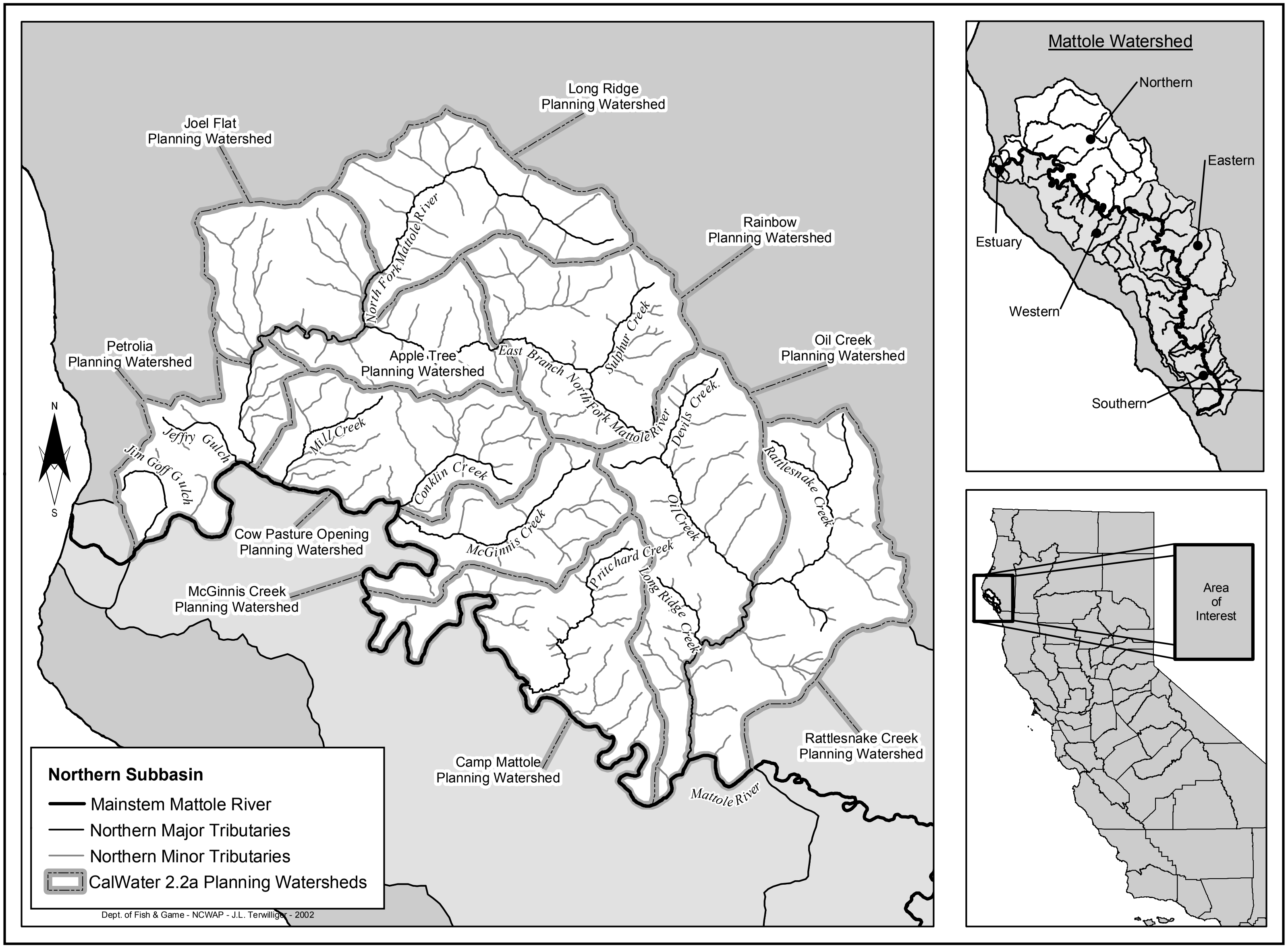

Figure 60. Mattole Northern Subbasin.

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.

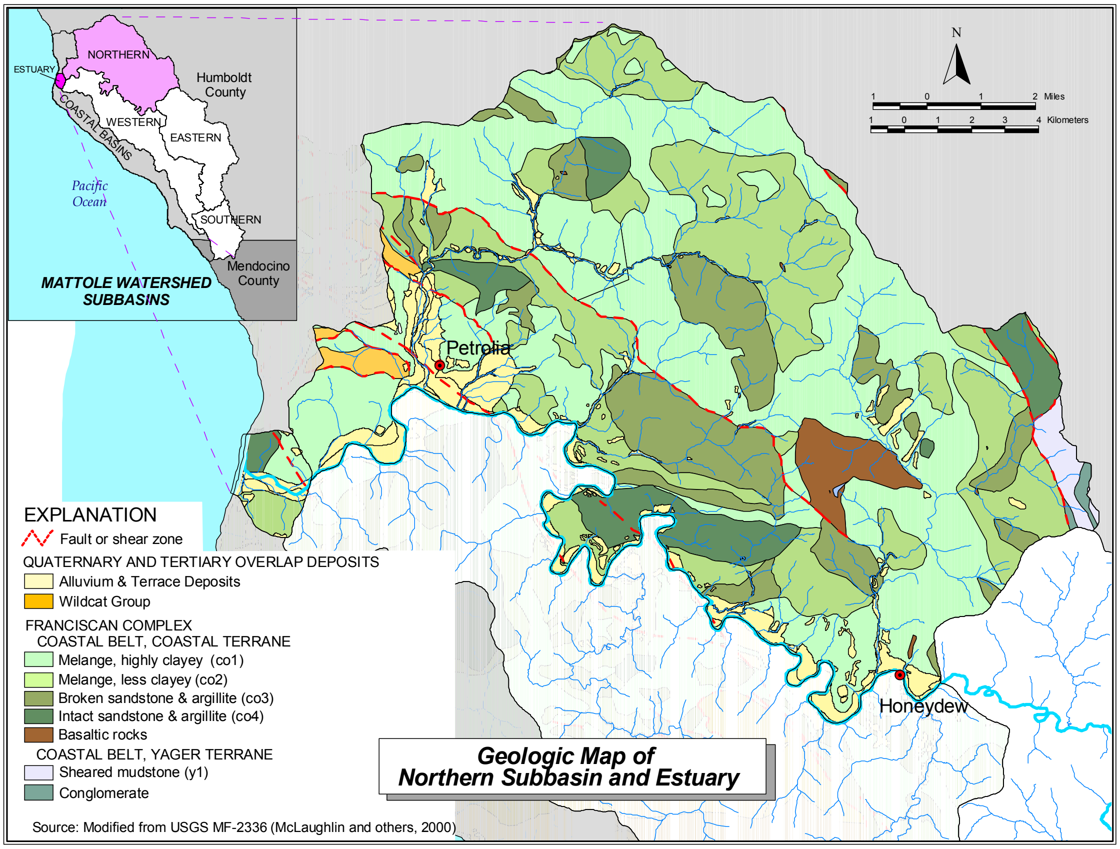

Figure 61. Geologic map of the Northern Subbasin.

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.

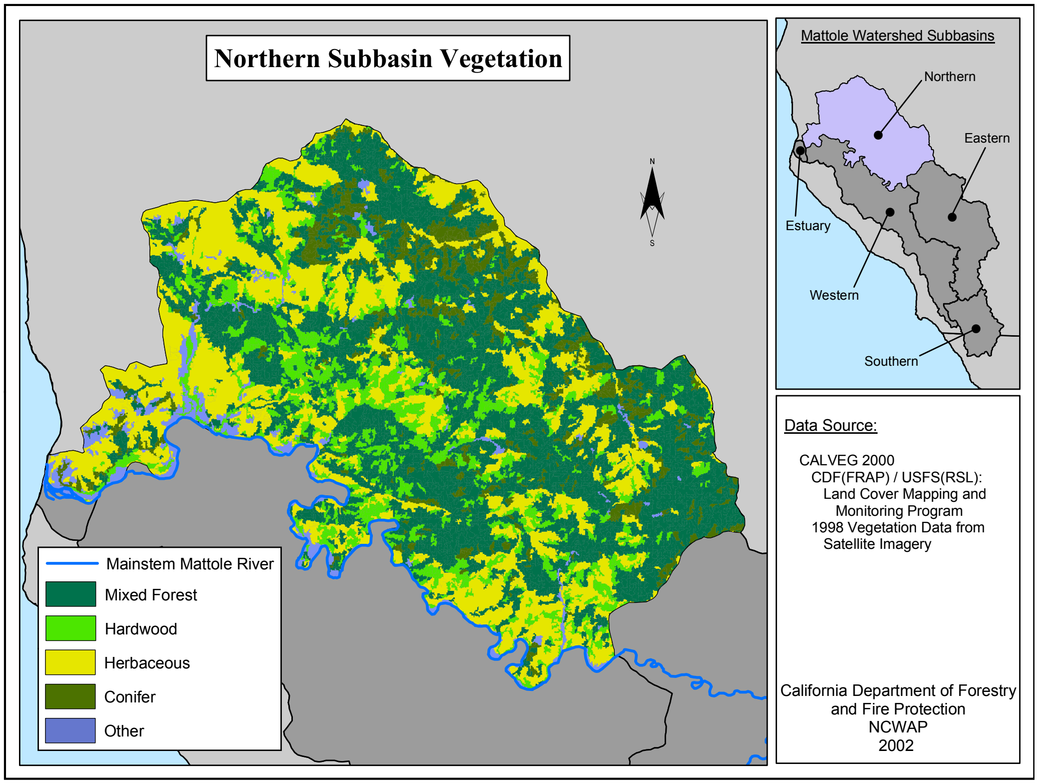

Figure 62. Vegetation pattern of the Northern Subbasin.

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.

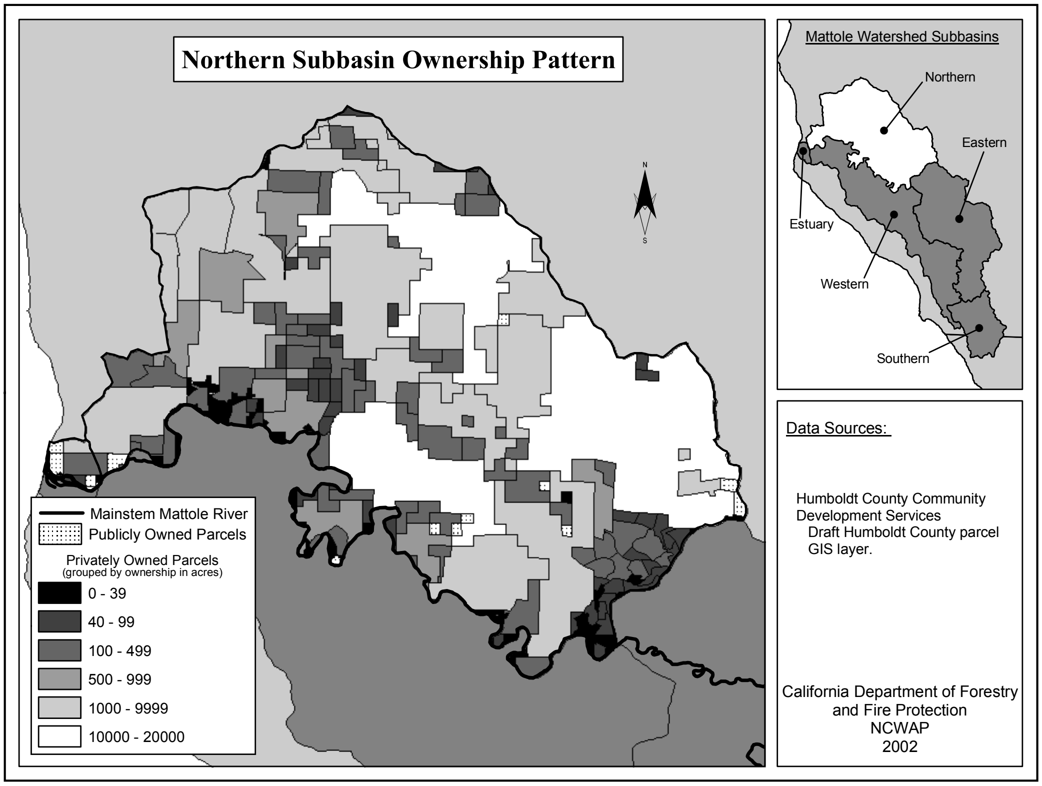

Figure 63. Ownership pattern of the Northern Subbasin.

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).

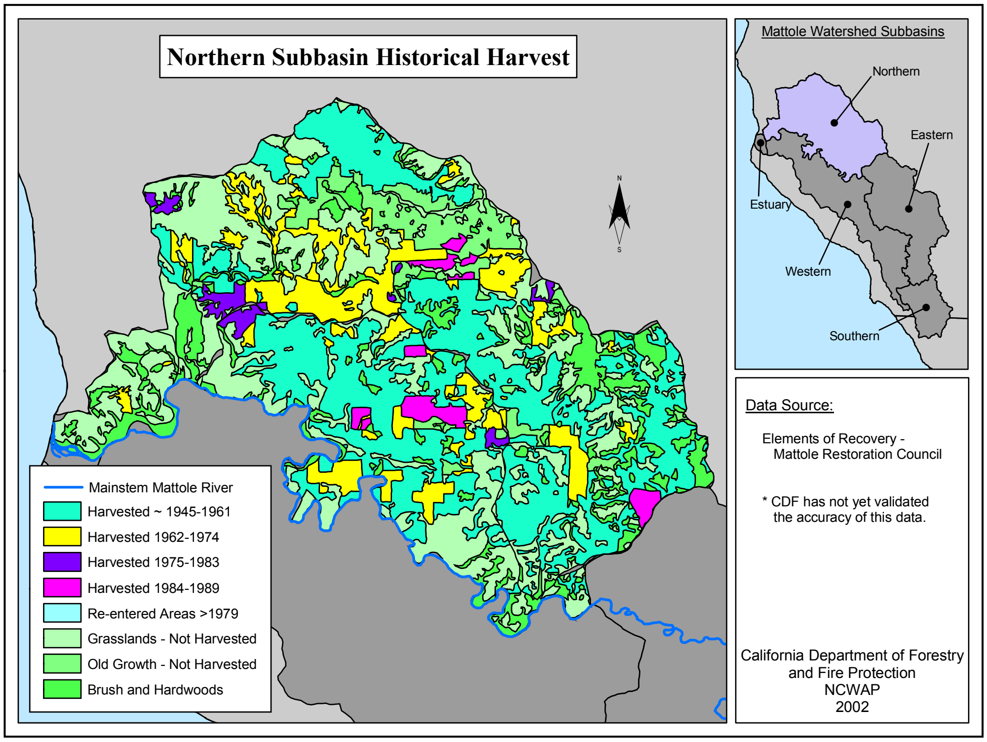

Figure 64. Timber harvest history for the Northern Subbasin.

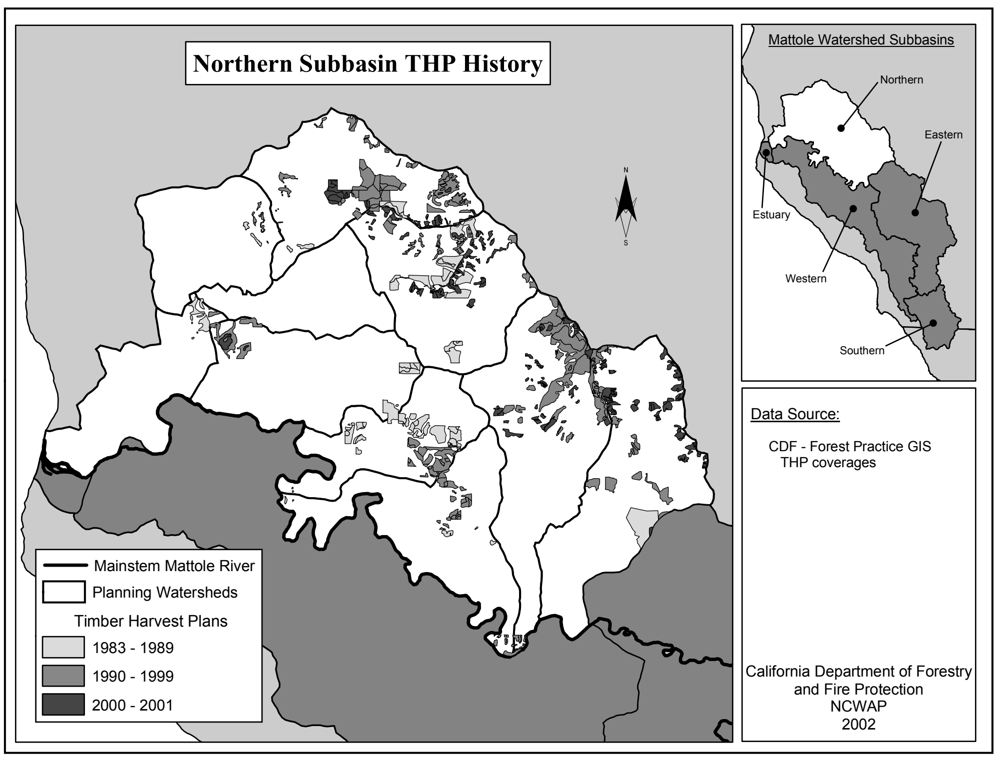

Figure 65. Timber harvesting plan history 1983-2001, Northern Subbasin.

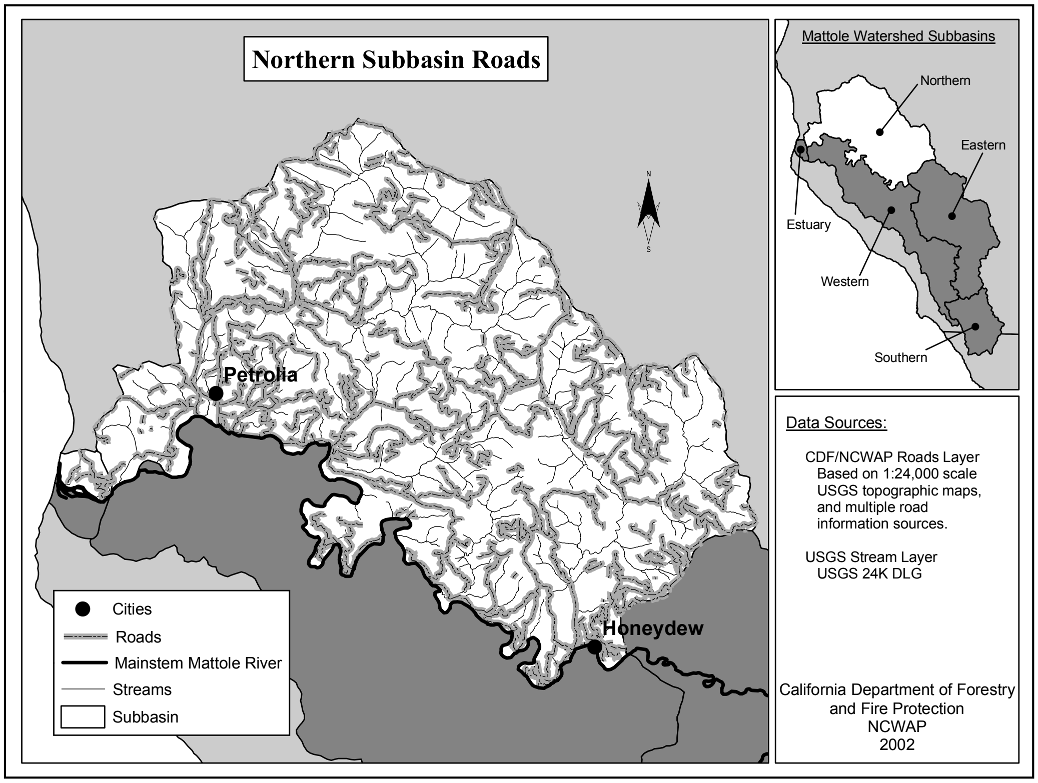

Figure 66. Northern Subbasin roads

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).

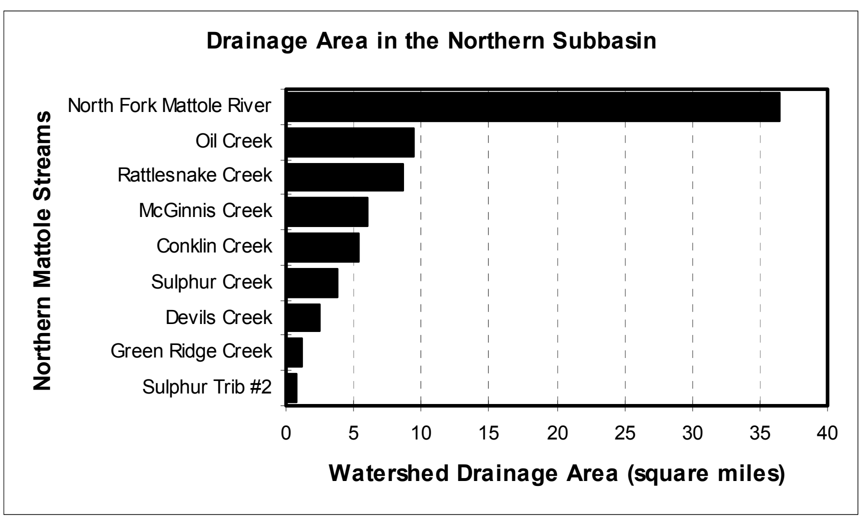

Figure 67. Drainage area of stream surveyed by CDFG in the Northern Subbasin.

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.

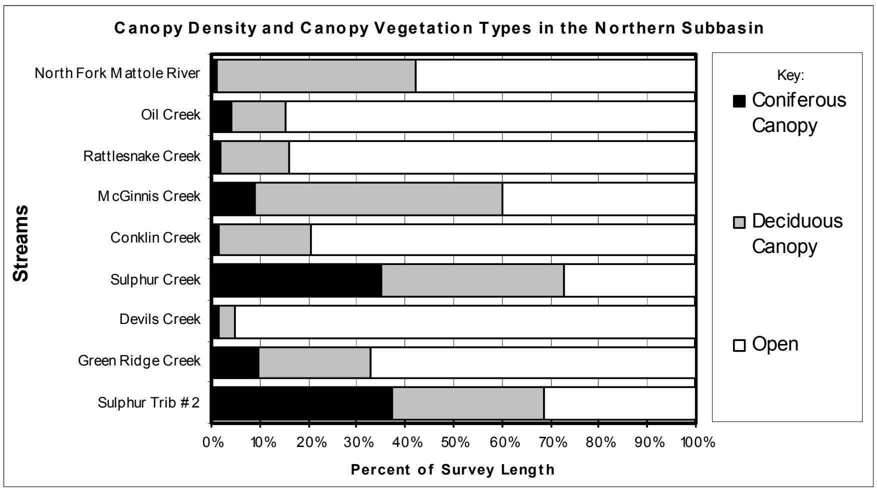

Figure 68. The relative percentage of coniferous, deciduous, and open canopy covering surveyed streams, Northern Subbasin

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.

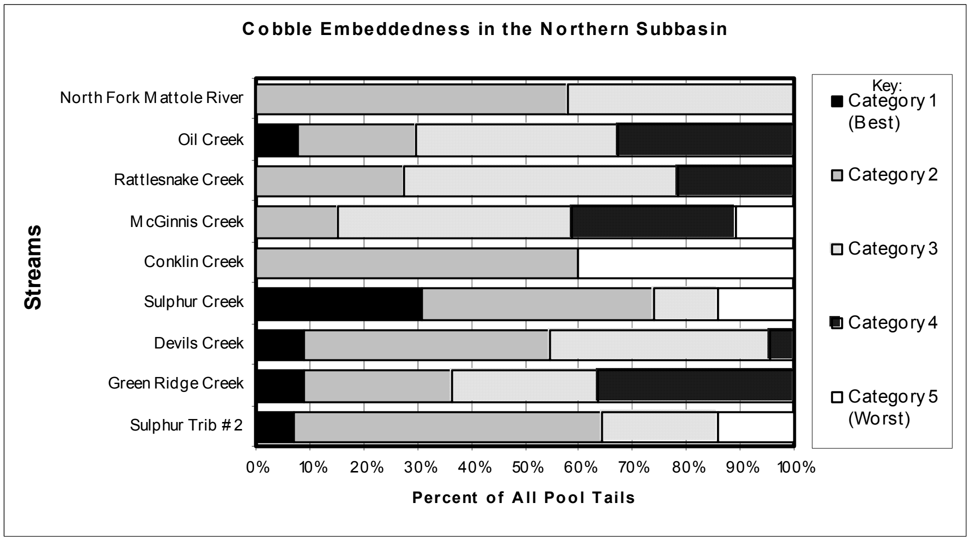

Figure 69. Cobble embeddedness categories as measured at pool tail crests in surveyed streams, Northern Subbasin

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.

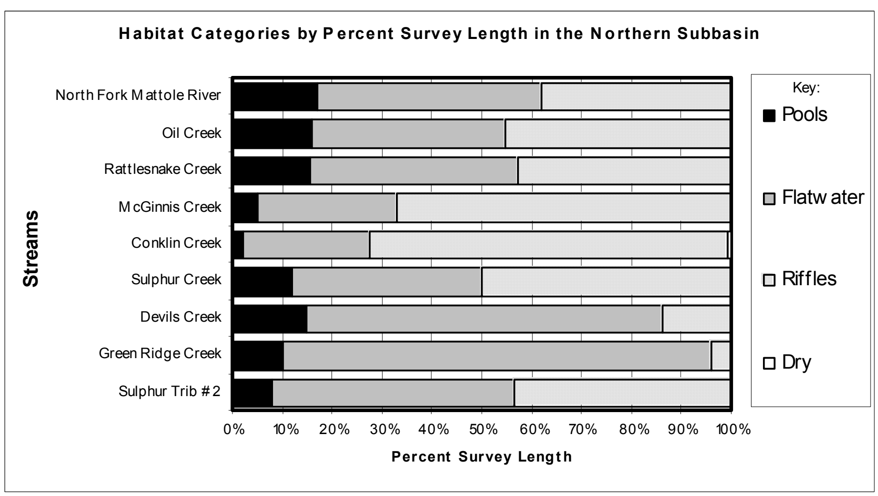

Figure 70. Percentage of pool habitat, flatwater habitat, riffle habitat, and dewatered channel by surveyed length, Northern Subbasin.

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.

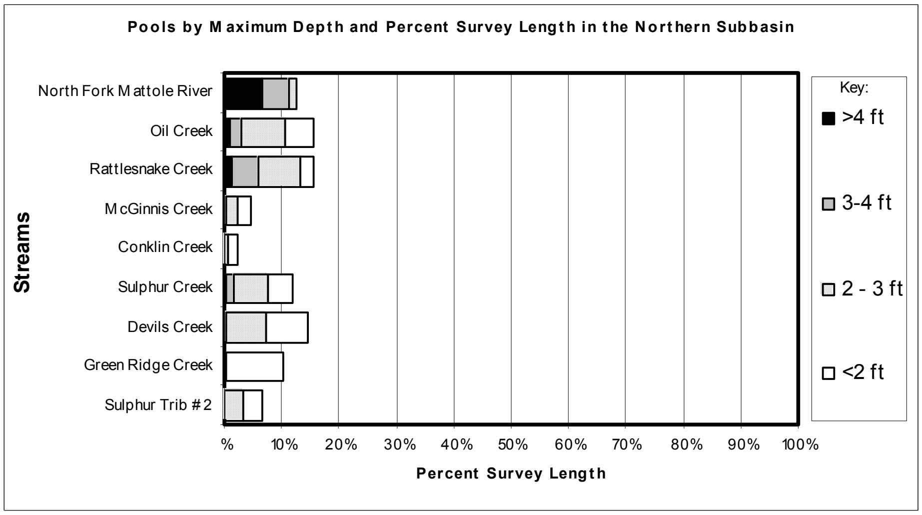

Figure 71. Percent length of a survey composed of deeper, high quality pools.

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).

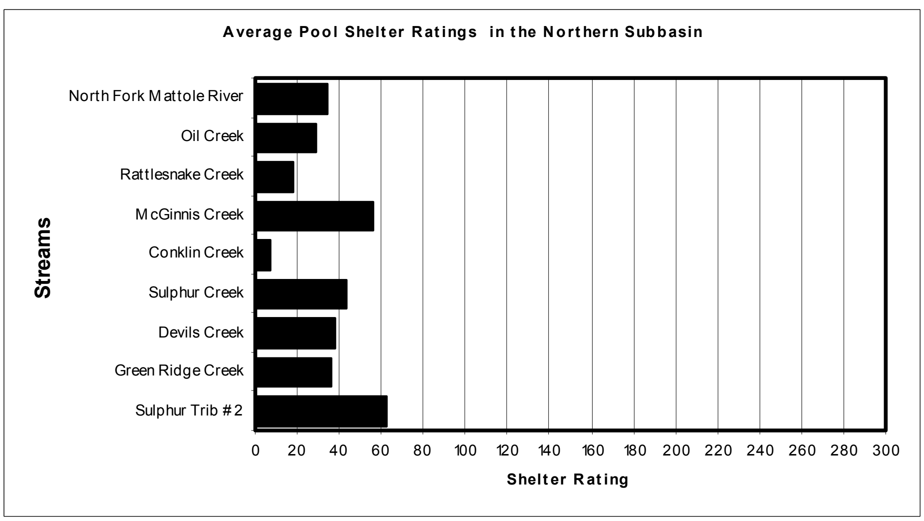

Figure 72. Average pool shelter ratings from CDFG stream surveys, Eastern Subbasin.

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)	Chambers 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

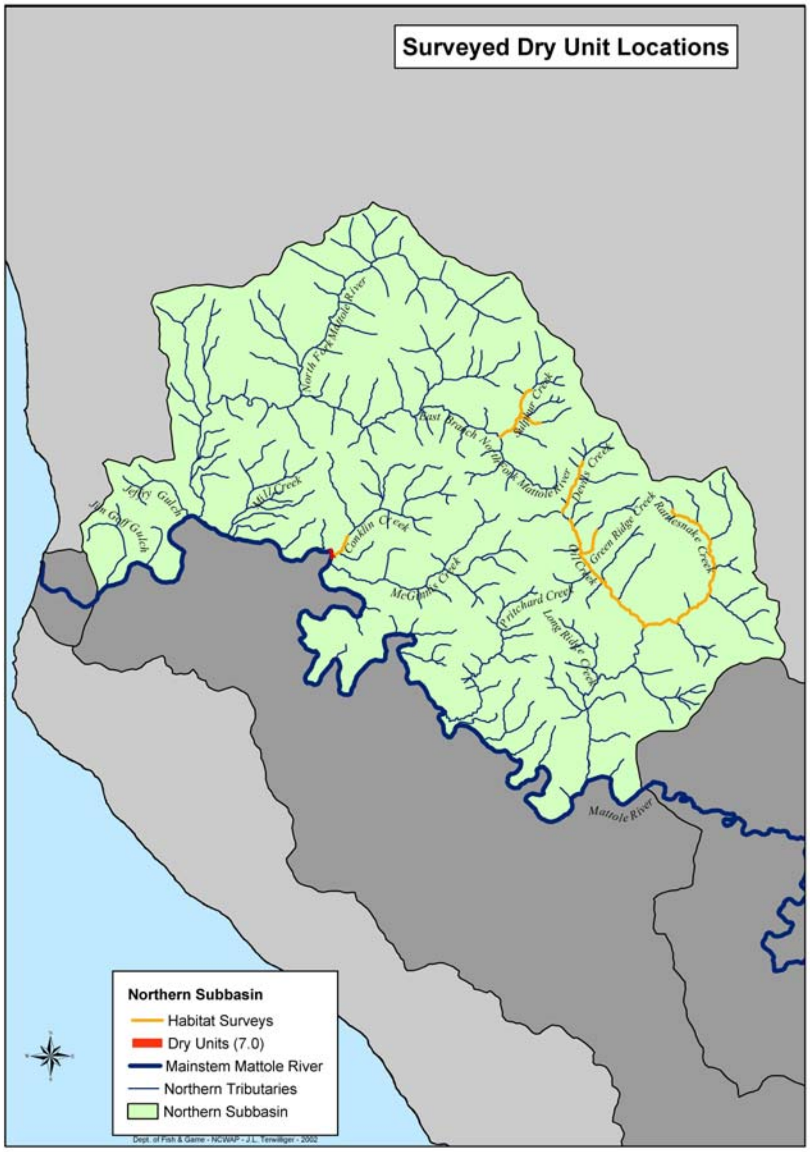

Figure 73. Mapped dry channels in the Northern Subbasin.

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							
	Conifer	Mixed	Hardwood	Grassland	Other	Total		
Hard	9%	62%	18%	10%	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 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.
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								
	Conifer	Mixed	Hardwood	Grassland	Barren	Other	Total		
Hard	13%	70%	13%	2%	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	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

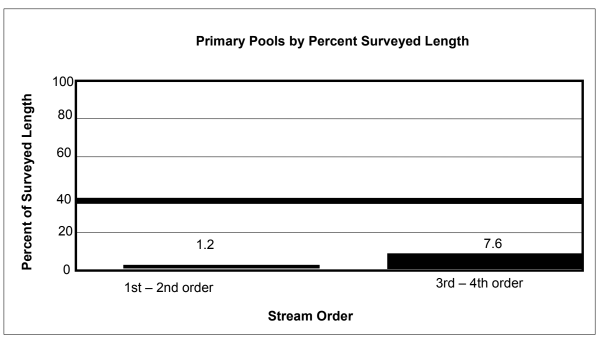

Figure 74. Primary pools in the Northern Subbasin.

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

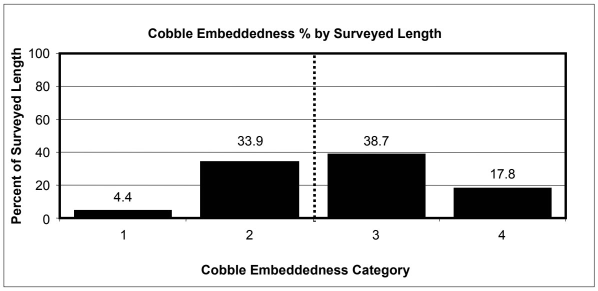

Figure 75. Cobble embeddedness in the Northern Subbasin.

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

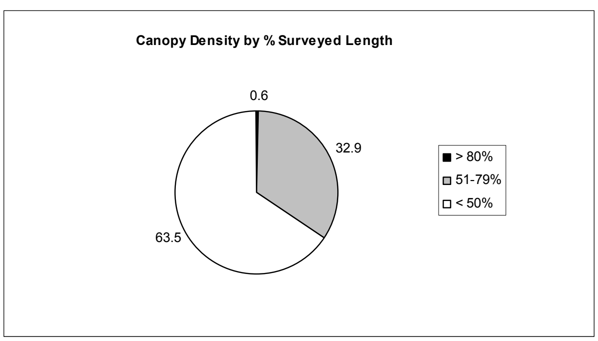

Figure 76. Canopy density in the Northern Subbasin 80 % is the target

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

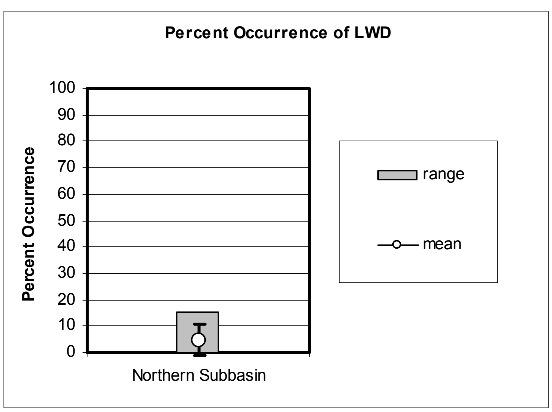

Figure 77. Large woody debris (LWD) in the Northern Subbasin.

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.

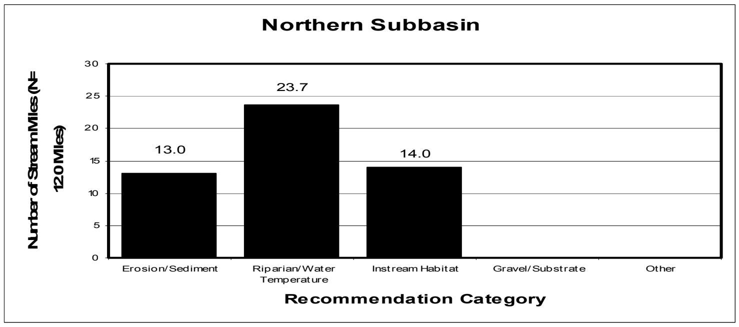

Figure 78. Recommendation categories by stream miles in the Northern Subbasin.

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.