North Coast Watershed Assessment Program

Gualala Watershed Synthesis Report

The mission of the North Coast Watershed Assessment Program is to conserve and improve California's north coast anadromous salmonid populations by conducting, in cooperation with public and private landowners, systematic multi-scale assessments of watershed conditions to determine factors affecting salmonid production and recommend measures for watershed improvements.

DRAFT

ACKNOWLEDGEMENTS

We wish to thank the following individuals for their thoughtful and constructive review of our draft: Kathleen Morgan, Doug Simmonds and Henry Alden. We are also grateful to the Gualala River Watershed Council and Gualala Redwoods, Inc. for sharing data, assisting field crews, and encouragement. Limited historic and current information existed on the watershed prior to this assessment. We are especially grateful to the numerous landowners who granted access to our field crews which enabled us to analyze current conditions and conduct the most accurate assessment possible. We wish to especially thank the following for their considerable time and resources: Soper-Wheeler, James Holmes, Mr. and Mrs. Forget, Stan Wells, Pioneer Resources, Laurie Withey, Mendocino Redwood Company, Mike Jani, Chris Surfleet, David Milbrath, Nola Craig, and the Wickersham and Kelly Road Associations. Finally, we thank the field crew who collected the current data used in this assessment.

Table of Contents

List of Figures

List of Tables

Executive Summary of Findings and Conclusions

An Interdisciplinary and Interagency approach to Watershed Assessment on California's North Coast

Introduction

This report constitutes a first public review draft of the North Coast Watershed Assessment Program's (NCWAP) watershed assessment work on the Gualala River basin. The North Coast Watershed Assessment Program (NCWAP) was established in 2000 to provide a consistent scientific foundation for collaborative watershed restoration efforts and to better meet the State needs for protecting and restoring salmon. The program was developed as an interagency effort by the California Resources Agency and CalEPA, and includes the Departments of Fish and Game (DFG), Forestry and Fire Protection (CDF), Conservation's Division of Mines and Geology (DMG), and Water Resources (DWR), and the State Water Resources Control Board's North Coast Region (NCRWQCB). The Institute for Fisheries Resources is a contractor to CDF assisting in the development of a computerized database adapted from the Klamath Resource Information System (KRIS). The process also involved scoping and interaction with the Gualala River Watershed Council (GRWC), Gualala Redwoods, Inc. (GRI), and landowners in the watershed. This report is designed to begin to assess watershed conditions as they relate to a set of critical questions about suitability for salmon habitat, tailoring the assessment process to those that are most relevant to each watershed. Its contents should be considered preliminary and subject to review and revision. A final watershed assessment report is to be completed in May 2002.

Profile of the Gualala River Watershed Basin

The Gualala River flows through its 298 square mile watershed along the coast of southern Mendocino and northern Sonoma Counties, entering the Pacific Ocean near the town of Gualala. The Gualala River watershed is elongated, running over 32 miles long north to south . Elevations vary from sea level to 2,602 feet at Gube Mountain and terrain is most mountainous in the northern and eastern parts of the basin. The five principal subbasins of the Gualala are the Wheatfield Fork, South Fork and Gualala Mainstem, North Fork, Buckeye Creek, and Rockpile Creek.

Coastal conifer forests of redwood and Douglas fir occupy the northwestern, southwestern and central portions of the watershed while oak-woodland and grassland cover many slopes in the interior basin. Coho naturally inhabited the streams flowing from coniferous forest but were likely sub-dominant to steelhead in interior basin areas
A long history of movement along the San Andreas Fault and the Tombs Creek Fault has been a dominant force in the shaping of the basin. The climate is influenced by fog near the coast with seasonal temperatures ranging between 40 to 60 degrees F, but the interior basin can range from below freezing to over 90 degrees F seasonally. Rainfall also varies by location within the basin with 31 inches falling on average near the town of Gualala and totals reaching over 65 inches in some areas.

Ninety-five percent of the Gualala watershed is privately owned. The watershed has supplied timber since before 1900, the first wave of harvests occurring around the turn of the century. The next most significant wave occurred in the 1950s and 1960s with the advent of tractor yarders. Harvest operations concentrated in riparian areas. Logging roads often followed streams. Tractors pushed logs and dirt into streams to make road crossings and landings. Accelerated erosion from those logged areas was especially pronounced during the 1964 storm. Natural clearings as well as human-cleared areas on the eastern side of the watershed are used for grazing, though to a lesser extent since the 1980s. Residential development near the coast and vineyard development inland have become dominant land use activities since the late 1990s.

Salmon , Stream, Watersheds, and Land Use

Anadromous Pacific salmonids spend over half their life history in the marine environment, which is generally beyond man's control other than to regulate harvest. However, they are also dependent upon a high quality freshwater environment at the beginning and end of their life cycles. As such, they thrive or perish depending upon the availability of cool, clean water, free access to migrate up and down their natal streams, clean gravel for successful spawning, adequate food supply, and protective cover to escape predators and ambush prey. These life requirement conditions can be identified and evaluated on a spatial and temporal basis at the stream reach and watershed levels. They comprise the factors that support or limit salmonid stock production.

The anadromous salmonid fisheries historically included coho (*Oncorhynchus kisutch*), possibly Chinook salmon (*Oncorhynchus tshawytscha*), and steelhead trout (*Oncorhynchus mykiss*). Surveys in 1970 found significantly higher numbers of salmonids in the streams surveyed as compared to current conditions. Electrofishing was used to sample presence and absence of salmonids in all the basins except Rockpile during September, 2001. Coho were not observed in the watershed in 2001 and were last observed in the Northfork subbasin in 1998.

Assessment and Analysis

The assessment process included defining the factors and corresponding ranges which could limit salmonid populations in the watershed, such as water temperature, spawning gravel composition, etc. Those ranges came from the literature, DFG's California Salmon Stream Habitat Restoration Manual, and the NCRWCB's *Water Quality Control Plan for the North Coast Basin* (1996) (Basin Plan). Instream data were compared to those ranges, and a decision support model was run with the data using those ranges to provide a perspective on overall stream reach and watershed conditions.

The California Department of Fish & Game inventoried over 100 miles of stream for salmonid habitat throughout the watershed from June-November, 2001. Streambed substrate and embeddedness varied by subbasin and was dominated by gravel. The earliest stream surveys recorded higher pool frequency and depth, and longer reaches of suitable spawning gravels. Post 1950's and 1960's era logging surveys documented a shallow pool structure, reduced pool frequency and water quality problems related to logging debris deposited into streams. Habitat inventories showed low pool frequency and shallow pool depth in most tributaries throughout all subasins where surveyed. Low stream pool frequency and shallow pool depth coincide with contemporary fisheries studies showing predominantly young of the year steelhead populations and absence of coho. This contrasts with the earliest fisheries studies showing deeper and more frequent pool structure with consistent coho observations and older steelhead found in many of these same areas.

Sediment conditions in the stream channels along with the declining anadromous salmonid fishery prompted a USEPA listing as impaired by sediment on the Clean Water Act Section 303(d) list in 1992, with the North Coast Regional Water Quality Control Board following suit during a subsequent listing. Sediment conditions in the Gualala River watershed appear to have recovered significantly from the 1964 flood event, however data from 1992-2001 show improvement in only a few of the areas sampled. Though data were limited in geographic area, and often insufficient to show temporal or spatial trends, streambed particle sizes are relatively small in the areas sampled. The data were not analyzed spatially to provide a broader perspective of the watershed, a limitation of the assessment due to staffing resources and timelines

Water temperature data provided by Gualala River Watershed Council and Gualala Redwoods Inc. from continuous recording devices were assessed from 1994-2001. Water temperatures expressed as the highest of the floating weekly average for the summer (MWAT) were within the proposed "fully suitable" range of 50-60 F (10 to 16 C) in many tributaries in the North Fork subbasin, and in some other small tributaries in other subbasins. Mainstem water temperatures for the larger streams (North Fork, Rockpile, Buckeye, Wheatfield Fork, and South Fork/Main Gualala) were above that range. In some areas, higher water temperatures were observed coming off the Franciscan Central Belt areas where open oak woodlands predominate, then cooling as the colder tributaries contributed their flow. The extent to which this is natural is unknown.

Canopy cover was complete in most tributaries as of 1942 indicating advanced regeneration from original old growth logging. Streams in the eastern portion of the Gualala basin have a naturally more open canopy even in 1942 photos. Aerial photos from 1961, 1963, 1965, and 1981 show canopy closure substantially reduced. In 2001, measurements taken during habitat inventory surveys showed greater and improved canopy closure. Aerial photos from 1999 and 2000 substantiate these findings. Most current riparian overstory conditions reflect shade canopy in-growth of young conifer/ hardwood regeneration from riparian zones entirely cleared of all vegetation between 1952 and 1968.

The relative lack of large wood in the stream channels was noted, though landowners are adding wood under various local, state, and federal grant programs. Improved habitat complexity and sediment metering in the channels is expected to result from large-wood installation; thus enhancing the future suitability for salmonids.

EMDS: A Tool for Synthesis

The NCWAP team is using computer models called knowledge base or expert systems. The software allows scientists to combine data of different environmental factors, such as stream temperature and substrate composition, to produce a synthesis of watershed conditions for native salmonids. The data that is fed to the knowledge base network comes from GIS (Geographic Information Systems) layers developed for the program.

EMDS will rank the environmental factors by their influence on the overall habitat indicator values derived, and will show which factors, with more complete and comprehensive data, would improve the quality of the analysis in the most cost-effective manner. Maps depicting those factors that may be the largest impediments, as well as those areas where conditions are very good, can help guide protection and restoration strategies

The software assists open communication with the general public about how the scientists define suitable conditions for salmonids, and produces simple graphics and easily understood flow diagrams. Another feature of the system is that can be test the sensitivity to different assumptions about the environmental factors and how they interact.

Subbasin Issue Synthesis and Recommendations

Natural variation among subbasins is at least partially a product of natural and human disturbances. Other variables that can distinguish areas, or subbasins, in larger basins include differences in elevation, geology, soil types, aspect orientation, climate, vegetation, fauna, human population, land use and other social-economic considerations. The combined complexity of large basins makes it difficult to speak about them concerning watershed assessment and recommendation issues in other than very general terms. In order to be more specific and useful to planners, managers, and landowners, the Gualala River Basin has been subdivided into five parts: the estuary and four distinct subbasins.
Issues of the five subbasins are identified. Hypotheses regarding linkages of these various factors and processes along with supporting and contradictory findings are presented. Recommendations based on those hypotheses range from road abandonment /upgrades to expanding existing monitoring activities.

Gualala Estuary

***Working Hypothesis:* The present state of estuarine habitat is limiting the production of salmonids in Gualala River.**

Supporting Findings: In progress.

Contrary Findings: None noted.

Potential Recommendations:

- Encourage present estuary assessment program and provide technical assistance when necessary.
- Develop long term temperature monitoring program.
- Continue and/or expand monitoring anadromous salmonid population efforts.
- Work with responsible agencies, the Gualala River Watershed Council and landowners to improve physical structure and biologic function of the estuary.
- Continue efforts such as road improvements and decommissioning throughout the basin to reduce sediment delivery to Gualala River and its tributaries.
- Ensure that adequate streamside protection zones are used to reduce solar radiation and moderate air temperatures in order to reduce heat inputs to Gualala River and its tributaries. Where current canopy is inadequate and site conditions are appropriate,

use tree planting and other vegetation management techniques to hasten the development of denser and more extensive riparian canopy.

North Fork Subbasin

Working Hypothesis: ***Water temperatures in the mainstem North Fork Subasin are not fully suitable for anadromous salmonids. Depleted overstory shade canopy cover along the North Fork and tributaries from legacy harvests continues to contribute to elevated water temperatures.***

Supporting Findings**:**

- MWATs exceeded the fully suitable range of 50-60 F at all eight North Fork mainstem sites for the period of record (1994-1998, 2000-2001), ranging from 62-72 F.
- Seasonal maxima exceeded the 75 F lethal maximum 40% of the time during the same period of record, ranging from 66-80 F.
- The highest MWATs for the period of record presented on a LandSat vegetation layer (Figure xx) point out: Water temperatures are higher in the upstream areas draining the northeastern portion. Vegetation in the area upstream of those high temperatures (Franciscan melange) is open oak grasslands with poor canopy
- Two historical timber harvest eras eliminated riparian shade canopy throughout the lower and middle reaches of the North Fork: 1860 to 1900, and 1952 to 1968, elevating stream temperatures as measured today in the latter, and presumed in the former.
- There is partial riparian cover in the oak woodland melange in the upper basin reaches.

Contrary Findings**:** Advanced conifer hardwood regeneration since 1968 has reinstated canopy cover throughout many of the highest tributary reaches.

Limitations:

- Data from Gualala Redwoods Inc.'s eight mainstem sites in about the lower 9 miles were evaluated. The North Fork mainstem is about 10 miles long, with headwater tributaries extending about another 11 miles. Data represents about 50% of total blue line length.
- The extent of the thermal reaches for the sites is unknown.
- Three sites had only one year's data.
- Raw data were not evaluated for inconsistencies, thus assumptions were made that GRI and GRWC performed quality assurance and quality control.
- Individual canopy measurements for the entire watershed were not available, Landsat 1994 layers from the US Forest Service were used instead

Conclusions: The hypothesis is supported, given the limitations.

Recommendations:

- Investigate the availability and quality of other data for the northeastern area. Include and reevaluate the hypothesis.
- More temperature, monitoring and canopy ground-truthing on the northeastern area would assist in further describing the relationship.
- Ensure that adequate streamside protection zones are used to reduce solar radiation and moderate air temperatures in order to reduce heat inputs to the North Fork and its tributaries.
- Where current canopy is inadequate, use tree planting and other vegetation management techniques to hasten the development of denser riparian canopy.

Working Hypothesis: ***Stream reach conditions in the North Fork subbasin are limiting the suitability for sustaining healthy populations of native anadromous salmonids in specific areas.***

Supporting Findings:

The EMDS reach model results indicate the following:

- Pool Shelter Complexity is low in Doty Creek and the Little North Fork upstream of Log Cabin Creek; very low in the Dry Creek tributary and in the Little North Fork from (and including) Log Cabin Creek downstream to the confluence with the North Fork; extremely low in Dry Creek downstream of the three tributary confluence and in the mainstem North Fork for the entire survey area from upstream of Dry Creek downstream to the confluence with the South Fork Gualala.

- Pool Quality rating is low in Robsinson Creek; very low in Dry Creek tributary, the little North Fork, Doty Creek; extremely low in Dry Creek below the three tributary confluence.
- Pool depth was rated extremely low in the Little North Fork watershed, Robinson Creek Dry Creek, and McGann Gulch.
- In-channel conditions were rated low in all watersheds within the subbasin, with the exception of the Mainstem North Fork.
- Embeddedness was high in the surveyed section of Robinson Creek, and very high in the surveyed section of Doty Creek.
    - Canopy Density is: Low in Dry Creek downstream of the three tributary confluence and in the surveyed section of Robinson Creek.Very low in the upper two-thirds of the surveyed section of the Dry Creek tributary.

Contrary Findings:
The EMDS reach model results indicate the following:
- Pool Shelter Complexity was rated barely suitable in the surveyed section of Robinson Creek.
- Pool Quality is somewhat suitable in the surveyed section of the mainsteam North Fork.
- Pool Depth is fully suitable in the surveyed section of the mainsteam North Fork.
- In-channel conditions are somewhat suitable in the surveyed section of the mainsteam North Fork.
- Embeddedness was low to very low in the subbasin, with the exception of Robinson Creek, Doty Creek, and McGann Gulch.
- Canopy Density is mostly suitable in the surveyed section of the mainsteam North Fork, and fully suitable in the Little North Fork subwatershed.

Limitations: Not all tributaries in the subbasin were surveyed.

Conclusions: Hypotheses are supported given the stated limitations.

Recommendations:
- Restoration activities should focus on areas needing improved pool quality, and on improving canopy density in Robinson and Dry Creeks.

***Working Hypothesis:* A lack of in-stream large woody debris contributes to simplified riparian habitat structure (e.g., lack of large, deep pools)**

Supporting Findings:
- Heavy tractors which built roads, landings, and skid trails in or adjacent to streams between 1952 and 1968 buried, removed, or dispersed large woody debris in the basin.
- Historic and recent timber harvest in lower and middle reaches frequently removed large conifer vegetation down to the stream bank, reducing the available recruitment supply of large woody debris.
- Although stream buffers are regenerating under current land management practices and Forest Practice rules, dense buffers of conifers large enough to function, upon recruitment, as large woody debris in channel formation processes have not yet been reestablished.
- Cleaning of streams to remove “fish barriers” made of large woody debris occurred throughout the subbasin.

Contrary Findings: None noted.

Limitations: None noted.

Conclusions: Hypotheses are supported given the stated limitations.

Recommendations:

- Gualala River Watershed Council and Gualala Redwoods Inc. are encouraged to do more large woody debris placement work throughout the N.F. basin. .
- Tree planting, thinning from below, and other vegetation management techniques will hasten the development of large riparian conifers.

***<u>Working Hypothesis:</u>* Due to the steep topography of the NF basin, many roads are located in erosion-prone areas, such as, adjacent to stream channels or across debris slide slopes.**

<u>Supporting Findings:</u>
- Debris slides and debris flows are very common in this subbasin. Delivery of that sediment to watercourses is high.
- Road density and stream density in the upper NF basin is the highest in the Gualala watershed [EMDS results]. This combination results in a high number of stream crossings. The steep topography and high stream density result in intense, flashy runoff, and frequent debris flows that challenge poorly engineered stream crossings.
- Mapping and aerial photo analysis shows that legacy roads preferentially followed streams up the narrow valleys resulting in stream side canopy removal and in-stream and near-stream grading.
- The fast runoff of storm water produces high peak flows along major tributaries that challenge in-stream and near-stream road related structures.
- The 1981 photos show a high density of road and landing failures along streamside roads throughout the steep, deeply incised terrain in the Stewart Ck. Planning watershed.
- The residual effects of heavy channel aggregation from streamside road system failures built in the 1950s and 1960s is noted in timber harvest plan records in Dry , Robinson, Stewart Creeks, and McCann Gulch. These sites are confirmed on ground by CDF and DMG field inspectors.

<u>Contrary Findings</u>: None noted.

<u>Limitations</u>: None noted.

<u>Conclusions:</u> Hypotheses are supported given the stated limitations.

<u>Recommendations</u>:
- Evaluate the feasibility of abandoning streamside roads.
- Culverts should be sized to accommodate flashy, debris laden flows. Trash racks or similar structures should be used to prevent culvert plugging. Critical dips should be required to minimize the impact of culvert failure.
- Existing roads systems should be maintained and new roads built in accordance to currently recognized Best Management Practices.
- Continue to decommission streamside roads and landings. The following tributaries contain the highest density of these still active sediment sources: Doty, Dry, Robinson, Stewart, and McCann Gulch.

***<u>Working Hypothesis:</u>* Accelerated erosion from roads has contributed to the sedimentation in the streams resulting in added degradation of salmon habitat.**

<u>Supporting Findings:</u>
- Comparison of historic stream survey and electrofishing show a decline in salmon populations.
- Comparison of historic stream surveys and current habitat inventory survey showed that pools of some tributaries have become shallower and some streambeds have become embedded with fine sediment over the last several decades. Both are limiting factors to salmonids.
- Both historic and modern aerial photos show that numerous debris flows and slides involve roads and that numerous failures occur along in-stream and near-stream roads and landings. These resulted in increased sedimentation in the streams.

<u>Contrary Findings</u>:
- Embeddeness is suitable on the Northfork, Little Northfork and Log Cabin creeks.
- Embeddeness may be suitable on additional tributaries which have not been surveyed.

<u>Limitations</u>: None noted.

<u>Conclusions:</u> Hypotheses are supported given the stated limitations.

Recommendations:

- Road managers should develop and adopt erosion control plans. Repairs and new road construction should be carefully designed and when necessary licensed specialists such as civil engineers, erosion control specialists, and engineering geologists should be consulted.
- Upgrading and diligent maintenance of existing road systems to reduce sediment impacts will slow the degradation of salmon habitat –specifically pools and spawning gravel. Careful engineering of new roads or repairs can reduce adverse sediment impacts.

Rockpile Creek Subbasin

Working Hypothesis: ***The Rockpile subbasin provides unsuitable habitat for coho and somewhat suitable habitat for steelhead.***

Supporting Findings:

- Water temperatures in lower three miles of mainstem exceed suitable range for salmonids.

Contrary Findings:

- Improving canopy
- We have no temperature data for upstream nor for other tributaries.
- Water temperature at a tributary site was within suitable range.

Working Hypothesis: ***Many roads, in the lower Rockpile Creek basin, are located in erosion-prone areas; such as, adjacent to stream channels or across debris slide slopes. In the upper basin, active earthflow complexes are so abundant that they are unavoidably crossed by many roads.***

Supporting Findings:

- Debris slides and debris flows are very common in this subbasin. Delivery of that sediment to watercourses is high.
- The large portions of the upper basin are underlain with the mélange of the Central Belt of the Franciscan Assemblage and vegetated with prairie and sparse oaks. Runoff from the prairie is rapid creating potentially high peak flows. Landsliding is especially abundant in the mélange. These high flows and landsliding challenge poorly engineered stream crossings.

Contrary Findings: None at this time.

Limitations: Field level analysis of sediment was limited.

Potential Recommendations:

- In the erosion-prone Rockpile Creek basin, careful road siting, design, and maintenance is necessary to avoid increased sedimentation of streams because poorly sited or engineered roads will likely produce sediment impacts to stream.
- Evaluate the feasibility of abandoning streamside roads.
- In steep terrain, culverts should be sized to accommodate flashy, debris laden flows. Trash racks or similar structures should be used to prevent culvert plugging. Critical dips should be required to minimize the impact of culvert failure.
- Existing roads systems should be maintained and new roads built in accordance to currently recognized Best Management Practices.

Working Hypothesis: ***Accelerated erosion from roads has contributed to the sedimentation in the streams resulting in added degradation of salmon habit.***

Supporting Findings:

- Comparison of modern and historic stream surveys show a decline in salmon populations.
- Comparison of modern and historic stream surveys show that some pools have become shallower and streambeds have become embedded with fine sediment over the last several decades. Both conditions are deleterious to salmon.

- Both historic and modern aerial photos show that numerous debris flows and debris slides involve roads and that numerous failures occur along in-stream and near-stream roads and landings. These resulted in increased sedimentation in the streams.

Contrary Findings: None at this time.

Limitations: Field level analysis of sediment delivery was limited.

Conclusions:

- Upgrading and diligent maintenance of existing road systems to reduce sediment impacts will slow the degradation of salmon habitat –specifically pools and spawning gravels.
- Careful engineering of new roads or repairs can reduce adverse sediment impacts

Potential Recommendations:

- Road managers should develop and adopt erosion control plans.
- Repairs and new road construction should be carefully designed and when necessary licensed specialists such as civil engineers, erosion control specialists, and engineering geologists should be consulted.

Working Hypotheses: Accelerated erosion from logged areas has contributed to the sedimentation in the streams resulting *in added degradation of salmon habit.*

Supporting Findings

- Comparison of modern and historic stream surveys show a decline in anadromous populations

- Comparison of modern and historic stream surveys show that pools have become shallower and streambeds have become embedded with fine sediment over between the earliest fisheries surveys between 1964 and present. Both conditions are deleterious to anadromous fisheries.

- Roads and landings are important sediment sources in the basin. Both historic and modern aerial photos show that numerous debris flows and debris slides involve roads and that numerous failures occur along in-stream and near-stream roads and landings. These resulted in increased sedimentation in the streams.

- Most of the roads in the basin were built strictly to support logging operations.

- Most of the middle reaches of the Rockpile basin were clear-cut between 1952 and 1968 buillding roads in or along the major tributaries streams and mainstem Rockpile. Timber operations were particularly pronounced immediately prior to the 1964 flood. Some larger tributary stream basins only required 3 to 5 years to liquidate the timber. This left large areas of disturbed ground on steep slopes.

- The residual effects of heavy channel aggregation from streamside road system failures built in the 1950s and 1960s is noted in timber harvest plan records, particularly the Middle Rockpile Planning Watershed.

- Comparative 20 year stream channel width measurements between 1961 and 1981 show channel width widening responses to more concentrated harvests upstream.
- Large in-stream landings were built in support of logging operations. Many of these were washed out during subsequent storms.
- Modern logging operations are far less intense than those practiced from 1950-1968. In-stream roads and landings are not permitted. Tractor logging on steep slopes is now restricted. The size and degree of clear cuts is now limited. Erosion control is now mandatory for harvested areas.

Contrary Findings: None at this time.

Limitations: These conditions are well constrained within the scope of work performed thus far.

Conclusions:

- Past logging practices, specifically tractor operations on steep slopes, accelerated erosion and added excess sediment to stream channels.

- Upgrading and diligent maintenance of existing road systems to reduce sediment impacts will slow the degradation of salmon habitat –specifically pools and spawning gravels. Careful engineering of new roads or repairs can reduce adverse sediment impacts.

Recommendations

- Road managers should develop and adopt erosion control plans. Repairs and new road construction should be carefully designed and when necessary licensed specialists such as civil engineers, erosion control specialists, and engineering geologists should be consulted.
- Spread timber harvesting operations through time and space to avoid concentrated road use by heavy equipment and resultant mobilization of road surface fines accessing watercourses.
- Continue to decommission streamside roads and landings. The following tributaries contain the highest density of these still active sediment sources: Red Rock Creek, Horsethief Canyon, and larger tributary watercourses in the middle reaches of the basin flanked by McGuire Ridge between Rockpile Peak and Robinson Ridge, downstream of Burnt Ridge Creek.

***Working Hypothesis:* Depleted overstory shade canopy cover along Rockpile Ck. and tributaries from legacy harvests continues to contribute to elevated water temperatures.**

Supporting Findings:
- Heavy tractors building roads, landings, and skid trails in riparian zones shortly after WW II eliminated overstory shade canopy cover throughout long sections of Rockpile Creek and tributaries. There was near entire canopy elimination in the Middle Rockpile Planning Watershed, with operations especially pronounced during the late 1950s to 1964.

Contrary Findings:
- Advanced conifer hardwood regeneration since 1968 has reinstated canopy cover throughout many of the highest tributary reaches.

Potential Recommendations:
- Ensure that adequate streamside protection zones are used to reduce solar radiation and moderate air temperatures in order to reduce heat inputs to Rockpile Ck. and its tributaries.
- Where current canopy is inadequate, use tree planting and other vegetation management techniques to hasten the development of denser riparian canopy.
- Increase continuous temperature monitoring efforts.

***Working Hypothesis:* A lack of in stream large woody debris contributes to simplified riparian habitat structure (e.g., lack of large, deep pools).**

Supporting Findings:
- Heavy tractors building roads, landings, and skid trails in or adjacent to streams between 1952 and 1968 buried, removed, or dispersed LWD in the basin. Field observations have confirmed low LWD distributions.
- Historic and recent timber harvest in lower and middle reaches frequently removed large conifer vegetation down to the stream bank, severely reducing the available recruitment supply of large woody debris.
- Although stream buffers are regrowing under current land management practices and Forest Practice rules, dense buffers of conifers large enough to function, upon recruitment, as LWD in channel formation processes have not yet been reestablished.

Contrary Findings: None noted.

Limitations: Limited formal stream reach surveys have been done for LWD; however observations of crews and findings regarding pool complexity indicate that there is limited instream LWD.

Potential Recommendations:
- Artificial LWD installation projects vastly speed up in channel diversity development

- Tree planting, thinning from below, and other vegetation management techniques will hasten the development of large riparian conifers.

Buckeye, Wheatfield and South Fork Subbasins

The following working hypotheses are still being explored for these subbasins. The NCWAP team will work with the public and stakeholders during the revision period to finalize analyses, draw conclusions about the level of support of findings, and develop appropriate recommendations.

***Working Hypotheses:* The subbasins provide unsuitable habitat for coho and somewhat suitable habitat for steelhead.**

Findings:
- EMDS results and temperature data still being analyzed.

Contrary Findings:
- Improving canopy for Buckeye subbasin.

Potential Recommendation:
- Survey ability was limited by landowner access. Agency Biologists and the Gualala River Watershed Council should consider training landowners to conduct habitat inventory and fisheries surveys.

Working Hypotheses: Accelerated erosion from logged areas has contributed to the sedimentation in the streams resulting in added degradation of salmon habit.

Supporting Findings

- Comparison of modern and historic stream surveys show a decline in anadromous populations.
- Comparison of modern and historic stream surveys show that pools have become shallower and streambeds have become embedded with fine sediment over between the earliest fisheries surveys between 1964 and present. Both conditions are deleterious to anadromous fisheries.
- Roads and landings are important sediment sources in the basin. Both historic and modern aerial photos show that numerous debris flows and debris slides involve roads and that numerous failures occur along in-stream and near-stream roads and landings. These resulted in increased sedimentation in the streams.
- Most of the roads in the Buckeye basin were built strictly to support logging operations.
- Most of the middle reaches of the Buckeye basin and the lower and middle reaches of the Wheatfield were clear-cut between 1952 and 1968, building roads in or along the major tributaries streams and mainstem Buckeye. Some larger tributary stream basins only required 3 to 5 years to liquidate the timber. This left large areas of disturbed ground.
- Conifer block removal, followed by permanent conversion to pastureland, in mainstem subbasin was the dominant historical land use practice in the basin.. Prolonged cattle encroachment into streams prevented timely riparian canopy reestablishment, reducing vegetation barriers to erosion.
- The residual effects of heavy channel aggregation from streamside road system failures built in the 1950s and 1960s is noted in timber harvest plan records, particularly the middle reaches in the Buckeye basin and the lower reaches of the Wheatfield.
- Comparative 20 year stream channel width measurements in Buckeye and Wheatfield subbasins between 1961 and 1981 show channel width widening responses to more concentrated harvests upstream.
- Large in-stream landings were built in support of logging operations. Many of these were washed out during subsequent storms.

- Past logging practices, specifically tractor operations on steep slopes, accelerated erosion and added excess sediment to stream channels.

Contrary Findings:

- Modern logging operations are far less intense than those practiced from 1950-1968. In-stream roads and landings are not permitted. Tractor logging on steep slopes is now restricted. The size and degree of clear cuts is now limited. Erosion control is now mandatory for harvested areas.
- Building fences along creeks, now highly encouraged by Resource Conservation Districts, is being implemented more widely on private ranches.

Limitations: Field work related to sediment delivery is limited.

Potential Recommendations

- Upgrading and diligent maintenance of existing road systems to reduce sediment impacts will slow the degradation of salmon habitat – specifically pools and spawning gravels. Careful engineering of new roads or repairs can reduce adverse sediment impacts.
- Road managers should develop and adopt erosion control plans. Repairs and new road construction should be carefully designed and when necessary licensed specialists such as civil engineers, erosion control specialists, and engineering geologists should be consulted.
- Spread timber harvesting operations through time and space to avoid concentrated road use by heavy equipment and resultant mobilization of road surface fines accessing watercourses.
- Continue to decommission streamside roads and landings. The following tributaries contain the highest density of these still active sediment sources:
    - Franchini, Grasshopper, and Osser Creeks in Buckeye
    - Lower reaches of House, Haupt and Tobacco Creeks, North Fork Wheatfield Fork Mckenzie Creek on South Fork main stem.

***Working Hypothesis:* Depleted overstory shade canopy cover along Buckeye Creek and Wheatfield Forks, and the higher reaches of Upper South Fork and Marshall Creek and their tributaries from legacy harvests continues to contribute to elevated water temperatures. In the mainstem these effects were followed by conversion to grazing.**

Supporting Findings:

- Heavy tractors building roads, landings, and skid trails in riparian zones shortly after WW II eliminated overstory shade canopy cover throughout long sections of Buckeye Creek, Wheatfield Fork, Upper South Fork and Marshall Creek and tributaries.
- Vineyard development in recent times in the mainstem may have encroached into riparian zones.
- There was near entire canopy elimination in the middle Buckeye basin reaches with operations especially pronounced during the late 1950's to 1964, and in lower mainstem and main tributaries of Wheatfield, particularly in the 1950's.

Contrary Findings:

- Advanced conifer and hardwood regeneration since 1968 has reinstated canopy cover through out many of the highest tributary reaches.

Potential Recommendations:

- Ensure that adequate streamside protection zones are used to reduce solar radiation and moderate air temperatures in order to reduce heat inputs to Buckeye Ck, Wheatfield Fork. and their tributaries.
- Where current canopy is inadequate, use tree planting and other vegetation management techniques to hasten the development of denser riparian canopy.
- Increase continuous temperature monitoring efforts.
- Exclude vineyard development from riparian areas on Mainstem.
- Encourage livestock exclusionary measures along streams in Mainstem.

***Working Hypothesis*: A lack of in stream large woody debris contributes to simplified riparian habitat structure (e.g., lack of large, deep pools).**

Supporting Findings:

- Heavy tractors building roads, landings, and skid trails in or adjacent to streams between 1952 and 1968 buried, removed, or dispersed LWD in the basin. Field observations have confirmed low LWD distributions.

- Historic and recent timber harvest in lower and middle reaches frequently removed large conifer vegetation down to the stream bank, severely reducing the available recruitment supply of large woody debris.
- Although stream buffers are regrowing under current land management practices and Forest Practice rules, dense buffers of conifers large enough to function, upon recruitment, as LWD in channel formation processes have not yet been reestablished.

Contrary Findings: None noted at this time.

Limitations: Limited formal stream reach surveys have been done for LWD; however observations of crews and findings regarding pool complexity indicate that there is limited instream LWD.

Potential Recommendations:

- Artificial LWD installation projects vastly speed up in-channel diversity development
- Tree planting, thinning from below, and other vegetation management techniques will hasten the development of large riparian conifers.

Program Introduction and Overview

North Coast Watershed Assessment Program (NCWAP)

Salmon / Stream / Watershed / Land Use Relationships

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

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

Through the course of the years, natural climatic, watershed hydrologic responses, and erosion events interact to shape freshwater salmonid habitats. These include the kind and extent of the watershed's vegetative cover as well, and act to supply nutrients to the stream system. "In the absence of major disturbance, these processes produce small, but virtually continuous changes in variability and diversity against which the manager must judge the modifications produced by nature and human activity. Major disruption of these interactions can drastically alter habitat conditions." (Swanston, 1991).

The results of a major disruption, which can be created over time by many smaller disruptions, can drastically alter instream habitat conditions and the aquatic communities that depend upon them. Thus, it is important to understand the critical, dependent relationships of salmon and steelhead with their natal streams during their freshwater life phases, and their streams' dependency upon the watersheds within which they are nested, and the energy of the watershed processes that binds them together.

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

In general, natural disruption regimes do not impact larger watersheds, like the 300 square mile Mattole, in their entirety at any given time. Rather, they rotate episodically across the entire mosaic of their smaller subbasin, watershed, and sub-watershed components over long periods of time. This creates a shifting mosaic of habitat conditions over the larger watershed, (Reice, 1994).

Human disturbances, although individually small in comparison to natural events, are usually spatially distributed widely across basin level watersheds (Table 1), (Reeves, et al., 1995). That occurs because market driven land uses tend to function in temporal waves, like the California Gold Rush or the post-WWII logging boom in Northern California. The intense human land use of the last century, combined with the energy of two mid-century, record floods on the North Coast, created stream habitat impacts at the basin and regional scales. The result has overlain the natural disturbance regime and depressed stream habitat conditions across most of the North Coast region.

TABLE 1: WATERSHED DISTURBANCE REGIMES (REEVES, 2001)

	Natural Disturbance	**Anthropogenic Disturbance**
Magnitude	High	Low, Medium
Frequency	Low	High
Area Affected	Small to Intermediate	Large
Coupling of System	Maintains	Decouples
Legacy	Wood, Sediment	Sediment

No long term fish counts exist for the Gualala River. However, the information, although of differing quantity and quality reflects the absence of coho in all subbasins since 1998, with the rate of decline most evident in the late 60's and early 70's. Steelhead also appear to have decline, more in some subbasins than others.

ADD FIGURES OF HISTORIC CREEL CENSUS

ADD E-FISHING GRAPHIC

Factors Affecting Anadromous Salmonid Production

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

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

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

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

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

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

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

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

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

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

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

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

Policies, Acts, and Listings

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

Federal Statutes

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

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

The federal **Endangered Species Act of 1973** (FESA) addresses the protection of animal species whose populations are dwindling to critical levels. Two levels of species risk are defined. “Threatened” means any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. “Endangered” species means any species that is in danger of extinction throughout all or a significant portion of its range. In general, the law forbids the “take” of listed species. Where specially permitted through the completion and approval of a habitat conservation plan, take of a species listed as threatened may be allowed. Many of California’s salmon runs are listed under FESA, including Mattole River chinook and coho salmon, and steelhead trout, which have been proposed for listing.

State Statutes

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

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

Sections 1600 et seq. of the Fish and Game Code, implemented by the Department of Fish and Game, are required for any activities that alter the beds or banks of streams or lakes. While treated as ministerial in the past, the courts have more recently indicated that these constitute discretionary permits and thus must be accompanied by an environmental impact review per CEQA.

The **California Endangered Species** Act (CESA) … The California Endangered Species Act (CESA) (Fish & Game Code §§ 2050, *et seq.*) generally parallels the main provisions of the Federal Endangered Species Act and is administered by the California Department of Fish and Game (DFG). Coho salmon, found in the Mattole, is currently a candidate for listing under CESA. The State Fish and Game Commission is expected to make the final listing decision of this species in 2002.

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

Act, the FPA and Rules provide for significant measures to protect watersheds, watershed function, water quality, and fishery habitat.

Assessment Needs for Salmon Recovery and Watershed Protection

The North Coast Watershed Assessment Program (NCWAP) is an interagency effort between the California Resources Agency and CalEPA which was established in 2000 to provide a consistent scientific foundation for collaborative watershed restoration efforts and to better meet the State needs for protecting and restoring salmon species and their habitats under State and federal laws. The program was developed by a team of managers and technical staff from the following departments with watershed responsibilities for the North Coast: California Resources Agency, California Department of Fish and Game (DFG), California Department of Forestry and Fire Protection (CDF), California Department of Conservation/Division of Mines and Geology (DOC/DMG), California Department of Water Resources (DWR), and the North Coast Regional Water Quality Control Board (RWQCB) of the State Water Resources Control Board. The Institute for Fisheries Resources (IFR) is also a partner and participant in this program. The California Resources Agency in coordination with CalEPA, initiated this program in part in response to specific requests from landowners and watershed groups that the State take a leadership role in conducting scientifically credible, interdisciplinary assessments that could be used for multiple purposes. The need for comprehensive watershed information grew in importance with listings of salmonids as threatened species, the TMDL (total maximum daily load) consent decree, and the increased availability of assistance grants for protecting and restoring watersheds.

Listings under the federal Endangered Species Act for areas within the NCWAP region (the North Coast Hydrologic Unit) began with coho salmon in 1966, followed by Chinook salmon in 1999, and steelhead in 2000. In 2001, coho was proposed for listing under the California Endangered Species Act. Concerns about the potential impacts of salmonid listings and Total Maximum Daily Loads (TMDL) on the economy are particularly strong on the North Coast where natural-resource-dependent industries predominate. Cumulative impacts related to these activities, along with natural processes, can adversely affect watershed conditions and fish habitat, including landslides, flooding, timber harvest, mining, ranching, agricultural uses and development. In order to recover California's salmonid fisheries, it is necessary to first assess and understand the linkages among management activities, dominant ecological processes and functions, and factors limiting populations and their habitat.

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

NCWAP Program Goals

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

1. Organize and provide existing information and develop limited baseline data to help evaluate the effectiveness of various resource protection programs over time;

2. Provide assessment information to help focus watershed improvement programs, and assist landowners, local watershed groups, and individuals to develop successful projects. This will help guide support programs, like DFG's Fishery Restoration Grants Program, toward those watersheds and project types that can efficiently and effectively improve freshwater habitat and lead to improved salmonid populations;

3. Provide assessment information to help focus cooperative interagency, nonprofit and private sector approaches to "protect the best" watersheds and streams through watershed stewardship, conservation easements, and other incentive programs; and

4. Provide assessment information to help landowners and agencies better implement laws that require specific assessments such as the State Forest Practice Act, Clean Water Act, and State Lake and Streambed Alteration Agreements.

Program Objectives and Guiding Questions

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

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

"What watershed factors are limiting salmonid populations?"

- What are the general relationships between natural event and land use histories, for example, fire, flood, drought, earthquake, etc.; and urban and rural land development, timber harvest, agriculture, roads, dams, and stream diversions. How is this history reflected in the current vegetation and level of disturbance in North Coast watersheds? How can these kinds of disturbances be meaningfully quantified?

- What is the spatial and temporal distribution of sediment delivery to streams from landsliding, bank, sheet and rill erosion, and other erosion mechanisms, and what are the relative quantities for each source?

- What are the effects of stream, spring, and groundwater uses on water quality and quantity?

- What role does large woody debris (LWD) have within the watershed in forming fish habitat and determining channel condition and sediment routing and storage?

- What are the current salmonid habitat conditions in the watershed, the aquatic/riparian zone, and the estuary (flow, water temperature/shade, sediment, nutrients, instream habitat, large woody debris and its recruitment); how do these compare to desired conditions (life history requirements of salmon, Basin Plan water quality objectives)?

- What are the history and trends of the sizes, distribution, and relative health and diversity of salmonid populations and/or other aquatic community organisms within the watersheds?

- Does the status of these populations reflect current watershed and stream habitat conditions or does it indicate constraints beyond the watershed might exist. For example, a lack of stream connectivity that prevents free movement for adults or juveniles, or a poor marine life history, could affect a salmonid population.

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

Program Assessment Region and Agency Roles

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

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

- DFG will compile, develop, and analyze data related to anadromous fisheries habitat and populations. It will also lead an interagency evaluation of factors affecting anadromous fisheries production at the watershed level and provide recommendations for restoration and monitoring in the final synthesis report.

- CDF will compile, develop, and analyze data related to historical land use changes in the watersheds. It will also take the lead on preparing reports that synthesize information, findings and recommendations, and develop a framework for assessing cumulative impacts.

- DOC/DMG will compile, develop, and analyze data related to the production and transport of sediment. Tasks will include baseline mapping of landslides, landslide potential, and instream sediment, as well as an analysis of stream geomorphology and sediment transport.

- RWQCB will compile, collect, and analyze water quality data for the assessments.

- DWR will install and maintain stream monitoring gages where needed to develop and analyze stream flow information.

Assessment Strategy and General Methods

Because the NCWAP is intended to provide information useful for several purposes, its approach emphasizes close coordination with clientele groups. The NCWAP products are expected to provide both context and content for finer scale analysis, set priorities for detailed analysis and program planning, and identify areas for further work. Therefore, although a relatively uniform assessment process will be followed in each basin, key issues and information are custom to each watershed. Variability in watershed condition, public resource values and concerns, land use and ownership, and the availability of existing data shape each assessment within the context of the guiding, critical questions. Public review of products will provide additional opportunities to adapt and enhance assessments in the future.

The steps of the NCWAP process in each basin are:

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

Step Two: Data compilation. The team will compile and screen existing data according to the quality and usefulness for answering critical questions and application to the program's Ecological Management Decision Support system model (EMDS). This model accepts information about the study watershed and /or stream, and helps process and explains relationships among current conditions affecting fishery production. Quality control processes are described in greater detail in Chapter 4 of the NCWAP's draft Method Manual. Mapping and geographical information system (GIS) presentation will be coordinated among the several departments.

Step Three: Initial Analyses. The team will use the EMDS model (described in Chapter 3 of the NCWAP's Methods Manual) to help analyze the habitat factors affecting fish production. This initial model run with existing data will help to identify significant data gaps (categories, location, and scale) and to focus field data verification and collection by DFG and others. The model will be updated as run as new data is collected and/or developed.

Step Four: Fieldwork. Agencies will conduct necessary fieldwork, including validation of existing data, verification of imagery or photo-based analyses, and collection of new data to fill critical gaps. Throughout this process, there will be coordination with local groups and landowners on access to private property and validation of findings.

Step Five: Analyze data. This includes the generation of maps, databases, and the more integrative analyses. Data will be analyzed in an interdisciplinary fashion where needed, particularly when answering critical questions, applying the limiting factors analysis, and developing general management and cumulative efforts recommendations.

Step Six: Develop Assessment Reports for Public Review: Draft products will include data developed or compiled by all the agencies as licenses or agreements permit (including photos and imagery); analytical products such as maps, limiting factor analysis results, GIS analyses, topical reports, etc.; and the review summary report with recommendations. These products will be made available in hard copy from NCWAP offices in Fortuna, Santa Rosa, and Sacramento; and also through the Klamath Resources Information System CD and on-line. A public review process will be established for each basin. The NCWAP team will summarize comments and revise preliminary products to reflect comments as feasible.

NCWAP Products

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

- Databases of information that the NCWAP has used and collected for its analysis. The NCWAP will also provide a data catalogue which identifies all the information we considered, and evaluates its usefulness for the NCWAP assessment process, as well as a bibliography of other references cited in the assessment report.

- Maps showing geology, geomorphic features related to landsliding, instream sediment and transport zones, and relative landslide potential developed by the Department of Conservation/Division of Mines and Geology.

- An Ecological Management Decision Support system (EMDS) model that describes how watershed conditions interact at the stream reach and watershed scale to affect suitability for fish.

- GIS-based models and analyses such as timber harvest frequency, road-based erosion model runs, vegetation, stream buffers, roads, road density, road and stream interactions, and roads on unstable slopes.

- An interdisciplinary analysis of the results of fieldwork, historical analyses, EMDS data, and other analytical products about the suitability of stream reaches and the watershed for salmonids.

- An interagency description of historic and current conditions as they relate to suitability for salmonid fisheries. This will address vegetation cover and change, land use, geology and geomorphology, water quality, streamflow and water use, and instream habitat conditions for salmonids. It will also contain hypotheses about watershed conditions that contribute to factors affecting salmonids.

- Recommendations for management and restoration to address limiting factors.

- Recommendations for additional monitoring to improve the assessment process.

- A CD developed through the Institute for Fisheries Resources (IFR) which uses the Klamath Resources Information System (KRIS) tool to store data, provide a regional bibliography of watershed studies and reports, present the NCWAP analyses, maps and other products, and store community based data over time.

- A synthesis report describing the results and implication of the watershed assessment.

All products will be made available electronically through the NCWAP website and the IFR's KRIS tool on CD and on their website.

Assessment Report Conventions and Use

Calwater 2.2a Planning Watersheds

NCWAP is using the California Watershed Map (CALWATER version 2.2a) to delineate watershed units. CALWATER is a set of standardized watershed boundaries meeting standardized delineation criteria. The hierarchy of watershed designations consists of six levels of increasing specificity: Hydrologic Region (HR), Hydrologic Unit (HU), Hydrologic Area (HA), Hydrologic Sub-Area (HSA), Super Planning Watershed (SPWS), and Planning Watershed (PWS). The primary purpose of Calwater is the assignment of a single, unique code to a specific watershed polygon. The Calwater Planning Watersheds are generally from 3,000 – 10,000 acres in size.

Primary purposes for Calwater 2.2 include but are not limited to mapping, reporting, and statistical analysis of water resources, water supply, water quality, wildlands, agriculture, soils, forests, rangelands, fish habitat, wildlife habitat, cross-referencing state and federal hydrologic unit or watershed codes and names.

CALWATER version 2.2 is the third version of Calwater (after versions 1.2 and 2.0), and is a descendent of the 1:500,000-scale State Water Resources Control Board Basin Plan Maps drawn in the late 1970's.

Tierra Data Systems completed Version 1.2 in 1995 by Tierra Data Systems (Jim Kellog). Line work was captured by overlaying the Basin Plan Maps on 1:24,000-scale USGS quad sheets, redrawing and digitizing lines to match 1:24,000-scale watershed boundaries, and subdividing the 4th level Hydrologic Subareas (HSA's) into 5th level Super Planning Watersheds (SPWS) and 6th level Planning Watersheds (PWS).

Hydrology Hierarchy

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

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

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

Gualala Watershed Profile

Introduction

The Gualala River drains 298 square miles along the coast of southern Mendocino and northern Sonoma Counties. The river enters the Pacific Ocean near the town of Gualala, 114 miles north of San Francisco and 17 miles south of Point Arena. The Gualala River watershed is elongated, running over 32 miles long north-south, with an average width of 14 miles. Elevations vary from sea level to 2,602 feet at Gube Mountain and terrain is most mountainous in the northern and eastern parts of the basin (Figure. 2). A long history of movement along the San Andreas Fault and the Tombs Creek Fault has been a dominant force in the shaping of the basin. The climate is influenced by fog near the coast with seasonal temperatures ranging between 40 to 60 degrees F, with the interior basin ranging from below freezing to over 90 degrees F seasonally. Rainfall also varies by location within the basin with 33 inches falling on average near the town of Gualala and totals reaching over 63 inches in some areas within the interior.

The five principal Gualala subbasins in order of size are the Wheatfield Fork (37% of drainage), South Fork and Gualala Mainstem (21%), North Fork (16%), Buckeye Creek 14%), and Rockpile Creek (12%), which also serve as subbasins for analysis in this study (Figure. 2). The mainstem Gualala extends only from the convergence of the North Fork and South Fork to the ocean, with much of this reach comprising the estuary or lagoon. Coastal conifer forests of redwood and Douglas fir occupy the northwestern, southwestern and central portions of the watershed while oak-woodland and grassland cover many slopes in the interior basin. Coho naturally inhabited the streams flowing from coniferous forest but were likely sub-dominant to steelhead in interior basin areas draining the mélange due to the more open nature of the channels, less suitable habitat, and naturally warmer stream temperatures. The interior basin is largely grassland with scattered oaks. Surface water in this area generally lack shade and are warmed with abundant sunshine.

Salmon / Stream / Watershed / Land Use Relationships

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

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

Through the course of the years, natural climatic, watershed hydrologic responses, and erosion events interact to shape freshwater salmonid habitats. These include the kind and extent of the watershed's vegetative cover as well, and act to supply nutrients to the stream system. "In the absence of major disturbance, these processes produce small, but virtually continuous changes in variability and diversity against which the manager must judge the modifications produced by nature and human activity. Major disruption of these interactions can drastically alter habitat conditions." (Swanston, 1991).

The results of a major disruption, which can be created over time by many smaller disruptions, can drastically alter instream habitat conditions and the aquatic communities that depend upon them. Thus, it is important to understand the critical, dependent relationships of salmon and steelhead with their natal streams during their freshwater life phases, and their streams' dependency upon the watersheds within which they are nested, and the energy of the watershed processes that binds them together.

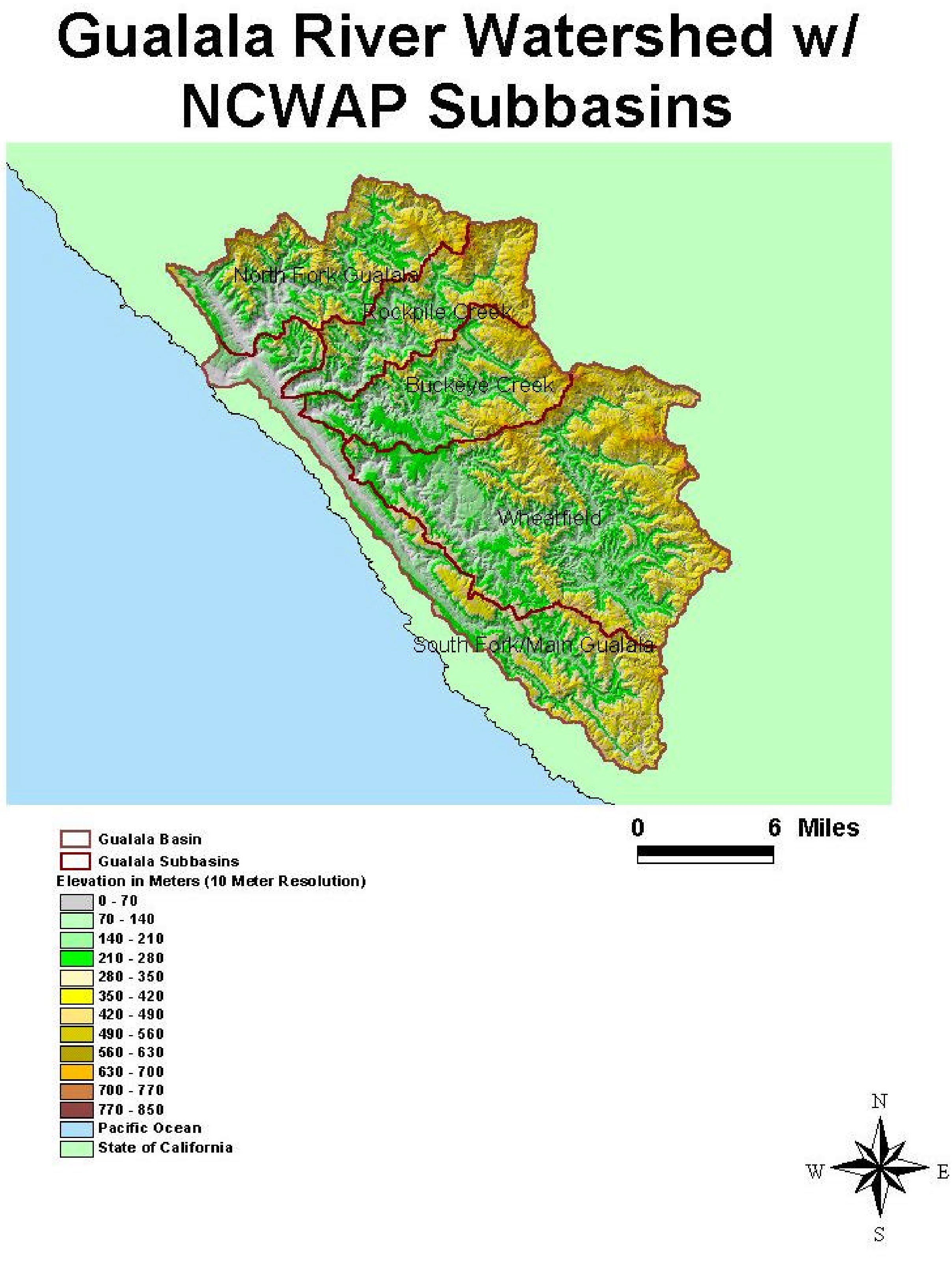


FIGURE 2: GUALALA RIVER WATERSHED W/ NCWAP SUBBASINS

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

In general, natural disruption regimes do not impact larger watersheds, like the 298 square mile Gualala, in their entirety at any given time. Rather, they rotate episodically across the entire mosaic of their smaller subbasin, watershed, and sub-watershed components over long periods of time. This creates a mosaic of habitat conditions over the larger watershed, (Reice, 1994).

Human disturbances, although individually small in comparison to natural events, are usually spatially distributed widely across basin level watersheds, (Reeves, et al., 1995). That occurs because market driven land uses tend to function in temporal waves, like the California Gold Rush or the post-WWII logging boom in Northern California. The intense human land use of the last century, combined with the energy of two mid-century, record floods on the North Coast, created stream habitat impacts at the basin and regional scales. The result has overlain the natural disturbance regime and depressed stream habitat conditions across most of the region.

Subbasin Scale

Natural variation in subbasins is at least partially a product of natural and human disturbances. Other variables that can distinguish areas, or subbasins, in larger basins include differences in elevation, geology, soil types, aspect orientation, climate, vegetation, fauna, human population, land use and other social-economic considerations. The combined complexity of large basins makes it difficult to speak about them concerning watershed assessment and recommendation issues in other than very general terms. In order to be more specific and useful to planners, managers, and landowners, it is useful to subdivide the larger basin units into smaller subbasin units whose size is determined by the commonality of many of the distinguishing traits.

Hydrology

The watershed has a long history of land use, fire, and floods. With steep slopes and high rainfall amounts, alterations of the landscape can likely change the hydrologic curves, flood frequencies and stream flow peaks within the subwatersheds. Aggradation of the streambed in many areas has probably reduced surface water flow during dry years.

The main stem of the Gualala River flows from the confluence of the South Fork and North Fork to the Pacific Ocean. This reach is greatly influenced by seasonal closures of the river mouth, which typically occur in early summer and last until the first heavy rains of October or November, although it may also close briefly during the winter months (CDFG 1968 and EIP 1994).

Precipitation in the Gualala watershed is highly seasonal. Most precipitation occurs between the months of October through April. Average annual precipitation ranges from 33 inches at the lower elevations near the Pacific Ocean to 63 inches at the higher elevations in the southeastern upper watershed.

Few long-term precipitation stations exist within the basin. The longest gauge record near the basin is the Cloverdale gauge with a continuous period of record of 1903 through the present. Annual precipitation at the gauge during this period ranged from 13.54 inches in 1924 to 79.26 inches in 1983. Mean annual precipitation for this station is 40.89 inches. A list of long-term precipitation gauges within or near the Gualala watershed and a location map are included in Appendix 6.

Similar to other watersheds within the North Coast, only a few stream flow gauging stations have historically operated within the Gualala watershed. Stream flow data had not been collected by any agency since 1994. To gain additional stream flow data, three stream flow gauging stations (one on the North Fork Gualala, one on the Wheatfield Fork, and one on the South Fork Gualala above the Wheatfield Fork) were installed by NCWAP during the fall of 2000. Zero flow occurred at the new Wheatfield and South Fork gauges during the late summer months of 2001, but the North Fork maintained a minimum base flow and was the major if not the only contributor of surface water flow to the estuary during low flow periods. A list of existing and discontinued stream flow gauging stations, their locations, and period of record along with a location map are provided in Appendix 6.

Only one stream flow gauge, USGS gauge #11467500 "South Fork Gualala River near Annapolis" was operated for a significant continuous period (October 1950 – September 1971). This station was located below the confluence with the Wheatfield Fork and measured the runoff from a drainage area of 161 of the 298 square mile Gualala watershed. The two highest peak flow events recorded for this station occurred in December 1955 at 55,000 cubic feet per second (cfs) and January 1966 at 47,800 cfs. While other North Coast rivers experienced near record flood flows in December 1964, the South Fork Gualala gauge recorded only 21,000 cfs. An examination of other stream flow gauges in the area indicates recent flood events at the South Fork Gualala gauge site of 30, 000 cfs or greater probably occurred in 1974, 1983, 1986, 1993, 1995, and 1997. A summary and statistical analysis of the flow data for this station are presented in Appendix 6.

A search of the SWRCB's Water Right Information System (WRIMS) was performed to determine the number and types of water rights within the Gualala watershed. The WRIMS database is under development and may not contain all post-1914 appropriative water right applications that are on file with the SWRCB at this time. Some pre-1914 and riparian water rights are also contained in the WRIMS database for those water rights whose users have filed a "Statement of Water Diversion and Use". A list of water rights and associated information contained within WRIMS for the Gualala watershed along with a location map are presented in Appendix 6.

SWRCB issued appropriative water rights for a total of about 4,500 acre-feet per year (ac-ft/yr) of water from the Gualala River watershed, at a maximum diversion rate of about 8 cfs. Because the watershed is sparsely populated, riparian extraction in the watershed is probably minimal. The potential peak demand from this use and additional future riparian uses in the watershed was estimated to be 2.5 cfs (EIP, 1994). Although municipal use is the dominant water use in the watershed, other uses of surface water include domestic, irrigation, stock watering, fish and wildlife enhancement, and fire protection.

Current water use in the Gualala River watershed by agricultural and rural development is probably minor. However, as stated in the Gualala River Watershed Literature Search and Assimilation (Higgins 1997): "While agricultural water use in the Gualala River watershed has been very low in the past, vineyards are now being developed in some areas. These" vineyards "may have a direct impact on tributary flow if surface water is used. If wells are drilled in upland areas, and if the aquifer is joined to headwater springs, flows in some tributaries could be affected". EIP Associates (1994) projected that development of vacation homes or residences could result in use of up to 2.5 cfs for the entire basin.

Two major municipal water users, the North Gualala Water Company (NGWC) and the Sea Ranch, currently extract water from the Gualala watershed. The SWRCB issued an appropriative water right permit to NGWC to divert water from the North Fork Gualala River. The permit stipulates a maximum diversion of 2.0 cfs, but when the natural flow of the North Fork falls below stipulated by-pass flows for fish, NGWC is prohibited from diverting any water from the North Fork. The by-pass flows vary with the time of year, but a minimum by-pass flow of 4.0 cfs is required at all times. In August 2000, the State Water Resources Control Board ruled that the by-pass flows applied to both surface water diversions and extractions from underground water from two NGWC off-set wells that had been previously found to fall under the SWRCB's jurisdiction as "subterranean streams flowing through known and definite channels". The SWRCB decisions regarding these water extractions are currently under litigation in the Superior Court of Mendocino County. The plaintiff, NGWC, is claiming the water extractions from their off-set wells do not fall under the jurisdiction of the SWRCB.

The Sea Ranch once drew surface water directly from the South Fork Gualala, but they currently draw water from the aquifer below the lower South Fork Gualala riverbed by off-set wells and have augmented storage with an off-site reservoir. The SWRCB again ruled that the water extractions from the aquifer are from "subterranean streams" and are therefore under the SWRCB jurisdiction. The Sea Ranch's appropriative water right permit allows for a maximum extraction of 2.8 cfs, although actual historic maximum diversions have been substantially less. These diversions are also dependent on minimum fish by-pass flows stipulated in the SWRCB permit. Current low flow constraints in the Gualala River will most likely prohibit future additional appropriative water allocations; however, greater use of the rights allocated to the Sea Ranch is expected in the future.

The NCRWQCB's Basin Plan designates ten existing and one potential beneficial use of water for the Gualala River watershed. The Water Board has responsibility for protecting all beneficial uses. Accordingly, the water quality parameters assessed in this report are compared to water quality objectives for the protection of all beneficial uses. However, the assessment is focused primarily on the salmonid fishery beneficial uses: COLD (cold freshwater habitat), SPWN (spawning, reproduction, and/or early development), MIGR (migration of aquatic organisms), EST (estuarine habitat), and REC-1 (water contact recreation-fishing). A complete list of beneficial uses is shown in Appendix 9.

Geology

The Coast Ranges in general and the Gualala Watershed in particular are areas of naturally high background levels of landslide activity due to geologic and climatic conditions; i.e., steep slopes, weak rock, high rainfall, seismic shaking, and uplift. The watershed resides wholly in the San Andreas Fault System and is bounded on the west and east by the San Andreas and the Maacama Faults. Drainage networks are largely fault controlled and vary from very long linear reaches (as along the Little North Fork and South Fork) to regions of simple zigzag patterns (Rockpile Creek), to high ordered convoluted patterns (eastern Wheatfield Fork). A disconnected series of northwest trending interior ridges subdivide the Gualala watershed into several sub-basins. The Geologic and Geomorphic Features Related to Landsliding Map (Plate 1) shows a complex pattern of lithology and landsliding.

The inland boundaries of the watershed and sub-basins are defined by the disconnected series of northwest oriented groups of ridges. Varying distributions of large earthflow and rockslide complexes are mapped (see Plate 1). Northwest oriented bands of poorly consolidated ancient marine terraces are concentrated in lower central and upper east reaches of the watershed. The Ohlson Ranch formation is subject to landsliding along the edges of terraces or along incised drainages.

The Gualala River system and surrounding topography evolved in response to rapid geologic changes along the west coast of North America over the past 30 million years, and especially in the last five million years. The drainage networks evolved along with the changing landscape. The landscape continues to actively change through the processes of erosion and mass wasting in ways that force the stream channels to continually adjust. It is unknown (and beyond the scope of the geologic portion of the assessment) to what degree land use has accelerated natural erosion levels and how long the residual effects will last. It is clear that past land-use practices that were indifferent to stream health triggered many landslides and directly placed large volumes of sediment in the stream channels.

Montgomery (2000) proposed that the geologic evolution of the Pacific coast created habitat diversity, which allowed for the evolution of the five species of Pacific salmon. It then follows that in the Gualala Watershed, the present ecology of the listed coho salmon and steelhead developed in sync with the geologic foundation, and modification to the landscape from historic time. Additional detail is presented in Appendix 7.

Land Use

The Gualala Watershed has one of the longest span of historical use compared to other North Coast watersheds. Logging of the virgin old growth redwood forest began during the mid 1800s. The first documented account dates to 1862 in lower portions of the watershed near coastal ramp and port facilities. This includes the lower reaches of the Little North Fork, North Fork, Pepperwood Creeks, and the lowest reaches of Rockpile and Buckeye Creeks at the confluence with the South Fork. There was concentrated demand of the resource after the 1906 earthquake and rebuilding of San Francisco. The first logging methods used oxen teams to move large old growth redwood logs to terminal points of lateral connecting rail lines, which extended along the South Fork to Gualala from the Santa Rosa Area. Watercourses were frequently used to move logs downslope including use of splash dams. Main rivers were used to float logs downstream. Fire was used extensively to reduce slash during logging and in attempts to convert redwood forest to grazing land after the logging.

Early logging activities left a legacy of impacts, some of which persist to the present. Splash dams and log drives tended to flatten and simplify stream channels. Rail line construction included massive cut and fill excavation along roadbeds which followed streams. Although wood trestles were built over larger watercourses, smaller watercourses were crossed by wood and earth fill which later failed. The introduction of the steam donkey by the turn of the century reduced ground impacts by cable pulling arge logs from fixed locations but allowed much more widespread forest harvest. These operations did not disturb the ground to the extent of more recent tractor operations characterized by large-scale sideslope excavations and skid trail networks. The gasoline powered crawler tractors made their appearance in the north coast in the late 1920s, but logging in the Gualala was inactive during the Great Depression.

Increased demand for lumber products during the 1950s coincided with the widespread deployment of heavy tractors greatly improved by technology advanced during World War II. Early versions of the D-8 and D-10 tractors, using refined track mounts and suspension systems, and powered by diesel engines, were ideally suited for moving large diameter logs over difficult terrain. This equipment was readily maneuverable, enabling large areas to be worked over in short time periods. Rail line networks were quickly abandoned and diesel powered log trucks transported logs along seasonal roads. Between 1952 and 1960, tractor method harvesting extended in a broad sweep from the upper reaches of the North Fork, east through the central and upper reaches of Rockpile and Buckeye creeks, and throughout lower and middle reaches of Wheatfield Fork. Harvest operations followed straight parcel lines regardless of watercourse condition or difficult terrain. Roads often followed the stream channel to enable downslope skidding. Many roads had steep gradients designed to access all positions of the sideslope. Skid trails frequently followed or crossed ephemeral stream channels. Landings were often located in, or adjacent to, watercourses. These were built by pushing wood debris into channel, and overtopped by dirt fill. Across steep terrain, skid trials cut deep into the sideslope, creating a terraced effect. By 1964, tractor harvesting had continued at an active pace to comprise a majority, and in some areas, most of the timbered areas in the west and central reaches of the watershed (See Figures 3, 3a-b below).

The lack of any erosion control facilities installed throughout large areas of the watershed, coupled with the uncontrolled installation of fills and failure to remove fills adjacent to watercourses, left the entire watershed particularly vulnerable to the 1964 flood event. During a period of one week in December 1964, the intense prolonged runoff caused massive erosion from downcutting, slides, and washing of soil and debris into watercourses. The residual effects are still observed in some areas today. Cal Trans aerial photos taken in June 1965 at 1,200 scale show stream channel meandering through wide, flat areas of buried stream pools, indicating channel aggradations. Roads following the stream channel repeatedly failed as fill sidecast washed out during peak flows. Debris slides above and below roads were frequent. Deep blowouts through landings built over channel are numerous throughout the 1965 photos. There were numerous watercourse diversions onto roads and skid trails.

After 1964, harvest operations resumed at an active rate in the lower and middle reaches of the North Fork and entire Little North Fork areas to remove most of the available timber base in these areas by 1973. Other areas of mature Douglas fir in (1) higher elevation areas and (2) east reaches of the watershed were harvested during this time. Only pocket stands and scattered larger timbered blocks remained. Roads and landings continued to be located low on the sideslope, frequently following the stream channel. Subsequent landing blowouts and road failures have been documented along the Little North Fork and central North Fork. There were large storm events in 1972 and 1974. With ranching being the dominant use in mixed conifer –oak woodland areas, logging of Douglas fir was frequently followed by prolonged cattle grazing. This reduced, and in many locations prevented conifer reestablishment altogether. Grassland became permanently established throughout compacted ground. In addition, removal of Douglas fir in mixed conifer-hardwood forests converted these stands to pure tan oak and madrone. Prolonged cattle grazing in riparian areas after harvest prevented timely reestablishment of canopy cover over fish bearing watercourses, elevating stream temperatures.
After 1973, logging operations had slowed. Smaller selection method harvests were predominant. By this time, tractor-yarding methods changed to maintain equipment exclusion zones and minimum vegetation retention standards adjacent to watercourses per 1973 Forest Practice Rules. New road locations were moved upslope, but the practice of using existing roads located near streams continued. The new forest practice rules limited the cutblock size, creating smaller logged areas.

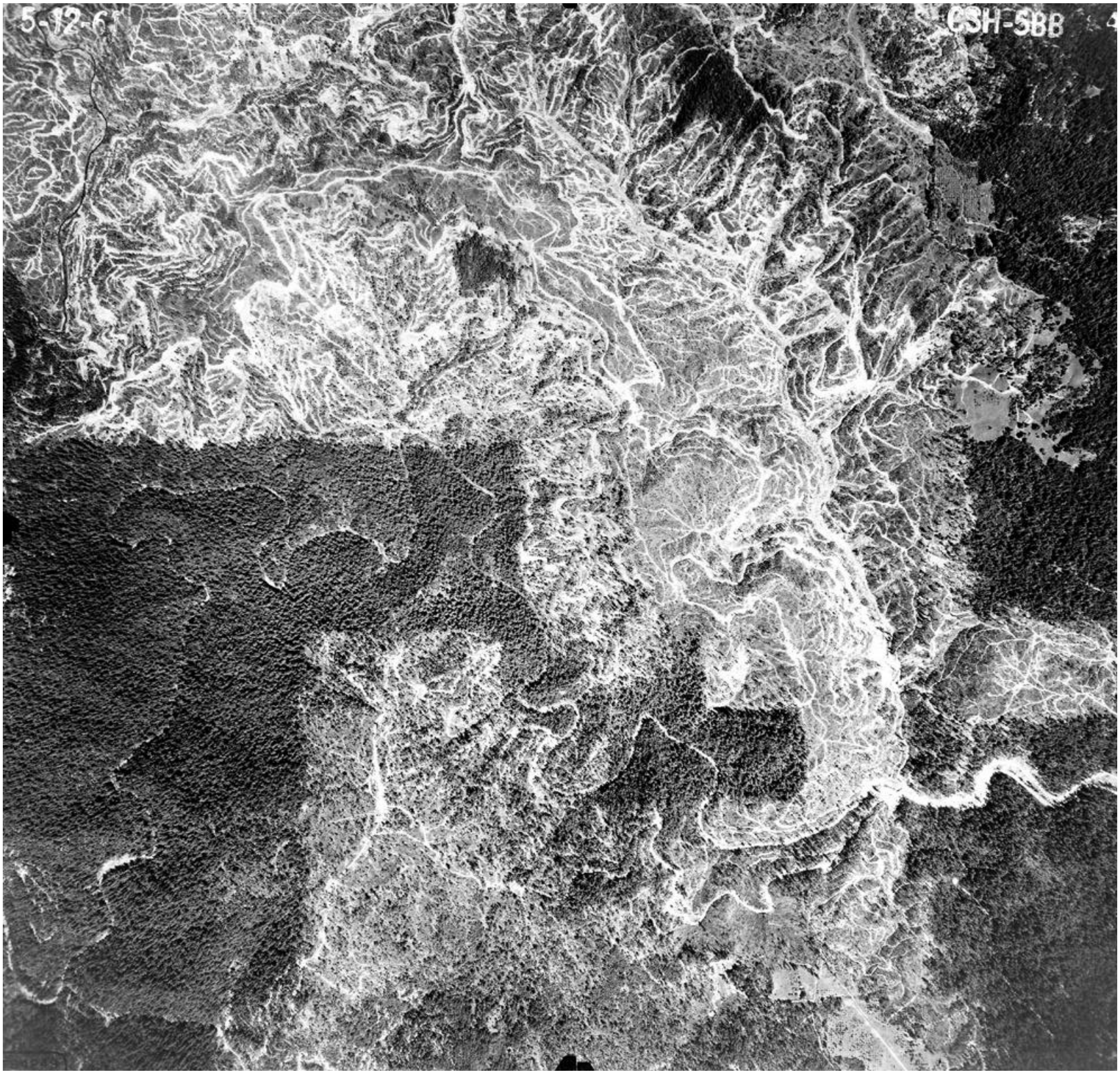
In the 1990s, harvest activity increased. Smaller but numerous clearcut blocks appear in the redwood lowland areas of the Gualala Redwoods ownership. Throughout the watershed, cable method yarding appears with new road construction now moved to upslope and ridgeline locations. Many sections of the older seasonal roads following the stream channel are either abandoned or removed. Numerous seasonal roads still exist in close proximity to streams, and are used as needed during timber harvest activities. During the mid 1990s, Coastal Forestlands (formerly R&J Timber Co.), purchased by Pioneer Resources in 1998, submitted numerous seed tree overstory removal/ dispersed harvest THPs, covering large areas but removing scattered single trees and remnant stands left from 1960s era entries. Agency review of these THPs clarified road upgrade work requirements to repair erosion conditions of pre-1973 operations. There has been little harvesting in these areas since 1998. Residential development near the coast, and vineyard development inland, become dominant land use activities by the late 1990s. Ninety-five per cent of the Gualala watershed is privately owned.

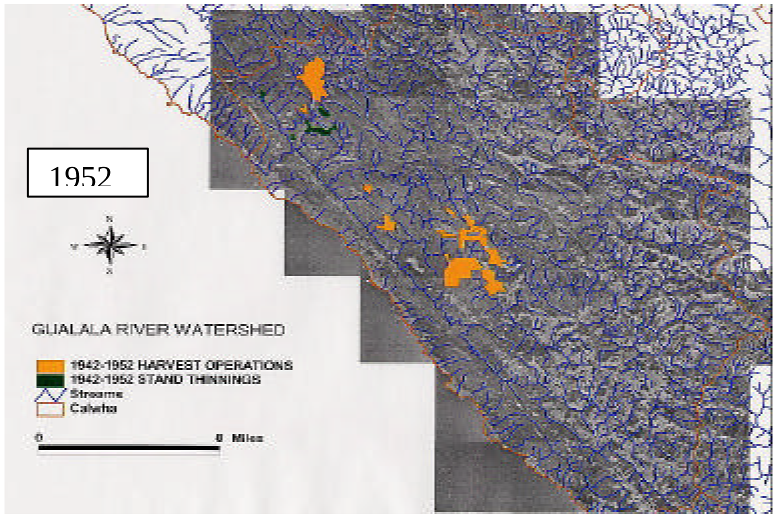
General Watershed Findings

1. Most current riparian overstory conditions reflect shade canopy in-growth of young conifer/ hardwood regeneration from riparian zones entirely cleared of all vegetation between 1952 and 1968. However, a full rotationary time period will be needed within WLPZs to fully reinstate overstory canopy strand structure of late seral trees to coincide with post Depression 1936-1942 era overstory canopy cover. In 30 to 40 year old conifer plantations in higher reaches of the watershed, entire bank to bank shade canopy cover has been reinstated over smaller streams. After initial land clearing and forest removal, prolonged pasture grazing spanning decades in the northeast and east areas of the watershed prevented timely reestablishment of canopy cover over watercourses. With the decline of ranching in recent years, young sapling sized conifers/ hardwoods have reestablished in riparian areas

FIGURE 3: 1961 aerial photo, Post World War II

Pre-Forest Practice Rules logging in the Buckeye Creek Subbasin. Franchini Ck. and a new streamside road are in upper right





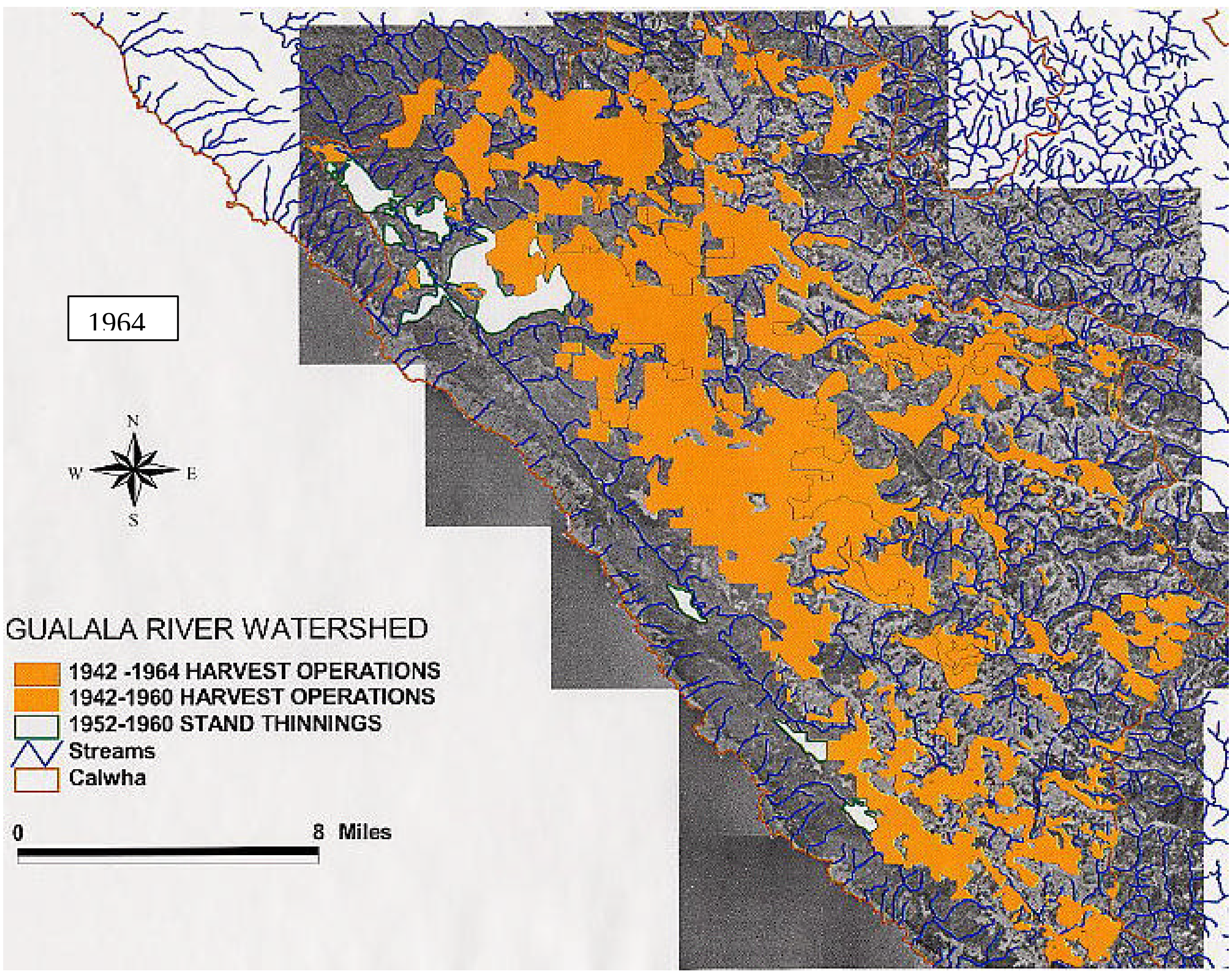


FIGURE 4. Harvest Operations 1942-1960

In a period of only twelve years between 1952 (top) and 1964 (below), heavy tractors eliminated most of the conifer dominated timberstand in the watershed. The 1964 flood rained down on vast areas of recently exposed ground with no erosion controls installed. Streamside roads and landings were built in or adjacent to most major watercourses in these areas.

2. The 1964 storm event rained down on large sub basin-wide timber harvest block areas. These areas were tractor yarded regardless of sideslope condition with no erosion control facilities installed or proper disposal of sidecast effected. This caused massive erosion, slides, and washing of soil and debris into watercourses. Sedimentation, pool infill, and stream widening have been documented at the point of discharge immediately after the 1964 flood. In steeper terrain, for example in the N.F/ SF. Fuller Creek and higher reaches of the North Fork and Rockpile sub-basins, sedimentation debris has washed downstream to low lying alluvial basins, per 1984 and 1999 photos and field observations, re-exposing a rocky substrate upstream to varying degrees. This substantiates more detailed studies of post 1964 sediment transport studies on Redwood Creek, which shows that sediment was dispersed downstream over time and deposited in lower energy environments on the flood plains and in the stream channels.

3. A shallow pool structure generally predominates in moderate gradient tributary streams. In these lower energy gradient environments, low stream pool frequency and shallow pool depth coincide with contemporary fisheries studies showing predominantly young of the year steelhead populations and absence of coho. This contrasts with the earliest fisheries studies dating back to the early 1960s showing deeper and more frequent pool structure with consistent coho observations, and older steelhead found in these many of these same areas. This is particularly noted adjacent to late 1950s/ early 1960s tractor areas that continue to discharge debris into watercourse during large storm events, i.e. Buckeye and Wheatfield Basins. The extent to which that recovery is slowed by current land use practices, interacted with more recent storm events, is unknown. However it is apparent that instream conditions noted in these areas are not fully supportive of anadromous salmonids today.

GENERAL RECOMMENDATIONS

1. Decommission or upgrade roads to minimize the potential for additional debris and sediment inputs to watercourses. This assessment finds that streamside roads and landings built 40 to 50 years ago are heavily concentrated in the watershed, and are a high priority need for stabilization. The Logging Impacts Map shows specific locations The large-scale stabilization program carried out in Fuller Creek is exemplary in promoting the recovery of the aggraded stream channel conditions in an area identified with the worst of the logging related damage in the watershed. Recommendations for road abandonment and improvements are:

2. Properly size all road watercourse crossings based on the 100 year return period standard recently implemented, and install bridge crossings over all Class I watercourses to reduce the potential for failure and washout.

3. Increase size and density of trees and promote replanting in the riparian corridors in the entire Gualala River watershed, especially in the eastern areas predominated by oak woodland and chaparral, and the Wheatfield Fork subbasin

Vegetation

Prior to European settlement, coniferous forest extended throughout approximately two thirds of the watershed. Dense old growth redwood forests occupied the northwestern portion of the watershed, particularly the alluvial North Fork sub-basin. Old growth redwood also lined the long and narrow South Fork valley basin. Douglas fir predominated in central and mid slope locations more distant from the coast.

Further inland in the eastern portion of the watershed, the natural distribution of Douglas fir becomes increasingly fragmented. Here, the long summer drought limits Douglas fir to north facing slopes. The oak-woodland predominates as a more continuous distribution on higher, inland terrain the more distant from the coastal marine influence. Large areas of prairie grassland occupy the driest sites along ridge and upslope locations. These occupy larger continuous areas on the highest and easternmost areas of the watershed.

Fluvial Geomorphology

In response to the 1964 storm, sediment accumulated in many of the upper reaches –the transport reaches. Prior land use, such as in-stream landings and roads, elevated sediment loads. Some of the sediment blocked active channels; the rest become stored outside of the active channel. Subsequently, the accumulated sediment in the active transport channels generally has been dispersed downstream, where its fate is unknown. The rest has been variably vegetated and stabilized but may remain available for remobilization during sufficiently high flows.

Although other recorded peak discharge flood events have exceeded the 1965 water year, data are not readily available for evaluating the relative impact of these individual events on the watershed. An indication of the recent general changes in channel character is being provided in the final DMG report through comparison of reconnaissance mapping from aerial photos taken in the springs of 1984, 1999 and 2000. These maps show that in much of the watershed the length of general channel characteristics indicative of excess sediment (multi-thread channels, numerous lateral bars, eroding banks, etc.) has decreased over the most recent 15 year period.

The Gualala River fluvial system is unique in many ways. In many areas during high flows, tributaries back up and drop sediment at their mouths, which is later incised as flows diminish. This backwater effect was noted in several of the main tributaries and has formed a sediment mound in the active channel. During low flows, stream water percolates though the mound rather than flowing over it. It is unpredictable, at this time, whether future flows will reduce or build these mounds. m

The river persists in transporting and storing sediment even at elevated loads. The residence time of excess sediment accumulated in transport reaches is relatively short (in a geologic sense) and some recovery is apparent over decades. However, excess sediment accumulated in lower depositional reaches is hard to quantify and may remain much longer with only vague evidence of recovery. The Gualala River Watershed was similarly affected by 1964 flood and antecedent logging, and was studied well beyond the scope of this assessment. There, long term channel surveys show sediment delivered during the 1964 flood are still stored in the middle and lower reaches (Oazki and Jones, 1998 and 1999).

Thalweg Surveys

The vertical complexity of the stream channel was measured using thalweg surveys at the GRI GRWC monitoring reaches. GRWC protocols were followed, recoding elevation and distance at every significant change in the streambed through a 1000 foot reach. Elevation was measured with an engineer's level and distance with a 200' tape. Benchmarks and fixed starting and ending points were used to assure that the surveys are comparable from year to year. Area under the thalweg to an arbitrary zero level was calculated to allow accurate comparisons of thalweg elevation between years. Thalweg aggradation or degradation is reported in feet relative to the elevation of the channel in the first year of measurement.

Following a large sediment event, a significant aggradation of the channel (>1') is expected, followed by a slow degradation over the next several years (Madej, 1999). A stable channel is expected to fluctuate a little (< ± 0.5') each year. We have re-measured six thalweg surveys since 1998. No measurement has exceeded ± 0.5' from the original measurement. The thalwegs are fluctuating up and down by a few inches per year. There was a significant event on New Years Day 1997. If it had resulted in lasting channel aggradation, it would be expected that the repeat surveys would show a steady degradation. This has not been the case. Although it has only been four years with no significant stressing events, what has been measured would be consistent with the behavior of a stable channel.

While there are no significant changes in bed elevation at these sites on a year-to-year basis, scouring and redeposition during storm events has not been measured. Such events within any one year can be catastrophic for salmonid embryo survival, destroying or capping redds.

Madej, (1999) suggests using the variation index as a way of quantifying the roughness of a stream and hence its suitability for fish. The variation index is defined as [(standard deviation of residual water depths/bankfull depth) * 100]. A flat wide streambed with sediment filled pools would have a low variation index. A stream with many deep pools interspersed with riffles would have a high variation index. As the streams in the Madej study cleared of flood deposits after major events, the variation index approached or exceeded 20. The extent to which these indices are directly comparable to Gualala River's geology, fluvial network and processes, and hyrdology is not specifically known. However, when the variation index was calculated for the GRI GRWC thalweg survey data using the maximum bankfull depth measured in the DFG 2001 habitat surveys in the Gualala, most of the variation indexes were well above 20.

TABLE 2: VARIATION INDEX

Variation Index of Thalweg Profiles
Watershed Cooperative Monitoring Program
(1998 - 2000)

Watershed	Site Number	Watershed* Size (acres)	Variation Index 1998	1999	2000	2001
North Fork Subbasin						
North Fork	473	30,600				36.8
North Fork	204	25,433		43.6		49.6
Little North Fork	404**	4,217				46.8
Little North Fork	203**	1,963	23.1	20.9	20.9	20.2
Robinson	207	1,068		18.2		
Dry Creek	211	4,104	63.3	57.6	58.8	55.6
Dry Creek	212**	3,756			43.8	
Rockpile Subbasin						
Rockpile Creek	221	22,373	19.0	11.9		
Buckeye Subbasin						
Buckeye Creek	223	25,588			46.4	
Buckeye Creek	231	21,198	53.4			
South Fork Subbasin						
South Fork	217**	157,415	39.1		36.5	33.9
South Fork	402**	31,081		21.0		
Pepperwood Creek	218**	1,825	19.5	17.5		

*Watershed size is calculated as the area above the monitoring site.

**Maximum Bankfull depth estimated from cross-section surveys

Water Quality

The water quality analysis included comparison of available data to water quality objectives from the Basin Plan, Total Maximum Daily Load suggested targets, and EMDS dependency relationships (thresholds) and other ranges and thresholds derived from the literature (Table 1). With the exception of the Basin Plan objectives, these ranges and thresholds are not legal regulatory numbers. Rather, they are based on information available at the time and are expected to change as new data and analyses become available.

The D_{50} ranges are based on a study by Knopp (1993) who measured a variety of instream parameters on a number of North Coast streams. He presented results for a group of 18 watersheds judged to have had no human disturbance history or little disturbance within the last 40 years. The mean D_{50} value of this data set was 69 mm. The minimum measured value was 37 mm, and the maximum was 183 mm. The intent in the analyses in this assessment is to evaluate the available data against Knopp's distribution. It is not the intent to suggest 37 mm as a minimum value independent of other information about the distribution of the data.

The temperature range for "fully suitable conditions" of 50-60 F (10-15.6 C) was developed as an average of the needs of several cold water fish species, including coho salmon and steelhead trout. As such, the range does not represent fully suitable conditions for the most sensitive cold water species (usually considered to be coho).

The lethal maximum temperature of 75 F (23.9 C) was derived from literature reviews presented in RWQCB (2000). Peak temperatures are important to consider as they may reflect short-term thermal extremes that, unless salmonids are able to escape to cool water refugia, may be lethal to fish stocks. The literature supports a critical peak lethal temperature threshold of 75 F, above which death is usually imminent for many Pacific Coast salmonid species (Brett, 1952; Brungs and Jones, 1977; RWQCB, 2000; Sullivan, et al., 2000).

TABLE 3: In-channel criteria used in the assessment of water quality data.

Water Quality Parameter	Range or Threshold	Source of Range or Threshold
PH	6.5-8.5	Basin Plan, p 3-3.00
Dissolved Oxygen	7.0 mg/L	Basin Plan, p 3-3.00
Temperature	No alteration that affects BUs [1]	Basin Plan, p 3-3.00
	No increase above natural > 5 F	Basin Plan, p 3-4.00
	50-60 F MWAT [2] – proposed fully suitable	EMDS proposed Fully Suitable Range [3]
	75 F daily max (lethal)	Cold water fish rearing, RWQCB (2000), p. 37
Sediment Settleable matter	Not to cause nuisance or adversely affect BUs	Basin Plan, p 3-2.00
Suspended load	Not to cause nuisance or adversely affect BUs	Basin Plan, p 3-2.00, 3-3.00
Turbidity	no more than 20 percent increase above natural occurring background levels	Basin Plan, p 3-3.00
Percent fines <0.85 mm	<14% in fish-bearing streams [4]	Gualala TSD, CRWQCB (2001)
Percent fines <6.4 mm	<30% in fish-bearing streams	Gualala TSD, CRWQCB (2001)
V* in 3rd order streams with slopes 1-4 % [5]	≤0.15 (mean) <0.45 (max)	Gualala TSD, CRWQCB (2001)
Median particle size (d_{50}) in 3rd order streams of slopes 1-4 %	>69mm (mean) >37mm (min)	Knopp (1993)

[1] BUs = Basin Plan beneficial uses
[2] MWAT=maximum average weekly temperature, to be compared to a 7-day moving average of daily average temperature
[3] EMDS = Ecological Management Decision Support model used as a tool in the fisheries limiting factors analysis. These ranges and thresholds were derived from the literature and agreed upon by a panel of NCWAP experts.

[4] fish-bearing streams=streams with cold water fish species
[6] CDFG=Calif. Department of Fish and Game habitat threshold

The data we compared to these ranges and thresholds from a water quality perspective were:

- Continuous water temperature data from data loggers
- Percent fines < 0.85 mm from McNeil samples
- D_{50} from pebble counts
- Dissolved oxygen, pH, conductance (dissolved solids), nutrients (nitrogen, phosphorus)

Turbidity and suspended solids data were not available for this assessment, and represent a limitation in the water quality part of the assessment. The data and summary plots are included in Appendix 9.

USEPA data from April of 1974 to June of 1988 indicate a moderately hard water oligotrophic stream with pH slightly above neutral, high dissolved oxygen, low dissolved solids, and low nutrients (nitrogen and phosphorus). RWQCB results from 2001 do not differ. There were no large differences among the stations, though South Fork pH and hardness values were somewhat higher than in the rest of the Gualala.

Water temperature is a limiting factor for most of the mainstem areas, and some tributaries. Water temperatures are expressed as the highest of the floating weekly average for the summer (MWAT). Those values were within the proposed “fully suitable” range of 50-60 F in many tributaries in the North Fork subbasin, and in some other small tributaries in other subbasins. Mainstem water temperatures for the larger streams (North Fork, Rockpile, Buckeye, Wheatfield Fork, and South Fork/Main Gualala) were above that range. More relationships by subbasin are provided in subsequent sections of this report.

Streambed substrate size is likely a limiting factor for salmonids. While streambed particle sizes (D_{50}) from 1997-2000 data provided by GRI and GRWC showed some improvements over time in some tributaries, D_{50} values were small in the remaining locations. It is well documented that small streambed particle sizes (gravel and lower) make for a more mobile streambed. Mobile streambeds can reduce salmonid embryo survival by destroying and/or capping the redds (Nawa et al., 1990). Smaller particles can smother salmonid embryos, especially those 6.5 mm and less in diameter (Bjornn, et al 1976).

Aquatic/Riparian Condition

Historic conditions for aquatic habitat in the Gualala River can only be inferred from fragmentary information in CDFG stream surveys from the 1960s and from historic aerial photo reconnaissance of canopy conditions. The stream surveys which are most useful are those that immediately followed World War II, and they revealed comparatively higher pool frequency and depth, and longer reaches of suitable spawning gravels. Post 1950s and 1960s era logging surveys documented a shallow pool structure, reduced pool frequency and water quality problems related to logging debris deposited into streams. Current habitat inventories showed shallower pool structure and reduced frequency on most of the tributaries surveyed throughout the watershed.

Canopy cover was complete in most tributaries as of 1942 indicating advanced regeneration from original old growth logging. Streams in the eastern portion of the Gualala basin had a naturally more open canopy even in 1942 photos. Aerial photos from 1961, 1965, and 1981 showed canopy closure substantially reduced. As of 2001, canopy cover measurements taken during habitat typing surveys show improving canopy closure. Aerial photos from 1999 substantiate these findings. Large wood is deficient in many areas of the Gualala River basin as a result of past timber harvest operations and large wood removal projects aimed at improving fish passage.

Stream buffers are important to the protection of fish habitat for several reasons. With respect to stream temperature, dense trees immediately along a stream provide shade from direct sunshine on the stream surface. Stream buffers with dense canopy also help to reduce air temperature, thus reducing convective heat inputs to streams; however, scientific investigations are still uncertain as to how wide and dense buffers need to be to adequately provide for this microclimate effect.

TABLE 4: Gualala Tributaries Surveyed 2001

Tributary Name	DFG Surveyed length (miles)	Length (Miles)	
		Permanent	Intermittent
Buckeye Creek	18.9	16.0	2.8
Danfield Creek	2.3	4.3	0.0
Doty Creek	1.2	2.7	0.0
Dry Creek	2.1	0.9	0.6
Dry Creek Trib. #1	0.5	0.0	2.9
Haupt Creek	0.4	4.8	0.9
House Creek	10.4	11.8	1.5
Little N. Fork Gualala	3.9	4.1	0.0
Little N. Fork Gualala Trib. 2	1.0	0.0	1.3
Log Cabin Creek	0.3	1.3	0.0
Marshall Creek	4.1	8.3	0.0
McGann Gulch	0.4	0.0	2.0
North Fork Gualala	11.3	13.6	0.0
Palmer Creek	0.1	0.0	1.3
Pepperwood Creek	3.4	3.7	1.1
Robinson Creek	1.5	0.8	1.6
Rockpile Creek	8.5	21.3	0.9
South Fork Gualala	1.6	35.7	0.6
Tombs Creek	7.1	8.5	0.0
Wheatfield Fork Gualala	22.1	28.8	2.6
TOTALS	**101.2**	**166.6**	**20.1**

ADD GIS-based HABITAT FIGURES HERE

Fish Habitat Relationship

Coho and steelhead utilize an anadromous life history strategy. The term anadromous refers fish that spawn in freshwater and migrate to the ocean to grow and mature before returning to freshwater streams to spawn. Anadromous salmonids have diverse life history strategies in order to reduce competition between species and also to increases the odds for survival of species encountering a wide range of environmental conditions in both the freshwater and marine environments. A summary of the life history strategies, and historic and current status the anadromous salmonid population of Gualala River is provided below. Further details are provided in each subbasin discussion. A detailed account of coho salmon and steelhead and life histories is presented in Appendix X.

The Gualala River historically has been an important stream for its runs of coho (silver) salmon and steelhead. Historical records document large coho and steelhead populations. A 1970's U.S. Bureau of Reclamation study of northern California estimated that 75 miles of habitat was available to coho salmon in the Gualala Basin and that 4,000 adults returned annually (U.S. BOR, 1974). The CDFG reported 16,000 steelhead, 4,000 coho and zero Chinook (California Department of Fish and Game, 1965). However, according to anecdotal information provided by anglers, "stray" chinook salmon inhabited low gradient reaches of the mainstem and larger tributaries

Coho were known to spawn and rear in 14 tributaries, but began to decline by the late 1960's and few were observed in the 1970's stream surveys. Cox (1994) reported that coho were known to have spawned and reared in the North Fork, Buckeye, Wheatfield Fork and South Fork subbasins, including the following areas: lower to middle reaches of the North Fork and Little North Fork, the middle reaches of Buckeye Creek, including Franchini Creek, the middle reaches of Wheatfield Fork, the larger Wheatfield Fork tributaries including Haupt, House, and Fuller Creeks, and Marshall and Sproule Creeks in the South Fork. Steelhead were found to be the most abundant species in a fish community composed of coho, roach, stickleback, sculpins and lampreys. DFG stocked the North Fork subbasin several times to increase coho spawning stock. The last recorded coho young-of the-year was in Dry Creek in 1998.

Surveys from the 1960's and 1970's found salmonids in considerably higher numbers and in a larger geographic area in the watershed. Due to a lack of quantitative information, historical population estimates of anadromous salmonids are unknown. However, based on anecdotal information, amount of historical and current suitable habitat, qualitative assessments, and comparisons with other north coast streams, it is highly probable that populations have declined compared to historical numbers throughout the watershed.

The 2001 electrofishing surveys showed that coho salmon were not observed in their historic tributaries and steelhead one year and older may have decreased in some tributaries in the watershed. Overall the watershed appears to be dominated by roach and steelhead young-of-the-year, with steelhead one year and older present, but in smaller numbers.

ADD FIGURES: BASIN HISTORIC AND CURRENT DISTRIBUTION

In 2001, the following tributaries were electrofished to identify species composition: North Fork; Little North Fork; Doty; Franchini; Wheatfield; House; Haupt; Pepperwood; and Tombs Creeks. Data indicated that differences in fish community structure exist between subbasins. The North Fork Basin was dominated by sculpin, roach and steelhead young of the year. Fish data was unavailable for the Rockpile subbasin. The Buckeye subbasin showed that Franchini Creek was dominated by steelhead one year and older in the middle and upper reaches with steelhead young-of the-year present. The Wheatfield subbasin was dominated by roach with few steelhead one year and older present. Very little of the South Fork was available to survey due to the lack of landowner access. Steelhead young of the year were dominant in the two reaches that were sampled. Further research and improved sampling strategies would greatly benefit stock assessment efforts.

ADD FIGURES: BASIN HISTORIC AND CURRENT DISTRIBUTION FROM EFISHING

TABLE 5: Fishery Resources of Gualala River

COMMON NAME	SCIENTIFIC NAME
ANADROMOUS	
Coho Salmon	*Oncorhynchus kisutch*
Steelhead Trout	*Oncorhynchus mykiss*
Pacific Lamprey	*Lampetra tridentata*
FRESHWATER	
Coastrange Sculpin	*Cottus aluticus*
Prickly Sculpin	*Cottus asper*
Threespine Stickleback	*Gasterosteus aculeatus*
MARINE OR ESTUARINEDEPENDENT	
Surf Smelt	*Hypomesus pretiosus*
Shiner Surfperch	*Cymatogaster aggregate*
Staghorn Sculpin	*Leptocottus armatus*
Starry Flounder	*Platicthys stellatus*
AMPHIBIANS	
Pacific giant salamander	*Dicamptodon tenebrosus*
Tailed Frog	*Ascaphus truei*
Red-Legged Frog	*Rana aurora*
Foothill Yellow-legged Frog	*Rana boylei*

Anadromous Salmonid Natural History

Steelhead

Steelhead trout are an anadromous strain of rainbow trout that migrate to sea and return to inland rivers as adults to spawn. In contrast to all Pacific salmon, not all steelhead die after spawning. U.S Fish and Wildlife service stated that a run of approximately 10,000 steelhead occurred in Gualala River in 1960 (USFW 1960). This is an uncertain estimate, for it was contrived from data relating to other streams of similar size and characteristics which were then applied to Gualala River. It is unknown if the Gualala River support different stocks of steelhead. Local fishermen remember three different stocks: winter run, “bluebacks” or “half-pounders”.

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

In the Gualala River watershed, steelhead were the only species of salmonids observed in 2001 electrofishing surveys. All streams surveyed in the watershed contained steelhead populations of various concentrations (Brown 1988; DFG surveys 2001). Young of the year steelhead were the dominant age class found.

Steelhead numbers have diminished from historic numbers, whereas coho were not observed anywhere in the subbasin. The ability of steelhead to persist may be attributed to their ability to inhabit stream conditions that are available in many of the tributaries of Gualala River. These tributaries have steep gradients, migration barriers, lack of channel complexity, and exhibit higher water temperatures that limit production of coho salmon. Steelhead have displayed more adaptability to these conditions.

Coho Salmon

California coho salmon (*Oncorhynchus kisutch),* also known as silver salmon, are listed as threatened under the Federal Endangered Species Act (ESA; NMFS 1995). This listing has come as a response to the declining numbers throughout their southern range. A 1995 estimate stated that less than 5,000 wild coho salmon (no hatchery influence) spawned in California each year (Moyle et. al 1995). This is a drastic decline from statewide estimates in the 1940's, which assumed there was anywhere from 200,000 to one million adult coho in California (Calif. Advisory Committee on Salmon and Steelhead Trout 1988). Essentially, coho populations are less than 6% of what they were in the 1940's.

Coho salmon exhibit a three-year life cycle and do not appear to have the genetically distinct and spatially separated runs that other salmon and steelhead trout have displayed. After spending two years in the ocean, coho return to spawn in late fall and early winter following seasonally significant rains. As with other species of salmon, coho die after spawning. Unlike other salmon species, coho salmon redds can be situated in substrates composed up to 10% fines (Emmett, et al, 1991), but typically spawning success and fry survival are favored by very clean gravel consisting of less then 5% fines (CDFG 1991).

Juvenile coho typically spend one year in the freshwater streams before migrating out to the ocean. Consequently, adequate cover, cool water, high canopy density, and sufficient food to sustain them through their fry and juvenile stages become critical habitat components. Specifically, secondary channel habitats, such as cool, backwater pools with a large woody debris cover, are highly preferred habitat conditions for developing juvenile coho salmonids (CDFG 1991).

The Gualala River watershed, like other systems in California, have suffered declines or absent populations of coho. Coho were estimated to have a run of _____ spawners in 1960 (U.S. Fish and Wildlife 1960).

Fish History and Status

Fishing Interests, Constituents

In progress

Fish Restrictions, Acts, Protections

In progress

Fish Restoration Programs

In progress

Special Status Species

In progress

Ecological Management Decision Support (EMDS)

Introduction

This report is intended to be useful to landowners, watershed groups, and individuals to help guide land use and management decisions. As noted above, the assessment operates on multiple scales ranging from the detailed and specific stream reach level to the very general basin level scale. In the Gualala, for example, there is a general problem with elevated amounts of fine-grained sediment in lower gradient stream channels. These are reaches used by coho salmon and steelhead trout. This sediment is generally harmful to salmonid habitat as discussed above, and developed in the following discussion about the EMDS model.

This condition is not uncommon throughout most of the overall NCWAP coastal region. To improve that condition, and therefore salmonid habitat, will require long periods of time even with reduced levels of erosion brought about by careful watershed stewardship. A goal of this program is to help guide, and therefore accelerate that recovery, by focusing, stewardship and improvement activities where they will be most effective. Scaling down through finer levels guided by the recommendations should help accomplish this focus.

To do so, the report is constructed to help provide that focus of energy and other resources. A user can focus down from the general basin finding and recommendation concerning high sediment levels to the various subbasin sections, or the summary subbasin recommendation table to see if the general recommendation is applicable to a subbasin of interest. From there, if that is the case, the next step is to determine which streams in the subbasin may be affected by sediment. There is a list of surveyed streams in each subbasin section. In the general recommendation section, there is a tributary finding and recommendation summary table that indicates the findings and recommendations for the surveyed streams within the subbasin. From there, if indicated, field investigations at the stream reach or project site can be conducted to make an informed decision on a project, or design improvement activities.

For example in the Gualala Wheatfield fork Subbasin, sediment is an issue in the findings and recommendations. From the list of tributaries in the subbasin section the tributary table can be referred. House Creek is a Wheatfield fork Subbasin stream on that list that has both streambank and road sourced erosion as issues for treatment related to land use projects or improvement activities.

During the past two years, numerous landowners gave permission for erosion control surveys to be conducted on their lands in cooperation with the Gualala River Watershed Council and the DFG Restoration Grants Program based upon the recommendation in this DFG Stream Report. NCWAP, through its EMDS tool and resultant spatial presentation of its findings will provide the opportunity to conduct better coordinated stewardship and restoration work like this at the much broader, basin scale.

A NCWAP Tool for Data Synthesis

As part of the watershed assessment, the NCWAP team is using computer models called knowledge base or expert systems. These are tools that help scientists define how a complicated ecosystem, such as a watershed, functions. The software allows scientists to combine data of different environmental factors, such as stream temperature and substrate composition, to produce a synthesis of watershed conditions for native salmonids. The tools provide a consistent and repeatable approach to evaluating conditions across numerous watersheds in the region. The knowledge base modeling software requires scientists to identify and evaluate specific environmental factors or attributes which contribute to the formation of anadromous salmonid habitats.

For this purpose, the NCWAP will employ a linked set of software: NetWeaver, Ecological Management Decision Support (EMDS) and ArcView™. NetWeaver (Saunders and Miller (no date)), developed at Pennsylvania State University, helps scientists build graphics of networks that specify how the various environmental factors are incorporated into an overall stream or watershed assessment. These networks resemble branching tree-like flow charts, and graphically show the logic and assumptions used in the synthesis.

EMDS (Reynolds 1999), was developed by Dr. Keith Reynolds at the USDA-Forest Service, Pacific Northwest Research Station. It uses the networks created with NetWeaver in conjunction with environmental data stored in a geographic information system (ArcView™) to perform the assessments and facilitate rendering the results into maps. This combination of NetWeaver/EMDS/ArcView software is currently being used for watershed assessment within the federal lands included in the Northwest Forest Plan.

The Knowledge Base Network

For California's north coastal watersheds, the NCWAP scientists built two knowledge base networks using the best available scientific studies and information on how various environmental factors combine to affect anadromous fish on the north coast. The first, called the Stream Reach model, addresses conditions for salmon on individual stream reaches. The second, the Watershed Condition model, serves as a framework for synthesis by watershed of a number of environmental factors. In creating both of these networks, the NCWAP scientists have used what is termed a 'top-down' approach.

This is perhaps best explained by way of example. The NCWAP scientists start from the proposition that the overall condition of a given watershed is suitable for maintaining healthy populations of native salmon and trout, and through the design of the knowledge base (the network) seek to evaluate the 'truth' of that assertion. They then constructed a knowledge base network is to specify the types of information needed to test the proposition, and how each will be used.

The 'ingredients', or data, needed for the assessment are broken down into categories. To evaluate watershed conditions for salmonids, the scientists specified that data are required on several general environmental factors. The knowledge base network (figure 1) shows that information on upland condition, roads, passage barriers, and stream condition factors are all needed in the watershed assessment. The 'AND' decision node (where the factors are combined) means that each of the four general factors must be suitable for the fish for the 'watershed is suitable for native salmonids' proposition to be evaluated as completely 'true'.

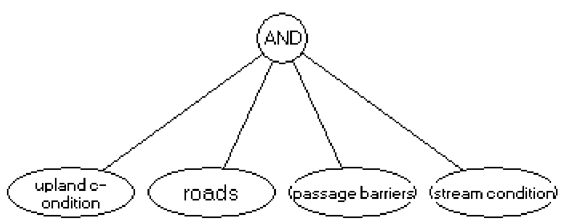


FIGURE 5

The Knowledge Base is for Assessing Watershed Conditions for Native Salmonids. Each of the Elliptical Boxes Shows a Factor Used in the Assessment and Lines Indicate How They are Linked to the "AND" Node Where They are Compared.

In a similar manner, each of the four main environmental factor is actually made up of smaller constituent components. For example, in the NCWAP Watershed Condition model the 'upland condition' factor consists of a sub-network of more detailed data on land use, land cover (vegetation) and slope stability that determine it (not shown in the above figure). Information in the sub-network that determines land use includes data on developed area, cultivated area, grazed area and area of timber harvests. In knowledge bases, this pattern of logic networks can be expanded up or down as much as desired, until there is a full picture of all factors affecting salmonid conditions in the watershed. The beginning boxes (end branches) in a knowledge base network are where the data is entered.

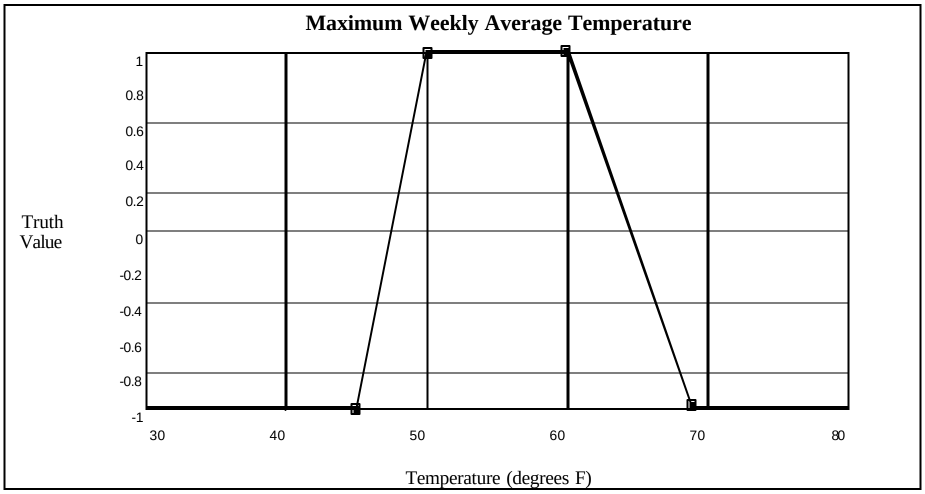


FIGURE 6: Relationship between Water Temperature and Suitability for Salmon

EMDS Uses this Type of Function in Conjunction with Data to Evaluate a Proposition, in this Case that "Water Temperature is Suitable for Native Salmon and Trout."

Wherever there is a proposition in the network, scientists use simple graphs that determine its degree of truth, according to the data and its implications for salmon. Figure 2 shows an example, where the proposition is “the stream temperature is suitable for salmon”. The horizontal axis shows temperature in degrees Fahrenheit, while the vertical is labeled ‘Truth Value’ and ranges from –1 to +1. The line shows what are completely unsuitable temperatures (-1), completely suitable temperatures (+1) and those that are in-between (> -1 and <+1). In this way, similar graphic relations are created for all propositions in the EMDS evaluation.

For all evaluated propositions in the network, the results are a number between –1 and +1. The number shows the degree to which the data support or refute the ‘conditions are suitable’ proposition. In all cases a value of +1 means that the proposition is ‘completely true’, and –1 implies that it is ‘completely false’, with in-between values indicate ‘degrees of truth’ (i.e. values approaching +1 being closer to true and those approaching –1 converging on completely untrue). A zero value means that the proposition cannot be evaluated based upon the data available. Breakpoints (where slope of function changes) in the figure 2 example occur at 45, 50, 60 and 68 degrees F. The NCWAP fisheries biologists determined these temperatures by a search of the scientific literature.

In EMDS, the data that is fed to the knowledge base network comes from GIS layers stored and displayed in ArcView. Thus many of the GIS data layers developed for the program will be used directly in the watershed condition syntheses.

Advantages Offered By Netweaver/EMDS/ArcView Software

The NetWeaver/EMDS/ArcView software offers a number of advantages for use in the NCWAP. At this time no other widely available package allows a knowledge base network to be linked directly with a geographic information system such as ArcView. This link is vital to the production of maps and other graphics reporting the watershed assessments.

The graphs and NetWeaver-based flow diagrams required that the NCWAP scientists be forthright and explicit in how they have defined suitable conditions for salmonids needed for the completion of their lifecycle. The process was thus formalized and quantified, and is now repeatable systematically throughout the assessments of all watersheds. Equally important, the nature of the networks assists open communication to the general public through simple graphics and easily understood flow diagrams.

Another feature of the system is the ease of running alternative scenarios. Scientists and others can test the sensitivity of the assessments (i.e. perform ‘sensitivity analyses’) to different assumptions about the environmental factors and how they interact, through changing the knowledge-based network and breakpoints. ‘What-if’ scenarios can be run by changing the shapes of curves (e.g. figure 2) at the base level, or by changing the way the data are combined and synthesized in the network.

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

NetWeaver ranks the environmental factors (given the logic and environmental factors <-> conditions relationships) by their influence on the overall habitat indicator values derived. They also show which factors, with more complete and comprehensive data, would improve the quality of the analysis in the most cost-effective manner.

EMDS and NetWeaver are public domain software (NetWeaver on a trial basis), available to anyone at no cost over the Internet. Although the NCWAP will employ EMDS and NetWeaver for watershed synthesis, this is not meant to preclude the use of other knowledge base expert systems, approaches, or models for further exploration of fish-environment relationships.

Management applications of watershed synthesis results

While EMDS-based syntheses are important tools for watershed assessment, they do not by themselves yield a course of action for management. EMDS results will require interpretation, and how they are employed depends upon other important issues, such as social and economic concerns. In addition to the accuracy of the expert opinion and knowledge base system constructed, the currency and completeness of the data available for a stream or watershed will strongly influence the degree of confidence in the results.

The output from EMDS Watershed and Stream Reach models will be used to support several levels of planning. At the regional level, the State anticipates the NCWAP analyses to be incorporated into coho, chinook, and steelhead recovery plans being developed by National Marine Fisheries Service (NMFS). It will provide a finer level of detail than factors identified at the Evolutionary Significant Unit (ESU) or domain level. This can assist recovery plan development, to focus on appropriate conditions and potential corrective actions by landowners and others. The results of the synthesis will also aid watershed level planning by watershed groups and others. It can provide direction for developing a strategy and sequence for fixing habitat “bottlenecks” to salmonid production or health.

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

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

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

EMDS in the Gualala River Assessment

Note to the reader: The final EMDS model was analyzed for the Northfork subasin. The other subbasins will be addressed in the next version of the synthesis report. The results are contained in the appendix.

Analyses and Results by Subbasin

Gualala Basins: Estuary, Northfork, Rockpile, Buckeye, Wheatfield, Main/Southfork

Introduction

For the purpose of the NCWAP study of Gualala River watershed, the basin is divided into five subbasins. The five subbasins conform with Calwater 2.2 Planning Watershed boundaries. Data analysis and subsequent synthesis was by subbasin, providing detail on a smaller scale. More detailed information is included in Appendices. Table 6 provides a subbasin summary table.

TABLE 6: Gualala Subbasin Summary.

Subbasin	Northfork	Rockpile	Buckeye	Wheatfield Ffork	Mainstem Southfork	Total
Square Miles	47.86	34.98		40.26	47.86	
Acreage, Total						
Private Acres	99%	100%	99%	99%	100%	
Federal Acres	0	0	0	0	0	
State Acres	0	0	0	0	0	
Principal Communities	Gualala	Gualala	Gualala	Annapolis	Cazadero	
Predominant Land Use	Timber Grazing Subdivision	Timber Grazing	Timber Grazing Agriculture	Timber Grazing Agriculture	Timber Grazing Agriculture	
Predominant Vegetation Type	Coniferous Deciduous					
Miles of Blue Line Stream						
Low Elevation						
High Elevation						

Gualala Estuary

Introduction

The Gualala River estuary/lagoon is located approximately 0.5 miles south of the town of Gualala. Estuaries are links between freshwater and marine environments where mixing of sea water and freshwater creates environmental conditions that are well suited for the anadromous life history life strategy used by salmon, steelhead, and cutthroat trout. These fish pass through the estuary during seaward migrations as juveniles and as adults, gain access though the estuary to the freshwater during spawning migrations. The brackish water of the estuary provides an important area where salmonids can acclimate to changes in salinity as they move between the freshwater and marine environments. In addition, the mixing of seawater and freshwater that occurs in the estuary helps create a very productive environment for fish. Because of their high productivity and isolation from predators, estuaries are considered important nursery areas for juvenile fish including salmon, steelhead, and coast cutthroat trout. During summer months, a sand bar typically forms across the mouth of the estuary that blocks the flow of tidewater and creates a coastal lagoon.

The Sotoyome Resource Conservation District, in partnership with the Gualala River Watershed Council, has been awarded a $150,000 grant by the California Coastal Conservancy to perform a Gualala estuary assessment and to develop an estuary enhancement plan. The goal of the assessment is to thoroughly assess the physical and biological conditions of the estuary and lower river, ascertain the estuary's importance to the life history pattern of salmonids, and determine how existing conditions may be impairing ecological productivity in the project area. The key questions to be answered are: *What is the role of the Gualala River Estuary with respect to salmonid abundance and distribution, as habitat for steelhead and coho salmon?* And second, *What factors may be limiting salmon and steelhead production in the estuary?*

Following this assessment, and based upon the findings of the assessment, an enhancement plan will be developed which will provide specific recommendations for the enhancement of the lower Gualala River and estuary.

Geology

In progress.

Vegetation

The riparian was probably alder with a redwood over story along the upper estuary (above the bridge). But most photos of the lower estuary are after the mill (on the flat area north and ocean side of the bridge) was built so we can't tell if that area was cleared or naturally scrub. Wetlands are primarily on the lower south side of the estuary.

Land Use

Early Land Use

Native Americans made extensive use of the Gualala River. Pomo villages and seasonal campsites were located throughout all of the Gualala River sub basins. Areas most frequently settled were "alongside river or creek banks, in sunny meadow clearings (Park, 1980). The forests contained abundant wildlife and salmon were available seasonally. Fire was used by the native americans as a land management tool. Forests were routinely burned to reduce the fuel loading as an aid to hunting and to urge new vegetation growth.

The Kashia Pomo occupied about 30 miles of the coast of northwest Sonoma County and extended inland for 13-15 miles (Bean and Theodoratus, 1978). This territory encompassed the Wheatfield Fork sub basin and the South Fork sub basin from its headwaters to the Wheatfield Fork. Bordering the Kashia to the north were the Yokiya of Rockpile. The Yokiya inhabited a " rough strip of land about eight miles in width along the coast, and possibly 18 miles inland" (Park, 1980). The Yokiya region appears to include both the Buckeye and Rockpile sub basins.

A third group of Native Americans that inhabited the watershed were the Bokeya Pomo. Lands of the Bokeya extended from the Gualala River to just north of the Navarro River. The Bokeya occupied the North Fork sub basin with villages and campsites at the headwaters of the North Fork and settlements at the coast near the mouth of the Gualala River.

Fish History and Status

The Gualala estuary/lagoon provides critical habitat in the life cycle of anadromous salmonids and many other valuable fishery resources. Estuaries are the nexus between freshwater and marine environments which anadromous salmonids pass through as juveniles during seaward migrations and where adults gain access to their natal rivers during spawning migrations. Estuaries are recognized as valuable salmonid nursery areas because they provide abundant food supplies, they offer protection from predators, and are diverse habitat areas. Several fish species, have adopted an estuarine residency, particularly for reproduction and early stages of their life cycle. Some species deposit eggs or give live birth directly in estuaries, while others have evolved mechanisms which help the delivery of their young into estuaries by ocean tides or riverine currents. Fish including salmonids that utilize estuaries for an important part of their life cycle are referred to as estuarine-dependant. The estuarine rearing is a strategy that adds diversity to juvenile salmonid life history patterns and likely increases the odds for survival of a species encountering a wide range of environmental conditions in both the freshwater and marine environments. 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. An Account of the Fishes Caught in the Lower Gualala River, California, 1984 through 1986 – Charles Brown Bay Delta Fisheries Project:

Subbasin	Northfork	Rockpile	Buckeye	Wheatfield Ffork	Mainstem Southfork	Total
Current Fish Species	steelhead pacific lamprey prickly sculpin coastrange sculpin roach 3 spine stickleback	steelhead roach pacific lamprey prickly sculpin coastrange sculpin 3 spine stickleback	steelhead roach pacific lamprey coastrange sculpin	steelhead roach pacific lamprey	steelhead roach pacific lamprey	steelhead roach pacific lamprey prickly sculpin coastrange sculpin 3 spine stickleback

Sampling occurred at seven stations, two upstream of the Highway 1 bridge. “We caught seven species of fishes in the Gualala Estuary and lower river. Steelhead were caught at all stations. Roach, coastrange and prickly sculpin were caught at lower river and upper estuary stations. Starry flounder and Pacific staghorn sculpin were only caught in the lower estuary near the ocean. Threespine stickleback were caught in the lower river and upper to mid-estuary”. “Steelhead were larger in the fall than in the spring at mid-estuary stations, but larger in the spring at lower estuary stations”.

Currently, the Gualala River Watershed Council has a grant for a two year study. The main stem tidal influence ending point is being identified and the study site includes up to the confluence of the NF.

The bar at the bridge appears to be increasing along with increased island formations around the old mill pier structures. Mendocino county has been doing cross-sections surveys at the bridge and Gualala Aggregates has cross-sections installed upstream of the bridge.

Fish Habitat Relationship

The present condition of the Gualala estuary/lagoon has limited the biological function and therefore production of salmonids. Over the past 100 years, the construction and operation of a mill in the 1860s to the early 1900s, railroad and road development within the flood plane, a Highway Bridge and artificial breeching of the bar have modified the physical structure of the estuary. The need for artificial breeching may have been due to both changes in the ocean currents and weather patterns and excessive sediment accumulations from naturally occurring geology and land use activities. Excessive sediment accumulation has probably reduced the size of the estuary and wetland areas, reduced the tidal prism, and altered drainage patterns all which impair the physical function and the ability of the estuary/lagoon to fully support salmonids.

Subbasin Issues

The term ‘issues” is used here in a generic sense to denote any topic of interest, concern, import, or relevance to the watershed assessment. As such, issues can be direct limitations on salmonid suitability, potential factors for consideration, concerns regarding potential practices, suggestions, or observations of the data that are particularly relevant to the development of hypotheses and recommendations.

Subbasin Issue Synthesis and Recommendations

Working Hypothesis: ***The present state of estuarine habitat is limiting the production of salmonids in Gualala River.***

Supporting Findings:

In progress.

Contrary Findings:

None noted.

Recommendations:

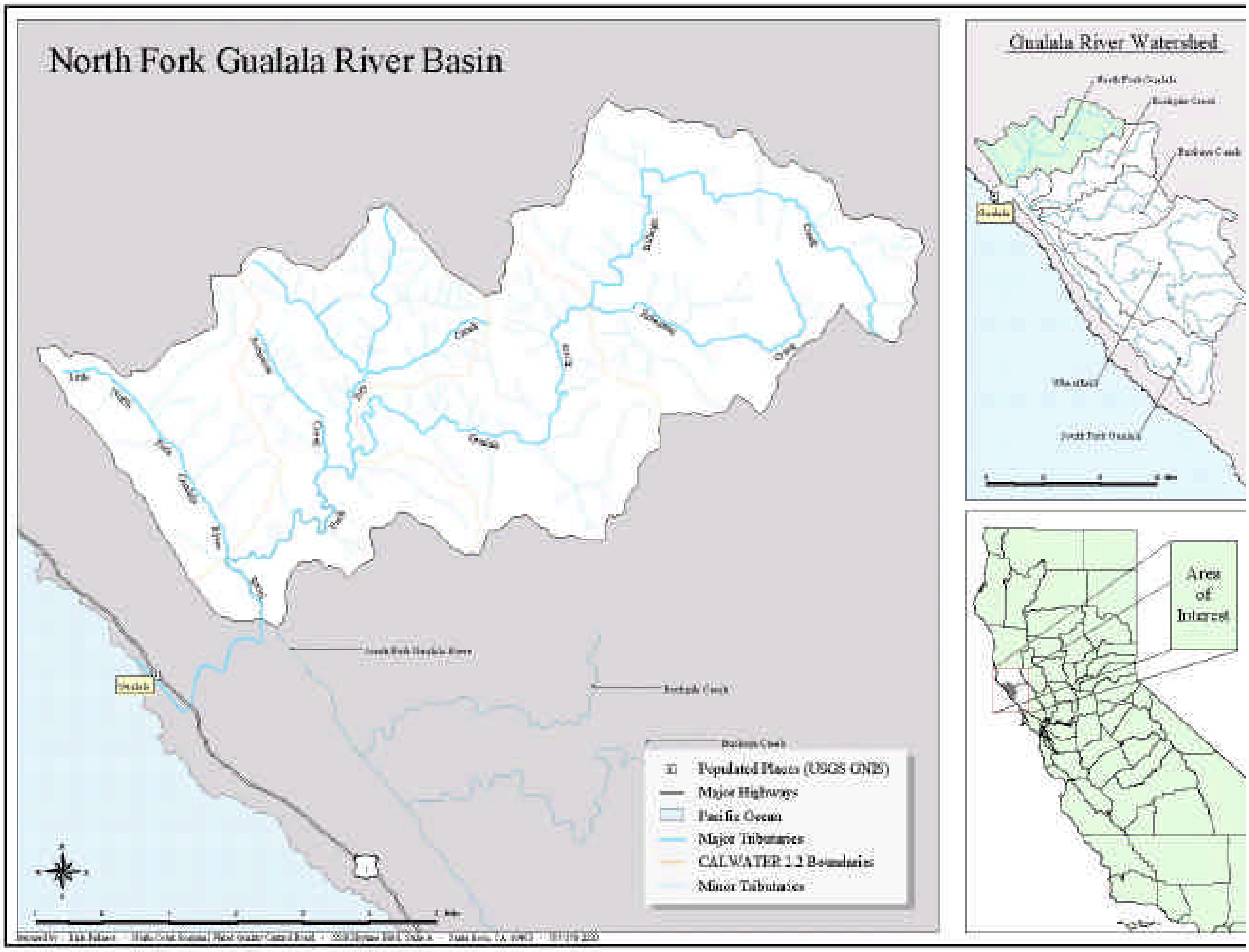
- Encourage present estuary assessment program and provide technical assistance when necessary.
- Develop long term temperature monitoring program.
- Continue and/or expand monitoring anadromous salmonid population efforts.
- Work with responsible agencies, the Gualala River Watershed Council and landowners to improve physical structure and biologic function of the estuary.
- Continue efforts such as road improvements and decommissioning throughout the basin to reduce sediment delivery to Gualala River and its tributaries.
- Ensure that adequate streamside protection zones are used to reduce solar radiation and moderate air temperatures in order to reduce heat inputs to Gualala River and its tributaries. Where current canopy is inadequate and site conditions are appropriate, use tree planting and other vegetation management techniques to hasten the development of denser and more extensive riparian canopy.

Northfork Subbasin

Introduction

The North fork subbasin is under management by the Pioneer Ltd., Mendocino Redwood Co., Gualala Redwoods Inc., and other smaller private landowners. The land is primarily used for timber production, grazing, small vineyards and rural 40 acre and larger subdivisions.

FIGURE 7: North Fork Gualala River Basin



Geology

The steepest topography and broadest tributary valleys are found in the North Fork basin (Plate 1). The area is characterized by rectilinear, low ordered drainages underlain by the Coastal Belt of the Franciscan Formation. Preliminary interpretations suggest that this part of the Gualala watershed was uplifted more recently than the remainder. A series of NW trending strike-slip faults have offset drainages in a uniform manner. Although the formation of this region created steep slopes, the area is relatively more stable and coherent compared to the rest of the watershed. Steep, V-shaped, narrow, rectilinear, fault controlled valleys characterize the upper reaches of the basin. A parallel network of faults creates a stream network with a simple zigzag pattern consisting of a high density of short, closely spaced drainages. Rosgen classes range from A++ to B types. Type A channels are characterized by "inherent channel sternness, high sediment transport potential, and relatively low in channel sediment storage capacity". In eastern half of the NF basin, Central Belt mélange underlies prairies. Large areas of active earthflows and other forms of landsliding are abundant and contribute sediment to watercourse. The steep drainage gradients in the upper reaches can be generally characterized as supply (>12%) or transport (4-12%) reach categories.

In lower reaches of the basin, streams generally meander through alluviated valleys that range from a couple hundred feet to almost one thousand feet across within steep, U-shaped valleys. Streams in this area are characterized by "C" type Rosgen with "sinuous, low level relief, well developed flood plains built by the river, and characteristic point bars within the active channel". Continual sediment deposition and storage in these reaches probably dates back millennia or more. The valley floors broaden downstream toward the San Andreas Fault.

There is an abrupt steepening of stream grade where the river enters the San Andreas Fault Zone. An anomalous mound of sediment has formed immediately upstream of the confluence with the Little North Fork as is common in many areas. This sediment accumulation may be related to deposition caused by the slowing of the North Fork as it merges with flows of the Little North Fork. This frequently observed situation is informally known as a "back water effect". The active channel of the North Fork has incised into the mound of sediment, leaving much of the sediment stored on the flood plain.

Vegetation and Land Use

The North Fork subbasin has the longest span of past land use practices in the watershed. The redwood dominated alluvial flats were clear-cut around the turn of the century. During the logging of the 50s and 60s, these areas were considered pre-merchantable young growth. In the purchase discussions for GRI in 1948, the second growth redwood was given zero value. These stands have mostly been selectively cut two times since the original turn of the century clear-cut. Aerial photos from 1936 show these areas area forested with predominantly mid-sized second growth redwood with no active road network. The 1936 shade canopy cover map (Figure 6 below) shows bank to bank exposure limited to the lower basins alluvial floodplains. At this time, the channel was naturally aggraded and wide, preventing dense wooded conifer growth adjacent to the stream channel. Upstream of the confluence with Dry Creek, topography is narrowly incised with conifer canopy entirely covering the main stem North Fork until one reaches the melange, which is largely non-coniferous and lacking in canopy. There was entire bank to bank cover over all tributary watercourses in the middle and lower North Fork basin, including Stewart Creek, Dry Creek, Robinson Creek, and Doty Creek.

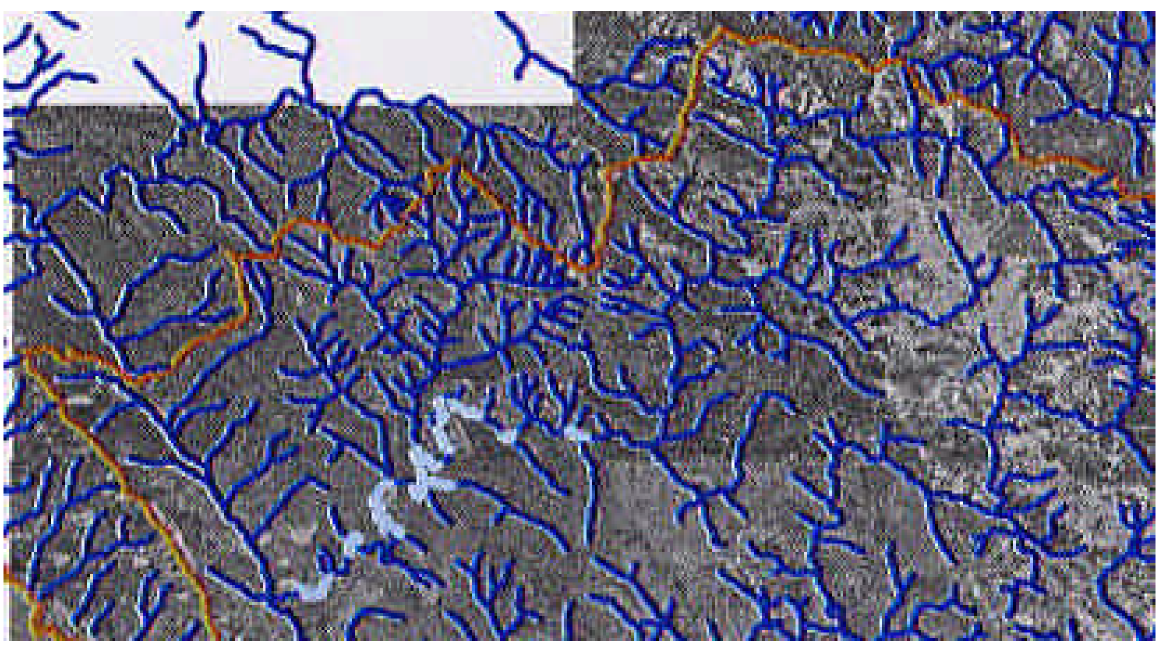


FIGURE 8: 1936 Bank to Bank stream shade canopy exposure (light blue)

Logging operations accelerated during the mid-1950s in inland Douglas fir dominated areas in the middle to upper reaches of the basin. Road construction was built running adjacent to the main stream channel of all primary tributary watercourses (See Figure 9).

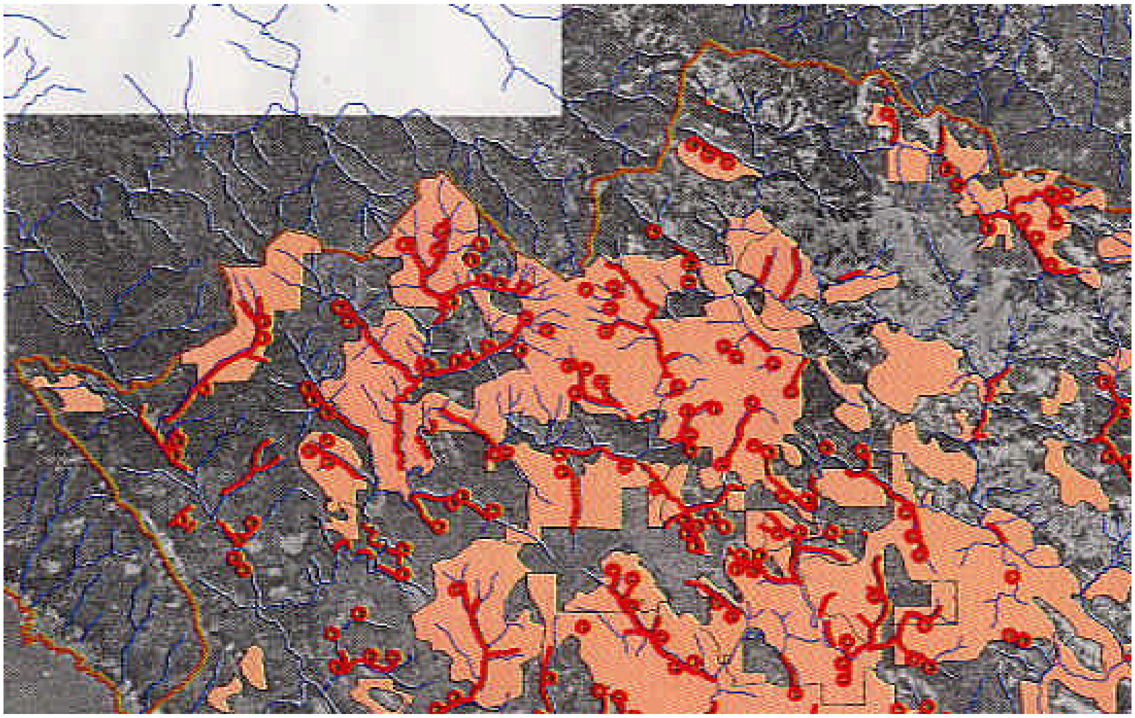


FIGURE 9: Harvest operations 1952-1964 & streamside roads/landings1952-1968

All red lines show where road fill has been pushed into the creek burying the streambank..

Roadfill sidecast to the stream channel was undermined during peak flows creating numerous debris slides and road fill failures discharging into watercourses. This upper area of the basin was affected by the 1964 flood although actual impacts that can be attributed directly to the flood were not documented with this assessment due to lack of 1965 air photo coverage in Mendocino Co. Most of the lower areas of the basin, including the Little North Fork, were logged between 1965 and 1968. Lateral road construction continued to follow the streambank channel to one side, removing riparian canopy.

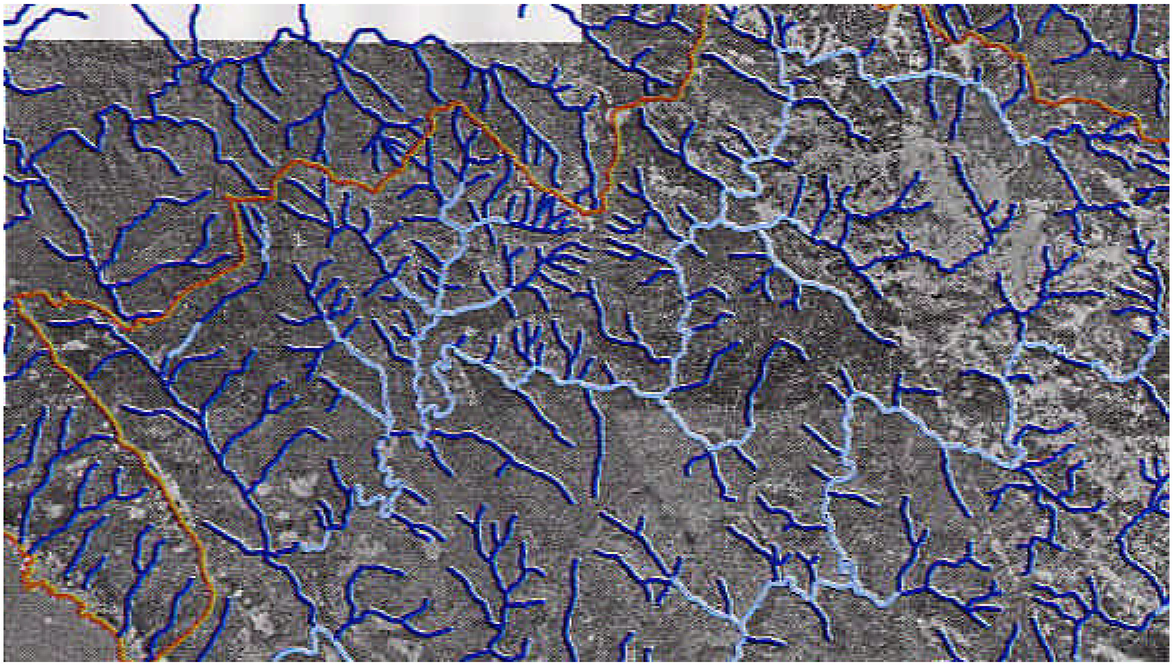


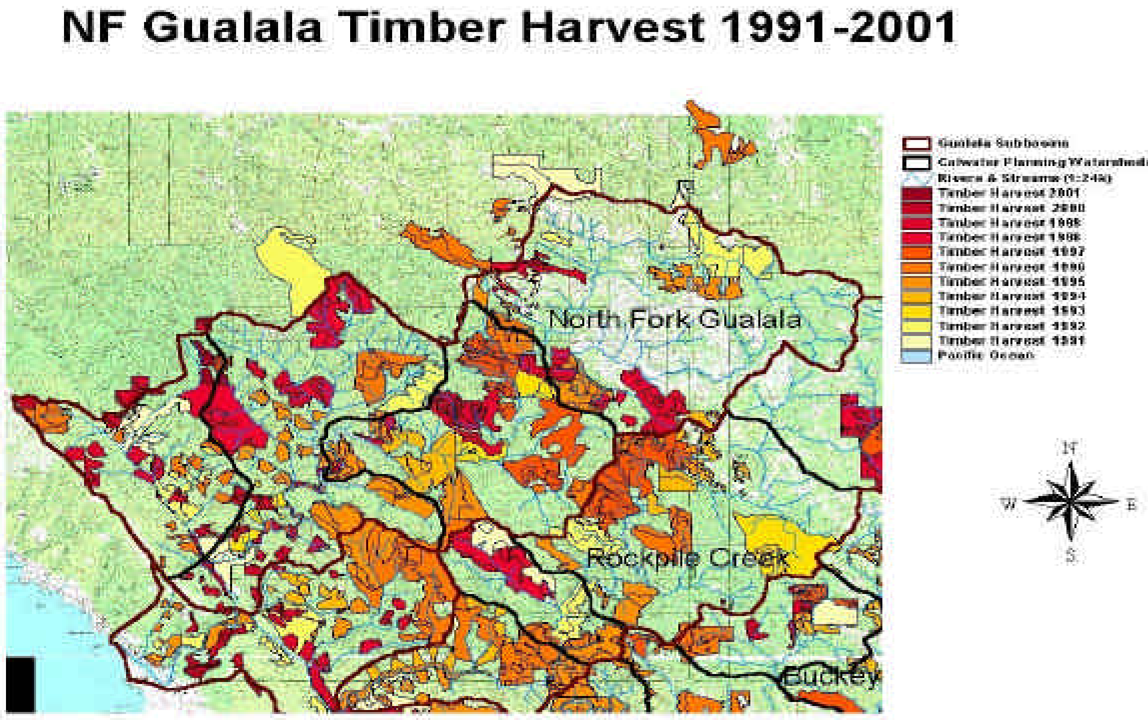
FIGURE 10: Bank to bank shade canopy exposure (white).

Blue shows partial to entire shade canopy cover.

This practice left bank to bank watercourse exposure throughout the main stem of the North Fork, and all major tributary watercourses including Stewart Creek, Dry Creek, Robinson Creek and Doty Creek (See 1981 Bank to Bank Shade Canopy Exposure Map, Figure 8 above). The bank-to-bank overstory shade canopy cover for 2000 shows improvement compared to 1981. DFG habitat typing data for 2001 shows average canopy density improving with 77% density for the North Fork mainstem and 84% for the North Fork basin tributaries. The habitat typing results are consistent with canopy measurements surveyed by the cooperative monitoring program between the Gualala River Watershed Council and Gualala Redwoods, Inc. The canopy condition is also consistent with the results of the Hillslope Monitoring Group Study (1998). The riparian protections provided by the Forest Practices Act over the last 25 years have resulted in a significant improvement of the riparian canopy over post WWII logging conditions. However, to achieve and maintain desired riparian conditions in the entire watershed, protections need to be implemented and adhered to.

1968 to 1990 was a period of relative inactivity compared to previous eras. Logging operations were slow during the recessions of 1970 and 1973. During the later 1970s, partial stand entries and commercial thinnings were the dominant stand treatments. Active harvest operations resumed from 1990 to present (see Figure 10). The clearcut method becomes predominant. Areas that had once been understocked and therefore avoided during the 1960s had become mature and were subject to harvest.

FIGURE 11: NF Gualala Timber Harvest 1991-2001



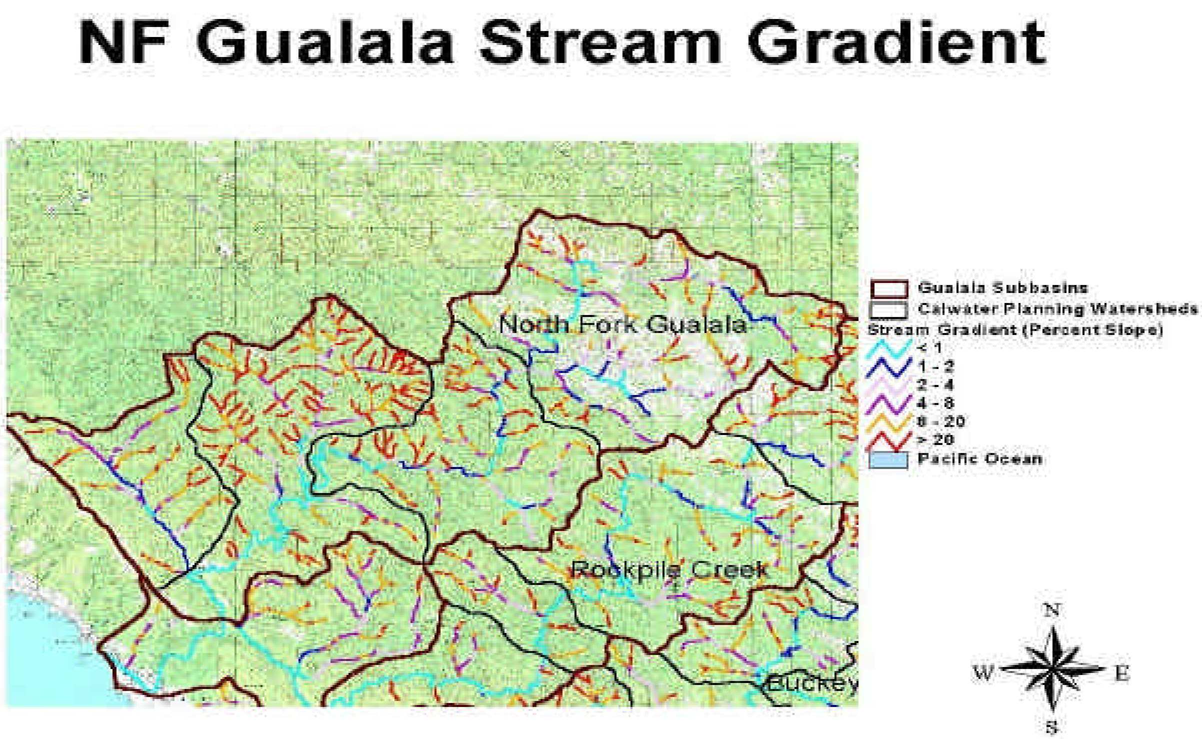


FIGURE 12: NF Gualala Stream Gradients

DISCUSSION

North Fork post WW II timber operations were the most dispersed compared to the other basins. Second growth redwood stands in the 1950s and 1960s in the lower and middle reaches had zero value, and were either thinned of other conifer species, or avoided altogether. The 1952 photos show that the first operational blocks in the watershed were in the North Fork. The last phase of the Post WWII logging boom was also in the middle reaches of the North Fork between 1964 and 1968. This contrasts with the Rockpile and Buckeye basins where most of the timbered areas were entirely removed in more narrow timeframes.

Comparative 20 year stream channel width measurements between 1936 and 1999 were inconclusive. However, the Rockpile, Buckeye, and Wheatfield Fk. basins did show channel width widening responses to more concentrated harvest operations upstream. In addition, the sharper contrast between steeper gradients in the upper NF reaches, and near level gradients along lower NF reaches compared to the other basins (see Gradient Map above) tended to wash fines downstream. This probably accounts for the suitable pool development generally observed by DFG in many of the stream reaches of the middle basin reaches. Streambed particle sizes (d_{50}) from 1997-2000 data provided by GRI and GRWC in the tributaries came out larger but more d50 sampling is needed in the tributaries to confirm this. These sites also showed some improvement over time (see Figure below). d_{50} values were small in many to most locations elsewhere. The smaller d50 values found in the lower reaches of the main stem can be attributed to high rates of sedimentation transport. Small streambed particle sizes (gravel and lower) create a more mobile streambed. Similarly, average embeddedness in the North Fork basin ranged from 26-50% (2001 data), less than optimum, and varied by major tributary watercourse. This still compares better than the other basins. The combinations of (1) high stream gradients, and (2) comparatively dispersed post WW II harvests, probably accounts for the McNiel sampling data falling within the higher range of U.S. EPA standards, but not exceeding them. TMDL threshold standards are set lower.

Roads

Successive aerial photo overlays show a shift in current road locations to ridgelines and mid slope benches. This coincides with general field observations that the older streamside roads are now mostly vegetated and wooded. In addition, the EMDS model shows the North Fork basin with the highest road density in the watershed, reflecting active timber harvesting during the 1990s. This can indicate a need to evaluate and upgrade road drainage facilities to current sizing standards in the North Fork, and to actively monitor the road network during the winter period to assure functional dispersal of drainage. Landowners within the North Fork basin have implemented road-upgrading programs. Many programs are developed in conjunction with the Gualala River Watershed Council, government agencies and/or Resource Conservation Districts. For example, Gualala Redwoods, Inc. in partnership with the Watershed Council and the Sotoyome Resource Conservation District (Sonoma County) has assessed and produced an implementation plan for the entire Little North Fork watershed. When the work is completed approximately 45 miles will be upgraded and an estimated 57,993 cubic yards of sediment will be prevented from entering the watercourses As part of Gualala Redwoods, Inc. road management program, an additional 32 miles of roads (26%) has been upgraded in the North Fork basin in the last three years reducing sediment delivery to streams by an estimated 8,606 cubic yards.

Fluvial Geomorphology

Doty Creek Planning Watershed

Aerial photo interpretation of the Doty Creek planning watershed found overall minor levels of channel disturbance in the 1984 photos. Most channel disturbance in this planning watershed was concentrated along Doty Creek where approximately 30 percent of the channel appeared disturbed and in an un-named tributary (S.11, T.11N., R.15W.) where approximately 50 percent of the channel appears disturbed. Overall there was a total of 27 small landslides in the 1984 imagery that appeared to deliver sediment into the channels. Eleven of those slides were adjacent to Doty Creek and 5 on the un-named tributary. Eleven more slides were scattered through the planning watershed.

Aerial photo interpretation of the Doty Creek planning watershed found overall conditions of the channels improved in the 1999/2000 photos. No major channel disturbances are visible on these recent photos and four landslides were mapped as delivering sediment to the channels. Three slides are along the upper reaches of Fleming Creek and one on Doty Creek are observed in 1984 photos.

Robinson Creek Planning Watershed

Aerial photo interpretation of the Robinson Creek planning watershed found overall levels of channel disturbance greater in the 1984 photos (WAC-84-C, 4-21-84) than the 1999/2000 photos (WAC–C-99CA, 4-13-99; WAC-00-CA, 4-2-00). In the 1984 images, approximately 75 percent of the North Fork Gualala River within the Robinson Creek planning watershed appeared disturbed with enlarged and numerous bars and lack of riparian vegetation. Seven landslides are mapped as delivering to the lower reach of main channel or to adjacent minor tributaries. By 1999/2000, the North Fork Gualala channel appears to have improved with disturbance between 50 and 75 percent, but channel bars appear smaller. Six delivering landslides are mapped in the lower reach, four at locations mapped in 1984.

Approximately 75 percent of the lower portion of Robinson Creek appeared disturbed in the 1984 photos with numerous longitudinal bars and cutoff chutes. Three landsides were mapped as delivering sediment into the channel. In 1999/2000, Robinson Creek improved having approximately 30 percent of the channel showing signs of disturbance, but the number of delivering landslide increased to 7, most were at location different from 1984.

Dry Creek had at least 80 percent of the channel disturbed in the 1984 images upstream from the junction with the North Fork Gualala to the confluence of Johnny Woodin and Fisher ridges (S. 6, T.11N., R.14W.). The upper reach of Dry Creek above this point is also disturbed at least 80 percent with 13 landslides mapped as delivering to the channel. On the north side of Fisher Ridge approximately 50 percent of the channel is disturbed and seven channel delivering landslides are mapped. Between Johnny Woodin and Brandt ridges an un-named tributary has approximately 30 percent channel disturbance with 11 landslides mapped as delivering to the channel. In the 1999/2000 images, the upper reach of Dry Creek improved to approximately 50 percent of the channel showing disturbance with 13 landslides, 5 of which are mapped in 1984. The lower reach also improved to approximately 50 percent of the channel showing disturbance and 8 delivering landslides. The un-named tributary between Johnny Woodin and Brandt ridges has less than 25 percent disturbance with 6 delivering landslides.

Aerial photo interpretation of McGann Gulch 1984 images found greater than 80 percent of the main channel disturbed with 9 delivering landslides. By 1999/2000, channel disturbance is less than 50 percent with most occurring in the lower reach. Four landslides deliver to McGann Gulch, all were also delivering in 1984.

Stewart Creek Planning Watershed

In the 1984 images, at least 80 percent of the North Fork Gualala River within the Stewart Creek planning watershed appeared disturbed with enlarged and numerous bars, cutoff chutes and a lack of riparian vegetation. Thirty-two landslides are mapped as delivering to the North Fork Gualala main channel or to adjacent minor tributaries. By 1999/2000, the North Fork Gualala channel appears to have improved to where 50 to 70 percent of the main channel appears disturbed. Thirty-four delivering landslides are mapped, 14 of which are at location mapped in 1984 images.

Stewart Creek appears to have at least 90 percent of the channel disturbed in 1984 images with 6 landslides delivering to the channel. By 1999/2000, the stream improved to where approximately only one-third of the upper reach appeared disturbed. Six delivering landslides were mapped in 1999/2000.

Billings Creek Planning Watershed

In the 1984 images, approximately 25 percent of the lower and 75 percent of the upper reaches of Billings Creek appeared disturbed with enlarged bars, multi-thread channels, bank erosion and lack of riparian vegetation. By 1999/2000, in the lowermost reach approximately 10 percent appeared disturbed. In the middle reach, 50 percent of the channel appeared disturbed with 7 delivering landslides. The upper reach appeared to improve with less than 50 percent of the reach disturbed and 6 delivering landslides.

Robinson Creek (a second creek) appeared to have approximately 70 percent channel disturbance in the 1984 images. Some improvement occurred by 1999/2000 with approximately 50 percent disturbance. Palmer Creek had minor sections of disturbance with 6 delivering landslides mapped on the adjacent slopes.

Water Quality

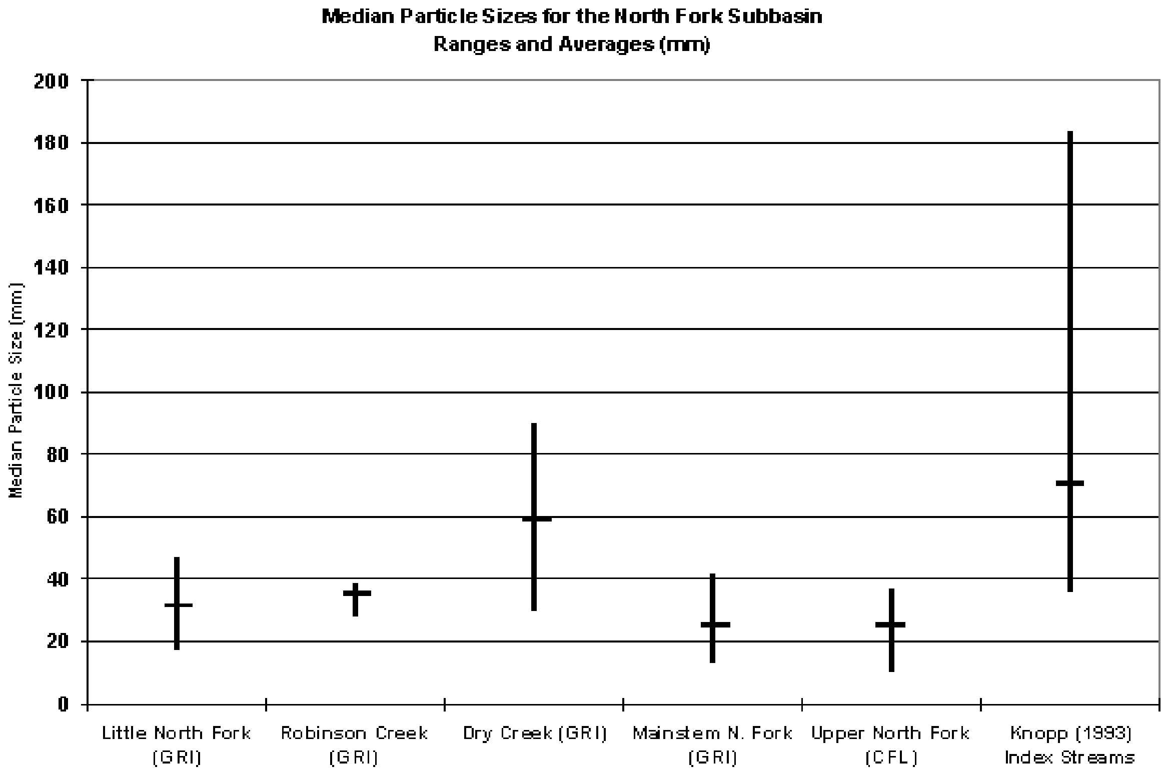
In-Stream Sediment

Pebble count data are available from GRI for a total of 12 sites (Figure 13) for the period of 1997-2001. Data from CFL are available for three sites for the period of 1995-1997. We compared those data to Knopp (1993), who collected instream substrate data from 18 north coast index streams judged to have had no human disturbance history or little disturbance within the last 40 years. He averaged d50 values for three riffles per reach, and found a minimum d50 value of 37 mm, an average of 69 mm, and a maximum d50 value of 183 mm. Knopp also presented the data with 80 and 95 percent confidence limits. We believe the GRI data to be comparable, and used the average of individual d50 values for the GRI riffles (3 riffles per site). The CFL d50 data were presented in a figure and the values estimated from the graph with a ruler. The analysis also would be improved by calculating the 80 and 95 percent confidence limits for both data sets as well. Once we determine that the data are comparable, we will perform that additional analysis. The minimum, average, and maximumfor the GRI and CFL data are compared to the same statistic from Knopp (1993) in the following table:

TABLE 7: Stream samples

Stream Name	Years	No. of Sites	No. of Samples *	Minimum (mm)	Mean (mm)	Maximum (mm)
Little North Fork (GRI)	97-01	3	8	18	30	46
Robinson Creek (GRI)	97, 99	2	3	29	34	38
Dry Creek (GRI)	97 98-01 one site	3	7	31	59	89
Mainstem N. Fork (GRI)	97 99, 01 one site	4	5	14	24	41
North Fork (CFL)	95-97	3	9	11	24	36
Knopp (1993) Index Streams	1992	18	18	37	69	183
* no. of samples = number of averages included in the comparison						

FIGURE 13: Median Particle Sizes for North Fork Subbasin



The significance of these data lie in the mobility of the sediments and the resultant impacts to salmonid embryo survival. Small particles are mobilized by smaller and more frequent flow events. Increased bedload mobility can directly impact salmonid spawning success due to redd destruction and capping (Nawa et al., 1990). Destruction of redds during incubation affects survival of the embryos from that spawning event, potentially affecting the timing of runs. Cedarholm (1983) found that a decrease in particle size distribution on the Clearwater River in Washington favored a later run timing in adult steelhead from January to March in response to bedload movement. Shifting bedload in northern California could have a greater impact on coho salmon, because they have not been documented spawning later than February in California coastal streams (Allen and Hassler, 1986).

Some temporal trends were observed in the lower Dry Creek site (DRY# 211)(Robinson Creek Planning Watershed). Of the three transects, one experienced a steady increase in D_{50} from 32 mm in 1997 to 64 mm in 2001. The other two transects increased in D_{50} from 31 and 30 mm in 1997 to 70 mm and 86 mm in 1999, then decreased to 54 mm and 45 mm in 2001.

In addition to bedload mobility, the median particle sizes observed in these areas are mostly at the low end of observed spawning use for steelhead and coho. Reiser and Bjornn (1979) present from literature, substrate sizes where various salmonids were observed spawning: 6-102 mm diameter for steelhead, and 13-102 mm for coho. In the same paper they caution that particles less than 6.4 mm hinder the emergence of chinook and steelhead embryos.

Although McNeil data can be quite variable across a riffle area, percent fines <0.85 mm from McNeil cores of riffles at four sites in the mainstem Little North Fork, one site in Doty Creek, and one site in McGann Gulch (sites dot 256, mcg 209, lnf 255, lnf 201, lnf 202, lnf 203), often exceeded the Gualala proposed TMDL target of 14% (Figure 12). Dry Creek site 211 was closer to the target, but exceeding in three of four years.

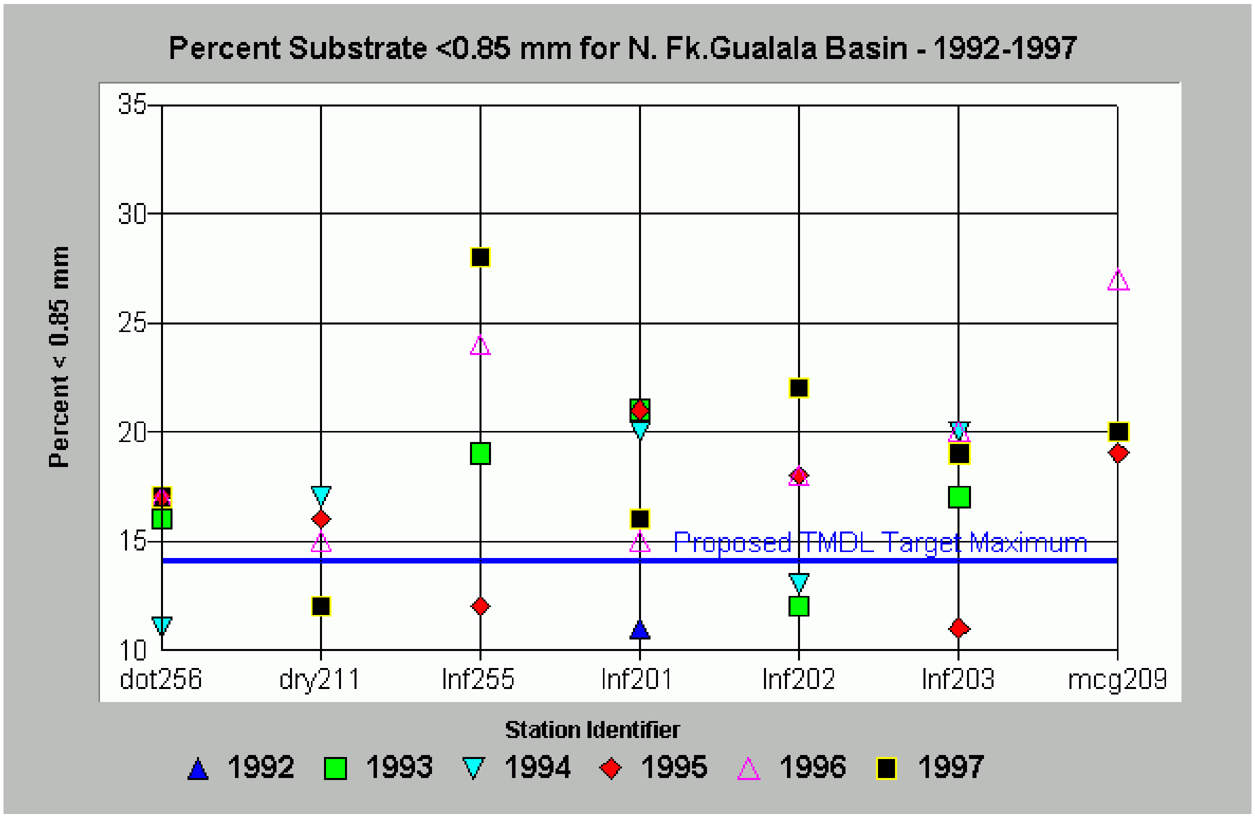


FIGURE 14: Percent substrate for North Fork Gualala Basin 1992-1997

Data are averages of eight McNeil core samples per site, wet sieved and volumetrically determined.

The Gualala Technical Support Document for the TMDL (CWQCB 2001) (Gualala TSD) lists the current top eight sediment sources as: road mass wasting, bank erosion, natural sources, surficial road erosion, timber harvest, road gullies, road crossing failures, and skid trails. Figure presents data used by Regional Board staff to prepare the Gualala TSD for the Total Maximum Daily Load for Sediment (CRWQCB, 2001). Figure 13 presents estimates of sediment delivery from mass wasting features greater than 10,000 ft^2 in plan area observed in the 1999/2000 photos, but not observed in the 1988 photos. The estimate also includes enlargement of previously existing features. Only features greater than 10,000 ft^2 in plan area were estimated. Estimates of sediment delivery are presented by geographic association with management activity, regardless of cause. Rates of sediment delivery were estimated based on feature area, average depth of failure of 56 measured features, proximity to watercourses, and a conversion factor of 1.48 tons/yd^3.

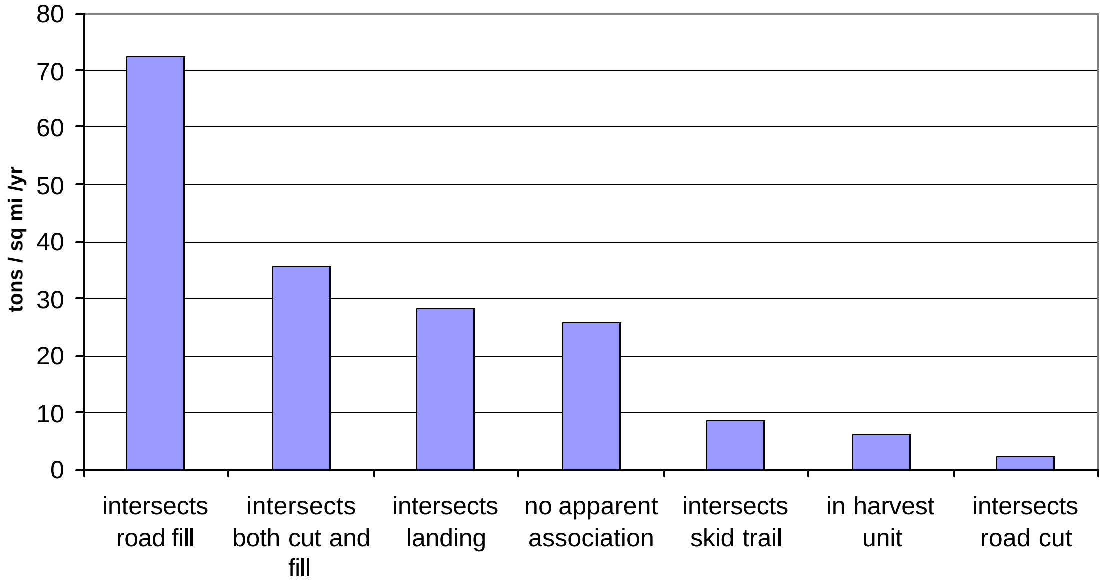


FIGURE 15: Results of Gualala TMDL Aerial Photo Inventory

Recently Active Mass Wasting Features (occurring between 1988 and 1999/2000 photo sets) with Management Associations (Plan Area > 10000 sq ft) - Total Estimated Sediment Delivery (ton/mi2/yr)

Major sediment sources still exist in this basin. For example, in McGann Gulch, a large in stream landing complex built in the late 1960s more recently failed. The upper reaches have scoured out leaving the sediment to settle out in the lower reaches. Due to the loading, McGann Gulch now flows underneath the gravel at the base of the Gulch during low flows, upstream of the North Fork, or dries up, stranding young of the year steelhead trout. In-stream landings and streamside roads from the 1960s are densely concentrated in Dry and Robinson Creeks. Some of these have been noted to continue to discharge during peak flows.

Water Temperature

Stream temperatures are limiting suitability for salmonids in specific areas of the North Fork subbasin. Water temperature data are available from GRI and GRWC for a total of 27 sites for the period of 1994-2001. In general, the MWATs from continuous monitors placed by GRI and GRWC in the smaller tributaries are within or near the 50-60 F range proposed as "fully supportive" of salmonids for all the North Fork tributaries. However, temperatures are above the fully suitable range in the North Fork mainstem. Water temperatures are high coming from the non-forested mélange in the northeastern portion of the subbasin. Water temperatures cool as the cooler tributaries provide inflow (Figure 16).

Maximum seasonal temperatures for the same sites in the North Fork subbasin were largely below the 75 F lethal maximum with four sites in the mainstem North Fork (sites nf258, nf214, nf216, nf272) exceeding the lethal maximum.

These temperature metrics represent conditions for the mainstem North Fork that are not fully suitable for salmonids. Canopy appears to be a factor in the higher temperature streams coming off the northeastern portion of the basin. A Landsat vegetation theme with maximum MWATs for the period of record shows the response of stream temperatures to low canopy and higher air temperatures in the open oak woodland in the eastern melange areas, and the influence of cooler tributaries (Figure 17). Tributary streams are cooler and have a cooling influence on the mainstem of the North Fork. Maintenance of dense coniferous riparian zones in the tributaries and reestablishment where possible in the mainstem North Fork and upper tributaries may improve stream temperatures in the moderately sized watersheds. These data and discussions support a finding of temperature as a limiting factor for salmonids in the North Fork subbasin. This conclusion is reflected in the Subbasin Issues and Hypotheses sections that appear at the end of this subbasin section.

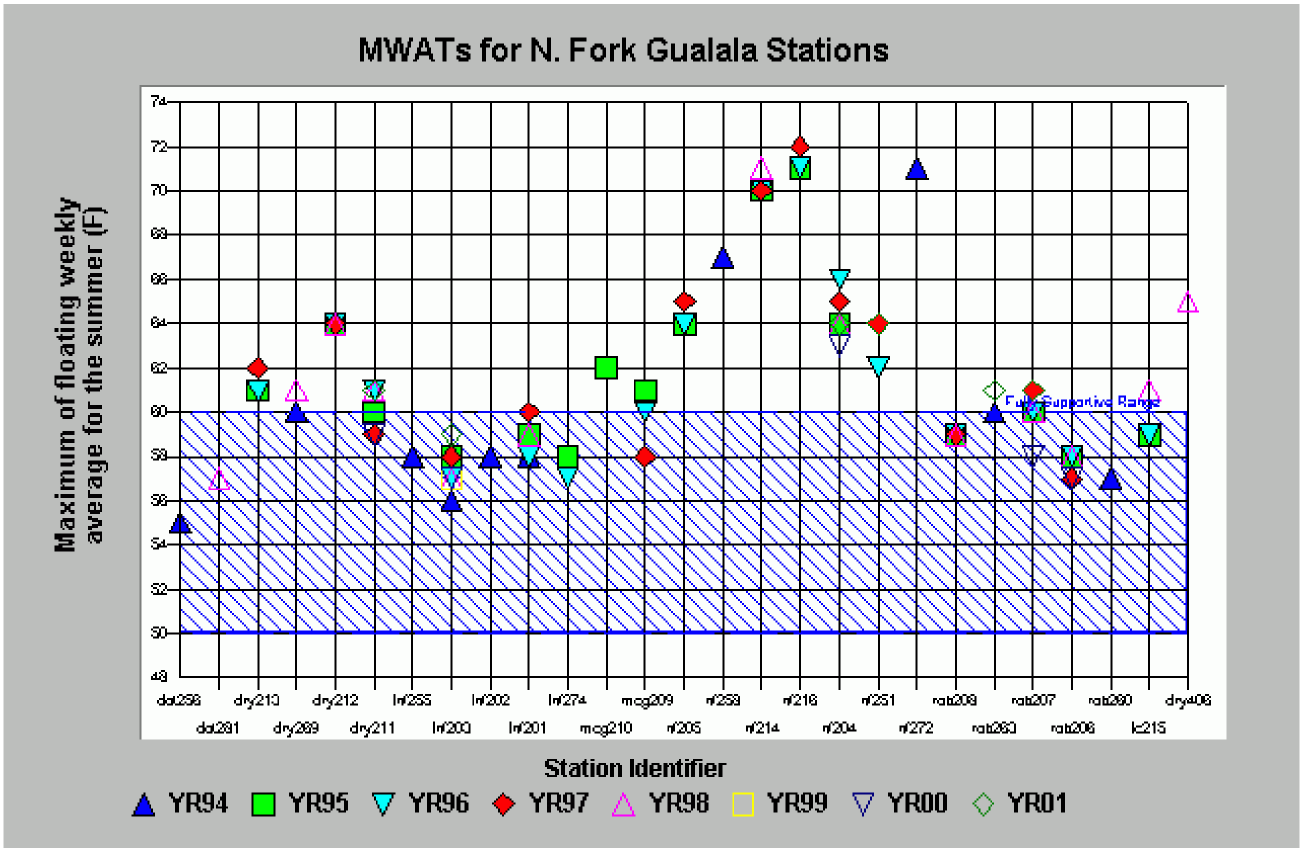


FIGURE 16: Maximum Weekly Temperatures 1994-2001

Data are from GRI and GRWC continuous monitoring devices.
Site locations are provided in Appendix 9.

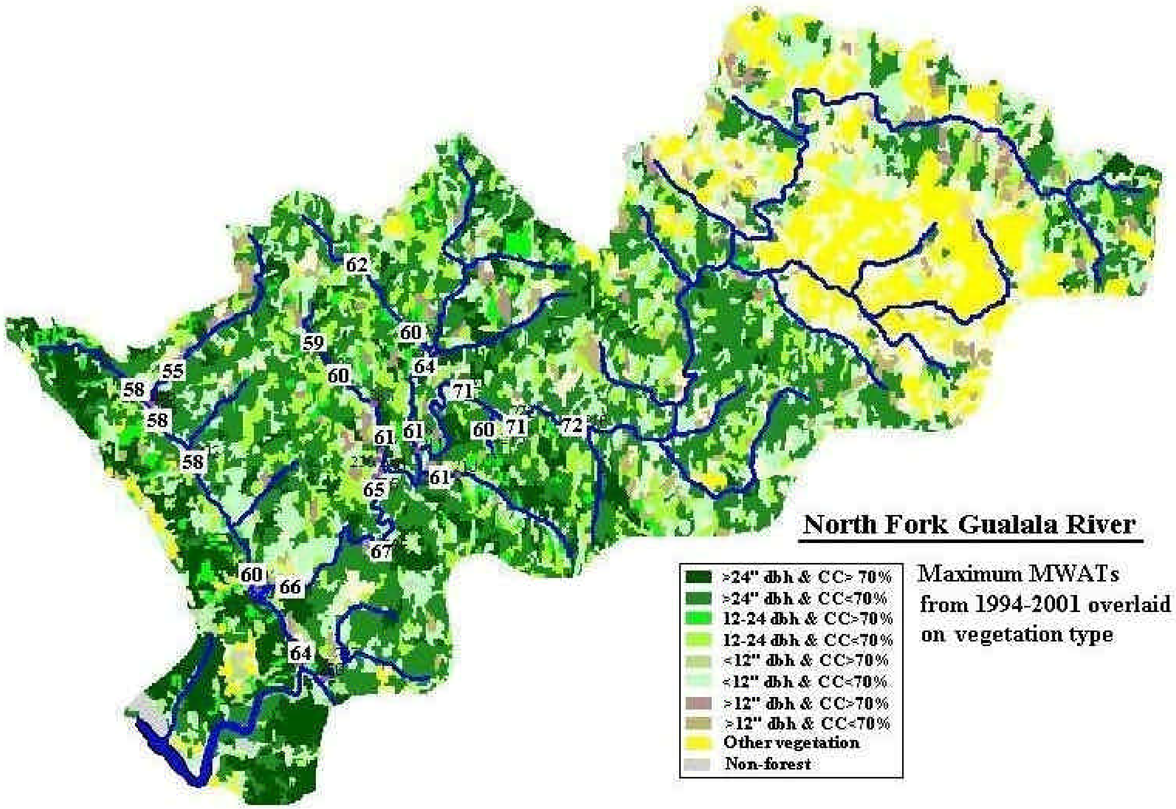


FIGURE 17: Maximum MWATs 1994-2001

1994 Landsat vegetation theme for the North Fork Gualala River Subbasin. The predominantly yellow and green are in the upper, northeastern portion of the watershed is the Franciscan mélange.

Aquatic/Riparian Conditions

Both the Gualala River Watershed Council and Gualala Redwoods, Inc. describe moderate to suitable pool formation for the upper tributaries. Habitat inventory surveys indicated good pool development along the main stem North Fork between Dry and Stewart Creeks in 2001 and along portions of the Little North Fork & Dry Creek. These surveys showed that pools comprised 43% of the habitat for the North Fork main stem and 50% and 42% for the Little North Fork and Dry Creek respectively.

In 1964, substrate in the upper reaches was characterized by DFG as boulder and cobble (60% boulder, 20% cobble, 20% gravel), and in the lower reaches as gravel and cobble (80% gravel, 20% cobble, 10% sand). In 2001, GWRC/GRI describes similar conditions. The upper reaches are dominated by boulder, cobble, gravel and the lower reaches by gravel. In the areas with small particle sizes, predominantly in the lower reaches, the lack of deep pools and predominance of small streambed particles indicate more sediment in the channel than can be transported and likely, a shifting streambed (smaller particles being more mobile). Lack of deep pool habitat for salmonids and a shifting bed where redds can be covered or destroyed reduce suitability for salmonids. In the Little North Fork there are few pools over three feet in depth, the large wood was yarded out of the stream, and the streambed is composed of gravel. In the North Fork mainstem, the DFG 2001 habitat surveys found pools comprised 43% of the habitat with a maximum pool depth of 11.2 feet, compared to 50% pools with a maximum depth of 10 ft in 1964. Adding large wood to the streams would assist in pool development and ordering of the stream substrate.

Habitat inventory surveys showed average canopy density improving with 77% density for the North Fork mainstem and 84% for the North Fork basin tributaries. These results are consistent with canopy measurements surveyed by the cooperative monitoring program between the Gualala River Watershed Council and Gualala

Redwoods, Inc. The canopy condition is also consistent with the results of the Hillslope Monitoring Group Study (1998).

Tables 8 and 9 show recent canopy density measurements within the North Fork Basin. Table 8 density and canopy composition are measured at the thalweg. Density is measured by using a spherical densiometer and the surveyor estimates canopy composition. Table 8 density is measured from the center of channel using a spherical densiometer. The canopy composition is measured by identifying and counting tree species in riparian plots that extend from bank full 100 feet inland on both sides of the channel.

TABLE 8: DF & G Habitat typing data

North Fork Subbasin
DF&G Habitat Typing Data
(June-August, 2001)

Tributary	Canopy Density	Canopy Composition	
		Coniferous	Hard wood
North Fork	77%	38%	62%
Dry Creek	73%	45%	55%
Dry Creek Tributary (1)	60%	52%	48%
Little North Fork	92%	46%	54%
McGann	80%	38%	63%
Doty Creek	94%	49%	51%
Log Cabin	93%	45%	55%
Robinson Creek	66%	39%	61%
Little North Fork Tributary (1)	100%	69%	31%

TABLE 9: Canopy Density

Canopy Density
North Fork Subbasin
Watershed Cooperative Monitoring Program
(1997-2001)

Tributary	Canopy Density	Riparian Composition	
		Coniferous	Hardwood
North Fork	65%	26%	74%
Dry Creek	69%	86%	14%
Dry Creek Tributary (1)	n/a	n/a	n/a
Little North Fork	93%	77%	22%
McGann	n/a	n/a	n/a
Doty Creek	n/a	n/a	n/a
Log Cabin	n/a	n/a	n/a
Robinson Creek	74%	80%	20%
Little North Fork Tributary (1)	n/a	n/a	n/a

Most large wood was yarded out of the streams during the 1950s, 1960s and 1970s. Recently, large wood surveys have been conducted in Robinson Creek, Dry Creek, the Little North Fork, and the lower section of the North Fork main stem as part of the Watershed Cooperative Monitoring Program. The literature suggests (Beechie and Sibley, 1997 and Martin, 1999) that about 130 pieces > 8" per 1,000 feet of large wood is an appropriate level. On average, the monitoring surveys demonstrate that large wood is deficient in most areas of the basin. However, as shown in Table 11, both Dry Creek and the Little North Fork have the highest wood volume and pieces per 1000 ft of stream reach for the basin. The high pool ratios in both tributaries could be a reflection of the large wood numbers.

To augment the natural recruitment process of LWD, an ongoing cooperative large wood placement project in the watershed has placed an additional 9,100 cubic feet of LWD in the Little North Fork and Robinson Creek tributaries. Approximately 64 pieces of LWD with an average diameter of 32 inches have been added to the Little North Fork at 8 sites along the stream reach. The placement of wood is not included in Table 11.

TABLE 10: DFG Habitat Typing Data (June-Aug 2001)

North Fork Subbasin

Tributary	Pool Frequency *	Pool Depth Maximum (Feet)	Pool Depth Mean (Feet)	Dominant Substrate	Substrate Embeddedness
North Fork	43%	11.6	1.0	Sand & Gravel	0-25%
Dry Creek	42%	2.9	0.7	Gravel	26-50%
Dry Creek Tributary (1)	44%	2.0	0.6	Boulders, Gravel & Cobble	51-76%
Little North Fork	50%	3.9	0.9	Gravel	0-25%
McGann	20%	1.8	0.5	Gravel & Cobble	51-76%
Doty Creek	35%	3.3	0.7	Gravel	51-76%
Log Cabin	29%	1.3		Gravel	0-25%
Robinson Creek	36%	4.8	0.8	Gravel	0-25%
Little North Fork Tributary (1)	33%	1.3	0.6	Silt & Clay	26-50%

* By habitat occurrence

TABLE 11: Summary of large woody debris

North Fork Subbasin
Watershed Cooperative Monitoring Program
(1998 - 2000)

Tributary	Site Number	Watershed* Size (acres)	Volume CuFt/1000'	Quantity Pieces/1000'
North Fork	473	30,600	1,567	33
North Fork	204	25,433	1,958	35
Little North Fork	404	4,217	5,099	50
Little North Fork	203	1,963	3,843	77
Robinson	207	1,068	1,592	39
Dry Creek	211	4,104	5,168	69
Dry Creek	212	3,756	2,470	27

*Watershed size is calculated as the area above the monitoring site.

Results from macroinvertebrate population sampling can be used to evaluate the occurrence of various types of pollutants and current watershed conditions. Samples taken at three reach sites in the North Fork basin in 2000 (Jon Lee) can be characterized as average when compared to similar north coast watersheds (Table 12).

TABLE 12: Summary of Macroinvertabrate Sampling

North Fork Subbasin
Gualala Redwoods, Inc.
(2000)

Tributary	Site Number	Richness	Simpson Diversity	Hilsenhoff	Abundance	Dominant Taxon
Little North Fork	203	31	0.85	4.5%	5,340	30%
Dry Creek	211	32	0.79	4.4%	1,857	40%
Dry Creek	212	41	0.92	4.5%	1,528	19%

Fish History and Status

Salmonid populations in the North Fork basin reflect a variety of factors, a major one being instream habitat, both physical structure and water temperatures. Larger and older age steelhead and coho require deep pools with sufficient shelter for rearing. Steelhead were observed in most of the basin. However, according to historical documentation steelhead one year and older have declined. GRI snorkel surveys conducted yearly in the Little North Fork since 1998 show a steelhead population dominated by young of the year but with one year and older age classes present. DFG electrofishing surveys in the Little North Fork show similar results. Coho have been observed in the basin historically, with the last documented observation of coho in the North Fork basin in 1998. Coho were not observed during the electrofishing surveys at sites on the Little North Fork and along the North Fork mainstem conducted in 2001.

Subbasin Issues

The term 'issues" is used here in a generic sense to denote any topic of interest, concern, import, or relevance to the watershed assessment. As such, issues can be direct limitations on salmonid suitability, potential factors for consideration, concerns regarding potential practices, suggestions, or observations of the data that are particularly relevant to the development of hypotheses and recommendations.

- Fish density – Based on limited sampling in the upper North Fork drainage, coho have not been found. Four years of electrofishing in three streams show stable population of juvenile steelhead.

- Fish population information is poor due to access issues for surveys. Considering the paucity of information on salmonid distribution and abundance, the possibility of training local landowners to survey their own streams and conduct fish population surveys would be advisable.

- Steelhead rescue project exists on Doty Creek.

- In-stream habitat diversity and complexity, based on surveys available, appears to be insufficiently diverse. Inadequate pool depth, and a lack of escape cover and LWD have contributed to a simplification of instream fish habitat.

- Large Woody Debris (LWD) recruitment potential is very poor overall due to naturally occurring geologic conditions. Past land use practices have limited large woody debris recruitment potential.

- Land use practices on steep and/or unstable slopes should be conducted in accordance with guidelines and recommendations in DMG Note 50.

- Roads – There is concern over abandoned roads, new road construction, and road maintenance issues related to landsliding and sediment input. Without appropriate maintenance or storm proofing, existing roads, both active and abandoned, may continue to supply sediment.

- Sub-division construction, grazing, feral pigs, and landuse conversions are issues in the upper Northfork subbasin..

- Water chemistry – No data are available on pH, dissolved oxygen, nutrients.

- Water temperatures during summer months do exceed optimal conditions for salmon throughout some of this planning basin, particularly in larger order streams.

- Instream sediment data is needed. Based upon a few samples over a short time period there is an indication that fine sediment levels are not fully suitable to salmonid populations.

- Wildlife/Plants -- Inadequate information exists to assess status and trends of flora and fauna, including invasive species.

The term "working hypotheses" presented below is used in a general sense, not in a rigorous scientific sense. What we refer to as hypotheses generally involve drawing cause and effect relationships between limiting factors and the natural or anthropogenic causes. We refer to them as "working" hypotheses because, in general, we are not "proving" them in a rigorous, scientific or statistical sense, but are proposing them because of relationships we see in the data we have evaluated. As such, they are not surprises, rather logical outgrowths of the data already presented, and they are often tied closely to the subbasin issues.

"Findings" generally refers to specific facts, which may also be connected with a reasonably well established scientific conclusion.

The "limitations" are issues of data, analysis, scientific understanding, etc., that limit our certainty about our findings or the supportability of the hypothesis.

The "recommendations" are actions we believe should be taken to address the limiting factor and causal mechanism identified in the hypothesis, where we conclude that the hypothesis is supportable; steps that should be taken to increase our understanding of the basis for rejecting or not rejecting the hypothesis

This section is a work in progress. That is, not all of the hypotheses have been developed by the Gualala Assessment Team. The hypotheses, findings, etc. offered below are not completely explained, but are given as examples that we will further develop. As we evaluate the results of the EMDS model runs more relationships will no doubt become apparent, and will be added as working hypotheses.

Subbasin Issue Synthesis and Recommendations

Working Hypothesis: ***Water temperatures in the mainstem North Fork Subasin are not fully suitable for anadromous salmonids. Depleted overstory shade canopy cover along the North Fork and tributaries from legacy harvests continues to contribute to elevated water temperatures.***

Supporting Findings:

MWATs exceeded the fully suitable range of 50-60 F at all eight North Fork mainstem sites for the period of record (1994-1998, 2000-2001), ranging from 62-72 F (Figure xx).

Seasonal maxima exceeded the 75 F lethal maximum 40% of the time during the same period of record, ranging from 66-80 F.

The highest MWATs for the period of record presented on a LandSat vegetation layer (Figure xx) point out: Water temperatures are higher in the upstream areas draining the northeastern portion. Vegetation in the area upstream of those high temperatures (Franciscan melange) is open oak grasslands with poor canopy

Two historical timber harvest eras eliminated riparian shade canopy throughout the lower and middle reaches of the North Fork: 1860 to 1900, and 1952 to 1968, elevating stream temperatures as measured today in the latter, and presumed in the former.

There is partial riparian cover in the oak woodland melange in the upper basin reaches.

Contrary Findings:

Advanced conifer hardwood regeneration since 1968 has reinstated canopy cover throughout many of the highest tributary reaches.

Limitations:

Data from Gualala Redwoods Inc.'s eight mainstem sites in about the lower 9 miles were evaluated. The North Fork mainstem is about 10 miles long, with headwater tributaries extending about another 11 miles. Data represents about 50% of total blue line length.

The extent of the thermal reaches for the sites is unknown.

Three sites had only one year's data (NF 258, NF 272, NF 406)

Raw data were not evaluated for inconsistencies, thus assumptions were made that GRI and GRWC performed quality assurance and quality control.

Individual canopy measurements for the entire watershed were not available, Landsat 1994 layers from the US Forest Service were used instead

Conclusions:

The hypothesis is supported, given the limitations.

Recommendations:

Investigate the availability and quality of other data for the northeastern area. Include and reevaluate the hypothesis.

More temperature, monitoring and canopy ground-truthing on the northeastern area would assist in further describing the relationship.

Ensure that adequate streamside protection zones are used to reduce solar radiation and moderate air temperatures in order to reduce heat inputs to the North Fork and its tributaries.

Where current canopy is inadequate, use tree planting and other vegetation management techniques to hasten the development of denser riparian canopy.

Working Hypothesis: ***Stream reach conditions in the Northfork subbasin are limiting the suitability for sustaining healthy populations of native anadromous salmonids in specific areas.***

Supporting Findings:

The EMDS reach model results indicate the following:

- Pool Shelter Complexity is low in Doty Creek and the Little North Fork upstream of Log Cabin Creek; very low in the Dry Creek tributary and in the Little North Fork from (and including) Log Cabin Creek downstream to the confluence with the North Fork; extremely low in Dry Creek downstream of the three tributary confluence and in the mainstem North Fork for the entire survey area from upstream of Dry Creek downstream to the confluence with the South Fork Gualala.

- Pool Quality rating is low in Robsinson Creek; very low in Dry Creek tributary, the little North Fork, Doty Creek; extremely low in Dry Creek below the three tributary confluence.
- Pool depth was rated extremely low in the Little North Fork watershed, Robinson Creek Dry Creek, and McGann Gulch.
- In-channel conditions were rated low in all watersheds within the subbasin, with the exception of the Mainstem North Fork.
- Embeddedness was high in the surveyed section of Robinson Creek, and very high in the surveyed section of Doty Creek.
    - Canopy Density is: Low in Dry Creek downstream of the three tributary confluence and in the surveyed section of Robinson Creek.Very low in the upper two-thirds of the surveyed section of the Dry Creek tributary.

Contrary Findings:
The EMDS reach model results indicate the following:
- Pool Shelter Complexity was rated barely suitable in the surveyed section of Robinson Creek.
- Pool Quality is somewhat suitable in the surveyed section of the mainsteam North Fork.
- Pool Depth is fully suitable in the surveyed section of the mainsteam North Fork.
- In-channel conditions are somewhat suitable in the surveyed section of the mainsteam North Fork.
- Embeddedness was low to very low in the subbasin, with the exception of Robinson Creek, Doty Creek, and McGann Gulch.
- Canopy Density is mostly suitable in the surveyed section of the mainsteam North Fork, and fully suitable in the Little North Fork subwatershed.

Limitations: Not all tributaries in the subbasin were surveyed.

Conclusions: Hypotheses are supported given the stated limitations.

Recommendations:

Restoration activities should focus on areas needing improved pool quality, and on improving canopy density in Robinson and Dry Creeks.

Working Hypothesis: ***A lack of in-stream large woody debris contributes to simplified riparian habitat structure (e.g., lack of large, deep pools)***

Supporting Findings:

Heavy tractors which built roads, landings, and skid trails in or adjacent to streams between 1952 and 1968 buried, removed, or dispersed large woody debris in the basin.

Historic and recent timber harvest in lower and middle reaches frequently removed large conifer vegetation down to the stream bank, reducing the available recruitment supply of large woody debris.

Although stream buffers are regenerating under current land management practices and Forest Practice rules, dense buffers of conifers large enough to function, upon recruitment, as large woody debris in channel formation processes have not yet been reestablished.

Cleaning of streams to remove “fish barriers” made of large woody debris occurred throughout the subbasin.

Contrary Findings: None noted.

Limitations: None noted.

Conclusions: Hypotheses are supported given the stated limitations.

Recommendations:

Gualala River Watershed Council and Gualala Redwoods Inc. are encouraged to do more large woody debris placement work throughout the N.F. basin. .

Tree planting, thinning from below, and other vegetation management techniques will hasten the development of large riparian conifers.

Working Hypothesis: ***Due to the steep topography of the NF basin, many roads are located in erosion-prone areas; such as, adjacent to stream channels or across debris slide slopes.***

Supporting Findings:

Debris slides and debris flows are very common in this subbasin. Delivery of that sediment to watercourses is high. [Plate 1: CDMG Map of Landslides and Geomorphic Features Related to Landsliding; Appendix XX: CMDG Report of Geologic and Geomorphic Characteristics of the Gualala Watershed]

Road density and stream density in the upper NF basin is the highest in the Gualala watershed [EMDS results]. This combination results in a high number of stream crossings. The steep topography and high stream density result in intense, flashy runoff, and frequent debris flows that challenge poorly engineered stream crossings.

Mapping and aerial photo analysis shows that legacy roads preferentially followed streams up the narrow valleys resulting in stream side canopy removal and in-stream and near-stream grading. [Appendix XX: CDF Map of In-stream Roads and Landings and Map of Vegetation Changes]

The fast runoff of storm water produces high peak flows along major tributaries that challenge in-stream and near-stream road related structures. [Appendix XX: DWR Hydrology Report of the Gualala Watershed]

The 1981 photos show a high density of road and landing failures along streamside roads throughout the steep, deeply incised terrain in the Stewart Ck. Planning watershed.

The residual effects of heavy channel aggregation from streamside road system failures built in the 1950s and 1960s is noted in timber harvest plan records in Dry , Robinson, Stewart Creeks, and McCann Gulch. These sites are confirmed on ground by CDF and DMG field inspectors.

Contrary Findings:

None noted.

Limitations:

None noted.

Conclusions:

Hypotheses are supported given the stated limitations.

In this steep, erosion-prone area, careful road sitting, design, and maintenance are necessary to avoid increased sedimentation of streams. Poorly sited or engineered roads will likely produce sediment impacts to streams.

Recommendations:

Evaluate the feasibility of abandoning streamside roads.

Culverts should be sized to accommodate flashy, debris laden flows. Trash racks or similar structures should be used to prevent culvert plugging. Critical dips should be required to minimize the impact of culvert failure.

Existing roads systems should be maintained and new roads built in accordance to currently recognized Best Management Practices.

Continue to decommission streamside roads and landings. The following tributaries contain the highest density of these still active sediment sources: Doty, Dry, Robinson, Stewart, and McCann Gulch.

Working Hypothesis: ***Accelerated erosion from roads has contributed to the sedimentation in the streams resulting in added degradation of salmon habitat.***

Supporting Findings:

Comparison of historic stream survey and electrofishing show a decline in salmon populations. [Appendix XX: DFG Catch Statistics]

Comparison of historic stream surveys and current habitat inventory survey showed that pools of some tributaries have become shallower and some streambeds have become embedded with fine sediment over the last several decades. Both are limiting factors to salmonids [Appendix XX: DFG Stream and Habitat Inventory Survey Reports]

Both historic and modern aerial photos show that numerous debris flows and slides involve roads and that numerous failures occur along in-stream and near-stream roads and landings. These resulted in increased sedimentation in the streams. [Plate 1: CDMG Map of Landslides and Geomorphic Features Related to Landsliding; Appendix XX: CMDG Report of Geologic and Geomorphic Characteristics of the Gualala Watershed]

Contrary Findings:

Embeddeness is suitable on the Northfork, Little Northfork and Log Cabin creeks.

Embeddeness may be suitable on additional tributaries which have not been surveyed.

Limitations:

None noted.

Conclusions:

Hypotheses are supported given the stated limitations.

Upgrading and diligent maintenance of existing road systems to reduce sediment impacts will slow the degradation of salmon habitat – specifically pools and spawning gravel. Careful engineering of new roads or repairs can reduce adverse sediment impacts.

Recommendations:

Road managers should develop and adopt erosion control plans. Repairs and new road construction should be carefully designed and when necessary licensed specialists such as civil engineers, erosion control specialists, and engineering geologists should be consulted.

Introduction

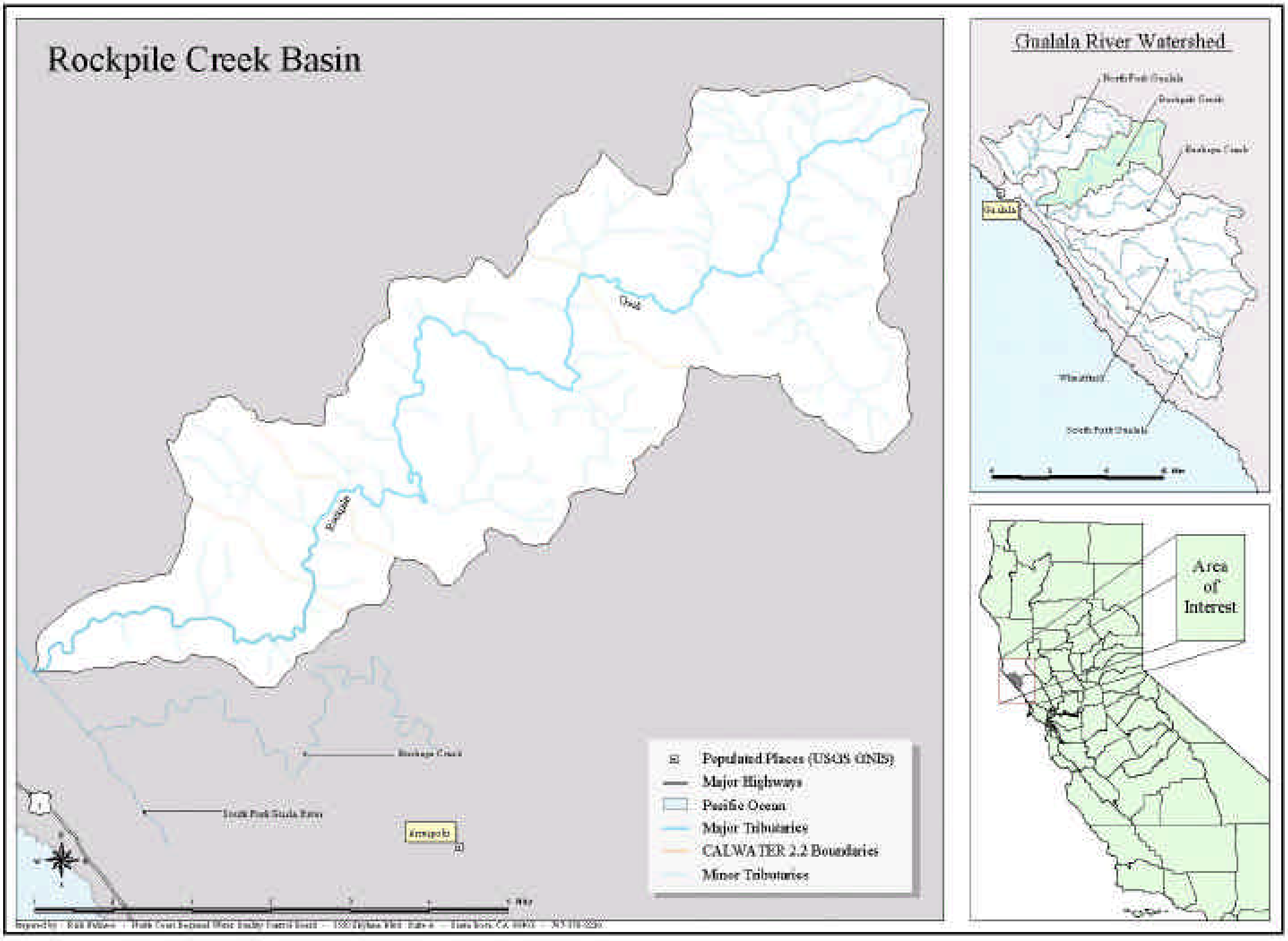


FIGURE 18: Rockpile Creek subbasin

Geology

Geologic conditions of the Rockpile Basin (12% of watershed) are very similar to the North Fork, except that topography is less steep and the main channel is narrower (Plate 1). A series of NW trending strike-slip faults have offset drainages in the middle and upper Rockpile basin. This created a zigzag pattern with abrupt turns in the stream network. The valleys in these areas are steep, narrow, and V-shaped. Horsethief canyon especially characterizes this topography. Drainage gradients in the higher reaches of the basin are characterized by Rosgen classes ranging from A++ to B types, with the upper B-type more predominant. (DMG NCWP) In the lower basin, a longer response reach of less than 4% gradient parallels Stanly Ridge

Vegetation

The narrow Rockpile basin contains high site timber ground downstream from Rockpile Peak. Upstream areas contain mixed conifer hardwood forests with grassland on ridgelines and south facing slopes. In the lower and middle reaches, the 1942 photos show dense mature coniferous shade canopy cover over all primary streams. Only the lowest reaches near the confluence point with the South Fork is Rockpile Creek wide enough to create bank to bank exposure in an alluvial flood basin (See Figure 19, below).

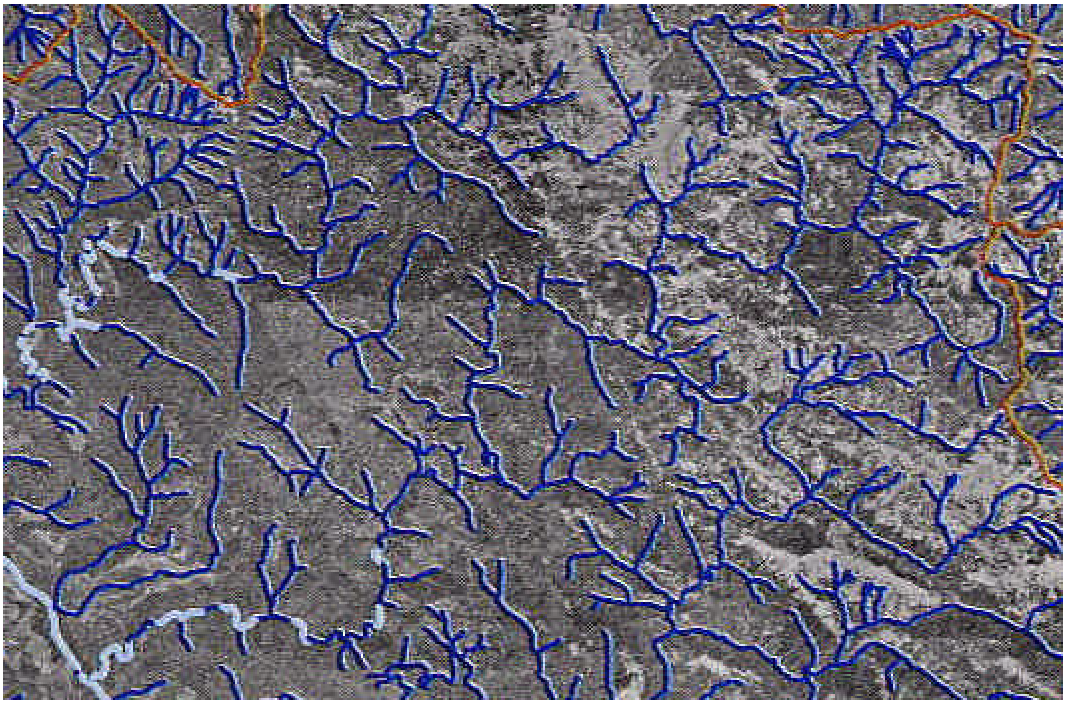


FIGURE 19: 1941 Rockpile Creek overstory canopy exposure

942 Bank to bank overstory shade canopy expose (white), lower left, on Rockpile Ck. Blue lines show partial to entire canopy cover.

Land Use

Logging operations resumed after the depression era lull in the Rockpile drainage in the mid 1950s. The middle reaches of Rockpile Creek downstream from Horsethief Canyon formed the central area of a large multi-basin operations unit stretching down from the upper North Fork southeast through Franchini Creek to the main stem Buckeye Creek. By 1960, rectangular block harvest areas following straight parcel lines appear in the middle to upper reaches. By 1964, each of these had enlarged to merge into one continuous harvest area Due to the steep, deeply incised terrain, haul roads and landings were densely concentrated along Class I watercourses

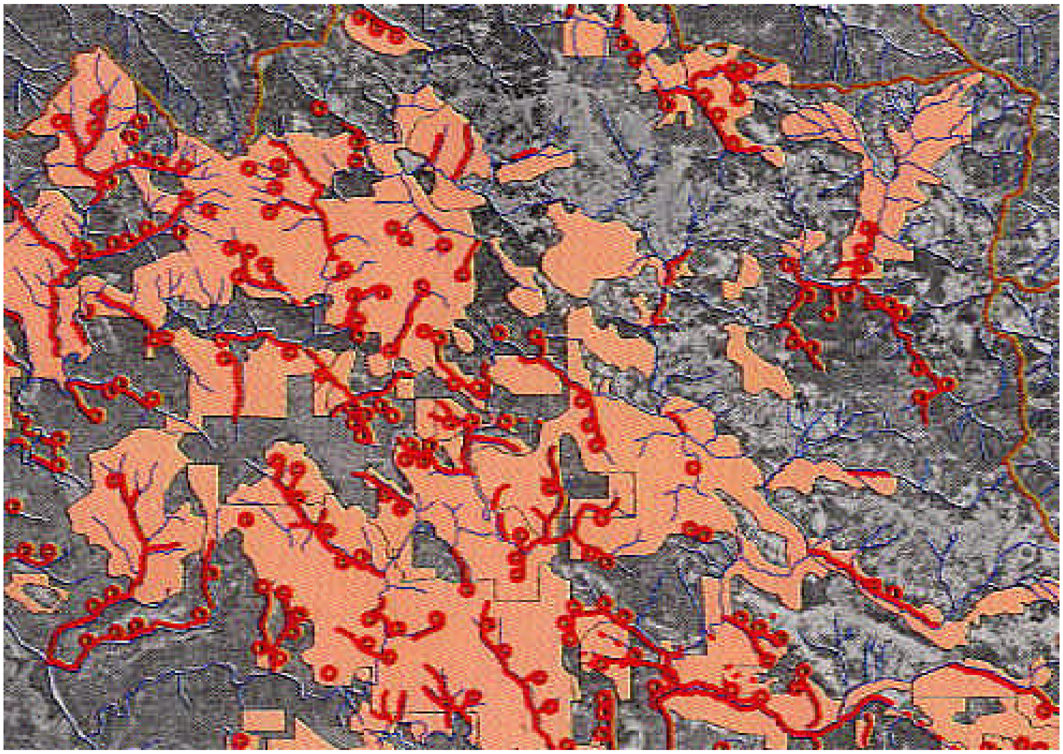


FIGURE 20: Tractor Harvest Operations 1952-1964

Also shown streamside roads and landings (red). Red lines show where tractors have pushed dirt fill into the watercourse to make the road , covering the streambank.

The central reaches of Rockpile had one of the largest continuous areas in the watershed logged between 1960 and 1964. This occurred in steep terrain with no erosion control structures installed just prior to the 1964 storms. Numerous road washouts and stream aggradations are referenced in the THP record attributable to this time period (See tributary descriptions below) Logging operations removed all riparian canopy cover leaving bank to bank watercourse exposure throughout the entire main stem of Rockpile Creek extending from the South Fork upstream to the Upper Rockpile Planning Watershed (see 1981 Shade Canopy Exposure Map, Figure 18 below).

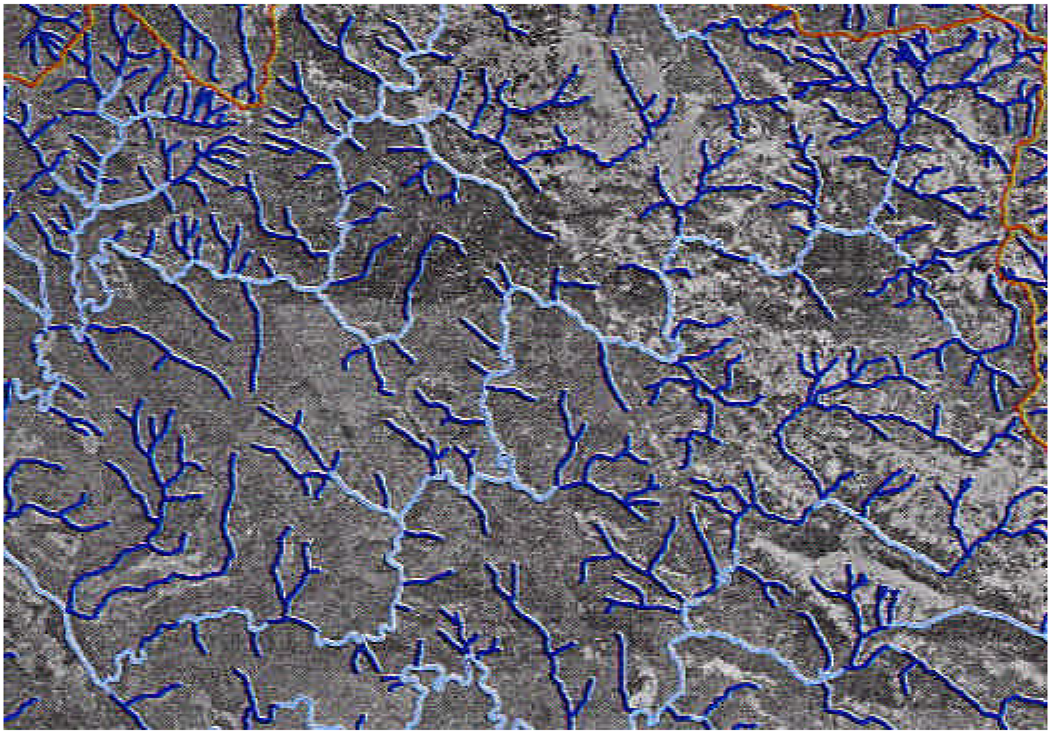


FIGURE 21: 1981 Bank to Bank shade canopy exposure

1981 Bank to Bank shade canopy exposure (white), Rockpile Ck.
Dark blue lines show partial to entrie canopy cover.

The bank-to-bank overstory shade canopy cover for 2000 shows improvement compared to 1981, reflecting riparian in-growth since the late 1960s. Coast Forestlands reported reinstatement of overstory shade canopy in numerous upper reach tributary watercourses (CFL SYP, 1997). CFL no harvest WLPZs are routinely stipulated for all THPs along Rockpile Creek and Class II tributaries to mitigate temperature impairment throughout the basin. Canopy cover is lacking in most areas along the main stem Rockpile Creek, mid to higher reaches (CFL THP 1-97-475).

The Gualala Technical Support Document (CWQCB 2001) identified roads as one of the major current sediment sources in the Rockpile Creek subbasin. Road densities range from a low of 2.8 miles per square mile (mi/sq mi) in the Upper Rockpile Calwater to a high of 7.5 mi/sq mi in the Red Rock Calwater, with Lower and Middle Rockpile both with about 6 mi/sq mi.

Central Rockpile Ck.

- By the early 1960s, the main haul road followed directly along the central reaches of Rockpile Ck. Remnants of road and landings in Rockpile Ck. continue to contribute sediment during peak flows. Shade limited along Rockpile Ck due to large amounts of road segments and landings directly in or adjacent to upper reaches of Rockpile Ck (THP 97-510 CFL) from 30 yrs ago.
- Skidding and hauling in watercourses during 1950s, 60s, were noted in central and upper reaches of Rockpile watershed. High sedimentation and accumulation of debris found in channel. Downcutting and subsequent downstream aggregations noted. Conditions described in a stage of recovery as stream flow continues to flush sediment and organic material downstream (CFL 97-341, 97-345). In very steep areas, Class II and III watercourses were not used as skid trails.

Red Rock Ck.

- Logged in 1959-1960. The main haul road was built along Red Rock Ck. for nearly the entire length of the Class I watercourse. Numerous in stream landings lined Red Rock Creek (CDF NCWP).
- In the mid 1990s, extensive streambank rehabilitation work was carried out by J. Monchke.

Upper Rockpile Ck.

- Seven seed tree overstory removal/ dispersed harvest THPs dated 1997-98 exceeded 60% of the 2700 acre Brandt tract within the Upper Rockpile Ck. WAA. These plans directed road repair work throughout the road network area wide. This included (1) repair of two watercourse diversions (CFL 97-371), (2) removal of a long section of seasonal road across Rockpile Ck. (legacy road), and (3) repair of two other watercourse diversions, (CFL 98-091). These THPs stipulated temporary watercourse road crossing specifications as the dominant use among seasonal road laterals. This requires abandonment of road crossing structures with road approaches bladed back to reestablish original streambank configuration and exposed soils treated with grass seed and mulch.

Fluvial Geomorphology

Rockpile Super Planning Watershed

Aerial photo interpretation of the Lower Rockpile Creek planning watershed found overall levels of channel disturbance greater in the 1984 photos (WAC-84-C, 4-21-84) than the 1999/2000 photos (WAC–C-99CA, 4-13-99; WAC-00-CA, 4-2-00).

Lower Rockpile Creek Planning Watershed

In the 1984 images, at least 80 percent of the lower reach of Rockpile Creek within the planning watershed appeared disturbed with enlarged and numerous bars, braided reaches, and a lack of riparian vegetation. Thirteen landslides were mapped along the reach as delivering sediment to the channel in 1984. By 1999/2000 there is some improvement in the channel conditions as 50 percent of the channel reach appears disturbed in the imagery. Three delivering landslides are mapped along the main reach and 12 slides are mapped in an un-named tributary located in Section 28, Township 11 North, Range 14 West.

Redrock Planning Watershed

Rockpile Creek in the Redrock planning watershed is also characterized by a high percentage, greater than 80 percent, of apparent channel disturbance in the 1984 imagery. Five delivering landslides are mapped along the main channel. An un-named tributary (S.22, T.11N., R.14W.) also has approximately 25 percent channel disturbance with 3 adjacent landslides likely delivering sediment to the channels.

By 1999/2000 there was some improvement in the channel disturbance characteristic in Rockpile Creek, resulting in 50 to 75 percent apparent disturbance. Four delivering landslides are mapped. The un-named tributary of section 22 showed an increase in disturbance indicators with approximately 50 percent of the channel disturbed and an increase to 13 delivering landslides.

Middle Rockpile Creek Planning Watershed

Approximately 75 percent of the middle reach of Rockpile Creek appeared disturbed in the 1984 imagery with bank erosion common, particularly in Section 12, Township 11 North, Range 14 West. Fourteen landslides were mapped as delivering sediment to the channel and adjacent tributaries. Two other un-named tributaries along the southeastern flank of McGuire Ridge showed signs of significant channel disturbance in Sections 14 and 15, Township 11 North, Range 14 West. These un-named tributaries appear to have at least 80 percent of the reach disturbed with 7 adjacent landslides delivering sediment.

By 1999/2000 disturbance in the middle reach of Rockpile Creek is reduced to approximately 50 percent with 10 delivering landslides. The two un-named tributaries in section 14 and 15 have also improved with disturbance approximately 25 percent of the reach and 2 delivering landslides.

Approximately 75 percent of the channels in Horsethief Canyon appear disturbed in the 1984 imagery with one delivering landslide. By 1999/2000, the upper reach improved and only 25 percent appears disturbed, most in the lower portion of the reach. However, 3 delivering landslides are mapped adjacent to the main channel or tributaries.

Upper Rockpile Creek Planning Watershed

Approximately 50 percent of upper Rockpile Creek channel shows characteristics of channel disturbance in the 1984 imagery. Twenty-seven landslides are mapped as delivering sediment to the channel. By 1999/2000 the overall disturbance is still approximately 50 percent, but the upper reach of the is less disturbed and the number of delivering landslide has decreased to 15.

Water Quality

In-stream Sediment

Small particle sizes observed from pebble counts provided by GRI, GRWC, and CFL indicate an unstable and mobile streambed potentially limiting suitability for salmonids in the lower and middle reaches of the Rockpile mainstem (Figure xx). Six sites were sampled in the lower three miles from 1997-1999 (GRI/GRWC) and the middle seven to 10 miles in 1995-1997 (CFL) (Figure 23). To compare the data to Knopp (1993), the individual D50 values for the sites (3 transects per site) were averaged. The minima, maxima, and averages for those averages were considerably lower than the same statistics from Knopp (1993):

TABLE 13: Sediment particle size sampling

Stream Name	Years	No. of Sites	No. of Samples	Minimum (mm)	Average (mm)	Maximum (mm)
Lower Rockpile Creek (GRI)	97 one for 97-99	3	5	25	28	32
Middle Rockpile Creek (GRI)	97, 99	3	9	16	25	38
Knopp (1993) Index Streams	1992	6	18	37	69	183

*no of samples = number of averages included in this comparison

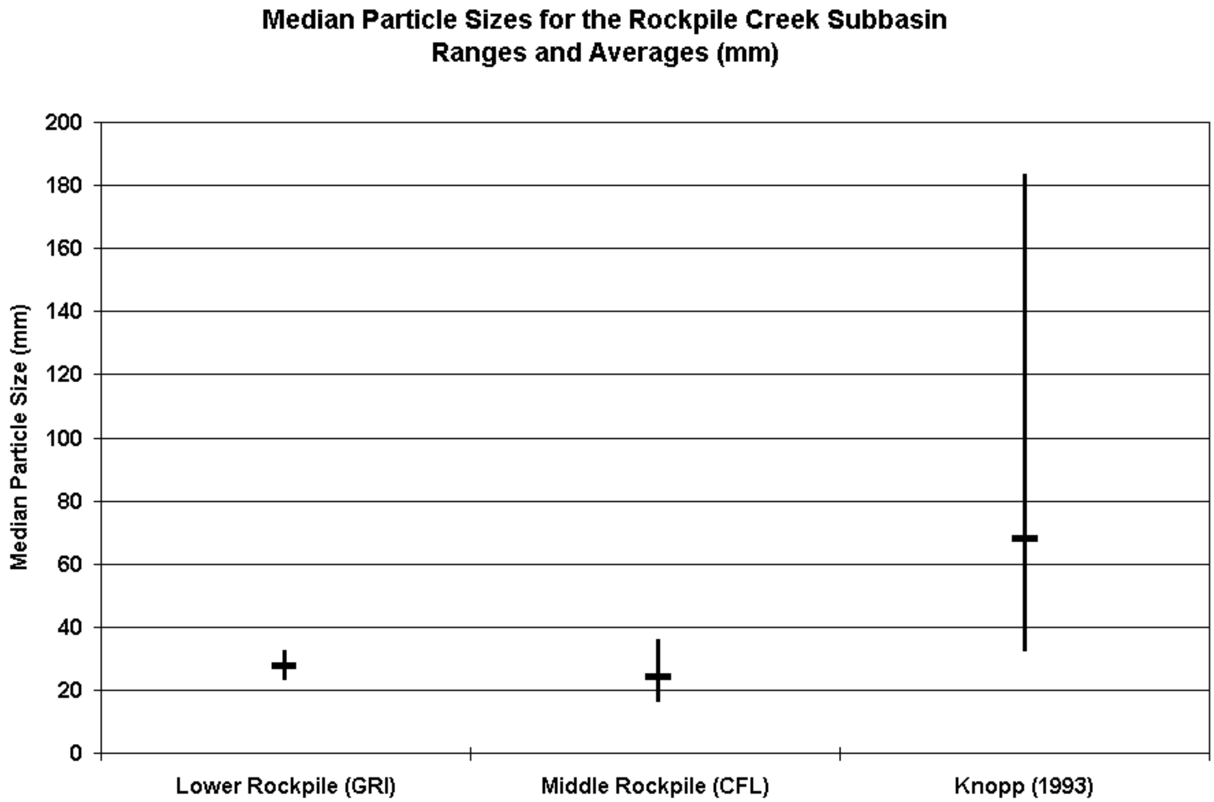


FIGURE 22: Median particle size sampling - Rockpile Creek

One transect of three at the lowest site in the subbasin (RP#221) had an increase in D_{50} from the 1997/98 median of 28 mm to 1999's D_{50} of 55 mm.

Small average particle sizes found at these sample locations result in increased bedload mobility. Finer grained beds are more easily mobilized by flows, resulting in shifting riffles and pools. One potential causal factor is sediment delivery from roads and associated erosional features. The Gualala Technical Support Document (CWQCB 2001) identified roads as one of the major current sediment sources in the Rockpile Creek subbasin. Road densities range from a low of 2.8 miles per square mile (mi/sq mi) in the Upper Rockpile CalWater to a high of 7.5 mi/sq mi in the Red Rock CalWater, with Lower and Middle Rockpile both with about 6 mi/sq mi.

The Gualala Technical Support Document (CWQCB 2001) identified roads as one of the major current sediment sources in the Rockpile Creek Subbasin. Road densities range from a low of 2.8 miles per square mile (mi/sq mi) in the Upper Rockpile Calwater. A high of 7.5 mi sq/mi in the Redrock Calwater, with the Lower and Middle Rockpile both about 6 mi/sq/mi.

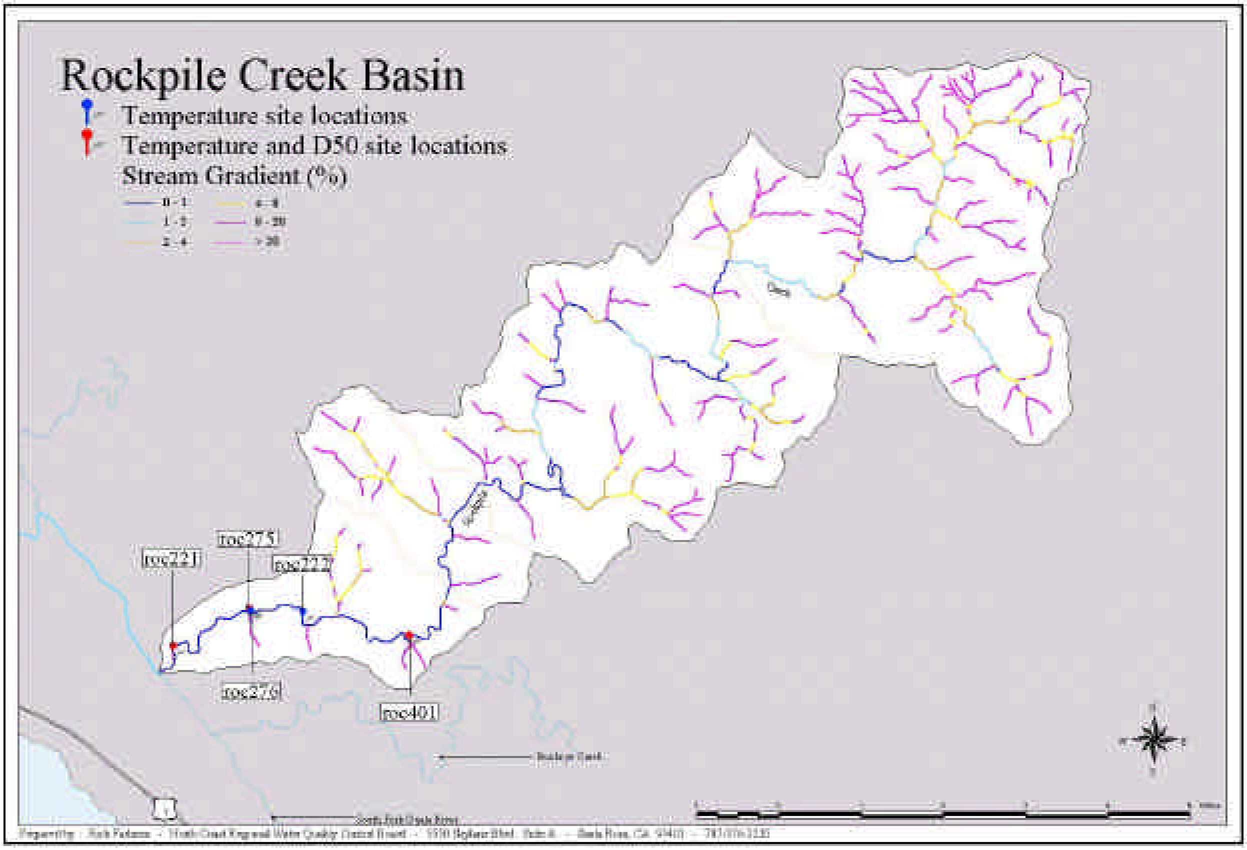


FIGURE 23: Rockpile Creek Temperature & D50 sites

Water Temperatures

Water temperature data were available from GRI for three mainstem and one tributary site in the lower three miles for 1994-98 and 2000-01 (Figure 23). Water temperatures expressed as the MWAT for the tributary (roc 276) were 57 F in 1997 and 1998 (the only years sampled), within the suitable range of 50-60 degrees F. The seasonal maximum for that tributary station was 59 F both years, well below the 75 F lethal maximum (Figure 24).

MWATs for the four sites in the lower three miles of mainstem Rockpile Creek exceeded the suitability range in the years sampled. Seasonal maximum temperatures for those four sites in the mainstem ranged from 71-75 F, just below the lethal maximum.

There was no apparent spatial or temporal trend to the mainstem water temperature data when compared to a LandSat derived vegetation theme. The stations are miles downstream of the open oak woodland, in a forested portion of the lower watershed. Rockpile Creek flows off the melange terrain and may be naturally warm in the Upper Rockpile CalWater, but open canopy along the main stem as it flows into the marine climatic influence probably contributes to high water temperatures lower in the subbasin or maintains the higher temperatures.

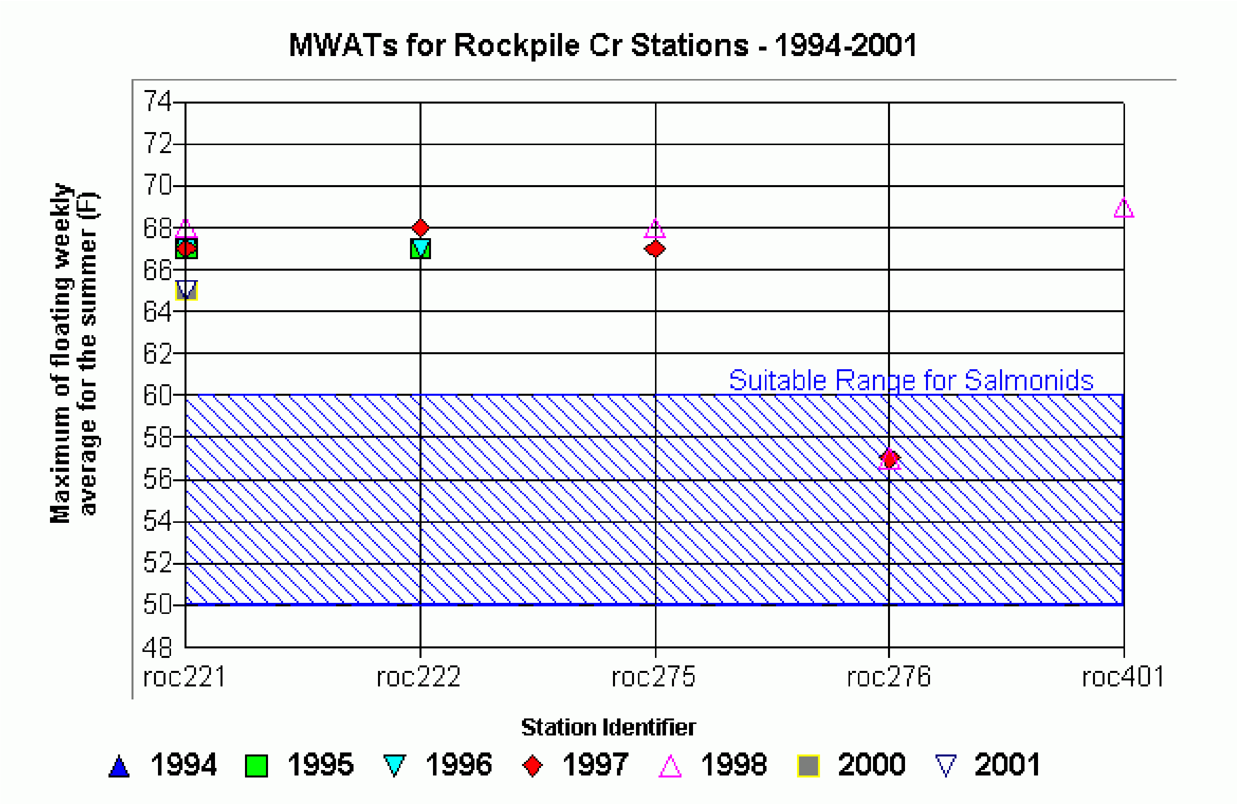


FIGURE 24: Maximum Weekly Avg. temperatures

Maximum weekly average temperatures for sites in the lower three miles of Rockpile Creek.

Roc 276 is a small tributary.

Aquatic/Riparian Conditions

High embeddedness levels found by habitat inventory surveys, along with gravel as the dominant substrate indicate unsuitable habitat for salmonids. In this low gradient environment, the high average range of embeddedness of 51 to 75% was measured from the South Fork confluence to approximately one eighth mile below Red Rock Creek. The survey describes this section of Rockpile as dominated by flatwater and lateral scour pools. Pool frequency by length was 36% and mean pool depth was 1.4 feet.

Large woody debris surveys from the Rockpile Creek subbasin "Watershed Cooperative Monitoring Program"1n 1998 and 1999 at a site in lower Rockpile (# 221) found 18 and 33 pieces per 1000 feet of stream channel with a volume of 1,291 and 2,520 cubic feet, respectively.

To augment the natural recruitment process of LWD, an ongoing cooperative large wood placement project in the watershed has placed an additional 2,909 cubic feet (18 pieces) of LWD in Rockpile Creek. The placement of wood is not included in Table 14.

TABLE 14: Summary of large woody debris surveys

Rockpile Subbasin Watershed Cooperative Monitoring Program (1998 - 2001)				
Tributary	Site Number	Watershed* Size (acres)	Volume CuFt/1000'	Quantity Pieces/1000'
Rockpile Creek	221	22,373	2,412	23

*Watershed size is calculated as the area above the monitoring site.

Fish History and Status

Gradient is suitable for coho salmon in the mainstem of lower Rockpile up through the Middle Rockpile CalWater, although tributaries to lower Rockpile are mainly too steep for the species. A 1974 fisheries survey reported coho juveniles. Electrofishing surveys in the 1990s conducted by CDFG and Coastal Forest Lands (CFL) along segments of Rockpile Creek have not detected coho juveniles. Since the Rockpile "stream system likely had coho in the past", the National Marine Fisheries Service has listed the entire ESU, not just streams which presently have coho populations. The high water temperatures in Rockpile Creek and restricted pool depth are likely limiting coho salmon and steelhead production.

Fish Habitat Relationship

Any redds built in these finer grained beds would be at a greater risk during flows that move the bed.

Subbasin Issues

- Fish density – No current data exists.

- In-stream habitat diversity and complexity, based on surveys available, appears to be insufficiently diverse. Inadequate pool depth, and a lack of escape cover and LWD have contributed to a simplification of instream fish habitat.

- Large Woody Debris (LWD) recruitment potential is very poor overall due to naturally occurring geologic conditions. Land use practices may have exacerbating the naturally occurring geological conditions.

- Land use practices on steep and/or unstable slopes should be conducted in accordance with guidelines and recommendations in DMG Note 50.

- Roads – There is concern over abandoned roads, new road construction, and road maintenance issues related to landsliding and sediment input. Without appropriate maintenance or storm proofing, existing roads, both active and abandoned, may continue to supply sediment.

- Sub-division construction are not an issue at this time. However, Pioneer Ltd owns a larger portion of the upper subbasin and is for sale. Grazing are possible issue as in the upper subbasin.

- Water chemistry – No data is available on pH, DO, nutrients.

- Water temperatures data suggests that summer high temperatures exceed optimal conditions for salmon throughout much of this planning basin.

- Instream sediment data is needed. Based upon a few samples over a short time period there is an indication that fine sediments may be approaching or exceeding levels that are considered suitable to salmonid populations.

- Wildlife/Plants -- Inadequate information exists to assess status and trends of flora and fauna, including invasive species.

Subbasin Issues and Recommendations

Working Hypothesis: The Rockpile subbasin provides unsuitable habitat for coho and somewhat suitable habitat for steelhead.

Supporting Findings:

Sources of upstream sediment include highly erodible earth materials, mass wasting, seismic activity, and land use.

Water temperatures in the estuary, as a result of warming effects upstream, may exceed a level that is fully suitable of salmonids.

Contrary Findings:

Improving canopy

Limitations:

Conclusion:

Recommendations:

Working Hypothesis: *Many roads, in the lower Rockpile Creek basin, are located in erosion-prone areas; such as, adjacent to stream channels or across debris slide slopes. In the upper basin, active earthflow complexes are so abundant that they are unavoidably crossed by many roads.*

Supporting Findings:

Debris slides and debris flows are very common in this subbasin. Delivery of that sediment to watercourses is high. [Plate 1: CDMG Map of Landslides and Geomorphic Features Related to Landsliding; Appendix XX: CMDG Report of Geologic and Geomorphic Characteristics of the Gualala Watershed]

The large portions of the upper basin are underlain with the mélange of the Central Belt of the Franciscan Assemblage and vegetated with prairie and sparse oaks. Runoff from the prairie is rapid creating potentially high peak flows. Landsliding is especially abundant in the mélange. These high flows and landsliding challenge poorly engineered stream crossings.

Contrary Findings:

None at this time.

Limitations:

These conditions are well constrained within the scope of work performed thus far.

Conclusions:

In the erosion-prone Rockpile Creek basin, careful road siting, design, and maintenance is necessary to avoid increased sedimentation of streams. Poorly sited or engineered roads will likely produce sediment impacts to streams.

Recommendations:

Evaluate the feasibility of abandoning streamside roads.

In steep terrain, culverts should be sized to accommodate flashy, debris laden flows. Trash racks or similar structures should be used to prevent culvert plugging. Critical dips should be required to minimize the impact of culvert failure.

Existing roads systems should be maintained and new roads built in accordance to currently recognized Best Management Practices.

Working Hypothesis: *Accelerated erosion from roads has contributed to the sedimentation in the streams resulting in added degradation of salmon habit.*

Supporting Findings:

Comparison of modern and historic stream surveys show a decline in salmon populations.

Comparison of modern and historic stream surveys show that some pools have become shallower and streambeds have become embedded with fine sediment over the last several decades. Both conditions are deleterious to salmon.

Both historic and modern aerial photos show that numerous debris flows and debris slides involve roads and that numerous failures occur along in-stream and near-stream roads and landings. These resulted in increased sedimentation in the streams. [Plate 1: CDMG Map of Landslides and Geomorphic Features Related to Landsliding; Appendix XX: CMDG Report of Geologic and Geomorphic Characteristics of the Gualala Watershed]

Contrary Findings:

None at this time.

Limitations:

These conditions are well constrained within the scope of work performed thus far.

Conclusions:

Upgrading and diligent maintenance of existing road systems to reduce sediment impacts will slow the degradation of salmon habitat –specifically pools and spawning gravels. Careful engineering of new roads or repairs can reduce adverse sediment impacts.

Recommendations:

Road managers should develop and adopt erosion control plans. Repairs and new road construction should be carefully designed and when necessary licensed specialists such as civil engineers, erosion control specialists, and engineering geologists should be consulted.

Working Hypotheses

Accelerated erosion from logged areas has contributed to the sedimentation in the streams resulting in added degradation of salmon habit.

Supporting Findings

- Comparison of modern and historic stream surveys show a decline in anadromous populations.[Appendix XX: CFG Catch Statistics]
- Comparison of modern and historic stream surveys show that pools have become shallower and streambeds have become embedded with fine sediment over between the earliest fisheries surveys between 1964 and presesnt Both conditions are deleterious to anadromous fisheries. [Appendix XX: CFG Stream Survey Report]
- Roads and landings are important sediment sources in the basin. Both historic and modern aerial photos show that numerous debris flows and debris slides involve roads and that numerous failures occur along in-stream and near-stream roads and landings. These resulted in increased sedimentation in the streams.

[Plate 1: CDMG Map of Landslides and Geomorphic Features Related to Landsliding; Appendix XX: CMDG Report of Geologic and Geomorphic Characteristics of the Gualala Watershed]

- Most of the roads in the basin were built strictly to support logging operations.
- Most of the middle reaches of the Rockpile basin were clear-cut between 1952 and 1968 buillding roads in or along the major tributaries streams and main stem Rockpile. Timber operations were particularly pronounced immediately prior to the 1964 flood. Some larger tributary stream basins only required 3 to 5 years to liquidate the timber. This left large areas of disturbed ground on steep slopes.
- The residual effects of heavy channel aggregation from streamside road system failures built in the 1950s and 1960s is noted in timber harvest plan records, particularly the Middle Rockpile Planing Watershed.
- Comparative 20 year stream channel width measurements between 1961 and 1981 show channel width widening responses to more concentrated harvests upstream.
- Large in-stream landings were built in support of logging operations. Many of these were washed out during subsequent storms.
- Modern logging operations are far less intense than those practiced from 1950-1968. In-stream roads and landings are not permitted. Tractor logging on steep slopes is now restricted. The size and degree of clear cuts is now limited. Erosion control is now mandatory for harvested areas.

Contrary Findings:

None at this time.

Limitations

These conditions are well constrained within the scope of work performed thus far.

Conclusions

Past logging practices, specifically tractor operations on steep slopes, accelerated erosion and added excess sediment to stream channels.

Upgrading and diligent maintenance of existing road systems to reduce sediment impacts will slow the degradation of salmon habitat –specifically pools and spawning gravels. Careful engineering of new roads or repairs can reduce adverse sediment impacts.

Recommendations

- Road managers should develop and adopt erosion control plans. Repairs and new road construction should be carefully designed and when necessary licensed specialists such as civil engineers, erosion control specialists, and engineering geologists should be consulted.
- Spread timber harvesting operations through time and space to avoid concentrated road use by heavy equipment and resultant mobilization of road surface fines accessing watercourses.
- Continue to decommission streamside roads and landings. The following tributaries contain the highest density of these still active sediment sources: Red Rock Creek, Horsethief Canyon, and larger tributary watercourses in the middle reaches of the basin flanked by McGuire Ridge between Rockpile Peak and Robinson Ridge, downstream of Burnt Ridge Creek

<u>Working Hypothesis:</u> ***Depleted overstory shade canopy cover along Rockpile Ck. and tributaries from legacy harvests continues to contribute to elevated water temperatures.***

<u>Supporting Findings:</u>

- Heavy tractors building roads, landings, and skid trails in riparian zones shortly after WW II eliminated overstory shade canopy cover throughout long sections of Rockpile Creek and tributaries. There was near entire canopy elimination in the Middle Rockpile Planning Watershed, with operations especially pronounced during the late 1950s to 1964.

Contrary Findings:

- Advanced conifer hardwood regeneration since 1968 has reinstated canopy cover throughout many of the highest tributary reaches.

Recommendations:

- Ensure that adequate streamside protection zones are used to reduce solar radiation and moderate air temperatures in order to reduce heat inputs to Rockpile Ck. and its tributaries.

- Where current canopy is inadequate, use tree planting and other vegetation management techniques to hasten the development of denser riparian canopy.

- Increase continuous temperature monitoring efforts.

Working Hypothesis: ***A lack of in stream large woody debris contributes to simplified riparian habitat structure (e.g., lack of large, deep pools).***

Supporting Findings:

- Heavy tractors building roads, landings, and skid trails in or adjacent to streams between 1952 and 1968 buried, removed, or dispersed LWD in the basin. Field observations have confirmed low LWD distributions.

- Historic and recent timber harvest in lower and middle reaches frequently removed large conifer vegetation down to the stream bank, severely reducing the available recruitment supply of large woody debris.

- Although stream buffers are regrowing under current land management practices and Forest Practice rules, dense buffers of conifers large enough to function, upon recruitment, as LWD in channel formation processes have not yet been reestablished.

Contrary Findings:

None noted.

Limitations: Limited formal stream reach surveys have been done for LWD; however observations of crews and findings regarding pool complexity indicate that there is limited instream LWD.

Recommendations:

- Artificial LWD installation projects vastly speed up in channel diversity development

- Tree planting, thinning from below, and other vegetation management techniques will hasten the development of large riparian conifers.

Buckeye Subbasin

Introduction

Of the three northern sub-basins of roughly equal size, the Buckeye basin (14% of watershed) contains the most moderate terrain compared to the North Fork and Rockpile

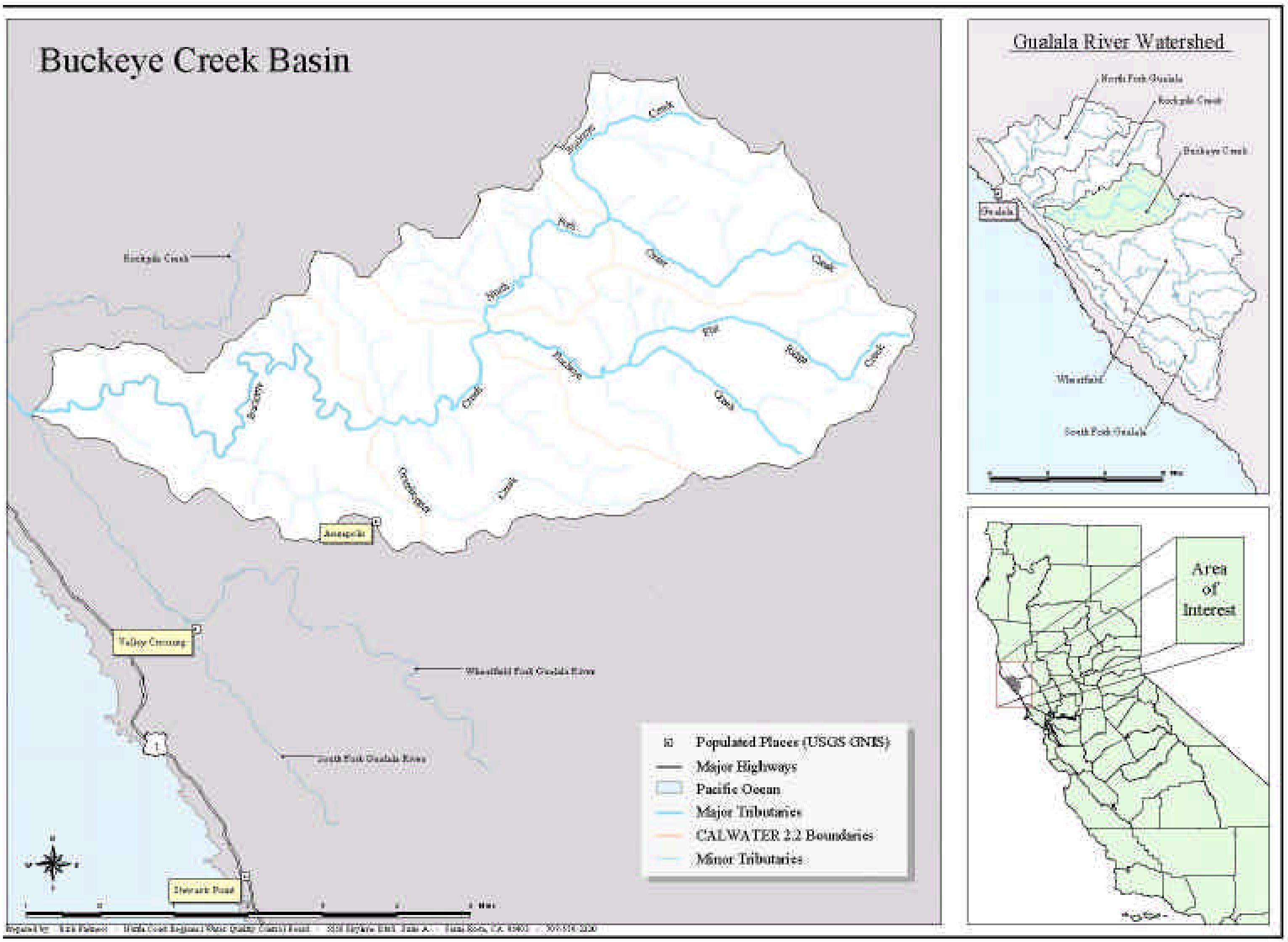


FIGURE 25: Buckeye Creek Basin

Geology

In the mid to upper reaches of Buckeye, stream channels cross and deflect along strike-slip faults creating abrupt zigzags. Osser and Flat Ridge Creeks are two examples. While the mainstem of Buckeye Creek maintains a mild gradient for most of its length, tributaries are steeper having headwaters in supply (>12%) or transport (4-12%) reach categories. Exceptions are Grasshopper, Osser and Roy Creeks, which have long response reaches of channels less than 4% gradient. CDF mapping found abundant landslides in the Buckeye basin following the 1964 storm as well as subsequent major storms. DMG mapping shows numerous historically active streamside failures occur all along its course. Many of these involve poorly maintained older roads. (Plate 1)

Vegetation

The wider Buckeye basin contains high site redwood ground in the lowest reaches. Further inland, Douglas fir and then mixed conifer-hardwood predominates. Oak and prairie grassland is the dominant vegetation type east of Osser and Flat Ridge Creeks. As in Rockpile Creek, the 1942 photos show mature coniferous shade canopy cover over all primary streams. Only the lowest reaches near the confluence with the South Fork is the main channel of Buckeye Creek wide enough to result in bank to bank exposure (see Figure 26 below).

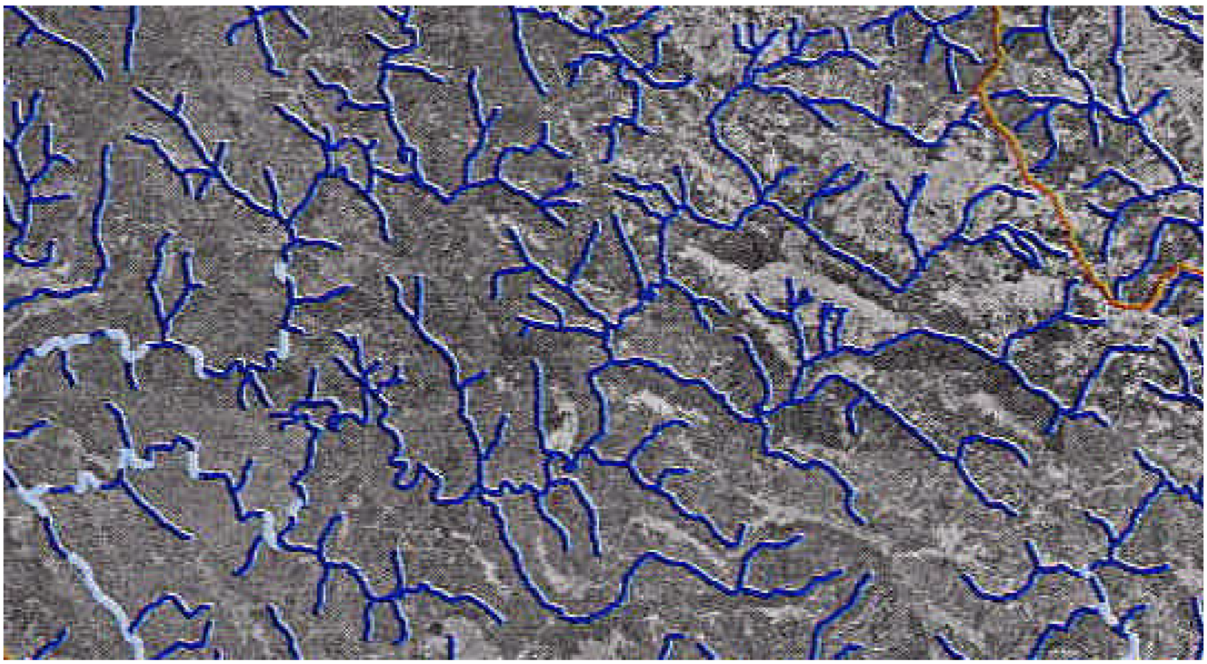


FIGURE 26: 1942 Bank to bank shade Canopy Exposure

Bank to bank shade canopy exposure (white) and partial to entire cover (blue).

Land Use

In the late 1950s, the Franchini Creek basin and surrounding area formed the south portion of the large multi basin harvest complex area bounded by the upper North Fork and the main stem Buckeye Creek. This unit followed a large mid 50s operation that extended south from the main stem Buckeye through the lower Wheatfield basin to lower Fuller Creek. In the middle 1950s, downslope Douglas fir trees lining a narrow riparian corridor were removed from both Roy and Osser Creeks. The Grasshopper Creek sub-basin was logged by 1964. Downslope areas of Douglas fir were logged throughout Soda Springs and Flatridge Creeks by 1964. Streamside roads and landings are particularly concentrated throughout (1) Francini Creek, (2) Grasshopper Creek, and (3) the North Fork Buckeye including Osser Creek. (See Figure 27 below).

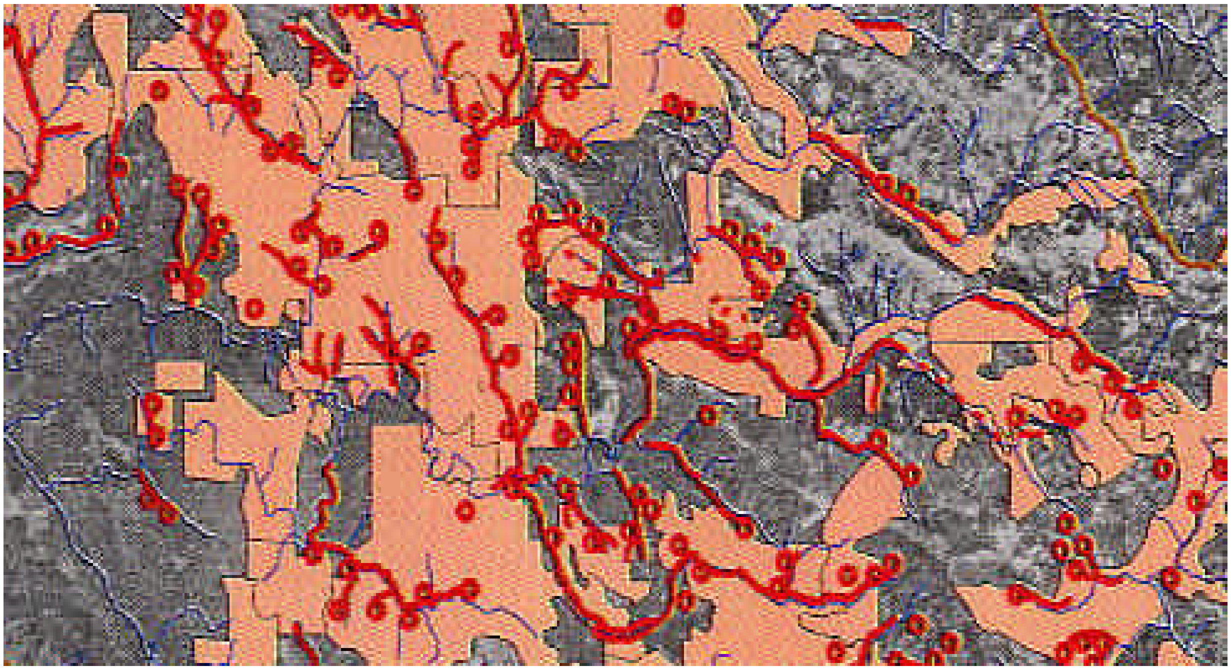


FIGURE 27: Buckeye Basin - Harvest Operations 1952-1964

Also shown above streamside roads and landings 1952 to 1968. Red lines show where road fill has been pushed into the creek

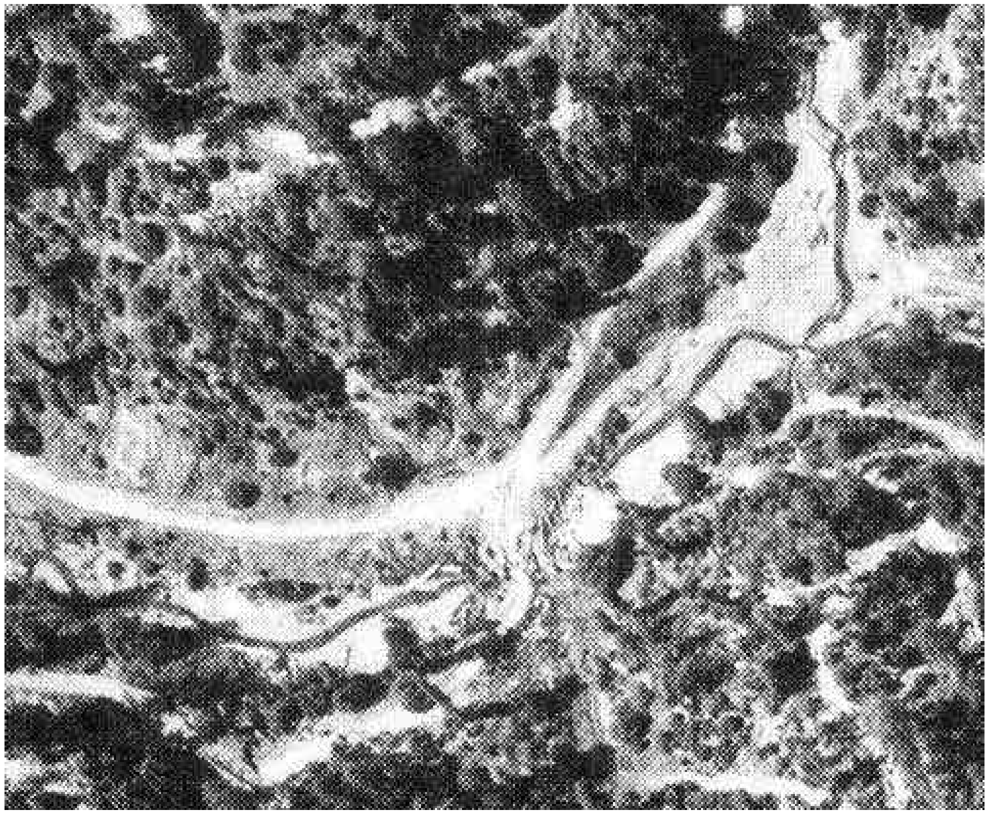


FIGURE 28: Grasshopper Creek

Tractor yarding was active in the Grasshopper Ck. basin in the mid 60s, leaving logs and wood debris piled over the stream channel. During the 1964 flood, this debris floated down to a low road crossing of Grasshopper Ck (left), creating a jam. The resulting dam breached at the south road approach, diverting onto the west road. approach, which collapsed into the Creek. Sinuous channel movement is evident through silt and sand depositions (left). Grasshopper Ck still has higher sediment loads today as a lower gradient watercourse.

Major sediment inputs from tractor logging areas by the 1964 flood and subsequent storms are well documented. Timing of pool infill and development

Over the streambank of a shallow pool structure coincides with declining fisheries and habitat conditions. See Fisheries Section for progression of declining stream stucture and fisheries distributions over time.

Twenty year interval stream channel width measurements from 1942 to 1999 show a response widening of the lower Buckeye storage reach between 1961 and 1981 from the mouth to Franchini Ck. This coincides with concentrated harvest activites between the late 1950s to 1968 when most of the timbered areas in the basin had been liquidated by tractors over a narrower time frame compared to the North Fork at this time, which did not show a response. 1942 channel widths can be considered baseline as most of the basin at this time consisted of undisturbed Douglas-fir timberlands.

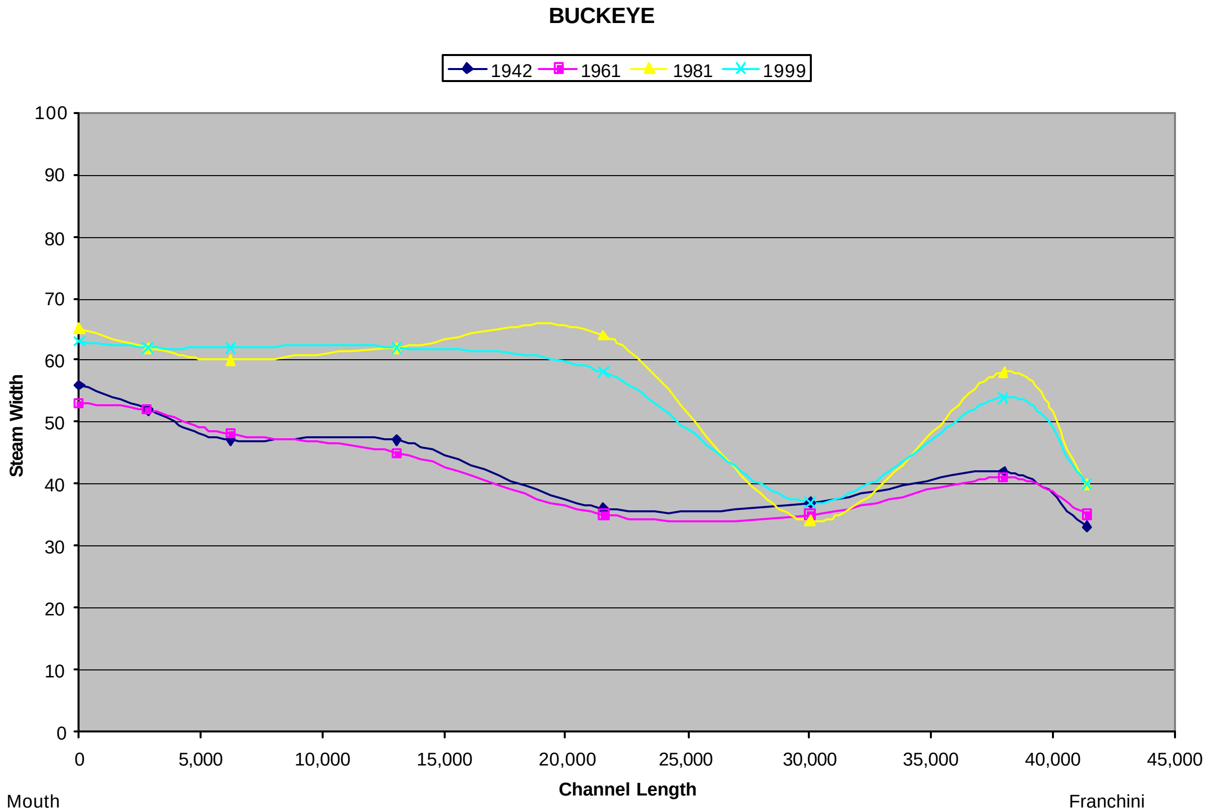


FIGURE 29: 20 yr. intervalstream channel

***1942 to 1999, lower Buckeye reach*.**

The interval between 1942 and 1961 shows similar widths at the time when the Francini Creek basin was just finished, and tractors were moving northeast towards Grasshopper Ck. No recovery or narrowing is indicated by 1999 compared to 1981.

During THP review, Senior DMG Geologist T. Spittler described "The Buckeye Creek watershed has been severely impacted by tractor logging between WWII and 1973. Skid trails were constructed in streams and draws, watercourses were filled, and surface flows were concentrated and diverted. As a result, Buckeye Creek is severely aggraded, filling most pools" (Geological Review 89-091 SON, T. Spittler). Past damage is still contributing significant quantities of sediment to streams. Large amounts of stored sediments are still present in these watercourses. During storm events, this material moves downstream filling pools, scouring channels, and silting spawning beds. Old woody debris pushed into the channel now rots out losing support strength among the soil matrix. This causes more stream channel failures and entry of soils and fine sediment into watercourses (CFL THP 1-95-114).

A no-harvest provision within the Class I (in the middle reaches on CFL lands and vicinity) follows a four year standard of added protection for Buckeye Creek. "The landowners and agencies agree that Buckeye Creek has a temperature problem and needs additional time to develop the shade and pools to improve fish habitat. The pre-1973 practice to build roads and landings in or near streams was widespread and led to massive degradation of the stream system. They were choked with sediment and large woody debris. Stream side vegetation was eliminated and shade canopy was greatly reduced." (S Smith, CDF Field Inspector).

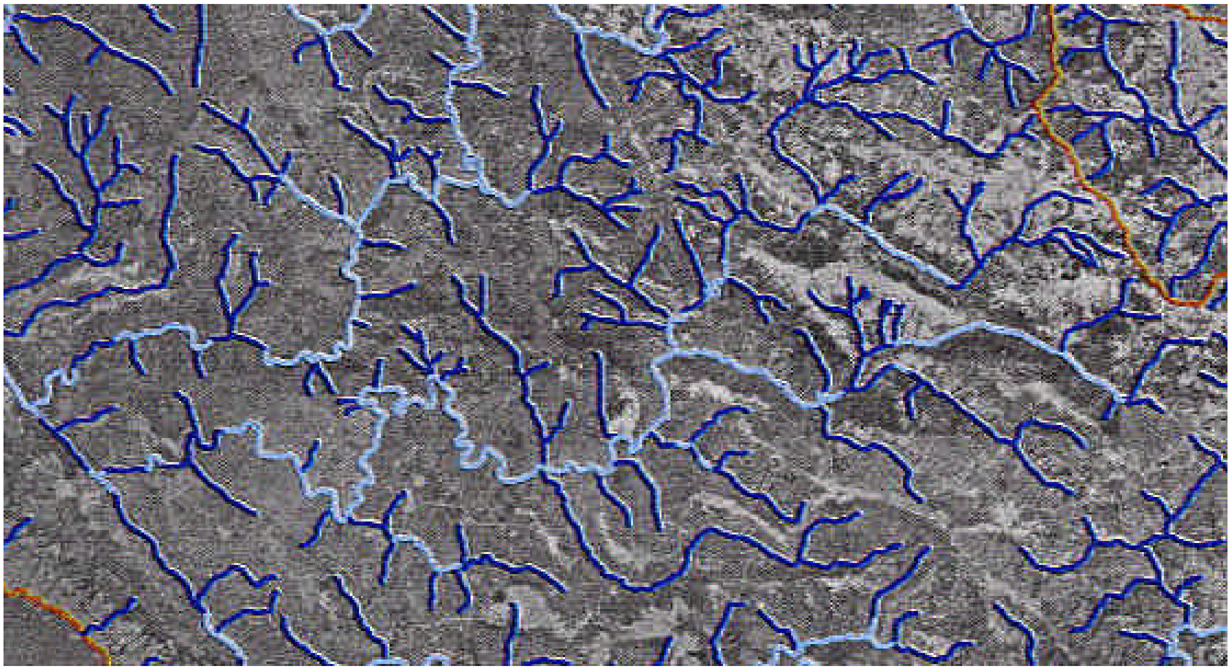


FIGURE 30: 1981 - Bank to bank shade canopy exposure

1981 Bank to bank shade canopy exposure (white) and partial to entire canopy cover (blue)

DOCUMENTATION OF LAND USE IMPACTS BY MAJOR TRIBUTARY

Little Creek

- The Little Ck. basin was logged during the late 1950s. The main haul road followed the stream channel throughout the entire Class I portion of Little Ck. Numerous in stream landings were concentrated in this tributary watershed.
- Lower to Mid Reaches Buckeye, CFL, the main seasonal road followed along the streambed or adjacent to Buckeye Ck. (See Logging Impacts Map , CDF NCWP). This road undercut steep ground between Stanly and Brushy Ridges causing landslides into Buckeye Ck. This road section has been abandoned by a rock slide and numerous washouts. Little River tributary also similarly tractor logged. Tractor logging occurred on slopes in excess of 65% (97-036, CFL).

Franchini Creek.

- The entire tributary basin was logged 1959-1960. The main seasonal road followed in and adjacent to the stream channel. Numerous debris slide failures have been noted along the main WLPZ road in 1961 and 1965 photos, as Francini Ck. undermined the road
- WQ stream surveys of Francini Ck find fine sediment almost completely burying cobble (WQ TMDL, 2001).
- The Francini Ck. watershed was burned through during the 1950s. Subsequent salvage logging used in WLPZ roads and in stream landings (97-034, CFL).

Grasshopper Creek.

- o The main haul road, now abandoned, followed the stream channel of Grasshopper Ck. leading west to the Buckeye Ck. Rd. No culverts were used and the road was abandoned with no stabilization measures applied. Logs were skidded downhill, often directly in watercourses. No waterbars were built or stream crossings ditched out. Stream channels now contain large amounts of stored sediment behind jams of large woody debris. The channel continues to downcut to pre-logging level. (93-328)
- o Fine sedimentation in pools relative to volume of fine sediment and water (V*) shows 59% pool volume filled with fine sediment, rating comparatively high (Knopp, 1992).
- o Grasshopper Creek enters a steep, narrow canyon before its confluence with Buckeye Creek. The canyon walls are mapped as debris slide slopes; although, no landslides were found in the photos

examined. In fact landsliding is somewhat rare in the Grasshopper Creek basin (DMG NCWP)..

Middle Reaches Buckeye Creek.

- Subject to harvest removals and conversion to pastureland, including burning, during the 1950s, 1960s. High sedimentation and accumulation of debris were found in channel. Downcutting and subsequent downstream aggregations were noted. Uncontrolled installation of fills, failure to remove fills, and lack of erosion control facilities has caused several landslides and locally severe erosion. Soda Springs Cks. are also Class I watercourses. PHI describes LWD as common in smaller streams. Existing haul road leads in and out of Buckeye Ck. There were major road repairs to correct on site sediment sources (97-070 and 442, CFL).

- Water T, 16 to 19C, east and west tributaries Buckeye Ck. exceed optimum for Coho south of Bear ridge, Kelly Rd (Flat Ridge Ck. Planning Watershed). Much of the streams are forested with sapling sized conifers/ hardwoods. Extensive grassland areas with more open riparian zones from older intent to conversion, now abandoned. Watercourse areas were heavily cut out during late 1950s tractor operations. Stream diversion repairs noted. New road construction to relocate road segments to ridgeline (CFL 97-227).

- Stream diversion realignments of Class II watercourses specified to repair deep gully erosion down roads and skid trails. This was required on an 800 acre plan upslope of Buckeye Ck as a Class I watercourse. A no-harvest provision within the Class I follows a four year landowner agreement standard of added protection for Buckeye Ck.

North Fork Buckeye

- Steelhead and Coho reported in North Fork Buckeye in 1964. A 1982 survey found pools at 25-40%. Steelhead comprised 40% of fish, among high temps, algae blooms, and lack of cover. A 1995 survey showed 20% pools.

- No harvest WLPZ measures implemented to mitigate streamshade deficiencies from pre 1973 era. Historically, area occupied by Douglas-fir. The area was tractor logged during the 1950s. Some areas entered lightly due to terrain and poor quality of the timber stand. Uncontrolled installation of fills, failure to remove fills, and lack of erosion control facilities has caused several landslides and locally severe erosion. Correction of on-site sediment sources with THPs. Watercourse diversion repairs were noted under THP 1-97-084. Historical intent to permanent conversion to grazing lands with the Howlett Ranch. The older haul road was located adjacent to NF Buckeye Ck. A diverted Class II watercourse triggered a large translational/ rotational slide and "massive erosion" (DMG Report, M. Manson CFL 97-084). The plan required redirection of the watercourse to natural channel by excavator work. Class II watercourse tractor crossings left in place from the 1950s have washed through leaving vertical cuts over 6 ft. down.

<u>Roy Creek (higher Buckeye watershed)</u>

- Most areas were tractor logged during late 1950s to 1960s. Logging was accompanied by attempted conversion to rangeland. Site recon. during several PHIs documents tractor skidding down all slopes irregardless of steepness, to roads and landings located in or adjacent to watercourses. The lack of erosion control caused deep gullying down skid trails discharging into watercourses. Large quantities of soil and debris was placed or washed into watercourses. Debris slides above and below roads are common and frequent. Maintenance of a passable road surface involves clearing of slide debris from the roads and installing infrequent ditch relief culverts. Recent timber harvest activity since 1973 repaired and improved drainage conditions where operations occurred. (M. Jameson, CDF Audit Forester, 1995).

- Roy Ck., in the lower 2 miles above the confluence with Osser Ck., is described in poor condition. High bedloads of sediment line the channel, partially filling pools. Size of pools is reduced by sediment. LWD is not abundant. Upper tributary of N.F.Buckeye Ck. is wide and shallow with low amounts of LWD. Most of the large hardwood and conifers that once lined the streambanks have been cut and the area converted to grass, creating high stream temperatures. (M. Jameson, 95-114). A pool at 2:00 P.M. 8/19/94 measured 75F, a second at 72F. With the recent elimination of grazing activity, conifers have begun to reinvade pastured areas

- The lower kilometer of Roy Creek crosses the Tombs Creek Fault Zone and is impacted by a large active earthflow complex that makes up the NW hillside above the creek. The earthflow formed in the Central Belt Formation which is on the NE side of the Tombs Creek Fault Zone. (the earthflow is a grassy area, probably never offered LWD

Osser Creek (higher Buckeye watershed)

- Logged by late 1950s. Many areas in Osser Ck. subwatershed were first harvested by a diameter limit cut. Tractor operations used some creek channels as skid trails, building landings in or near watercourses. Sediment pushed into creeks from historical operations is still present, and slowly flushing during peak flow events (CFL 99-145).

- Field recon during several PHIs describes Osser Ck subject to heavy deposits of soil and debris (CFL 97-070 and CFL 95-114). Size of pools reduced substantially by filling with fine sediments. An active earthflow impinges on the creek in areas probably contributing fines but on-site evaluation is needed to verify. Most channel overstory cover removed by historical logging and conversion to pastureland. Current shade on Osser Ck. is estimated at 80% in upper reaches, and increasingly lower in downstream reaches. Current condition is described in a stage of recovery, requiring many decades for fine materials to flush downstream during high flow events. Background levels of sedimentation are generally high but not specifically known and should be considered in evaluating recovery from land use disturbance. Streamside shading will similarly require several decades to recover with conifer ingrowth after cessation of grazing and conversion to pastureland. (M. Jameson, 95-114).

Fluvial Geomorphology

Aerial photo interpretation of the North Fork Gualala planning watershed found overall levels of channel disturbance greater in the 1984 photos (WAC-84-C, 4-21-84) than the 1999/2000 photos (WAC–C-99CA, 4-13-99; WAC-00-CA, 4-2-00).

Little Creek Planning Watershed

Buckeye Creek in the Little Creek planning watershed is characterized by approximately 80 percent apparent channel disturbance in the 1984 imagery. Bank erosion is common in the reach upstream of Little Creek. Seventeen delivering landslides are mapped. Little Creek has approximately 80 percent apparent channel disturbance in the 1984 imagery with some areas of bank erosion and 14 delivering landslides.

By 1999/2000, Buckeye Creek has recovered some with approximately 50 to 75 percent channel disturbance and 12 delivering landslides. Bank erosion continues upstream of the junction with Little Creek. Little Creek has recovered more with approximately 25 percent of the channel having disturbance characteristics and 6 delivering landslides mapped.

Grasshopper Creek Planning Watershed

The 1984 imagery of Grasshopper Creek planning watershed shows that Buckeye Creek between Grasshopper and Soda Springs creeks is approximately 25 percent disturbed with some areas of bank erosion and two delivering landslides. By 1999/2000 the area increase in apparent disturbance to less than 50 percent, continued bank erosion and seven landslides delivering sediment to the channel.

In Francini Creek, the 1984 imagery shows at least 90 percent channel disturbance with 17 delivering landslides. In the 1999/2000 imagery some improvement is evident with approximately 50 percent of the reach apparently disturbed reach with 2 delivering landslides.

The lower reach of Grasshopper Creek is approximately 50 to 75 percent disturbed in the 1984 imagery with 3 delivering landslides. By 1999/2000 signs of apparent channel disturbance are less than 25 percent of the reach, mostly in the upper portion. Four delivering landslides are mapped from the 1999/2000 images.

Soda Springs Creek shows approximately 25 percent apparent channel disturbance and 2 delivering landslides in 1984 imagery. In the 1999/2000 images, disturbance characteristics are seen on less than 10 percent of the reach, but 4 delivering landslides are mapped.

Harpo Reach Planning Watershed

In the 1984 imagery, the North Fork of Harpo Reach planning watershed shows approximately 10 percent apparent disturbance most within a mile upstream of the junction with Buckeye Creek. Some additional disturbance is mapped along an un-named tributaries in Sections 29 and 30, of Township 11 North, Range 13 West. Ten delivering landslides are mapped across this planning watershed.

By 1999/2000 the un-named tributaries in Section 29 continue to show disturbance while the section of North Fork above Buckeye Creek appears to have recovered. A new portion of Buckeye Creek for approximately one mile below the North Fork Osser planning watershed boundary now has signs of channel disturbance. Other areas of the watershed show general improvement in channel conditions.

Flat Ridge Creek Planning Watershed

The lower reach of Buckeye Creek below Flat Ridge Creek is generally disturbed up to 75 percent of the reach in the 1984 imagery and 4 delivering landslides are mapped. Above the junction with Flat Ridge Creek, the 1984 imagery shows less disturbance in Buckeye Creek with up to 50 percent impacted and 8 deliverin landslides.

By 1999/2000 the portion of Buckeye downstream of Flat Ridge Creek has improved with approximately 20 percent disturbed and 7 delivering landslides. Above Flat Ridge Creek, Buckeye Creek continues to have approximately 50 percent disturbed reach, but the disturbed areas are a higher percentage in the downstream portion.

Flat Ridge Creek shows approximately 70 percent disturbance in the 1984 imagery and 10 delivering landslides. By 1999/2000 the reach has generally recovered from the disturbance.

North Fork Osser Creek Planning Watershed

In the 1984 imagery, Roy Creek shows less than 10 percent of the channel disturbed with 2 delivering landslides near the junction with Osser Creek. In the 1999/2000 images, channel disturbance appears to increase to less than 25 percent. Osser Creek has approximately 10 percent disturbance and 4 delivering landslides in the 1999/2000 images.

Water Quality

In-stream Sediment

Streambed particle sizes are small compared to Knopp (1993), and may be a limiting factor for salmonid suitability in parts of the Buckeye Creek subbasin. Median particle size (D_{50}) measurements were provided by GRI for three sites in about the lower three miles of the Buckeye mainstem (Little Creek Planning Watershed). Data from three sites in the middle section, from 3.5 to 13 miles upstream (Little Creek, Grasshopper Creek, and Flat Ridge Creek Planning Watersheds), were provided by CFL (Figure 31).

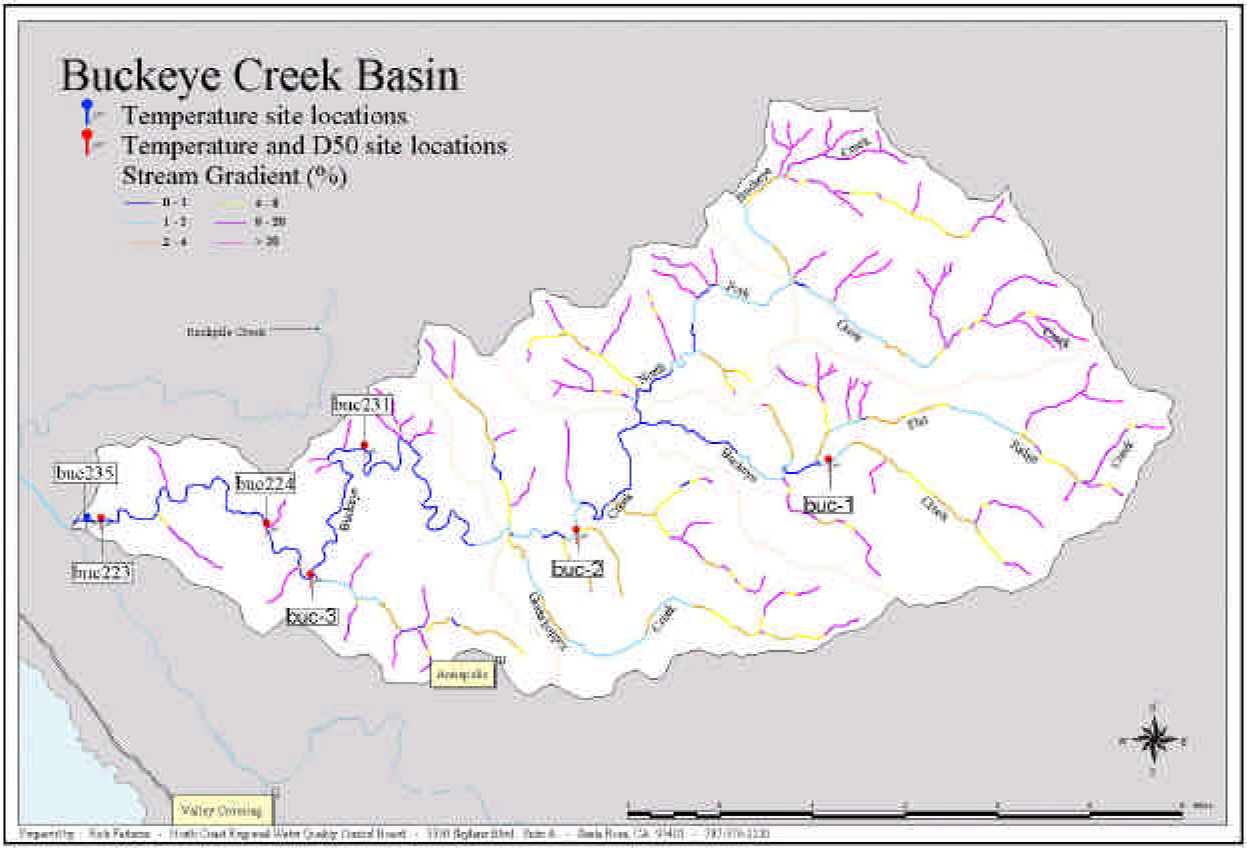


FIGURE 31: Buckeye Creek sampling sites

(buc-1, buc-2, and buc-3 are CFL sites)

GRI measured D_{50} at three transects per site in 1997, the upper site in 1998, and the lower site in 2000. CFL measurements are for the 1995-1997 period. The lowest site in the basin (BC#223) showed some improvement over time, two transects of three showing an increase in D_{50} from the 1997 medians of 16 and 30 mm to D_{50} values of 35 and 47 mm in year 2000.

The CFL data showed a decrease in particle size from their upper site to the lower site, a span of about 9 miles. The upper site D50 was 24 mm, the middle site was 18 mm, and the lower site was 9 mm.

To compare the data to Knopp (1993), the individual D_{50} values for the sites (3 transects per site) were averaged. The minima, maxima, and averages were considerably lower than the same statistic from Knopp (1993): following table and figure.

Stream Name	Years	No. of Sites	No. of Samples *	Minimum (mm)	Average (mm)	Maximum (mm)
Lower Buckeye Creek (GRI)	97 one for 97-99	3	5	25	28	32
Middle Buckeye Creek (GRI)	97, 99	3	9	16	25	38
Knopp (1993) Index Streams	1992	6	18	37	69	183
* no. of samples = number of averages included in the comparison						

TABLE 15: Median Particle size (D50) sampling efforts

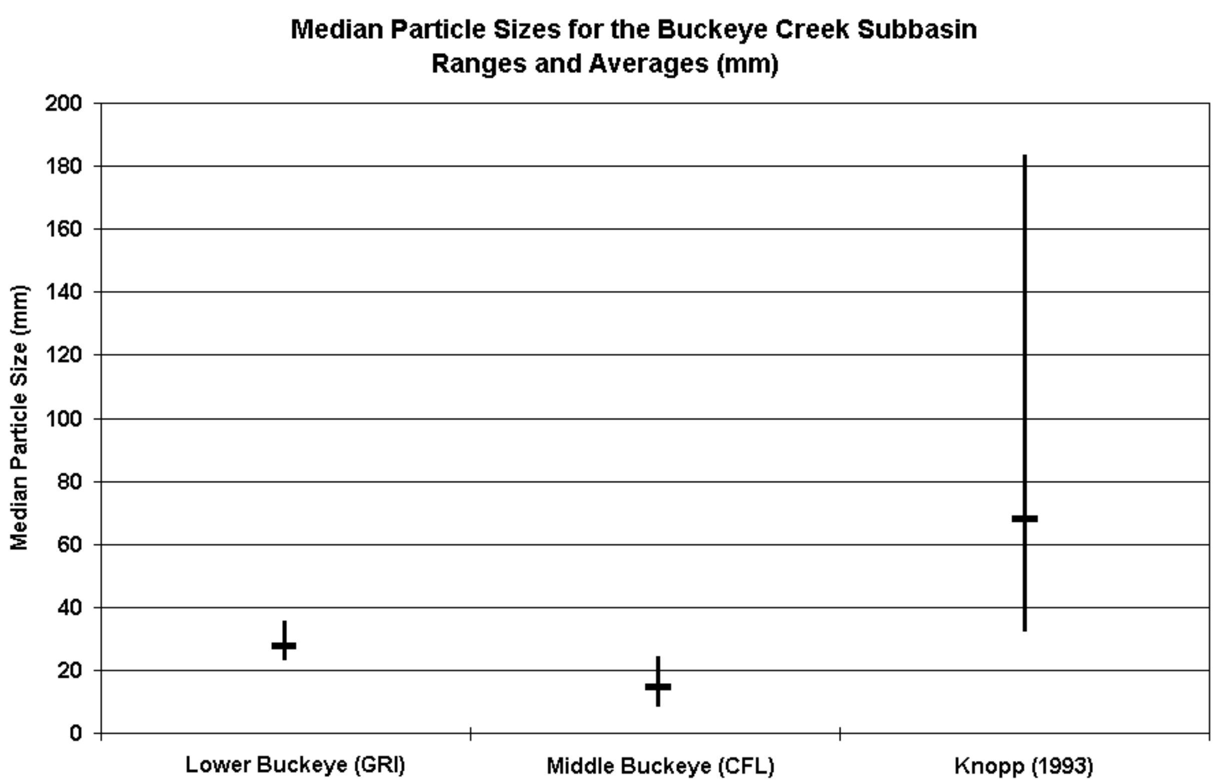


FIGURE 32: Median particle sizes in Buckeye Creek Subbasin

The lowest site in the basin (BC#223) showed some improvement over time, two transects of three showing an increase in D_{50} from the 1997 medians of 16 and 30 mm to D_{50} values of 35 and 47 mm in year 2000.

Water Temperature

Water temperatures for the mainstem Buckeye Creek in the lower three miles are probably limiting suitability for salmonids. Continuous temperature monitoring data were available from GRI for four sites in the same area as the sediment data (lower three miles of the mainstem), for a total of 15 seasonal points in the period of 1994-1977 and 1999-2001 (Figure 31, above).

Seasonal maximum temperatures for the mainstem ranged from 70-76 F, close to the lethal maximum. MWAT values were above the proposed "fully suitable range" of 50-60 degrees F at all sites in all years, with an apparent downstream cooling (Figure 33).

The LandSat-derived vegetation theme for the Buckeye Creek subbasin shows more open stream canopy than for Rockpile as Buckeye flows into the marine influence, probably contributing to high water temperatures low in the subbasin to a greater extent.

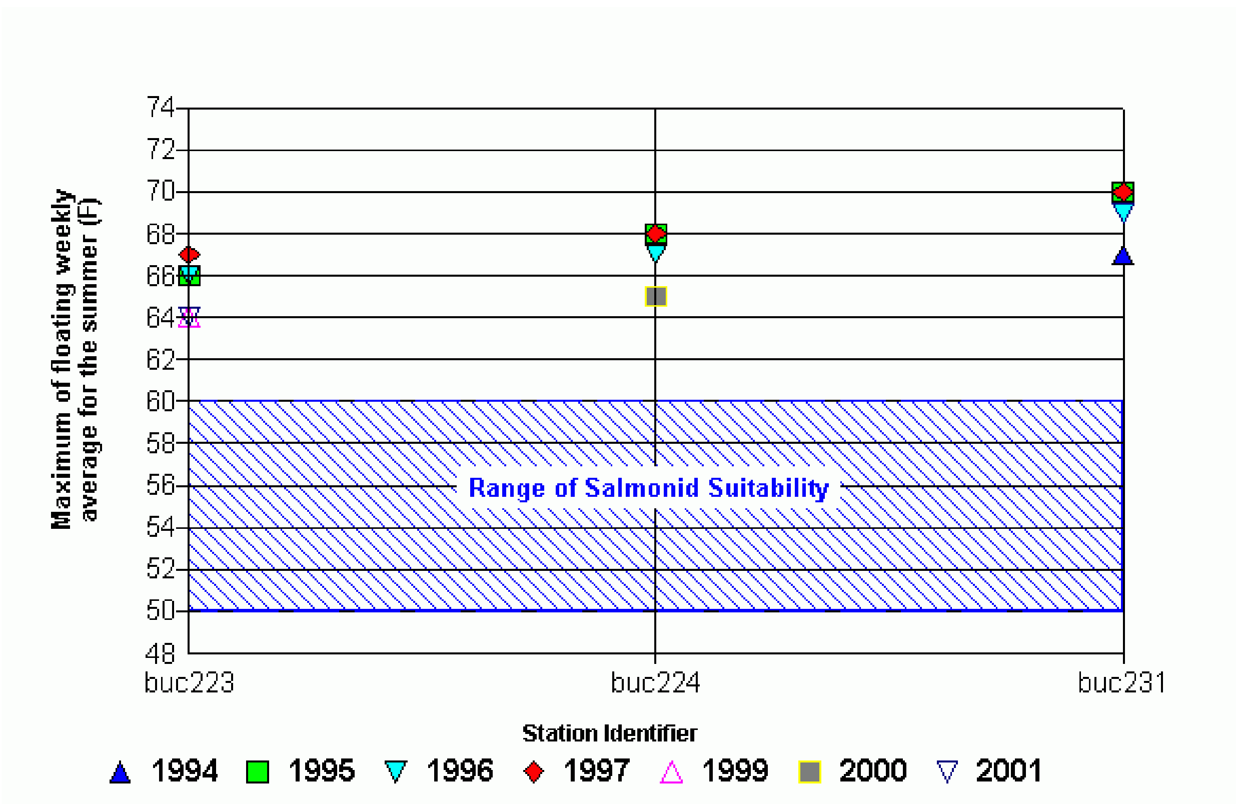


FIGURE 33: MWAT - lower three miles - 1994-2001

Maximum weekly average temperatures (MWAT) for the lower three miles of the Buckeye Creek subbasin, 1994-2001.

Aquatic/Riparian Conditions

Habitat inventory surveys conducted in 2001 showed the dominant substrate as gravel. Average embeddedness from DFG surveys in 2001 was higher than optimal, ranging from 26-50% along the main stem to Flatridge Creek.

TABLE 16: Instream Data

Buckeye Subbasin

DF&G Habitat Typing Data

(June-August, 2001)

Tributary	Pool Frequency *	Pool Depth Maximum (Feet)	Pool Depth Mean (Feet)	Dominant Substrate	Substrate Embeddedness
Buckeye Creek	41%	3.5	1.2	Gravel	26-50%

* By habitat occurrence

TABLE 17: Summary of Large Woody Debris

Buckeye Subbasin
Watershed Cooperative Monitoring Program
(1998 - 2000)

Tributary	Site Number	Watershed* Size (acres)	Volume CuFt/1000'	Quantity Pieces/1000'
Buckeye Creek	223	25,588	2,946	49
Buckeye Creek	231	21,198	0,228	7

*Watershed size is calculated as the area above the monitoring site.

The Cooperative Monitoring Program surveys show both Buckeye Creek sites lacking in volume and pieces of LWD (Table 17). Buckeye is slated to be part of phase two of the LWD cooperative placement project in the watershed.

Results from macroinvertebrate population sampling can be used to evaluate the occurrence of various types of pollutants and current watershed conditions. Samples taken at one reach site in the Buckeye subbasin in 2000 by Jon Lee can be characterized as average when compared to similar north coast watersheds (Table 18).

TABLE 18: Summary of Macroinvertabrate Sampling

Gualala Redwoods, Inc.
Buckeye Subbasin
(2000)

Tributary	Site Number	Watershed* Size (acres)	Richness	Simpson Diversity	Hilsenhoff	Abundance	Dominant Taxon
Buckeye	223	25,588	32	0.88	4.0%	5,713	26%

*Watershed size is calculated as the area above the monitoring site.

Fish History and Status

Buckeye Creek spawning areas were noted to be an average of 25-50% embedded, which is over the optimal range for salmonid spawning substrate in 1998. Electrofishing of Franchini Creek in 2001 observed steelhead, and no coho were found.

A second 1995 survey showed that Buckeye Creek had a fish community dominated by less than one year old steelhead with a few sculpin also present. Yearling and two year old steelhead were present but in low numbers.

Kimsey (1953) reported steelhead young-of-the-year were concentrated in the upper reaches. One year and older congregated in the lower reaches during the summer. Cox (1994) stated that coho had once existed in Buckeye Creek and Franchini Creek. Fox and Quinn (1964) reported incidental occurrence of coho and steelhead upstream in the North Fork Buckeye below Osser and Roy creeks, although roach predominated the sample.

The summer 1964 survey showed 50% pools among boulders occupied by steelhead at 250/ 100 ft. 1-8 inches long. One stream temp of 72 F was measured during the September 1964 survey.

Fish Habitat Relationship

Habitat inventories were conducted on the entire 53,653 feet of mainstem Buckeye Creek in 2001. The pool frequency was 44% by percent occurrence. Maximum pool depth was 3.5 feet and mean pool depth was 1.2 feet.). Survey reaches were co-dominated by mid-channel pools and flatwater with a substrate consisting of gravel. Canopy closure averaged 53% with conifers contributing 35% and deciduous tree the remainder.

A 1970 survey reported 30% pools, and substrate from predominantly gravels to 50% silt and 30% sand, after logging and 1964 flows. A 1980 survey found steelhead, fine sediment and lack of shade documented (99-445). Stream aggradation is indicated as a result of past forest practices as evidenced by numerous alluvial flats and general absence of deep pools. A 1995 survey found 20% pools, majority in 3 to 4 foot depth range and deeper. Limited watercourse shade canopy overstory cover was reported in higher (east) portions of the Buckeye Creek watershed.

Subbasin Issues

- Fish density – No current data exists.
- In-stream habitat diversity and complexity, based on surveys available, appears to be insufficiently diverse. Inadequate pool depth and a lack of escape cover and LWD have contributed to a simplification of instream fish habitat.
- Large Woody Debris (LWD) recruitment potential is very poor overall due to naturally occurring geologic conditions. Land use practices may have exacerbating the naturally occurring geological conditions.
- Land use practices on steep and/or unstable slopes should be conducted in accordance with guidelines and recommendations in DMG Note 50.
- Roads – There is concern over abandoned roads, new road construction, and road maintenance issues related to landsliding and sediment input. Without appropriate maintenance or storm proofing, existing roads, both active and abandoned, may continue to supply sediment.
- Sub-division construction are not an issue at this time. However, Pioneer Ltd owns a larger portion of the upper subbasin and is for sale. Grazing are possible issue as in the upper subbasin
- Water chemistry – No data is available on pH, DO, nutrients.

- Water temperatures data suggests that summer high temperatures exceed optimal conditions for salmon throughout much of this planning basin.

- Instream sediment data is needed. Based upon a few samples over a short time period there is an indication that fine sediments may be approaching or exceeding levels that are considered suitable to salmonid populations.

- Wildlife/Plants -- Inadequate information exists to assess status and trends of flora and fauna, including invasive species.

Subbasin Issue Synthesis and Recommendations

Working Hypothesis*:* ***The Buckeye subbasin provides unsuitable habitat for coho and somewhat suitable habitat for steelhead.***

Supporting Findings:

- EMDS results and temperature data are still being analyzed.

Contrary Findings:

Improving canopy

Potential Recommendations:

Working Hypotheses

Accelerated erosion from logged areas has contributed to the sedimentation in the streams resulting in added degradation of salmon habit.

Supporting Findings

- Comparison of modern and historic stream surveys show a decline in anadromous populations.[Appendix XX: CFG Catch Statistics]

- Comparison of modern and historic stream surveys show that pools have become shallower and streambeds have become embedded with fine sediment over between the earliest fisheries surveys between 1964 and present. Both conditions are deleterious to anadromous fisheries. [Appendix XX: CFG Stream Survey Report]

- Roads and landings are important sediment sources in the basin. Both historic and modern aerial photos show that numerous debris flows and debris slides involve roads and that numerous failures occur along in-stream and near-stream roads and landings. These resulted in increased sedimentation in the streams. [Plate 1: CDMG Map of Landslides and Geomorphic Features Related to Landsliding; Appendix XX: CMDG Report of Geologic and Geomorphic Characteristics of the Gualala Watershed]

- Most of the roads in the basin were built strictly to support logging operations.

- Most of the middle reaches of the Buckeye basin were clear-cut between 1952 and 1968 building roads in or along the major tributaries streams and main stem Buckeye. Some larger tributary stream basins only required 3 to 5 years to liquidate the timber. This left large areas of disturbed ground.

- The residual effects of heavy channel aggregation from streamside road system failures built in the 1950s and 1960s is noted in timber harvest plan records, particularly the middle reaches Buckeye basin.

- Comparative 20 year stream channel width measurements between 1961 and 1981 show channel width widening responses to more concentrated harvests upstream.

- Large in-stream landings were built in support of logging operations. Many of these were washed out during subsequent storms.

- Modern logging operations are far less intense than those practiced from 1950-1968. In-stream roads and landings are not permitted. Tractor logging on steep slopes is now restricted. The size and degree of clear cuts is now limited. Erosion control is now mandatory for harvested areas.

Contrary Findings:
None at this time.

Limitations

These conditions are well constrained within the scope of work performed thus far.

Conclusions

Past logging practices, specifically tractor operations on steep slopes, accelerated erosion and added excess sediment to stream channels.

Upgrading and diligent maintenance of existing road systems to reduce sediment impacts will slow the degradation of salmon habitat – specifically pools and spawning gravels. Careful engineering of new roads or repairs can reduce adverse sediment impacts.

Potential Recommendations

- Road managers should develop and adopt erosion control plans. Repairs and new road construction should be carefully designed and when necessary licensed specialists such as civil engineers, erosion control specialists, and engineering geologists should be consulted.
- Spread timber harvesting operations through time and space to avoid concentrated road use by heavy equipment and resultant mobilization of road surface fines accessing watercourses.
- Continue to decommission streamside roads and landings. The following tributaries contain the highest density of these still active sediment sources:
  - Franchini, Grasshopper, and Osser Creeks.

Working Hypothesis: ***Depleted overstory shade canopy cover along Buckeye Ck. and tributaries from legacy harvests continues to contribute to elevated water temperatures.***

Supporting Findings:
- Heavy tractors building roads, landings, and skid trails in riparian zones shortly after WW II eliminated overstory shade canopy cover throughout long sections of Buckeye Creek and tributaries. There was near entire canopy elimination in the middle reaches and upper reaches of the Buckeye basin, with operations especially pronounced during the late 1950s to 1964.

Contrary Findings:
- Advanced conifer hardwood regeneration since 1968 has reinstated canopy cover throughout many of the highest tributary reaches.

Recommendations:
- Ensure that adequate streamside protection zones are used to reduce solar radiation and moderate air temperatures in order to reduce heat inputs to the Buckeye Creek and its tributaries.
- Where current canopy is inadequate, use tree planting and other vegetation management techniques to hasten the development of denser riparian canopy.
- Increase continuous temperature monitoring efforts.

<u>Working Hypothesis:</u> ***A lack of in stream large woody debris contributes to simplified riparian habitat structure (e.g., lack of large, deep pools).***

<u>Supporting Findings:</u>

- Heavy tractors building roads, landings, and skid trails in or adjacent to streams between 1952 and 1968 buried, removed, or dispersed LWD in the basin. Field observations have confirmed low LWD distributions.
- Historic and recent timber harvest in lower and middle reaches frequently removed large conifer vegetation down to the stream bank, severely reducing the available recruitment supply of large woody debris.
- Although stream buffers are regrowing under current land management practices and Forest Practice rules, dense buffers of conifers large enough to function, upon recruitment, as LWD in channel formation processes have not yet been reestablished.

Contrary Findings:
None noted.

Limitations: Limited formal stream reach surveys have been done for LWD; however observations of crews and findings regarding pool complexity indicate that there is limited instream LWD.

Potential Recommendations:

- Artificial LWD installation projects vastly speed up in channel diversity development

- Tree planting, thinning from below, and other vegetation management techniques will hasten the development of large riparian conifers.

Wheatfield Fork Subbasin

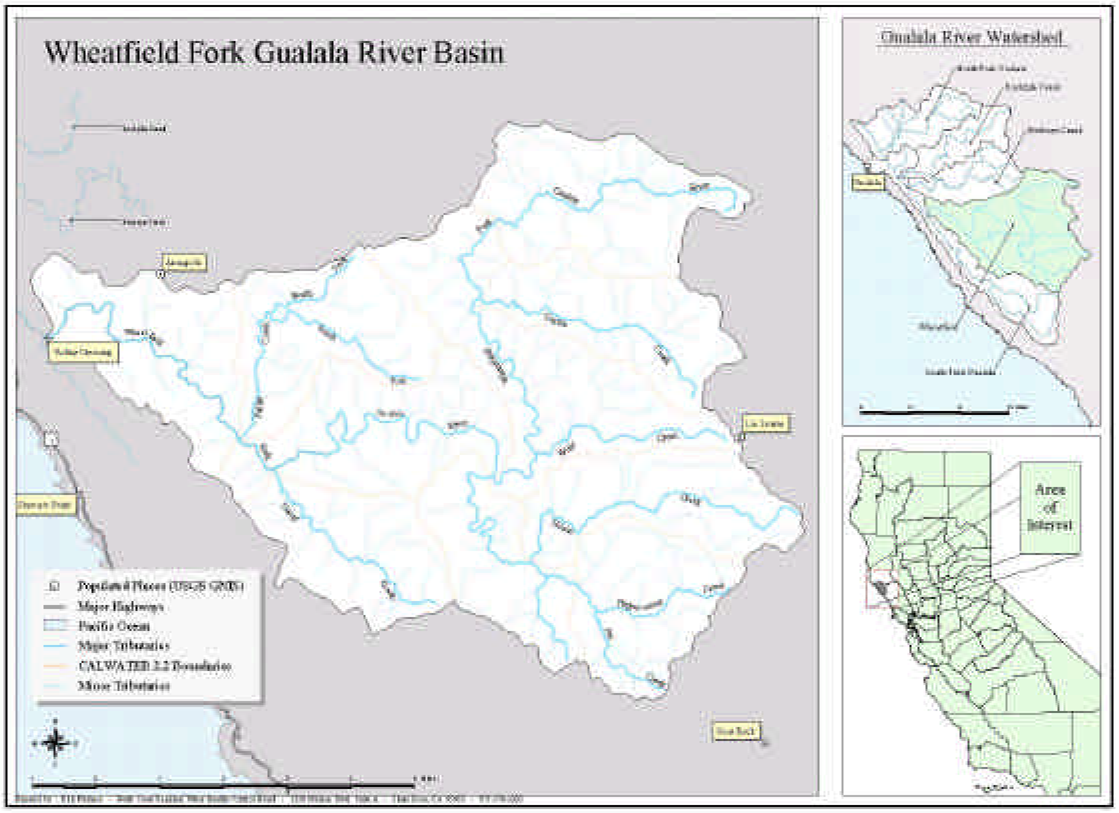


FIGURE 34: Wheatfield Fork Subbasin

Geology

The Coastal Belt of the Franciscan Formation is bounded on the east and west by major strike-slip faults, the Tombs Creek Fault and the San Andreas Fault, respectively. These and several strike-slip faults cut the bedrock in this basin. Multiple generations of lateral movement along these strike-slip faults have progressively disrupted and rearranged drainage and created vertical changes in the topography. The winding path of the Wheatfield Fork is 56 km wide long, compared to a total lineal distance of 24 km. This is due to two parallel, NW oriented shutter ridges that form obstacles around which the river flows. The shutter ridges probably slid progressively NW and/or uplifted into position along the San Andreas and Tombs Creek, and ancillary faults. The ridges shunt Wheatfield Fork drainage along their NW trending, east facing range fronts. More complex patterns of stream disruption due to faulting are evident in the eastern portion of the subbasin and are described in the geology report in the Appendix. The headwaters of the Wheatfield lie on the east side of the Tombs Creek Fault Zone within the Central Belt of the Franciscan Formation. Large earthflow complexes are abundant in this area. Large complexes of rockslides flank the ridges along the Tombs Creek and San Andreas Faults. The Ohlson Ranch Formation is poorly consolidated and is subject to landsliding along the edges of terraces or along incised drainages.

VEGETATION

The 1942 photos show dense mature Douglas-fir redwood timber bordering both sides of the lower reaches of the Wheatfield Fork mainstem. However, in 1942, the river frequently shifted back and forth to the opposite stream bank throughout an aggraded channel basin. Despite the large standing timber flanking the streambank, the channel is wide enough to still create longer sections of bank to bank canopy exposure from the South Fork upstream to the confluence with Tombs Creek allowing for long term warming. The main tributary watercourses were largely covered. There was dense coniferous canopy cover over Fuller, Tobacco, and Haupt Creeks. There was partial to entire canopy cover over the more inland locations including NF Wheatfield, Tombs and House Creeks. These was consistent partial to entire oak-woodland cover along riparian channels in the dense melange soil type

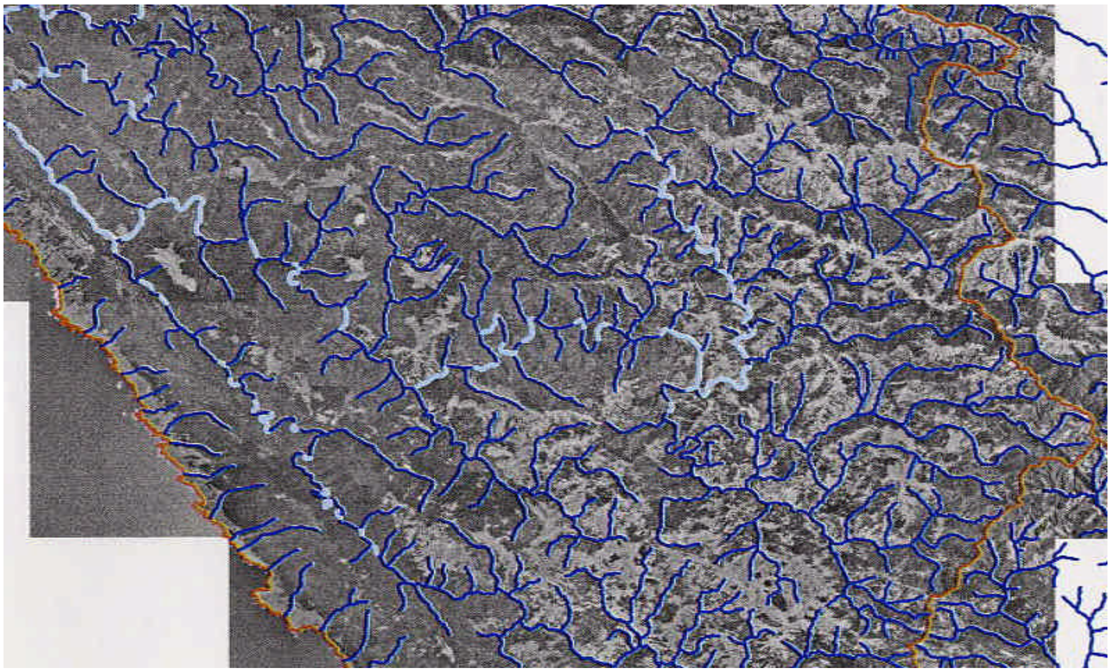


FIGURE 35: 1942 Bank to bank streamside canopy cover

1942 Bank to Bank streamside shade canopy cover (white). Blue shows partial to entire shade canopy cover.

LAND USE

Timberland use and ranching have been the dominant land use practices. The highest timber site ground is in the lower reaches within the coastal fog influence. After WW II, these areas were logged first in the early 1950s, south of Knob Hill and flanked by Burnt Knoll Ridge to the east. During the middle to later 1950s, proximity to coastal transportation routes confined logging operations to the lower reaches of Fuller, Tombs, and House Creeks. Logging operations then spread east and north when road networks were built inland. The late 1950s, and early 1960s were the most active harvests in the North Fork of the Wheatfield, Tombs, and House Creeks. Timber clearance, road building followed by prolonged pastureland use was the dominant practice in this portion of the sub-basin, most evident in the Pepperwood Creek tributary to House Creek

Throughout all of these areas during this time period, inner riparian areas were the central locations of road building. tractor yarding, and timber removal. In the steep, deeply incised Sullivan and Fuller Creek canyons, the entire logging road network was built along the creek at the base of steep ravines. Streamside roads and landings are particularly concentrated along Tobacco Creek, lower House Creek, central North Fork Wheatfield, and central to higher Tombs Creeks.

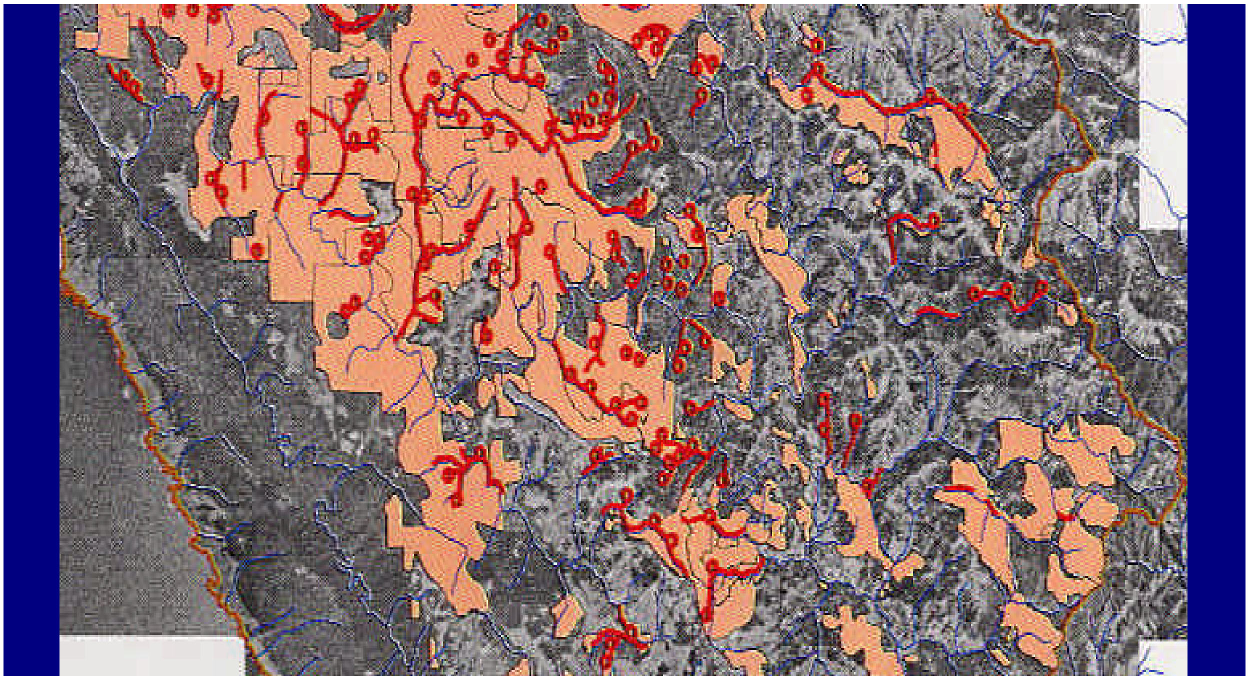


Figure 36: TIMBER HARVEST OPERATIONS 1952-1964

Streamside roads and landings (red). As a result, the 1964 flood event incised the in-stream landings and undercut streamside roads collapsing sections into the creek. The non-existent road drainage concentrated runoff triggering debris slides accessing watercourses.

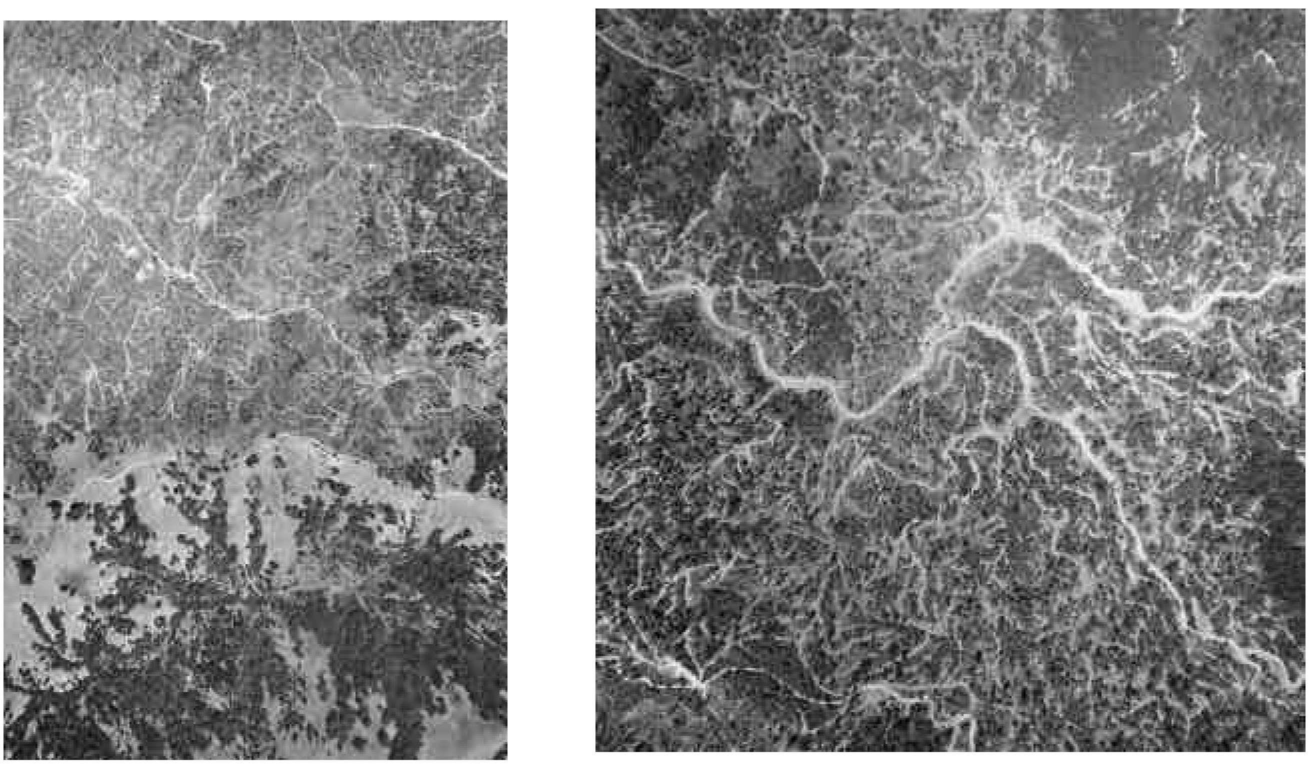


Figure 37: Conifer Block removal exposing Tobacco Ck.
Streamside roads along N.F. Fuller (right) June, 1965 CalTrans 1200 scale

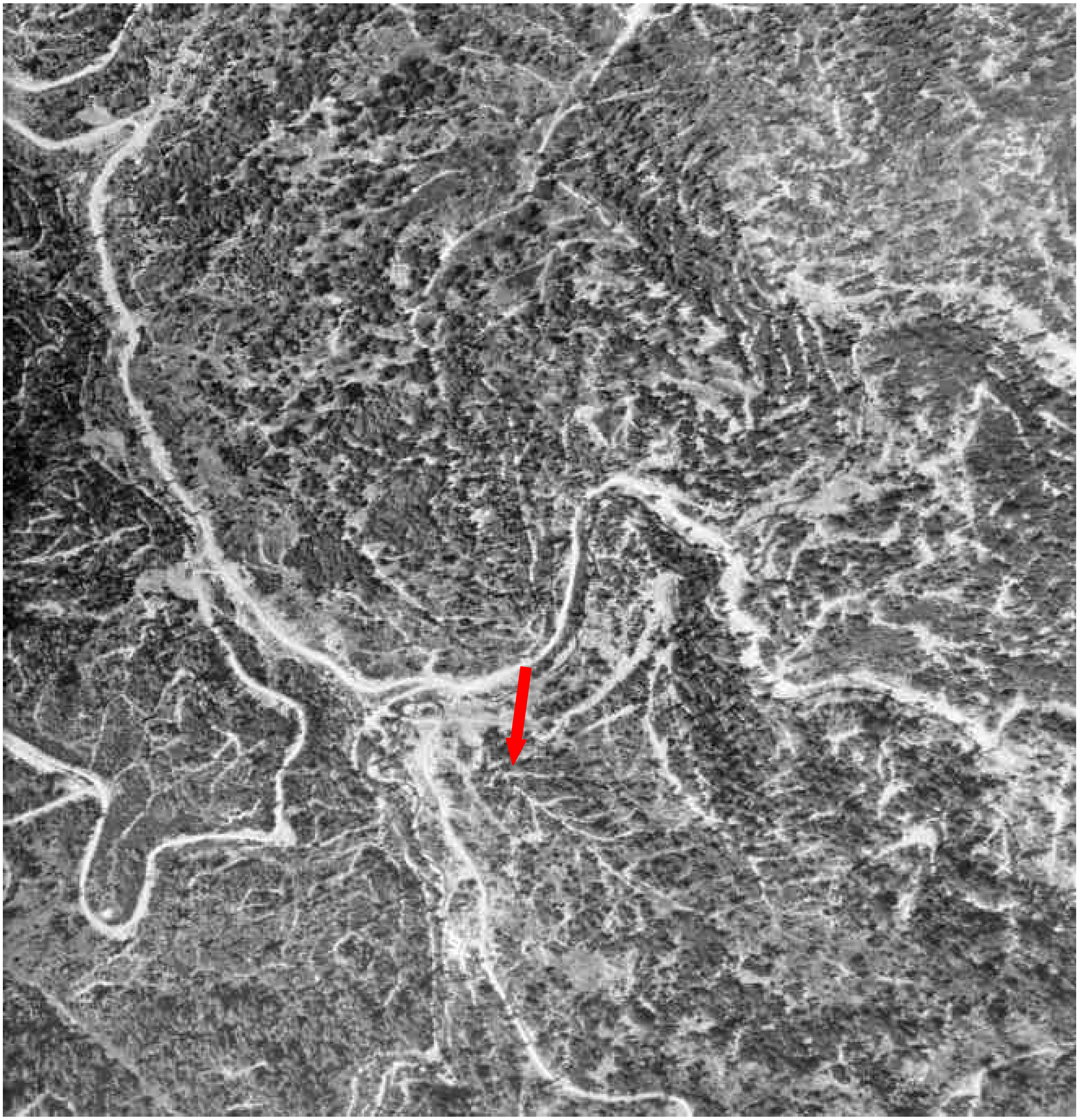


FIGURE 38: Central Landing Complex - Main Stem Fuller Ck.

The 1964 winter storm surge incised the landing complex (lower left) and destroyed the lower NF Fork Road (upper right). Note meandering stream flow patterns over filled substrate (red arrow). By 1984, most of this debris had washed downstream, and Fuller Creek, flowed straight through the original V-shaped stream channel bordering the landing. The 1996 storms washed remaining debris out to expose the graveled substrate seen today.

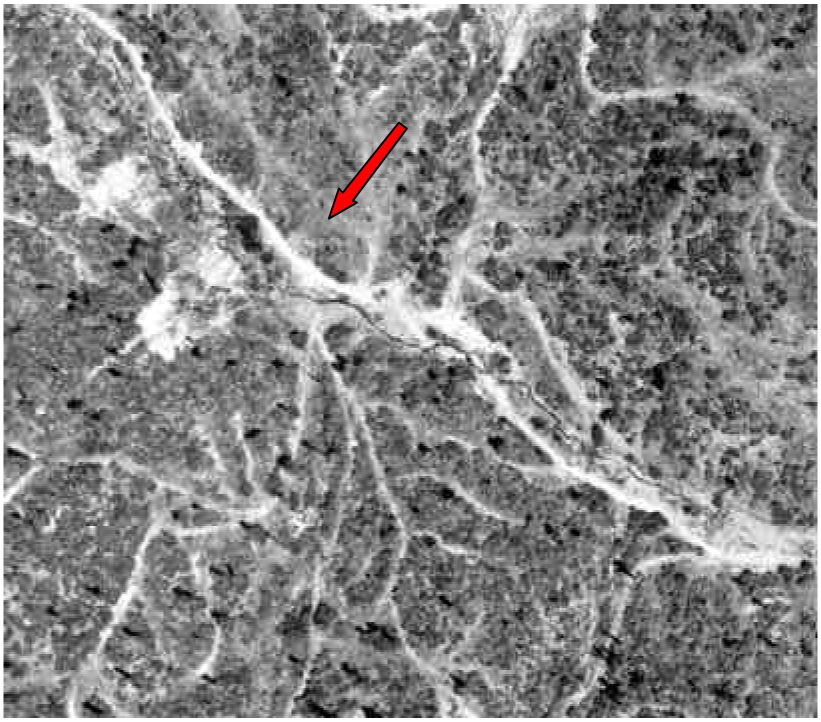
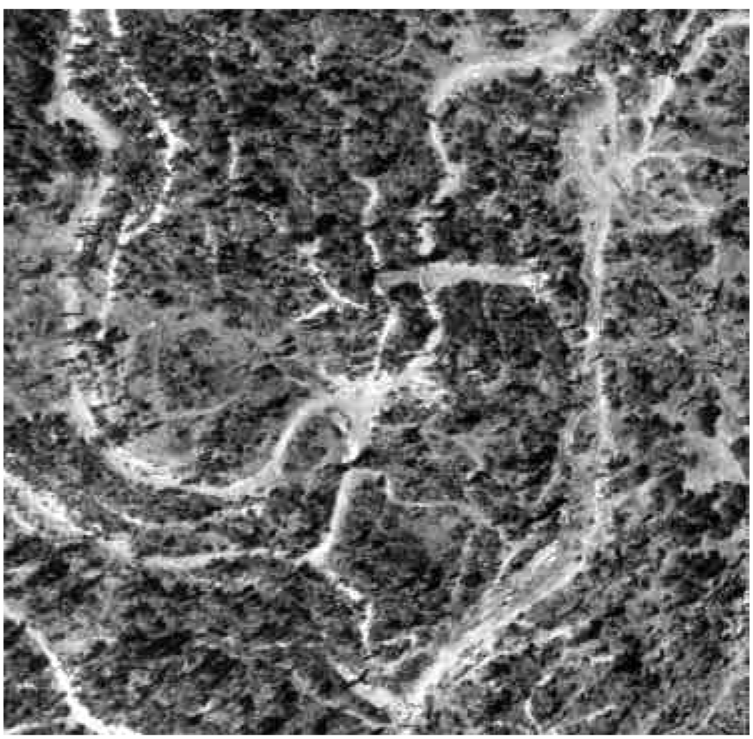


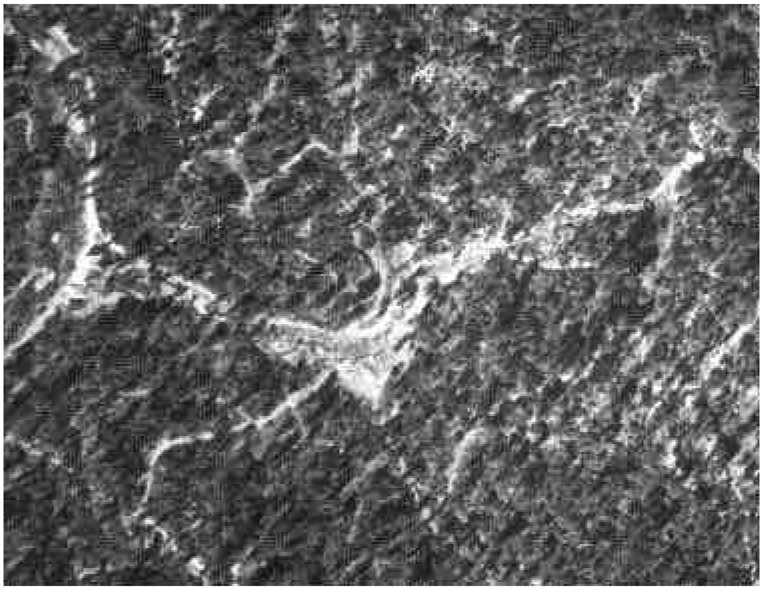
FIGURE 39: Tobacco Ck. 1964



Tobacco Ck. incised the in-stream landing (upper left) during the 1964 winter storm surge, creating a canyon on the discharge side (red arrow).

Debris slides slice through several road contours, discharging onto a tributary watercourse to Wheatfield Fork, at Annapolis Fire Station, 1965 (lower left). Note complete absence of any erosion control measures, including road cross ditches, and dipped road watercourse crossings.

FIGURE 40: Wheatfield Fork - Annapolis Fire Station



Sullivan Creek meanders over buried stream pools, June 1965. Sullivan Creek follows a fault that separates the Coastal and highly erodible Central Belts of the Franciscan Formation and crosses the poorly consolidated Ohlson Ranch Formation As a deeply incised canyon, the haul road was built along the creek. By 1984, this debris had washed downstream. Sullivan Ck returned to a linear drainage. Much of this debris is probably still deposited on the aggregated substrate of Wheatfield Fork, one quarter mile downstream .

FIGURE 41: Sullivan Creek, 1965

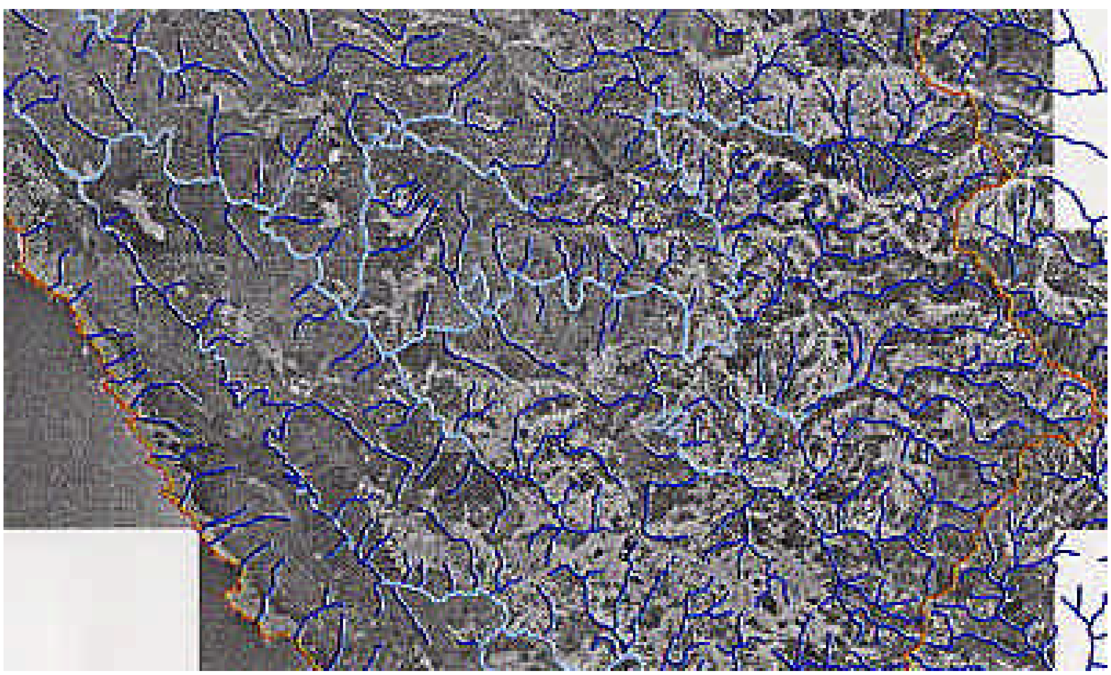


FIGURE 42: Bank to bank shade canopy exposure 1981

1981 Bank to bank shade canopy exposure (white) and partial to entire shade canopy cover (blue).

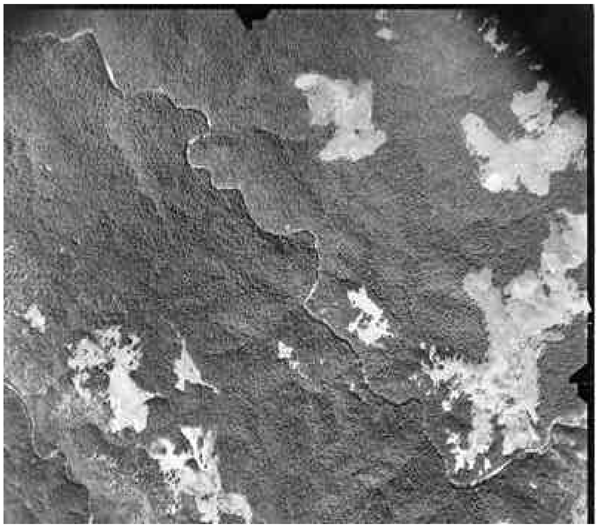


FIGURE 43: Lower Wheatfield Fork 1942

1942, lower Wheatfield Fork, Fuller Ck. (right). The Gualala study used 1936 and 1942 photos to show baseline conditions of riparian cover. Old growth logging was basically finished by the turn of the century. The watershed was inactive during the Great Depression. Large tracts of original Douglas-fir stands dominated the middle reaches of Rockpile, Buckeye, and Wheatfield basins by 1942. Baseline stream channel widths were measured, progressing upstream to House Ck. from the confluence with the South Fork

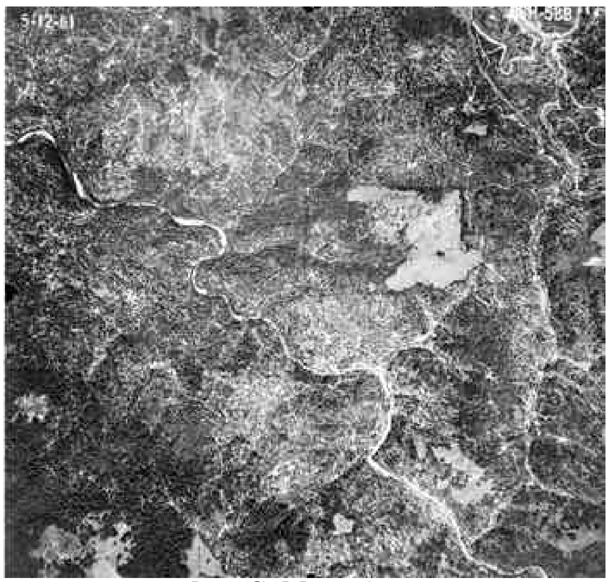


FIGURE 44: Wheatfield Basin 1961

1961. Starting during the mid 1950s, early versions of the D-8 and D-10 tractors block cleared the entire lower Wheatfield basin. Tractors roamed up and down smaller creeks, and built roads and landings in or along larger streams. The lack of any erosion control measures in these areas made large parts of watershed vulnerable to large storm events. Stream channel widths did show a widening response, see Figure
below. Tractors eliminated riparian canopy cover and in stream Large Woody Debris.

There were still consistent Coho salmon and larger steelhead counts during this time period.

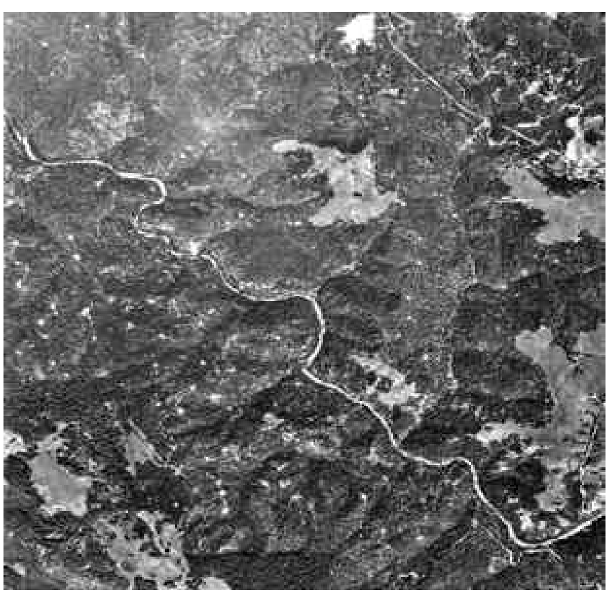
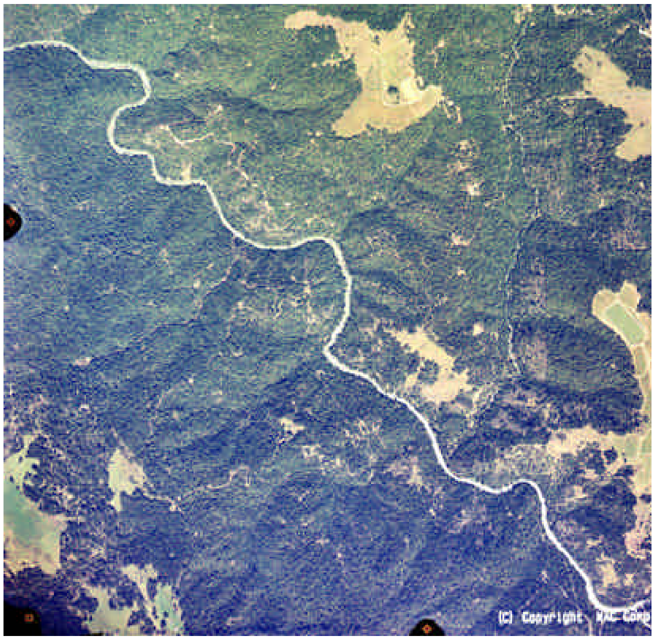


FIGURE 45: 1984 photo

1984. Young conifer in-growth reestablished vegetative cover, although storm run-off continues to concentrate along streamside legacy roads and skid trails. Pool infill, shallow pool structure, stream simplification, and increasing embeddednes, impair anadromous fisheries viability. DMG mapped stream channel disturbances in addition to landslide densities using the 1984 aerial photos. Stream surveys show declines of anadromous fisheries.



1999. The area is now more fully vegetated. Streamside legacy roads and landings have increasingly stabilized. Deep road and skid trail gullies may have incised down to rock or hard clay. DMG generally found fewer stream channel disturbances compared to 1984. Road related debris slides generally diminish. The Gualala Watershed Restoration Council has removed many of the old log chunk, dirt fill road stream crossings in Fuller Creek (right). Lower Wheatfield Fork. continues to show a widened channel width compared to 1942.

FIGURE 46: Fuller Creek 1999

Twenty year interval stream channel width measurements from 1942 to 1999 show a response widening of the lower Wheatfield Fork between 1942 and 1961 from the mouth to Haupt Ck, but possibly narrowing back down to 1942 widths at House Ck. This coincides with concentrated harvest activites between 1952s and 1960 when most of the timbered areas in this part of the basin had been operated by tractors over a narrow time frame. 1961 to 1981 continues to show a response widening compared to 1942. 1942 channel widths can be considered baseline as most of the basin at this time consisted of undisturbed Douglas-fir timberlands (see 1942 photo above)

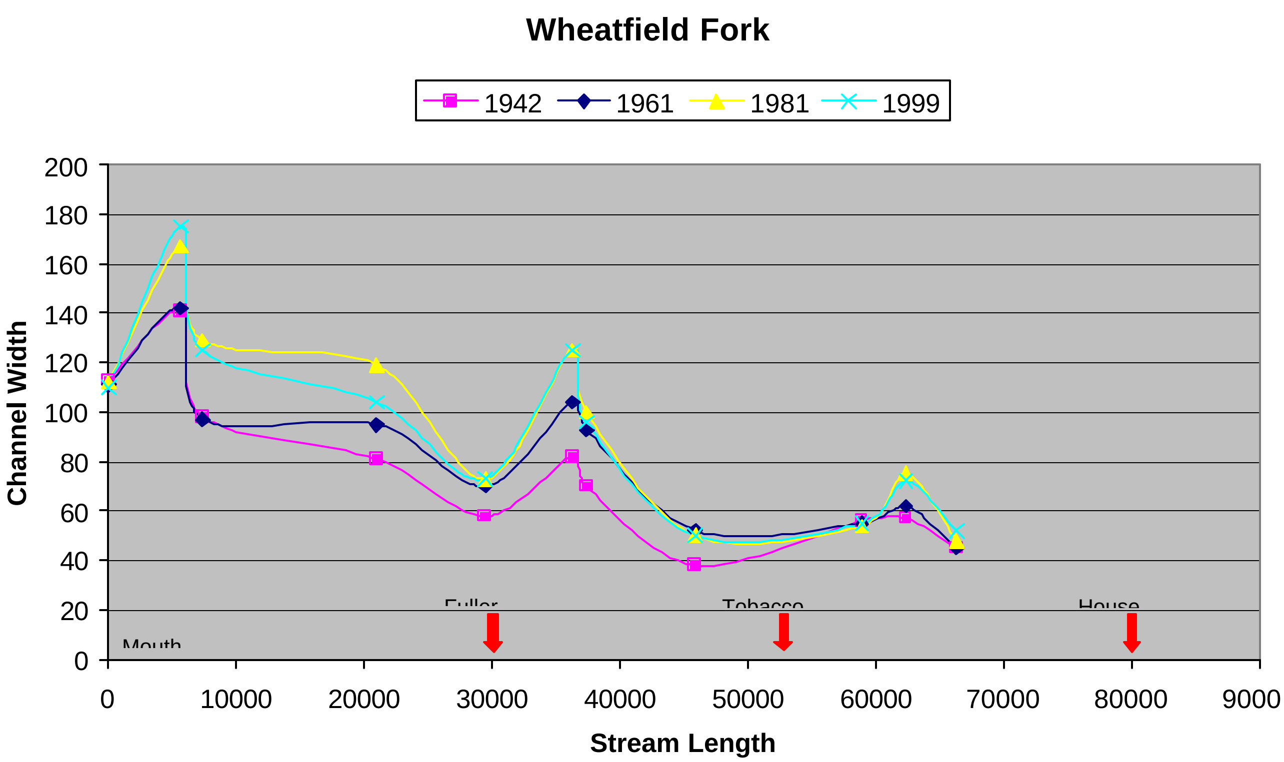


FIGURE 47: Stream channel measurements-Wheatfield Fork

Land Use Impacts Documentation

Fuller Creek

The Fuller Ck. sub-basin consis ts of steep, deeply incised terrain. Upper reaches are characterized by inner gorge ravines. In the lower reaches, there has been deep downcutting by Fuller Ck. between plateau areas of moderate to near level terrain upslope. The upper sub-basin including North and South Forks were mostly logged by between 1960 and 1964. The Lower reaches south of Fuller Mt. were logged during the mid to late 1950s (See Logging History Maps). Main haul roads were all built along the creek channel at the base of steep terrain. Large in stream landing complexes were built by filling the channel with wood debris chunks and topped with dirt. Skid trails were constructed in streams and draws, and surface flows were concentrated and diverted. The 1964 flood event caused massive erosion downcutting, slides, and washing of soil and debris into watercourses. Numerous stream surveys spanning 1964 to present correlate declining fisheries populations with shallow pool structure and declining pool frequency. More recently, there has been concentrated restoration work to stabilize sediment sources.

- Four large debris flows are apparent in the 1965 photos. These slides originate from areas that were severely disturbed by logging. By 1984 these slides are obscured by revegetation. Active landsliding is most abundant along the SF of Fuller. An unmaintained logging road parallels the creek on the north side. The road is generally 20-30' above the creek. The slopes are steep, large debris slides are very common. The road has been obliterated by debris slides. 1961 photos show minimal active slide movement prior to harvesting. The 1942 photos show dense mature wooded cover with few visibly apparent active slides. Similarly, the South Fork contained dense mature conifer cover, which was logged by 1964. To this day, sideslopes along the S.F. continue to discharge a variety of sediment in the creek. The roadbed is actually intercepting large volumes of sediment. Field inspection of two of the delivering debris slides revealed that the one consisted mainly of coarse gravel and the consisted mainly of crumbly shale that would readily decompose into fines. The streambed below these slides consisted of coarse gravel and cobbles and did not seem excessively sediment impacted (DMG NCWP).
- By 1968, a massive debris slide breached two road spans contouring steep terrain in the South Fork. Starting from the Fuller Mt. Ridge, the slide mass rammed down onto the South Fork, creating a lake. This later breached, leaving a water-fall appearance in the channel (CDF NCWP).
- The earliest documented fisheries survey in Fuller Ck. dates to summer, 1964. At this time, Rowell and Fox found the main stem Fuller Ck. (up to NF/SF) still supporting salmon and steelhead. Pools constituted 70% of the stream reach with a maximum pool depth of six ft. Fine sediment comprised 20% of the stream substrate. By 1971, Parke and Klamt found pools reduced to 40% of the reach, maximum pool depth at 4 ft., and silt and sand at 35%. Of total stream substrate.
- In 1964, Rowell found the North Fork still supporting salmon and steelhead but in rapid decline due to logging, reporting pools at 30% total reach, and 40% substrate consisting of sand and silt, deepest pools at 3 ft, and overstory canopy depletion by removal of riparian conifers. By 1971, Parke and Klamt found pools reduced to 25% of the stream reach of the NF, and maximum pool depth at 2 ft.
- In 1964, Rowell and Fox reported in the South Fork heavy sand deposits at 50% of the substrate among dense concentrations of jams, logging slash and debris. Pools had completely filled in with a maximum depth of 2 ft. and average depth of six inches. By 1971, Parke and Klamt reported some recovery in the SF to 15-20% favorable habitat by reach, maximum pool depth 2.5 ft., silt and sand comprising 50% of total substrate, but a water temperature of 78F. The 1964 flood may have flushed some of the logging debris downstream by 1971 since coho and steelhead counted at 100/100 ft. reach.
- By 1996, Sotoyome reported the Main Stem Fuller comprised of 61% riffles and 39% pools, similar to the 1971 survey. In the NF, Sotoyome found pool frequency at 36% and maximum pool depth at 3 ft., and 68% shade canopy cover, indicating recovery from logging damage. In the SF, Sotoyome found pools had increased to 35% reach and maximum depth at 4 ft. Only 37% of pools were greater than 2 ft. depth. Shade canopy cover measured at 59%. Cox (1989) found densities of steelhead juveniles at 53/100 ft. reach but a 1995 survey reported half this density (Cox, 1995). These factors indicate recovery, but slower compared to the NF (P. Higgins, 2001).
- The 1995 Sotoyome survey describes Sullivan Ck. in mid-recovery at 23% pools but 16% of the streambed was dry from aggregation. Average depth of pools was 2 ft. but 38% of pools were greater than 3 ft. deep. Canopy had recovered to 89%.

Tobacco Creek

- Main road built along Tobacco Ck. with series of landings in or adjacent to the main creek. The 1964 flood event incised each of these landings cutting deep vertical gorges and creating canyons on the discharge side (See Figure above)
- By 1964, harvest operations advanced east of the Tobacco Ck. area to the higher reaches of an adjacent larger order stream flowing down a ravine to Wheatfield Fk. The 1964 flood event triggered a long torrent slide all the way down the creek through a mature timbered tract discharging into Wheatfield Fk. By the late 1960s, a haul road was built over the torrent slide following the creek
- Three large dormant landslides line the creek.

Haupt Creek

- First logged in the late 1800s to early 1900s with steam donkeys. Ben May logging Co. Lumber Co. was the first major landowner The lower portion of Haupt Ck. was logged during the late 1950s. (98-281, MRC). Most remaining areas upstream were logged by 1970.
- The creek runs through the Coastal Belt Franciscan and forms a steep inner gorge with debris slide slopes In 1964, Klamt and Pool described the headwaters and lower reaches of Haupt Ck. "so aggraded from the previous logging that the stream flowed underground in places" Pools comprised 80% reach length, with maximum pool depth at 5 ft. Coho and steelhead equally abundant but at densities of 25/100 ft. Roach found at 200 per 100 ft. In 1970, Park and Klamt found that pools had declined to 60% stream reach, and maximum depth reduced to 3 ft. Coho salmon still noted in 1970 at densities of 25/ 100 ft., but only in the lower reaches. Steelhead had increased substantially to 500/ 100 ft in the lowest reach and 100/100 ft. further upstream. Steelhead compete well in altered stream habitats (Higgins, 1995). The aggregation point causing subsurface stream flow in lower Haupt, had washed downstream by 1970.
- Coho was not observed in the middle reach during electrofishing conducted in October, 2001. The lower reach was dominated by steelhead young-of-the-year and roach, with sculpins, stickleback, steelhead 1+ and newts present (DFG, 2001). As noted in a 1964 stream report: Haupt Creek is polluted from siltation and slash from past logging operations (DFG NCWP).
- Currently, the LP SYP describes the main channel of Haupt Ck. having relatively low structural diversity with long shallow stretches and only occasional pools. Heavy aggregation is not indicated. Historically active landsliding has been limited to small (< 100' greatest dimension) events. Best ratings for spawning conditions of all tributaries to Wheatfield Ck (98-281, LP SYP). Currently, Coho are not found. Steelhead only (T. Wooster, DF&G). Haupt Ck. is highly responsive to rainfall probably because of its steep narrow inner gorge (98-281 MRC). Major tributary Class II in lower south bank of Haupt, used as a skid trail prior to 1970, downslope of Tin Barn Rd.

North Fork Wheatfield (upstream from Tombs Creek)

- Downslope areas along the Main Stem N.F. Wheatfield, flanked by Bear and Gibson ridges, were tractor logged during the late 1950s. This reach cuts a steep valley across Central Belt terrain and is flanked on both sides by earthflows.(DMG NCWAP) Upslope areas were logged by 1964. Tractor skid trails were excavated throughout deeply incised terrain along the N.F. No active slide areas are apparent in 1942 photos. The 1964 photos show numerous steep inner channel debris slides along the N.F. among recently logged areas. During the 1964 flood, one watercourse diverted onto the haul road, discharging at the headwall of one the larger slides Another major watercourse diversion onto roads is noted in this area An earthflow and rock slides are notable along the stream. In the steep canyon shallow debris sliding is common, mapped as debris slide slopes.
- Northeast corner of Wheatfield watershed logged 1991 thru 1997, most heavily roaded area. Remaining portion of this part of the watershed helicopter logged due to steep terrain . Ridge tops converted to orchards or vineyards.
- The upper part of the reach (above Tombs Creek) was heavily dominated by roach (26), Elk Creek
- Elk Creek, tributary to the higher reaches of N.F. Wheatfield, was used historically for livestock grazing known as the Tabor Ranch. Mixed conifer/ hardwood stand developed in response to clearing and burning operations with intent to convert to pastureland. Elk Ck. was heavily impacted by tractor operations in 1950s, 1960s. Upper segments of Elk Ck. were used as skid trails with instream landings at truck road crossings. Logging debris and soil placed in stream beds. Flushing of this material continues with peak flow events. Existing road adjacent to Class II abandoned with new road relocated to the ridgeline (93-436 CFL. Five steam diversions onto truckroads repaired (92-382). Streambank rehabilitation work directed by J. Monchke.

Tombs Creek

- The sub-basin in underlain by the Central Belt of the Franciscan Formation, containing a high concentration of landslides, many active
- Upper Wheatfield, Tombs Creek, timber harvested to convert to grazing land in larger areas of the subwatershed. Sedimentation and accumulation of organic debris in channels during original tractor logging during the late 1950s and 1960s (CFL 97-158). Conversions to pastureland have been the dominant form of historical use. Tractor skidding down watercourses removed overstory canopy cover with intent to maintain permanent conversion for grazing use.
- One channel type of B4 was electrofished and showed that roach dominated (134) with steelhead 1+ (25), steelhead young-of-the-year (18), stickleback (5), newt (5), and steelhead 2+ (2) present. A roach dominated community indicates impaired conditions (DFG NCWP, 2001).

House Creek

- Coho were known to spawn and rear in House Creek (Cox, 1994). A 1965 survey found steelhead ranging from 75 to 125/ 100 ft. among near equal number of roach and stickleback along three sample reaches. No coho were reported in this 1965 survey. Pollution-Use by horses, cattle and sheep (DFG, 1965). A 1970 survey reported Coho at 25/ 100 ft. in the lowest sample reach. Steelhead – 500+/100 ft. in lower sections and 100/100 ft. in upper section. Sheep in upper one mile of stream (DFG, 1970).
- The gate on a 4-5' high dam on house creek on Soper Wheeler property has been opened because the reservoir has been completely filled with bedload from upstream. Downstream of the dam the channel is incised to bedrock, probably due to the depletion of bed and suspended loads. In a few areas along House Creek, remnant bedrock terraces – capped with cobble sized alluvium- are found above the channel (as much as 1-5-20' in one area)
- Downstream of the dam, House Creek, the bed changes dramatically from a shallow flat bottomed, fines-dominated condition to a bedrock terrace covered with cobbles coarse sands, and gravels. A large portion of the alluvium is out of the active channel. This terrace occurs approximately at the toe of a large active landslide. Some of the coarse material may have derived from the slide. The bedrock terrace may represent a localized uplift or tilting, perhaps due to deep-seated forcing of the landslide against the bank. For example some slides move by rotational about a horizontal axis. So, in rotational slides, the toe area may become somewhat elevated. However; no attempt has been made to test these hypotheses Continued use by cattle has trampled the banks in some areas and may adversely contribute to the nutrient load – algae was noted to be common in pools in House Creek
- In the lowest reaches of House Ck. near Wheatfield Fork, roads were built up several Class I tributary watercourses during the late 1950s throughout a larger timbered tract flanked by Skyline Ridge. Peak flows during the 1964 flood removed several sections of the road
- In the highest reaches of the House Ck. basin, upstream of the confluence with both Brink and Cedar Cks., Douglas-fir tracts on north facing slopes were entirely removed during the mid 1950s. Long sections of riparian areas were entirely cleared of all overstory canopy cover with intent for conversion to pastureland. Lack of erosion control facilities created gully erosion noted in 1965 photos

Pepperwood Ck. (Tributary to House Ck.)

- In the headwaters of Pepperwood (Oak Mountain) landsliding is especially abundant, active, and complex. Downstream in map sections 15 and 16 the stream cuts into a broad alluvial terrace that is almost 900 feet wide at the confluence with Jim Creek. Much of terrace material is outside of the active channel. This terrace and those along House Creek seem to be isolated remnants of former drainage patterns and may even be related to isolated fluvial deposits along the crest of Kings Ridge about a mile to the south and elsewhere in the uplift. And so it is uncertain whether the coarse and locally abundant alluvial deposits and bedload result solely from sediment transport within the current stream network from the abundant landslides in the headwaters or from a former system that has been deranged by faulting and uplift and no longer operates.
- Other abandoned areas have regenerated with young conifer/ hardwood overstory. Numerous active earthflows occur along large portions of channels, even more abundant are dormant earthflows that potentially could be reactivated. In each of these landslide-impacted reaches, the channels widen.
- Vegetation has been shaped by repeated fires. Area entirely burned over in 1955, with other subsequent fires to present. Conversions to pastureland have been the dominant form of historical use. Tractor skidding down watercourses removed overstory canopy cover with intent to maintain permanent conversion for grazing use. In many areas, soil compaction by heavy cattle access has prevented timely reestablishment of overstory canopy cover of watercourses with recent abandonment of agricultural use.

Fluvial Geomorphology

Wheatfield Fork-Lower Wheatfield Fork Super Planning Watershed

Annapolis Planning Watershed

In the 1984 imagery at least 80 percent of Wheatfield Fork of Gualala River appears disturbed with large lateral bars common, bank erosion in several areas, and 25 delivering landslides. By 1999/2000 there is some reduction in the size of the bars in the middle reach, less bank erosion, and 9 landslides, three are in the same location as in the 1984 imagery.

Flat Ridge Creek Planning Watershed

In the 1984 imagery, Fuller Creek below the North Fork/South Fork junction has less than 80 percent disturbed with several areas of multithread channel, 5 delivering landslides are mapped. Sullivan Creek appears disturbed for approximately one-half mile upstream of Fuller Creek. In the 1999/2000 imagery less than 30 percent of the lower portion of Fuller Creek is disturbed, but 13 delivering landslides are mapped.

The North Fork of Fuller Creek appears to be less than 50 percent disturbed in the 1984 imagery, mostly in the upper reaches, six delivering landslides are mapped. By 1999/2000 less than 25 percent of the upper reach is disturbed and 9 landslides are mapped.

The South Fork of Fuller Creek is at least 80 percent disturbed in the 1984 imagery with braided channels common, and 39 delivering landslides. By 1999/2000 less than 50 percent of the channel appears disturbed, some bank erosion associated with a near channel road and 30 delivering landslides are mapped.

Tobacco Creek Planning Watershed

In the 1984 imagery, Wheatfield Fork in the Tobacco Creek planning watershed is at least 75 percent disturbed with bank erosion along the outside bends common, and 37 delivering landslides. By 1999/2000 less than 50 percent of the channel appears disturbed. Bank erosion on the outside of bends continues, 29 delivering landsides are mapped, 15 at locations mapped from the 1984 images.

Tobacco Creek has approximately 30 percent channel disturbance in the 1984 imagery with braided and incised channels common. An un-named tributary in Sections 22 and 27, Township 10 North, Range 13 West has approximately 50 percent disturbance and 5 delivering landslides in 1984 imagery. By 1999/2000, less than 20 percent of Tobacco Creek appears disturbed, most in the lower reach, and 3 delivering landslides are mapped in the upper reach area.

Haupt Creek Planning Watershed

In the 1984 imagery, approximately 30 percent of Haupt Creek appears disturbed mostly in Sections 9 and 12 of Township 9 North, Range 13 West, and 4 delivering landslides are mapped. By 1999/2000, less than 30 percent is disturbed with the disturbance shifting downstream to the lower half of the channel, mostly in Sections 4, 9 and 10, Township 9 North, Range 13 West. Twenty-one delivering landslides are mapped from the 1999/2000 imagery.

Wheatfield Fork-Hedgepeth Lake Super Planning Watershed

House Creek Planning Watershed

In the 1984 imagery, channel disturbance ranged from 25 to 50 percent with 2 delivering landslides mapped along House Creek. By 1999/2000, less than 25 percent of House Creek appears disturbed.

Pepperwood Creek Planning Watershed

Pepperwood Creek appears to have approximately 50 percent channel disturbance in the 1984 imagery and 25 to 50 percent in the 1999/2000 imagery. Two delivering landslide are mapped from the 1999/2000 imagery.

Danfield Creek has approximately 50 percent channel disturbance in the 1984 imagery and 5 delivering landslides. In the 1999/2000 imagery, approximately 30 percent of the channel is disturbed.

Britain Creek Planning Watershed

The upper reach of House Creek above Pepperwood Creek and Pepperwood Creek in Sections 3, 4 and 5, Township 9 North, Range 12 West, both appear to have 50 percent disturbance in the 1984 imagery. The amount of channel disturbance in 1999/2000 imagery is similar to 1984 with addition of 2 delivering landslides.

Wheatfield Fork-Walters Ridge Super Planning Watershed

Wolf Creek Planning Watershed Planning Watershed

In the Wolf Creek planning watershed, Wheatfield Fork channel disturbance ranges from 25 to 50 percent in the 1984 imagery with 18 delivering landslides mapped. In the 1999/2000 imagery less than 25 percent of Wheatfield Fork within Wolf Creek planning watershed appears disturbed and 10 delivering landslides are mapped, 8 upstream of the confluence with Tombs Creek.

In the 1984 imagery, less than 25 percent of Wolf Creek appears disturbed, mostly in the upper reach, and 4 delivering landsides are mapped. By 1999/2000 less than ten percent of the channel is disturbed with 3 delivering landslides.

Approximately 50 percent of Spanish Creek appears disturbed in the 1984 imagery mostly upstream of the confluence with Buzzard Creek, 3 delivering landslides are mapped. By 1999/2000 less than 25 percent of Spanish Creek is disturbed above the junction with Buzzard Creek.

Tombs Creek Planning Watershed Planning Watershed

Fifty to seventy-five percent of the Tomb Creek appears disturbed in the 1984 imagery with 10 delivering landslides. In the 1999/2000 imagery less than 25 percent of the channel is disturbed, mostly in Section 17, Township 10 North, Range 12 West, and 4 delivering landslides are mapped.

Buck Mountain Planning Watershed Planning Watershed

In the 1984 imagery, the Wheatfield Fork in Buck Mountain planning watershed has less than 75 percent disturbed channel, mostly in the lower reach, and eleven delivering landslides. By 1999/2000 the channel disturbance is less than 30 percent and seven delivering landslides are mapped.

Tobacco Creek Planning Watershed

In the 1984 imagery, Wheatfield Fork in the Tobacco Creek planning watershed is at least 75 percent disturbed with bank erosion along the outside bends common, and 37 delivering landslides. By 1999/2000 less than 50 percent of the channel appears disturbed. Bank erosion on the outside of bends continues, 29 delivering landsides are mapped, 15 at locations mapped from the 1984 images.

Tobacco Creek has approximately 30 percent channel disturbance in the 1984 imagery with braided and incised channels common. An un-named tributary in Sections 22 and 27, Township 10 North, Range 13 West has approximately 50 percent disturbance and 5 delivering landslides in 1984 imagery. By 1999/2000, less than 20 percent of Tobacco Creek appears disturbed, most in the lower reach, and 3 delivering landslides are mapped in the upper reach area.

Haupt Creek Planning Watershed

In the 1984 imagery, approximately 30 percent of Haupt Creek appears disturbed mostly in Sections 9 and 12 of Township 9 North, Range 13 West, and 4 delivering landslides are mapped. By 1999/2000, less than 30 percent is disturbed with the disturbance shifting downstream to the lower half of the channel, mostly in Sections 4, 9 and 10, Township 9 North, Range 13 West. Twenty-one delivering landslides are mapped from the 1999/2000 imagery.

Wheatfield Fork-Hedgepeth Lake Super Planning Watershed

House Creek Planning Watershed

In the 1984 imagery, channel disturbance ranged from 25 to 50 percent with 2 delivering landslides mapped along House Creek. By 1999/2000, less than 25 percent of House Creek appears disturbed.

Pepperwood Creek Planning Watershed

Pepperwood Creek appears to have approximately 50 percent channel disturbance in the 1984 imagery and 25 to 50 percent in the 1999/2000 imagery. Two delivering landslide are mapped from the 1999/2000 imagery.

Danfield Creek has approximately 50 percent channel disturbance in the 1984 imagery and 5 delivering landslides. In the 1999/2000 imagery, approximately 30 percent of the channel is disturbed.

Britain Creek Planning Watershed

The upper reach of House Creek above Pepperwood Creek and Pepperwood Creek in Sections 3, 4 and 5, Township 9 North, Range 12 West, both appear to have 50 percent disturbance in the 1984 imagery. The amount of channel disturbance in 1999/2000 imagery is similar to 1984 with addition of 2 delivering landslides.

Wheatfield Fork-Walters Ridge Super Planning Watershed

Wolf Creek Planning Watershed Planning Watershed

In the Wolf Creek planning watershed, Wheatfield Fork channel disturbance ranges from 25 to 50 percent in the 1984 imagery with 18 delivering landslides mapped. In the 1999/2000 imagery less than 25 percent of Wheatfield Fork within Wolf Creek planning watershed appears disturbed and 10 delivering landslides are mapped, 8 upstream of the confluence with Tombs Creek.

In the 1984 imagery, less than 25 percent of Wolf Creek appears disturbed, mostly in the upper reach, and 4 delivering landsides are mapped. By 1999/2000 less than ten percent of the channel is disturbed with 3 delivering landslides.

Approximately 50 percent of Spanish Creek appears disturbed in the 1984 imagery mostly upstream of the confluence with Buzzard Creek, 3 delivering landslides are mapped. By 1999/2000 less than 25 percent of Spanish Creek is disturbed above the junction with Buzzard Creek.

Tombs Creek Planning Watershed Planning Watershed

Fifty to seventy-five percent of the Tomb Creek appears disturbed in the 1984 imagery with 10 delivering landslides. In the 1999/2000 imagery less than 25 percent of the channel is disturbed, mostly in Section 17, Township 10 North, Range 12 West, and 4 delivering landslides are mapped.

Buck Mountain Planning Watershed Planning Watershed

In the 1984 imagery, the Wheatfield Fork in Buck Mountain planning watershed has less than 75 percent disturbed channel, mostly in the lower reach, and eleven delivering landslides. By 1999/2000 the channel disturbance is less than 30 percent and seven delivering landslides are mapped.

Water Quality

In-stream Sediment

The NCRWQCB evaluated median particle size (D_{50}) measurements provided by GRI for two sites in 1997 WF#227 and WF#403) and one site (WF#226) in 1997 and 2000 from the lower three miles of the Wheatfield Fork mainstem (Annapolis Planning Watershed) (Figure 40). To compare the data to Knopp (1993), the individual D_{50} values for the sites (3 transects per site) were averaged. Then the minimum, maximum, and average for those averages were compared to the same statistic from Knopp (1993) in the following table.

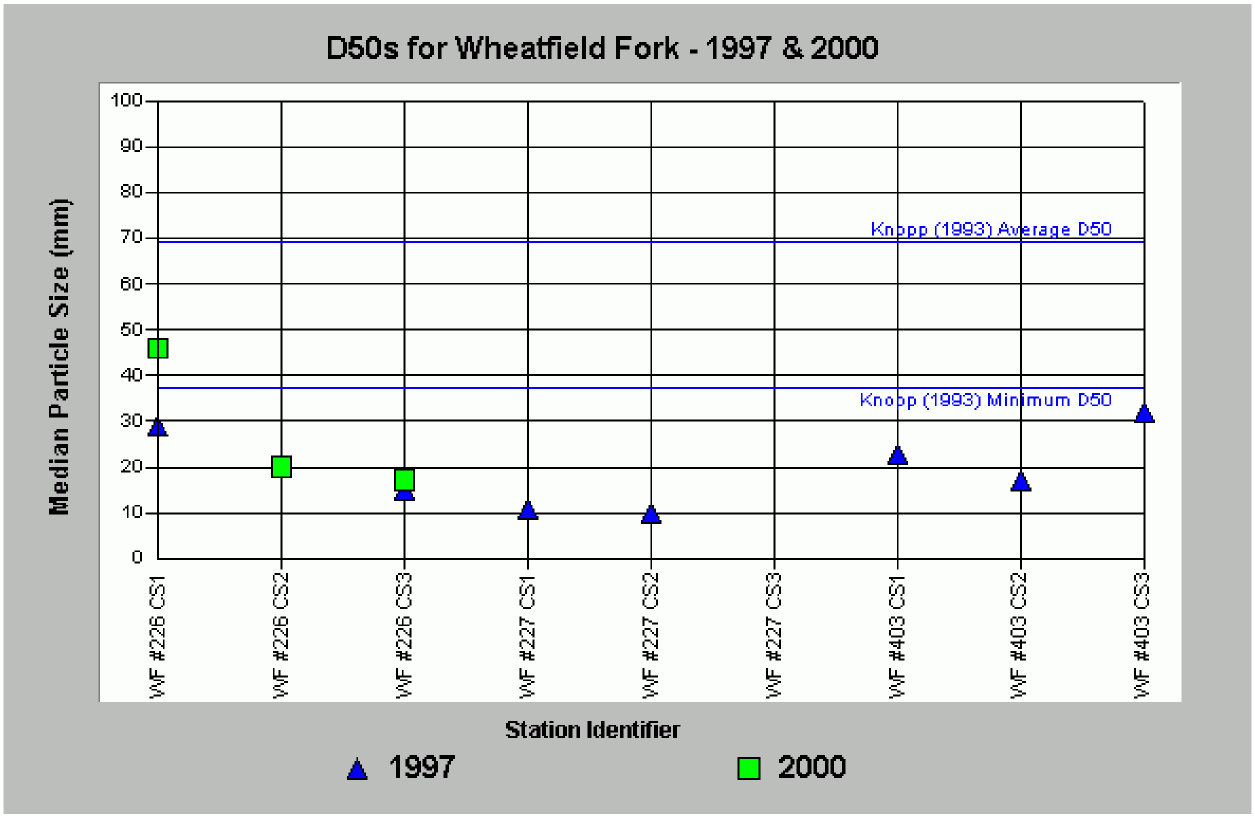


FIGURE 48: Median particle sizes - Wheatfield Fork 1997/2000

While the lowest site in the subbasin showed an increase in D_{50} in one transect of three from the 1997 value of 29 mm to the year 2000 value of 49 mm, median particle sizes at the sites measured in the subbasin are small. DFG embeddedness values for the subbasin overall averaged in the 26-75% range, outside of optimum and into ranges not suitable for salmonid spawning. Both those parameters indicate that sediment particle size and the amount of fine sediment are limiting factors for salmonids. Having maps of landslide activity, roads and other human landscape disturbances, and embeddedness and dominant

Aggradation is indicated by the 1964 survey observation of a large rock outcrop extending 12 feet over the water near the confluence of the Wheatfield with the South Fork. Here, the depth of the Wheatfield Fork was estimated at 10 to 15 ft. in depth. Subsequent aggradation is indicated by a 1995 watercourse survey reporting only the tip of this same rock outcrop. This indicates aggradation of 20-25 ft. between 1950 and 1995 where the elevation is 80 ft (Cox, 1997).

Water Temperature

The NCRWQCB evaluated water temperature data for the subbasin provided by GRI and GRWC from continuous monitors for the periods 1995-1998 and 2000-2001 at 13 sites (total of 25 measurements for the period). The highest MWATs for the period of record from Wheatfield Fork mainstem stations going from upstream of Haupt Creek downstream to near the confluence from the South Fork ranged from 69-73 F, all above the proposed “fully supportive” range of 50-60 F (Figure 49). The seasonal maxima for those same stations ranged from 74-82 F, near or above the lethal maximum of 75 F.

Some evidence of mainstem cooling by tributaries was seen in the 2001 data, with an MWAT in the mainstem above Fuller Creek (wf 617) at 72 F and in the mainstem downstream (wf 600) at 70 F (Figure 49). Water temperatures were lower in one small tributary (wf 228) sampled from 1995-1998 with MWATs ranging from 56-58 F and seasonal maxima ranging from 57-59 F, all within proposed “fully supportive” ranges. Water temperatures in the Fuller Creek watershed (fc 901, fc 618, fc 619, fc 608, fc 606) were on the high side, with MWATs ranging from 59-66 F at five stations in 2000 and 2001.

Water quality data from StoRet for 1988 and from NCRWQCB sampling in 2001 indicate a relatively soft water oligotrophic system. All parameters measured were within the Basin Plan limits and nutrient levels (nitrogen and phosphorus) were below detection limits (Appendix 9).

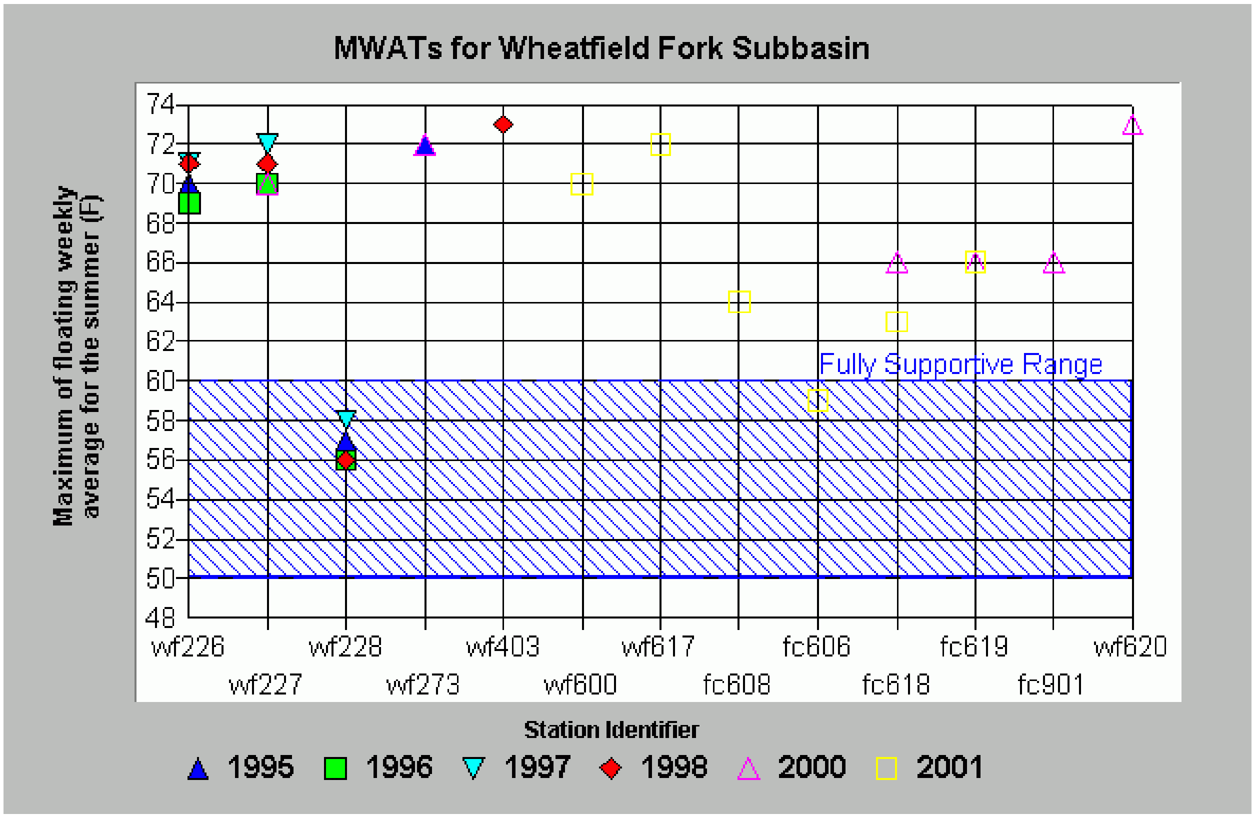


FIGURE 49: MWAT - Wheatfield Fork 1995-2001

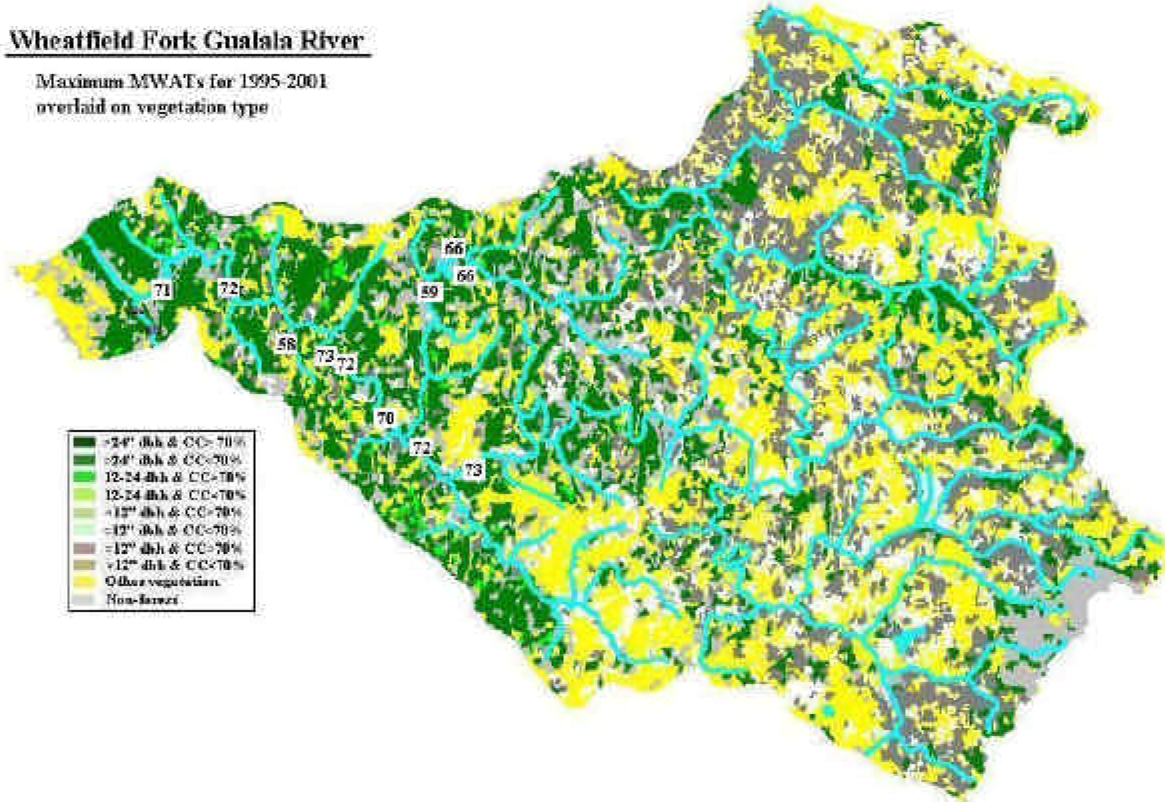


FIGURE 50: Wheatfield Fork Subbasin

Aquatic/Riparian Conditions

The 2001 DF&G surveys describe fish habitat along the Wheatfield Fork dominated by flatwater and riffles with substrates consisting of cobble/ gravel, silt/ clay and bedrock. The mean pool depth in areas sampled is less than 0.50 ft with an average embeddedness of 26-70%. A mostly deciduous canopy covers less than 50% on average sub-basin wide.

TABLE 19: Instream Data - Wheatfield Fork Subbasin

Wheatfield Fork Subbasin

DF&G Habitat Typing Data

(1996 - 2001)

Tributary	Pool Frequency*	Pool Depth Maximum (Feet)	Pool Depth Mean (Feet)	Dominant Substrate	Substrate Embeddedness
Wheatfield Fork	35%	9.3	1.0	Gravel	26-50%
Tombs Creek	45%	3.9	1.0	Gravel	26-50%
Pepperwood Creek	27%	1.5	1.3	Gravel	0-25%
Danfield Creek	22%	5.8	1.5	Cobble	51-75%
Haupt Creek	33%	1.6**	1.6**	Sand	76-100%
Fuller Creek Mainstem	41%	6.0	1.1	Gravel	76-100%
NF Fuller Creek	51%	1.0	1.0	Gravel	51-75%
SF Fuller CreeK	50%	30/4.5	0.9	Gravel	51-75%
Sullivan CreeK	36%	3.4	1.0	n/a	51-75%

* By habitat occurrence **Partial survey

The Louisiana-Pacific Corporation's (formerly, MRC) Sustained Yield Plan shows low (0-39%) watercourse shade canopy cover for most higher (east) portions of the Wheatfield Fork watershed. Smaller sections show moderate cover (40-70%). The LP SYP notes no spawning gravel along a survey strip along Wheatfield Fork. The SYP describes spawning habitat as fair, summer rearing habitat as poor, and overwintering habitat as fair. LWD is described as not abundant in any of the survey reaches.

Tables 20 and 21 show recent canopy density measurements within the Wheatfield Basin. Table 20 density and canopy composition are measured at the thalweg. Density is measured by using a spherical densiometer and the surveyor estimates canopy composition. Table 21 density is measured from the center of channel using a spherical densiometer. The canopy composition is measured by identifying and counting tree species in riparian plots that extend from bank full 100-ft. inland on both sides of the channel.

Table 20: Canopy Density - Wheatfield Subbasin

DF&G Habitat Typing Data

(1996- 2001)

Tributary	Canopy Density	Canopy Composition	
		Coniferous	Hardwood
Wheatfield Fork	44%	48%	52%
Tombs Creek	65%	70%	30%
Pepperwood Creek	9%	95%	5%
Danfield Creek	49%	100%	0%
Haupt Creek*	81%	47%	53%
Fuller Creek Mainstem	67%	44%	56%
NF Fuller Creek	68%	59%	39%
SF Fuller Creek	59%	54%	45%
Sullivan Creek	89%	58%	42%

*Partial survey

Table 21: Watershed Coop. Monitoring prog.

\Watershed Cooperative Monitoring Program

(1996-2001)

Tributary	Canopy Density	RiparianComposition	
		Coniferous	Hardwood
Wheatfield Fork*	40%	90%	10%
Tombs Creek	n/a	n/a	n/a
Pepperwood Creek	n/a	n/a	n/a
Danfield Creek	n/a	n/a	n/a
Haupt Creek	n/a	n/a	n/a
Fuller Creek Mainstem	n/a	n/a	n/a
NF Fuller Creek	n/a	n/a	n/a
SF Fuller CreeK	n/a	n/a	n/a
Sullivan CreeK	n/a	n/a	n/a

*Only one reach site surveyed on lower Wheatfield

TABLE 22: Summary of Large Woody Debris surveys

Wheatfield Subbasin
Watershed Cooperative Monitoring Program
(1998 - 2001)

Tributary	Site Number	Watershed* Size (acres)	Volume CuFt/1000'	Quantity Pieces/1000'
Wheatfield Fork	226	71,409	1,531	15

*Watershed size is calculated as the area above the monitoring site.

The Cooperative Monitoring Program surveys show the lower Wheatfield lacks volume and pieces of LWD.

Results from macroinvertebrate population sampling can be used to evaluate the occurrence of various types of pollutants and current watershed conditions. Samples taken at one reach site in the Wheatfield basin in 2000 by Jon Lee can be characterized as average when compared to similar north coast watersheds (Table 23).

TABLE 23: Summary of Macroinvertebrate Sampling

Wheatfield Subbasin
Gualala Redwoods, Inc.
(2000)

Tributary	Site Number	Watershed* Size (acres)	Richness	Simpson Diversity	Hilsenhoff	Abundance	Dominant Taxon
Wheatfield Fork	226	71,409	32	0.85	4.3%	7,312	32%

*Watershed size is calculated as the area above the monitoring site.

Fish History and Status

Historically, the sub-basin was dominated by steelhead rainbow trout with a small number of roach. Steelhead and coho spawned in the tributaries. The earliest fisheries surveys date back to 1964. A summer 1964 stream survey of Wheatfield Fork from the headwaters to Redwood Creek found 50% gravel and 5% fine sediment, conductive to steelhead habitat with juvenile densities averaging 200 per100 feet of watercourse reach. A 1964 survey found the main stem Fuller Creek still supporting salmon and steelhead. Pools constituted 70% of the stream reach with a maximum pool depth of six feet. Fine sediment comprised 20% of the stream substrate. In 1970, coho salmon were found in the lower reaches of Haupt Creek at densities of 25 per100 feet. Steelhead had increased substantially from 1964 to 500 per100 feet in the lowest reach and were lower at 100 per 100 feet further upstream. A 1970 survey in House Creek estimated coho at 25 per100 feet in the lower section, and steelhead at 500+per100 feet in lower sections and 100 per100 feet in the upper section.

Since 1970, Coho have not been observed in the Wheatfield subbasin. Steelhead one year and older have declined or were not observed in the tributaries during 2001 surveys where current and previous data exist and can be compared.

Currently, the fish community appears to be dominated by roach, stickleback, and sculpin, with smaller, less than one-year-old steelhead. Older one and two year steelhead are present only in low numbers. The numbers of steelhead are notably lower than observed in the 1970 surveys. Specifically, the lowest reach survey was dominated by roach (228), with sculpin (9), stickleback (6), steelhead young-of-the-year (2) and steelhead 1+ (2) present. The middle part of the reach was heavily dominated by roach (58), with sculpin (2) and stickleback (2) present. Steelhead young-of-the-year and steelhead 1+ or older were not observed. The upper part of the reach (above Tombs Creek) was heavily dominated by roach (26), with sculpin (2), stickleback (3), steelhead young-of-the-year (1) and steelhead 1+ (1) and 3+ (1) present. Two steelhead (2) were observed, but not netted.

Subbasin Issues

- Fish density –

- In-stream habitat diversity and complexity, based on very limited surveys appears to be insufficiently diverse. Inadequate pool depth, and a lack of escape cover and LWD have contributed to a simplification of instream fish habitat.

- Large Woody Debris (LWD) recruitment potential is very poor overall due to naturally occurring geologic conditions. Land use practices may have exacerbating the naturally occurring geological conditions.

- Roads – There is concern over abandoned roads, new road construction, and road maintenance issues related to landsliding and sediment input. Without appropriate maintenance or storm proofing, existing roads, both active and abandoned, may continue to supply sediment.

- Vineyards are very prevalent, grazing and sub-division development are also issues at thitime. Feral pigs also impact the land.

- Water chemistry – No data is available on pH, DO, nutrients.

- Water temperatures data is very limited throughout the subbasin. Data on the Southfork showed temperatures above the fully suitable range for salmonids. Summer high temperatures probably exceed optimal conditions for salmon throughout much of this planning basin. This may be due to natural existing conditions in some areas.

- Instream sediment data is needed. Based upon a few samples over a short time period there is an indication that fine sediments may be approaching or exceeding levels that are considered suitable to salmonid populations.

- Wildlife/Plants -- Inadequate information exists to assess status and trends of flora and fauna, including invasive species. Pampas grass is observed.

Subbasin Issue Synthesis and Recommendations

Working Hypothesis: ***The Wheatfield fork subbasin provides unsuitable habitat for coho and somewhat suitable habitat for steelhead.***

Supporting Findings:

- Sources of upstream sediment include highly erodible earth materials, mass wasting, seismic activity, and land use.

- Water temperatures in the estuary, as a result of warming effects upstream, may exceed a level that is fully suitable of salmonids.

Contrary Findings:

Recommendations:

Working Hypotheses

Accelerated erosion from logged areas has contributed to the sedimentation in the streams resulting in added degradation of salmon habit.

Supporting Findings

- Comparison of modern and historic stream surveys show a decline in anadromous populations.[Appendix XX: CFG Catch Statistics]

- Comparison of modern and historic stream surveys show that pools have become shallower and streambeds have become embedded with fine sediment over between the earliest fisheries surveys between 1964 and present. Both conditions are deleterious to anadromous fisheries. [Appendix XX: CFG Stream Survey Report]

- Roads and landings are important sediment sources in the basin. Both historic and modern aerial photos show that numerous debris flows and debris slides involve roads and that numerous failures occur along in-stream and near-stream roads and landings. These resulted in increased sedimentation in the streams.

- Most of the lower and middle reaches of the Wheatfield Fork basin were clear-cut between 1952 and 1961 building roads in or along the major tributaries streams and main stem Buckeye. Some larger tributary stream basins only required 3 to 5 years to liquidate the timber. This left large areas of disturbed ground.

- The residual effects of heavy channel aggregation from streamside road system failures built in the 1950s and 1960s are noted in timber harvest plan records, particularly the lower reaches of the Wheatfield Fork basin.
- Comparative 20 year stream channel width measurements between 1942 and 1961, and 1981 show channel width widening responses to concentrated harvests upstream.

- Large in-stream landings were built in support of logging operations. Many of these were washed out during subsequent storms.

- Modern logging operations are far less intense than those practiced from 1950-1968. In-stream roads and landings are not permitted. Tractor logging on steep slopes is now restricted. The size and degree of clear cuts is now limited. Erosion control is now mandatory for harvested areas.

Contrary Findings:
None at this time.

Limitations
These conditions are well constrained within the scope of work performed thus far.

Conclusion
Past logging practices, specifically tractor operations on steep slopes, accelerated erosion and added excess sediment to stream channels.

Upgrading and diligent maintenance of existing road systems to reduce sediment impacts will slow the degradation of salmon habitat –specifically pools and spawning gravels. Careful engineering of new roads or repairs can reduce adverse sediment impacts.

Recommendations

Road managers should develop and adopt erosion control plans. Repairs and new road construction should be carefully designed and when necessary licensed specialists such as civil engineers, erosion control specialists, and engineering geologists should be consulted.

- Spread timber harvesting operations through time and space to avoid concentrated road use by heavy equipment and resultant mobilization of road surface fines accessing watercourses.

- Continue to decommission streamside roads and landings. The following tributaries contain the highest density of these still active sediment sources:

- Lower reaches of House Creek, Haupt Creek, Tobacco Creek, North Fork Wheatfield Fork

Working Hypothesis: ***Depleted overstory shade canopy cover along Wheatfield Fork and tributaries from legacy harvests continues to contribute to elevated water temperatures.***

Supporting Findings:
- Heavy tractors building roads, landings, and skid trails in riparian zones shortly after WW II eliminated overstory shade canopy cover throughout long sections of Wheatfield Fork and tributaries. There was near

entire canopy elimination along the lower main stem and main tributaries, especially pronounced during the mid to late 1950s.

Contrary Findings:

- Advanced conifer hardwood regeneration since 1968 has reinstated canopy cover throughout many of the highest tributary reaches.

Recommendations:

- Ensure that adequate streamside protection zones are used to reduce solar radiation and moderate air temperatures in order to reduce heat inputs to Wheatfield Fork and its tributaries.
- Where current canopy is inadequate, use tree planting and other vegetation management techniques to hasten the development of denser riparian canopy.
- Increase continuous temperature monitoring efforts.

Working Hypothesis: ***A lack of in stream large woody debris contributes to simplified riparian habitat structure (e.g., lack of large, deep pools).***

Supporting Findings:

- Heavy tractors building roads, landings, and skid trails in or adjacent to streams between 1952 and 1968 buried, removed, or dispersed LWD in the basin. Field observations have confirmed low LWD distributions.
- Historic and recent timber harvest in lower and middle reaches frequently removed large conifer vegetation down to the stream bank, severely reducing the available recruitment supply of large woody debris.
- Although stream buffers are regrowing under current land management practices and Forest Practice rules, dense buffers of conifers large enough to function, upon recruitment, as LWD in channel formation processes have not yet been reestablished.

Contrary Findings:

None noted.

Limitations*:*

Limited formal stream reach surveys have been done for LWD; however observations of crews and findings regarding pool complexity indicate that there is limited instream LWD.

Recommendations:

- Artificial LWD installation projects vastly speed up in channel diversity development.
- Tree planting, thinning from below, and other vegetation management techniques will hasten the development of large riparian conifers.

Mainstem/South fork Subbasin

Geology

Most of the SF is an alluvial stream that mostly flows within the linear valley formed by San Andreas Fault (Figure 39). However the upper reaches are incised to bedrock and occupy a parallel valley east of the San Andreas Fault. Large active earthflows are common along most the length of South Fork (Plate 1). Small (< 100 feet greatest dimension) historically active slides that delivered into SF are especially abundant from Russian Trough Spring and northward. From our limited observations the sediment production along the roughly parallel lengths of

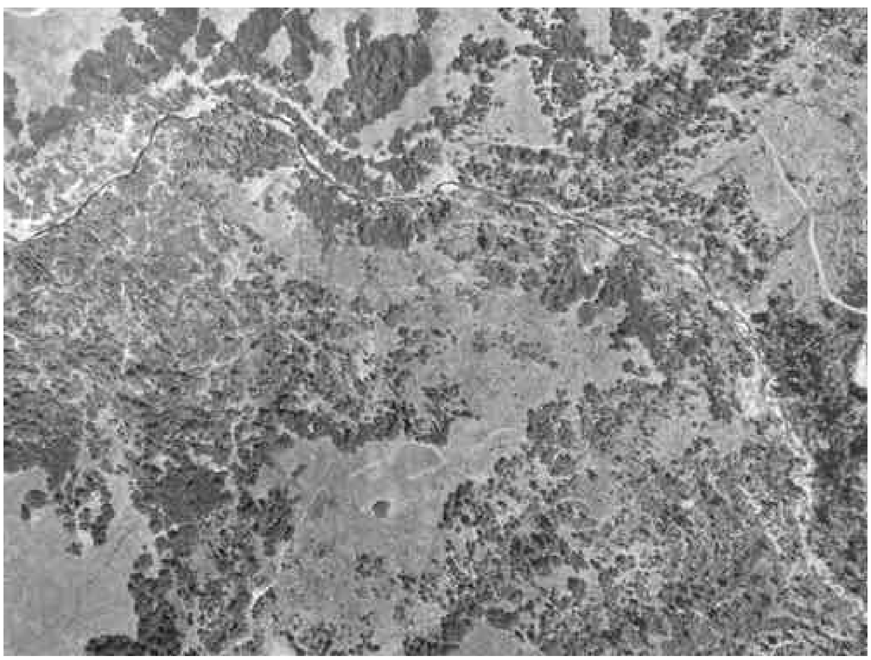
Marshall Creek and SF is similar. But unlike the Marshall Creek, the majority of the historically active, small landslides occur within the generally more stable Coastal Belt Franciscan rocks. These rocks presumably have been severely weakened by shearing within the San Andreas Fault Zone

VEGETATION

The 1942 photos show the South Fork upstream of the Wheatfield, bordered by a variety of timber types as a result of an area-wide fire in the early 1900s. There was partial to entire canopy cover throughout most reaches along the main stem Upper South Fork, Marshall Creek, and tributaries. McKenzie Creek had dense mature Redwood Douglas fir cover. There was consistent oak-woodland cover along upland riparian channels in the dense melange soil type. This prairie grassland-oak woodland is the dominant vegetative cover in upslope areas

LAND USE

Timber use and ranching have been the dominant landuse activities. Tractor logging operations began early in the basin due to the proximity of the coast and available road networks. Timbered areas along the lower to central reaches of the main stem Marshall Creek were logged during the mid 1950s. This removed overstory shade canopy from north facing slopes where conifered areas were confined. During the mid to late 1950s, all downslope conifered areas throughout Wild Cattle and Palmer Canyons were removed during an area wide conversion. Logging operations used stream channels for skid trails, truck roads, and landing sites. Harvest operations removed overstory canopy cover with intent to maintain permanent conversion for grazing use Two large fires burned through the area. The first was in 1955. The Creighton Ridge Fire burned through the area during the early 1980s.



Overstory shade canopy elimination,

FIGURE 51: Upper South Fork, June 1965

At the turn of the century, the railroad was built along the South Fork Gualala to transport old growth logs to the Clipper Mill. The local area was initially harvested during the turn of the century. Remnants of turn-of the-century era logging systems are still evident in portions of the watercourse channel. Old growth cutover areas were then used as grazing land. The current second growth stand in the South Fork is the result of regeneration following a severe fire in the early 1900s. The area was reentered during the 1950s for removal of scattered larger sized timber. Recently, vineyard development along the uppermost ridgelines has been the dominant activity with a decline in ranching.

Conversion project removing conifers over the creek, leaving hardwoods upslope.

FIGURE 52: Conversion Project

Marshall Ck.

- Marshall Creek drains an area where the Central and Coastal Belts of the Franciscan Formation have been complexly faulted and shuffled. Large active earthflows within the Central Belt rocks are common along most the length of Marshall. Small (< 100 feet in greatest dimension) historically active slides that delivered into Marshall Creek are especially abundant in the lower reaches where the stream crosses the weak rocks of the Central Belt Franciscan Formation
- Conversions to pastureland have been the dominant form of historical use. Major portions of riparian areas were converted to pastureland A loop conversion project removed all downslope conifered areas eliminating the riparian zone throughout Wild Cattle Canyon, extending east in an arc connecting Palmer Canyon, during the later 1950s. Sheep were noted grazing in riparian zone in Palmer Canyon during a 1981 survey.

McKenzie Creeks.

- The McKenzie drains Kings Ridge, which is a small portion of a 4kmx8km area that was uplifted no later than the last 5 million years as a result of compression along the San Andreas Fault. See the geology report for explanation. Within this uplift, the upper two forks of McKenzie flow through parallel steep canyons flanked by debris slide slopes where the channels widen. The lower McKenzie narrows and flows southward across the uplift and joins Marshall
- Numerous active earthflows occur along large portions of channels, even more abundant are dormant earthflows that potentially could be reactivated. In each of these landslide-impacted reaches, the channels widen
- A continuous wide belt of mature Douglas-fir occupied the lower and central reaches of McKenzie Ck. extending from the confluence with Marshall Ck. to Devils Rib Ridge. Parker and Pool (1964) surveyed this tributary to Marshall Ck. finding optimal steelhead habitat. Fine sediment only comprised 10% substrate with pools at 60% habitat by reach. Steelhead densities were estimated at 50/ 100 ft. length, and ratio of steelhead to roach were estimated at 95:5 (P. Higgins Gualala Compilation, 2001). The Upper McKenzie was then logged after the 1964 fisheries survey. The main haul road followed the stream channel. Numerous in stream landings are located throughout the basin. The riparian zone was cleared of all overstory vegetation.
- A 1999 stream survey found 43% pools by reach and 1.2 ft. depth, 23% riffles, and 29% flatwater. Substrate consisted of 47% cobble/ gravel, 30% boulders, and 12% silt and sand. Substantial post logging damage noted.
- The McKenzie Ck. sub-basin has been a high priority area with the Gualala Watershed Restoration Council. Numerous restoration projects have been completed.
- Wild Hog Canyon Creek and Carson Creek Both creeks were logged during the late 1950s. The haul road and landing sites lined the main channel. Overstory riparian canopy was removed.

Fluvial Geomorphology

Marshall Creek Super Planning Watershed

Middle South Fork Gualala River Planning Watershed

In the 1984 imagery, channel disturbance in the South Fork Gualala River ranged from 50 to 75 percent with 26 delivering landslides. By 1999/2000, the length of channel disturbance had not changed significantly and 41 delivering landslides are mapped. Wide lateral bars and bank erosion are common.

Upper South Fork Gualala River Planning Watershed

Channel disturbance in the 1984 imagery ranges from 25 to 50 percent with 16 delivering landslides. In the 1999/2000 imagery approximately 25 percent of the channel is disturbed and 19 delivering landslides are mapped.

Lower Marshall Creek Planning Watershed

In the 1984 imagery, the lower reach of Marshall Creek has 50 to 75 percent channel disturbance. In 1999/2000 imagery, approximately 50 percent of the channel is disturbed downstream of McKenzie Creek and 10 delivering landslides are mapped.

Upper Marshall Creek Planning Watershed

McKenzie Creek is greater than 50 percent disturbed in the 1984 imagery with three delivering landslides. In the 1999/2000 imagery, less than 25 percent appears disturbed with 2 delivering landslides.

Lower South Fork Gualala River Super Planning Watershed

Big Pepperwood Creek Planning Watershed

In the 1984 imagery, less than 25 percent of Big Pepperwood Creek and tributaries appear disturbed with 16 delivering landslide mapped. South Fork Gualala commonly has large lateral bars with less than fifty percent of the channel appearing disturbed. By 1999/2000 Big Pepperwood Creek has less than 25 percent disturbed channel with 12 delivering landslides. The South Fork Gualala channel bars near Big Pepperwood Creek appear to be reduced in size.

Mouth of Gualala River Planning Watershed

In the 1984 imagery approximately 50 percent of the South Fork of the Gualala River in the Mouth of Gualala River planning watershed appears to have large lateral and mid-channel bars, especially at tributary with Wheatfield Fork. By 1999/2000 the size of the bars appears smaller in the imagery, more vegetation on bars, but the Wheatfield Fork confluence still appears impacted. Excess bars appear at the mouths of Wheatfield, Buckeye and Rockpile creeks. Field reconnaissance found that sediment build up at the mouth of the major channels causes surface water to flow subsurface for several hundreds feet upstream from Gualala River.

Water Quality

In-stream Sediment

Substrate particle sizes were measured by GRI at four sites in the lower South Fork subbasin, two in the mainstem (GUAL # 402, GUAL # 225) and two in Big Pepperwood Creek (PW #218, PW #219). To compare the data to Knopp (1993), the individual D_{50} values for the sites (3 transects per site) were averaged. Then the minimum, maximum, and average for those averages were compared to the same statistic from Knopp (1993) in the following table.

Stream Name	Years	No. of Sites	No. of Samples *	Minimum (mm)	Mean (mm)	Maximum (mm)
Upper South Fork	97-99	1	2	13	16	20
Lower South Fork	98, 00	2	3	20	23	25
Big Pepperwood	97, 98, 99	2	4	31	35	40
Knopp (1993) Index Streams	1992	18	18	37	69	183
* no. of samples = number of averages included in the comparison						

TABLE 24: Median particle sizes - South Fork subbasin

Median particle sizes from five sites sampled by GRI in 1997-2001 in the South Fork subbasin.

Streambed particle sizes at site SFG #402 sampled by GRI in 1997 and 1999 are small, and indicate sediment in this area, at least, as limiting (Figure XX). To compare the data to Knopp (1993), the individual D_{50} values for the site (3 transects) were averaged. Then the minimum, maximum, and average for those averages were compared to the same statistic from Knopp (1993) in the following table:

Stream Temperature

Water temperature data were available for 15 sites in the South Fork/Main Gualala subbasin for the period of 1994-2001. Seven sites were located in the mainstem, four sites in the Pepperwood Creek watershed, two sites in Groshong Gulch, and two sites in McKenzie Creek watershed (Figure 53).

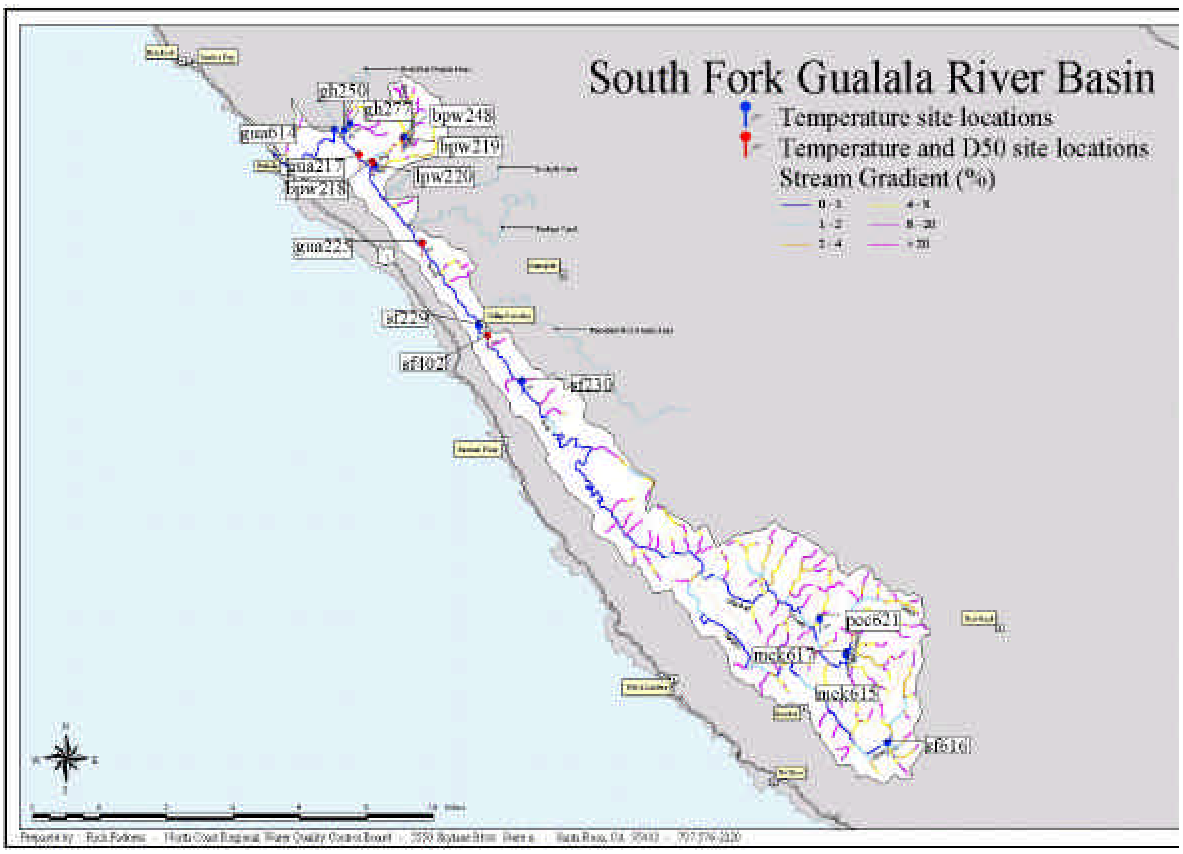


FIGURE 53: South Fork Gualala River Basin

Water temperature and sediment sampling sites in the South Fork/Main Gualala subbasin.

Water temperatures at the mainstem sites were above the suitable range for salmonids, while the lower tributaries were much cooler. MWATs at the seven mainstem stations (gua 614, gua 217, gua 225, sf 229, sf 402, sf 230, sf616) ranged from 64-72 F, all above the proposed suitable range for salmonids (Figure 54). Seasonal maxima ranged from 66-78 F, the lowest occurring at the farthest upstream site (sf616).

Tributaries to the lower mainstem generally exhibited lower MWATs. Water temperature observations for two sites in Groshong Gulch (gh250, gh 277) from 1996, 1999, and 2000 provided an MWAT range of 56-58 F, within the proposed "fully supportive" range. Seasonal maxima ranged from 57-64 F, under the lethal maximum limit (Figure 39, above). Sites in the Pepperwood creek watershed (lpw 220, bpw 218, bpw 219, bpw 248) had MWATs slighty below the upper level of the suitable range, with the Little Pepperwood Creek site (lpw220) MWATs hovering around the upper level.

While the lower tributaries exhibited lower MWATs than the mainstem sites, this was not the case for the McKenzie Creek sites (mck615, mck 617). Data for the two years of record (2000, 2001) produced MWATs ranging from 61-68 F, above the suitable range (Figure 54). Seasonal maxima for those two sites ranged from 61-75 F, below and close to the lethal limit of 75 F. Vegetation in the upper reaches of the watershed, especially McKenzie Creek tend towards non-forested types with lower canopy in the riparian zone (Figure 55).

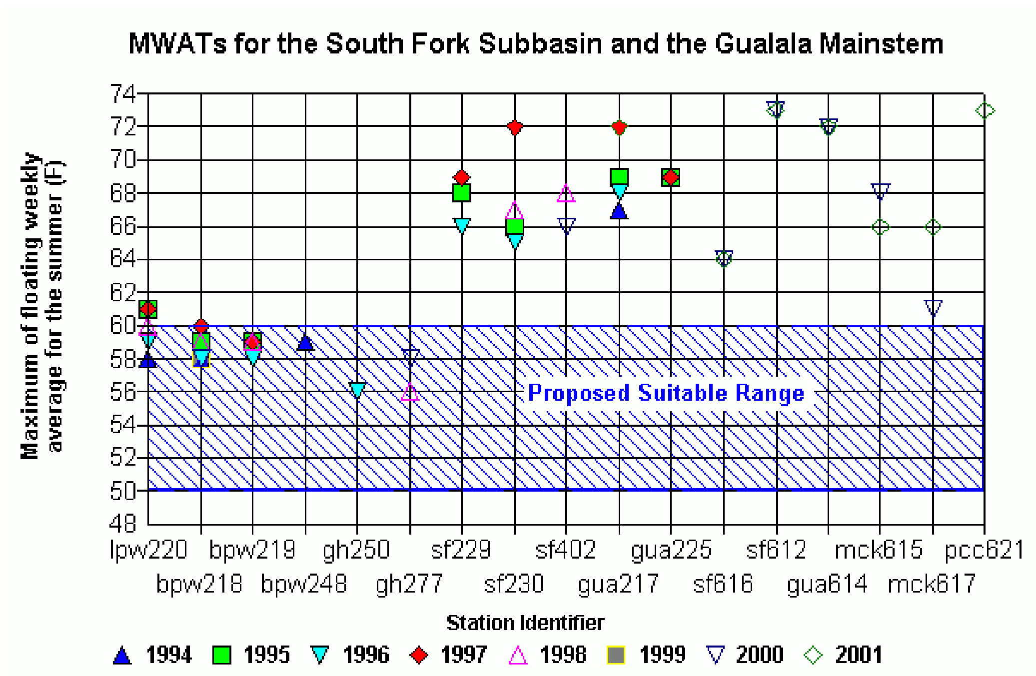


FIGURE 54: MWAT - South Fork Subbasin/Gualala Mainstream

Maximum weekly average temperatures for the South Fork/Main Gualala subbasin, 1994-2001. Data are from continuous temperature monitors placed by GRI and GRWC.

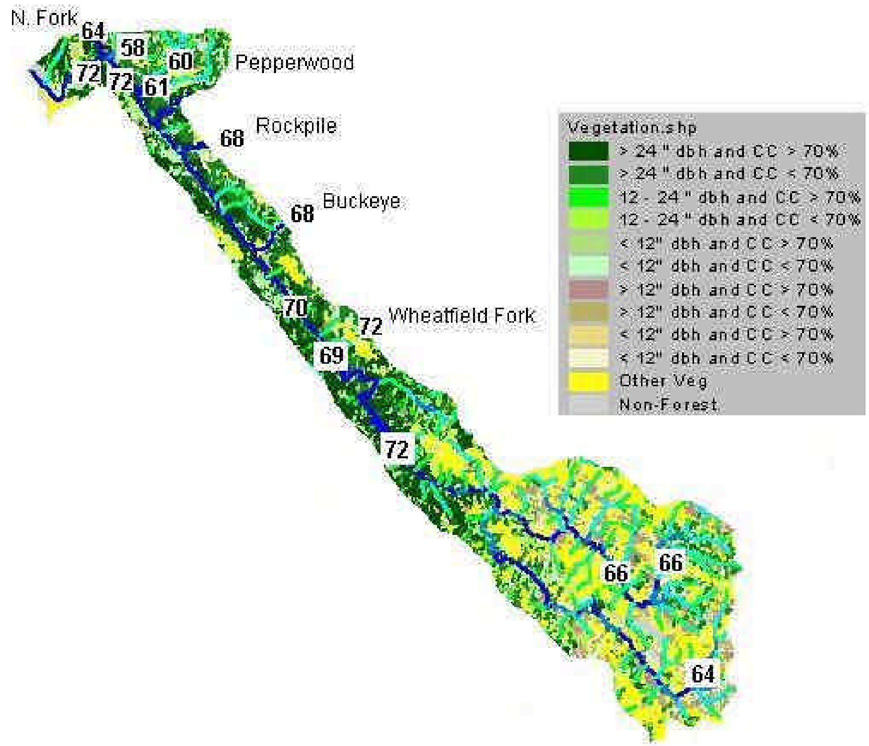


FIGURE 55: MWAT - 1994-2001

Highest MWATS for the period of record of 1994-2001 on a 1994 LandSat vegetations theme for the South Fork//Main Gualal aubbasin. The predominantly yellow and light green areas in the upper watershed (southern portion) indicate oak woodland and grasslands on the Franciscan melange.

Aquatic/Riparian Conditions

TABLE 25: Instream Data - Upper South Fork Subbasin

DF&G Habitat Typing Data

(1999 - 2001)

McKenzie Creek	43%	8.8	1.2	Gravel	26-50%
Carson Creek	49%	4.6	1.0	Gravel	51-75%
Camper Creek	30%	2.6	0.9	Gravel	26-50%
Wild Hog Creek	35%	3.1	0.6	Gravel	26-50%
Marshall Creek					
Palmer					

Tables 26 shows recent canopy density measurements within the Upper South Fork Basin measured at the thalweg. Density is measured by using a spherical densiometer and the surveyor estimates canopy composition. No Watershed Cooperative Monitoring Program data were available.

TABLE 26: Canopy Density - Gualala Mainstream & South Fork Subbasins

DF&G Habitat Typing Data (1999 - 2001)

	1999	2000	2001
McKenzie Creek	69%	44%	56%
Carson Creek	84%	44%	56%
Camper Creek	87%	49%	51%
Wild Hog Creek	73%	24%	76%
Marshall Creek			
Palmer			

TABLE 27: Summary of Large Woody Debris Surveys

Gualala Mainstem & Lower South Fork Subbasin
Watershed Cooperative Monitoring Program
(1998 - 2001)

Tributary	Site Number	Watershed* Size (acres)	Volume CuFt/1000'	Quantity Pieces/1000'
Pepperwood Creek	218	1,825	2,275	61
Gualala South Fork	217	157,415	1,207	23
Gualala South Fork	402	31,081	1,390	23

*Watershed size is calculated as the area above the monitoring site.

The Cooperative Monitoring Program surveys show the lower South Fork and Pepperwood Creek lack volume and pieces of LWD.

Results from macroinvertebrate population sampling can be used to evaluate the occurrence of various types of pollutants and current watershed conditions. Samples taken at one reach site in the Lower South Fork basin and one reach site in Pepperwood Creek in 2000 by Jon Lee can be characterized as average when compared to similar north coast watersheds (Table 28).

TABLE 28: Summary of Macroinvertebrate Sampling

Gualala Mainstem & South Fork Subbasin
Gualala Redwoods, Inc.
(2000)

Tributary	Site Number	Watershed* Size (acres)	Richness	Simpson Diversity	Hilsenhoff	Abundance	Dominant Taxon
Pepperwood Creek	218	1,825	32	0.79	4.7%	4,961	39%
South Fork Gualala	217	157,415	28	0.87	4.4%	7,112	28%

*Watershed size is calculated as the area above the monitoring site.

Fish History and Status

The Upper South Fork was historically dominated by steelhead/ rainbow trout with a small number of roach. Suitable anadromous spawning and rearing habitat existed in the tributaries. The higher 6 mile reach was optimal steelhead habitat with abundant steelhead spawning gravel. The middle reach contained stagnant areas with some dry areas. No coho salmon were found during this survey. However, coho salmon were found in another 1964 survey in Marshall Creek at 30 per 100 feet. Along the main stem Upper South Fork, steelhead densities were 100 per 100 feet in the upper survey reach, 25 per 100feet in the middle reach, and 10 per 100 feet in the lowest reach. The lowest 15 miles downstream of Marshall Creek was not surveyed (Higgins 1997).

Two reaches of the upper South Fork were electrofished in November, 2001. Only young of the year (less than one year old) are dominant. One and two year age classes were present.

Coho are currently not known to exist in the South Fork Gualala Watershed. Barraco and Boccione (1977) surveyed the lower South Fork finding pools to comprise 70% stream reach habitat

Fish Habitat Relationship

Subbasin Issues

- Fish density – Little current data exists. Electrofishing of the Upper Southfork observed multi-age class composition of steelhead, but no coho.

- In-stream habitat diversity and complexity, based on very limited surveys appears to be insufficiently diverse. Inadequate pool depth, and a lack of escape cover and LWD have contributed to a simplification of instream fish habitat.

- Large Woody Debris (LWD) recruitment potential is very poor overall due to naturally occurring geologic conditions. Land use practices may have exacerbating the naturally occurring geological conditions.

- Land use practices on steep and/or unstable slopes should be conducted in accordance with guidelines and recommendations in DMG Note 50.

- Roads – There is concern over abandoned roads, new road construction, and road maintenance issues related to landsliding and sediment input. Without appropriate maintenance or storm proofing, existing roads, both active and abandoned, may continue to supply sediment.

- Sub-division construction is an issue at this time. Timber harvest, grazing and vineyards are prevalent. Feral pigs also impact the land.

- Water chemistry – No data is available on pH, DO, nutrients.

- Water temperatures data is very limited throughout the subbasin. Data on the Southfork showed temperatures above the fully suitable range for salmonids. Summer high temperatures probably exceed optimal conditions for salmon throughout much of this planning basin. This may be due to natural existing conditions in some areas.

- Instream sediment data is needed. Based upon a few samples over a short time period there is an indication that fine sediments may be approaching or exceeding levels that are considered suitable to salmonid populations.

- Wildlife/Plants -- Inadequate information exists to assess status and trends of flora and fauna, including invasive species. Pampas grass is observed.

Subbasin Issue Synthesis and Recommendations

Working Hypothesis: ***The South Fork subbasin provides somewhat suitable and unsuitable habitat for coho and somewhat suitable habitat for steelhead.***

Supporting Findings:

- Sources of upstream sediment include highly erodible earth materials, mass wasting, seismic activity, and land use.

- Water temperatures in the estuary, as a result of warming effects upstream, may exceed a level that is fully suitable of salmonids.

Contrary Findings:

None noted.

Recommendations:

- Survey ability was severely limited by landowner access. Agency Biologists and the Gualala River Watershed Council should consider training landowners to conduct habitat inventory and fisheries surveys.

Working Hypotheses

Accelerated erosion from logged areas has contributed to the sedimentation in the streams resulting in added degradation of salmon habit.

Supporting Findings

- Comparison of modern and historic stream surveys show a decline in anadromous populations.[Appendix XX: CFG Catch Statistics]

- Comparison of modern and historic stream surveys show that pools have become shallower and streambeds have become embedded with fine sediment over between the earliest fisheries surveys between 1964 and present. Both conditions are deleterious to anadromous fisheries. [Appendix XX: CFG Stream Survey Report]

- Roads and landings are important sediment sources in the basin. Both historic and modern aerial photos show that numerous debris flows and debris slides involve roads and that numerous failures occur along in-stream and near-stream roads and landings. These resulted in increased sedimentation in the streams.

- Conifer block removal, followed by permanent conversion to pastureland, was the dominant historical land use practice in the basin.. Prolonged cattle encroachment into streams prevented timely riparian canopy reestablishment, reducing vegetational barriers to erosion.

- Large in-stream landings were built in support of logging operations. Many of these were washed out during subsequent storms.

- Modern logging operations are far less intense than those practiced from 1950-1968. In-stream roads and landings are not permitted. Tractor logging on steep slopes is now restricted. The size and degree of clear cuts is now limited. Erosion control is now mandatory for harvested areas.

Contrary Findings:
None at this time.

Limitations

These conditions are well constrained within the scope of work performed thus far.

Conclusions

Past logging practices, specifically tractor operations on steep slopes, accelerated erosion and added excess sediment to stream channels.

Upgrading and diligent maintenance of existing road systems to reduce sediment impacts will slow the degradation of salmon habitat –specifically pools and spawning gravels. Careful engineering of new roads or repairs can reduce adverse sediment impacts.

Recommendations

- Road managers should develop and adopt erosion control plans. Repairs and new road construction should be carefully designed and when necessary licensed specialists such as civil engineers, erosion control specialists, and engineering geologists should be consulted.

- Building fences along creeks is now highly encouraged by Resource Conservation Districts, and now more widely implemented on private ranches.
- Continue to decommission streamside roads and landings. The following tributary contain the highest density of these still active sediment sources:
- McKenzie Creek.

<u>Working Hypothesis:</u> ***Depleted overstory shade canopy cover along the higher reaches of the Upper South Fork, and Marshall Creek and tributaries from legacy harvests, followed by conversion to grazing land, continues to contribute to elevated water temperatures.***

<u>Supporting Findings:</u>

- Heavy tractors building roads, landings, and skid trails in riparian zones shortly after WW II eliminated overstory shade canopy cover throughout long sections of the Upper South Fork, Marshall Creek and tributaries. There was near entire canopy elimination in many areas.
- Vineyard development in recent times can encroach into riparian zones.

<u>Contrary Findings: None</u>

<u>Recommendations:</u>

- Encourage livestock exclusionary measures along streams.
- Exclude vineyard development from riparian areas.
- Where current canopy is inadequate, use tree planting and other vegetation management techniques to hasten the development of denser riparian canopy.
- Increase continuous temperature monitoring efforts.
-

<u>Working Hypothesis:</u> ***Depleted overstory shade canopy cover along the South Fork and tributaries from legacy harvests continues to contribute to elevated water temperatures.***

<u>Supporting Findings:</u>

- Heavy tractors building roads, landings, and skid trails in riparian zones shortly after WW II eliminated overstory shade canopy cover throughout long sections of South Fork and tributaries. There was near entire canopy elimination in the middle reaches and upper reaches of the South Fork basin, with operations especially pronounced during the late 1950s to 1964.

<u>Contrary Findings:</u>

- Advanced conifer hardwood regeneration since 1968 has reinstated canopy cover throughout many of the highest tributary reaches.

<u>Recommendations:</u>

- Ensure that adequate streamside protection zones are used to reduce solar radiation and moderate air temperatures in order to reduce heat inputs to the South Fork and its tributaries.
- Where current canopy is inadequate, use tree planting and other vegetation management techniques to hasten the development of denser riparian canopy.
- Increase continuous temperature monitoring efforts.

<u>Working Hypothesis:</u> ***A lack of in stream large woody debris contributes to simplified riparian habitat structure (e.g., lack of large, deep pools).***

<u>Supporting Findings:</u>

- Heavy tractors building roads, landings, and skid trails in or adjacent to streams between 1952 and 1968 buried, removed, or dispersed LWD in the basin. Field observations have confirmed low LWD distributions.

- Historic and recent timber harvest in lower and middle reaches frequently removed large conifer vegetation down to the stream bank, severely reducing the available recruitment supply of large woody debris.

- Although stream buffers are regrowing under current land management practices and Forest Practice rules, dense buffers of conifers large enough to function, upon recruitment, as LWD in channel formation processes have not yet been reestablished.

Contrary Findings:
None noted.

Limitations: Limited formal stream reach surveys have been done for LWD; however observations of crews and findings regarding pool complexity indicate that there is limited instream LWD.

Recommendations:
- Artificial LWD installation projects vastly speed up in channel diversity development.
- Tree planting, thinning from below, and other vegetation management techniques will hasten the development of large riparian conifers.

Limitations of the Assessment

This assessment provides useful and valuable information represented a considerable effort of the involved agencies, contractors, and public. It was limited in duration, scope, detail, and analysis level due to constraints in budget, time, access, and overall resources. Where data are limited, working hypotheses are offered along with recommendations to test or improve the knowledge base. Specific limitations are presented below to put the assessment in context.

- Point or more local data, e.g., individual stream reaches, were described in relation to those small geographical areas. As descriptions and inferences are drawn from those data to a more regional, watershed scale the certainty associated with those conclusions and inferences is reduced. In those cases, the NCWAP team offered working hypotheses with suggestions for testing or improving the level of certainty. This is due to lacking historical and current data compared to the Mattole and Redwood River watersheds coupled with the unique geology of the Gualala watershed make subbasin comparisons difficult. Hence, this draft hopes to describe sound hypotheses based upon the most current information available to reduce speculation.
- DFG conducted over 100 miles of habitat inventory on streams throughout the entire watershed from June – November, 2001. Approximately 15 miles of habitat inventory data existed prior to this assessment, collected by the Sotyomy RCD (1995) and DFG (1999). This immense amount of data collect in 2001 has undergone and continues to undergo QA/QC processing, however, without this extensive fieldwork, current instream conditions would have remained unknown and the EMDS model could not have been used on the Gualala. DFG conducted electro fishing surveys in all subbasins except Rockpile through November, 2001 for this assessment. Data are still being compared to past existing data.
- DMG's landslide and geomorphic analyses were limited to aerial photo interpretation from two sets of photos: 1984 and1999-2000, and limited field verification. Limited aerial photo coverage does not bracket temporal distribution of important watershed events, which may not be evident in photos taken years after the fact. Field checking of interpretations was extremely limited.
- The geologic analysis did not identify erosion sources beyond mass wasting and gullying, such as surface erosion or erosion induced by human activities.
- At the analysis scale of 1:24,000, the detection of geologic features smaller than 100 feet in greatest diameter is poor.
- Detailed site level mapping of landslides and sediment delivery were conducted by outside parties in various portions of the watershed. However, time and staffing constraints prevented evaluation of those data.
- DMG has not reviewed all geologic references from other sources used in this report. Geologic conclusions cited by others do not necessarily reflect the views of DMG.
- DMG's assessment of fluvial and hillslope conditions has not been completed; findings may change when relative potential maps are completed.
- Existing geologic mapping of the Rockpile Creek subbasin is limited to the CDMG 2-degree sheet. The presence and location of geologic features in this area were inferred from surrounding areas where more detailed mapping was available.
- CDF's land use analysis used aerial photos exclusively. Sediment sources found in earlier photo sets were not field reviewed to ascribe current comparative condition.
- Localized point source channel aggradations and meandering flows observed shortly after the 1964 storms were not systematically compared sequentially through time to detail evolving stream channel morphology. Only spot point comparisons with 84, 88, and 1999 photos were done depending on where 1964 flood damage was observed.
- There was only time to compare the broadest contrasts between 1950s/ 1960 era impacts with declining habitat conditions. More subtle habitat changes to properly characterize recent land use activities requires a far larger and detailed data base to make significant conclusions.
- NCRWQCB's water chemistry analysis was limited to available USEPA StoRet data for the period April of 1974 to June of 1988 at three locations, and three samples obtained by NCRWQCB at five locations in 2001. The sampling frequency and small number of locations did not allow for any detailed temporal analysis.
- Pesticide data were not available from StoRet, nor collected in the NCRWQCB sampling of 2001.
- Collection of additional water quality data on daily dissolved oxygen, pH, conductance, and temperature at locations near the confluences of several major tributaries did not occur due to access limitations.
- NCRWQCB analyzed water temperature and in-channel data supplied by the GRWC and GRI for the period from 1992 to 2001. Not all locations received sampling throughout that period, limiting the ability to compare across years and among sites.
- The temperature range used for "proposed fully suitable" of 50-60 F was developed as an average of the needs of several cold water fish species, including coho salmon and steelhead trout. As such, the range does not

represent fully suitable conditions for the most sensitive cold water species (usually considered to be coho).

- In-channel data and some temperature data were provided as summary statistics (medians, means, and maximums), limiting the ability to factor variability into the analysis, and not allowing for independent checks on the data quality. As such, the analyses and subsequent assessment are limited in scope.
- Temperature data analysis did not include probability of exceedence from cumulative distribution plots, or hours of exceedance of a threshold. This analysis was limited by not having raw data for all sites, obtaining raw data late in the analysis, and data interface problems.
- NCRWQCB did not have turbidity nor suspended solids data, though considers them critical to watershed analysis. The absence of those data and any analysis of suspended loads and turbidity are limitations in this assessment.
- Analysis of temperature information is without knowledge of the extent of a thermal reach upstream of the continuous data logger.

References Cited

These references were specifically cited in the body of the report. A complete listing of the data and literature sources used in the watershed assessment is presented in Appendix 4.

California Department of Fish and Game. 1968. Drainage description, discussion of riparian community, climate, soils, fisheries, flow data (1950-1971) in the Gualala and Garcia Rivers. 10pp., maps. California Department of Fish and Game, Region 3, Yountville, CA. (Date of report estimated by Bill Cox).

Coastal Forestlands 1997 Sustained Yield Plan.

CRWQCB. 2001. Gualala River Watershed Technical Support Document for the Total Maximum Daily Load for Sediment. NCRWQCB, Santa Rosa, CA: 132 pp

EIP & Associates. 1994. Gualala Aggregates, Inc., Draft EIR

EIP Associates. 1994. Gualala Aggregates, Inc. Draft Environmental Impact Report. State Clearinghouse No. 92123014. October 1994. Permit and Resource Management Department, Sonoma County, CA. 58 pp.

EIP Associates. 1994. Gualala Aggregates, Inc. Draft Environmental Impact Report. State Clearinghouse No. 92123014. October 1994. Permit and Resource Management Department of Sonoma County, CA.

Higgins, Patrick. 1997. Gualala River Watershed Literature Search and Assimilation. Funded by Coastal Conservancy. Under contract to Redwood Coast Land Conservancy.

Higgins, Patrick 2001. Gualala River Watershed Literature Search and Assimilation. Revised.

Louisiana Pacific Corporation. 1997. Sustained Yield Plan. Vol. 6. South Coast.

RWQCB. 2000. Review of Russian River Water Quality Objectives for Protection of Salmonid Species Listed Under the Federal Endangered Species Act. Regional Water Quality Control Board, August 18, 2000: 80 pp.

RWQCB. 2001. Methods Manual for Water Quality Data Gathering and Analysis for the North Coast Watershed Assessment Program. N. Coast Regional Water Quality Control Board, Santa Rosa, CA, May 8, 2001 draft: 11pp + 1 attachment + 6 appendices.