TEN MILE RIVER WATERSHED 1995
INSTREAM MONITORING RESULTS

Georgia-Pacific West, Inc.
Fort Bragg, CA

VOLUME I

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1995 Georgia-Pacific TMRW Monitoring Plan

CONTENTS

ACKNOWLEDGMENTS

In last year's Ten Mile River Watershed monitoring report I placed the acknowledgments in the back, and of course no one read them. Hopefully, by putting it in the front, those reviewing this report will read the names of the colleagues whose contributions has resulted in the success of this report. I applaud them all - they deserve it. The Georgia-Pacific wildlife staff, many of whom co-authored this report, were the principal contributors to gathering and compiling the 1995 data set. The standards of excellence and dedication exhibited by my staff this year makes me feel extremely privileged to have worked with all of them. Their names are Tim (The Martyr) Burnett, John (Bug Man) Drew, Jimi (The Library) Gragg, Diana (Not-another-day-with-Lundby) Hines, David (Squeaky-Wheel) Hines, David (Wiseguy) Lundby, and David (Gramps) Wright.

Mark Hannon is first on the list of those outside the Wildlife Dept., who contributed, I thank him for streamlining so much of our work in 1994 and 1995. The following people are listed in no order of preference because they all gave so much. Chris Hayter for helping to figure out how to convert those ancient F&G dbase programs into something useable for us. Deborah White for helping with the interpreting, analyzing, and crunching of all those numbers. Bob Taylor for analyzing the sediment data on a moments notice. Scott Downy and Gary Flosi for clarification of the habitat typing manual. Doug Mallory for improvements across the watershed. Alan Hess for assessing Patsy Creek. Jason Sickmiller for the maps. Dick Jordan for the enhancement projects. Isabel Haahs for **volunteering** to work with us during the field season. Tom Ray for the foresight and the budget. And Charlotte Morrison who irritated all the authors by hacking draft after draft to pieces with her brutal editing skills, although monitoring plan results are not something to curl up in bed with, (unless one suffers from insomnia) she helped make it much more readable.

JA

KEY TO ABBREVIATIONS

C	Celsius
CDF&G	California Department of Fish and Game
CEMR	California Educational Manpower Resources
CFS	cubic feet per second
CFT	Clark Fork Ten Mile River
CFTW	Clark Fork Ten Mile Watershed
cm	centimeters
cms	cubic meters per second
CONFL.	confluence
CONTRJB.	contributing
EPT	Ephemeroptera-Plecoptera-Trichoptera
FBI	Family Biotic Index
FFFC	Fish Farms Forestry Commmittee
ft	feet
HWAT	highest weekly average temperature
in	inches
km	kilometers
LB	left bank
LNFT	Little North Fork Ten Mile River
LWD	large woody debris
LWDA	large woody debris accumulation
m	meters
mm	millimeter
MWAT	maximum weekly average temperature that should not be exceeded for a particular species
CRWQCB	California Regional Water Quality Control Board
NFT	North Fork Ten Mile River
NFTW	North Fork Ten Mile Watershed
NMFS	National Marine Fisheries Service
OBS.	observed
RB	right bank
RBA	Rapid Bioassessment
RR	Railroad
SFT	South Fork Ten Mile River
SFTW	South Fork Ten Mile watershed
STHD	Steelhead Trout
STS	Southern Torrent Salamander
SWD	small woody debris
SWDA	small woody debris accumulation
TMR	Ten Mile River
TMRW	Ten Mile River Watershed
trib.	tributary

KEY TO ABBREVIATIONS

UILT	upper incipient lethal temperature
UUILT	ultimate upper incipient lethal temperature
WD	woody debris
YOY	young of the year (fish)

Abstract

The information presented in this document describes results from the third year of monitoring for Georgia-Pacific West, Inc. in the Ten Mile River Watershed. This monitoring plan is the realization of an agreement between Georgia-Pacific and the California Regional Water Quality Control Board - North Coast Region. Current conditions of instream aquatic habitat have been evaluated using information from stream temperatures, sediment sampling, fish habitat, aquatic macro-invertebrates, salmonid distribution and estimations of aquatic vertebrate populations. These monitoring results will ultimately direct Georgia-Pacific 's restoration and enhancement efforts by addressing the specific needs of the local environment.

INTRODUCTION

Georgia-Pacific West Corporation (Georgia-Pacific) has completed a third year of instream monitoring for the Ten Mile River Watershed (TMRW). The California Regional Water Quality Control Board - North Coast Region (CRWQCB) expressed concern over possible instream impacts associated with Georgia-Pacific land management activities on the TMRW; as a result, Georgia-Pacific and the CRWQCB agreed to a instream monitoring plan for the TMRW. From the inception of this monitoring plan in 1993, Georgia-Pacific annually produces a document detailing instream monitoring results for the TMRW.

Watershed monitoring along the Pacific Northwest has been catalyzed, in part, by concerns regarding the effects of land management activities on critical instream habitat factors potentially limiting salmonid abundance, occurrence and species distribution. These critical habitat factors, which influence viability and productivity of salmonid populations during their inland life requisites, include: stream temperature, in-stream gravels, large woody debris, nutrient input, aquatic macro-invertebrate distribution and water flow. By quantifying these critical habitat components, Georgia-Pacific can focus specific efforts on those habitat features most limiting for the watershed and enhance these environmental features via restoration or active management.

Although TMRW is the primary monitoring watershed, methods herein are currently applied to varying degrees throughout other watersheds within Georgia-Pacific ownership. The TMRW was chosen as the primary watershed to study stream conditions since most is solely contained within Georgia-Pacific ownership (85 %). In addition, corrective efforts throughout the watershed can be implemented more effectively (minimal access problems) and be evaluated more efficiently (effects are more direct).

Although the standard monitoring parameters have not changed since 1993, methods are continually reviewed in concert with improving scientific techniques. In this respect, Georgia-Pacific's monitoring will continue to be refined to ensure data collection is both scientifically sound and environmentally conscientious.

In addition to the standard parameters measured (stream temperatures, (potential) spawning gravels, and aquatic vertebrate populations and distribution) this monitoring plan includes results from instream habitat typing and macro-invertebrate sampling. The results of this information will ultimately be used to pin-point areas where capital improvements can have their greatest benefit. Findings from 1995 capital improvement activities and stream enhancement projects are also included in this report.

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STUDY AREA

Location & Geography

The Ten Mile River (TMR) is located in central coastal Mendocino County in Northern California (Reference Figure 1 for map of Georgia-Pacific ownership). The nearest city is Fort Bragg, 13 kilometers (km) to the south. The TMRW drains an area of approximately 31,000 hectares. The TMRW consists of approximately 192 km (Table 1) of Class 1 watercourses (within Georgia-Pacific ownership) with three main forks (Figure 2): North Fork (70.6 km), Clark (Middle) Fork (57.2 km) and South Fork (65.0 km). In general, the forks of all three mainstems flow from east to west.

The TMRW is highly convoluted and incised with many ridges and deep ravines. Slow downward soil movement and landslides are the natural erosional processes chiefly responsible for shaping the hills in this area. Like most of the Coast Range, deep soils mantle nearly all of the TMRW, covering bedrock and giving the hills their softly-rounded shape (Alt and Hyndman 1982). Elevations range between 0 meters (m) and 977 m. The Clark Fork extends the furthest inland (approximately 22 air-km from the coast), followed by the South and North Forks respectively.

Climate and Hydrologic Processes

The TMRW is influenced by the Maritime climate of the Pacific Northwest and the Mediterranean climate of central and southern California. Summers are punctuated by cool breezes and fog, along the coast, and hot, dry conditions inland (temperatures up to 37 ° Celsius are not uncommon). Winters are characterized by abundant rainfall and cool temperatures. Precipitation consists primarily of rain, with some limited snowfall on the highest ridges during the colder months. Fog and fog-drip are an important climatic feature to the region during summer months, providing a cooling influence as well as significant precipitation at some locations near the coast. This form of precipitation is generally not included in annual precipitation data. However, Azavedo and Morgan (1974) found precipitation from fog-drip ranging between 25.4 cm to 30.5 cm in the open and 18.4 cm to 21.6 cm under forested canopy within the western Eel River divide in southern Humboldt County.

Rain distribution varies both temporally and spatially. Approximately 90% of the annual precipitation occurs between October and April with most of this precipitation (approximately 75 %) occurring between November and March. Annual average rainfall varies considerably depending on location, generally increasing with higher elevation. Western portions of the TMRW receive about 102 cm of precipitation per year, while the majority of the watershed receives approximately 152 cm to 178 cm per year. The eastern edge of the TMRW has an annual precipitation average of 203 cm (Georgia Pacific SYP 1995).

Watercourse characteristics are dictated by these temporal and spatial patterns of precipitation and the topographic characteristics of the area. Stream flows can dramatically respond to rainfall fluctuations. While interior, higher-elevation, areas receive higher annual rainfall, most of this precipitation tends to occur from relatively few intense winter storm events. These intense storm events, coupled with generally steep terrain, lower inland fog-drip and hot, dry summers, result in many ephemeral watercourses of significant size which may be completely dry by summer.

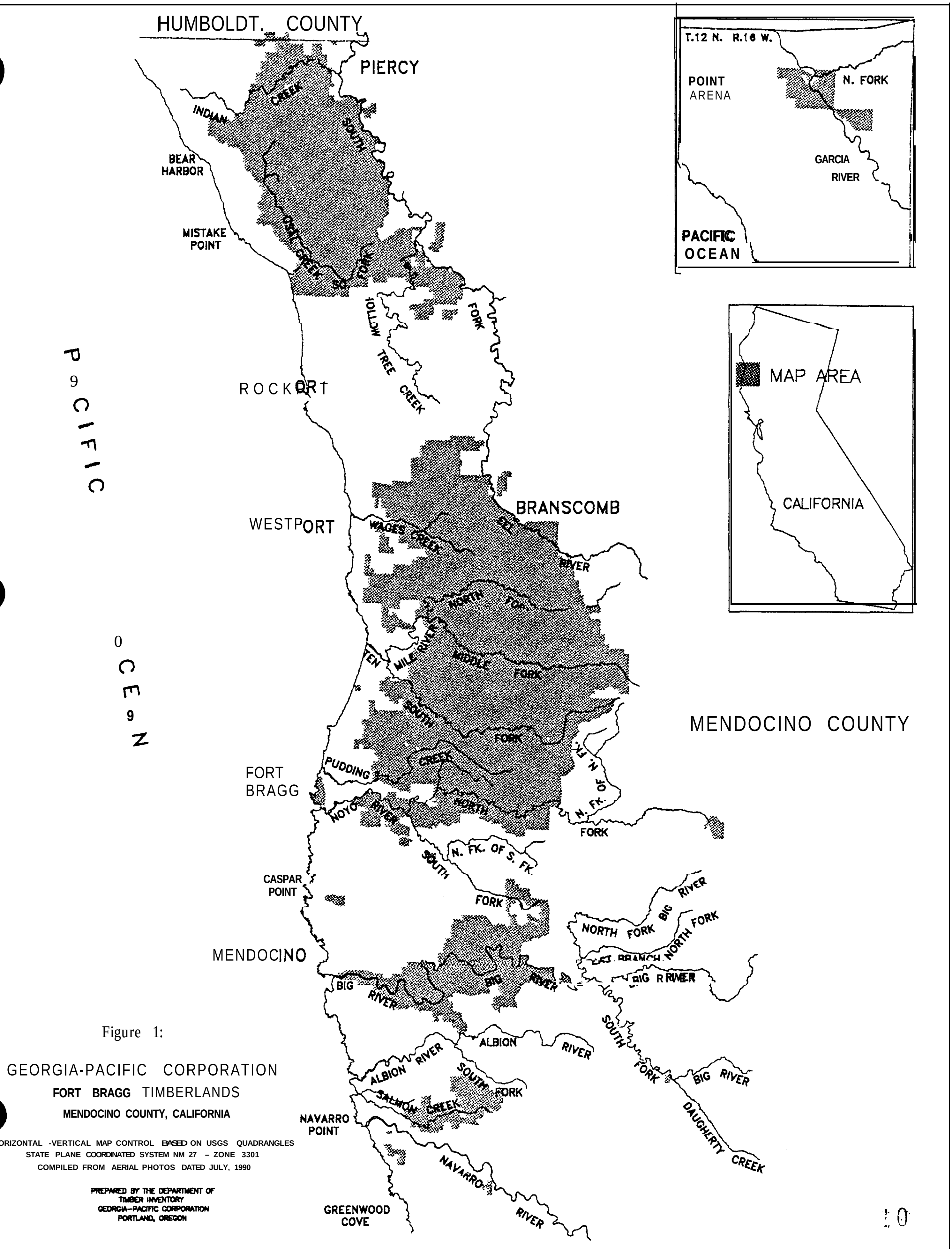

Figure 1:

GEORGIA-PACIFIC CORPORATION
FORT BRAGG TIMBERLANDS
MENDOCINO COUNTY, CALIFORNIA

HORIZONTAL -VERTICAL MAP CONTROL BASED ON USGS QUADRANGLES
STATE PLANE COORDINATED SYSTEM NM 27 – ZONE 3301
COMPILED FROM AERIAL PHOTOS DATED JULY, 1990

PREPARED BY THE DEPARTMENT OF TIMBER INVENTORY
GEORGIA-PACIFIC CORPORATION
PORTLAND, OREGON

Figure 2:

Ten Mile River Watershed Map

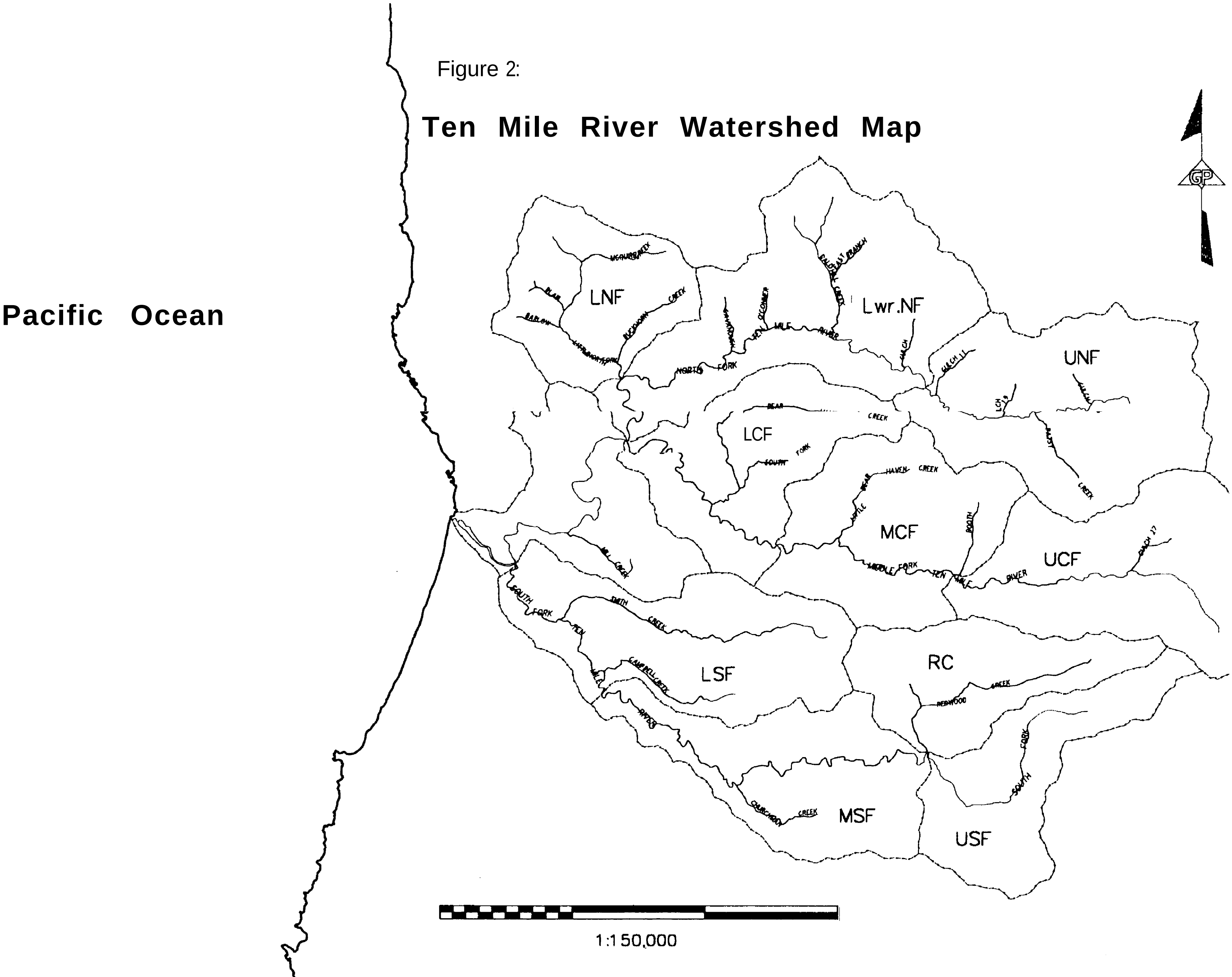

Figure 2 (cont.): Stream Profile and Monitoring for South Fork Ten Mile River. Georgia-Pacific Corp., Fort Bragg, CA, 1995

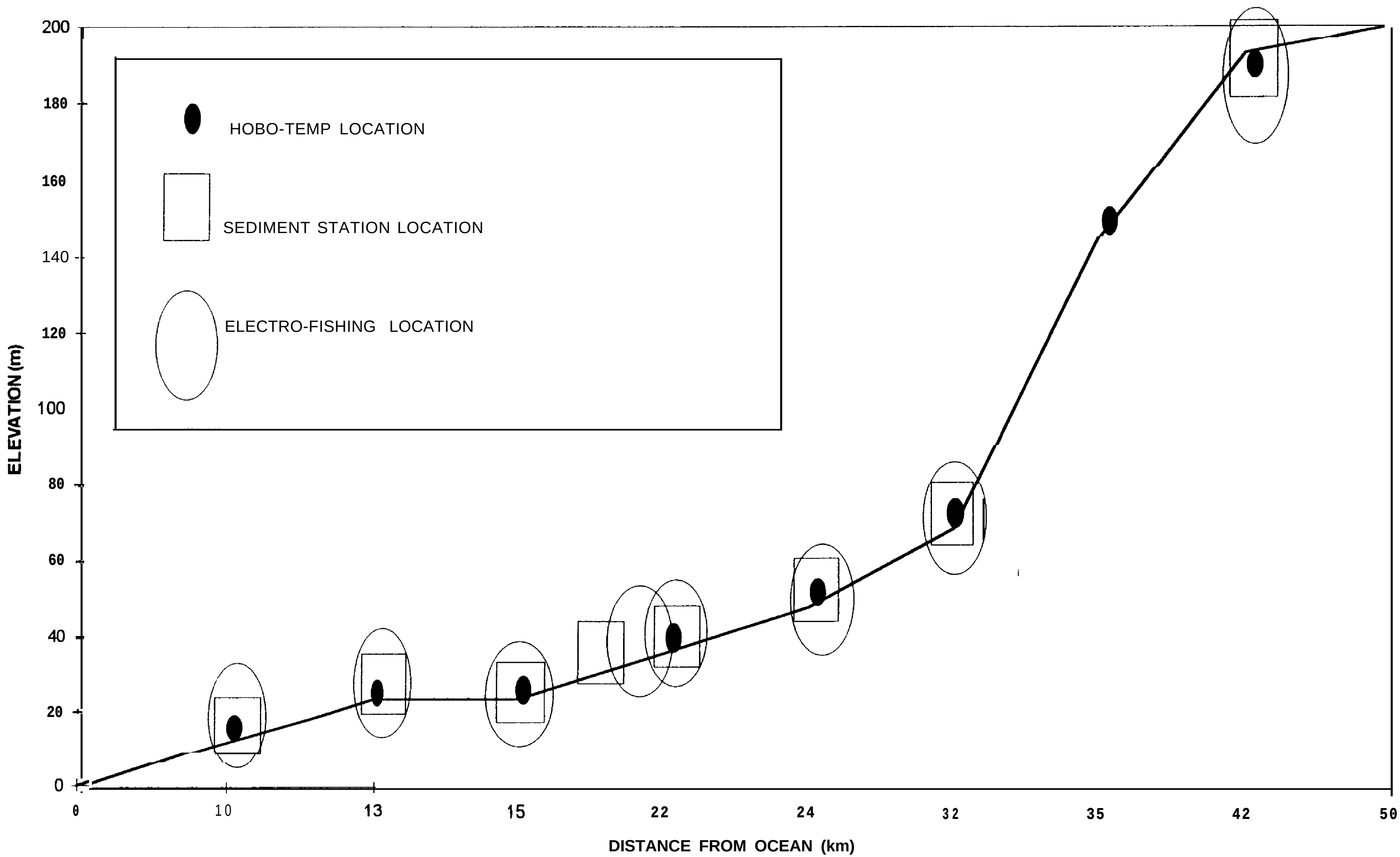

TABLE 1: CLASS 1 GEORGIA-PACIFIC STREAM KILOMETERS IN TEN MILE RIVER WATERSHED

NORTH FORK			
Bald Hill Creek	8.8 km	Patsy Creek	5.0 km
E. B. Bald Hill Creek	1.6 km	Barlow Gulch	2.2 km
N.E. Fork Bald Hill Creek	.96 km	Cavanough Gulch	1.8 km
Blair Gulch	1.3 km	Gulch 8	1.6 km
West Blair Gulch	.26 km	Gulch 19	1.6 km
Buckhorn Creek	3.5 km	Gulch 23	1.5 km
Little North Fork Ten Mile	6.6 km	Gulch 11	1.5 km
North Fork Ten Mile River	25.6 km	McGuire Creek	3.1 km
O'Conner Gulch	1.1 km		
		Total	68.0 km

CLARK FORK			
Bear Haven Creek	19.2 km	Little Bear Haven Creek	3.7 km
So. Fork Bear Haven Creek	1.8 km	Booth Gulch	3.2 km
Clark Fork Ten Mile River	27.5 km	Gulch 27	1.8 km
		Total	57.2 km

SOUTH FORK			
Campbell Creek	5.8 km	Churchman Creek	7.0 km
Redwood Creek	7.4 km	E. F. Redwood Creek	.74 km
South Fork Ten Mile River	33.9 km	Smith Creek	10.6 km
		Total	65.4 km

TEN MILE			
Ten Mile River	1.2 km	Mill Creek	1.2 km
		Total	2.4 km

Vegetation

The TMRW is located in the North Coastal Forest Plant Community (NCFPC) (Ornduff 1974) with a dominant overstory consisting of Redwood (Sequoia sempervirens) and Douglas-fir (Pseudotsuga menziesii). Redwood is a dominant constituent of coastal forest stands, Douglas-fir dominates the more inland sites. Monor conifers components in the area, include, Grand Fir (Abies grandis) and Western Hemlock (Tsuga heterophylla).

Tanoak (Lithocarpus densiflorus) and Pacific Madrone (Arbutus menziesii), which occur together on major ridgelines and mid-slopes, are common components of conifer stands on xeric sites. Generally, Tanoak and Pacific Madrone constitute a higher percentage of the stands in the inland portions of the TMRW. Interior Live Oak (Ouercus wislizenii) is a minor component at most xeric sites on inland ridges.

Further inland, near the headwaters of the North Fork and Clark Fork, the conifer overstory turns to open grasslands. These grasslands also have valley and foothill woodlands with a dominant overstory of California Black Oak (Ouercus kellow) and Oregon White Oak (Quercus garryana) punctuated with Douglas-fir/Redwood/Tan Oak stands.

Geology

The geology of the area is comprised of Franciscan sedimentary rocks uplifted from the ocean floor approximately 40 million years ago which formed the California Coast Range. The Franciscan formation is a heterogeneous mixture of rocks with diverse origins (War-rick and Wilcox 198 1). Graywackie sandstone and associated shale are the dominant rock types in the Franciscan assemblage. Altered sea floor basalt, siliceous chert, and exotic high-pressure/low temperature metamorphic rocks also occur widely. Serpentine is associated with much of the Franciscan formation, especially along fault zones (Bailey et al. 1964). The Franciscan formation in the TMRW is generally a dark mudstone, with smaller proportions of conglomerates and serpentines. The Franciscan complex is relatively young and highly erosive, and it has been suggested rivers and streams on the North Coast act as sediment ‘conveyer belts’ between the hills and the sea (Alt and Hyndman 1982).

About 15,000 years ago, the ocean level was approximately 90 m lower than its present level. While the sea level was lower, coastal rivers cut channels deeper into the terrain. As sea levels rose, coastal river valleys were flooded to create estuaries. Many of the rivers in Northern California, including the TMR, have these estuaries which are now bordered by alluvial floodplains as a result of sediments carried down-river over thousands of years. The expansive tract of sand dunes covering several square km south of the TMR estuary are upstream deposits which prevailing winds and tides have moved back on shore. Similar to many coastal streams and rivers, the mouth of the TMR is completely blocked by a sandbar during the summer months and remains so until the first autumn rains.

Logging History

Georgia-Pacific owns approximately 85 % of the TMRW which is comprised almost primarily of second and third growth forests under active timber management. Various silviculture prescriptions have occurred within the watershed since the first harvest began over 100 years ago. Current timber harvest techniques are radically different than those of the past where sluice dams, steam yarders, bull teams, railroads, road building and heavy equipment were used adjacent to and/or within the stream. Sluice dams are not known to have been used within the TMRW, rather it was primarily railroad logged until the 1930’s. With the passage of railroad logging came the advent of tractor logging which probably resulted in the greatest in-stream impacts. It is generally agreed that most in-stream impacts occurred between the 1940's and 1960's, before the passage of the Z-berg - Nejedly Forest Practice Act of 1973.

Harvest techniques were different within the three main forks of Ten Mile partially as a result of access, technology and economic considerations. Due to these influences it is more effective to describe the timber management history separately. The difference in harvest techniques in the three main forks also influenced the overall analysis within this monitoring plan. Due, in part, to historical differences within the watershed we felt it best to consider each fork independently. Most of the following historical information was adapted from the 1 September 1995 Georgia-Pacific Com. Sustained Yield Plan, written by Georgia-Pacific procurement forester Jere Melo.

North Fork Ten Mile River

In 1870, and continuing until the mid-1880's, logging efforts began in the mainstem of Mill Creek. Essentially, a clear-cut method was used, trees were felled and the bark was peeled. Fire was used to dispose of the bark and limbs, providing the loggers and animal teams access for logging activities. Cut logs were rolled by hand into gulches, and teams of oxen pulled them to a rail tram located along Mill Creek, where they were hauled to the Fort Bragg sawmill. Fire was used to clear slash following logging, and regeneration was by natural means.

Railroad access became available in the North Fork in the late 1920's. Logging advanced slowly within the North Fork since this area was not the primary location for log supply to the Fort Bragg mill (the South Fork of Ten Mile was the primary location). Slackline cable systems were used to remove logs in the area up to and including the Little North Fork. Timber was felled essentially as a clear-cut, and trees not cut were knocked down by cables. Slash fires were regularly used to remove peeled bark and cut limbs prior to yarding and, again, after yarding to clear the land. Regeneration was again by natural means.

Currently, thinning operations and some even-age regeneration harvests are being conducted in stands that range in age from 45 to 65 years. Tractors are now used on slopes below 40 percent with running skyline cable systems used on steeper slopes.

As logging progressed up the North Fork, east of the Little North Fork Ten Mile River, methods changed. During the late 1930's and 1940's, equipment changed from the heavy slackline systems to tractors pulling wheeled arches for log yarding on most slopes, and, for the very steep slopes, to double-drum ground-lead cable systems with a short reach capability. This change in equipment started a move away from a total clear-cut method to an economic clear-cut. The more mobile equipment allowed "seed trees" to be left, typically those tress less than 91 cm diameter. In the North Fork, the area covered by these practices ran from the Little North Fork up to and including Bald Hill Creek. Beginning in the late 1960's and continuing to the mid- 1980's, residual trees left from the first entry were removed. Regeneration was accomplished by aerial seeding from the mid- 1960's to early 1970's, after which tree planting has been used.

Practices differed east of Bald Hill Creek. Logging in the late 1940's to 1960's was almost entirely by tractors. Cutting practices during this time period included the regulation of cutting to diameter limits (122 cm in Redwood and 91 cm in Douglas-fir), resulting in many more remaining "seed trees." Regeneration after these operations was by natural means. During the late 1960's, operations began to remove residual trees, and this continued to the mid-1980's. Regeneration was accomplished by aerial seeding in the early 1970's and tree planting in the mid-1970's. For operations on steep slopes at this time, running skyline systems were used.

Clark Fork Ten Mile River

Early logging in the Clark Fork area occurred on the north slopes of Sherwood Peak. Railroad access from the area northwest of Willits (what is now the Brooktrails community) allowed logging to occur along the range line between R 15 W and R 16 W, generally south of the river. Timber was clear-cut and peeled, followed by slash fires to provide room for additional logging. Cable systems were used to move logs to the railroad. These operations ran from the late 1890's to about 1920.

Young-growth stands that grew after the early logging in Clark Fork were entered in the early 1980's, and operations continue to the present. Even-age regeneration cuts have been used: clear-cut and cable yarding on steeper slopes and shelterwood and tractor yarding on gentle slopes. Large volumes of hardwoods have been removed. Hardwoods were quite dense in these stands resulting from repeated fires occurring in the area during the period from the 1940's to the early 1960's. Tree planting has been used to regenerate harvested lands.

As in the North Fork of the TMR, railroads provided access for logging at the mouth of the Clark Fork in the late 1920's. Generally, timber stands in the Clark Fork were of very high volume and quality compared to the North Fork, so harvest operations were concentrated in the Clark Fork from 1930's to 1960's. In the 1930's and 1940's, the economic clear-cut concept was used, generally leaving trees less than 91 cm as "seed trees." Log yarding was by tractors pulling wheeled arches, except for the double-drum cable systems used on very steep slopes. By the 1950's, diameter limits were imposed, 122 cm for Redwoods and 91 cm for Douglas-fir, and regeneration was by natural means. From the mid- 1960's to the late 1980's, residual trees were removed followed by tree planting and aerial seeding.

South Fork Ten Mile River

In the mid 1910's, plans were prepared to build a railroad into the TMR area from the sawmill at Fort Bragg. Timber stands of the Noyo River area had been depleted quite some distance from Fort Bragg and a new access route was needed. About 1917, a main logging camp was established along the South Fork of Ten Mile, near the mouth of Smith Creek. From the late 1910's to the 1940's, the South Fork was the major log supply source and transportation was by railroad. The typical logging operation was to fell and peel trees, burn the slash for access, chop the trees into logs, and then transport the logs to the railroad or to an incline connecting to the railroad at the river. This resulted in very large continuous clear-cuts which were repeatedly burned to clear the land for grazing.

Regeneration for the area was by natural means until the 1920's. A tree nursery was then established in Fort Bragg, and large areas were hand planted up to the early 1930's. From the 1930's to the 1970's regeneration was by natural means.

In 1945, a severe and particularly destructive fire occurred in the South Fork. A lightning strike started a fire on the west slope of Sherwood Peak. For about two weeks, the fire burned slowly on the ground. A weather change resulted in dry, east winds and high temperatures. The fire "blew up" and burned to the south and to the west. It burned the area between Sherwood Ridge and Smith Ridge and westerly between Riley Ridge and Leidig Ridge roughly to the mouth of Churchman Creek. About 17,000 acres burned in three days. This ultimately resulted in a 10 to 20 year delay in reproduction for the area compared to other areas of the South Fork..

About 1948, the sawmill company at Fort Bragg was required to sell a large acreage of cutover timberlands to pay back a loan from the federal government. In the aftermath of World War II, a loan to stimulate business under the Reconstruction Finance Act had been granted to the local company. Courts later found the Reconstruction Finance Act unconstitutional. In the South Fork, lands were sold from near the mouth of Smith Creek to Churchman Creek; the entire Campbell Creek drainage was also sold. Owners of these cutover lands used repeated burning to convert and maintain the lands for grazing. On north-facing slopes, fires burned cooler and less successfully than on south-facing slopes. At the end of this slash burning period (early 1960's), the lands were purchased back for timber growing. The stands on northern slopes were generally older and better-stocked than stands on south slopes.

Beginning in the late 1970's and continuing to the present, thinning and even-age regeneration harvests have been used in stands from 45 to 70 years of age. Regeneration following these harvests has been by tree planting and natural regeneration. Log yarding has been by tractors on slopes under 40 percent and by running skyline systems on steeper slopes.

Instream History

Unlike land management history within the TMRW, information of in-stream conditions prior, or during logging activities prior to the 1930's is practically non-existent for coastal Mendocino County. However, effects of these past practices can be witnessed today in many other watersheds. Increased sedimentation, instream blockages and other operations which occurred directly in the stream zone probably resulted in extreme environmental impacts.

Information which does exist is primarily in the form of California Department of Fish & Game (CDF&G) surveys, from the 1950's and 1960's. These surveys of biotic and abiotic conditions appear to be the earliest to provide instream descriptions. This information is important but much of it so anecdotal that quantifiable conclusions are usually difficult to obtain.

Today much more information on the TMRW's instream parameters exists, most collected by CDF&G, the Salmon Trollers Marketing Association and Georgia-Pacific. Georgia-Pacific has collected, by far, most of this information and will continue to do so as part of its commitment to the environment.

JA

MONITORING DESIGN

In the past, most habitat enhancement or restoration projects had either no data or only limited data before they were initiated (Bryant 1995) - Georgia-Pacific was no exception. Although some instream information existed from surveys conducted by local agencies, most of the information for TMRW was too scattered and anecdotal to have any influence on the initial design of this project. In addition, much of the literature on evaluations of the stream environment lies hidden in unpublished reports, so when a manager approaches a stream problem to determine a solution, it is necessary to start from scratch (Platts *et al.* 1983). Progress (for most monitoring plans) has largely been by trial and error with no source of standard measures and procedures available for guidance (Platts *et al.* 1983) and Georgia-Pacific's instream sampling strategy began much the same way. Many of the sites selected for sampling in 1993 were not based on locating a representative reach of the drainage. Representative reaches were delineated, *a priori,* due to the lack of information in 1993. To compensate for the lack of stream reach information, however, a large number of sample sites were distributed throughout the watershed to increase the magnitude of the sampling scheme and facilitate analysis of instream conditions. Over the past few years, Georgia-Pacific's efforts have moved towards a monitoring design that is both factual and comprehensive.

As with any monitoring plan, there are a variety of inherent constraints involved with sampling the aquatic ecosystem, several of these include:

- lack of *a posteriori* information
- the random nature of climatic events
- Anthropomorphic effects (i.e. fishing pressure)
- lag time between a management action and its effects on water quality
- difficulty in distinguishing between effects of management activities and natural events
- larger watersheds often have multiple management activities, making problem sources harder to pin-point

Sample site selection was based on horizontal and vertical distribution (Figure 1 and Figure 2), adjacency to confluences, historical data and logistic constraints.

Many monitoring stations were placed adjacent to confluences which can assist in isolating discrete inputs from upper reaches; thus, piloting stream enhancement efforts. For example, temperature monitors were placed above and below confluences in many areas to monitor thermal inputs from high order streams into low order streams.

Areas with historical information are also important, even if such sites are few and locations possibly biased, they provide comparisons to present data which is very important for trend determination. Replication of previous efforts has resulted in a more complete data set which is presented in this document.

Due to the extent of the monitoring program, logistical constraints also dictated the sampling scheme. For example, company biologists often selected locations in consideration of weather conditions (i.e. wet roads, high stream flows), extent of sampling equipment, transportation time and other priorities (other monitoring efforts). Since much of the TMRW is rather remote, and access to many areas limited, monitoring efforts often prove time-consuming and difficult. Additionally, aquatic vertebrate monitoring and sediment sampling stations must be sampled within one week of the previous survey efforts to reduce statistical bias.

Constraints such as these are part of any monitoring program and must be addressed in a manner to enhance annual comparability of data. This data set will facilitate monitoring and analysis of yearly instream conditions and trends.

In 1995 sampling across the TMRW included: 25 aquatic vertebrate stations (approximately 1 per 7.68 km of Class 1 stream), 35 temperature monitoring stations (approximately 1 per 5.49 km of Class 1 stream), 27 aquatic macro-invertebrate stations (approximately 1 per 7.11 km), and 23 sediment sampling stations (approximately 1 per 8.34 km of Class 1 stream). Stream habitat typing was a two year long process that consisted of a 100% inventory in SFT for 1994 and a partial (10%) inventory in Clark Fork and North Fork. Variables measured during habitat typing included, but were not limited to: percent embeddedness, canopy cover, pool parameters, dominant substrate, instream cover, bank substrate and cover, and channel width.

Georgia-Pacific will continue to refine the TMRW monitoring plan, based on the best available information, to facilitate collection of scientifically sound data. To keep up with this myriad of evolving metrics, Georgia-Pacific has been an active participator in the Fish, Farms and Forestry Committee (FFFC) both at the policy and technical levels since 1993. The FFFC has been reviewing issues and monitoring techniques unique to the Northcoast inland fishery resource. Georgia-Pacific will implement and adhere to methods which conform to the most recent techniques recommended by the scientific community. In gauging the integrity of this monitoring design, professionals are consulted and the most recent literature is reviewed. For example, a qualitative ranking of monitoring parameters (especially for areas under timber management) provided by the Environmental Protection Agency (1991) was reviewed to assess the usefulness of our methods (Table 1). Innumerable sources have been utilized to ensure our methods and protocols remain consistent.

Conclusions

In today's methodologies (where the "state-of-the-art" lacks refinement and the form often is directed by expediency and low cost), the observed physical, biological, and chemical conditions and variations used to predict fishery condition and reaction have often been of low value for providing valid interpretations (Platts et al. 1983). To compensate for these deficiencies during the refinement stages of a project, it is essential that protocols are well-described to ensure consistency (Bryant 1995). Without well-decried protocols and a method of evaluating current conditions (standard concern thresholds), interpretation of the information on a uniform basis is impossible, leaving restoration never realized. Hence, Georgia-Pacific has set some standard threshold limits for sedimens and is evaluating thresholds for many of the other data measured. Sediment thresholds for example, if exceeded, will facilitate enhancement and restoration measures for the affected area. It is Georgia-Pacific's goal to maintain a program which will integrate restoration, providing a continuous barometer of the response of the ecosystem, and allow mid-course corrections throughout the life of the monitoring plan (Bryant 1995). The underlying principles are to ensure that methods are consistent, repeatable and measurable under a well-designed plan which iterative processes will refine the conceptual model of the ecosystem as key variables are identified and less important variables are excluded (Bryant 1995).

Since its inception in 1993, the monitoring design has expanded to encompass a variety of metrics. We believe this design provides, rigorous quantitative data from which measured and appropriate land management decisions can be implemented.

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Figure 1: Distribution of Monitoring Stations Throughout the TMRW in 1995

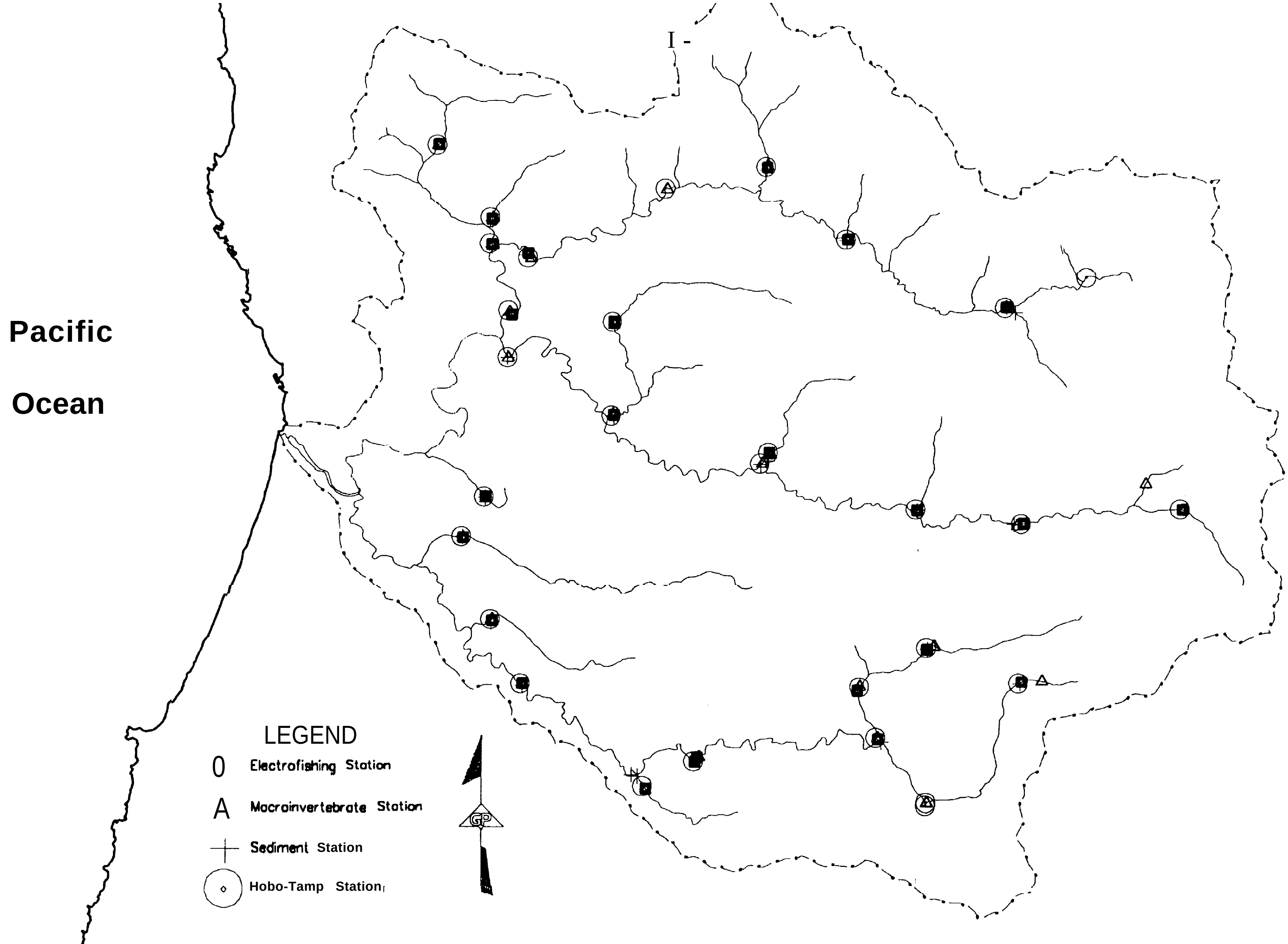


Figure 2: **Stream** Profile and Monitoring Stations for North Fork Ten Mile River. Georgia-Pacific Corp., Fort Bragg, CA 1995

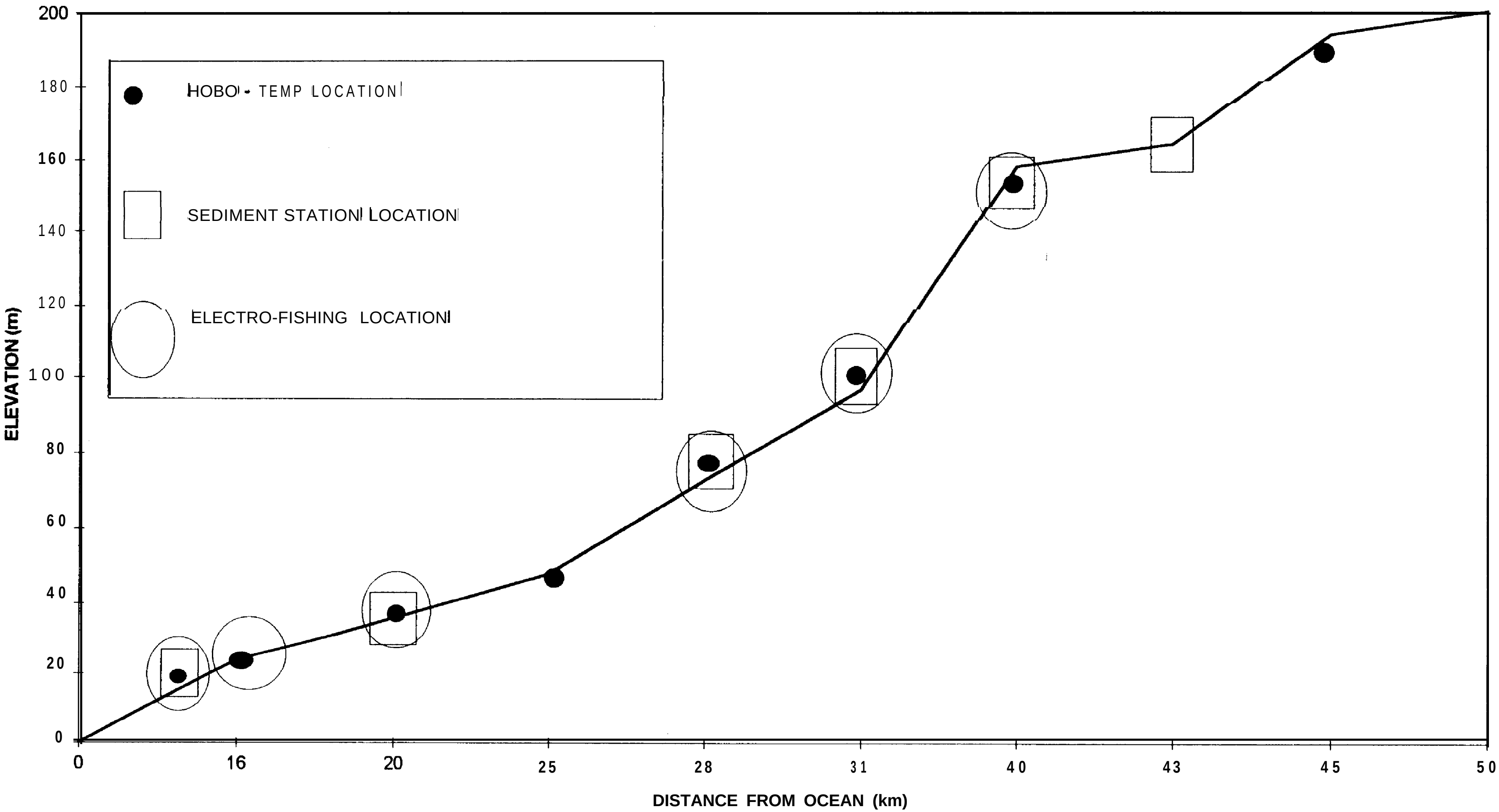


Figure 2 (cont.): **Stream Profile and Montoring Stations for Clark Fork Ten Mile River. Georgia-Pacific Corp., Fort Bragg, CA**

1995

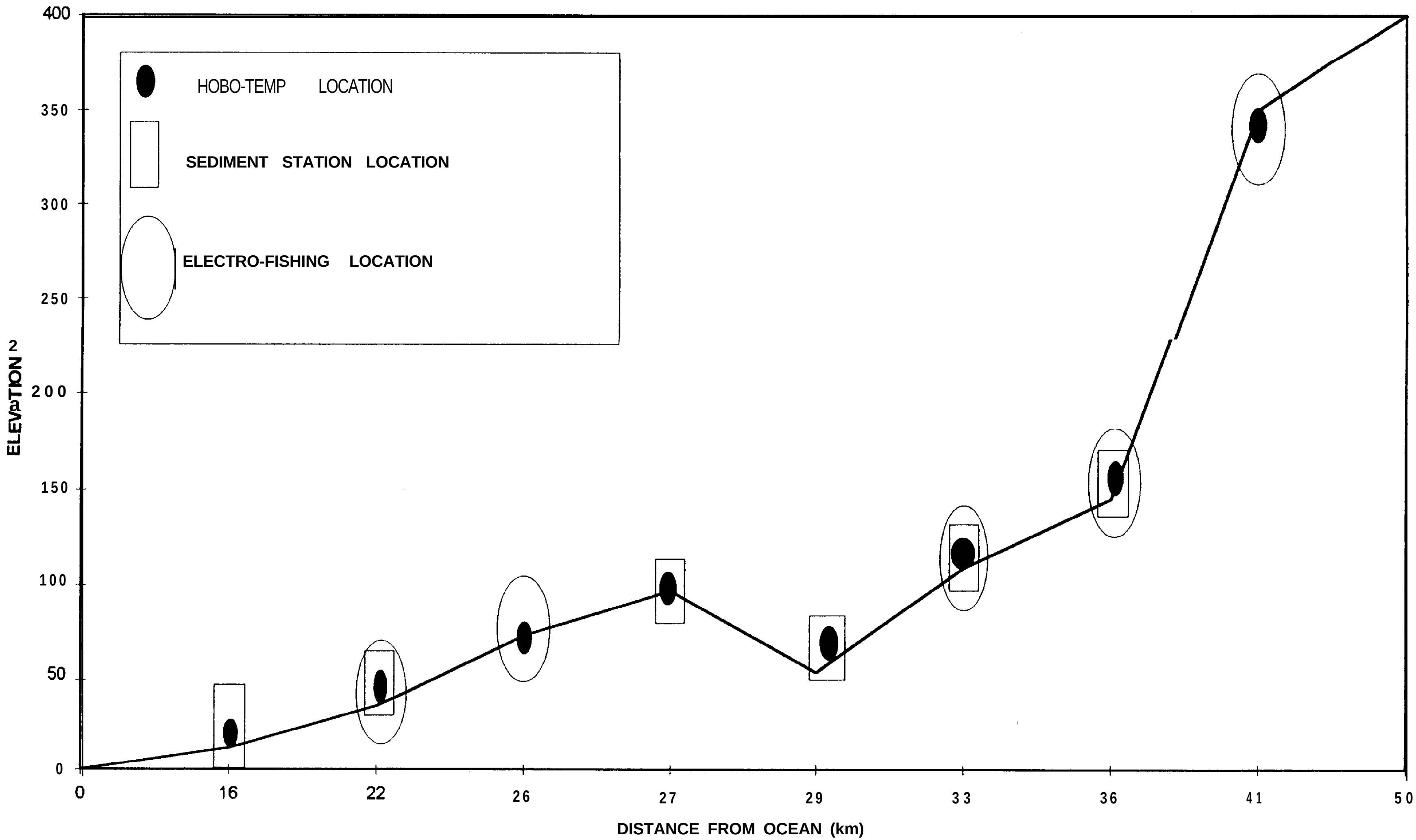


Table 1
Qualitative Ranking of the Usefulness of Monitoring Parameters, EPA (1991)
(Parameters Shaded are those analyzed within the TMRW monitoring plan)

Parameters	Forest Management Activities	
	Harvest	Road Building and Maintenance
Water Column		
Temperature	1-3	3
pH	3	4
Conductivity	3	2-4
Dissolved oxygen	3	4
Intergravel DO	2	2
Nitrogen	3	3
Phosphorus	3	3
Herbicides	4	3-4
Pesticides	4	4
Flow		
Peak flows	4	3
Low flows	2	4
Water yield	3	4
Discharge	3	2
Sediment		
Suspended	2	2
Turbidity	2	2
Bedload	4	4
Channel Characteristics		
Channel Cross-sections	2	2
Channel Width/Depth	2	2
Pool parameters	2	2
Thalweg profile	2	2
Habitat units	3	3
Bed Particle Size	2	2
Embeddedness	3	2
Surface vs. subsurface	3	2
Large woody debris	2	3
Bank stability	2	2
Riparian		
Canopy opening	2	2
Vegetation	2	2
Aquatic Organisms		
Bacteria	4	4
Algae	3	4
Invertebrates	2	2
Fish	3	3

Legend

1 = Highly likely to be useful
2 = Moderately likely to be useful
3 = Unlikely to be useful (or little relationship)
4 = Not useful

INSTREAM SUBSTRATE COMPOSITION

Introduction

McNeil sediment samples (McNeil and Ahnell 1964) have been used on Georgia-Pacific's ownership in the past by company personnel and others (Bums 1972, Valentine and Jameson 1993) to indicate particle size distribution and percentages of fine sediments in stream systems within the ownership. Methods for McNeil sampling follow those recommended by Valentine (1993), Timber-Fish-Wildlife Ambient Monitoring Program Manual (Schuett-Hames et al. 1994) and CRWQCB. McNeil samples were utilized to calculate particle size distribution of instream substrate and corresponding values of geometric mean diameter and Fredle index. These three measurements have been used by others to calculate survival to emergence ratios (STE) of salmonids, to (arguably) link stream conditions to land management activities, and percent finer material in potential salmonid redds.

McNeil samples, of all the current instream metrics (Q-STAR, V-STAR, RASI, D-50, etc.), exhibit the most direct link between stream condition and subsequent biological effects. Survival-to-emergence depends on the amount and grain size of fine sediment deposited at different depths in spawning gravel, as well as on biologic and water-quality factors (Chapman 1988). Despite complexities in determining effects of the amount and distribution of gravels to-embryo survival, sediment is a clear and quantifiable parameter. Fine sediment in spawning gravels have been suggested to influence the STE of salmonid through several possible mechanisms which include: (a) reduction in intragravel water flow with a subsequent buildup in metabolites and a corresponding reduction in dissolved oxygen, (b) smothering of embryos and sac fry from high concentrations of suspended sediment particles entering the redd; and (c) entrapment of fry attempting to emerge from the gravel to reach the water column. Clean gravel allows for high permeability and greater flow of intragravel water to developing embryos and larvae. Other techniques such as arithmetic mean particle size (Crisp and Carling 1989), median particle size (Witzel and MacCrimmon 1983), sorting coefficient (Sowden 1983), and skewness (Crisp and Carling 1989) may adequately establish instream trends but they lack clear and easily quantifiable parameters between the biology of a fish lifestage and instream condition.

Methods

All samples were taken with a modified McNeil sampler* (modified with a Koski plunger to avoid loss of core material) with a core measuring 15.5 cm in diameter, 13.5 cm in length and capable of holding 2547.3 cubic centimeters (cc) of material. All samples were processed in-situ and wet-sieved (volumetric method) rather than dry-sieved (gravimetric method). The volumetric method is advantageous because it is less time intensive and requires less equipment than the gravimetric method (expediency is critical to this monitoring program due to the short sampling period and the large number of samples taken in the TMRW as well as other watersheds within the Georgia-Pacific ownership). Wet-sieving does produce error since water is increasingly retained with

* In the 1993 and 1994 monitoring plan we indicated that a shovel in conjunction with a McNeil sampler would be utilized. The literature described it as a statistically comparable technique to the McNeil (Grost et al.. 1991), we have not implemented this procedure.

decreasing sieve size allowing for greater volumetric displacement of smaller sediments. Correction factors (Shirazi and Seim 1979) will account for this type error but they frequently are not used nor were they suggested by Valentine (1993). Correction factors were not calculated for the 1993, 1994, or the 1995 monitoring efforts. Furthermore, all known historical sediment sampling was done using the volumetric method without correction factors. These historic data further reinforced our decision to utilize the volumetric method.

To classify the overall particle-size distribution of the sample, based on a geometric progression, the following 30.5 cm diameter sieves were used: 63 .O mm, 3 1.5 mm, 16.0 mm, 8.0 mm, 4.0 mm, 2.0 mm, 1 .O mm, and 0.85 mm as recommended by Shirazi *et al.* (198 1). Instream characteristics noted during collection were stream gradient, water temperature, and stream flow.

Fines within the TMRW monitoring plan were defined as material < 0.85 mm. A great deal of discrepancy exists in the literature concerning the definition of what constitutes percent fines. According to Waters (1995) fines less than 0.8 mm is well established and accepted by many researchers as the criterion above which significant mortality of embryos could be expected. Other definitions include: 0.83 mm (McNeil and Ahnell, 1964; Hall and Lantz 1969), 0.84 mm (Reiser and White 1984) 1 .O mm (Hall and Campbell 1969) 2.0 mm (Hausle and Coble, 1976) 3.3 mm (Koski 1966), 4.0 mm (MacCrimmon and Gots 1986), 6.3 mm (Burton *et* al. 1990) and 6.35 mm (Bjomn 1969). Sediment is a natural part of the instream environment on the North Coast, yet high sediment input, especially fines, can have a deleterious effect on aquatic vertebrates and invertebrates. The threshold of concern for salmonid eggs and larvae development usually falls around 20% (Lisle and Eads 1991). Twenty percent was considered as the threshold of concern in Georgia-Pacific's monitoring plan.

All samples, while not necessarily extracted from known salmonid redds, were taken from areas known to closely replicate spawning sites (pool\rifle junctures). Riffle crests are used by nearly all anadromous fishes, and is often the first area in the stream selected by salmonids for spawning (Tripp and Poulin 1986). Typically they are located at the transition between the two areas most heavily utilized for spawning by salmonids, pool tailouts and riffles. Samples taken from the pool/riffle juncture indicate a worse case scenario of the true sediments found in the substrate (Valentine 1993). .

Measurements were taken during the non-spawning time of year for salmonids in the TMRW. Salmonids have been observed spawning in coastal streams between November and May during adequate flow. We sampled during late summer and early fall, low flows, when fines are most concentrated in gravels.

Two riffles were sampled at each station, with four cores taken at each riffle, for a total of eight cores per station. There were 23 stations in the TMRW: eight in NFT (two more than last year), six in CFT, and nine in SFT. Samples were taken within one week of last year's sampling effort to reduce sampling bias. All sample locations sampled in 1993 and 1994 were revisited in 1995 (Figure 2). However, the same pool\riffle junctures were not necessarily sampled each year. High winter flows often moved these junctures or eliminated them completely; in such cases, we sampled from the nearest suitable location.

Individual cores were averaged and particle distributions are presented graphically, and in tabular form. Geometric mean and Fredle index were calculated individually, averaged, and presented graphically. Two approaches are widely used to describe substrate composition (Young *et* al. 1991; Waters 1995): particle size distribution and the central tendency. In the first, the proportion of substrate particles less than a given size is quantified by weight or volume (generally percent finer). In the second approach, aspects of the central tendency of the entire particle distribution are described (geometric mean, Fredle index, and others). However, most of the recent literature estimated STE from either geometric mean or Fredle index rather than percent fines. A single measure of substrate composition is probably inadequate at this point in time; consequently, we present percent fines, geometric mean particle size Platts et al. 1979) and Fredle index (Lotspeich and Everest 198 1).

A Multivariate analysis of variance (MANOVA) for the past three years data was analyzed with both fixed and random effects using the program, Statistica. The "fork" (SFT, CFT, NFT) and "stream type" (tributary or mainstem) were fixed effects. The "creek" (Campbell Creek, Smith Creek, etc.), "site" (sample station) and "year" (1993, 1994, 1995) effects were random. The "year" effect was a repeated-measure analysis. The "fork" effect was fixed because they constitute different analysis areas. "Stream type" was fixed to account for different sampling intensities within the three principal watersheds. In 1993 and 1994, CFT and NFT had six sample locations and SFT had nine. Sample size had to be equal in order'to analyze differences between "forks". Consequently, since both CFT and NFT had three stations in higher order tributaries and three in mainstems it was necessary to choose the same criterion for SFT. Six sample sites were chosen at random for both tributaries and the mainstem in SFT for this analysis.

The 63 mm size class was not analyzed because this sieve size was not utilized in 1993 or 1994. New sample sites from NFT were not incorporated into the analysis for the same reason. Each percentage was transformed with the formula, Y = 2 * ARCSIN(SQRT(X/lOO)), to stabilize variances. Analysis of differences in percent finer between the three forks was calculated to determine if significant differences existed (P-value < 0.01)

Additionally, an analysis of variance was calculated to determine if a significant increase (P-value < 0.05) in percent finer could be determined in two of the three forks,

Results

A total of 184 cores samples were extracted in the TMRW in 1995 from 23 locations in the watershed (Figure 1). Results are displayed graphically in Appendix A. Individual particle-size distribution, per core, with corresponding geometric mean, Fredle index, and standard deviation are presented in Table 1. Overall averages for percent fines from all three forks are displayed in Figure 2.

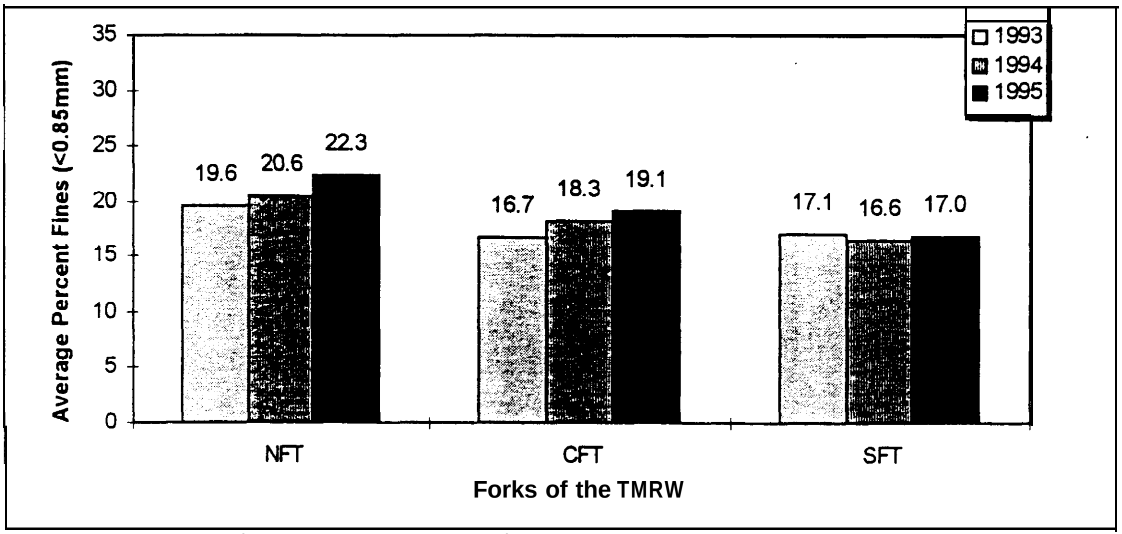


Figure 2. Summary of Sediments <0.85mm for the entire TMRW McNeil Sediment Sampling Sites, 1995.

Substrate particles < 0.85 mm for the TMRW ranged (per station) from 14.0% (Upper South Fork Ten Mile-head waters of SFT) to 28.8% (Patsy Creek-upper NFT). Percent finer material increased in 1995 over 1994 and 1993. Increases were noted at 11 locations, decreases were noted at eight locations, two stations remained consistent with last year's results, and two stations were not sampled in 1994. In NFT, fines < 0.85 mm increased 7.8%, from 20.6% in 1994 to 22.75% in 1995, between eight sample stations (Figure 3). The two new sample sites in NFT were not included when determining percent difference between years.

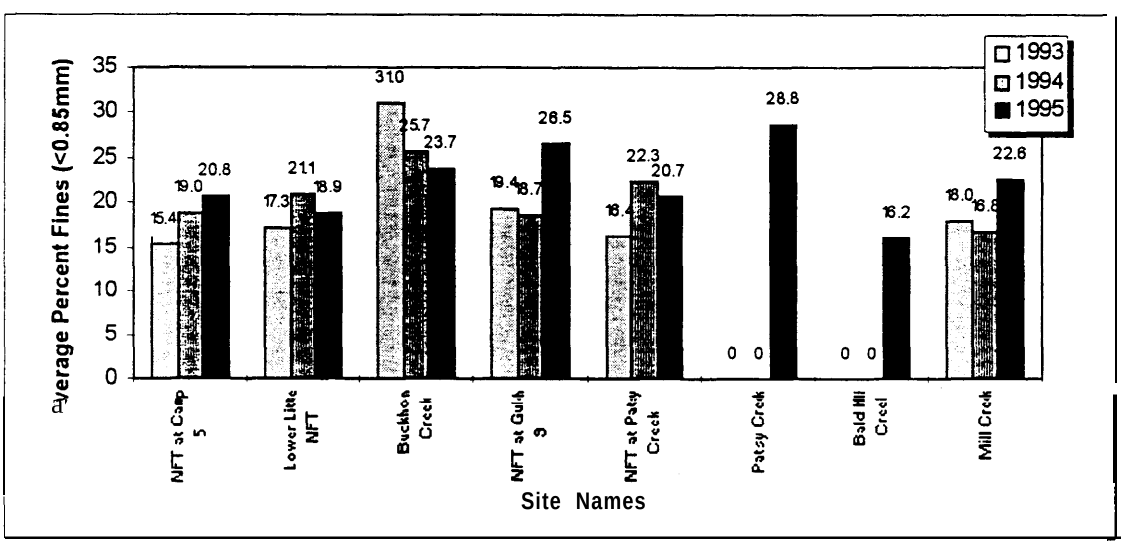


Figure 3. Summary of Sediments <0.85mm for NIT McNeil Sediment Sampling Sites, 1993-1995.

In CFT, fines < 0.85 mm increased 4.5%, from 18.3% in 1994 to 19.13% in 1995, between six sample locations (Figure 4).

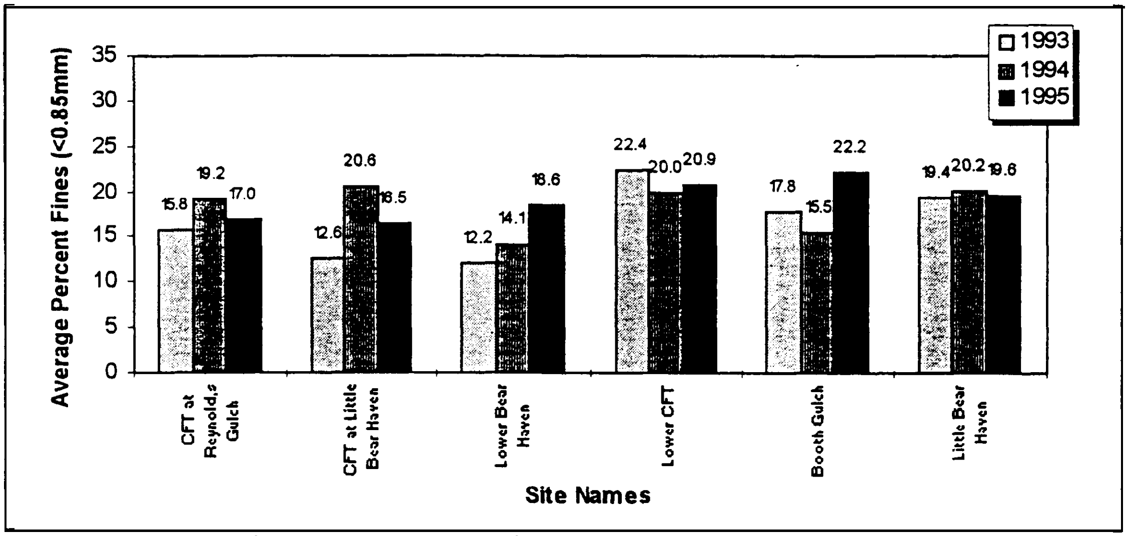


Figure 4. Summary of Sediments <0.85mm for CFT McNeil Sediment Sampling Sites, 1993-1995.

In South Fork Ten Mile (SFT), fines < 0.85 mm increased 3 .0%, from 16.6% in 1994 to 16.97% in 1995, between nine sample locations (Figure 5).

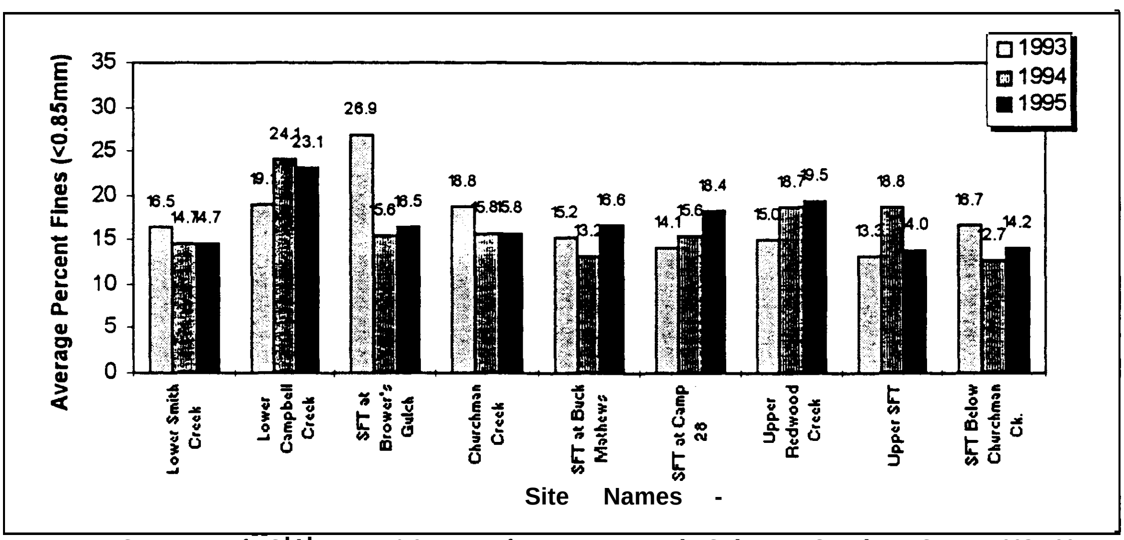


Figure 5. Summary of Sediments <0.85m.m for SFT McNeil Sediment Sampling Sites, 1993-1995.

Increase in percent finer for over the three year period in all three forks was determined not to be statistically significant. In NFT the P-value = 0.38, in the CFT P-value = 0.33. A P-value calculation was not appropriate for SFT because percent fines decreased overall during the three year period Variability within the three years data did not allow for trend determination.

For actual differences between the three forks we found a significant difference in five of the particle sizes including percent fines (Table 2). This suggests the differences found (i.e. percent fines) between NFT, CFT, and SFT may be the result of actual differences in particle size distributions of each fork's respective bedloads when compared to each other.

Table 2: MANOVA between NFT, CFT, and SFT to determine if fork has a significant effect on measure sediment fractions. Shaded rows = Statistically significant.

MANOVA Depend. variable	Main Effect: Fork Fork, Streamtype, and Year are independent variables			
sieve size	Mean Sqr. Effect	Mean Sqr. Error	F(df1,2) 2,129	p-level
32.0mm	.563326	.136499	4.12698	.018310
16.0mm	.038577	.027552	1.40019	.250273
8.0mm	.296838	.025909	11.45687	.000026
4.0mm	.128622	.012682	10.14214	.000081
2.0mm	.026002	.014262	1.82624	.165638
1.0mm	.064223	.017911	3.58578	.030511
.85mm	.011225	.009803	1.14508	.321411
<.85mm	.193633	.033357	5.80480	.003855

While these data show an increase in fines in the watershed as a whole over the past three years it was not statistically significant (P-value = 0.055). This is an important point as it suggests we cannot yet determine trends from percent fines from the past three years data set.

Geometric mean particle-size ranged from 3.7 mm to 15.9 mm for the TMRW with an overall average of 7.10 mm. Geometric mean decreased overall from 1993 (8.79 mm) to 1994 (7.71 mm) to 1995 (7.10 mm) within the TMRW. In NFT geometric mean particle size ranged from 4.6 mm (Buckhom Cr.) to 12.6 mm (Baldhill Creek) with an overall average of 6.86 mm. In CFT geometric mean particle size ranged from 5.1 mm (Little Bear Haven) to 9.9 mm (Reynolds Gulch) with an overall average of 6.83 mm. In SFT geometric mean particle-size ranged from 3.7 mm (Churchman Cr.) to 15.9 mm (Upper South Fork Ten Mile) with an overall average of 7.50 mm.

The Fredle index ranged from 1.2 to 5.5 for the TMRW with an overall average of 2.02. There was overall decrease in the Fredle index from 1993 (2.91) to 1994 (2.40) to 1995 (2.02) within sample locations in the TMRW. In NFT the Fredle index ranged from 1.2 (Mill Creek and Gulch 9) to 3.9 (Bald Hill Creek) with an overall average of 1.73. In CFT the Fredle index ranged from 1.4 mm (Booth Gulch) to 3.6 (Clark Fork below Little Bear Haven Creek) with an overall average of 1.9. In SFT the Fredle index ranged from 1.2 (Campbell Creek) to 5.5 (Upper South Fork Ten Mile) with an overall average of 2.36. Percent STE, per site, is plotted against Fredle index in Figure 6

Discussion

Percent finer material in 1995 had an overall increase from 1993 and 1994 while geometric mean and Fredle index had an overall decrease. High flows were hypothesized in last years monitoring results as having the potential to decrease percent finer material. However, due to the high variability t-hat is inherent with sediment sampling studies we could not conclude, statistically, if changes in percent fines were the result of changing stream conditions. These results are to be expected when the inherent variability of particle sizes within pool\riffle junctures are considered. Valentine (1993) described a number of other possible influences that obscure determination of current conditions:

Current condition can be variable due to localized natural geologic events, historic land uses, current land uses, and short- (1-5 year) to long-term (decade +) climate conditions. Relative to land-use decisions, interpretation of the significance of 'condition' is complicated by this inherent variability. Even short-term conditions may be critical when the population of a species (be it fish or of another taxa) which is sensitive to substrate character is extremely low. However, generally trend is of greater significance than a 'snap-shot' of current condition. Repeated application of these guidelines over time will enable trend to be assessed

As I interpret these data collected over the past three years the variability within and between sample sites does not surprise me. In the field, a great deal of variability in substrate composition within a pool/riffle juncture exists. Looking at individual samples in Table 1 will illustrate this point. Despite this variability, overall percentages from the same sample locations appear to remain relatively stable (within a few percentage points for the smallest fractions). It will probably take many years to describe the trend of these data with any statistical reliability, but again this should be expected when gathering baseline data on any physical process. Unfortunately, the impatience of some observers will allow them to see "trends" even when they cannot be proven. According to EPA Monitoring Guidelines (1991) the definition of baseline monitoring is to:

. . characterize existing water quality conditions, and to establish a data base for planning future comparisons. The intent of baseline monitoring is to capture much of the temporal variability of the constituents of interest.. .

Georgia-Pacific will continue to compile data on stream bedload composition into the future, eventually allowing for a determination of trends in the TMRW.

Valentine (1993) recommended the taking of measurements along the second medial axis of the three largest rocks collected per individual core. If the largest particles are greater than 1\3 - 1\4 the diameter of the sampling core, a larger sampler is suggested. However, due to incomplete data records we have not analyzed available data to date. We do intend to utilize shovels on sample sites with larger particle sizes in 1996. This should provide a more precise indication of particle size distribution from these sites.

In NFT fines increased past the 20% threshold in 1994. Fines remained elevated in 1995 (22.27%); subsequently Georgia-Pacific will continue to concentrate restoration efforts in this part of the watershed in 1995 (Also see section on Improvements, Restoration and Enhancement). I suspected fines are elevated within NFT due in large part to effects of past practices. Tractor logging, especially in the upper end of NFT, was utilized up and down virtually every slope in the watershed. The landscape often take decades to recover from the effects of such techniques. Since access throughout this watershed was opened to the upper end of NFT in late 1994 Georgia-Pacific has been able to identify and correct many of these problems. Georgia-Pacific however will not limit restoration activities solely to the NFT; where feasible, such activities will also be evaluated in CFT and SFT on a site specific basis.

While Georgia-Pacific owns the majority of the North Fork it is not the sole landowner. The areas above Georgia-Pacific ownership have been indicated by the

California Dept. of Forestry and Fire Protection as a possible source of sediment input into the watershed (Appendix B).

The addition of sediment from these other sources is important in evaluation but is often an unquantifiable parameter. In addition, the lack of consistency among scientists regarding the most accurate methods of analyzing has created a data processing nightmare. Many studies have attempted to relate land management activities with instream sediments while others have shown more effects from natural geology. For example, Beschta (1982) noted the percentage of fine sediment was better than the geometric mean as an indicator of the intensity of land use. Cederholm *et al.* (198 1) showed that the percentage of sediment (<0.85 mm) in spawning gravels increased in proportion to basin area affected by timber harvesting and roads. Duncan *et al.* (1985) however, found the amount of fine sediment (<2 mm) was more closely correlated to the lithology and soils of the watershed than to forest management practices. They did find a significant positive correlation between percentage of watershed area in sedimentary rock, and percentage of medium and fine sand and silt particles in spawning gravels. Beschta (1982) stated a modified Fredle index might be the best statistic for describing the composition of spawning gravels. Stowell *et* al. (1983), Bjornn(1969), Phillips *et al.* (1975) and others however attempted to estimate survival to emergence (STE) ratio from the percentage of fine sediment in a substrate. Young *et al.* (199 1) found predicting STE from the percentage of substrate less than a given size unsatisfactory because survival was sensitive to the distribution of sediment size within the target range. Their studies indicated geometric mean particle size was the best predictor of STE. There is much controversy in the literature as to the best statistic to estimate STE and detect change in substrate composition caused by land use. Due to the Franciscan formation that comprises the geology of the area, the conflict of results in studies and the lack of natal streams in our immediate area where data cannot be compared it is difficult to connect percent fines to a specific land management activity.

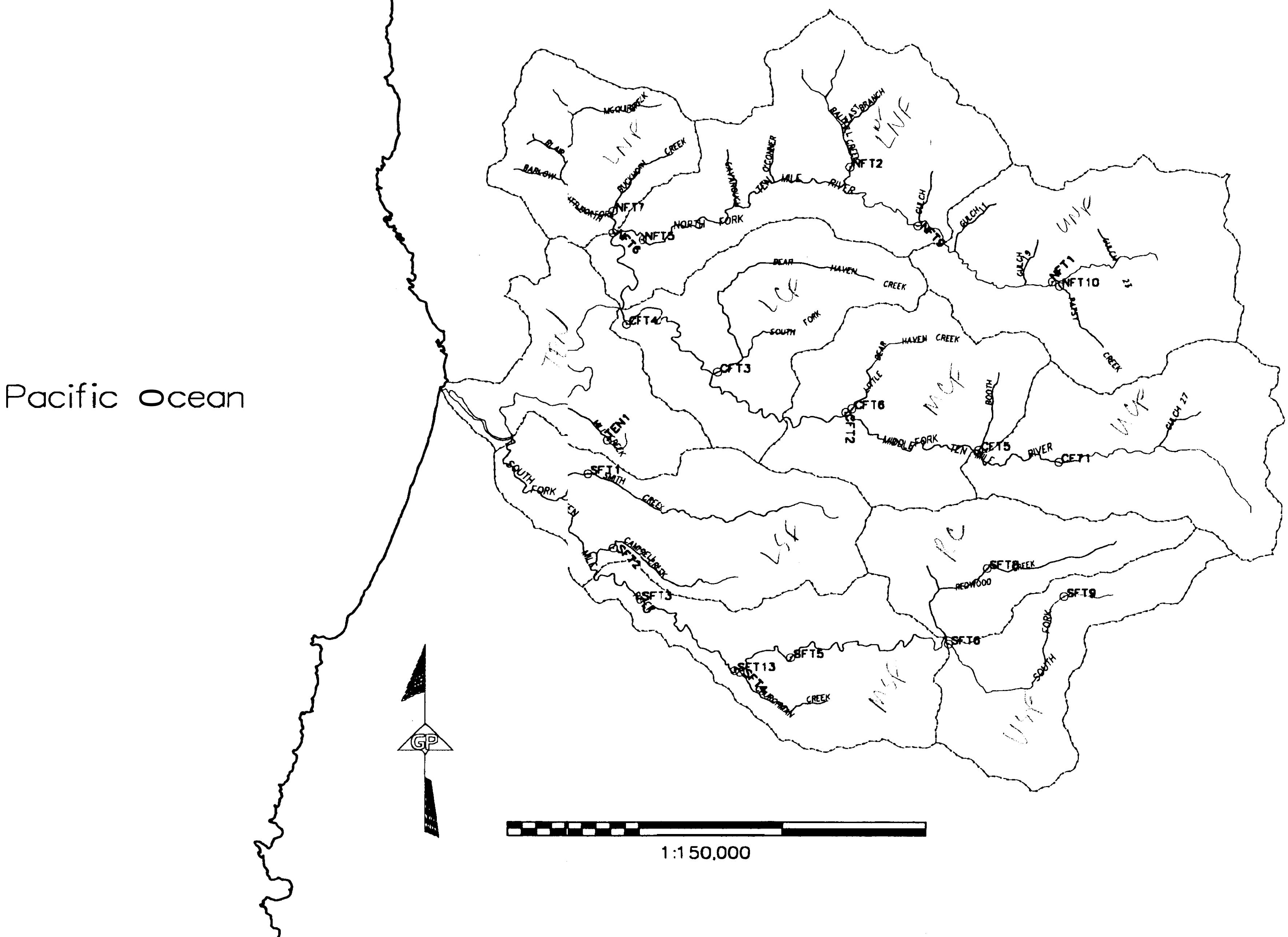
— Other considerations which may dictate instream fines during spawning and rearing include the flushing of fines during redd construction.-Considerable flushing of the finer sediments occurs during redd construction (Kondolf *et al.* 1993) Although an extreme example, data for Chinook Salmon (Oncorhvnchus tshawvtscha) in Evans Creek, Oregon (Everest *et al.,* 1987) indicated, fine sediment content lowered during spawning from 30% to 7.2%. Such extreme modification is unusual, but not unique. Salmonids utilizing the TMRW are smaller than Chinook, subsequently decreases in finer material would not be as extreme. Conditions in the actual redds can be expected to be no worse at least, than the samples, and so actual survival would likely be better than indicated. Neave (1949) observed that the high egg-to-fry survivals achieved by Coho Salmon Oncorhvnchus kisutch) in comparison with other salmonids were due to the selection of better spawning sites in areas of good flow stability and to less crowding. This further illustrates that STE is probably higher than what is indicated by these data since sampling occurred at pool/riffle junctures, not necessarily redds.

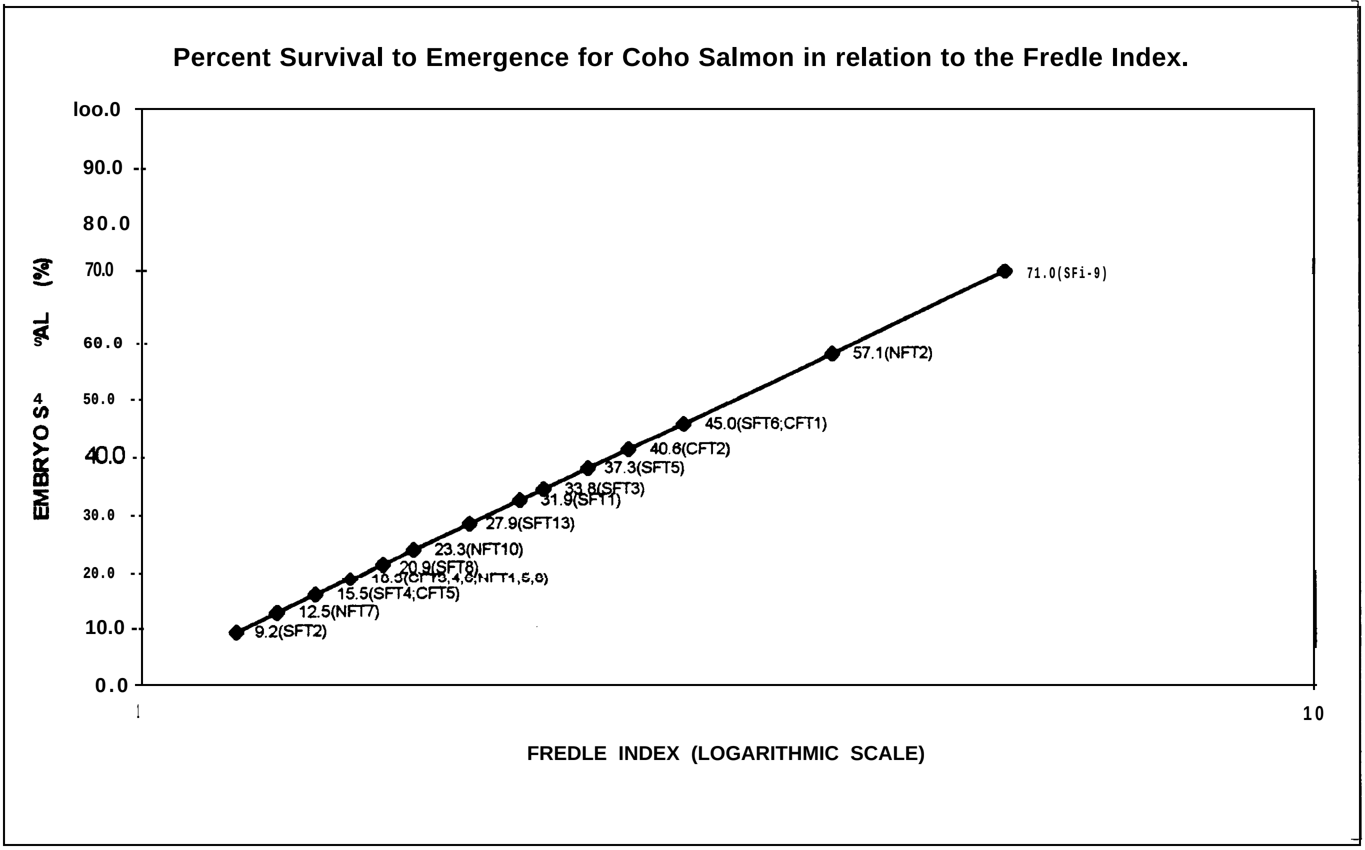
Georgia-Pacific will continue to monitor the TMRW instream sediments in the future. The analysis is expected to expand each year in conjunction with new incoming information and resources. In time, we hope to gauge actual instream conditions and trends for salmonids. Additionally, it is our goal to effectively monitor restoration activities in order to more effectively meet needs of the fishery resource in our local environment.

JA

igure 1:

Ten Mile River Watershed McNei Sediment Sample Station Map (1995)





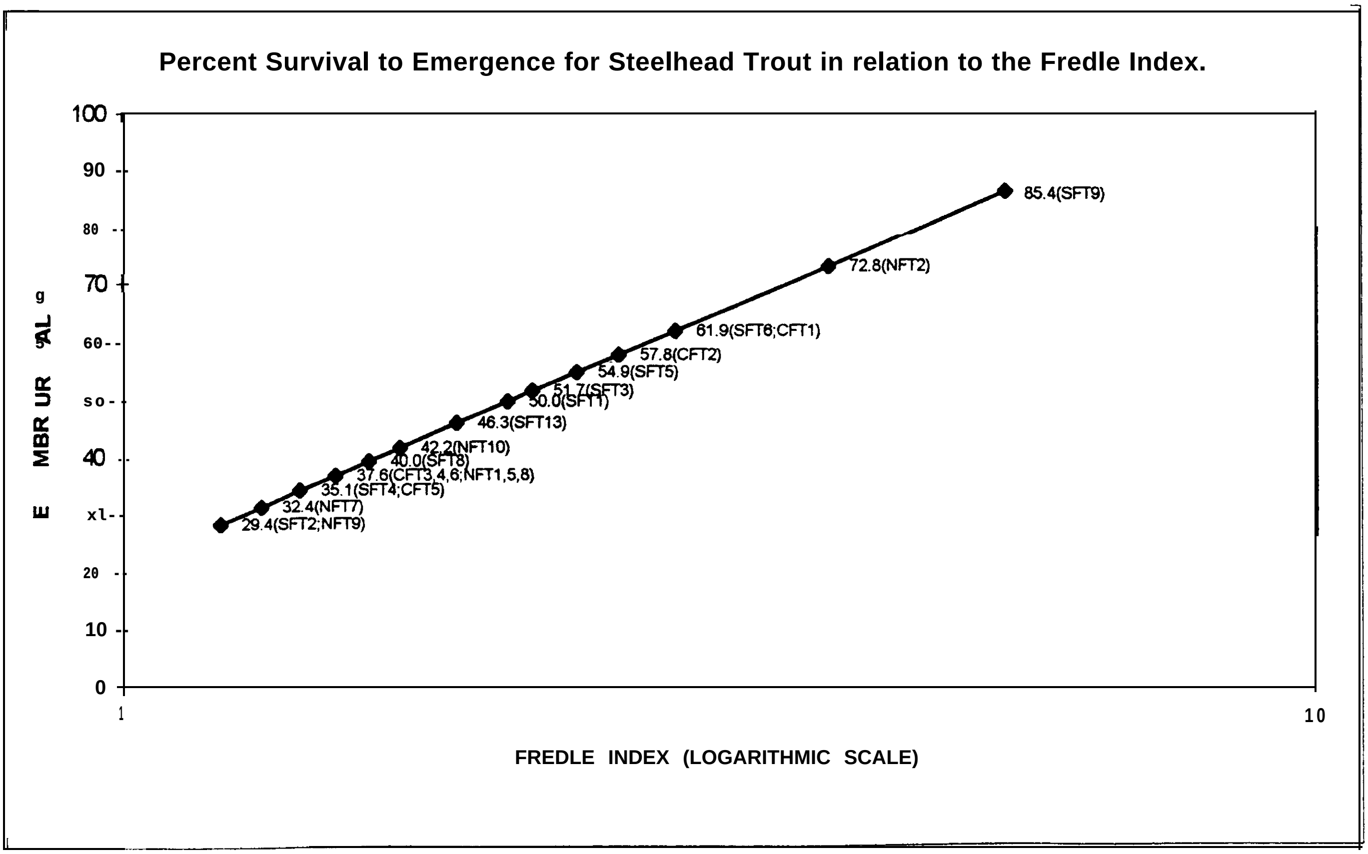


Figure 6: Estimated percent survival to emergence for Coho and Steelhead using the

STREAM AGGRADATION PILOT STUDY

Introduction

In January 1995, Georgia-Pacific implemented a pilot study to measure changes in stream bedload levels in South Fork Ten Mile River. In some North Coast watersheds, sediment bedload levels have filled estuaries and/or river mouths as a result of increased sediment loads. As these mouths fill, access for anadromous fish is hindered. Increased flooding frequency, possibly as a result of elevated stream bottoms, has raised concerns regarding increased bedloads. This pilot project was initiated to ameliorate such concerns. Aerial photographs of the TMR estuary from the 1940's to present indicate that such sediment loads are not present in the TMRW and the estuary has remained essentially the same.

Although the McNeil sediment sampling technique measures specific composition (relative size and volume) of stream sediments, it does not reflect the dynamic action of deposition (as do metrics such as scour chains). Georgia-Pacific consulted Ted Wooster (Environmental Specialist IV, CDF&G, Yountville) concerning possible techniques to quantify instream deposition rates. He suggested a sediment aggradation study using permanent instream benchmarks and measuring these benchmarks through time. This pilot study attempted to document large-scale sediment transport in SFT.

Study Area and Methods

Three 1 ,OOOm study sites were located in the mainstem of SFT, and one 500m reach located in Redwood Creek, immediately above its confluence with South Fork Ten Mile. Stations were placed 250m apart in each study area. Stations consisted of .95cm diameter steel rebar rods or 2m fence posts driven into the stream bed. The rebar came in two lengths, 91cm and 198cm, to facilitate placement in deep-water situations and sub-surface obstructions. In addition, two pools from each study site were chosen. Rebar was placed at the head, tail, left, right, and center portions of each pool. A total of 62 pieces of rebar and fence posts were utilized for the study. The primary measurement was length of rebar above the substrate. Differences in lengths were recorded and calculated to determine if bedloads were increasing or decreasing within the reach.

Placement was conducted in January 1994, prior to any major storms or resulting runoff. In August 1994 and November 1995 each station and pool was revisited and data was recorded.

Results and Discussion

Preliminary results indicated an active sediment transport system. In 1994 the overall removal of sediments upstream were matched by an average increase in sediment levels downstream. There was tremendous variation in deposition and mobilization in each study area. Some pools apparently filled, while others scoured.

High flows in 1995 dramatically altered the instream environment within study sites in the South Fork. Those study sites in lower South Fork were particularly impacted by last years high winter flows. Many pieces of rebar and all fence posts were bent down to the stream bed. Scour and deposition removed or buried many pieces of rebar from the lower study areas. In the upper reaches of SFT and Redwood Creek the rebar faired better, especially those pieces situated in pools. The bedrock stream bottom present in many if the upper study sites helped hold the rebar in place, however virtually every piece was bent down to the stream bed.

In a stream system as dynamic as SFT a study utilizing rebar and fence posts as permanent benchmarks is inadequate. Benchposts of more sturdy construction would prove more successful but the cost and labor involved would defeat the initial purpose of this pilot project. This project was initiated in an attempt to provide an expeditious technique to ascertain trends of stream-bed movement with minimal financial and time expenditures. Unfortunately, this proved unsuccessful due to the high 1994/l995 winter flows and will not be implemented as a metric for future TMRW monitoring plans.

STREAM TEMPERATURE MONITORING

Introduction

Stream temperature is one of the most important environmental factors affecting fish (Fry 1969, 197 1; Hutchinson 1976). Temperature regimes influence migration, egg maturation, spawning, incubation success, inter- and intraspecific competitive ability, resistance to parasites, diseases, and pollutants (Armour 1991). In fish, metabolic activity is directly related to temperature and affects processes such as enzymatic activity and whole organismic activity such as growth (ODEQ 1994). Although optimal temperature range for most juvenile salmonid species is approximately 12-14 °C (Brett 1952), the impacts of threshold temperatures to natural fish populations is not well documented. According to Bjornn and Reiser (1991):

> *Sub-lethal and lethal effects vary according to factors such as acclimation temperature, duration of temperature increase, daily fluctuations and ecological adaptations. Studies have shown that many populations of native salmonids respond to natural temperature patterns in streams by moving upstream or downstream when water temperatures become unsuitable. In small streams where daily maximum temperatures approach lethal values, salmonids can thrive if the temperature is high for only a short time and then declines into the optimum range.*

Nevertheless, temperatures which increase to levels beyond the thermal tolerance limits for long periods of time can cause stress, reduced immunological resistance to pathogens and reduced growth in fish (Sniezko 1974; Avtalion 1981; Wishkovsky and Avtalion 1982). It is difficult to describe how fish respond physiologically to temperature stress because temperature modifies the clinical signs of stress (Strange et al. 1987; Barton and Schreck 1987). Elevated temperatures can eventually lead to death by direct and indirect modes. Lethal levels for adult salmonids will vary according to the above mentioned factors and generally are in the range of 23-29 °C (Bjornn and Reiser 1991).

Summer in-stream temperatures have been identified as a limiting factor for juvenile salmonids. Mendocino County streams reach highest temperatures from mid to late summer, the time of greatest solar incidence, low water flows, and ambient air temperature. Anthropogenic activities can exasperate the summer instream thermal conditions. If stream temperatures are warmed in one location, that heat is transported downstream. If several activities occur along a stream, their effects on temperature can be additive for some distance (ODEQ 1994) unless diluted by other cool water sources or climatic conditions (fog influence, topography etc.). If temperatures exceed thermal tolerances of a given species they can reduce habitat availability for rearing juvenile fish by excluding accessibility.

In an effort to evaluate temperature as a possible limiting factor for salmonids in the TMRW, Georgia-Pacific initiated an instream temperature monitoring program in 1993. Temperature data loggers are distributed each year throughout the TMRW during the summer low flow when thermal regimes attain their maximums. Within the TMRW

Coho Salmon and Steelhead Trout juveniles are the two primary vertebrate anadromous residents. Coho Salmon have a narrow range of thermal tolerance and are more susceptible to impacts of higher water temperatures than Steelhead Trout. To address limiting temperatures for the most sensitive fishery resource in the watershed, Georgia-Pacific's adjusted average weekly temperature threshold is 18.3 ° C for the TMRW.

Methods

Temperatures were measured continuously with 35 temperature data loggers (Onset Computer Corp. model Hobo-Temp temperature logger) in Class 1 streams throughout the TMRW (Figure 1). Hobo-Temps are relatively inexpensive and allow uninterrupted data collection to occur throughout the critical over-summer period. Hobo-Temps were placed in pools near the bottom, and towards the deepest portion, to record in-stream temperatures. They were anchored with 95 mm diameter steel rebar and secured by 2 mm steel wire. In-stream and riparian measurements were taken at all Hobo-Temp locations. Although a large source of temperature variation results from flow, flow measurements were not taken during 1995 due to unavailability of an affordable and reliable continuous flow meters.

Hobo-Temps can be set to record temperatures at different time intervals resulting in a corresponding variety of memory longevity intervals. In 1993, all Hobo-Temps were set at a time interval of 1.2 hours between sample periods. Upon further analysis of these data it was revealed a number (2-4) of redundant data points existed at critical high and low peaks in daily temperature fluctuations. Furthermore, an interval setting of 1.2 hours resulted in a memory life of only three months for each data logger. Subsequently, the data collection interval was changed to 2.4 hours; thus, allowing for complete capture of thermal peaks and extending data logger memory life to six months. A six month time interval allowed for complete bracketing of critical summer low flow temperatures by capturing initial summer temperature increase and subsequent autumn decrease. All 35 Hobo-Temps were installed in the TMRW between 5 June 1995 and 18 July 1995 and removed between five and six months later. Installation dates for each Hobo-Temp occurred one day before the first day logged on the continuous temperature monitoring figures. This was done in order allow for the data loggers to reach equilibrium with the instream temperature regimes and to capture complete daily cycles.

Although calibration is suggested by Schuett-Hames ***et al.*** (1994) and Valentine (1994), Hobo-temps were not calibrated and it is possible some readings may be either higher or lower than actual water temperatures. Hobo-Temp calibration is planned for temperature monitoring within the TMRW for 1996.

Many juvenile salmonids congregate in pools over the summer months; hence, pools were chosen (over riffles and runs) for Hobo-Temp locations. Nielsen ***et al.*** (1994) found that when thermal stratification occurred in pools in Northern California streams, significant numbers of Steelhead Trout utilized the cooler portions (bottom) of the pool. Cool water refugia, or pools, are thought to provide critical habitat in streams with elevated daily and/or weekly average temperatures and would comprise the last available habitat in a thermally stressed environment.

Since 1993 Hobo-Temps have been placed in pools; nonetheless, due to concerns regarding possible biases associated with placement (i.e. sampling the coolest portions of the stream may not give an accurate representation of the aquatic habitat), four riffle temperatures were monitored in 1995. These Hobo-Temps were installed in four different riffles immediately adjacent to pool locations to determine if riffle/pool temperatures differed.

Data from the 1995 temperature monitoring effort were displayed in two formats: continuous temperature monitoring and mean weekly averages. Average weekly temperatures were calculated for the seasonal temperature peaks, mid-June through mid-August. From these data the highest weekly average temperature (HWAT) was calculated. The beginning of the calendar week was chosen as the basis for initiating weekly average temperatures. Seven day moving maximums and seasonal cumulative temperature were not calculated, but could provide a basis for additional analysis in future monitoring efforts.

The maximum weekly average temperature (MWAT) that should not be exceeded for Coho Salmon is 18.0” C to 18.3 ‘C. This MWAT is Georgia-Pacific’s threshold temperature above which this critical habitat feature would be considered limiting to salmonids in the TMRW. This threshold was calculated for the resource in the watershed most limited by increasing, or high, temperatures (Coho Salmon). MWAT was derived from EPA (1976) water quality criteria for fish growth and survival (18.0 ° C) and from Armour (1991) using the following formula:

$$MWAT = OT + (UUILT - OT)/3$$

where

OT = a reported optimal temperature for the particular life stage or function, of a particular species.

and

UUILT* = the ultimate upper incipient lethal temperature (Fry et al. 1946).

MWAT was then calculated using the following numerics:

OT = 15°C (USDI 1970)
UUILT = 25 °C (Brett 1952)

Mean weekly average temperatures portray a more complete representation of stream temperatures during the period of greatest ambient air temperatures and solar incidence. This type of analysis provides an index to the average temperature conditions for fish (which they are more likely to respond physiologically), than the short (2-3 hour) peaks above optimal. The overall stream conditions are more difficult to analyze with continuous temperature graphs and the diurnal fluctuations can sometimes be misleading (Both types of graphs are presented in this report). In

* The upper temperature at which tolerance does not increase with increasing acclimation temperatures.

addition, analysis of instream thermal regimes based on mean weekly average temperate has been suggested by EPA (1986) as a method to estimate thermal thresholds.

Results

Of the 35 Hobo-temps deployed in the TMRW, three failed to download when retrieved at the end of the sampling period and their data was lost. These sites were located in the South Fork at Gulch 11, Churchman Creek, and lower Redwood Creek (riffle). Furthermore, a Hobo-Temp placed near Georgia-Pacific's property boundary near the headwaters of the North Fork was removed and placed on the streambank by unknown individuals. Thirty-one Hobo-Temps were successfully downloaded, results from each sampling location are displayed in Appendix 1.

Temperatures in the TMRW did not exceed MWAT in 1995 at any of the sampling locations. There was an overall trend for temperatures in the TMRW to increase as stream order increased. However, the sample stations (CFT4, SFT3, NFT4) lowest in each of the three forks of the TMR did not record the overall HWAT for their respective forks. The HWAT were recorded from the following five sites: SFT5 (17.7°C), NFT1 (17.6°C), NFT5 (17.6°C), CFT2 (17.4°C), and SFT6 (17.3°C).

HWAT varied according to drainage and placement of the monitoring station (pool vs. riffle). HWAT for riffle locations were obtained during the weeks of 2 July 1995 through 22 July 1995. Interestingly, HWAT in riffle locations occurred one to three weeks before the HWAT in immediately adjacent pools. The HWAT for Hobo-temps placed in pools occurred during 23 July 1995 through 5 August 1995 in all but one station (Buck Mathews Gulch--SFT5--which had the highest overall HWAT in the TMRW).

HWATs varied between drainages. In the South Fork, HWAT was reached between 30 July 1995 and 5 August 1995 in 80% of the sample locations. In the North Fork, 100% of sample locations reached HWAT during the week of 23 July 1995 through 29 July 1995. In the Clark Fork, HWAT varied considerably more, reaching their average peaks between the weeks of 23 July 1995 through 5 August 1995.

Discussion

Results for 1995 temperature monitoring program suggested temperatures in the TMRW were below the Coho Salmon MWAT threshold of concern for all sample sites. From these data it appears temperatures were not a concern for salmonid species in the TMRW for 1995. Seven stations (SFT5, SFT6, CFT4, CFT9, CFT2, NFT5 NFTl), however, did record peaks of 20 ° C or slightly higher during 1995. These temperatures peaks were of short duration and were preceded by gradual decreases in daily temperature peaks. The diurnal fluctuations likely contributes to some levels of stress endured by juvenile salmonids. Slight fluctuations in temperature may allow juvenile salmonids the acclimation time necessary so that these peaks do not encourage physiological stress, thus, allowing for adaptable temperature tolerances within the fish. Studies with juvenile Rainbow Trout (Threader and Houston 1983) and yearling coastal Cutthroat Trout (Health 1963) confirmed that salmonids which experienced diurnal fluctuations of 6.5 °C and 10°C respectively, had significantly higher UILT's than fish exposed to continuous temperatures. Bjornn and Reiser (1991) found that in small streams where daily maximum temperatures approach upper incipient lethal values, salmonids can thrive if the temperature is high for only a short time and then declines well into the optimum range.

The following is an analysis, by forks, of the thermal regimes within the TMRW.

North Fork Ten Mile

Stream temperatures for NFT were warmest near the headwaters (NFTl) and exhibited a general downstream cooling trend. NFT4 was the furthest downstream sample station on the North Fork and reached a HWAT of 17.1 °C during the week of 23 July 1995. The average temperature for NFT was 16.8 °C for the two warmest weeks (23 July 1995 - 5 August 1995)) recorded from pools in the watershed for the year. NFT1 reached a HWAT of 17.6°C during the same week with an average temperature of 17.45 °C for the two warmest weeks, resulting in a 0.6 °C difference between those two sites.

Temperature differences probably resulted from a variety of influences affecting water temperatures. NFTl , near the headwaters of the North Fork drainage, is below areas of open grasslands with poor riparian canopy cover. Additionally, the channel above this station is comprised of bedrock and was labeled as a bedrock reach by Georgia-Pacific's habitat typing crew. Beschta et al. (1987) found bedrock channels are more efficient than gravel-bed channels at conducting heat. These factors undoubtedly contributed to this station registering the highest weekly temperatures in this fork of the TMR.

The NFTM generally flows east to west from the headwaters until it reaches the confluence of the Little North Fork of the TMR. At this confluence the river flows north to south until it reaches the TMR estuary. The summer solar angle contributes less thermal energy to north-south flowing streams, than east/west flows. Hence, east/west flows would be expected to have a higher summer instream temperature unless protected by heavy canopy cover and/or incised channels.

This apparent cooling trend is not atypical for a mainstem and other studies have resulted in similar findings (Valentine-et al. 1995). This event may provide evidence of extraneous influences such as effects of climate (effects of fog from the coast), topography (topographic and vegetative shading) and hydrology (cool-water inputs from tributaries and groundwater flow). Incidental review of the most obvious cooling inputs (tributaries) shows many kilometers of perennial water entering the mainstem. The mainstem of the North Fork above NFT4 is approximately 24.5 km long and has approximately 40.8 km of Class 1 streams flowing into it. For every one km of mainstem along the North Fork, there are 1.6 km of tributaries flowing into it. This ratio is much higher for North Fork than for the other two main forks of the TMR. (In the Clark Fork, for every one km of mainstem there are approximately 0.7 km of tributaries and in the South Fork for every one km of mainstem there are approximately 0.9 km of tributaries).

Furthermore, stream temperature is a function of many factors driven by the principle that the main source of heat for small mountain streams is the solar radiation that directly strikes the surface of the stream (Brown 1971). North Fork tributaries comprised an average canopy cover of 86% while the mainstem had an average canopy cover of approximately 70 % . Canopy cover facilitates the reduction of solar energy from reaching the creek. Accordingly, it would be expected with the high degree of average canopy cover on NFT, tributary temperatures would be cooler than those on the mainstem. Results indicate that this was the case for 1995.

Clark Fork Ten Mile

A general warming trend occurred from the headwaters to the Clark Fork/ North Fork confluence. The highest weekly average temperature occurred at CFT2, roughly 9.6 km above the Clark Fork/North Fork confluence. CFT4, the lowest sample station on the mainstem, reached a HWAT of 16.7 ° C and had an average HWAT of 16.7’ C during the warmest two weeks of the year (23 July 1995 -5 August 1995). The HWAT for CFT2 was 17.4 ° C for the Clark Fork/North Fork confluence with an average temperature of 17.15 ° C during the two warmest weeks of the year (as indicated by records from pools in the watershed). The HWAT for CFT8, the furthest station up the watershed, was 14.3’ C with an average of 14.05’ C during the two warmest weeks.

The HWAT within the mainstem of the Clark Fork exhibited an increasing trend from the headwaters to CFT4, then a slight cooling trend near the confluence of CFT and NFT. As with the North Fork, reasons for fluctuating thermal regimes are complex. Tributaries constitute less area per area of mainstem than the other two watersheds (however average summer flows from these tributaries are unknown). The thermal regime of the Clark Fork is also influenced by the fact that it flows east to west for essentially its entire length. This greatly increases the duration of solar exposure on the mainstem. However, the degree of solar radiation directly reaching the creek is more likely mitigated by an average canopy cover of 76% on the mainstem and 90% in the tributaries.

Additionally, coastal maritime influence, ground water input, and topographic effects all influence the instream thermal regime, and act cumulatively to cool the mainstem’s temperatures as it approaches the confluence with the North Fork.

South Fork Ten Mile

Streams in SFT reached HWAT (17.7 ° C) at SFTS located (approximately) midway between the headwaters and mouth of the South Fork. Temperatures, like those in the CFT, exhibited a general warming trend as they moved from the headwaters (SFT9) to the lowest sample station on the mainstem of the South Fork (SFT3). The HWAT for SFT9 was 15.2 ° C for the week 30 July 1995 and averaged 14.85 ° C for the two warmest weeks of the year. SFT5 reached its HWAT considerably sooner than any other of the other Hobo-Temps located in pools (9 July 1995 - 16 July 1995); reasons for this are not clear.

The South Fork flows essentially east/west until the confluence of Churchman Creek where it flows generally from the southeast to the northwest. Topographic shading, cool water influence from nearby tributaries, and coastal maritime influence appear to cool stream temperatures between SFT5 and SFT3. There was a 0.9° C difference between these two sites during their respective HWATs.

SFT5 and SFT6 both had temperature peaks over 20° C in July. As with the other sites in the TMRW, the peaks were of short duration and all weekly average temperatures were below the Coho MWAT. Temperatures in the South Fork appear to reach their maximums between SFT5 (Buck Matthews Gulch) and SFT6 (South Fork above Camp 28) and cool as they approach SFT3 (Browers Gulch). Canopy closure on mainstem SFT averaged 77 % and 85 % in the tributaries.

Discussion - Continued

In general, the tributaries of the TMRW exhibited instream thermal consistency. These constant temperatures are promoted by the cumulative effects of topography (channels are smaller), solar influence (many drain from north to south) and a higher percentage of canopy with the ability to offer solar deflection. According to Sullivan et *al*. (1990) the most important factor in maintaining temperature in small streams is canopy relative to surface area and discharge. Greater canopy cover reduces solar influence and results in corresponding decrease in temperatures and daily fluctuations (Brown 1971). Temperatures in the mainstems were higher in daily peaks, daily fluctuations and overall weekly average temperatures than the tributaries. This was expected since the surface area of the water is greater, thus, naturally reducing the ability of the canopy to provide adequate protection from solar input. Mainstems are also influenced by a myriad of inter-acting factors which are contribute to higher instream thermal regimes than the smaller perennials.

Riffles, while showing more daily fluctuation than pool temperatures did not differ appreciably in overall peak weekly, or daily maximum, temperatures than those placed in pools. However, it is significant to note that the timing of HWAT differed by one to three weeks from those temperatures found in pools and can possibly be explained by the time lag involved between air temperatures and their subsequent effects on water temperatures. Water temperature, in other words, apparently lags behind seasonal patterns of solar radiation. Some research has shown that potential solar radiation reaches a maximum in late June of each year, air and water temperatures may not attain their maxima until one to three months later (ODEQ 1994). It was likely, that instream habitats with shallow and slow-moving water heats more quickly than other types of habitat (i.e. pools, glides, etc.).

Interestingly, no apparent differences occurred between pool/riffle MWAT or pool/riffle HWAT, thus suggesting that pools eventually reached the average temperatures of the riffles and thermal stratification may be negligible. These data may conflict with Nielsen *et al.* (1994) who found thermal stratification between 3-9 ° C from the surface of the water to the bottom of the pool, in areas where thorough mixing of the water was constrained. It is unknown if pools in our 1995 monitoring effort possessed elements which may have constrained mixing. A temperature stratification study in 1994 did not indicate stratification differences between riffle temperatures and pool temperatures, although these data have not been thoroughly analyzed.

Conclusions

The 1995 instream thermal regime data for the TMRW indicate MWAT below the threshold for Coho Salmon. Average temperatures over the long term will be analyzed to identify trends within the TMRW. Specific on-site additions to the in-stream monitoring design will include additional placement of Hobo-Temps below the confluence of NFT and CFT and below the Smith Creek confluence on the mainstem of SFT. This will aid in the determination of mainstem thermal regimes. Furthermore, we will focus on expanding the placement of Hobo-Temps in riffles for 1996 in order to determine if this year's results were an artifact of small sample size or an actual phenomenon occurring in TMRW.

JA

AQUATIC VERTEBRATES

Introduction

In July of 1996, the National Marine Fisheries Service will make its final decision whether to list Coho Salmon *(Oncorhynchus kisutch)* as threatened under the Federal Endangered Species Act. The events leading up to this decision have raised many questions regarding the status of this species and reasons for its decline. Thus, there has been an increasing interest in north coast fisheries, particularly since the listing of the Coho Salmon would have consequences for land managers. Partially in response to this and in response to concerns about other watershed issues, Georgia-Pacific initiated an aquatic vertebrate sampling program as a critical component of the greater TMRW monitoring program. The goal of this study is to estimate the presence, distribution and abundance of aquatic vertebrates in the watershed. The information contained herein presents findings from a study in progress. As the amount of data accumulates over the years, a more accurate image of the biotic community will emerge.

Methods

Aquatic vertebrates were sampled at twenty five locations throughout all three forks of the Ten Mile River (Figure 1). Each site was sampled within a week of last year's sampling date for consistency (Table 1). The section on overall study design discusses the selection and placement of these sites.

A minimum stream reach of 30 meters was established for each station, with the limits defined by change in habitat type (i.e. pool, riffle or run). Seine nets of 4.5mm mesh were placed across the stream at the boundaries of the sampling unit to prevent emigration and immigration of vertebrates.

A Smith-Root Model 12 Backpack electrofisher was used to stun all specimens. Field technicians began shocking at the downstream end of the unit and worked their way to the top. Moving from bottom to top helped maintain visibility in the water and aided detection and removal of stunned organisms. The completion of one shocking attempt from the bottom seine net to the top constituted a single pass (Reynolds 1983).

In addition to the electrofisher, two technicians collected all stunned vertebrates with dip nets and placed them in buckets containing stream water. These temporary holding tanks were kept cool by placing them in the shade until the catch was processed and released into an adjacent stream reach. All specimens were collected under California Department of Fish and Game (CDF&G) scientific collection permits, #2221 and #1326.

After each pass, species were identified and the number of individuals recorded. Fork length of all Salmonids, snout to vent length of all amphibians, total length of Lampreys and total biomass of each species were also recorded.

The following habitat variables were also noted:

1. Surface area. Stream widths were measured at three meter intervals along the sample reach. Stream depths were measured at the center of the stream channel, left of center and right of center. They were taken at the same three meter intervals as stream width. These data were used along with population estimates to calculate densities in fish per square meter.
2. Stream Flow. Flows were measured using a Marsh-McBimey Flo-Mate Model 2000 flow meter.

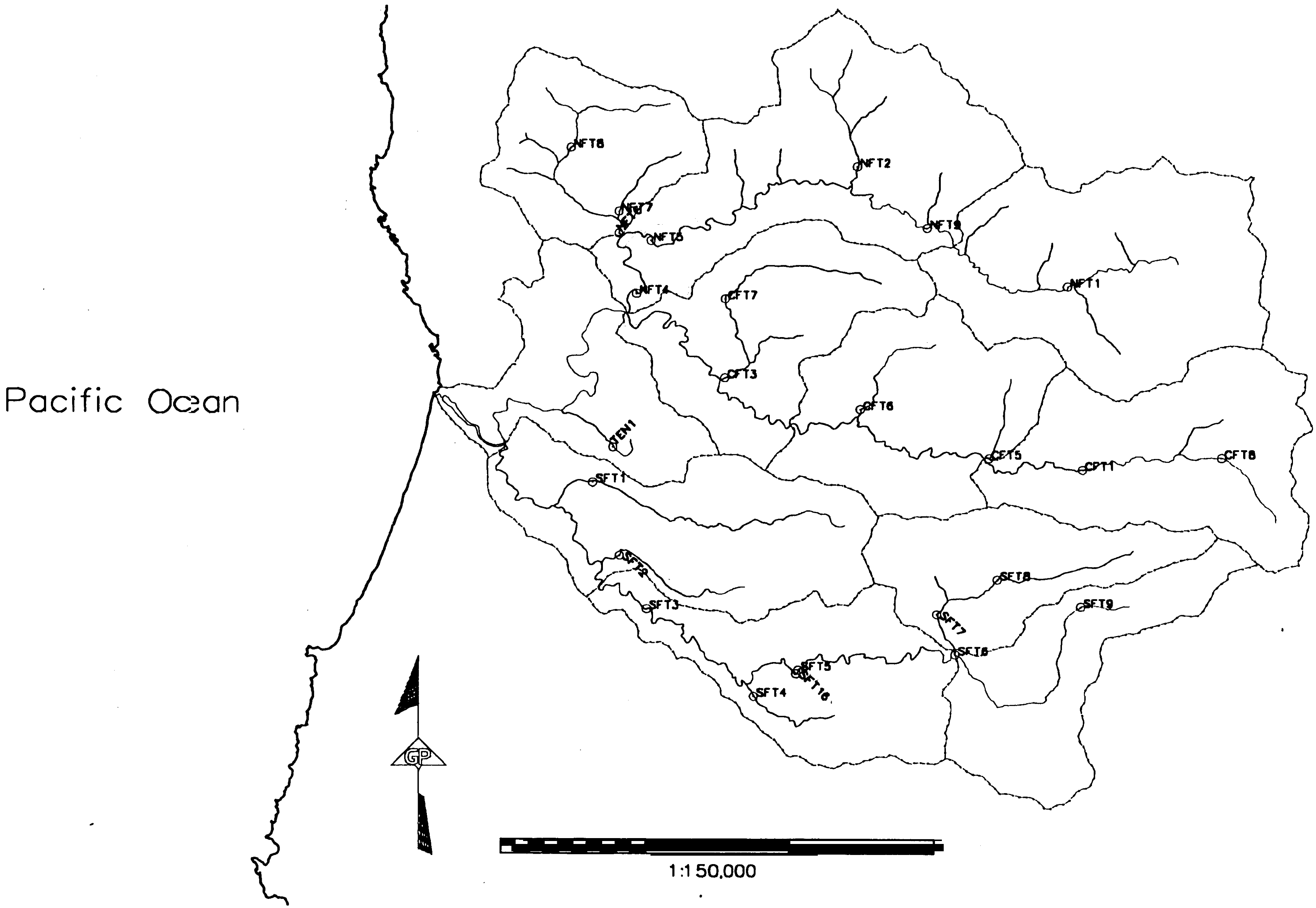


Figure 1. Electrofishing Monitoring Sites within the TMRW, 1995.

3. Temperatures. Ambient air and water temperatures were taken using hand held Celsius thermometers.

4. Substrate composition. Visual estimates of substrate composition of the wetted channel were given as percent boulder, rubble, gravel, sand, silt and clay.

5. Percent canopy cover.

6. Salmonid mortalities: The number of salmonid mortalities, water conductivity, voltage and hertz output were all documented in an attempt to monitor and reduce the mortality typically associated with this sampling method.

Data sheets were provided by CDF&G (See Figure 2).

A removal depletion strategy was employed to estimate populations within the sample unit. To establish an adequate regression, a minimum of three passes at each site was necessary (Brower et al. 1990). Salmonid populations were calculated using the MicroFish 3.0 Population Estimator (Van Deventer and Platts 1989). Other vertebrate population estimates were equal to the combined catch of each species for all passes. As mentioned previously, aquatic vertebrate densities were calculated by dividing the population estimates by the stream surface area.

In an attempt to evaluate site conditions associated with Coho salmon use, comparisons were made between Coho sites and non-Coho sites. Sites were considered Coho sites if known to be used by this species in 1995 or if there was evidence of use for more than one year prior to 1995. Criteria for use included detection by electrofishing or spawning observations. Records consulted were: 1993- 1995 Georgia-Pacific electrofishing records; CDF&G, Region 1 electrofishing records collected by Wendle Jones for the years 1983, 1989 and 1991; 1990-91 through 1991-92 spawning survey results (Maahs 1993); and unpublished observations regarding spawning activity in 1995. Site specific results for three different metrics were lumped into two categories (Coho and non-Coho). The values of each category were averaged and the averages were compared using a significance test of 0.05 to determine differences. The metrics tested included those for aquatic invertebrates, substrate composition and water temperature. This comparison encompassed all monitoring sites electrofished in 1995.

Two additional metrics were compared in a similar way but they were from the 1995 Georgia-Pacific habitat typing study. These metrics did not correspond specifically with electrofishing sites; rather, they represented averages for their respective tributaries. The comparison was between Coho tributaries rather than Coho sites. This restriction eliminated many of the sites from the comparison. The three habitat metrics were:

1. % canopy. These values represented overall average canopy cover for the named tributary.

2. Pool Depth. These values were the average depth of all the measured pools in that tributary

3. % LWD Pools. These values described proportions of measured pools formed due to the presence of large woody debris.

The ubiquitous presence of Steelhead Trout provided enough density values to allow correlation analyses between Steelhead density and other site specific metrics. Fish densities were correlated with aquatic invertebrate, substrate composition and

Electroshocking Data Sheet (1)

PERSONNEL ____________________

Drainage	Stream	Station	Date

Shock Duration (seconds)			Shocker Data	% Bottom Type					
Pass 1	Pass 2	Pass 3	Type Volts Output	Clay	Silt	Sand	Gravel	Rubble	Boulder

Surface Area			Cover Type Rating				Spawning			Temperature (C)
Pool	Riffle	Run	Surface Turb.	Object Cover	Undercut Banks	Overhang Veg.	Habitat Rating	Est. % Flow Gnd.	Lng Stn. % Cnpy	Air
%	%	%	%	%	%	%				

Stream Widths, Meters (estimate undercut banks to nearest tenth)

3m	6m	9m	12m	15m	18m	21m	23m	27m	30m

Cross-Sectional Stream Depths (cm)

3m	6m	9m	12m	15m	18m	21m	23m	27m	30m	
										Mid
										Left Bank 1/4
										Right Bank 114

Stream Flow Measurements

Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8	Cell 9	Cell 10	
										Cell width (ft)
										Cell depth (ft)
										Water Vd. (f/o)

Station Notes :

Note: For fish species that are to be measured in length only, please use Electroshock Data Sheet (2)!

Pass	Spec. Code	No. Coll	Biomass (gms)	Fork Length (mm) and Weight (gm)								
				Length	Wt	Length	wt	Length	wt	Length	Wt	Length

Figure 2. Electrofishing Data Form, 1995.

temperature values. In addition, sites were divided into two categories: high-density Steelhead sites and Low-density Steelhead sites. Average values for each metric were compared for significant differences in precisely the same manner as with the Coho analysis.

The criterion for high density Steelhead sites was a fish density greater than 0.7 fish/m2 for more than one of the last three years (G-P electrofishing records 1993-95). The 0.7 f/m2 cutoff was arbitrary; however, it allowed us to isolate those few sites having consistently higher Steelhead densities.

Results

This year's aquatic vertebrate sampling in the TMRW began on 8 August 1995 and was completed on 3 1 October 1995 (Table 1). This schedule was intended to coincide with the late summer period when juvenile salmonid populations are typically most stable (Meehan and Bjomn 1991).

Table 1. Aquatic Vertebrate Sampling Sites within the TMRW.

Sampling Date	Area Code	Site Name
950808	CFTl	CFT at Reynold's Gulch
950810	CFT3	Lower Bear Haven Creek
950921	CFT5	Booth Gulch
951025	CFT6	Little Bear Haven Creek
951012	CFT7	Upper Bear Haven Creek
950811	CFT8	Upper CFT/Ford
951003	NFTl	Patsy Creek
951002	NFT2	Bald Hill Creek
951023	NFT4	NFTatCamp3
950929	NFT5	NFTatCamp5
950919	NFT6	Lower Little NFT
950919	NFT7	Buckhom Creek
950927	NFT8	Upper Little NFT
950928	NFT9	NFT at Gulch Nine
950825	SFT1	Lower Smith Creek
950816	sFT15	SFT at Big Cat Crossing
950825	SFT2	Lower Campbell Creek
950905	sFT3	SFT at Brower's Gulch
950831	SFT4	Churchman Creek
950817	SFT5	SFT at Buck Mathews
950824	SFT6	SFT at Camp 28
951031	SFT7	Lower Redwood Creek
950822	SFT8	East Branch Redwood Creek
951020	SFT9	Upper SFT
951017	TEN1	Mill Creek

Two of the twenty five sites yielded Coho Salmon, Lower Smith Creek (SFT1) and Lower Campbell Creek (SFT2). One juvenile was found in Smith Creek (0.01 f/m2) and two were found in Campbell Creek (0.02 f/m2). The comparison between Coho

Table 2. Comparisons between sites with and without Coho Salmon presence. Highlighted rows represent sites where Coho have been found for at least two years.

Area:	Site Name:	1995 Densities: Coho Salmon	Aquatic Invertebrates: Real % EPT	% Similarity	Sediments: % Fines	Fredle Index	Stream Temps: HWAT
CFT1	CFT at Reynold's Gulch	0	56.9	96.2	17	2.9	16.4
CFT2	CFT at Little Bear Haven		39.8	73.3	16.5	2.6	17.4
CFT3	Lower Bear Haven	0	80.9	102.2	18.3	1.5	14.7
CFT4	Lower CFT		73.9	108.2	20.9	1.5	16.7
CFT5	Booth Gulch	0			22.2	1.4	14.6
CFT6	Little Bear Haven	0	81.6	81.9	19.5	1.5	14.1
CFT7	Upper Bear Haven	0	85.2	101.7			13.7
CFT8	Upper CFT/Ford	0	77.4	116.5			14.3
NFTl	Below Patsy Ck.	0	45.4	78.0	20.7	1.5	17.6
NFT11	NFT Property Line						
NFT2	Bald Hill Creek	0	58.9	83.8	16.2	3.9	15.2
NFT3	NFT Below O'Conner Gulch		50.9	88.5			16.9
NFT4	NFT at Camp 3	0	66.2	87.7			17.1
NFT5	NFT at Camp 5	0	81.3	95.1	20.9	1.5	17.6
NFT6	Lower Little NFT	0	82.8	101.9	18.4	1.5	14.8
NFT7	Buckhom Creek	0	70.5	80.3	23.7	1.3	13.5
NFT8	Upper Little NFT	0	74.3	89.9	.		14.3
NFT9	NFT at Gulch 9	0	63.1	83.9	25.7	1.2	17.1
NFT10	Patsy Creek				27.7	1.7	
SFT1	**Lower Smith Creek**	**0.01**	70.4	96.5	14.7	2.1	15.2
SFT11	Gulch 11		53.8	70.2			
SFT12	SFT Above Gulch 11						16.5
SFT2	Lower Campbell Creek	0.02	76.8	97.6	23.1	1.2	15.5
SFT3	SFT at Brower's Gulch	0	36.6	66.1	‘16.5	2.2	16.9
SFT4	Churchman Creek	0			15.8	1.4	
SFT5	SFT at Buck Mathews	0	45.4	88.2	16.6	2.4	17.7
SFT6	SFT at Camp 28	0	46.2	78.6	18.4	2.9	17.3
SFT7	Lower Redwood Creek	0	77.4	94.8			15.9
SFT8	East Branch Redwood Creek	0	83.5	82.6	19.5	1.6	15.6
SFT9	Upper SFT	0	59.8	83.8	13.4	5.5	15.2
SFT16	SFT at Big Cat Crossing	0					
TEN1	Mill Creek	0	50.0	83.0	22.6	1.2	13.4
	Coho Average:		75.6	96.6	18.7	1.6	14.9
	Non-Coho Average:		64.9	88.0	19.2	2.1	15.7
	P-Values:		0.053	0.06	NA	NA	0.082 <P< .0139

and non-Coho sites using other metrics (Table 2 and Figure 3) failed to show significant differences in the averages (using a .05 level of significance). However, the aquatic invertebrate metrics %EPT and overall % similarity were close with .053 and .059 P-values respectively. In contrast, Coho/habitat comparisons (Table 3 and Figure 3) did show a significant association (P-value of 0.020) between Coho sites and occurrence of pools formed by large woody debris (% LWD).

Table 3. Habitat comparisons between tributaries with and without Coho Salmon presence. Highlighted rows represent Coho tributaries.

		Physical Parameters:		
Area:	Site Name:	% Canopy	Pool Depth (ft.)	% LWD Pools
CFT	Lower Bear Haven	89	2.03	39
CFT	Booth Gulch	91	2.15	1
CFT	Little Bear Haven	91	2.00	6
NFT	Bald Hill Creek	87	1.97	16
NFT	Little NFT	90	2.04	40
NFT	Buckhorn Creek	93	1.64	3
NFT	NFT at Gulch 9	86	1.93	3
SFT	Lower Smith Creek	83	1.95	54
SFT	Lower Campbell Creek	83	1.94	51
SFT	Churchman Creek.	90	1.74	51
SFT	Redwood Creek	84	2.4	30
TEN	Mill Creek	97	1.58	40
	Coho Average:	86.3	2.0	46.0
	Non-Coho Average:	89.9	1.9	18.8
	P-Values:	NA	.283	.020

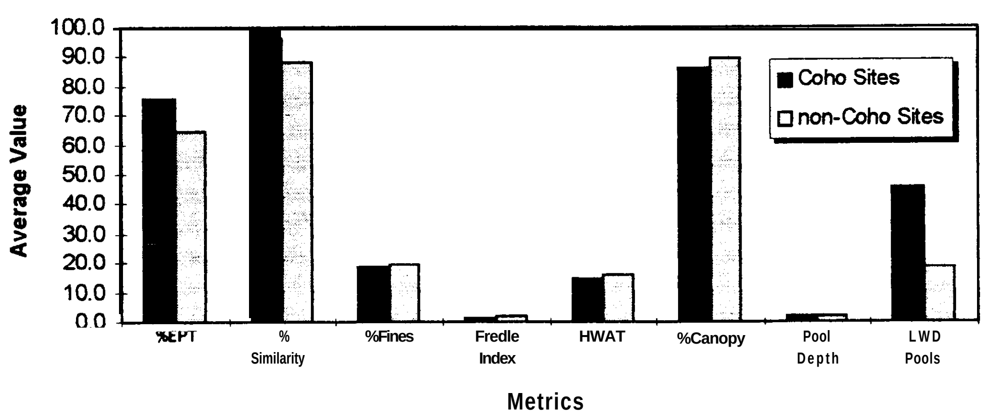


Figure 3. Comparison of average values for various metrics to test for differences between Coho and non-Coho sites.

Steelhead Trout were found in all 25 sites. Their densities ranged from 1.74 f/m2 at Camp 28 (SFT6) to 0.04 f/m2 at Camp 5 (NFT5). Correlation analysis between

Table 4. Correlations between Steelhead Trout densities and other watershed metrics. Highlighted (***) rows represent sites with high densities for at least two of the last three years..

		1995 Densities:	Aquatic invertebrates:		Sediments:		Stream Temps:
Area:	Site Name:	Steelhead Trout	Real % EPT	% Similarity	% Fines	Fredle Index	HWAT
***CFT1	**CFT at Reynold's Gulch**	**0.78**	**56.9**	**96.2**	17	2.9	16.4
CFT2	CFT at Little Bear Haven		39.8	73.3	16.5	2.6	17.4
***CFT3	Lower Bear Haven	0.61	80.9	102.2	**18.3**	**1.5**	14.7
CFT4	Lower CFT		73.9	108.2	20.9	1.5	16.7
CFT5	Booth Gulch	0.74			22.2	1.4	14.6
CFT6	Little Bear Haven	0.36	81.6	81.9	19.5	1.5	14.1
CFT7	Upper Bear Haven	0.71	85.2	101.7			13.7
CFT8	Upper CFT/Ford	0.28	77.4	116.5			14.3
NFT1	NFT Below Patsy Ck.	0.58	45.4	78.0	20.7	1.5	17.6
NFT11	NFT Property Line						
NFT2	Bald Hill Creek	**0.53**	**58.9**	**83.8**	16.2	3.9	15.2
NFT3	NFT Below O'Conner Gulch		50.9	88.5			16.9
NFT4	NFT at Camp 3	0.12	66.2	87.7			17.1
NFT5	NFT at Camp 5	0.04	81.3	95.1	20.9	1.5	17.6
NFT6	Lower Little NFT	0.57	82.8	101.9	18.4	1.5	14.8
*** **NFT7**	Buckhorn Creek	0.75	70.5	80.3	**23.7**	1.3	13.5
NFT8	Upper Little NFT	0.85	74.3	89.9			14.3
NFT9	NFT at Gulch 9	1.63	63.1	83.9	25.7	1.2	17.1
NFT10	Patsy Creek				27.7	1.7	
SFT1	Lower Smith Creek	0.36	70.4	96.5	14.7	2.1	15.2
SFT11	Gulch 11		53.8	70.2			
SFT12	SFT Above Gulch 11						16.5
SFT2	Lower Campbell Creek	0.74	76.8	97.6	23.1	1.2	15.5
SFT3	SFT at Brower's Gulch	0.19	36.6	66.1	16.5	2.2	16.9
SFT4	Churchman Creek	0.37			15.8	1.4	
SFT5	SFT at Buck Mathews	0.57	45.4	88.2	16.6	2.4	17.7
***SFT6	**SFT at Camp 28**	1.74	46.2	78.6	18.4	2.9	17.3
***SFT7	Lower Redwood Creek	0.77	77.4	94.8			15.9
SFT8	East Branch Redwood Creek	0.25	83.5	82.6	19.5	1.6	15.6
SFT9	Upper SFT	0.34	59.8	83.8	13.4	5.5	15.2
SFT16	SFT at Big Cat Crossing	0.39					
TEN1	Mill Creek	0.38	50.0	83.0	22.6	1.2	13.4
		Correlations:	-0.18	-0.11	0.38	-0.03	0.13
		Averages:					
		Hi-density Site:	66.4	90.4	19.4	2.2	15.6
		Low-density Site:	67.0	89.3	19.1	2.0	15.6
		P-Values:					

Steelhead densities and other metrics and comparison of averages revealed no associations (Table 4 and Figure 4). There was no clear trend in densities from year to year (Table 5); rather, results were characterized by tremendous variation (Figure 6).

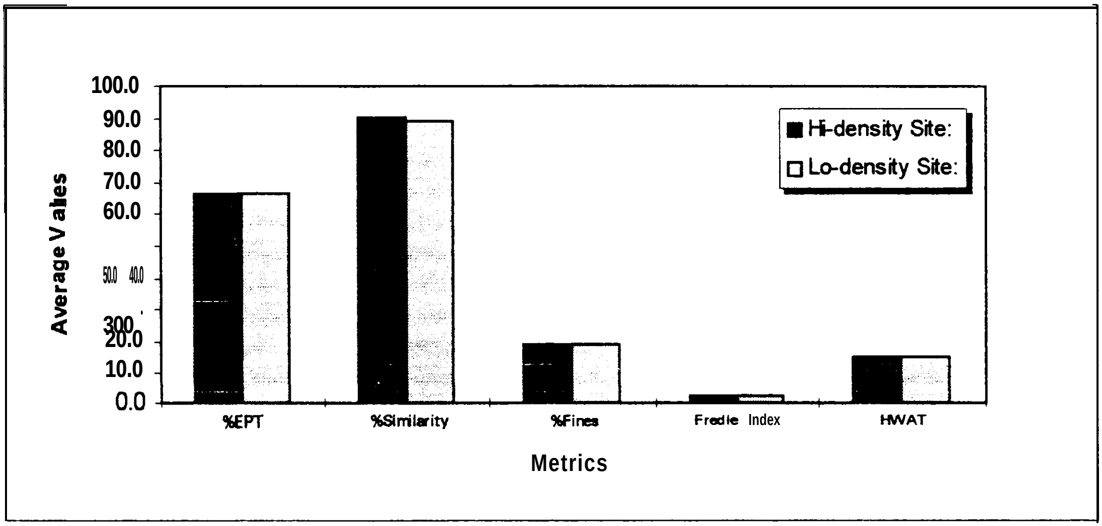


Figure 4. Comparison of average values for various metrics to test for differences between high-density and low-density Steelhead Trout sites.

Georgia-Pacific issued permits to allow fishing in its streams from January through March of 1995. Twenty-four percent of permit recipients returned the fishing report as requested of them when the permit was issued. Forty-five percent of those who returned the report caught no fish. Seventy-nine adult Steelhead were reported to be caught in the TMRW. The average weight for males was 3.4 kg. The average weight for females was 3.9 kg. See Figure 5 for weight distributions.

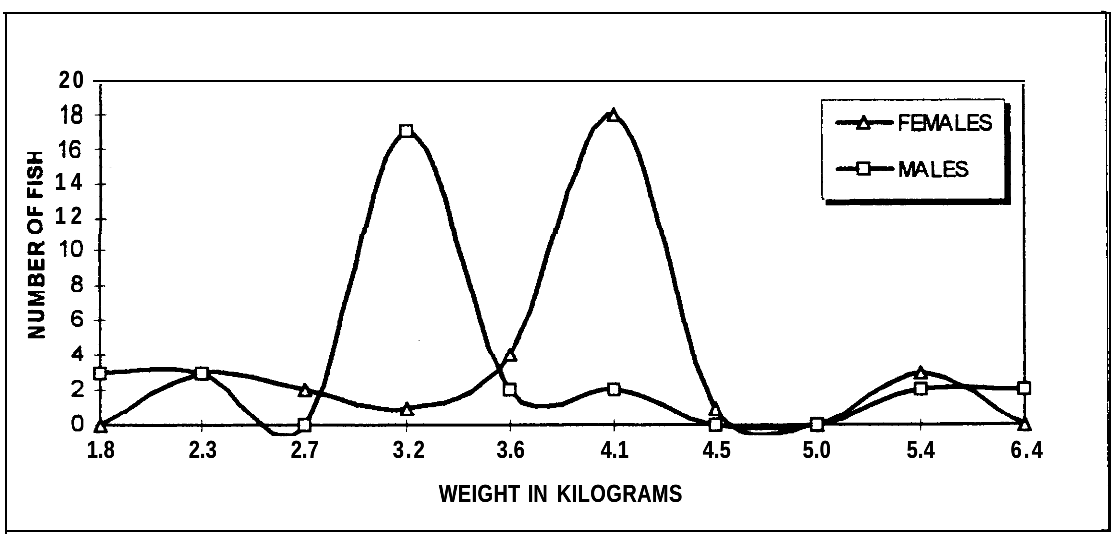


Figure 5. Distribution of Steelhead Trout weights from sportfishing catches in the TMRW, 1995.

The number of species detected per electrofishing site ranged from eight to two. Figure 7 shows species richness for each site, grouped by drainage. There were a total

Table 5. Comparison of Steelhead Trout densities from 1993 to 1995.

Site Name	1993 (FISH/m2)	1994 (FISH/m2)	1995 (FISH/m2)	2 Year Ave.	Std. Dev.	Difference
Booth Gulch	0.45	0.13	0,74	0.29	0.31	0.45
Little Bear Haven	0.28	0.4	0.36	0.34	0.06	0.02
Lower Bear Haven	0.83	1.2	0.61	1.02	0.30	-0.41
CFT at Reynold' s Gulch	0.74	0.44	0.78	0.59	0.19	0.19
Upper CFT/Ford	0.2	0.15	0.28	0.18	0.07	0.11
Upper Bear Haven	0.48	0.58	0.71	0.53	0.12	0.18
Bald Hill Creek	0.48	0.47	0.53	0.48	0.03	0.06
Buckhorn Creek	0.5	0.72	0.75	0.61	0.14	0.14
NFT at Camp 3	0.36	0.99	0.12	0.68	0.45	-0.56
NFT at Camp 5	0.39	0.6	0.04	0.50	0.28	-0.46
NFT at Gulch 9	0.32	0.64	1.63	0.48	0.68	1.15
Lower Little NFT	0	1.5	0.57	1.50	0.00	-0.93
NFT Below Patsy Creek	0.45	0.47	0.58	0.46	0.07	0.12
Upper Little NFT	0.38	0	0.85	0.19	0.43	0.66
SFT at Big Cat Crossing	0.32	0.92	0.39	0.62	0.33	-0.23
SFT at Brower' s Gulch	0.08	0.66	0.19	0.37	0.31	-0.18
SFT at Buck Mathews	0.23	0.83	0.57	0.53	0.30	0.04
SFT at Camp 28	0.85	2.3	1.74	1.58	0.73	0.17
Churchman Creek	0.42	1.2	0.37	0.81	0.47	-0.44
East Branch Redwood Ck.	0.25	0.7	0.25	0.48	0.26	-0.23
Lower Campbell Ck.	0.3	0.61	0.74	0.46	0.23	0.29
Lower Redwood Ck.	0	0.89	0.77	0.89	0.00	-0.12
Lower Smith Creek	0.53	0.67	0.36	0.60	0.16	-0.24
Upper SFT	0.17	0.35	0.34	0.26	0.10	0.08
Mill Creek	0.32	0.32	0.38	0.32	0.03	0.06
					Average Difference:	0.00

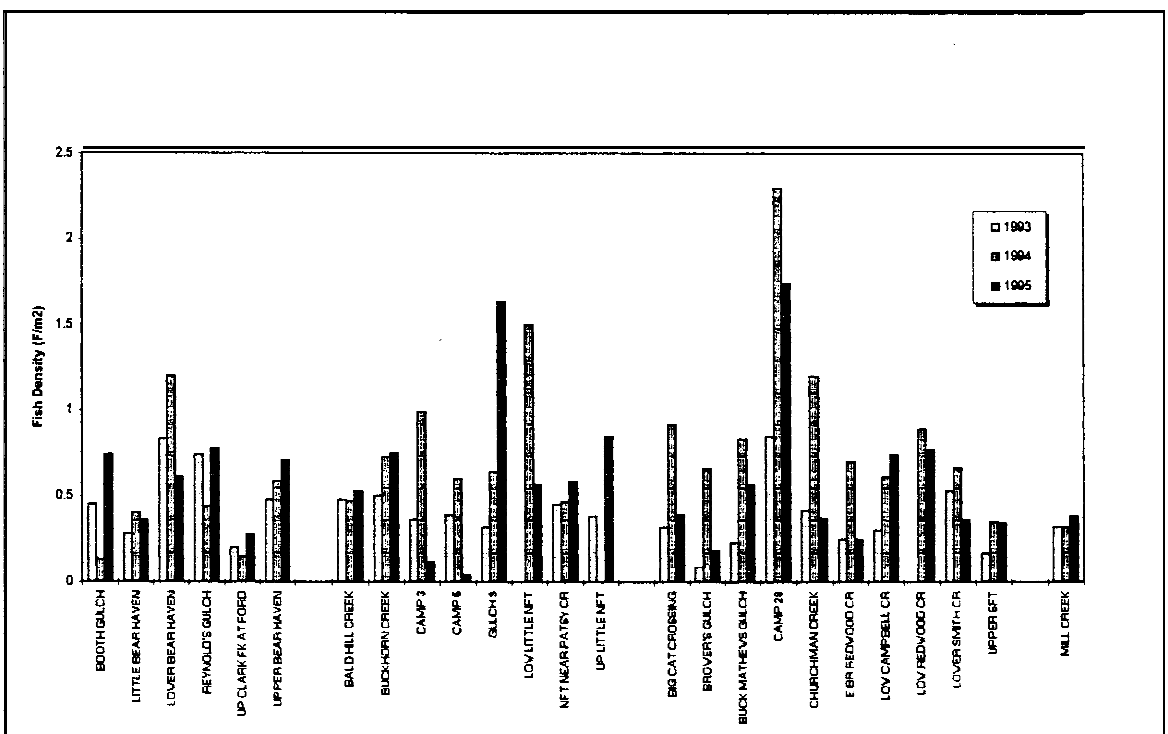


Figure 6. Steelhead density comparisons from 1993 to 1995.

of twelve species identified during our sampling effort in the TMRW. Table 6 shows a list of those species and the number of sampling sites where they were found.

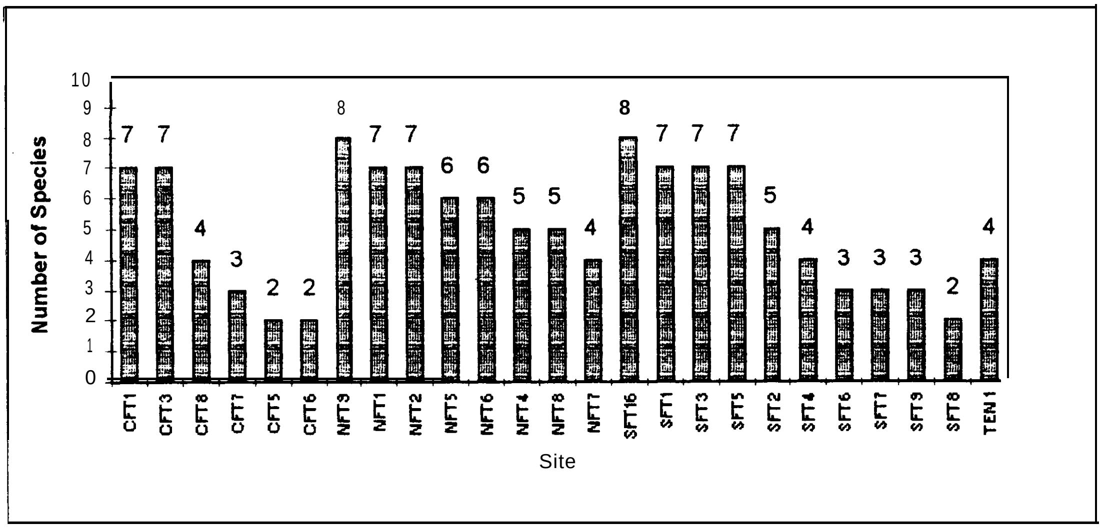


Figure 7. Number of aquatic vertebrate species per site based on 1995 electrofishing results in the TMRW.

Table 6. Resulting list of Species from the TMRW aquatic vertebrate survey.

Common Name:	**Scientific Name:**	**# of Sites:**
Coho Salmon	*Oncorhynchus kisutch*	2
Steelhead Trout	*Onchrhynchus mykiss*	25
Three-Spined Stickleback	*Gasterosteus aculeatus*	13
Coastrange Sculpin	*Cottus aleuticus*	12
Prickly Sculpin	Cottus *asper*	15
Lamprey	*Lampetra spp.*	12
Pacific Giant Salamander	*Dicamptodon ensatus*	24
Rough-Skinned Newt	*Taricha granulosa*	6
Red-Bellied Newt	*Taricha rivularis*	2
California Newt	*Taricha torosa*	1
Yellow-Legged Frog	*Rana boylii*	11
Tailed Frog	*Ascaphus truei*	*4*

It is important to understand that these 12 species are those detected by this particular survey method and not the total number of species that are known to occur in the watershed. Appendix A shows species and densities presented in a site by site format.

The Foothill Yellow-Legged Frog was found at 11 sites and primarily in mainstem locations with typically less canopy cover and more extensive gravel beds. Sightings of this species were quite numerous throughout the watershed in addition to the 11 survey detections.

Tailed Frogs were found at four sites but were quite uncommon. They were typically found as tadpoles in shallow riffles. In addition to electrofishing surveys, Georgia-Pacific conducted intensive surveys in 1994 and 1995 within a 50 meter reach on a Class Two tributary (Fox Gulch of CFT). In 1994 18 tadpoles were found within the study reach. In 1995 23 tadpoles and one adult were found. Georgia-Pacific will continue to monitor this site.

The presence of sculpins within sample sites revealed an interesting pattern. There was a tendency for both Prickly Sculpin and Coastrange Sculpin to be found together. There were no sites where Coastrange Sculpin were found alone and only three of 15 sites where Prickly Sculpin occurred without Coastrange Sculpin.

Lamprey of two morphological stages were encountered, ammocoetes and those in the macropthelmia stage. The latter was a transitional condition between the ammocoete and adult morphologies in which the eyes were proportionately larger, the structure of the gill openings and mouth were different and the overall body color changed from brown to gray. These two morphologies did not represent distinct species. Species differentiation of ammocoetes is based primarily on myomere counts and other more qualitative factors (Hopkirk Pers. comm.). Three species are known to occur in this area: the Pacific Lamprey (Lampetra tridentata); the River Lamprey (Lampetra ayresi); and the Western Brook Lamprey *(Lampetra richardsoni).* Lamprey were not identified to species in this study.

Discussion

The goal of this monitoring plan was to estimate distribution and abundance of aquatic vertebrate populations from year to year by sampling the watershed in representative locations. The 1995 results are an early measure in a long term monitoring effort which may, in time, reveal trends in abundance and distribution. Although it may be fair to judge the current conditions based on our results, thus far it is premature to say anything conclusive about population trends. The responses of salmonid populations, whether to terrestrial, oceanic or climatic changes, may be carried through several life cycles, each of which averages three years for Coho Salmon (Bryant 1995). Abundances in one year are not directly related to the next, but to every fourth year. This highlights the need for long term monitoring and limits conclusions pertaining to short term variations in fish densities.

Nonetheless, it is apparent the Coho Salmon population in this region is depressed even from the 1960's level (Bums 1972; Valentine 1994). Georgia-Pacific recognizes the need for restoration efforts in order to conserve this resource.

With so few detections of Coho in the TMRW, it is difficult to conclude much other than few juvenile Coho are rearing in the areas we sampled. However, Coho use is not necessarily limited to the two sites where they were found in 1995 (Lower Smith Creek and Lower Campbell Creek). Hatchery trapping efforts for the 1994-95 spawning season demonstrate spawning activity in other areas (unpubl.). Ten juvenile Coho were also trapped coming out of the South Fork Ten Mile River in 1995 by the outmigrant trapping efforts of the Salmon Trollers Marketing Assoc. Inc. (Maahs 1995). The exact tributary of origin cannot, of course, be determined. Additionally, when Coho fry emerge from their spawning gravels they disperse both upstream and downstream and reside in suitable rearing habitats (Meehan and Bjomn 1991). This may result, particularly for small populations, in an uneven distribution throughout the stream reaches. This complicates the issue of obtaining a representative sample. Ideally, sampling sites should be established in areas of suitable habitat as determined by habitat typing analysis (Overton pers. comm.). Georgia-Pacific biologists are participating in discussions through forums such as the Fish, Farm and Forest Communities Technical Committee and the NMFS coastal salmon sampling methodology workshop in order to implement more accurate and standardized methods.

Steelhead Trout, unlike Coho Salmon, remain widespread in the TMRW. To the degree that juvenile salmonid populations are determined by instream conditions, the difference in distribution and abundance between Coho and Steelhead indicates pronounced differences in survivability in response to the habitat conditions in the TMRW. This differential ecological tolerance in favor of Steelhead is likely due to differences in the life history traits of the two species (Thorpe 1994). Steelhead Trout appear to be habitat generalists whereas Coho Salmon are less so.

Conclusions about trends for Steelhead populations are subject to similar limitations already discussed in reference to Coho populations. In addition, our data for Steelhead densities throughout the watershed in the last three years indicate that no trend is, as yet, discernible (Figure 5). Some sites show dramatic increases, others have decreased and some appear stable, indicating a high degree of variability within and between sites. Nonetheless, we compared this year's results with the average for the previous two years and found no overall significant difference in the Steelhead Trout population (Table 5).

Because the physical conditions of streams influence presence, density and survival of salmonids, stream parameters were compared to determine if there were significant differences between those sites used by Coho Salmon and those where there is no evidence of recent use (Tables 2 and 3). Interestingly, the only parameter showing a strong association with Coho use was the occurrence of pools formed by large woody debris (LWD). This observation indicated the importance of LWD in streams. LWD in the form of rootmasses and windfall trees are known to provide shelter and protection for juvenile salmonids (Shirvell 1989; Meehan and Bjomn 1991). Furthermore, it is known that interactive segregation occurs between Coho and Steelhead with the result that Coho occupy pools and tend to displace Steelhead (Meehan and Bjomn 1991). Since Coho are likely to occupy this habitat type, it is not suprising to find that Coho sites occur in streams with a high incidence of pools containing LWD.

High values from metrics in the aquatic invertebrate study also showed some association with Coho sites, although not to the .05 level of significance. As described in the invertebrate section, % EPT and overall % similarity are measures of epibenthic fauna and its response to water pollution (sedimentation in this case) (Waters 1995). As such, it is indirectly related to salmonid abundance. As with streambed composition, invertebrate metrics related more to spawning conditions than to rearing habitat. It is unlikely the association is related to invertebrates as a food source because salmonids feed preferentially on instream invertebrates (i.e. those drifting in the water column) (Meehan and Bjomn 1991).

Stream parameters were also compared as they relate to Steelhead densities. The results indicated no significant correlation with Steelhead density (Table 4), meaning, site conditions tested appeared to have no bearing on Steelhead. Of course that is not the only possible explanation. The distinction between a high density site and a low density site was somewhat arbitrary. From Figure 5, there was no obvious break in the distribution of density values. Therefore, the criteria for groups may have been too artificial to reflect any real differences. There may also have been some overriding factor or combination of factors not taken into account that may have obscured influences of the metrics. However, the perception of Steelhead as habitat generalists does seem to be supported by this analysis.

There are several other fisheries related activities occurring within the TMRW worthy of note. Salmon Trollers Marketing Assoc. Inc. has conducted spawning surveys for the winters of 1990-91 and 1991-92. Contained in their report were complete accounts of spawning records for those years. A 1995-96 survey is in progress, but results are not yet available. This same group has also completed an outmigrant study in 1995. They are tentatively planning to repeat the study for 1996 (Maahs 1995).

Another fisheries activity in the TMRW is the fish hatchery operated by the Salmon Restoration Association since 1989. Native Steelhead have been raised and successfully released since 1990. Attempts to raise Coho Salmon have had mixed results. Small numbers were released from 1992 through 1994. In 1995 bacterial kidney disease (BKD) was detected and all salmon eggs/fry were subsequently destroyed. Trapping stations on SFT and Bear Haven Creek have been operated for the last three years and were the source for all Coho Salmon in the hatchery (Ed Moore Pers. Comm.).

It should be noted that the NMFS Status Review of Coho Salmon from Washington, Oregon, and California incorporated into its evaluation information stating that the Coho Salmon in the TMRW are the only native fish, lacking a history of supplementation with non-native hatchery stocks in the Central California Coast ESU (Weitkamp ***et al.*** 1995). The statement appears on pages 107-109 in the section titled Analyses of Extinction Risk by ESU and is attributed to an estimate of spawning escapements by Brown and Moyle (1994). However, the spawning survey report by Salmon Trollers Marketing Assoc. Inc. clearly describes the annual release of up to 200,000 Coho Salmon from the years 1974 to 1977 into the Ten Mile River. These salmon originated from stocks in Oregon (Maahs 1995; Taylor 1978).

Georgia-Pacific's aquatic vertebrate sampling effort has and will continue to be of tremendous value in understanding the status of the biotic community in this important watershed.

DH

AOUATIC MACROINVERTEBRATE RAPID BIOASSESSMENT

Introduction

As part of Georgia-Pacific's TMRW monitoring plan, a macroinvertebrate study was initiated in an effort to assess water quality. Aquatic macroinvertebrates are considered by some experts to be a superior monitoring tool due to their abundance, sedentary nature, short life cycle and sensitivity to change (EPA 1991). A form of aquatic macroinvertebrate sampling known as Rapid Bioassessment (RBA) has received much research and review in parts of the United States (Hilsenhoff 1988, Plafkin et al. 1989, Lenat and Barbour 1994). However, California is in the preliminary stages of using RBA as a monitoring tool and predictable patterns of the effects of timber harvest have not yet been established. Georgia-Pacific's 1995 RBA is breaking new ground by using this technique in an effort to provide baseline data for quality and trends within the aquatic community.

Field Methods

Twenty-seven RBA sites were chosen in the TMRW (Figure 1) based on two criteria. The first was proximity to specific monitoring locations. Georgia-Pacific monitors temperature, stream substrate composition and aquatic vertebrates each summer/fall as part of its long term monitoring plan. All RBA sites (excluding CFTM #3) were located in riffles adjacent to these monitoring stations. They were sampled prior to other monitoring activities to ensure that other monitoring activities did not affect the collecting of insects. The second criterion was the even distribution of sites throughout the TMRW. We attempted to distribute sites throughout the watershed in an effort to sample many different habitat types.

For comparison, three reference sites were chosen (Figures 2a and 2b). Montgomery Creek (two sites) runs through Montgomery Woods State Reserve located in central Mendocino County. Elder Creek (one site) is part of the Nature Conservancy holdings in northern Mendocino County. These reference sites were considered to be relatively uninfluenced by timber harvest activities and represent the "best attainable" condition.

Macroinvertebrate sampling for reference and TMRW sites was conducted by Georgia-Pacific staff from 12 June to 8 August, 1995 (Table 1). All sites were sampled according to California Department of Fish and Game's California Stream Bioasssessment Procedure outlined by Harrington (1995). At each site, three random transects were chosen perpendicular to the riffle. Beginning with the downstream transect, macroinvertebrates were collected at three locations using a D-shaped kick net. The three locations were near the left and right banks and at the center of the stream (Figure 3). The contents of the net were then placed in a labeled jar containing an aqueous solution of 70 % ethanol. This process was repeated for each transect resulting in three transect jars (or samples) per RBA site.

Laboratory Methods

Contents of transect jars were rinsed through a standard testing sieve size 35 (0.5 mm) and evenly distributed in a tray with numbered grids. Using a 4X magnifying glass and forceps, a total of 300 macroinvertebrates were removed from randomly chosen grids and placed in a labeled vial containing an aqueous solution of 70% ethanol. In some cases, it was necessary to use all grids for transect jars with less than 300 macroinvertebrates. For identification, the subsample vials were emptied into petri dishes and viewed under dissecting stereoscopes with 10X to 45X magnification. Macroinvertebrates were identified to the family level (when possible) using taxonomic keys from Merritt and Cummins (1984) and Thorp and Covich (199 1).

Data Analysis

Data analysis was initiated by grouping the three subsamples from each RBA site into a single sample. Five metrics described by Plafkin et al. (1989) and Lenat and Barbour (1994) were chosen to quantify the data. The five metrics were: Family Biotic Index (FBI), Taxa Richness (Family Richness), Ephemeroptera-Plecoptera-Trichoptera (EPT) Richness, %EPT, and %Chironomidae. TMRW sites were evaluated for individual metrics by calculating their percent similarity to the reference site median. In turn, those individual percent similarities were averaged to give an overall assessment.

For individual metrics and overall assessment, evaluation of TMRW sites was based on percent similarity to the reference site median value and results in a classification of impaired or not impaired. Two thresholds for classification have been discussed in the literature. Plafkin et al. (1989) suggested if a site is less than 83 % similar to the reference median, the site is considered impaired. Hannaford and Resh (1995)) however, recommended a 65 % threshold to allow for natural variability. To account for variability within the reference sites, and to address the physiographic differences between TMRW sites and reference sites, the 65 % threshold seemed most appropriate (Resh, pers comm. 1995). Therefore, sites scoring less than 65 % similar to the reference median were considered impaired and sites above 65 % were considered not impaired.

Results-General

A total of 15,972 insects were identified to Family. A list of the 57 aquatic insect families and the 6 non-insect groups identified within the TMRW are listed in Table 2. Sample sizes for the TMRW sites ranged from 115 macroinvertebrates to 9,208 (estimated total) with a median sample size of 631.5 (Table 1). Twenty-one of the TMRW sites (77.7%) averaged less than 900 macroinvertebrates for the site (not the subsample). Reference site samples ranged from 439 to 1,670 (estimated) macroinvertebrates with a median sample size of 1,403 macroinvertebrates.

Median reference site values for FBI, Taxa Richness, EPT Richness, % EPT and %Chironomidae were 2.65, 28, 17, 63.2 and 5.6 respectively. Table 1 shows each of the TMRW and reference sites with their metric values.

Results-Overall Assessment

No sites showed impairment when all metrics (excluding %Chironomidae) were calculated cumulatively to give an average percent similarity to the reference median

(Graph 1). The metric %Chironomidae was not considered in the cumulative metric assessment due to high variability which will be discussed later.

Results-Individual Metrics

Twenty-six sites (96.3%) showed no impairment using the FBI metric. One site (3.7%), CFTM3, showed impairment (Graph 2). The FBI metric is unique because it is possible to give an assessment of the site without having a reference site. Hilsenhoff (1988) developed organic pollution tolerance values (O-10) for different aquatic insect families that enables sites to be classified from excellent to very poor (o-10). Reference sites ranged from 2.40-3.50, while TMRW sites ranged from 2.26-4.39. Table 3 shows the values for the corresponding water quality conditions from Hilsenhoff (1988). Of the 27 sites sampled, 86.7% of TMRW sites were considered excellent, 10 % were considered very good and 3.3 % were considered good.

Using the Taxa Richness metric, 25 of the sites (92.6%) showed no impairment. Two sites RCl and SFTM 1 showed impairment (Graph 3). Twenty-two sites (81.5 %) showed no impairment using the EPT Richness metric. Five sites (18.5 %), BKHNl, RC2, SFTMl, SFTM4 and LBHl did show impairment (Graph 4). Using the %EPT metric, 25 sites (92.6 %) showed no impairment. Impairment was calculated for two sites (7.4 %): SFTMl and CFTM2 (Graph 5).

Though %Chironomidae was not used for the overall assessment, eight sites (29.6%) showed impairment using this metric: BHl, BKHNl, MILLl, SFTM2, SFTM3, CFTM2.5, CFTM3, ELDRl. Seventeen sites (63.0%) showed no impairment using the % Chironomidae metric.

Discussion

Although none of the sites showed impairment with the overall assessment, there were sites within individual metrics that showed impairment. Analysis of how each metric detects impairment, along with field investigation, is needed to evaluate these impaired sites.

Impairment indicated by the metrics %EPT and EPT Richness may be the most important indicators of impairment. Macroinvertebrates within these three orders are considered to be the most sensitive to pollution (Plafkin et al. 1989). North Carolina biologists found EPT Richness to be the most reliable indicator of impairment and more sensitive to water quality changes than simple taxa richness (Lenat and Barbour 1994). EPT impaired sites may indicate low amounts of pebble and cobble substrate and/or a loss of interstitial space. Macroinvertebrates within the EPT orders inhabit the surface of stones and the interstitial space between cobbles and pebbles (Waters 1995, Erman and Erman 1984). A comparison between EPT and percent fines from the 1995 particle size distribution study revealed non-significant ($p > 0.05$) correlation ($r = 0.27$).

An increase in the taxa richness metric may not reflect an increase in water quality. A site with poor water quality conditions may have supported high numbers of pollution tolerant families such as Chironomidae. The two TMRW sites (RC2 and SFTMl) showed impairment for this metric and EPT Richness suggesting poor conditions for sensitive families (EPT).

The FBI metric was designed to assess water quality with regard to organic pollution in Wisconsin (Hilsenhoff 1988). Plafkin et al. (1989) suggested regional modification of FBI may be necessary and its ability to detect non-organic pollution has not been thoroughly evaluated. However, the FBI metric is good at evaluating the overall tolerance of macroinvertebrates to a disturbance (Resh pers. comm. 1995). Impairment in the FBI metric for CFTM3 was possibly due to upstream grazing which could be a source of organic enrichment. The highest %Chironomidae was also found at this site. High numbers of Chironomidae have been associated with fine-particle substrates (Erman and Erman 1984) and evaluation of the sediment data for this area is needed.

Metrics involving %Chironomidae (and total number of Chironomidae) were not used to evaluate sites for two reasons. One, to accomplish the RBA within a reasonable amount of time, delegation of the subsampling (three people) and identifying (two people) was divided among five personnel. Though the subsampling was standardized, some people were better at spotting chironomids than others. Values for %Chironomidae and percent similarities between the reference site (Table 1) indicated that %Chironomidae results were highly variable, including a reference site (ELDRl) that showed impairment. Secondly, due to the sensitivity of ratios to small changes, the metrics EPT/Chironomidae abundance ratio and EPT/ (Chironomidae + EPT) were not evaluated. However, information gained from %Chironomidae can be inferred from data for %EPT. By calculating a linear correlation between values for %Chironomidae and %EPT, a negative correlation was found (r = -.45). Therefore, sites with low %EPT can be associated with sites high in %Chironomidae.

The metrics; % Contribution of Dominant Taxa, Community Similarity Index, Diversity Index and Functional Feeding Groups were also not used in the data analysis. Rae (1995) found the % Contribution of Dominant Taxa had the highest variability of all metrics used to assess water quality within logged watersheds. Diversity indices may be helpful to analyze RBA's; however, they seem more appropriate for analysis down to the genus or species level. Lenat and Barbour (1994) caution when using metrics for Community Similarity Indices and Functional Feeding Groups in basin-wide studies.

Conclusion

Preliminary results of 1995 RBA indicate a healthy composition of macroinvertebrates within the TMRW. However, caution must be exercised in interpreting these results for only one year of data. The Georgia-Pacific 1995 RBA will be most useful as baseline data for long-term monitoring within the TMRW. Using information from stream sediment samples and continuous temperature stations in the TMRW, it may be possible to develop a metric to address possible effects of timber harvest activities on macroinvertebrates in the redwood bioregion.

Research Needed

Assuring a sample of 300 macroinvertebrates/transect (900/site) is an issue that needs to be clarified in the current protocol. A subsample of 300 macroinvertebrates can not be achieved at each transect if the collector maintains equal effort between sites. If equal effort is sacrificed, then any metrics involving biomass or relative abundance become invalid. Metrics involving relative abundance, biomass, and total number of individuals have been suggested in the literature by Plafkin et al. (1989), Rosenberg and Resh (1993), Harrington (1995). Sampling more reference sites and identifying macroinvertebrates to the generic level may provide a finer resolution for classifying impaired sites.

An established time period for sampling should also be addressed in the protocol to eliminate a possible source of variation. Potential database reference sites and monitoring sites need to be collected within this established time period for results to be both valid and comparable.

JD&DL

IMPROVEMENTS, RESTORATION AND ENHANCEMENT

Introduction

Throughout the Pacific Northwest historic harvest activities resulted in streams being utilized as the transportation zone for sluice dams, bull teams, tractors and other heavy equipment. Eventually these methods and practices came to an end with the development of new technologies, increased awareness of the impacts of such activities and legislation. The impacts of these anthropogenic influences resulted in the degradation of aquatic habitat in watersheds throughout the western United States. Aggradation, sedimentation, increased temperatures, loss of LWD (and so on), cumulatively impacted stream conditions. As time passed, improved land management practices significantly reduced additional inputs to the aquatic system (Appendix 1). Resultingly, most streams are undergoing a period of recovery and vast efforts are currently being directed to enhance and restore these streams back to a more natural condition.

The monitoring information, contained within this report, will ultimately drive restoration, enhancement and management practices. Thus, increasing our effectiveness in the areas of greatest need while increasing our efficiency for cost and effort. Although the ultimate purpose of this plan is to evaluate trends over-time, baseline data must be established in order to evaluate instream conditions of the TMRW. Most of the information contained herein, and from previous monitoring efforts, can only be considered baseline data; nonetheless, some general inferences can be made regarding restoration. Information collected from previous monitoring years has already facilitated direct corrective measures in the TMRW. For example, sediment sampling has provided the impetus for corrective work directed at reducing potential sediment inputs (i.e. upgrading roads and culverts).

Results

Results from the 1994 TMRW particle-size distribution study indicated percent finer in the NFT exceeded 20%. Georgia-Pacific's percent fine threshold of concern is 20% (<0.85 mm), a well established criterion above which significant mortality of embryos could be expected (Waters, 1995). Subsequently, corrective measures were implemented in 1995 to ultimately reduce percent finer material the North Fork (See 27 January 1995 Memorandum, Appendix 2). In addition, several stream enhancement and mitigation proposals (Appendix 2) were also implemented.

Several types of enhancement efforts have been accomplished to date, in NFT, which focused on reducing sediment input and increasing fish habitat. Efforts to reduce sediment input into the stream system has included the upgrading of roads and culverts, proposed closing of failing roads over the next ten years, and bridge installations (Appendix 3). In addition, waterbars have been placed at a frequency exceeding those required by the Standard California Forest Practice Rules. Whole mulching and silt barriers are also being used for sediment reduction. Efforts to enhance fish habitat and extend anadromy has included bridge installation (Figure **1** and Appendix 4) and proposed jump pool construction (Appendix 2).

Georgia-Pacific remains very active in maintaining and upgrading roads and culverts within the entire TMRW (Appendix 5). Road maintenance is crucial because poorly constructed or maintained roads can increase erosion and consequently sedimentation (Meghan 1987). Waters (1995) stated excess sediment generation is greatest by far from logging roads, particularly if built near streams. Thus, road maintenance will be considered under stream restoration since it is crucial to the preservation of a healthy instream ecosystem.

Rocking is one of the most effective sediment controls for logging roads. Borroughs et al. (1989) stated rocking reduced erosion between 70% with a 15 cm lift to 97 % with a 20 cm lift on forested roads. Many km of roads were rocked in the North Fork in 1995 as a method of sediment control. A total of 9.3 km of roads were newly rocked at a cost of $174,500.00 and 5.63 km of road were re-rocked at a cost of 20,300.OO. In Clark Fork and South Fork, 13.63 km of roads were rocked at a cost of $306,000.00. Over the past three years 105.36 km of road has been rocked within the TMRW.

Improvements and enhancements were not just concentrated in the NFT. For example, in the Clark Fork three dirt stringer bridges were replaced with railcar bridges for a total cost of $108,000.00. In the South Fork, Georgia-Pacific solicited California Educational Manpower Resources (CEMR), a non-profit restoration organization, to modify blockages to anadromous fish migration and areas of stream bank erosion in the mainstem and North Fork Redwood Creek (Figure 2) By November of 1995, CEMR crews, utilizing on site materials modified, stabilized, and replanted these areas of concern (Appendix 6). Due to the efforts of CEMR, upstream access for anadromous salmonids was increased by approximately 6.83 km in the Redwood Creek watershed.

Conclusions

Many problem areas within the North Fork have been identified and corrected. For 1996, restoration will target Patsy Creek due to the high percentage of fines (28 %) estimated from the 1995 sampling effort. Georgia-Pacific logging engineer, Alan Hess, evaluated this watershed in January 1996 and proposed approximately 19 mitigations within Patsy Creek to ameliorate the high percentage of fines (See Patsy Creek field review, (Appendix 7).

Data gathered from stream typing will be used to evaluate and prioritize future instream enhancement projects for the TMRW. The initial phases of evaluation and prioritization have already begun using data from 1994 and 1995. Instream efforts will focus on providing large woody debris structure to create refugia habitat for salmonids throughout the watershed.

APPENDIX 1

STATE OF CALIFORNIA-THE RESOURCES AGENCY PETE WILSON, Governor

DEPARTMENT OF FORESTRY AND FIRE PROTECTION
COAST/CASCADE REGION
P. O. BOX 670
~~135 RIDGWAY AVENUE~~
SANTA ROSA, CA 95402-0670
(707) 576-2275

Date: December 1, 1995
Ref.: Ten Mile River

Mr. Ross Liscum, Chairman
California Regional Water Quality Control Board
North Coast Region
5550 Skylane Blvd., Suite A
Santa Rosa,, CA. 95403

Dear Mr. Liscum:

It has come to the department's attention, that the Regional Board will soon consider the addition of the Ten Mile River to a list of impaired waterbodies. I was asked to correspond to the board regarding this issue, since I have extensive experience with this particular watershed. In addition, I am the department's field audit inspector, having evaluated local timber harvest operations within the drainage along with the local forest practice inspectors. I have also coauthored local fishery study within the county, and have periodically monitored fish habitat parameters in the past.

Without exact knowledge of the criteria utilized in the consideration of water bodies for the purposes of your potential designation, my comments will be limited to the general condition and trends within the Ten Mile Rive watershed.

In general, we have found that the condition of the Ten Mile River watershed is greatly improved from its condition just 20 or 30 years ago. Tributary channels which were very open, very warm, and void of fish habitat in the early 1960s are now fully shaded and providing cool waters to the main river system. There are still some portions of the main channels with slightly elevated temperatures, but these are expected to drop as the shade canopy continues to develop along the banks. The timberland owners within the watershed have done an admirable job of stream protection in recent years. Sediment samples taken within potential spawning riffles indicate that fine sediments are within the range of those found in unlogged Mendocino streams in the mid 1960's (Burns, 1972). These numbers fluctuate slightly from year to year, but remain within the statistical range of Burns's early samples.

The condition of fish habitat has improved greatly, and will continue to improve into the foreseeable future. Although salmon populations are believed to have declined significantly during the 1940s to 1970s, the drainage supports a large population of juvenile salmonids. The presence of these juvenile fishes suggests that conditions are favorable for salmon rearing and survival. Unfortunately, the number of returning adult spawners is low. The causes of widespread coho salmon decline from central California to northern Washington have perplexed us all, but we do not believe that recent land management activities within the Ten Mile River watershed has contributed to any decline. We believe that stream habitat improvement is occurring and relatively rapid within the watershed. Jennifer Neilsen (1991), under contract to the Department of Fish and Game, said this regarding Mendocino County streams which she evaluated; "Surveyors were surprised by the extent and quality of habitat available on Mendocino streams. They expected to find streams in much poorer condition. They were struck by the obvious lack of fish using the existing habitat."

Most of the timbered acreage within the drainage is subject to existing and proposed long-term management plans. These plans include provisions for watershed protection and long-term monitoring of watershed conditions. Your staff participates in the review of these plans, and contributes to viable monitoring plans and protection efforts. These long-term plans will enable us to evaluate and protect the resources within the drainage.

The current condition of the Ten Mile River represents a success story, recovering from the poor logging and agricultural practices of the 1910 to 1970 period. With the advent of long-term sustained yield management plans and continued monitoring of habitat conditions, we can all rest assured that wise land use will continue. I urge the Board to visit the drainage and view its condition first hand.

Sincerely,

LLOYD I. KEEFER
Region Chief

By: Marc J. Jameson
Division Chief,
Forest Practice

cc Ted Wooster DFG
CDF, Sacramento
Tom Osipowich
Dean Lucko

APPENDIX 2

GeorgiaPacificCorporation

90 *West Redwood Avenue*
Fort Bragg, California 95437-3471
Telephone (707) 964-5651

To: All Potential Readers Date: 27 January, 1995

From: Jonathan Ambrose, Wildlife Biologist

Subject: Preliminary Enhancement and Corrective Measures to be Implemented in North Fork Ten Mile

Results from Georgia-Pacific Corporations 1994 Ten Mile River Monitoring plan indicated fine (< 0.85 mm) sediments exceed the 20% threshold in the North Fork of Ten Mile. Georgia-Pacific and others consider 20% to be the point of concern for successful salmonid egg survival. When a threshold of 20% is reached the literature shows a marked decline in overall egg survival. In response to these findings Georgia-Pacific is focusing instream and upslope to identify, address, and alleviate areas of potential sediment production in an effort to reduce fines that could potentially reduce salmonid survival to emergence ratios. One of the principle purposes of the Ten Mile River Monitoring plan was to detect areas where enhancement and restoration was needed. The purpose of monitoring is to guide management to minimize impacts and in this respect the monitoring plan was very successful.

The main stem of the North Fork Ten Mile was primarily tractor logged and has not undergone harvest for approximately ten years. The area above Cavanaugh Gulch has been essentially inaccessible for a number of years and was reopened in late 1994. By reopening this area we will be able to conduct a number of enhancement projects as well as correct problems from past management activities. This is intended to be a three step process throughout the North Fork to be conducted over time.

The first step in this process will be to identify and assess areas to be enhanced or corrected We plan on utilizing our road engineer, biologists, and foresters to identify and prioritize these areas throughout the North Fork.

The second step is the most involved and it concerns corrective measures to be employed. Already a number of areas have been identified as being areas suitable for enhancement or corrective actions. Some of the proposed measures include but are not limited to;

1. Rock fill up slope of all culverts > 36” beyond F&G recommendations. Additionally we propose to rock fill up-slope of many culverts <36" by hand.
2. In areas of streamside erosion we intend to aggressively rip-rap and/or plant with conifers and/or hardwoods.
3. Continue to replace dirt stringer bridges and Humboldt crossing throughout the North Fork
4. Search drainage for problem areas (a great many which occurred before passage of the forest practice act) that can be eliminated by waterbars, in or out-sloping and mulching.
5. Evaluate which roads can be abandoned and remove potential problems in these areas such as poor stream crossings, slides, failed culverts, etc. before “buttoning” these road closed.
6. Place downspouts and/or rock on all functional culverts.
7. Three streams were determined to be fish impassable in a cursory survey conducted during the week of January 15-2 1. We intended to replace the obstructions, upon consultation with F&G for the most feasible methodology, at all three locations with upgraded culverts, bridges, or fish ladders. This will open up almost 2 l/2 miles of Class 1 streams that are currently closed to anadromous fishes. If other streams with similar fish migration constraints are identified they will be addressed in a similar fashion.
8. Increase erosion control measures (waterbarring, mulching, silt barriers, downspouting) on roads and skidtrails beyond forest practice rules requirements.

The third step will be the evaluation of the effectiveness of the latter applications through routine maintenance and increased instream monitoring. Georgia-Pacific's biologists intended to increase their instream substrate composition monitoring throughout the North Fork to better identify reaches that may be potential problems. By narrowing the sampling universe we will be able to concentrate enhancement and corrective processes in areas of the most need. Furthermore, as the whole North Fork is evaluated we intended on conducting a culvert inventory and map it out on the GIS system with distinctive labels being given to each culvert size class.

As other situations and problems are evaluated other corrective and enhancement measures will also be proposed. Within the last year Georgia-Pacific has already made strides towards improving the road system in the North Fork by replacing old and installing new culverts, removing stringer bridges and Humboldt crossings and rocking over five miles of road. Unfortunately, activities within the headwaters of the North Fork are outside of Georgia-Pacific's control and we will be unable to take action to reduce suspected sediment sources in this area. Georgia-Pa&c is committed to improving the overall health of the North Fork and intends on taking a wide variety of corrective actions to reduce the amount of fines ($<$ 0.85mm) within this fork of the Ten Mile.

APPENDIX 3

North Fork Ten Mile Enhancements in 1995

Road Upgrades

As part of Georgia-Pacific's 1995 Sustained Yield Plan a number of roads have been identified and proposed for closure over the next ten years. In the North Fork drainage a total of 9.75 km of roads have been identified. While there are many more km of proposed road building within this drainage, impacts are greatly reduced and effects minor compared to those from improperly used, or failing, roads The roads proposed for closure may significantly reduce fine sediment input into the watershed.

Culvert Upgrades

1. One culvert > 36" was installed above Patsy Creek. Rock fill was placed upslope of this culvert. Rock fill up-slope of culverts > 36" has become company policy.

2. A number of new and upgraded culverts were established into the existing road system throughout the North Fork. As an example Table 1 summarizes road improvements through a series of culvert installations on the North Fork Ten Mile Main haul road (between 9.1 mile and 18.4 mile) in 1995. A total of 62 culvert upgrades (at a cost of $39,000.00, outside of harvested areas, occurred in the NFT watershed in an effort to reduce road impacts to the watershed (Table 1).

3. Rock fill upslope of culverts < 36" and down spouts (when applicable) has become company policy.

4. During the initial evaluation of potential fish bearing streams blocked to anadromous fish, three were identified for North Fork Ten Mile: O'Conner Gulch, Gulch 2, and Gulch 19. After further evaluation during low summer flows Gulch 2 was determined to offer only very marginal habitat for spawning salmonids and none for juveniles. Gulch 2 is currently downcutting large amounts of soil that have entered the stream due to past land management activities and inadequate culvert placement. This downcutting is the result of a newly installed upgraded culvert that is allowing the creek to degrade to its natural equilibrium. We anticipate this stream will ultimately provide beneficial habitat to the TMRW fishery.

Bridge Installations

Two dirt stringer bridges were replaced in 1995; one at LNF Ten Mile Creek and one on the North Fork Ten Mile main haul road. Total cost was $125,500.00.
At O'Conner Gulch a culvert with a 2.4 m drop served as a barrier to anadromous fish migration. California Department of Fish & Game concurred that the bridge would

provide access for fish migration. A bridge was installed by Georgia-Pacific in November of 1995. Total cost was $45000.00.

Jump pool Construction

A jump pool was recommended by the CDF&G as the most viable solution to a fish barrier at Gulch 19. Funding for this project was approved by the Redwood Conservation District and was expected to be initiated in 1995 and constructed by California Education Manpower Resources (CEMR), a non-profit restoration organization. Unfortunately, funding fell short last year but is expected to be approved for 1996. To help expedite this project and defer costs, Georgia-Pacific will provide materials and equipment to aid CEMR during the construction of this pool.

Other Mitigations

1. Rip-rap was placed at the toes of three areas with stream bank erosion (near the 10.5 mile marker, 14.5 mile marker, and the 17.5 mile marker on the main North Fork Haul Road). Total cost was $21,500.00.

2. Stream-side planting, to reduce erosion, occurred along the banks of newly constructed bridges and crossings throughout NFT.

3. Waterbeds were placed at a frequency that exceeded California Forest Practice rules by almost twice the requirements, by the beginning of the winter period. Throughout the TMRW, whole mulching and silt barriers have been placed in an effort to reduce sediment input whenever feasible.

These enhancements were not affiliated with timber harvest planning.

APPENDIX 4

STATE OF CALIFORNIA - THE RESOURCES AGENCY

PETE WILSON, Governor

DEPARTMENT OF FISH AND GAME
POST OFFICE BOX 47
YOUNTVILLE, CALIFORNIA 94599
(707) 944-5500

July 28, 1995

Mr. Tom Ray, Resource Manager
Georgia-Pacific Corporation
90 West Redwood Avenue
Fort Bragg, California 95437

Dear Mr. Ray:

The purpose of this letter is to commend you and your staff on recent activities involving the North Fork Ten Mile River watershed. Georgia-Pacific Corporation's watershed monitoring plan identified the North Fork Ten Mile as a prime candidate for specific restoration projects. Georgia-Pacific Corporation is now in the process of implementing some of the restoration projects that were noted in the watershed plan.

My staff has informed me that you will be replacing the culvert crossing at O'Conner Gulch with a flatcar bridge. Completion of this project will open up sites in O'Conner Gulch that have not been available to spawning salmon and steelhead for approximately 20 years. In our opinion, projects like these are the most prudent measures landowners can take for improving salmon and steelhead populations along the northcoast.

Thank you for your efforts at improving habitat for salmon and steelhead in the North Fork Ten Mile watershed. The initiative that Georgia-Pacific Corporation has taken could be used as a model for other landowners who wish to maintain and improve habitat for salmon and steelhead in California.

If you have any questions regarding our comments, contact Rick Macedo, Associate Biologist, at (707) 928-4369; or Larry Week, Environmental Specialist, at (707) 944-5526.

Sincerely,

Ken Aasen

Ken Aasen
Acting Regional Manager
Region 3

APPENDIX 5

STATE OF CALIFORNIA - THE RESOURCES AGENCY

PETE WILSON. Go-r

DEPARTMENT OF FISH AND GAME
OST OFFICE BOX 47
YOUNTVILLE, CALIFORNIA 94599
(707) 944-5500

December 27, 1995

Mr. Tom Ray, Resource Manager
Georgia-Pacific Corporation
90 West Redwood Avenue
Fort Bragg, California 95437

Dear Mr. Ray:

The purpose of this letter is to commend you and your staff on recent improvement activities in the Ten Mile River watershed.

During a January 15, 1994 Department survey of the lower part of the Ten Mile River, numerous upgradings of drainage structures were noted (Appendix 1). Included in this list was an old Humboldt Crossing of Mill Creek which needed debris cleaned from below it before it failed. This site was identified by Mr. Pete Ribar of your staff to be replaced with a bridge under THP l-94-346 MEN. The crossing was replaced with a bridge in the fall of 1994. Examination of the site on December 14, 1995 indicates the stream now has full clearance through the area. In addition, the boulder rip rap used to protect the bridge has caused the stream to dig out a pool area above the bridge resulting in improved stream habitat for salmonids. Gravels under the bridge were found to be clean and loose.

Thank you again for your efforts at improving habitat for salmon and steelhead in the Ten Mile watershed.

Sincerely,

Ken Aasen

Ken Aasen
Acting Regional Manager
Region 3

Enclosure

State of California

The Resources Agency

Memorandum

To :Ten Mile River System Files

Date: December 19, 1995

From : Department of Fish and Game

Subject: Field Surveys, January 15, 1994

Mileage From Highway 1	Time	Location	Observation
0.0	0922		
0.5	0924	side of stream	2 geese
0.7	0926	bridge over So. Fork	3 male & 3 female common mergansers
0.8	0928	side overflow area with standing water	3 male mallards 3 female mallards 1 great egret 1 snowy egret
1.4	0935		New 18-inch culvert to drain inside ditch
1.5			New 18-inch culvert to replace old 12-inch clogged one; 3 woodrat houses; 40 ft. apart on north side of road.
1.7			New 18-inch culvert to drain inside ditch.
1.75			New l8-inch culvert to replace old failed 12-inch culvert.
1.9			New 18-inch culvert to drain inside ditch (8 feet of vegetated filter).
2.0			New 18-inch culvert to drain inside ditch (10 feet of vegetated filter).

2.02		New 18-inch culvert to drain inside ditch (80 feet of vegetated filter).
2.1		New 18-inch culvert to replace faled 12-inch culvert (100 feet of vegetated filter to river).
2.2	0947	one raven, **one** stellar jay at ravine with MD137. New 18-inch culvert to drain side ravine.
2.3	0949	**one** winter wren; existing functioning culvert has ± 100 ft filter strip to river.
2.5		Functioning existing 16-inch culvert.
2.53		GP gate to Mill Creek.
2.54	0958	Mill Creek. Has old Humboldt crossing. (Needs woody debris cleared out from below or will **fail** in **high water.)**

Theodore W Wooster

Theodore Wooster
Environmental Specialist
Region 3

TW/jp

APPENDIX 6

The Center for Education and Manpower Resources
Post Office Drawer F • Ukiah, California 95482
(707) 468 - 0194 . FAX (707) 468- 0407

MENDOCINO FISHERIES PROGRAM
FINAL REPORT FOR CONTRACT # WC4021

September 1995

The Center for Education and Manpower Resources, Inc. is pleased to **announce the** completion of stream enhancement activities on Redwood Creek, a tributary to the South Fork of Ten Mile River, which flows into the Pacific Ocean. It is known to have historical runs of Coho and Chinook salmon as well as Steelhead Trout.

Location:
USGS Quad. Sherwood Peak T 19N, R 16W, section 14
$27,000.00

Contract # WC 4021 was received by CEMR on Nov. 28, 1994. The objective of the project was to modify a large barrier to encourage the return of a healthy coho salmon population to Redwood Creek and its tributaries, The barrier was in place just below the confluence with the North Fork of Redwood Creek. At the site, flows diverted into the south bank causing erosion and contributing significant sediment into the stream. Scarps appeared below a former skid road and large trees, including a towering fir, had already fallen across the channel. The wet winter of 1995 changed the profile of the site. The former complete barrier had shifted as **a** result of extremely high flows. Now, fish could pass upstream during high water. Howcvcr, enough instream material still existed to continue the erosion problem. The probability of another complete barrier reforming at the site was still of great concern,

The **Mendocino** Fishery crew began work on the logjam at the end of May. Using chainsaws, griphoists and other hand tools, the original logjam was modified. The channel was opened to allow clear passage of the stream's flows in its center. Using a system of high lines and intricate multiple blocking, the crew repositioned very large material from the barrier and constructed a log crib at the toe of the unstable bank to armor it from further eroding into the creek. After hand excavating a bench, a 40" log, 28 ft. long was placed as the base for the structure. 1 1/2" and larger willows were planted in a trench behind the base log and directed over it, into the channel. **24"** logs were then split and rebarred into notches in the base log and to the bank, Two more logs were then similarly placed and anchored to create a crib 33 ft. long and approximately 7 ft. high. The large woody material that had accumulated as part of the original barrier was placed behind the crib to fill the hole and further stabilize the bank.

A large pool area now existed in the center of the channel. To further enhance the area, two large rootwads were placed in front of the crib. **A "digger** log" was cabled between the two and left extended into to center of the pool, All of these were fastened to each other and the crib using 5/8" rebar and cable.

As a final complement, the crew thinned a very densely populated grove of l-3 year old alders that had sprouted above the eroding bank in the former skid road, These were transplanted with 2-3 ft. spacing to cover the unstable bank. The *entire* area was **then** mulched with four bales of straw.

3/8ths. of a mile upstream, another large, complete 8' high X 25' wide barrier was identified. Again using chainsaws, suspended cables, blocks and griphoists, the crew **modified** the barrier to allow up and downstream passage. Since a redwood rootwad approximately 16 ft. in diameter, blocked the **greater** part of the channel, bank erosion was severe at the site. Passage was cleared on both sides of the rootwad, which could not be moved. The south bank was armored by the placement of a 36" log at its base. This was anchored into exposed rock using 5/8" rebar, cable and epoxy, Straw was spread at the work site to protect the bank where entrance to the site and log extraction had created a trail.

The MFP crew is very proud of this project Through extensive use of high lines and innovative placement of blocks, extremely large material was salvaged intact and later used in the construction of protective and enhancement structures. Ordinarily, heavy equipment is utilized to accomplish such a task **Since the** project design was predicated on the inclusion of such large material, but the presence of heavy equipment would have been detrimental to the habitat, this technique proved to be the appropriate solution. We look forward to taking advantage of similar methods in the future.

Three and one half (3 l/2) miles of Redwood Creek were made available to migrating Coho Salmon by the completion of this project Nine hundred and fifty four (954) hours were expended,

The Center for Education and Manpower Resources

Post Office Drawer F • Ukiah, California 95482
(707) 468.0194 • FAX (707) 468-0407

MENDOCINO FISHERIES PROGRAM
FINAL REPO[illegible] CONTRACT # WC4067

December 1995

The Center for Education and Manpower Resources, Inc. **is** pleased to announce the completion of stream enhancement activities on North Fork Redwood Creek, a tributary to Redwood Creek and the South Fork of Ten Mile River, which flows into the Pacific Ocean. It is known to have historical runs of Coho and Chinook salmon as well as Steelhead Trout.

Location:
USGS Quad. Sherwood Peak T 19N, R 16W, section 14
$39,000.00

Contract # WC 4067 was received by CEMR on May 17,1995. The objective of the project was to create passage through multiple barriers for migrating salmon and steelhead. In addition to modifying seven sites where passage was a problem, bank erosion was severe above the fourth and largest logjam. There, the unstable bank was collapsing into the stream, contributing to the excessive sediment problem found in the downstream pools.

Beginning in May, the crew began work on the North Fork. The first five site's were in the lower 1/2 mile above the confluence with Redwood Creek. All, complete barriers, needed extensive work. The largest was at the base of an active slide. Using chainsaws, griphoists and other hand tools, the barriers were modified. With the available material from barrier #4, cable and rebar, a log crib structure was constructed and anchored in place at the toe of the slide. This stabilized the bank and will provide shelter and habitat. Willows were laid in a trench behind the structure to encourage revegetation and increase durability and cover.

As much material as possible was left in the channel at all seven of the sites. Only that which posed a threat to continued fish passage or deflected stream flows into the banks, was removed. Subsequent monitoring and follow up assessment of the area is recommended. The good canopy, abundant pools and in-stream organic material define this creek as prime spawning habitat for the threatened coho salmon.

Three quarters (3/4) of a mile of prime spawning and rearing habitat were significantly improved by the completion of this project. Access to another mile of potential spawning habitat above the sites was also opened. One thousand five hundred and thirty four (1,534) hours were expended.