ELEMENTS OF RECOVERY

An Inventory of Upslope Sources of Sedimentation in the Mattole River Watershed

with

Rehabilitation Prescriptions

and

Additional Information for Erosion Control Prioritization

Prepared for the California Department of Fish and Game

by

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ELEMENTS OF RECOVERY

Erosion is as common an aspect of life in the Coast Range as Pacific sunsets. As the mountains rise up out of the soft ocean bottom, a tenuous and fluid equilibrium is established -- most of each year's uplift is washed or shaken back into the sea. An inch of soil which took a hundred years to build can wash away in a single storm unless held in place by grasses, shrubs, and trees. The streams and rivers are conduits for all this material on its way downhill. Yet under conditions of equilibrium, no more sediment enters the stream than can be easily stored or quickly transported through the system. The Mattole in prehistoric times was able to move thousands of yards of sediment each year and still be called "clear water," the meaning of the word Mattole in the native tongue. To give an idea of how much material is moving through the fluvial system, one geologist has estimated that Kings Peak would be 40,000 feet high were it not for this "background" erosion.

It doesn't take much to create a disturbance in such a delicately balanced system. The erosive power of water increases in proportion to the square of its volume. A midslope road poorly placed, or built on the cheap, or lazily maintained, or abandoned, can divert large volumes of water from one drainage to another, or onto a slope unarmored by large rock or tree roots. Some of the catastrophic events mapped here, the large landslides and gullies, appeared after a single storm, were the result of a single failed road. The growth of others can be traced back over many years of hard land use. Others would have appeared had humans never come this way.

So far, the land is resilient and the processes of recovery are marvelous to watch. Coyote brush sprouts on slopes too steep to stand on and where there seems to be no soil or water. An ugly gully is halted by a rock outcropping and quits creeping up the slope; its sides calve off until it has reached an angle of repose gentle enough to catch seed and sprout vegetation. Fifty years later, the raw gully has become a shaded draw. Creeks which have been buried in twenty feet of rubble cut their way down to bedrock again -- a geological age imitated in forty years. Really, we could all just leave for two hundred years and it would be hard to tell we had been here.

But we don't want to leave, and neither do we want to think of ourselves as despoilers of the land. We need to be able to learn from what has gone before—if we have made mistakes, admit them and move on. As inhabitants working to restore natural systems, we will learn to see the healing processes and to align ourselves with them. It's time now for human populations to become one of the elements of recovery.

Freeman House, Project Coordinator

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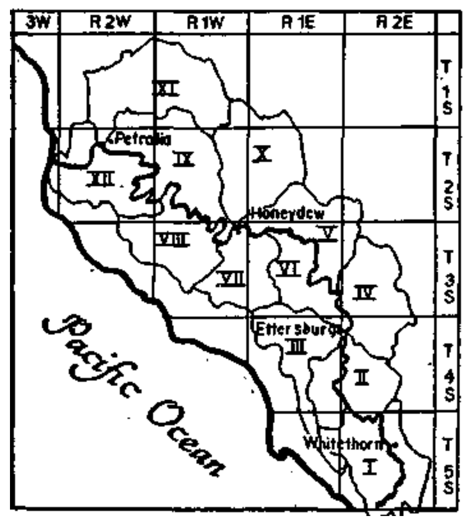

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INTRODUCTION

In 1987, under contract to the California Department of Fish and Game (DFG), the Mattole Restoration Council (MRC) began to inventory upslope sources of sedimentation in the Mattole watershed. The goal of the contract was to develop erosion control and salmonid habitat enhancement projects wherever appropriate, and to gain a better understanding of how to prioritize the work.

The contract was undertaken with the full knowledge that the problems of erosion and erosion control in the Mattole can only be partially addressed by large scale, after-the-fact rehabilitation projects. The most effective means of erosion control will always be prophylactic (avoiding land use techniques which create erosion), and small-scale (treating the gully, sheet wash, or slump before it contributes to massive amounts of soil loss and sedimentation); in other words, activities undertaken as elements of day-to-day management by the responsible landowner.

This report is a summary and index of that inventory, organized to make the voluminous materials generated in the course of its development accessible to landowners and residents interested in erosion control and land use practices which minimize erosion. The smallest job in gully repair, slope stabilization, or road maintenance can be made more effective by more information about what's happening upstream or upslope. This report is also presented as a set of recommendations toward a comprehensive watershed restoration plan.

Gaining a better understanding of the larger processes at work on the hillsides and in the watershed should help us to understand where best to put our energies as participants in natural recovery. Coming to understand which of our human activities contributed to and aggravated erosional processes should help us avoid making the same mistakes in the future.

An incidental benefit of this survey for workers and participatory landowners has been the direct experience of the natural processes of recovery. Using 1984 photos to direct us to trouble spots three and four dry years later has made us aware of short term healing processes like the rapid growth of riparian vegetation during years when low-flow winters allow the young plants to survive. On tributaries up and down the drainage, we found dramatic advances in the growth of willow and red alder which had been absent altogether in the '84 photos. Comparing the '84 photos with aerial photos from 1942 and other historical photos allowed us to date some of the larger landslides and gullies. Once on site, we were able to determine which of these events was still active and contributing sediment to the system, and which of them was beginning to stabilize through natural revegetation, or reconfiguration of the slope to an angle of repose. A random sampling of the forms filled out for field investigation will reveal that more than half of the disturbances investigated were judged to be past the time of their major contribution of sediment and well advanced in the process of recovery. Of the 956 disturbances mapped, 165 or 17% were inspected in the field. Prescriptions were developed for 76 of these disturbed areas; 46% of the sites visited or 7.6% of sites mapped.

Of the several human activities which cause or contribute to erosion problems, roads are the most critical. Ranch roads, homestead access roads, and timber hauling roads are all likely to cause problems if maintenance is ignored. Any one of these roads may cause problems, too, if constructed on a slope too steep or across a perennially wet surface. This type of problem occurs often enough in the Mattole to merit concern, but the most problems, by an overwhelming number, are caused by skid and haul roads abandoned after timber harvest. Literally hundreds of miles of these roads criss-cross Mattole slopes, diverting water from drainage to drainage and developing tremendous erosive power through the concentration of flows. Stream crossings, whether built on logs (the infamous "Humboldt crossing") or across culverts, inevitably fail if not maintained, releasing yards of sediment beyond calculation into the fluvial systems. Failures in both cut and fill are commonplace, and often mark the beginning of a debris torrent the effects of which will be felt far downstream. The tendency of deserted roads to capture and channelize water flows often keeps them active as contributors to erosion many years after their intended use is over. In the disturbance maps displayed here, the symbol R is used to indicate a road which is currently in use. The symbol r indicates roads which have been abandoned.

Before the Z'Berg-Nejedly Forest Practice Act of 1973, these roads were built without regulation and the creek channels themselves were sometimes used as skid trails. The new regulations govern the placement of roads and provide for erosion control measures to be taken at the termination of a timber harvest, which has improved logging practices considerably. Our limited observations indicate that increased enforcement or (preferably) supervision is needed to make these practices as effective as they need to be. (See discussion, Drainage Area IX.)

In the Mattole, 76% of the disturbances mapped were related to roads. Nearly all rehabilitation prescriptions generated by this survey mitigate, to one degree or another, for road related contribution of sediment, either nearby or upstream.

No methodology was developed to measure the contribution of other human activities to erosion problems. A list of these activities would include logging itself (that is, the removal of vegetation, especially by clearcutting); conversion of forest land to pasture, and occasional overgrazing.

The relationship of fire to erosion is an important one, especially in chaparral, where a hot fire will result in the soil being impregnated with a wax that impedes absorption of rainwater and increases runoff. The chronological relationship of wildfire to flood and removal of vegetation can also provide insight into the historical causes of a particular erosion problem. An attempt to develop a fire history for the Mattole as part of this inventory was abandoned when we discovered that the California Department of Forestry and Fire Protection does not maintain historical fire maps or fire records.

The comprehensiveness of the survey was severely limited by two elements, budget and access. Once materials such as aerial photographs and maps had been purchased and time scheduled for coordination, compilation, writeup and publication, less than eighty dollars per square mile remained for mapping and field work. Systematic survey was sometimes made impossible by the refusal of access permission, but this happened rarely. All landowners in the watershed were originally contacted via the Mattole Restoration Newsletter which described the survey and invited them to return an enclosed access permission form. Seven percent of absentee landowners contacted responded at this time, as did four percent of resident landowners.As access needs became clearer, some landowners were contacted a second or third time.Over all, the access needs of the survey were served by the cooperation of something more than ten percent of the Mattole landowners. No field inspections were performed without landowner permission.

Constraints on time in the field led to the decision not to attempt to quantify potential volumes of sediment contributions from the disturbances examined. Neither were we able to develop costs for the rough prescriptions we were able to develop. Given the absence of these two essential sets of data -- comparative volumes of sediment and project costs -- we were not able to prioritize the rehabilitation prescriptions in any absolute way. The materials developed here are meant to serve as aids to prioritization of jobs on a comparative basis and to guide the potential erosion controller to the original sources, to the more than twelve hundred informational forms completed, and to surveyors' field notes kept on file in the office of the MRC.

As field trips were planned in each drainage area, it became apparent that disturbances which should be inspected were going to be omitted because of time or access constraints. These omissions are noted in the summary text for each area and on the disturbance maps. The bulk of investigation was consciously weighted in the direction of upslope sediment contributions, and secondarily to the cumulative effects due to aggradation in the channels themselves.

No systematic survey for riverbank erosion was undertaken on the mainstem of the Mattole, which was considered outside the scope of this contract. With the completion of the survey in hand, and the anticipated completion of the hydrological survey of the Mattole estuary/lagoon, this absence of information about the mainstem will become the single missing element in a comprehensive understanding of the hydrological and sediment transport processes in the Mattole River watershed.

How To Use the Inventory

This report is designed as an index to a series of forms (samples attached) which were used to catalog base data for the survey, and also as a summary of surveyors' field notes, and as a referral to original sources used for mapping. Additional general information concerning erosion control in the Mattole is provided in the form of a summary of fisheries information, a brief cultural history, a primer of rehabilitation techniques, and a selected bibliography for the reader who wishes to delve more deeply into the subject.

Inventory procedures were determined by the requirements of a contract with the Department of Fish and Game, and by a technical team chosen by the Mattole Restoration Council (MRC). The technical team often called on the services of geologists Terry Spreiter, David Burnson, and David Steensen, and of fisheries biologist Gary Peterson. Two other projects with their own sources of funding were coordinated with this one -- a map of Distribution of Old-Growth Coniferous Forests in the Mattole River Watershed, 1947 and 1988 (May, 1988), and the reorganization of landowner addresses by tributary watershed. These projects were made possible by a grant from the L.J. Skaggs and Mary C. Skaggs Foundation.

Whenever possible, surveyors were selected and trained for work in the tributary in which the surveyor resided. When this choice was not available, mapping and additional surveying was done by other MRC technicians. Surveyors were trained in the field and in a classroom situation by the coordinators and by the consulting geologists.

Six survey forms were developed for use with mapping and in the field. Several of them are reproduced here to give the reader a sense of the range of information on file in the MRC office. Each notation on the disturbance maps (i.e. Cr2, MR1, G2, etc.) is described in more detail on a form entitled Inventory from Air Photos. This form contains a general description of the disturbances, which have been categorized as mass movement, gully, channel disturbance, surface erosion, and road related. (See A Primer *of Erosion Control Techniques,* or the Glossary, for definitions of terms.) Information is also gathered on this form concerning the identity of the landowner, current and historical land use, access, and proximity to salmonid habitat. Surveyors used these completed forms to select priority sites for field inspection. Of disturbances inspected in the field, more than half revealed themselves as unsuitable for treatment. The reasons for unsuitability were noted on the original survey form, or on field notes keyed to aerial photos at the scale of 1 inch = 400 feet. When rehabilitation treatment was deemed appropriate, one of five additional forms was used, each keyed to a category of disturbance. These prescriptions are summarized in the text of the discussion of individual drainage areas. Prescriptions are necessarily sketchy and non-conclusive. Residents or watershed groups wishing to develop project proposals from these prescriptions should refer themselves to the original materials and notes, and return to the field prepared to make more detailed measurements of the size of the disturbance and potential volumes of sediment. Only at this point will projects become specific enough for costs to be estimated and effectiveness to be evaluated.

The Drainage Area

Watersheds are an expression in time of adjustments toward equilibrium between the forces of tectonic uplift, the movement of water, gravity, and weather. Using this definition, watersheds are the only realistic context within which to consider erosion and erosion control. All of this survey has been organized first in the context of the Mattole River watershed, and secondly, in the context of individual tributary drainages. For the purposes of publication, and to create an initial level of prioritization, it was necessary to select an intermediate level of organization, which we have done by grouping contiguous tributaries into twelve drainage areas. Five of the drainage areas are occupied for the most part by the five largest tributaries of the Mattole; the remaining seven are selected to whatever degree possible for their common geomorphology.

The Timber Harvest Maps

Historically, timber harvesting (clearcutting in particular) and road building associated with timber harvesting have caused more large-scale erosion than any other land use practice. In the Mattole River watershed, more than 91% of the original coniferous forests have been harvested at least once.

When assessing the desirability of rehabilitation projects on one site or another, it is useful to know the approximate date of harvest. The California Department of Forestry and Fire Protection uses a rule of thumb which suggests that the largest amount of slope and road failure, sedimentation, deposition, etc., occurs within the first three years after logging. While this rule almost certainly will hold true for any gross quantification of soil movement, it disregards the types of disturbances which are gradual rather than catastrophic, and ignores a very significant source of slope failure as rootwads of cut trees rot and lose their tensile strength three to twenty years after harvest. (Sidle, R.C. "Factors Influencing the Stability of Slopes," in Proceedings *of a Workshop on Slope Stability,* Pacific Northwest Range and Experiment Station, U.S. Forest Service, PNW 180, 1985). The erosion controller will also need to take note of the time of harvest because of the different regulations applied to aspects of timber harvest like road construction and restocking before and after the Z'berg-Nejedly Forest Practice Act of 1973.

Timber harvest records were kept by Humboldt County between 1962 and 1978 on maps at a scale of one inch = one thousand feet. Data on the maps was based on 1960 aerial photography. Copies of these maps were purchased from the Humboldt County Assessor's office; a copy is available in the MRC office. Mendocino County kept much sketchier records during the same time period. The parts of the Mattole watershed which overlap with Mendocino County may display a higher incidence of inaccuracy in mapping than does the larger part which lies in Humboldt. In order to extend this record to the present, we relied on 1984 aerial photographs at a scale of 1 inch = 400 hundred feet prepared by W.A.C. Corporation, 520 Conger Street, Eugene OR 97402. We also used these same photographs in stereo pairs at the scale of one inch to 2,640 feet. All photos are available in the MRC office in addition to a few aerial photos from the 1988 coverage by the same company. Data was kept current from 1984 to present by reference to a comprehensive file of Mattole Timber Harvest Plans for that period.

Data from the assessor's maps were transfered by hand to an overlay on a fifteen minute topographic map. The drawings were then digitally scanned and the legend added using MacPaint and Super MacPaint programs from Apple Computer, Inc.

In order to translate the county assessor's maps to a reproduceable scale, the copies were reduced to fifty percent of their original size xerographically. This process produced some distortion, and the maps should be used for comparative purposes only.

The legend attached to the timber harvest maps is for the most part self explanatory, but some clarification is in order.

The categories, ROADED AND CUT 1975-1983, and ROADED AND CUT 1984-1989 overlap in time with the category REENTERED SINCE 1979. The first categories have been used whenever forestland was commercially harvested for the first time during that time period. The second category is used when a harvest during that time period is demonstrably the second commercial harvest that has taken place on that property. In most cases where this grid is used, the first harvest occurred prior to 1962.

The category, OTHER, includes forestlands that are predominately hardwoods, and also brushlands and gravel bars.

The category, GRASSLANDS, describes natural prairies as of 1960, and does not describe areas which have been converted to pasture through removal of vegetation and regular burning.

The category, OLD-GROWTH, describes coniferous forests of twenty acres or more that have a continuous canopy of Douglas-fir or redwood. Most of these areas have never been commercially logged, but field inspection of a few of these parcels has revealed that some of them have been "high-graded" (the very best timber specimens removed) at some indeterminate time in the past.

The Disturbance Maps

Aerial photographs taken in 1984 by W.A.C. Corporation were used to identify erosional disturbances. (See previous section for scales.)

Again, we wish to stress the fact that even at the scale of 1 inch = 400 feet, all but the largest erosion problems are invisible. The greatest number of smaller and more treatable erosion sites are hidden today by a canopy of young tanoak, Douglas-fir, and *Ceanothus*. Mapped here are the largest disturbances, the massive landslides, and the gullies which have contributed --and will continue to contribute—millions of cubic yards of sediment to the river system. When these events can be healed or partly stabilized, we have erosion control on an heroic scale, equal to the massive and sustained mechanical assault that made these scars in the first place.

Each year, however, a larger amount of sediment is put in the waterways by innumerable disturbances too small to be seen on most aerial photographs. These new gullies and small slumps, plugged culverts, and unrocked roads are the purview of the resident, the landowner, and the road association. In the long run, the prompt treatment of these small events before they have grown into catastrophies, performed by the people who live closest to them, offers the only realistic pathway to a healthy and productive watershed.

Disturbances were mapped by individual surveyors and technicians on 7 1/2 minute USGS quadrangles, and were later transferred to 15 minute quads which had been enlarged to 115%. Again, parallax problems occurred in the enlargement process, and distortions limit the use of the maps to comparison with the timber harvest history maps.

The disturbances which have been field checked have been identified so that the reader may refer to additional field notes in the MRC office should he/she wish to do so. This legend also indicates that for one reason or another, prescription for rehabilitation was found inappropriate.

Disturbances for which prescriptions have been developed will be summarized in the accompanying text, and will have on file additional standardized forms.

Areas identified as priority sites for further field investigation were not reached in the course of the survey due either to budget constraints or limited access.

A Discussion of Priorities

The following considerations were used by surveyors to determine which disturbances to investigate in the field, and again, to determine which disturbances required a prescription for rehabilitation. As proposals for projects are fleshed out with estimated costs and potential sediment volumes, the MRC will use a similar set of criteria to prioritize its restoration work. The individual landowner, resident, or road association will find the same considerations valuable as an aid in approaching the management of any particular erosion control problem.

1) Consider the tributary drainage in terms of its overall production of sediment. To date these values have been approximated through informal observation after major storms. Tributaries which run muddier than others, other conditions remaining equal, are obviously contributing more sediment to the system. Grossly observed, drainage areas II, III, IV, V, and VIII are contributing the largest volumes of sediment in the Mattole watershed. Rehabilitation proposals in these drainages have been given slightly higher priority than those in other areas.

2) Review what is known about salmonid habitat in each drainage, and about king salmon spawning habitat in the mainstem, using 1982 habitat surveys and local knowledge. If a disturbance is introducing large amounts of sediment directly into spawning gravels or rearing pools, it will likely receive higher priority for treatment than one which is not. Keep in mind, however, that all sedimentation eventually effects salmonid habitat. Habitat information is summarized on page For more detail, Coastal Headwaters Association's 1981-82 surveys are available from MRC.

3) How long is it since the site has been disturbed? Roughly speaking, treatment that is done within the shortest time elapsed after the disturbance will be the most effective. The largest amounts of soil will be kept on the slopes through the action which is most prompt. The nature of the disturbance enters into this consideration, course. A poorly maintained road is capable of diverting water to form a gully in a new location each wet season. As a matter of general observation, logging practices in the early seventies were sometimes sloppier (and therefore productive of more sediment) than those which occurred either earlier or later. Timber harvest history maps have been provided for each drainage to give a general picture of the largest sediment producing disturbances in the last fifty years.

4) Look at the disturbance in relation to other disturbances in the drainage, especially upstream and upslope. Often one must choose between one erosion control job and another due to limited time or resources. Or, if work is being designed for a larger area, decisions must be made as to which problems to treat first. Disturbance maps for each drainage are provided here as a directory to the large erosion events visible in aerial photos. Treatment of a small gully, for instance, may become less attractive when it becomes known that a large landslide upstream is contributing a great deal more sediment to the same channel than is the gully. Streambank armoring may make no sense if the source of aggradation upstream is going to bury it in a year or two. These considerations will be balanced against the knowledge that, in the Mattole drainage, any soil kept on the slope and out of the waterway is a positive contribution to the health of the system.

5) A "Primer of Erosion Control Techniques" presented here is designed to help you judge the effectiveness of various types of treatment on any given erosion problem. Two mistakes commonly made in erosion control are to attempt to treat or control natural events, and to rehabilitate man made erosion problems too late in the process of soil loss to be effective. In the hills and valleys of the Mattole watersheds, natural earthflows and deep-seated rotational landslides are commonplace. In most cases, it will prove fruitless to attempt to stabilize these large moving blocks of earth. It takes some education to identify these natural events, but one quickly learns to see hummocky hillsides, scarps, bowed and jack-strawed trees, midslope terraces, and springs as indicators of natural movement. It is a common and worthwhile procedure to mitigate for man-made exacerbations of these events, rerouting water off a slide surface that has been diverted onto it by a misplaced road, for instance. It is foolhardy, however, to attempt to stop one of these events by, say, buttressing at the toe. (There are times when the immediate health of the system requires that the effects of natural earthflows be postponed by creating a catchment basin for sediment short of its entry into the waterway, or by diverting the waterway away from the toe of a slide.)

6) Consider physical access. The presence or absence of passable roads will often effect the type of rehabilitation work prescribed. Heavy equipment, for instance, may be dismissed from consideration if no road exists on which to bring it in. The same condition might convince the surveyor to prescribe seed rather than seedlings for a revegetation job, or use on-site logs for streambank armoring, rather than hauled rock.

For a more comprehensive discussion of prioritization, refer to a paper available from the MRC, prepared by Randall Stemler in conjunction with this survey entitled "Prioritization." The author adapts the work of T.L. Saaty on hierarchies and priorities to decision making for erosion control in the Mattole.

Landforms, Waterflow, and People of the Mattole Watershed

Location

The Mattole watershed encompasses 304 square miles of the northern California Coast Range mountains along the western edge of the North American continent. The Mattole River starts as a small stream in northern Mendocino County, flows almost due east for a few miles, then passes into Humboldt County where it turns north, then west, to complete its sixty-two mile run to the sea. The river flows into the Pacific Ocean ten miles south of Cape Mendocino, the westernmost point of land in the lower forty-eight states. This rugged and remote coastal region, known as the "Lost Coast," forced the builders of Pacific Coast Highway 1 to throw up their hands and turn the highway thirty miles inland.

The Mattole watershed is thirty-six miles long, four to twelve miles wide, and lies parallel to the coast, its western edge within four miles of the Pacific Ocean. This western flank of the Mattole basin, along the Pacific coast, is dominated by the King Range, a steep ridge rising to an altitude of 4087 feet at Kings Peak, the highest point of the watershed. While the King Range borders its western boundary, the Mattole watershed is bordered on the north by the Bear River watershed, and on the east and south by the South Fork of the Eel River watershed.

There are three "post office" towns within the Mattole watershed: Whitethorn in the headwaters region, Honeydew near the center of the watershed, and Petrolia near the mouth. The resident population of the watershed is estimated at around two-thousand people. The largest nearby city is the Humboldt County seat of Eureka, about forty miles north up the coast. San Francisco lies about three hundred miles south of the Mattole basin.

Hydrology

The watershed is mostly steep mountainous topography, with almost all land in slope. The watershed is highly dissected by the Mattole River and its tributaries. The Mattole River has moderate to high streambed gradients, beginning in the headwaters at a 1350 foot elevation at Four Corners, and dropping to 1000 feet at Thorn Junction, 700 feet at Ettersburg, 350 feet at Honeydew, 100 feet at Petrolia, and sea level at the mouth. This configuration shows that the upper half of the Mattole River is almost twice as steep as the lower half, and helps explain why the upper section displays deeply incised stream channels, while the lower section is characterized by broad flats dominated by massive gravel bars. Just before entering the ocean, the Mattole River flows into an estuary which forms a lagoon during the summer when low river flow and a sandspit close the mouth. The river runs all year, with tremendous differences of water volume between the summer and winter flows. A stream gauging station has been monitoring the river above Petrolia since 1950, catching in its measurement 240 of the watershed's 304 square miles. The average annual flow of the Mattole River is 1,340 cubic feet per second (cfs), with average monthly winter flows between 1,710 and 4,170 cfs, and the maximum flow measured 90,400 cfs. The summer and fall flows drop below 60 cfs, with the minimum measured flow of 20 cfs.

Climate

The general climate along the North Coast of California is Mediterranean; mild temperatures with wet winters and dry summers, but with fog in the summer. Such is the case with the Mattole, but there are three distinctive influences on the climate of the Mattole: its proximity to the ocean, to Cape Mendocino, and to the King Range.

Proximity to the Pacific Ocean is the major factor for the characteristically mild climate of the Mattole watershed. The entire drainage is affected by the marine influence. Throughout the year, the temperature of the ocean varies between 52 and 60 degrees F. Localized summer fog and clouds form in places along the coast due to the mixing of warm interior air with cool ocean air at the meeting of land and sea. Along the coast, average air temperatures are mild, and range from approximately 46 to 56 degrees F, with occasional exceptions in either direction. Inland from the coast, there is a greater range of average air temperatures. In the vicinity of Honeydew, twenty-seven miles upriver from the mouth, temperatures range from over 100 degrees F to below freezing. Infrequent snowfall sticks mainly on peaks and ridges.

Up the coast, ten miles north of the Mattole, the 1200-1500 foot high Cape Ridge forms Cape Mendocino, the westernmost point in the lower forty-eight states. Cape Mendocino pushes out to sea the summer fog which prevails along the coast and in the Humboldt Bay region. As a result, most of the lower Mattole Valley is relatively fog-free during the summer, with blue skies and a warmer coastal climate. But more than thirty miles south, the summer fog pattern of the North Coast is reestablished; summer fog frequently intrudes into the headwaters of the Mattole basin, coming over the ridge at Point Delgada and extending east to Thorn Junction. Because of this intrusion, the upper basin has a cooler climate with vegetation more closely resembling the moisture-loving redwood forests of the Eel River watershed.

The watershed's western boundary is formed by ridges rising sharply from sea level: Cooskie Mountain, the King Range, and Chemise Mountain. Winter storm clouds circling onshore from over the ocean must first rise abruptly over these peaks and ridges before passing into the Mattole basin. As rainclouds rise, they cool, condense, and release precipitation. Thus, the orographic uplift of storm clouds such a short distance from the ocean causes heavy rainfall in the Mattole basin, particularly areas just east of the coastal peaks. The rainy season is generally from October to April. The dominance of winter rainfall, compounded by the occurrence of large storms and the release of intense precipitation due to orographic uplift, brings flood or near-flood conditions to the Mattole relatively often.

The Mattole basin around Honeydew is surrounded by high ridges: Cooskie Mountain and the King Range to the south and west, and Rainbow Ridge, Panther Gap, and Gilham Butte to the north and east. These high ridges create a weather anomaly known as the "Honeydew Hole." The ridges shelter the Honeydew area from cooling ocean fog in summer, creating climate hotter than elsewhere in the valley—hot enough for the appearance of rattlesnakes. The same ridges force orographic uplift of winter storm clouds, creating intense precipitation in the Honeydew area. Honeydew has a monsoon climate, with average annual rainfall well over 100 inches, the highest average daily rainfall recorded in California, and the most rainfall recorded in a single year.

Elsewhere in the watershed, Petrolia averages 50 inches of rain annually, Ettersburg 90 inches, and Whitethorn 80 inches. The water year of 1982-83 produced unusually high precipitation figures. Near the mouth of the river, the Rathbuns of Petrolia recorded 115 inches of rain. In the middle of the watershed on Wilder Ridge, the Trowers recorded 212.3 inches, and the Corringtons recorded over 240 inches. In the headwater region, 248.4 inches were recorded by David Stevenson in Bridge Creek near Thorn Junction.

Geology

The area offshore of Cape Mendocino is part of an active portion of the earth's crust known as the Mendocino Triple Junction. Here, three tectonic plates meet: the Gorda and Pacific plates slide past each other and, at the same time, both are moving east to jam under and force up the North American plate. This dynamic interaction produces numerous earthquakes and reflects still-active faulting, uplift, and subsidence in the region. The land rising out of the ocean here is geologically some of the very youngest of North America. Franciscan rocks elevated less than 15 million years ago have been found in the central King Range. The Mattole area has some of the highest ongoing uplift rates in the state -- 10 feet every 1000 years at Cape Mendocino, 1.3 feet every 1000 years at Honeydew, and 3.2 feet every 1000 years at Whale Gulch. At the same time the land is uprising, Mattole streams are actively incising into the landscape. General Mattole landforms which show recent tectonic uplift include: abundant terraces, elevated above major streams; narrow, deeply-cut stream canyons below more moderately dipping slopes; active headward and downward cutting drainages in the steep headwater regions; and rapid erosion and sediment rates.

The Cape Mendocino area is crisscrossed by the tail ends of two major tectonic systems: by the San Andreas Fault from the south, and by the Cascadia Subduction Zone from the north. The area just offshore of the mouth of the Mattole River is the most seismically active region anywhere in or near California. In addition, the Mattole Fault Shear Zone lies beneath the lower or northern half of the basin, and is a specific, major source of seismic activity. In addition, there is a fault line on the western edge of the basin. U.S. Geological Survey research shows an important causative relationship between strong seismic events and massive land-sliding in the Mattole area. Stream valleys often follow structural zones of weakness. There is a general increase in erosion potential from south to north, and from west to east in the Mattole basin.

The basin is primarily underlain by rocks belonging to the coastal belt Franciscan Formation. This formation is an uplifted collection of deep water sediments, marine volcanic material, and serpentine laid down over 145 million years ago. No bottom has been found for this formation, even at a depth of 25,000 feet. In this formation, sandstone, shale, serpentine, and chert are mixed in a matrix of clay.

Clay merits detailed description, since its qualities make it extremely erosion-prone. Clay platelets are small (less than .02 mm diameter) and flat. Between the platelets are numerous pore spaces which can slowly absorb and hold large amounts of water. When the soil is saturated, the cohesion between the platelets gives way, and the platelets slip and slide over one another. This explains clay soils' low shear strength and instability. When clay particles are compacted, the soil's water absorption ability diminishes, with increased runoff as a result.

Over geologic time, the rocks within the Mattole basin have been severely folded, intensely fractured, and deeply weathered. Mattole rock is incompetent, meaning it breaks down very easily and is therefore susceptible to erosive forces.

Soils and Vegetation

Various soils have derived from the parent rock and associated riverine topography, influenced by climate and vegetation over time.

The soils of this watershed are of two main types, forestland soils and grassland soils, with the forestland soils dominating the acreage. Forest soils are predominately Hugo, and grasslands are usually of the Kneeland type.

Reflecting the underlying soils, forestland dominates the acreage of the watershed, while grassland most often appears on south-facing ridges and slopes. Most areas of the Mattole have been changed from dense forests of Douglas fir and some redwood to transitional forests of a young Douglas fir and hardwood mixture. In some places, forest stands were cut and repeatedly burned, creating "stump meadows." Subsequent years of sheep and cattle grazing have checked many areas' return to forest.

Cultural History

The original human occupants of this watershed are known by us today as the Mattole and the Sinkyone. The Mattole occupied the lower watershed, and the Sinkyone occupied the upper watershed. Little is known about these Native Americans because they were so quickly displaced by the European-Americans. The Mattole and the Sinkyone belong to the Athapascan language group. They had settlements inland from the coast, but spent time at the ocean. In general, summertime -- dry weather --travel was along the river and streams, and wintertime – wet weather -- travel routes followed ridges. These original watershed inhabitants must have enjoyed salmon, game, ocean creatures, tanoak acorns, berries, grasses, and herbs as the staples of their diet. What their culture was like --their social structures, cosmological beliefs, their holidays, their ideals of behavior and of what was good -- we can only imagine.

One of the first known European-American visits to the Mattole Valley was when James Young and Alfred Hadley came through in 1853-54, looking for gold. They found none, but Hadley returned in 1857 and settled for ranching. The upper Mattole was settled first. The land provided good farming and ranching for the early settlers. Friction between these new settlers and the native people began by 1858. What were once prime hunting grounds were now pasture for domestic stock, the hunting of which by native Mattole people brought reprisal by the new settlers. By 1864, many killings had occurred, including a massacre of Mattole people at their Squaw Creek settlement. A brigade composed of local and area-wide volunteers calling themselves the "Mountaineer Battalion" killed or rounded up most of the remaining Mattole and Sinkyone, transporting the survivors to a reservation at Round Valley in Mendocino County. A small group of survivors was left to live at the mouth of the Mattole River, until a measles epidemic wiped out nearly all of them in 1868. In the span of eleven years, a culture and people which had been in place for hundreds or thousands of years was completely decimated.

The new culture and its population were growing. By 1859, areas up and down the river were being inhabited by the new settlers, and a school was begun in the lower valley town of "Mattolia" (Petrolia). That year, across the country, the first oil well was drilled in Pennsylvania, and petroleum production began to emerge as a major industry. Two years later, in 1861, the first oil well drilled in California was drilled near Mattolia, three miles north of town in the Lower North Fork tributary. This prompted the local citizenry to rename their town "Petrolia" in 1864 (also the year of the first Petrolia store). The Mattole Union Oil Company made its first shipment of oil to a San Francisco refinery in June 1865 when one hundred gallons of oil in goatskin bags were packed out of the valley on mules. Drilling was only continued there for four more months, and not more than one hundred barrels were pumped. Other wells were drilled within a few miles of this one, as well near Honeydew. By 1867, there were fourteen registered oil wells dug in the area between Bear River and the upper Mattole. What had been a small community based on ranching and farming now experienced a bustling influx of population in response to the perceived oil boom. The hoped-for oil boom never happened, and pumping as an industry in the Mattole Valley was terminated within a short time.

The 1870's and 1880's saw greater development of the Petrolia area, and by the late 1800's, the economic diversity, stability, and self-sufficiency of the lower Mattole was at its zenith, far greater than today. In Petrolia, there was a school, a general store, a blacksmith shop, a livery stable, two hotels, two saloons, at least two churches, a sawmill, a gristmill on Mill Creek and one on Squaw Creek, a butcher, post office, slaughterhouse, and a harnessmaker.

During its first thirty-five years, up until about the turn of the century, Petrolia was supported primarily by crop raising, with the raising of stock as the secondary industry, and timber production third in scope. Agriculture included home garden production and the commercial production of fruit, vegetables, grains, corn, potatoes, and beans. Between 1890 and 1910, a great number of apple and nut orchards were planted the length of the entire valley, likely due in great part to the work of Albert A. Etter, the "Luther Burbank of Humboldt County."

During these early years, the route of travel between the lower Mattole and Eureka was different than it is today. Starting in the north from Eureka, one traveled by boat to the north side of the mouth of the Eel River, then crossed it at low tide. Once across, mules, horses, OP wagons were mounted for the ride along the beach to Bear River. Travelers often spent the night at Capetown. From Capetown, the route cut up the hill to Cape Mendocino, down to the beach, and then along the "Indian" trail on the beach to the mouth of the Mattole River. Here, the route followed the north bank of the river to Petrolia.

In the early part of this century, a tanoak bark industry developed in the valley. Tanoak bark yields tannin, used for tanning leather. Residents stripped the bark of the trees for export. From about 1905 to 1908, a railroad ran between Petrolia and a wharf that existed at the mouth of the Mattole River, where the bark was loaded on ships bound for San Francisco. In 1908, tanoak bark stumpage was worth $1.50 per cord, with a cord being 2,550 pounds of the bark. If the bark was prepared and left stacked by the county wagon road for easy pickup and transport to the wharf, a price of $8 per cord was paid.

A tannin extract plant existed in Briceland, a few miles east of the upper Mattole watershed. The six vat plant purchased bark and processed it. Barrels of tannin extract were more profitable for them to ship out than the bark. The barrels were taken by wagon to ships at Shelter Cove. The extract process consumed three thousand cords of bark annually, and bark was bought for $15 a cord delivered to the factory.

Stripping the tanoak trees of bark left the wood to dry and season quickly, and this fuel loading of the forest increased fire danger until the cut trees began rotting. Eventually, however, the tanoak bark industry sunk into decline after the resource was "peeled out."

Around this same time, the wharf at the mouth of the river was abandoned after annual winter storms had damaged it beyond repair. The wharf had played a useful role in the export of fruit and tanoak bark produced in the valley.

A major fire in the town of Petrolia destroyed many buildings in 1903. Three years later, the earthquake of 1906 which razed San Francisco was felt here.

By 1919 the Bull Creek route was completed, offering an alternative access to the valley, especially useful for residents of the Honeydew area.

Trapping of otter, mink, bobcat, weasel, fox, racoon, skunk, porcupine, fisher and other animals for pelts continued profitably until recently.

Aerial photographs of the Mattole watershed in 1942 show dense forest cover, with creeks hard to discern from the air. Salmon and steelhead were abundant. The Mattole River was narrower than now, more shaded, and with many deep pools. The lower half-mile of the river was against the south bank, not the north bank where it is today.

Fishing was always part of a Mattole livelihood. Abundant chinook (king) salmon, coho (silver) salmon, and steelhead runs in the Mattole River were part of valley life. Stories have been handed down to us of streams teeming with salmon, spooking horses at crossings, and of men with pitchforks standing on shore and pitching the salmon into wagons. Harbors at Shelter Cove and Eureka allowed ocean fishing of the salmon returning to reenter the Mattole for migration to spawning grounds to complete their life cycle. In addition to commercial ocean fishing, and to the sustenance fishing of the river by residents, sportfishing became an annual river event, as anglers from all parts of the state converged here during the salmon and steelhead runs of winter.

After World War II, modification of the military tank into the track-driven bulldozer allowed expanded access to forests of this steep watershed. Around this time the Douglas-fir was recognized as an economic timber crop, after earlier being overlooked in the rush to log redwood. Bulldozers could operate on steep terrain, and so widespread logging of the watershed occurred from 1950 to 1970. Eight sawmills existed in the town of Honeydew. Bulldozer logging left countless skid trails, including in and across creeks. Consequently, microdrainage networks of the slopes were disrupted when cut into by skid trail and road networks, allowing water to be captured and concentrated by roads, and turned into runoff, rather than infiltrating into the soil.

Region-wide floods in 1955 drastically altered the character of the Mattole River. The river channels literally filled with sediment, in places to a depth of many feet. The river jumped its stable channel to uproot linear miles of riparian vegetation, and sections of the lower river gained the broad cobbled flood plains that can be seen today.

Three Geomorphic Sections of the Mattole

The Mattole watershed can be seen as having three geologically distinct sections, the Upper, Middle, and Lower Mattole, each with its own characteristics.

The Upper Mattole watershed is characterized by: frequent protrusions of bedrock into the river and streambed channels, a predominantly north-south orientation of the mainstem river, and steep river gradient.

The abundance of bedrock in the river and streams of this section, and the steep gradient, provide important controls to erosional and depositional processes. The channels do not show the extensive aggradation and scour, with resultant bank erosion and mass wasting that is seen in the rest of the watershed. The bedrock is critical to the maintenance of summer flows, and it acts as an energy (heat) sink by day and an energy release at night, thus moderating stream temperature. The high frequency of bedrock protrusions helps to maintain the relatively high quality of habitat in the upper basin, and also help to insure the long-term stability of the upper watershed. This section of the watershed clearly contains the most important salmonid spawning habitat remaining in the Mattole.

The predominately north-south orientation of the river minimizes solar exposure, helping to keep water temperatures cooler than other sections of the river. The river and its tributaries are narrowly defined by the vertical topography, and have a steep gradient which hinders the formation of floodplain areas, the most notable exception being an ancient alluvial fan at McKee Flat near Thorn Junction. There is a cooler, more foggy coastal climate in this section of the watershed, with much vegetation of the redwood biome—redwood trees, and moisture-loving ferns -- in contrast to the rest of the Mattole, which is notably lacking in redwood trees. There is generally a closed canopy of tree cover over the river. The riparian zones are generally intact and occupied by vegetation. This closed canopy benefits the river as fish habitat in a number of ways: by keeping water temperatures cooler in the summer, by adding greater energy and diversity to the foodchain with the presence of insects and appropriate inputs of organic matter and woody debris, and by providing cover for fish to hide from predators.

In the Middle Mattole the river flows in a northwesterly direction. In general, the weather here is the most extreme in the watershed, wetter in winter and hotter in summer than either up or downstream. Much of the Middle Mattole is underlain by the Mattole Shear Zone. Stormflows are flashy and the area is subject to periodic heavy rainfall. Geologic material in this area is relatively soft and highly fractured sandstone and loosely structured shale decomposing to clay. Sandstone slopes over 50% are prone to sliding and slumping. Slopes of clay and decomposing shale over 25% are prone to rotational slumping when saturated with water. Gradients adjacent to streams in this section range up to 90% and are extremely unstable.

Normally, roots of live hardwood and conifer trees provide tensile and shear strength to these marginally stable slopes and are the key factor in maintaining long-term watershed stability and productivity. In most areas, extensive past logging has resulted in the reduction of live tree roots' contribution to slope stability, and in the concentration of the erosive energy of water caught in unarmored watercourses created by roads, skid trails, and cat tracks. The resultant erosion and sedimentation to the creeks and river causes a heavy bedload of sediment during winter storms from such tributaries as Bear, Blue Slide, Mattole Canyon, Grindstone, and Gilham Creeks. The bedload causes filling of the pools in the river and this in turn causes lateral migration of the channel. King salmon eggs laid in this section are easily destroyed by gravels due to bedload sediment overload. Landslides adjacent to the mainstem also contribute large quantities of sediment to the river. Other impacts of sediment overload and channel migration include:

1) Destruction of riparian habitat which means that during summer the river flows through extensive areas deficient in shade, resulting in high water temperatures. Loss of riparian vegetation also limits the organic food supply to aquatic insects and thus to fish.

2) Fewer pools and shallower pools resulting in much less rearing habitat for silver salmon and steelhead trout.

3) Continued bank undercutting and destabilization of slopes adjacent to the river channel resulting in the input of ever more landslide material.

The Middle Mattole watershed has two distinctive reaches, upstream and downstream of Westlund Creek. The downstream reach differs from what has already been described in that the mainstem flows through a distinct canyon. The mainstem is relatively narrow with steep slopes on both sides, and many gradient drops. The river gradient is about half as steep as the upper section of the watershed, yet steeper than the lower section. The Honeydew Slide occurred at the downstream end of this canyon section.

Vegetation is mixed conifer and hardwood tree species, and many trees grow to the river's edge. Riparian vegetation is very good in the canyon area, and steep side slopes also provide shading from the sun. This section of the mainstem is inaccessible by road.

The Lower Mattole is characterized by low river gradient, a generally northwesterly flow, a more open, broad valley, and large river meanders.

In general, the Lower Mattole basin is steep and mountainous. However, there are extensive areas of flat or gently sloping land, mostly adjacent to the mainstem and along the Lower North Fork. The Mattole River flows onto an open alluvial plain east of Honeydew. The river has large meander loops with broad, flat slip-off slopes to one side and steep river bluffs to the opposite side. Sand and gravel deposits are located along the channel. East of Petrolia, the river flows along the broad, flat alluvial plain where it is joined by the Lower North Fork. From here, the river flows southwesterly to the sea. The valley narrows near Moore Hill, and the river flows into an abbreviated estuary, which forms a lagoon in the summer when the river mouth closes. The river enters the sea in a narrow mouth with only a small delta. This terminal reach of the river receives the greatest proportion of runoff. Here we see the cumulation of upstream impacts and sediment inputs. The gentle mainstem gradient has allowed massive alluvial deposits to fill the channel. The result has been that the river is mostly riffles and shallow pools. Extensive aggradation in the mainstem has reduced the channel's capacity to contain peak flows, in effect causing channel migration, accelerated bank cutting and landsliding, removal of riparian vegetation, and an increased risk of flooding of downstream flats.

Salmon habitat is limited in quantity and quality. Extreme exposure of the river to solar radiation through natural river orientation, topography, and lack of riparian vegetation has resulted in near-lethal water temperatures for salmon in the summer months.

The Lower Mattole has the greatest amount of pastural cultivation due to the flat and fertile floodplain deposits of upriver topsoil. Many large and small ranching operations continue to function, with recent emphasis shifting from sheep to cattle. Watershed vegetation consists of mixed fir and hardwood forests, tanoak and tanoak/madrone forests, riparian woodland, brushland, cleared grassland, and high prairie. Very few stands of ancient forest remain. Most of the marketable timber in the lower basin was harvested or by the mid-1960's. Large areas of this section have experienced severe disturbances and greatly accelerated erosion due to logging, fires, overgrazing, and road construction.

Janet Morrison

Selected References

California State Resources Agency, Department of Water Resources. 1973. Character and *Use of Rivers, Mattole River.* Department of Water Resources, Sacramento, CA 95814

Coastal Headwaters Association. 1982. Mattole *Survey Program First Annual Report.* P.O. Box 12, Whitethorn, CA 95489.

Jager, D., C. Skau. 1989. *Hydrologic Analysis of Proposed Timber Harvest Plan in the Mattole River Basin*, Eel River Sawmills, Inc., Fortune, CA 95540

Mattole Union School. 1962. The *Book of Petrolia*. Petrolia, CA 95558

U.S. Department of the Interior, Bureau of Land Management, Pacific Outer Continental Shelf Office, U.S. Fish and Wildlife Service. 1981. An Ecological Characterization *of the Central and Northern California Coastal Region, Volume IV, Chapters 17-29,* Watersheds and Basins. FWS/OBS-80/48.2

SALMONID HABITAT
Of the MATTOLE RIVER
and its TRIBUTARIES

This is a summary of known use of habitat by salmonids in the tributaries of the Mattole. Information on king salmon spawning habitat is based on nine years of spawning surveys by the Mattole Watershed Salmon Support Group. Circle notations on the watershed map are an estimation of the upstream limit of the use of that stream by any Mattole salmonid: king salmon, silver salmon, or steelhead. These notations are sometimes based on a physical barrier such as a bedrock falls or a semi-permanent logjam, and sometimes on a single "most upstream" observation made by a surveyor or other resident. Numerals next to creek names refer to stream miles of known salmonid habitat in each creek. These estimations are based on findings from the Mattole *Survey Program, August 1981 – August 1982,* conducted by the Coastal Headwaters Association, and are augmented by observations of surveyors made during the course of the current survey.

DRAINAGE AREA I

McNasty Creek
Thompson Creek
Baker Creek
Ravasoni Creek
Bridge Creek

Area I corresponds to that part of the Mattole which grows redwood and associated vegetation, due to the presence of different soil types and a more normal exposure to coastal fog than is experienced in the rest of the Mattole. Unlike other conifers, redwood will quickly regenerate from a cut stump, contributing to an overstory recovery after disturbance which makes aerial photographs of little use for the identification of point sources of sedimentation any more than ten years after logging. The area was thoroughly logged prior to 1960, and large timber owners like Eel River Sawmills and Barnum Timber Company have begun to reenter at a rapid rate and large scale. This time, because of changing market conditions, operators are taking out hardwoods as well as the few remaining seed trees and young second growth conifers. While harvest practices are far superior to what they were thirty years ago, the practice of removing all large trees (and burning what slash is left behind as site preparation for single species plantations) needs to be reconsidered both in terms of reduced soil fertility and high erosion hazards.

The viability of the native Mattole king salmon population is disproportionately reliant on this reach of the mainstem, as these good gravels on gentle gradients are the preferred spawning grounds of a high percentage of the largest of salmonids each year. Since 1981, the Mattole Watershed Salmon Support Group (MWSSG) has trapped adult king salmon in this reach for the purpose of taking eggs for fertilization and hatchbox incubation. Fine sediments are not flushed out of the mainstem as quickly as they have been introduced from the steeper tributary channels, and their accumulation and compaction has critically reduced the amount of oxygen available to incubating salmon eggs. This phenomena has reduced the egg-to-fry survival rate of salmonids to an estimated 15% or less. By imitating an ideal river bottom condition in streamside hatchboxes, MWSSG has consistently been able to attain egg-to-fry survival rates of over 80%. In its nine years of operation, MWSSG has released more than a quarter of a million native salmonid juveniles back into the wild in the Mattole River. MWSSG maintains a major holding and incubation site on Arcanum Creek with the cooperation and assistance of Arcanum Ranch. The

California Conservation Corps (CCC) has substantially increased the amount of habitat available to salmonids through logjam removal and modification on the eastern tributaries of Area I, and on Thompson Creek and Bridge Creek. Some of the most visible and inspirational restoration work in the Mattole has been the dry wall masonry approach to riprap at seventeen sites on the Mattole where it runs parallel to the county road in Mendocino County. The hand-placed rock work armors oversteepened river banks and mitigates for the sediment introduced by the unpaved county road. *Paving this road would make the largest single contribution to the reduction of sedimentation in all of the headwaters area.*

Of all the Mattole drainage areas created for this survey, Area I hosts the largest human population. This factor no doubt contributes to an awareness of a pressing need for ecological reserves where the survival of species diversity takes precedence over other potential uses. Sanctuary Forest, a land trust organized in *1986* as an expession of this awareness, has been instrumental in making real the concept of Mattole Ecological Reserves. 1164 acres of ancient forest habitat has been set aside for this purpose in the headwaters area.

McNASTY CREEK

This most upstream tributary was logged prior to 1962 and is presently densely covered with a mosaic of vegetation predominantly made up of hardwood and chaparral species. The carcass of a spawned-out steelhead was identified approximately one mile up the western fork in the winter of 1988-89. Surveyors found recovery processes well advanced and advised careful monitoring and maintenance of homestead access roads as the most effective means of erosion control in the future.

Surveyors for McNasty Creek:
Whale Gulch School
Ray Raphael
P.O. Box 979
Redway, CA 95560

THOMPSON CREEK

Budgetary constraints compounded by access problems precluded systematic survey of this drainage. Three factors should give this creek high priority for continued survey. 1) Thompson Creek is an important spawning and rearing tributary for king and silver salmon and steelhead (the creek has been stocked with native king salmon by the Mattole Watershed Salmon Support Group three times since 1981); 2) Sanctuary Forest Ecological Reserves provide a large base of stability on Yew Creek, the largest tributary of Thompson Creek; and 3) Redwoods Monastery at the mouth of Thompson Creek is home to an extremely stable and ecologically sensitive community.

Rehabilitation Prescriptions

T5S R2E Section 29
SR1 - Culvert outflow has caused vertical slumping of 15 feet. Armor to dissipate energy, reduce flow at intake, plant disturbed area.
SR2 - Culvert outflow has capacity to move enough material to change course of creek. Armor for energy dissipation, plant disturbed area.

BAKER CREEK

The mouth of Baker Creek is managed by the California State Park system, and the remainder of the 1.6 square mile drainage is held by Barnum Timber Company. Over 70% of this drainage has been harvested or reharvested in the last ten years, and much of this disturbance has occurred since 1982-83, which was the last time a ten year storm was experienced. The quality of harvest practices varies considerably, from sloppy tractor logging with minimal erosion control mitigations, to state-of-the-art high lead cable logging. THP 1-89-230, scheduled for completion in 1990, will allow the clearcutting of the small amount of unprotected old-growth which remains in this tributary.

Baker Creek has been subjected to a very large amount of disturbance which has yet to experience a ten or twenty year storm. Baker Creek also has the unusual distinction of having experienced a broad range and intensity of disturbance in a short time on similar landforms and soil types. This tributary should not only be made a high priority site for rehabilitation prescriptions, but should be closely monitored to determine the erosional effects of various styles of logging practices and of reentry thirty to forty years after the original disturbance.

Mapping for Baker Creek:
Randall Stemler
c/o MRC
and Will Bell
P.O. Box 273
Whitethorn, CA 95489

RAVASONI CREEK (Unnamed on USGS topo) -also known as East Anderson

This small (less than one mile square) drainage enters the Mattole from the east about two-thirds of a mile downstream of Whitethorn. A 120 acre tractor logging show in 1987 (THP 1-86-578) left the middle and upper parts of the drainage with multiple erosion problems, including Class III streams which had been erased and recreated with the tipped blade of a bulldozer, and skidroads cut down slopes with gradients in excess of seventy percent.

Rehabilitation Prescriptions

Under the direction of Terry Spreiter, head rehabilitation geologist at Redwood National Park, the disturbed area was mapped intensively and erosion problems identified. Appropriate rehabilitation measures identified include seeding and mulching, tree planting, rerouting of streambeds back into their original channels, and the use of instream debris to improve habitat and structure. This project has been proposed to the California Department of Fish & Game (DFG), but has yet to be approved for funding.

Surveyor for Ravasoni Creek:
Jim Durvin
Project proposed by:
Richard Gienger
c/o MRC

BRIDGE CREEK

This 5.3 square mile drainage enters the Mattole River near where the Shelter Cove Road crosses the river. Unique among Area I tributaries, this watershed is steep, canyon-like, and extraordinarily wet. Dr. David Stevenson's fifteen years of annual rainfall records often show an excess of exceed 200 inches for any one year. Historically, Bridge Creek has been a major king salmon spawning stream, and still supports a remnant population. Extensive reaches of good spawning gravels are currently impacted by high levels of sedimentation still occurring each year. While vegetative recovery is generally good upslope, inner gorge areas are often denuded due to debris torrents, landslides, and road related erosion. Streambank erosion is a major problem because of the flashy runoff to which this drainage is naturally subjected.

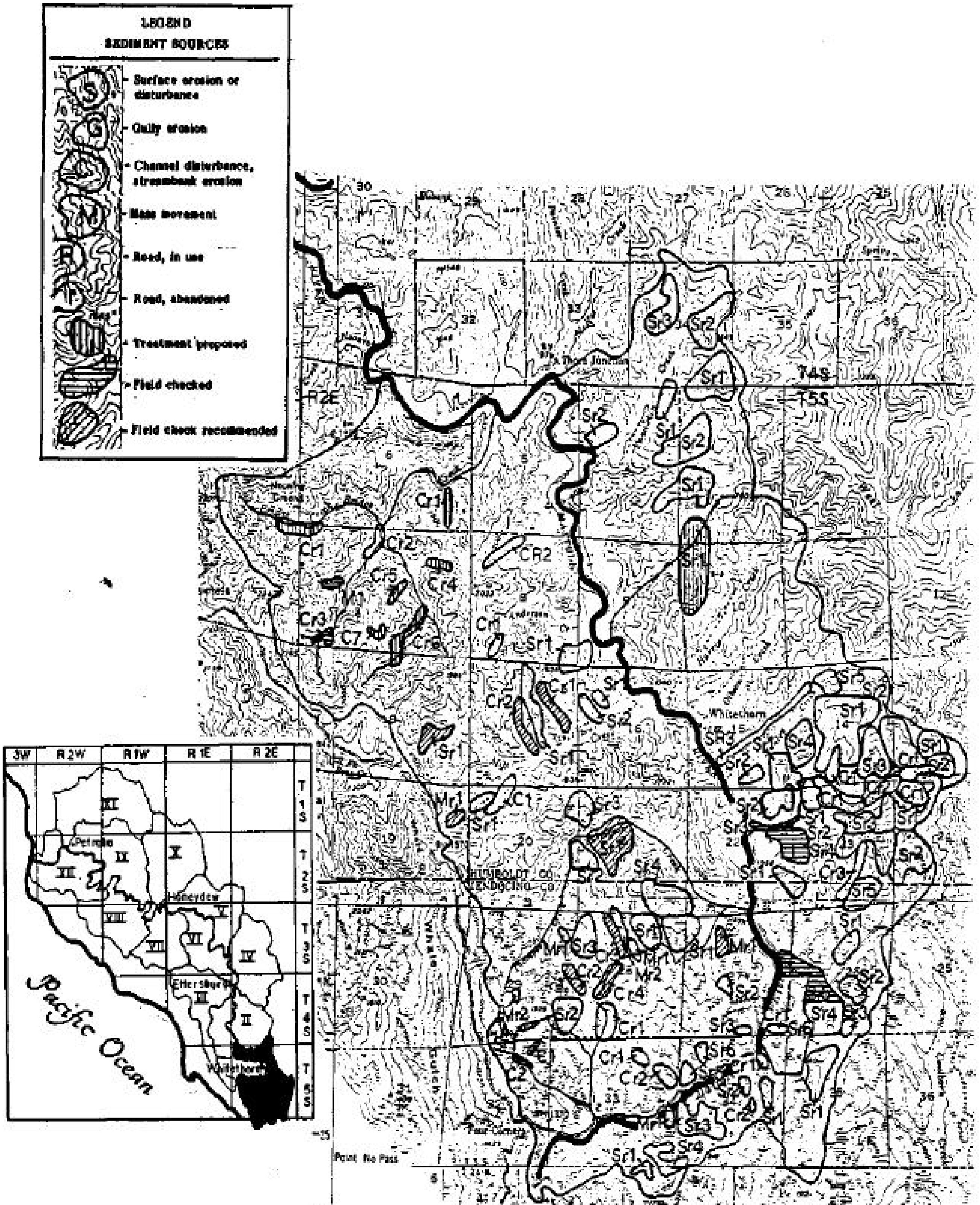
Rehabilitation Prescriptions

A comprehensive rehabilitation plan for Bridge Creek has been proposed by MRC, but has yet to be funded by DFG. The following is a summary of the work proposed.

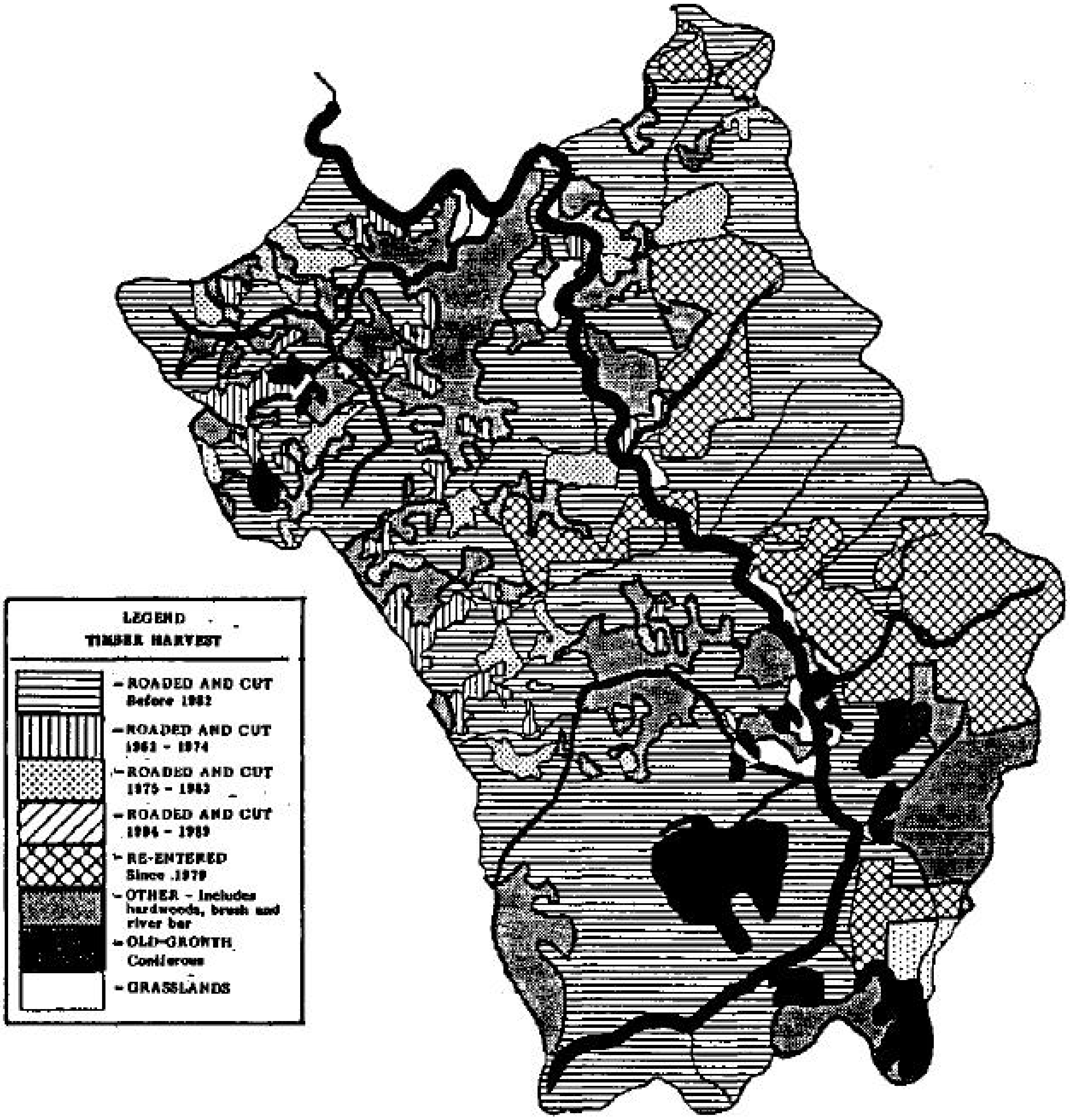
Ten thousand Douglas-fir will be planted to help stabilize streambanks, slides, steep and raveling bare areas, and eroding skid trails. Drainage problems will be corrected through waterbars and replacement of channels back into their original stable courses. Unstable channels will be armored with woody debris and rock. Slides and debris torrents will be stabilized to the greatest degree possible through toe protection and reenforcement, horizontal terracing and ravel catching structures, revegetation and dewatering of the slide/debris torrent surfaces. Instream structures using available materials will re-divert flows away from unstable banks, improve sediment transport dynamics, and enhance the pool-to-riffle ratio. 450 cubic yards of imported rock will be used in a careful drywall rip-rap fashion to stabilize accessible eroding streambanks, tributary crossings, and road-related drainage problems. Eighty hours of heavy equipment time will be utilized to remove crossing material and to reroute drainages to their original stable channels.

Mapping for Area I was performed by Mel Lynn for Mill Creek, Freeman House for Van Arken Creek, and Randall Stemler for Thompson Creek and other upstream tributaries.

Surveyor for Bridge Creek:
Richard Gienger
Box 283
Whitethorn CA 95489



DRAINAGE AREA I



DRAINAGE AREA I

DRAINAGE AREA II

Nooning Creek
Eubanks Creek
Big Finley Creek
Little Finley Creek

Most of this drainage was burned catastrophically in the Finley Creek fire of 1973, and salvage logged following the fire. The western two-thirds of the area has been managed by the Bureau of Land Management (BLM) as part of Zone 6 of the King Range National Conservation Area (KRNCA). The BLM's primary management goal for this zone is timber production. With the exception of fairly extensive areas in the headwaters of Big and Little Finley Creeks, most of the area had been logged before acquisition by BLM. The fire of 1973 burned so hot that most remaining coniferous seed trees were killed, as well as mycorrhizal fungi in the soil. As a result of these factors, natural regeneration has occurred primarily through various brush species. Extensive rehabilitation work has occurred in Nooning Creek and in Eubanks Creek, but Big and Little Finley have suffered in this regard due to their remoteness.

The major rock type in this area is hard sandstone (graywacke) with interbedded shale. The graywacke is generally fairly stable on slopes, but the addition of interbedded shale substantially decreases stability. Most of the soils in the area have been mapped as Hugo.

NOONING CREEK

Under the direction of biologist Jim Decker, an exemplary watershed restoration plan has been developed and implemented by BLM in Nooning Creek. By 1980, the sediment storage and transport capacity of the stream had been so overburdened that woody vegetation in the riparian zone had become almost nonexistent, raw streambanks were continuing to deliver large amounts of sedimentation to the system, and water temperatures had risen to the point of being lethal to salmonids. Decker designed a rehabilitation program which included placement of rock structures for streambank armoring and to create scouring and deflection; excavation and removal of log road crossings; modification of log jams and use of the woody debris to armor failing streambanks; broadcast seeding of grass species in the riparian zone; and planting of eighteen thousand trees, largely alder, along more than one mile of the mainstem.

The program was implemented from 1982 through 1985, mostly by California Conservation Corps (CCC) crews.

Survival and growth of riparian plantings has been excellent. Streamside alders have reached heights of 12 to 20 feet by 1989, with 70 to 100% shading on the mainstem of the creek. Decker has been able to demonstrate a useful rule of thumb at this site: each *10%* increase in riparian cover is likely to reduce water temperature in the stream at that point by one degree Fahrenheit.

A self-guiding tour and visitors' center is planned for this area in cooperation with local schools, which will create an excellent opportunity for the public to gain experience and insight into the potential of various rehabilitation techniques.

Mapping for Nooning Creek:
Randall Stemler
c/o MRC

EUBANKS CREEK

Whereas Nooning Creek is almost entirely in public land, Eubanks Creek, which enters the Mattole just downstream, is almost entirely in private hands. Historical reports name the latter creek as one of the best salmon streams in the area, but for an indeterminate amount of time before 1983, a logjam about 0.7 miles above the mouth had acted as a barrier to the upstream migration of salmonids. CCC crews modified the barrier in that year, and king salmon redds were reported upstream of the jam in January of 1984. In 1984-85, the lower reach of Eubanks Creek was targeted as a rehabilitation site. Work included planting 7500 Douglas-fir and 1500 alder. Windrows were staked into talus slopes to prevent the clogging of inboard ditches. Other road mitigation work included construction of waterbars, trash racks at culvert mouths, and rock armoring of culvert outflows. A second phase of work took place during 1986-87 with the planting of 15,000 Douglas-fir, and the broadcast seeding of 2,000 pounds of mixed grass and legume seed. Extensive windrow and other road mitigation work was also continued. These sites will continue to be monitored through 1991.

Surveys as part of this inventory were conducted in November, 1988, and yielded, in part, the following report: Upslope rehabilitation projects have been highly successful. A new high quality bridge has been installed over the creek where the lowest ford was. The 1983 modification of the main jam pursuant to our recommendations is still having upstream effects. The channel above that jam now contains deeper pools and has less sand, and these new effects reach much farther upstream than previously. Because of abundant bedrock, stability there is not a problem. Due to the success of previous rehabilitation projects in the lower watershed, opportunities for further significant projects are diminishing. Based upon our consultation with the Torberts (landowners in the lower reach) and our surveys, we have identified two significant if relatively small projects. The first involves drainage improvements to the road from the north end of the new bridge to the Torberts' driveway, which is a short distance. We have discussed the project with the owners, who appear interested in providing major material assistance. A new small culvert with outfall flumes is needed and an outside berm should be partially removed, among other things. The other project is smaller but probably more significant for fisheries. We recommend that certain small jams (in Section 29, C1) be slightly modified so as to flush cementing sand and fine sediments from otherwise good gravel beds. This would require approximately one or two persons with chainsaws one or two days.

BIG FINLEY CREEK

Due to a change in land ownership which made access permission unavailable, this remote tributary was not visited although the surveyor recommends this creek as the site of high priority rehabilitation work. We will rely on a firsthand report submitted in 1982 by the same surveyor:

"... The stream gradient is typically rather steep and pools and runs are infrequent, however there are frequent bedrock controls. The many earthflows and slumps toeing into the creek appear to be fairly well stabilized. There is, however, extensive bank erosion, and Big Finley runs much dirtier than the Mattole.

"... Debris jams are frequent and there is virtually no canopy. The mainstem is strewn along its length with many logs of various sizes which could at higher flow considerably exacerbate the existing debris jam problem. The easiest significant treatment would be to seed red alder along the banks. This would stabilize banks, reduce upslope sediment inputs, and provide shade and a food source, among other benefits.

"... A jam at the mouth is large, but is not an obstacle to fish passage. . . . This jam abuts the toe of an active slump and its removal would accelerate erosion. Thus we recommend this jam not be removed."

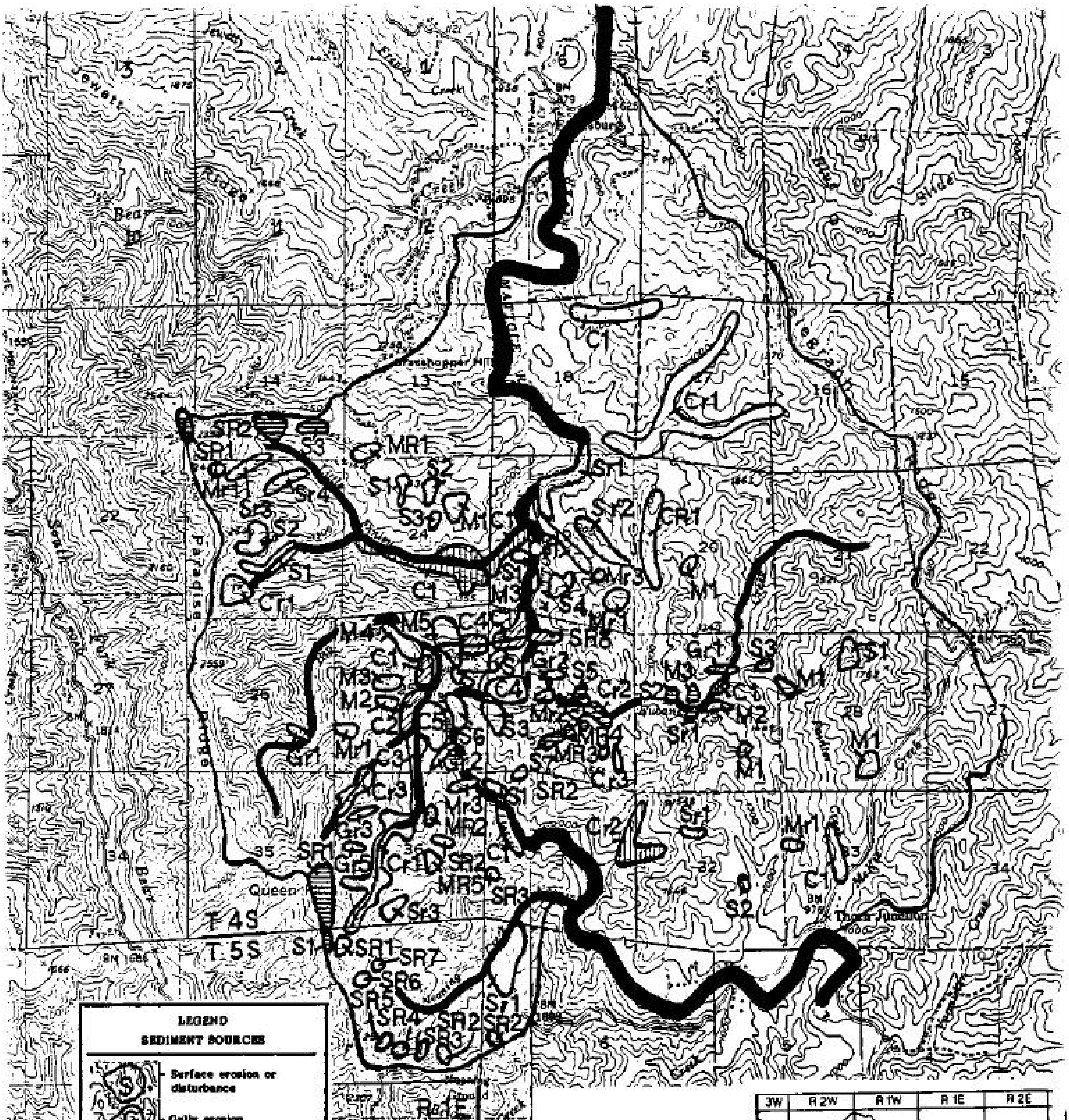
If conditions elsewhere in the Mattole hold true for this tributary, a good deal of natural reseeding may have occurred in the intervening years. As of 1989, we recommend a reexanimation of the main channel of Big Finley Creek. It wouldn't hurt anything if the surveyor had a backpack full of red alder seed cones.

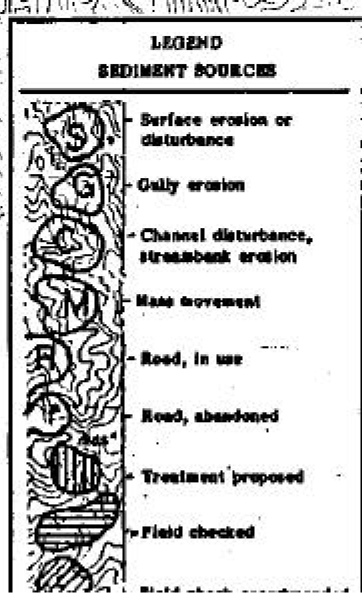
LITTLE FINLEY CREEK

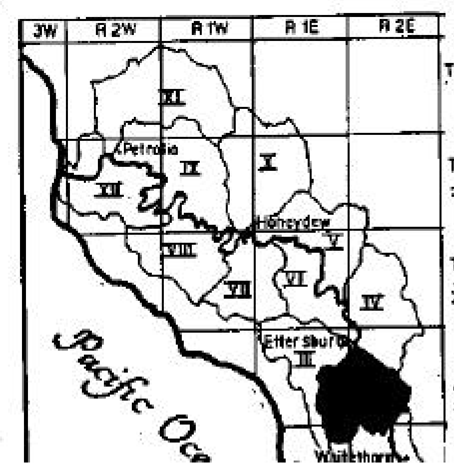
Much of the northern side of this watershed is sloping grasslands; the central, western, and southern parts of the watershed are steep and forested and have been logged poorly. In the headwaters area above the main forks, there are extensive forests remaining with trees of 100 years and older. This forest was probably "high-graded" (the best and largest timber removed) at some time in the past. While the forest exhibits neither old-growth characteristics nor a closed canopy, it has served to protect the upper watershed against the worst symptoms of erosion. The upper mainstem has been subject to heavy sediment flushing. At least one source of sediment was identified at a crossing near the southern edge of Section 14 where a freshly reinstalled Humboldt crossing is contributing significant sediments. This crossing should be culverted or removed.

Downstream of the major forks, the creek has been severely damaged by logging and wildfire. In 1982, these channels were judged to be extremely significant contributors of sediment to the Mattole. In 1988, some sediment sources had stabilized enough so that in spite of three days of rain prior to the survey, Little Finley Creek was running clearer than the Mattole. This was the case in spite of the fact that riparian recovery is, as yet, minimal. Riparian and upslope plantings are recommended for stabilization and shading. Some log jam modification may be indicated here. The presence of stability in the headwaters, landowner cooperation, and over a mile of salmonid habitat which is very likely to be under utilized combine to make the lower reaches of this tributary a high priority candidate for labor intensive rehabilitation work.

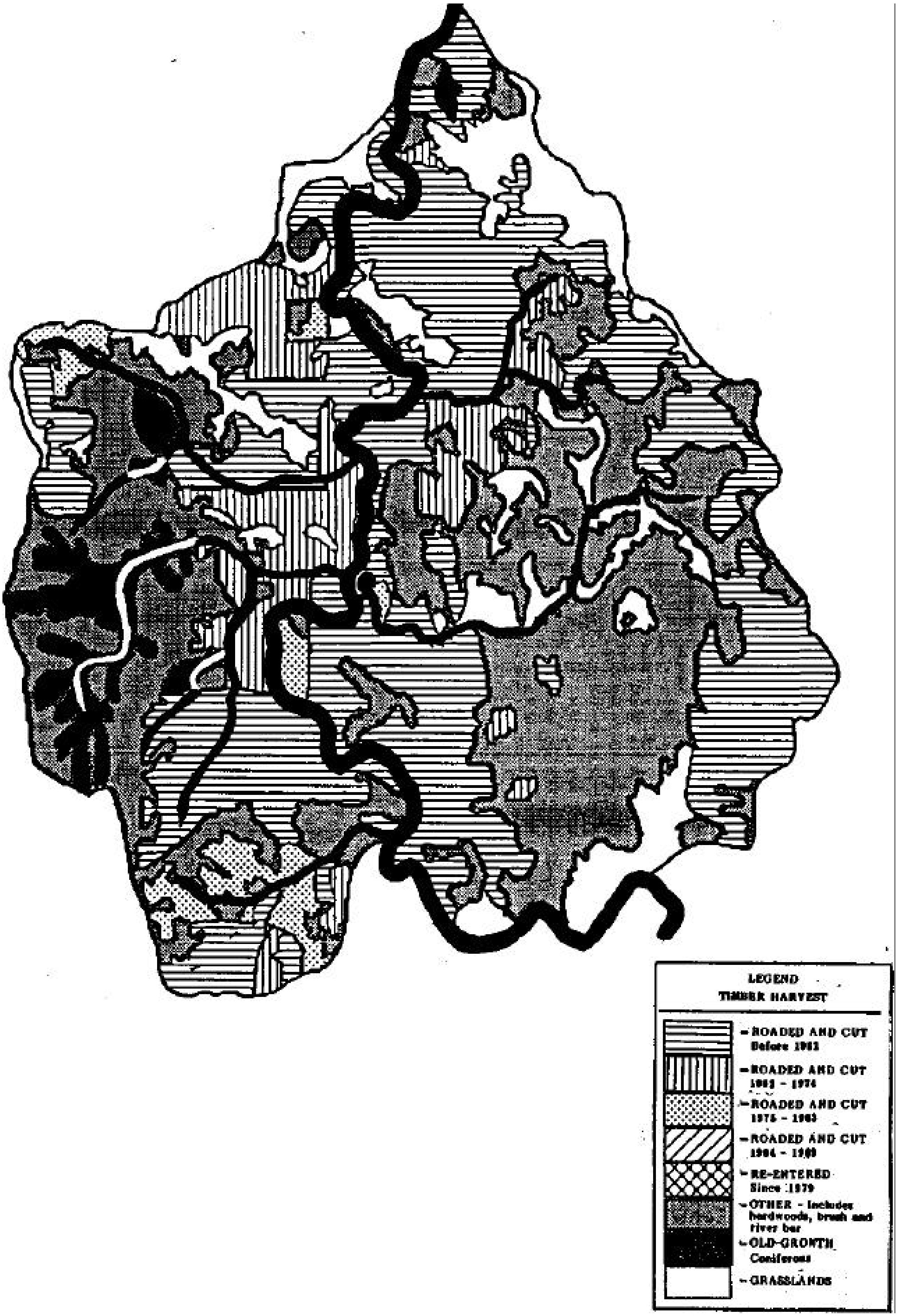
Surveyor for Eubanks, Big Finley,
and Little Finley Creeks:
Robert Sutherland
P.O. Box 996
Redway, CA 95560







DRAINAGE AREA II



DRAINAGE AREA II

DRAINAGE AREA III
Bear Creek
Jewett Creek

BEAR CREEK

Bear Creek is the third largest tributary in the Mattole River watershed. It flows north and east, draining southern and central areas of the King Range. The terrain is steep and unstable. The rainfall averages from 120 to 140 inches per year, though years with over 200 inches are not uncommon.

Historically the area was heavily forested and supported abundant wildlife, including plentiful runs of silver (coho) and king (chinook) salmon. Native inhabitants prospered amid this abundance until the arrival of white men in the mid-1800's.

By the 1950's the Indians were gone and the wildlife decimated, yet the salmon survived. Then began large scale logging of the climax forest. By the 1970's the Douglas-fir forests and the salmon were nearly gone. Though some cattle are grazed and there are a few small orchards as well as fourteen inactive mining claims, timber production has had the largest impact and will continue as the major impact unless more sensitive harvest practices are embraced. As a direct result of the intensive logging, several million cubic yards of soil, rock and debris flowed into Bear Creek. Though slowed down by gradual slope stabilization and natural revegetation, the erosion continues. Logging will also continue, as the Bureau of Land Management (BLM) plans to use much of the watershed for timber production, with mining, recreation and wildlife protection assigned lesser roles. The King Range National Conservation Area (KRNCA) was established in 1970. Consequently, most of the Bear Creek watershed is now administered by the BLM.

In 1973, when the large scale logging was near its end, a devastating fire burned approximately 3000 acres around the South Fork of Bear Creek. This aggravated logging damage and set back recovery processes, and additional silt and debris clogged the creek. The fire eliminated most riparian growth in prime South Fork salmon spawning habitat. As more and more sediment and debris clogged the creek, salmon runs continued to decline to an estimated one hundred spawners in Bear Creek in 1979.

At this point, citizens' groups and government agencies began efforts to repair the damage. Volunteers surveyed the creek, documenting spawning grounds and monitoring salmon runs. With the aim of protecting and restoring the health of Bear Creek, the Bear Creek Watershed Association (BCWA) was formed in 1979 by a number of local property owners. Soon after this, the Mattole Watershed Salmon Support Group (MWSSG) began helping in the restoration effort. Around this time also, the California Department of Fish & Game (DFG) planted a large number of young steelhead in the South Fork of Bear Creek.

By 1982 the California Conservation Corps (CCC) had begun removing log jams, hoping to facilitate fish passage. More than five miles of spawning habitat was opened up in this way. Also in 1982, the Bear Creek salmon hatchbox program started as a joint effort between MWSSG and BCWA with the cooperation of DFG.

The site chosen for the first hatchbox was Tim Day's property near the headwaters of South Fork Bear Creek. A well cared-for north facing slope and abundant clean water made it an ideal location. At that time it was felt that native Bear Creek salmonids were in danger of extinction. The intention was not to greatly increase the salmonid populations, but rather to avoid extinction by enhancing the surviving runs while we continued the task of restoring the watershed to its pre-logging health. When the watershed is restored, the fish population is expected to rise accordingly. Each year 10-20,000 chinook salmon are hatched and cared for at our first hatchbox site.

Small scale restoration work continued. BLM closed and "put to bed" many erosion-causing roads. A major gully near the source of South Fork Bear Creek was brought under control at the landowner's expense with MWSSG and BCWA assistance. This project slowed the movement of silt into crucial spawning areas.

In 1987 a site was selected for a coho salmon hatchbox on the Lingel/White/Self property, approximately three miles downstream from the chinook hatchbox. In 1988 BCWA hatched and released 9500 coho into Bear Creek; and in 1989 BCWA hatched and released 4500 coho in under utilized rearing habitat. Once again this is seen as a holding action while restoration progresses. Population estimates conducted by DFG have indicated that these releases were successful.

We divide the Bear Creek watershed into two distinctive zones. Though the degree of erosion damage in these zones differs greatly, one single factor underlies the problems in both areas. Nearly all past, present, and ongoing erosion is road related. In the headwaters area south of the Queens Peak mine road (Zone #1), logging was done on a smaller scale over a long period of time, and slopes are gentler. The land in this southern area remains mostly in private hands. The logging circumstances and terrain enabled this zone to recover more fully from damage that was less severe to start with. Thus the erosion problems here are primarily related to private driveways and the county road.

North of the Queens Peak mine road (Zone #2), the terrain is much steeper; the inner gorge begins here. The inner gorge is that part of the Bear Creek valley adjacent to the stream where the slope becomes abruptly steeper to 65% or over. Slopes this steep are particularly sensitive to disturbance.

The bulk of the logging in this area was done between 1966 and 1974 in large cut blocks, nearly all clearcut. The roads creating the problems in this area are the thousands of skid trails and many haul roads with their associated water diversions, fill failures, and slope disturbances. Though we estimate that 80% of the eroding materials have already moved into Bear Creek, there is still a potential for hundreds of thousands of cubic yards of additional erosion. South of the Queens Peak mine road there is abundant riparian growth and salmonid habitat, but the area to the north is still a scene of devastation. Riparian growth is returning slowly in some areas, and not at all in others. The stream bed is choked with silty, unsorted gravels, and only a small proportion of the creek offers suitable spawning gravels and habitat.

Rehabilitation Prescriptions

Our field trips, examinations of aerial photos, and consultations with geologist David Burnson have convinced us that the worst problem in the Bear Creek watershed is the condition of the inner gorge and the stream channel from T4S R1E Section 16 to the mouth of Bear Creek. Ideally, we would like to stop the flow of eroding materials into Bear Creek. Such a project, however, would be extremely expensive. Because so much vegetation and earth would be disturbed in the process, the project could easily cause a great deal of erosion, thus defeating our purpose. If we concentrate on the inner gorge and stream channel we considerably narrow the scope and cost of the project. We also reduce the likelihood of aggravating erosion by leaving most of the logged land undisturbed, while at the same time protecting and restoring the most sensitive areas. Restoring the inner gorge and the stream channel would both decrease the volume of materials moving into the creek and enable the creek to better handle these materials.

We propose the following five steps in the inner gorge of South Fork and mainstem Bear Creek.

1. Several monitoring stations should be set up in Bear Creek and its main tributaries to document water and sediment flows. Stations in both damaged and pristine locations will allow comparisons and provide a measure of our progress in restoration.

2. An excavator and perhaps other heavy equipment should remove road fill from the stream banks and crossings. This fill material is the most immediate threat to adjacent spawning grounds.

3. The stream channel should be armored at strategic points to allow the inner gorge slopes to stabilize, further slowing erosion.

4. Heavy equipment and/or work crews should manipulate woody debris in the stream channel to encourage gravel sorting and recruitment. This will help to recreate the pool and riffle sequence characteristic of high quality spawning grounds.

5. Wherever appropriate, the inner gorge should be revegetated with native species to further help stabilize slopes and reestablish riparian habitat.

We recommend that this project be begun at the southernmost limit of the inner gorge, near Queens Peak, and be expanded northward as time and money allow. Because BLM manages most of the property in the watershed, we need their cooperation in all phases of the restoration work. It is our hope that BLM will participate in a cost-sharing plan for any work done.

The North Fork Bear Creek watershed is in a condition similar to the lower South Fork and mainstem as discussed above, though on a smaller scale. Thus we give the North Fork second priority and suggest the same prescription.

T4S R1E Section 14

Cr1 - An additional high priority rehabilitation site has been identified along an unnamed tributary of Bear Creek approximately two miles from its confluence with the Mattole. Debris torrents have resulted in a trashed channel one quarter mile long with the channel widened by 20 feet and deepened by the same amount. A drainage area of 100 or more acres is involved in this event, all of it in private holdings. Roaded access is available to within one quarter mile of the channel; bulldozer or excavator could reach the channel via failed roads. Geologist David Burnson estimates that one week of excavator work here pulling back road fill would prevent 5,000 cubic yards of sediment from reaching Bear Creek. This site would also benefit from the planting of three thousand mixed tree and brush species. The entire sub-drainage is geologically active and groundwater is frequently present. The whole drainage should be geologically mapped before a more detailed prescription is made.

Our third priority is within the above described Zone #1, the headwaters of South Fork Bear Creek, from the Brown property south to the source. As in the other priority areas we recommend sediment and flow monitoring at several representative locations. The county road and private driveways are the major erosion problems here. For *the* county road *we would like to see the Chemise Mountain Road paved from its intersection* with *the Shelter Cove Road to the top of Whale Gulch at the McGreevy property in T5S R2E Section 18.* Pavement will stop the flow of fine sediment from Chemise Mountain Road into nearby South Fork Bear Creek. In the rainy season, constant traffic and occasional road grading causes enough erosion to turn the creek orange at times. Until pavement is possible we suggest that no fine materials be spread on the road surface, particularly during the rainy season.

All water diversions caused by the county road, such as noted in T5S R1E Section 2, should be corrected. Further field work is necessary to discover all such diversions. Road grading should be scheduled to avoid the rainy season and spawning times. Also, the road should be graded so as to eliminate inboard ditches and water concentration wherever possible. These matters should be discussed with the Humboldt County Department of Public Works, and the Board of Supervisors. Regarding private driveways, we recommend a program to contact and educate residents. This program would suggest appropriate methods of driveway installation and maintenance, such as outsloping and water bars. It would encourage proper culvert installation, especially the matching of culvert diameter to maximum water flows, and armoring to protect adjacent fill and stream banks. Though not a serious problem at this time, suggestions should also be made to help landowners avoid livestock-caused erosion. Although neighborhood meetings and personal contact may help in some cases, we believe a well prepared booklet would convey this information best, while causing the least defensive resistance from private property owners.

In conclusion, we recommend extensive additional field work in the top two priority areas. This should include specialists in geology and hydrology to help develop site specific plans. Within the above priorities it appears that due to the considerations of scope, cost and access, the most easily applied prescriptions are those within the headwaters area. Nonetheless, all priorities must be addressed in order to restore the Bear Creek watershed to a healthy condition.

Surveyors for Bear Creek:
Ray Lingel
Gene Brown
1197 Kings Peak Road
Whitethorn, CA 95489

JEWETT CREEK

This major tributary of Bear Creek drains more than two square miles. Extensive logjam modification and removal by California Conservation Corps (CCC) crews in 1984 and 1986 has quickened the recovery of this basin, most of which was logged thirty or more years ago. The creek has downcut back to bedrock at many locations in the lower reaches, and recovery of riparian vegetation is excellent on most banks. Salmonids have evidently not recolonized this habitat in any numbers and very few fish were observed during a survey in May, 1988. Electrofishing by DFG might demonstrate large areas of underutilized habitat in this creek, in which case introduction of native silver salmon or steelhead should be considered.

Sr1, Section 2 is the site of a clearcut performed within the last decade. Inspection revealed good regeneration with no major erosion problems. Two current sources of sedimentation were identified.

Rehabilitation Prescriptions

T4S R1E Section 2

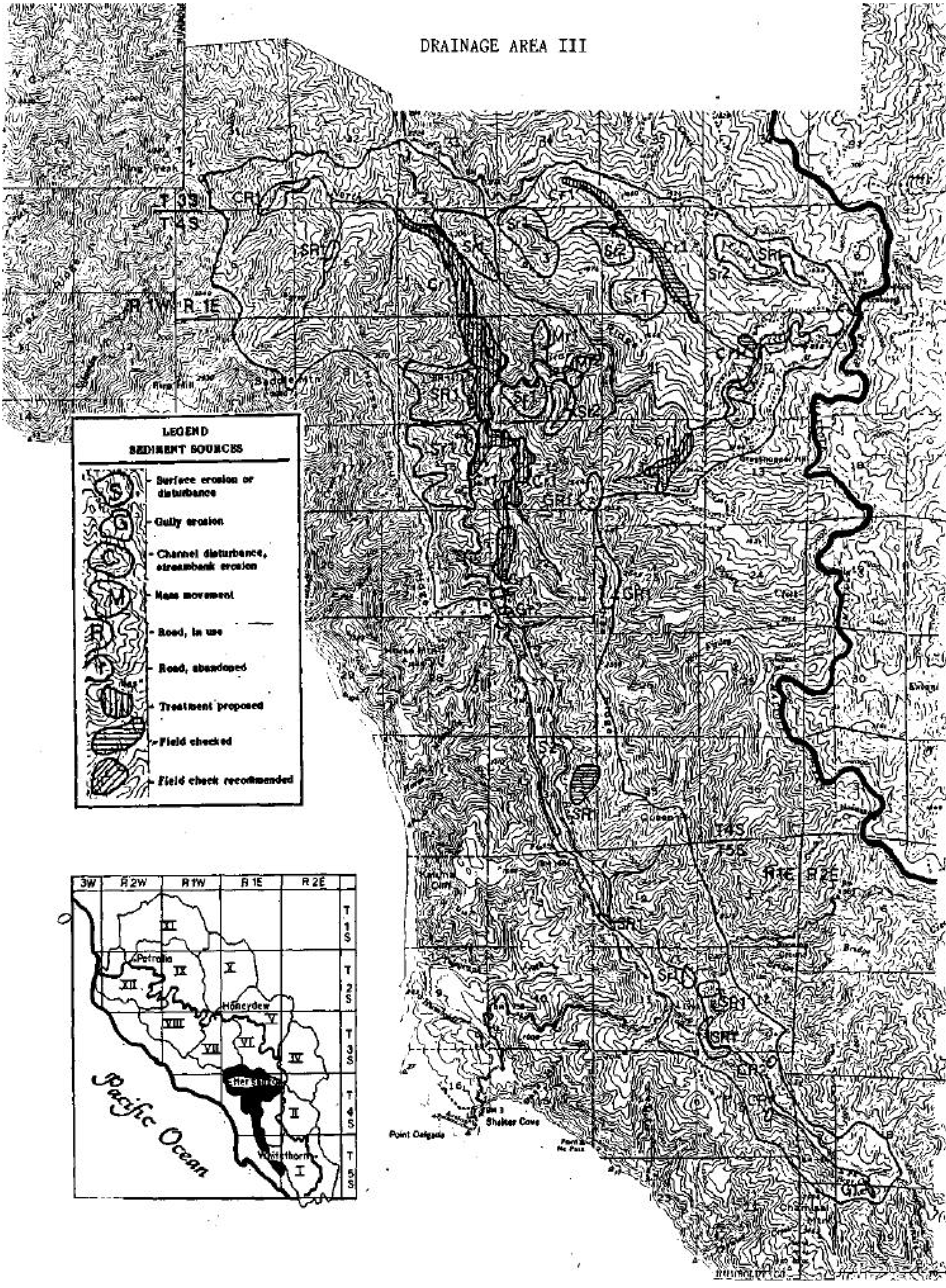
Crl - A collapsed Humboldt crossing drives the creek underground for 100 feet during the dry season. No fish were observed upstream of this point. This crossing should be pulled out of the channel using an excavator if access is available.

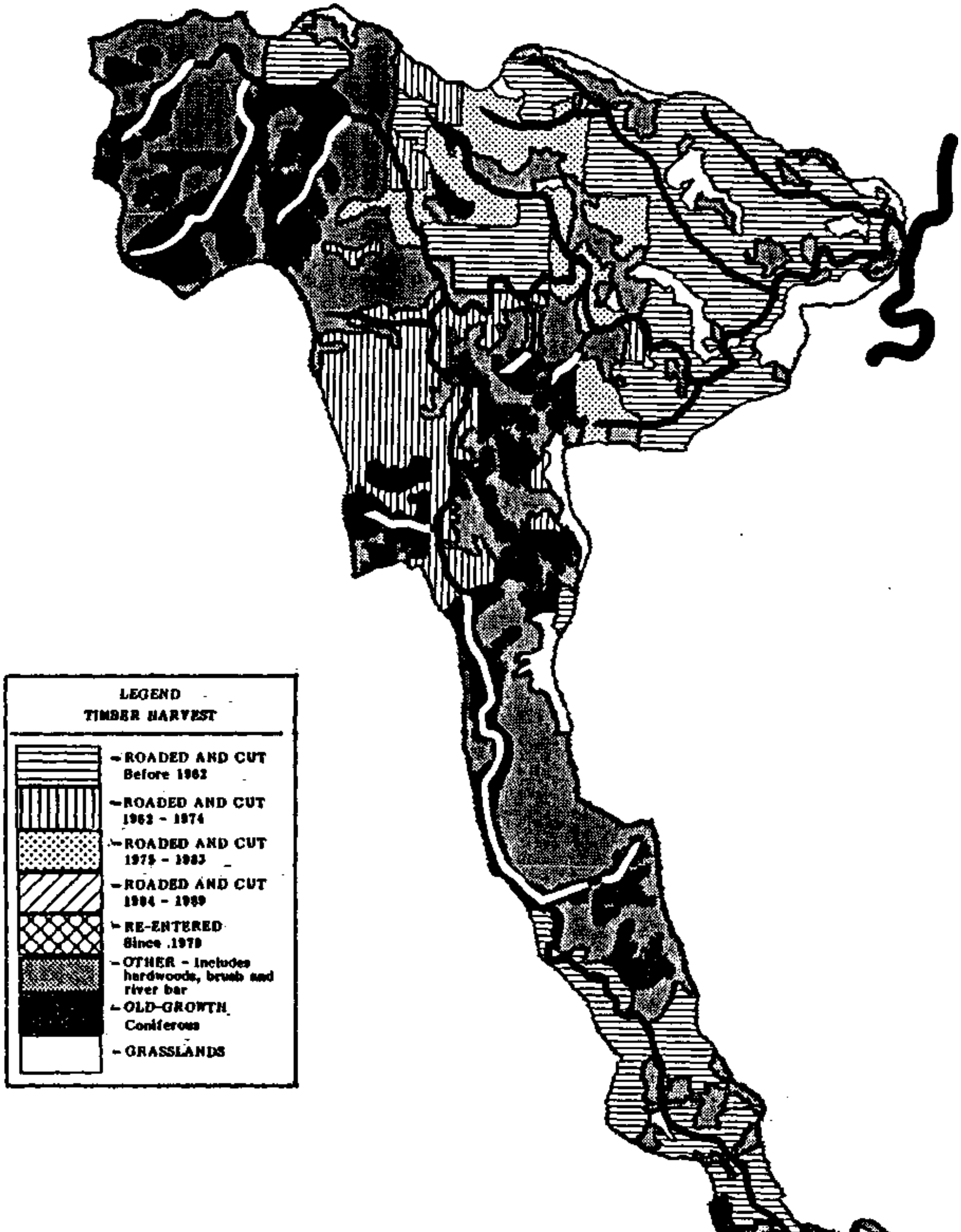
T3S R1E Section 34 & 35

Crl - Five active streambank failures within three quarters of a mile of headwaters. These may be related to the powerline right-of-way between the creek and Wilder Ridge Road, or drainage diverted by new roads recently built across the headwalls of a north fork (Section 35). Woody debris is present on-site in quantities sufficient to armor failing banks.

Surveyor for Jewett Creek:
Rob Grenchfield
2000 Fox Springs Road
Garberville, CA 95440

DRAINAGE AREA III





DRAINAGE AREA III

DRAINAGE AREA IV

Blue Slide Creek
Mattole Canyon Creek
Grindstone Creek

This area along with Drainage Area V is characterized by a rapid rise in elevation, from 500 to 3000 feet above sea level, with inner gorge slopes adjacent to streams having gradients up to 90%. Geological materials tend to be highly fractured sandstone and loosely structured shale rapidly decomposing to clay. Materials of this type are extremely likely to move in mass; sandstone slopes of over 50% are prone to sliding and slumping, and slopes of clay and decomposing shale of over 25% are prone to rotational sliding when saturated with water. These creeks would probably be significant contributors of sediment to the Mattole system with no human disturbance. The majority of forests in this drainage were cut prior to 1962, and most of the rest between 1963 and 1973. Small amounts of logging have been conducted since 1973, and none since 1984. Roads cut for the purpose of timber harvesting, and then abandoned, have disrupted natural drainages and exacerbated the natural instability of these slopes. Although most creeks are downcutting at this time, indicating that the drainages are advancing in the healing process, this drainage area, along with Drainage Area V, continues to be the heaviest contributor of sediment to the Mattole. This factor should be included in all considerations of prioritization of rehabilitation jobs.

BLUE SLIDE CREEK

Three general areas of Blue Slide Creek were surveyed for erosion problems. Area I is associated with an active access road (the Mattole side of China Creek Road). Area II is a perennial tributary (Fire Creek). Area III is in the lower mainstem, one-half to one mile from its confluence with the Mattole River. All three areas were logged in the fifties and sixties, and burned by wildfire in 1970.

Rehabilitation Prescriptions

T4S R2E Section 9 - Area I

Area I has three major sources of sedimentation and many smaller ones; all are active and treatable. Access is available. Many bare areas are found along the roadcut and need broadcast seeding and/or mulch. Gullies need checkdams or brush sediment traps. Some instream channel work and armoring of slide toes would be effective. Inappropriate road maintenance with heavy equipment needs to be addressed. Some steelhead have been observed in Area I, but in general salmonid habitat is poor.

MR1 - An access road crosses an active earthflow with springs. The toe of the slide is in the creek. Armor the toe with onsite rock and woody debris, and redivert waterflow into appropriate drainages.
M2 - A one-half acre deep-seated slide is more than half stabilized with new vegetation. There is a significant amount of potential for further movement. Armor the toe with onsite materials, dewater, and revegetate.
SR1 - A solid berm captures runoff from the road and creates a debris torrent. The berm should be broken and the road waterbarred periodically. The road may need to be redesigned.
CR1 - Many major bank failures are caused by diversion due to aggradation and woody debris. Modify or move debris that is diverting flow; bring in rock for bank armoring; revegetate with willow.

T4S R2E Section 4 - Area II

Area II comprises Fire Creek, a perennial tributary of Blue Slide. The slopes are very active naturally, with four large earthflows identified in the lower two miles of the watershed. Homestead access roads traverse the slopes near both ridgelines; some of these homesteads are occupied by members of the Fire Creek Watershed Association, a member group of the MRC. A good deal of stream and upslope rehabilitation work has already been accomplished by this group. The area has had extraordinary land use pressures put on it. Completely logged before 1962, an earthen dam was built near its headwaters to provide recreation for a proposed vacation home development. The failure of the dam in the flood of 1964 created a debris torrent that scoured the entire length of the stream, leaving raw slopes which were tending to slide into the creek *before* they were denuded. Just as vegetative recovery was becoming established, an extremely hot fire swept the area in the summer of 1970, stripping the slopes once more.

Rehabilitation efforts by residents have been labor intensive and site specific. Success has been variable from site to site. Comprehensive planning for the rehabilitation of this drainage would find effective practitioners. Surveyors have identified areas that would respond positively to micro drainage stabilization upslope, gully brush sediment traps, upslope reforestation, broadcast seeding and mulching, riparian revegetation with local stock, and armoring of channels and toes of slides with locally available rock and woody debris.

Gr2 - Skid road perpendicular to slope has captured runoff to form a large gully which is still eroding headward. Armor headcut, and revegetate with drought resistant species.
Cr1 - A logjam is diverting flow into streambanks. Modify the logjam and use the materials to armor banks. Some revegetation is indicated.
Mr2 - A five acre slide with springs has the toe undercut by a bend in stream, and is crossed by a road. Dewater, armor the toe, and revegetate.
Gr1 - This represents a large gully system that is very active. Although there is no access by road to this site, local residents have performed some rehabilitation and revegetation work. The effectiveness of this work is unknown. It needs additional revegetation, probably by broadcast seeding of drought-resistant species.
Mr1 - A twenty acre earthflow is crossed by a road. Armor the toe and revegetate.
M3 - This is a seven acre earthflow into a creek. Rehabilitation has been started with tree planting and channel armoring. This area needs more seed, mulch, and seedlings.

T3S R2E Section 33
Crl - In this headwaters area, the channel has been used as a skid road, and there are other crossings. There is a very active streambank failure due to aggradation. Normal riparian species are not present. The introduction of alder and willow here might provide seed source for areas downstream.

T4S R2E Section 5 - Area III

This area represents the lower mainstem of Blue Slide Creek. These grassland earthflows undercut by the outside of oxbow turns in the creek present massive and difficult erosion control problems. This area presents both the best salmonid habitat in the drainage and the largest potential for introduction of sediment on a large scale, largely due to natural geological formations. This challenging area should receive further study before large investments are made. Southern exposure and likelihood of heavy sod make tree planting difficult but not impossible. Scalping can be effective in eliminating competition from grasses, and this could prove an interesting area to experiment with seral plantings over time and/or sunscreens should geologists advise that tree planting can contribute to stability here. Other possible treatments to be considered: Broadcast seed and mulch, rock or gabion riprap, armoring to prevent undercutting with cribwalls or revetments, debris traps, and sediment basins.
Gr1 - This large active gully system would benefit from rock armoring.

Surveyors for Blue Slide Creek:
Lary Carpenter
Michael Courson
P.O. Box 1502
Redway, CA 95560

MATTOLE CANYON CREEK

Mattole Canyon Creek offers one of the most extreme examples of cumulative effects resulting from logging and roadbuilding on steep and fragile slopes. Nearly the entire length of the mainstem has had its sediment transport and storage capacity exceeded over and over again in the last thirty years. The result has been a braided and unstable channel diverted and rediverted into the steep banks of the inner gorges, under cutting the toes of slopes and causing further massive landslides. Mile-long stretches of the slopes adjacent to mainstem channels remain raw and active. In the winter of 1981 alone, two road related landslides contributed enough sediment to fill in most pools and choke spawning gravels the length of the mainstem channel. King salmon observed in the middle reaches of the creek in the early winter of 1981 suffered nearly complete destruction of redds.

The delta at the mouth of Mattole Canyon Creek has nearly doubled in width over the last forty years to its current span of 500 feet. The delta has intruded into the Mattole River channel, forcing the river channel against the opposite bank. Hydrologist Richard LaVen observed in 1986 a condition here that has become typical of several larger tributary channels in the Mattole River system. As the aggraded channel upstream of the delta begins to downcut, additional sediment is deposited near the mouth of the delta, decreasing the gradient. As the gradient flattens out, the stream loses energy sufficient to the task of moving sediment out of the delta and into the Mattole River, especially when the river is running full. This results in a "perched channel" configuration, with the delta of the tributary creek gradually gaining elevation over the channel of the river.

Gil Gregori, a landowner and resident of the Mattole Canyon Creek drainage, has assumed the long range goal of enhancing the recovery of the creek's delta through a biotechnical approach which has included the planting of 15-20,000 willows and alders, the construction of several rock groins, or wing dams, and various methods of bank armoring. These measures all function to force the flow of the creek into a more concentrated channel, increasing the sediment transport capacity of the water. The groins, put in place in 1986 as part of a CFIP project, have the additional function of providing more "sediment storage compartments" in the delta area. The location of the braided channel has varied in the dry winters between 1986 and 1989, and the flow has "missed" some of the expensive groins intended for its containment. For this reason, Gregori feels that the vegetative approach has been more cost effective than the structural approach, as the channel has continued to downcut and perhaps stabilize itself near the alder plantations. It should be noted, however, that the structures have yet to be tested by the full channel which will result from a ten or twenty year storm event.

The Doodyville Road Association is one of the largest road maintenance associations in the region, serving thirty-five to seventy families.

This creek should have a high priority for additional rehabilitation work based on its very high contribution of sediment, on its king salmon habitat, and on the presence of cooperative landowners. Private donations have been pledged to the MRC for use in project development in Mattole Canyon Creek.

Mapping for Mattole Canyon Creek:
Randall Stemler c/o MRC

GRINDSTONE CREEK

This steep creek drains Gilham Butte, and some of its headwaters slopes are stabilized by significant stands of old-growth, which are administered by BLM. Road related mass wasting and gullying are common on slopes of over 5596. Many massive log jams remain in the channel and act as sediment traps for the large amounts of earthen materials entering the stream. Some of these jams also buttress active debris slides on the slopes adjacent to the channels. These jams have the effect of restricting salmonid use of Grindstone Creek to the lowest one quarter mile (as of 1983). Spawning king salmon were observed in this reach in 1981. Because of sediment storage basins created by the jams, the contribution of sediment from Grindstone Creek to the mainstem of the Mattole is moderate.

This creek did not receive field inspection in the course of this survey due to budgetary constraints. However, 8.5 miles of its channels were surveyed on foot by Jerry Kreger during the 1981-83 surveys for salmonid habitat by Coastal Headwaters Association.

Kreger, a forest engineer, has since left the area, but while residing here exemplified a model resident's passion for erosion control and stream rehabilitation. He was personally responsible for 160 acres of streambanks being seeded with alder, and 720 acres of mass wasting seeded with coyote brush and white-thorn. It should also be noted that two large landowners in the area, Robert Stansberry and Lee French, have indicated an interest in seeing rehab work done on this creek. This combination of factors (extreme aggradation, islands of old-growth stability, previous revegetation work, use by salmonids, likelihood of current landowner cooperation) make this creek an attractive candidate for project development.

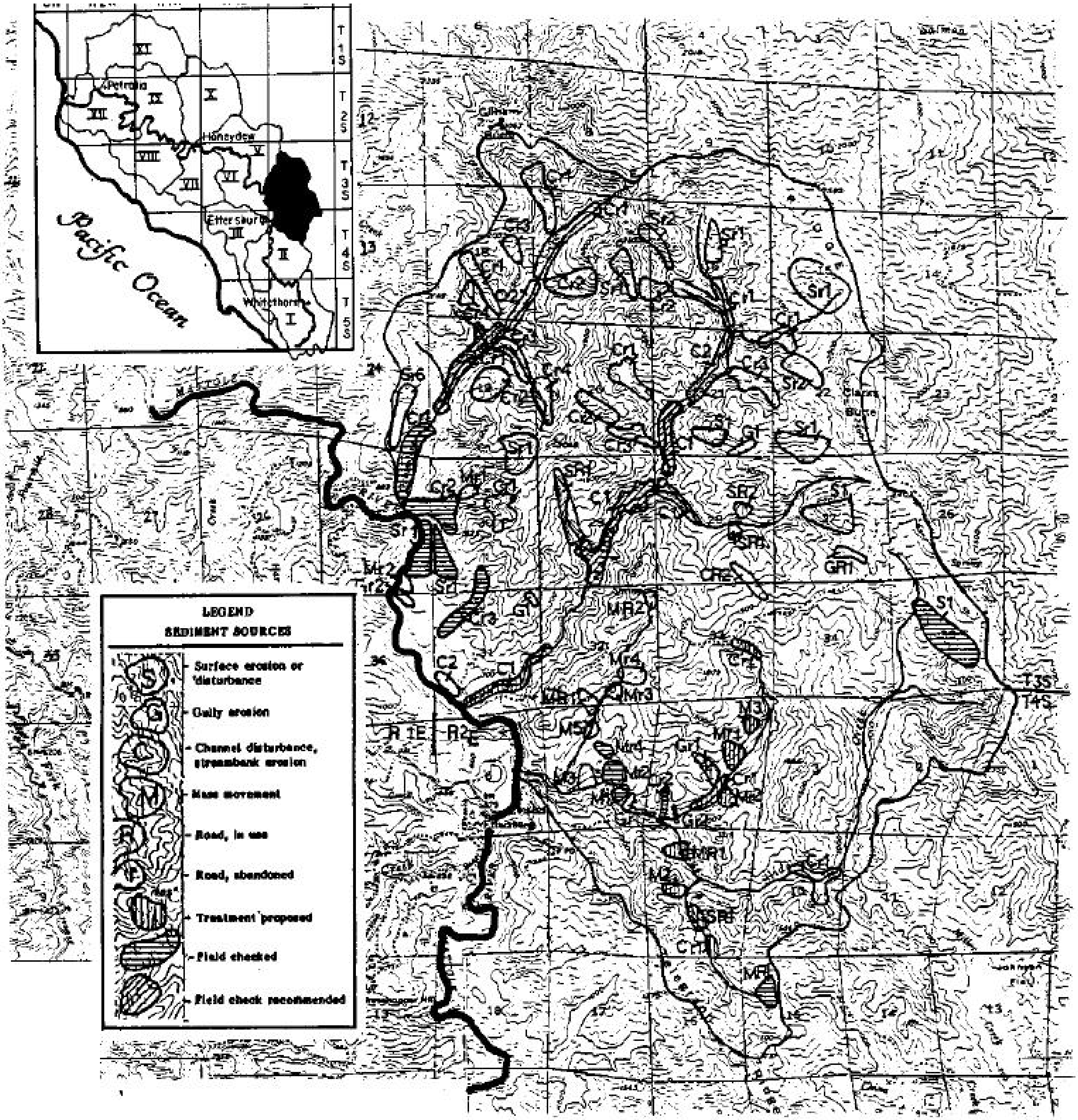
Rehabilitation Prescriptions

T3S R2E Sections 17, 18, & 19

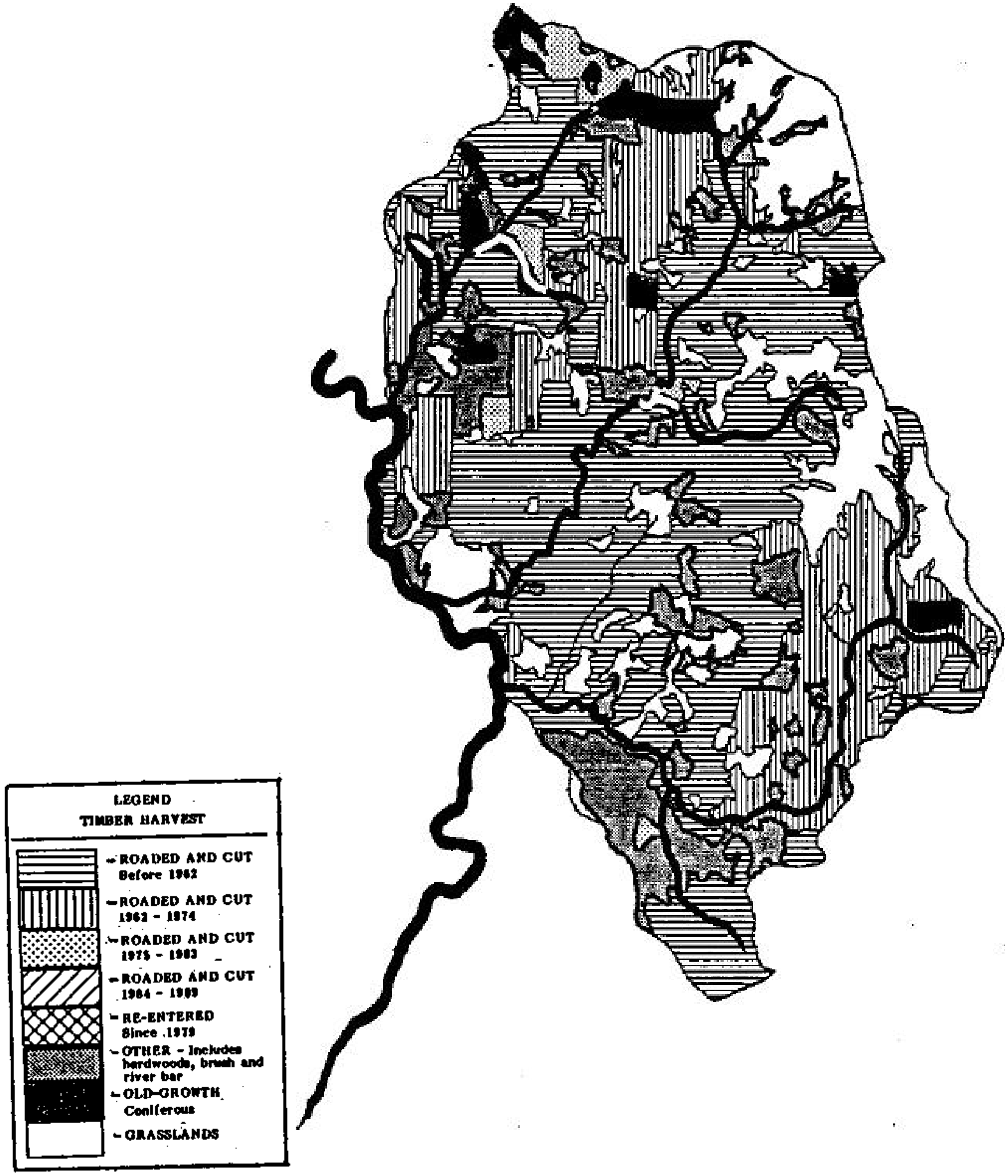
Kreger recommended in 1982 that the logjams not be removed, as disturbance of the jams would release massive amounts of sediment into the system, and might cause increased landsliding on slopes adjacent to the streams. He further recommended revegetation of stored sediment areas behind the jams and of slide areas adjacent to streams. Due to the remoteness of much of this area, revegetation might be most effectively accomplished through broadcast seeding of whitethorn, Baccharis, alder, and maple.

Much of the Grindstone Creek watershed would be eligible for work under the California Forest Improvement Project (CFIP) program, as it was logged before replanting was required by law.

Mapping for Grindstone Creek:
Janet Morrison
c/o MRC



DRAINAGE AREA IV



DRAINAGE AREA IV

DRAINAGE AREA V

Gilham Creek
Westlund Creek
Middle Creek
Dry Creek
Honeydew Slide

GILHAM CREEK

Gilham Creek received no field inspection due to budgetary constraints, but several factors make it a high priority candidate for further survey and potential treatment. Gilham Creek flows off Gilham Butte, which has recently become a part of anew Old-Growth Reserve System, under a recent Bureau Of Land Management (BLM) Area Plan. In addition to the contiguous Gilham Butte Area (1,320 acres) which forms the headwaters of Gilham and several other Mattole creeks, a number of scattered parcels of old-growth are included in the Gilham Butte management area. Approximately 150 acres of this non- contiguous Gilham Butte forest lies within the Gilham Creek watershed, and its future disposition (along with other scattered parcels) is unknown. There is a known predisposition among BLM managers for disposal of these parcels, as they are difficult and unwieldy to manage. In terms of both the stability of the Gilham Creek watershed and the survival of the area's old-growth dependent wildlife species, these scattered parcels may become important. BLM will make critical decisions concerning these scattered parcels in 1992 or 1993, when an Activities Plan for the Gilham Butte Area will be subject to public review. We recommend that further field surveys in this drainage be carried out before that time, and that erosion problems there be examined in terms of both their likely response to treatment, and the likelihood of their effect on undisturbed areas.

Aerial photographs show the remnants of old-growth in the Gilham Creek drainage to be islands of stability in an otherwise seriously damaged watershed. Most of the area was logged in 1964, and a great deal of bare soil was exposed to the torrential rains that produced the epochal flood that winter. Because of the unfortunate timing, the scale of the damage was extreme, and healing has proceeded more slowly than in some other areas. Inner gorges of even Class II streams are still denuded and active, and numerous skid roads are still unvegetated. Skid roads often offer the only flat partially shaded terrain after timber harvest, and as such they are usually favorite locations for natural revegetation by Douglas-fir. The absence of vegetation after twenty-five years makes it seem likely that the roads have disrupted and concentrated natural drainages and in some cases become wintertime torrents themselves. Several areas of this sort have been selected as target survey sites in this watershed. Most of this watershed not under federal management is managed by a single cooperative landowner.

T3S R1E Section 13

Sri 4 Sr2 - Walk drainages from ridgeline down to creek, noting skid road crossings and disruption of drainage patterns.

T3S R1E Section 11
Cr2 - One quarter mile of channel here is a major contributor of sediment to mainstem. Check heads and toes of slides for dewatering and armoring possibilities; check roads upslope for disruption of drainages.

Mapping for Gilham Creek:
Janet Morrison
c/o MRC

WESTLUND CREEK

There are relatively few disturbances requiring treatment in this watershed, but those that do exist are large, remote, and tend to be of difficult access. Most are located in headwaters areas, restricting use by spawning salmonids and contributing to sediment loads downstream. Several are located on commercial timberland owned by Eel River Sawmills, and are in the proximity of some large stands of commercial old-growth timber. These stands are, in turn, part of the Gilham Butte forest, most of which is managed by the BLM, and which recently has been given the administrative status of Research Natural Areas/Areas of Critical Environmental Concern as part of a newly established Old-Growth Reserve System. The BLM has also made it a priority to purchase lands in this area.

The remoteness and size of these disturbances will make any treatment costly; the steep terrain and high rainfall will increase the tendency of gullies and landslides toward headward erosion into virgin areas. The new interest on the part of BLM in erosion control, and the proven concern on the part of Eel River Sawmills for ecologically sound timber harvesting, plus the existence of a concerned and responsible local community makes imaginative cooperative approaches to these problems a possibility.

Salmonid habitat is improving over the last short period of time with young fish observed in large stretches of the stream. The water temperatures have steadily decreased over the last ten years due to increased shading by alders in the riparian zone. This recovery is related to the fact that almost no logging has occurred in the basin in the last twenty years, and the runoff levels during the winters since 1983-84 have been quite low, which allows for the establishment of larger streamside vegetation.

A long homestead access road is in use on the ridgeline between Middle and Westlund Creeks. Many small problems were observed, for the most part resulting in low sediment yield well distributed. There is no reason not to expect residents to continue their generally high quality of maintenance work on this road.

Unusually good base data on the lower mainstem of Westlund Creek is available in the form of Department of Fish & Game surveys performed in 1963 and 1965. The stream was evidently much improved as salmonid habitat when the flood of 1964 flushed out sediments and logjams left behind by logging which occurred before the flood. (These DFG reports are on file at the MRC office.)

Rehabilitation Prescriptions

T2S R2E Section 31

(Work in this section is highest priority in Westlund Creek)

Grl - This is a one and one half acre gully that is downcutting and eroding headward. It has good roaded access. Dewater by waterbarring skid trails; plant, seed, and mulch.

Crl - This disturbance consists of eight acres of choked and active channel producing very large contributions of sediment due to diversion against banks. The channel is downcutting, and there are many incipient bank failures. Some are large. Very little riparian vegetation is present. Large amounts of material are available for structures and armoring. Young fish were observed directly downstream on 10/25/88. Funding for project development is recommended.

Cr2 - One-half mile of channel needs bank armoring and logjam modification.

T3S R2E Section 6

Cr2 - One-half mile of channel in a steep canyon that is draining Gilham Butte, is storing large amounts of sediment behind buried logs. Sediment storage capacity has been exceeded so that the stream is whiplashing and causing additional bank failures. No vegetation here is more advanced than horsetail & fern. Bank armoring and revegetation are required, but the site is very remote. The closest road is three-quarters of a mile distant.

T3S R1E Section 1

Crl - A three-quarter mile section of a channel draining Gilham Butte has multiple log jams contributing to one-half mile of continuous bank failure. Modify logjams. Use local materials to armor banks and define channel; and revegetate with alder, coyote brush, Douglas-fir, and madrone.

Mr3 - The toe of this one acre slide is being undercut by the creek due to a logjam diversion. Modify the jam, and use woody debris to armor the toe of the slide. Plant with alder at waterline, Douglas-fir and coyote brush upslope. Excellent salmonid habitat makes this site high priority for work. Access is available and the landowner cooperative.

GR2 - This seven acre gully originated from a plugged culvert. The gully is no longer active but its banks are oversteepened. It would not be advisable to slough the banks due to large trees at the lip of the gully. Broadcast coyote brush seed, plant Douglas-fir on protected shelves. Owner cost-sharing is likely.

T3S R1E Section 2
Crl - This is a severely aggraded channel due to mass movements and associated cumulative streambank failures. Skidroads and disrupted microdrainages upslope need to be inspected for contribution of sediment. Bank armoring with logs and rootwads available locally will make upslope revegetation with coyote brush and Douglas-fir possible. Riparian planting with alder and willow also is indicated. Landowner cooperation and good access both exist. Assessment for project development is recommended.

Surveyor for Westlund Creek:
Mark Chesebro
P.O. Box 265
Scotia, CA 95565

MIDDLE CREEK

Nowhere is the cycle of channel aggradation and degradation more visually apparent than in the mainstems of Middle and Dry Creeks. Here one can observe twenty foot deep deposits of silt and cobble through which the creek has carved its way back down toward bedrock again, the whole process occuring in the last forty years. These are steep creeks in steep canyons; Dry Creek in three miles drops from 3100 feet above sea level to just under 500 feet. All this sediment moving through has produced at the mouth of Middle Creek a dramatic alluvial fan of thirty acres or more. This delta has forced the Mattole against its opposite southern bank and aggravated another twenty acre mass movement there. Historically, these creeks have produced sediment out of proportion to their drainage area. Drainage Areas V and VI, the "canyon creeks," remain today the heaviest contributors of sediment of all drainage areas in the Mattole River system.

The lower reaches and slopes of the Middle Creek watershed require additional study to determine the reasons for the anomalous lack of revegetation in some areas. These areas were logged in the late fifties, burned by wildfire in the seventies, after which they were re-entered and salvage logged for seed trees. Operators often cut a disproportionate amount of roads compared to timber salvaged; no post-harvest correctives were put in place, and the resulting water diversion, gullying, and mass wasting have been particularly severe.

DRY CREEK

Further field study should occur on the East Fork of Dry Creek. Access was not available at the time of the survey.

Rehabilitation Prescriptions

T2S R1E Section 28
CR1 - This eight acre complex gully system is eroding headward and undercutting the county road. Humboldt County has installed a complex drainage diversion system which makes it difficult to ascertain origins of gullies. The new drainage system is causing further gullying downhill, and disturbed groundwater systems have slowed recovery of large gullies. This section of road needs further assessment by county road engineers to determine appropriate system of culvert placement. Headcut and sides of gullies should be sloughed and planted with harsh-site species such as Bacchoris and gooseberry. Ceanothus seedlings would be practical at some sites.

GR3 - A culvert under the county road has been misplaced fifty feet downhill of the natural drainage and its outfall has created a 10' x 6' gully on private property several hundred feet long. The County should reposition the culvert in the natural drainage and, in general, inspect this section of the Honeydew-Bull Creek Road for similar problems.

T2S R1E Section 33
CR1 - This is a very large bank failure due to creek diversion from large logs and other debris. Logs currently diverting stream could be used to construct cribwalls below raw banks. Good access for heavy equipment exists here. Further inspection should occur for other diversion problems upstream, and for potential of the road to deliver sediment at the downstream end of the disturbance. Revegetate with alder.

T2S R1E Sections 3 & 4
MR1, CR1 - This three acre mass movement contributes to five acres of disrupted channel immediately downstream, making it the largest contributor of sediment in the lowest one mile of the mainstem of Dry Creek. The lower three-quarter mile of Dry Creek is stabilized by old-growth and is the site of excellent salmonid habitat. Deep pools and clean gravels are present here (downstream of the disturbance) and young salmonids were observed in 1988. These factors combine to make this a very high priority rehabilitation site. It is recommended that MRC make project development funds available.

A natural earthflow is indicated here by the presence of scarps, midslope terraces, and bowed trees. This feature was exacerbated in the early 1980's when Eel River Sawmills clearcut this slope. Natural armoring at the toe of the slide is contributing to the restabilization of the creek channel, but the slopes remain 50 to 75% unvegetated. Skid road networks should be investigated for diversion and concentration of runoff. Opportunities for construction of scouring structures downstream should be investigated. This northeast facing inner canyon slope would be an excellent candidate for planting with all stages of vegetational natural succession from wild rye bunchgrass plugs (Elymus glaucus), to coyote brush (Baccharis pilularis), and blueblossom (Ceanothus *thyrsiflorus),* as well as Douglas-fir.

T2S R1E Section 34

SRI - This abandoned road has unculverted crossings and is eroding. It is located upstream from mapping symbol GR1. There is a point on the road where half a day of shovel work could prevent a debris torrent.

Surveyor for Dry Creek:
Bill Bush
P.O. Box 85
Honeydew, CA 95545

HONEYDEW SLIDE

T2S R1E Sections 31 & 32
T3S R1E Sections 5 & 6

M2 - By April 1, 1983, 141.27 inches of rain had been measured in Honeydew for the season, and 112 inches of it had fallen in the previous four months, thoroughly saturating the ground. A relatively small earthquake moving along the Mattole shear zone a mile away was enough to trigger a landslide which involved 375 acres, and delivered 430,000 cubic yards of debris directly into the channel of the Mattole River. The foundations of two dwellings were moved a considerable distance, forcing the owners to evacuate, and the mainstem of the river was temporarily dammed to form a lake more than a mile long and up to thirty feet deep. The river remained partially dammed until two years later, during which time the lake had filled in with silt delivered from upstream, and the channel had relocated to the opposite or south bank of the river. The relocated channel had undercut a large section of "Ab Hill," activating another earthflow which delivered an additional 38,000 cubic yards of material into the river channel.

In 1983, the Mattole Watershed Salmon Support Group (MWSSG) in collaboration with the Department of Fish & Game and the California Department of Forestry andFire Protection developed a contingency plan to move migrating salmon upstream in the event that the slide-related debris prevented their progress upstream to preferred spawning grounds. This proved to be unnecessary, and in 1984 MWSSG proposed to several state agencies treatments of the slide area which included revegetation, channel restabilization, and armoring. Because of the magnitude of the event, and the fact that so little is known about the mechanics of landslides, the Coastal Conservancy funded the local group in 1986 for a study of the rehabilitation needs in the slide area.

Under the inspection of geologists, the area revealed itself to have been the site of previous earth flows, debris torrents, and landslides. Stumps showed that trees were no older than 120 years. Inspection of historical aerial photos also demonstrated a progressive deforestation of the area during the fifties and sixties which no doubt contributed to the later catastrophic event. In 1973, high rainfall had triggered a debris flow of 5,000 to 10,000 cubic yards in the same area as the 1983 event.

The study, led by geologist David Steensen, produced several important observations.

1) The most immediate problem for human settlement posed by the introduction of

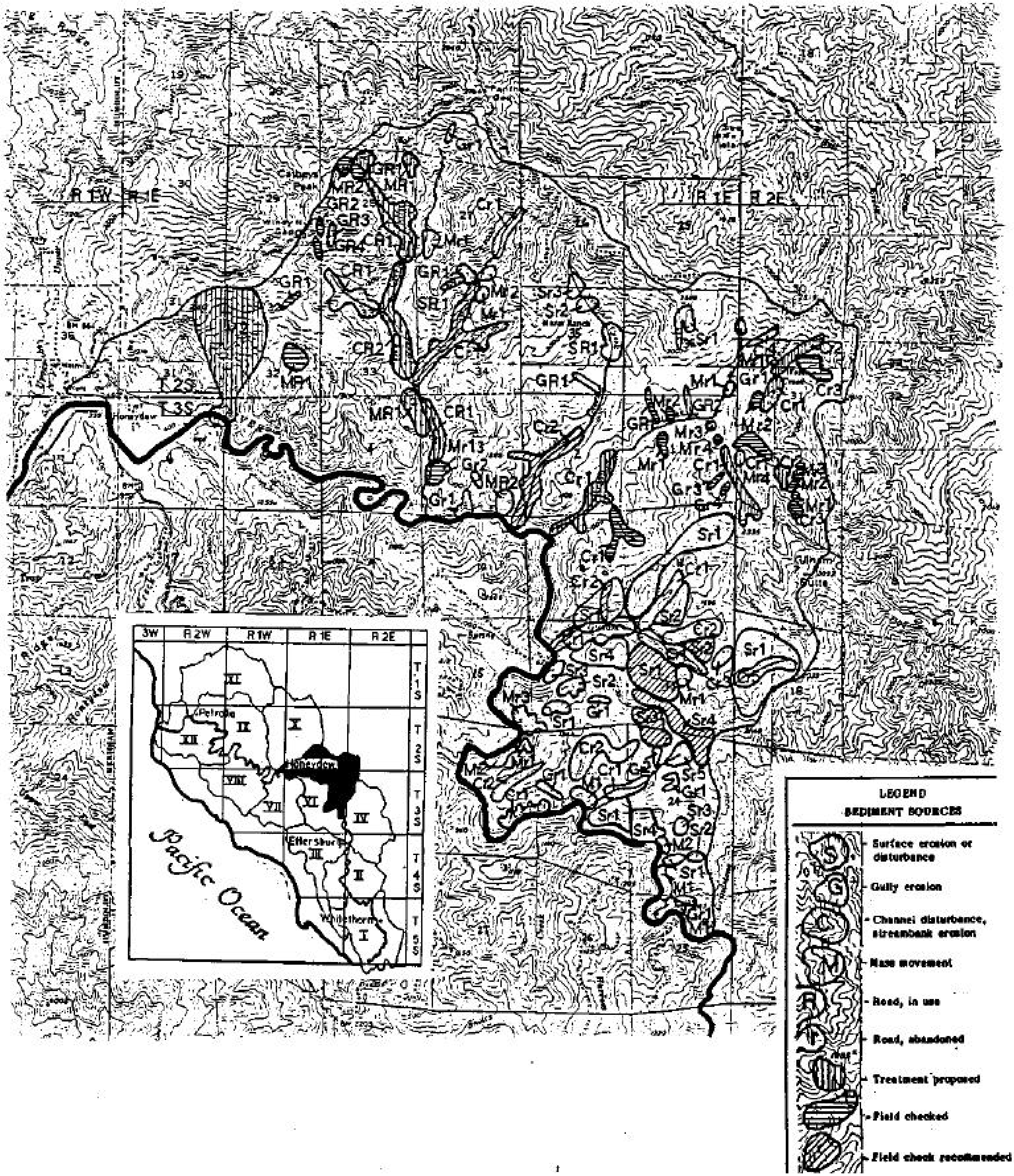
such large amounts of materials into the river is the storage of sediments in the area of alluvial flats with agricultural potential between the slide area and the town of Honeydew. This already aggraded reach has suffered further constriction of its channels and consequent widening of the flood plain. Immediate results include additional problems for fisheries habitat (filled-in pools and riparian vegetation removed), potential flooding of county roads, and increased loss of agricultural lands due to an increased frequency of local flood events. (Before the slide, flooding of these fields occurred during five year storms; since the event, a two year storm can flood this area.) Erosion in this area, of course, will cause additional cumulative effects downstream.

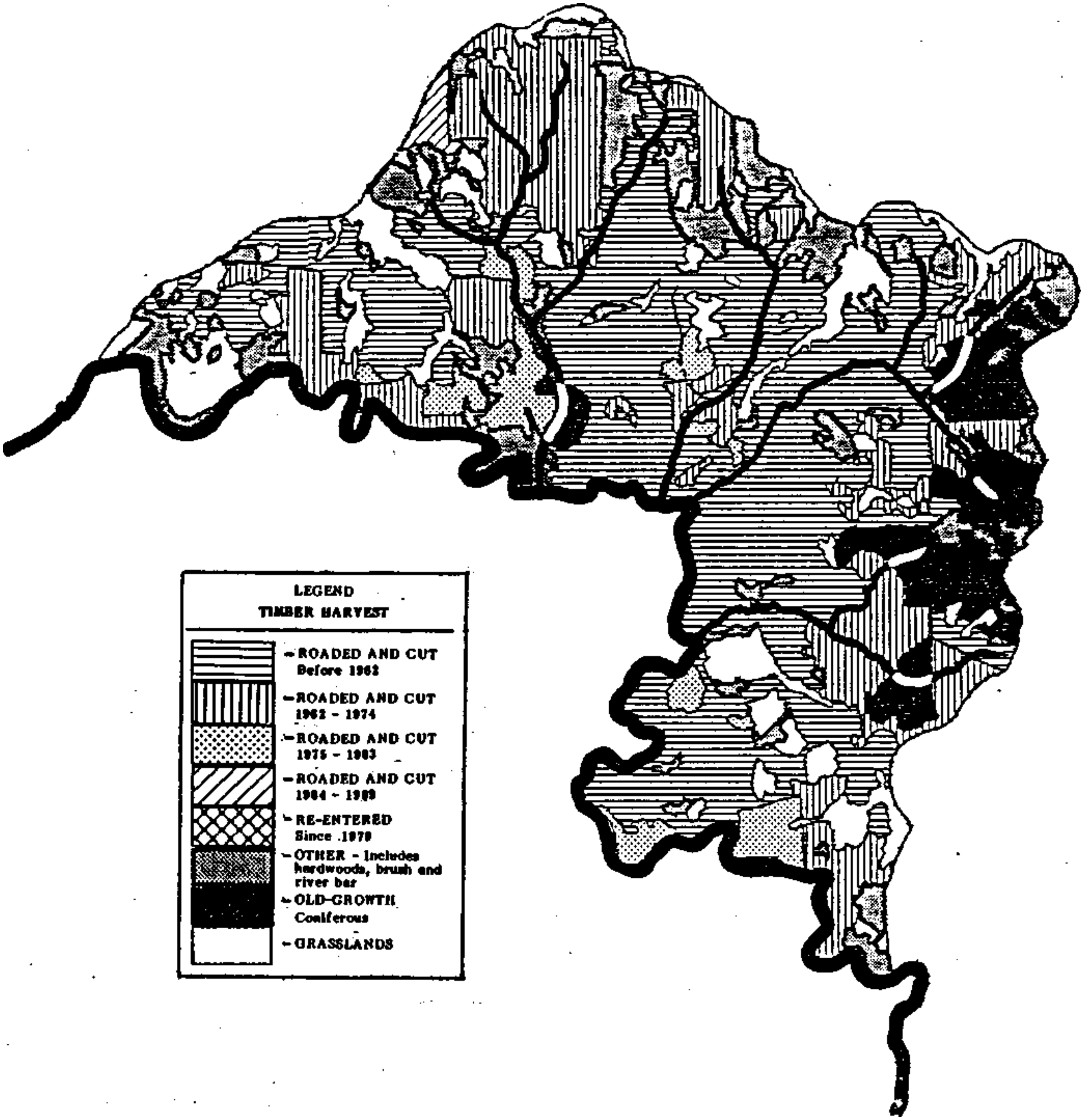
2) The slide surface and the fan at its base appear to be relatively stable, but the relocated river channel has continued to undercut Ab Hill with the result that the entire slope has been destabilized and will eventually enter the river unless prevented, producing further effects downstream.

In 1987 MWSSG developed a proposal aimed at reducing the volume of sediment entering the river in the slide area. The largest part of the budget was to provide for heavy equipment to remove parts of the debris fan so that the river could move more quickly away from the base of Ab Hill and toward its original channel. Some landowners whose access permission was critical were not in agreement with the proposal and the project has not been pursued.

Honeydew Slide Study available from:
MWSSG
Box 188
Petrolia, CA 95558

DRAINAGE AREA V





DRAINAGE AREA V

DRAINAGE AREA VI

Harrow Creek
Shales Creek
Fourmile Creek

HARROW CREEK

A low gradient, low volume stream mostly logged over before 1962, Harrow Creek is well advanced in recovery processes. The lower one quarter mile is used by steelhead, and access beyond this point is blocked by a 20 foot bedrock falls. Modification of logjams in this stretch of habitat might make it available to more salmonids.

Rehabilitation Prescriptions

T3S R1E Section 25
GR1 - Lack of waterbars on upper east fork roads (both abandoned and active) is leading to formation of gullies. Gullies should be dewatered and seeded with brush species. Waterbars should be maintained on roads.

T3S R1E Sections 26 & 35
SRI - (THP 1-86-796 HUM) This is a reentry with partial application of "hardwood management" silvicultural treatment for two hundred acres, and allowance of winter operations. The operation was completed during 1989. The price of hardwood chips for pulp has increased geometrically in the last two years, which has given rise to the increased use of hardwood management timber harvest plans. The hardwood management classification in the California forest practice rules and regulations allows a great deal of discretion to the operator and can result in a *de facto* unregulated clearcut followed by little or no stocking. Until it has been inspected, there is no reason to believe that THP 796 has had this result, but this prescription for THP's will be used more and more and should be monitored to avoid abuse and to gather impetus for new legislation if necessary. The current regulations were written at a time when hardwoods were not considered a commercial species, and their unlikely harvest was left unregulated. It has often been the root strength of hardwoods that has held the fragile slopes of the Mattole in place after commercial harvests of conifers.

SHOLES CREEK

Rehabilitation Prescriptions

T3S R1E Section 33
Crl - A number of access roads were bulldozed and abandoned in 1985 on this already active northfacing slope. Diverted and concentrated microdrainages aggravate mass movement over an area of twenty acres. If active access is still a priority for the landowner, it would be wise to retire all roads but one and to improve that one with culverts and waterbars. The toe of the slide is (as of 1988) anchored with a single line of Douglas-fir, which is also slowing deposition of sediment in the channel. If road problems are treated, barren parts of the toe of the slope should be planted with fast growing vegetation. The south facing slope north of the channel is also naturally active, but dry and sparsely vegetated. Broadcast seed with drought resistant species, i.e. Bacchoris or Whitethorn.

T3S R1E Section 34
Ml - This one acre slump is aggravated by failure of abandoned road upslope. Dewater active slump and restabilize surrounding microdrainages. Access is difficult.

Cr2 - Sidecast roadfill has overweighted the hillside causing debris torrents into the creek two hundred feet down slope. Water diverted by road failure has contributed to formation of two significant gullies. Riparian vegetation is sparse. A logjam is diverting the creek into the south bank, undercutting the toe. The logjam can be modified by burning out the center to reduce its height and allow the creek to concentrate in the center of the channel. Recent downcutting, both up and downstream, would seem to indicate that this reach can accommodate more sediment flushing. Concentrations of water from the failed road should be corrected. The cost of putting a portion of the road to bed should be estimated. The riparian corridor and upslope areas should be planted.

T3S R1E Section 35
Mr2 - This ten acre natural earthflow is largely healed except for gullies caused by road related water diversion near the top. Waterbar the road. Gentle gradients of gullies lend themselves to treatment by brush checkdams.

Ml - A logjam is diverting the creek into the toe of an earthflow, causing this mass movement with the potential of delivering several thousand cubic yards of sediment to the creek. Modify the jam to allow the creek to move away from the toe.

Cl - A logjam has formed a sediment catchment basin fifteen feet deep, and diverted flow against banks in an old-growth area so that two hundred year old trees are being affected and sometimes toppled. The jam blocks upstream migration by salmonids to more than two miles of excellent spawning and rearing habitat. The jam should be modified to allow for fish passage, and cabled in to prevent sudden release of stored sediments. The Department of Fish & Game has approved a contract to treat this log jam and the jam associated with Ml, but has not released funds as of 12/89.

FOURMILE CREEK

This remote and sparsely settled basin drains Wilder Ridge to the east. Headwall and inner gorge areas are steep while the gradient of the creek itself is relatively gentle. Any amount of disturbance can move large amounts of sediment into the channel, where they move through the system very slowly. A relatively large part of this drainage was logged between 1975 and 1984, and the mechanics of large scale disturbance are still very apparent, both on the ground and in 1984 aerial photos.

The "Riel Slide" (Mrl, Sections 20 & 29) which is not apparent on the 1942 aerial photos, is the largest single point source of sediment in the tributary. Covering twelve acres, this slide has delivered more than forty thousand cubic yards of sediment and rubble to the stream channels. Although relatively inactive today, much of its mass is still stored in the south fork of Fourmile Creek, where deposition as much as twenty to forty feet deep can still be seen.

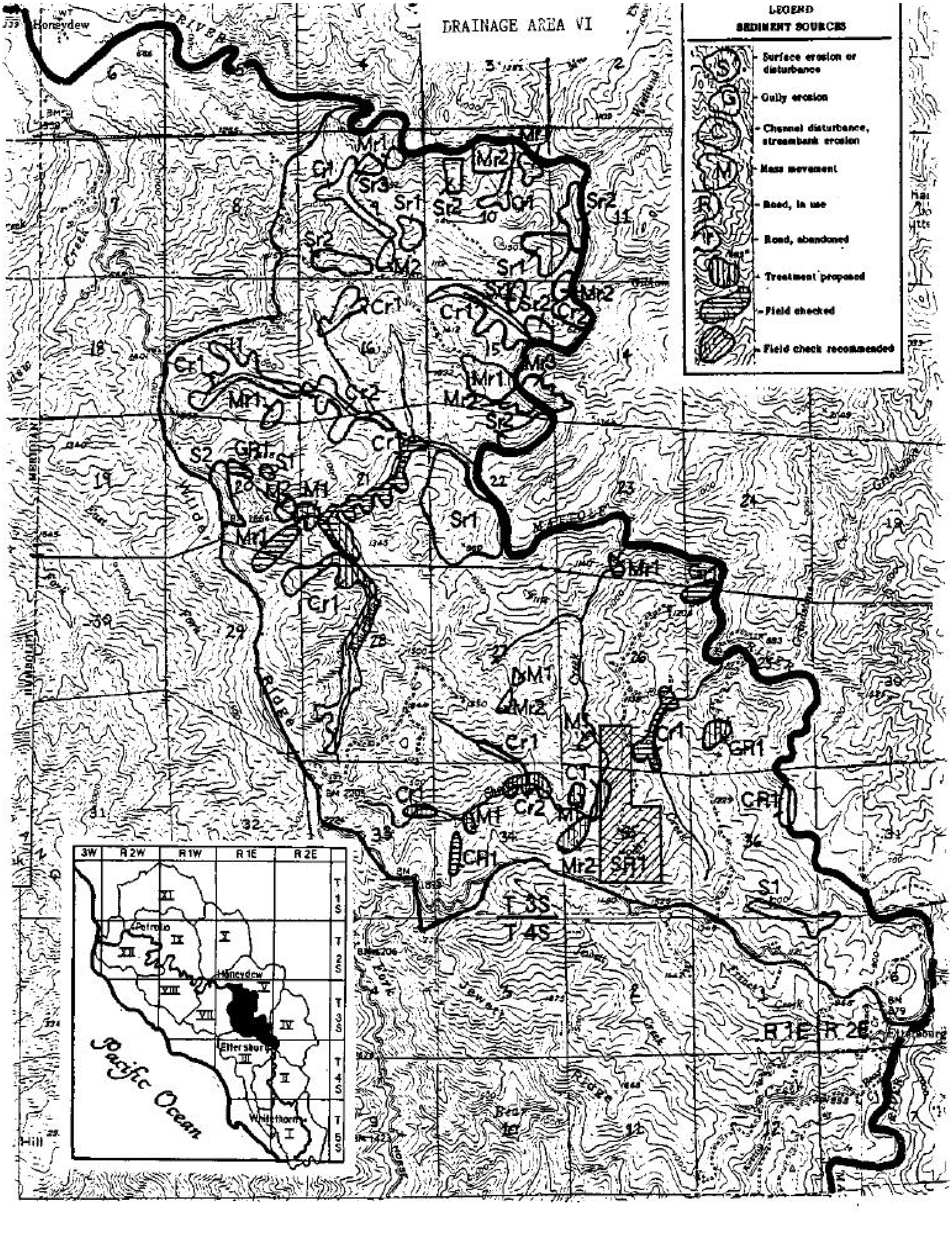
Throughout the southern half of the basin the scars of recent disturbance are apparent— mazes of skid roads, whole small drainages scoured by debris torrents, raw inner gorges, and broad cobbled floodplains with braided channels. In the lower reaches of the mainstem and the south fork, riparian vegetation has shown the same dramatic rate of recovery in the past four years as it has elsewhere in the Mattole.

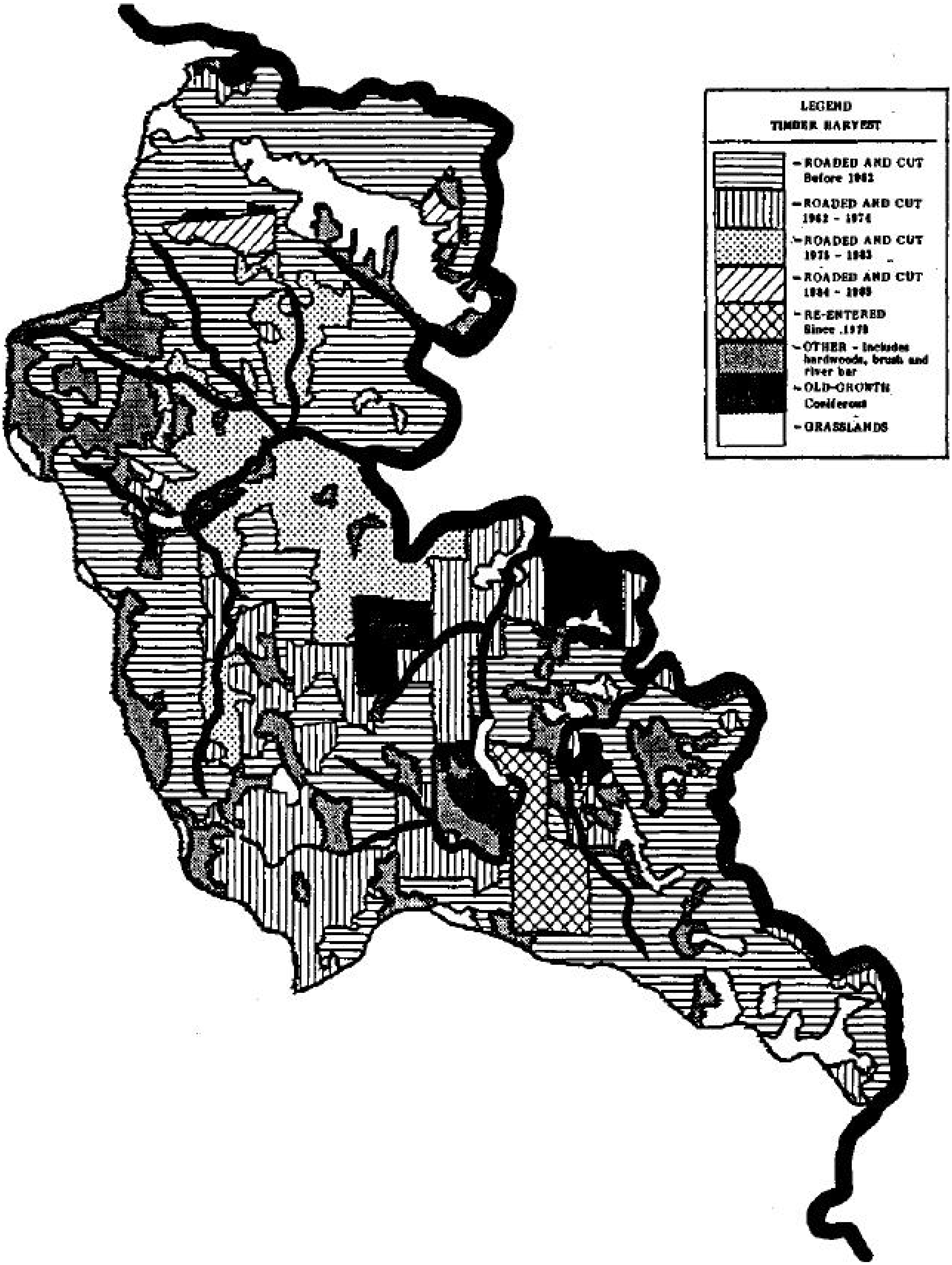
Rehabilitation Prescriptions

T3S R1E Section 21
Ml - Slides on both sides of the channel are adding to deposition from upstream and keeping the channel buried in up to forty feet of sediment, rubble, and debris. The south slope should respond well to planting, but the north slope will be more difficult as the sun rarely reaches it.

T3S R1E Section 28
Crl - This mile-long reach of the south fork is aggraded and beginning to downcut for most of its length. In some cases, earth flows activated by skid roads crossing them on either side of the channel are introducing sediment in quantities greater than are being flushed out. The downstream half of this channel should respond well to planting of riparian species, and possibly to installation of scour structures.

Surveyor for Area VI:
Rob Grenchfield
2000 Fox Springs Road
Garberville, CA 95440


DRAINAGE AREA VI
LEGEND
SEDIMENT SOURCES
Surface erosion or disturbance
Gully erosion
Channel disturbance, streambank erosion
Mass movement
Road, in use
Road, abandoned
Treatment proposed
Field checked
Field check recommended
Honeydew
RIVER
MATTOLE
Ridge
T 3S
T 4S
R 1E
R 2E
Pacific Ocean
Petrolia
Ettersburg
Whitethorn



DRAINAGE AREA VI

DRAINAGE AREA VII

High Prairie Creek
Honeydew Creek
Lower East Fork Honeydew Creek

Nearly all of Drainage Area VII consists of the Honeydew Creek basin. The fourth largest tributary in the Mattole watershed, Honeydew Creek historically was noted for strong runs of king salmon, silver salmon, and steelhead. As in other parts of the Mattole, current runs of salmon are considerably reduced, although healthy populations of steelhead are still in evidence. Previous restoration work in the Honeydew Creek basin includes tree planting in the Bear Trap Creek tributary drainage under Bureau of Land Management (BLM) contracts during 1987 and 1988, fishway construction at the mouth of High Prairie Creek by Coastal Headwaters Association with California Department of Fish and Game and California State Coastal Conservancy funding during 1984 and 1985, and logjam modification work in High Prairie Creek by the California Conservation Corps during 1985.

HIGH PRAIRIE CREEK

High Prairie Creek is a two and a half mile long perennial stream that enters Honeydew Creek from the east one and a half miles above its confluence with the Mattole River. The creek drains an area of about 2.6 square miles. The watershed is situated in rugged mountainous terrain. Nearly all commercial timber was harvested over thirty years ago. A current timber harvest plan has been submitted to the Department of Forestry and Fire Protection (CDF) which would allow reentry to a limited upland portion of the watershed (11/1/89). The county road between Honeydew and Ettersburg crosses High Prairie Creek near its mouth.

Around 1960 a concrete culvert was constructed to allow the creek to pass beneath the road. This culvert prevented adult salmonids from migrating upstream until 1984 when a fish ladder was constructed. In 1986 the California Conservation Corps invested 120 hours of work in log jam modification to help ensure fish passage to the relatively undisturbed north fork of High Prairie Creek.

Preliminary geomorphic analysis by geologist David Burnson reveals the slopes of this watershed to be unstable with hillslope processes of debris slides, block glides, and soil creep occuring naturally. Historically, these processes were in equilibrium with sediment transport. In other words, no more sediment was delivered to the hydrological system than could be flushed through in a relatively short time.

In the late 1950's, roads were pushed across the slopes to allow logging, greatly impacting their equilibrium. Fifty percent of the roads subsequently failed; nearly seventy-five percent experienced "adjustment" and are still seeking equilibrium. The stream channel was overloaded and aggraded in a short period of time, destroying riparian and fisheries habitats. The basin is now in a process of recovery and the stream carries high sediment loads. Treatment will speed the channel's recovery of stability and enhance its fisheries and wildlife habitat, both through riparian plantings, and the use of structures (armoring the toes of slides, and rearranging woody debris so that it buffers sediment discharge, influences the scouring of pools, and controls the drop in stream profile).

T3S R1E Section 7

Crl - As of October 1989, the DFG has contracted the Mattole Restoration Council to "restore historic stream channel geometry, morphology, and hydrology of the lower 3,300 feet of High Prairie Creek ... and to revegetate [the] riparian zone and adjacent slopes." The former will be accomplished with the help of an excavator and a bulldozer. Revegetation will be done using alder, willow, poplar, maple, and Douglas-fir.

HONEYDEW CREEK

The southwestern two-thirds of the Honeydew Creek watershed has been under public management since 1970. It is managed by BLM as part of Zone 7 of the King Range National Conservation Area with the primary use designated as wildlife habitat. The second largest stand of old-growth forest in the entire Mattole protects the headwaters of Honeydew Creek, and over seventeen hundred acres of pristine habitat on the West Fork, the mainstem, and on the Upper East Fork have been given the administrative designation Area of Critical Environmental Concern. Because of these relatively undisturbed headwaters areas, overall habitat conditions are slightly in advance of other Mattole watersheds in their tendency toward recovery. Considering the size of the basin, relatively few active sources of sedimentation have been identified, and rehabilitation efforts here promise to show cost-effective benefits.

Rehabilitation Prescriptions

T3S R1W Section 13

S1 & Crl - This whole slope, lying between the Smith-Etter road and Honeydew Creek and an unnamed tributary of Honeydew Creek on the south, appears to be unstable. Natural movement has been exacerbated through a combination of land use techniques which include improperly drained roads, overgrazing, fire, and some logging. This slope forms a little more than half of a Bureau of Land Management grazing lease known as the Bear Trap Ridge Allotment.

This property was acquired by BLM in 1983. A lease agreement made in 1984 was not picked up by the lessee, and the range has remained inactive since that time. (Personal communication with Robert Walker, BLM, 11/1/89)

Pasture on the northwest side of the ridge appears to be on more stable slopes and does not show the same symptons of soil erosion and mass movement. Portions of this slope were planted with Douglas-fir in 1987 and 1988.

1941 air photos show natural draws on the eastern slope to be stable due to riparian vegetation. Today these draws are denuded and have active gullies with remnants of charred woody debris and stumps. Wildfire burned through this area in 1974.

The Smith-Etter Road crosses this slope near the headwaters of the unnamed tributary to Honeydew Creek to the south, and diverts concentrations of water onto the slope in quantities sufficient to cause active gullying. Correction of this problem may require an 18" culvert with energy dissipation of some sort on the down-stream side.

Slumped and gullied draws should be treated wherever possible without the use of heavy equipment, and mulched and seeded where feasible. There are good sites for the use of native bunch grass plugs. Treatment of the draws will require the continued interruption of grazing for some years while vegetation reestablishes itself. Whether or not grazing should be reintroduced to this slope is a question which should receive careful consideration.

An access road running parallel to Honeydew Creek (a spur of the Smith-Etter Road) crosses an apparently deep-seated mass movement and contributes to a large landslide which flows directly into salmonid habitat in Honeydew Creek. The road tends to blow out at several locations including the mouth of the unnamed tributary each winter. This road was ripped and seeded in 1985-86 by BLM crews. (Personal communication, John Lloyd, BLM)

The use of this road should be discontinued and the feasibility of putting it to bed examined.

The sediment storage capacity of the unnamed tributary south of Honeydew Creek has been exceeded and the creek is choked with woody debris, sometimes forming logjams which divert water against an otherwise stable south bank. The north bank of the creek is failing for most of its length, as the dechannelized creek undercuts the unstable slope. These factors combine to make this drainage a very large contributor of sediment to the Honeydew Creek system. The channel should be resurveyed with an eye toward armoring and scouring structures, modifications of logjams, and revegetation with riparian species. This is a high priority site, to be approached in collaboration with BLM. It should be noted that the allotment lies within a Wilderness Study Area.

T3S R1E Section 7 - Mainstem Honeydew Creek

Cr2 - This is a large and complex system including deep-seated mass movements, earthflows, debris torrents, and gullies. The toe of this mass movement is in the creek, and often undercut by high flows delivering large amounts of debris and sedimentation. This disturbance requires further consultation with a geomorphol-ogist to determine if treatment is feasible.

T3S R1W Section 24 - Dpper East Fork
Crl - (parts in mainstem) Three hundred feet of a vertical sandstone face is undercut at high flows resulting in moderate introduction of sediments. It would benefit from armoring of the toe with on-site materials, followed by riparian planting of alder.

T3S R1W Section 25 - King's Peak Road
Mrl - Cut and fill bank failure, harsh site, poor soil. Broadcast coyote brush seed. Parts of this road are prioritized in BLM erosion control activities for 1990.

LOWER EAST FORK HONEYDEW CREEK

T3S R1E Sections 32, 29, 19
Ml and various streambank erosion sites downstream -

Complex geological processes coupled with intense climatic events have produced a sequence of slides on a small tributary of the Lower East Fork, which is the largest point source of sedimentation in the Honeydew Creek watershed. The disturbed area encompasses nearly forty acres. Geologist David Burnson has identified the slide as a recurrent translation/debris torrent. When the soils at the head of the slide become so saturated that their weight tips the mass/balance equilibrium, debris torrents down the slope and fills the channel gorge to the first natural constriction. According to local residents, the slide failed in 1955 and again in 1964. Geomorphic and vegetal evidence suggest that it also failed about one hundred years ago.

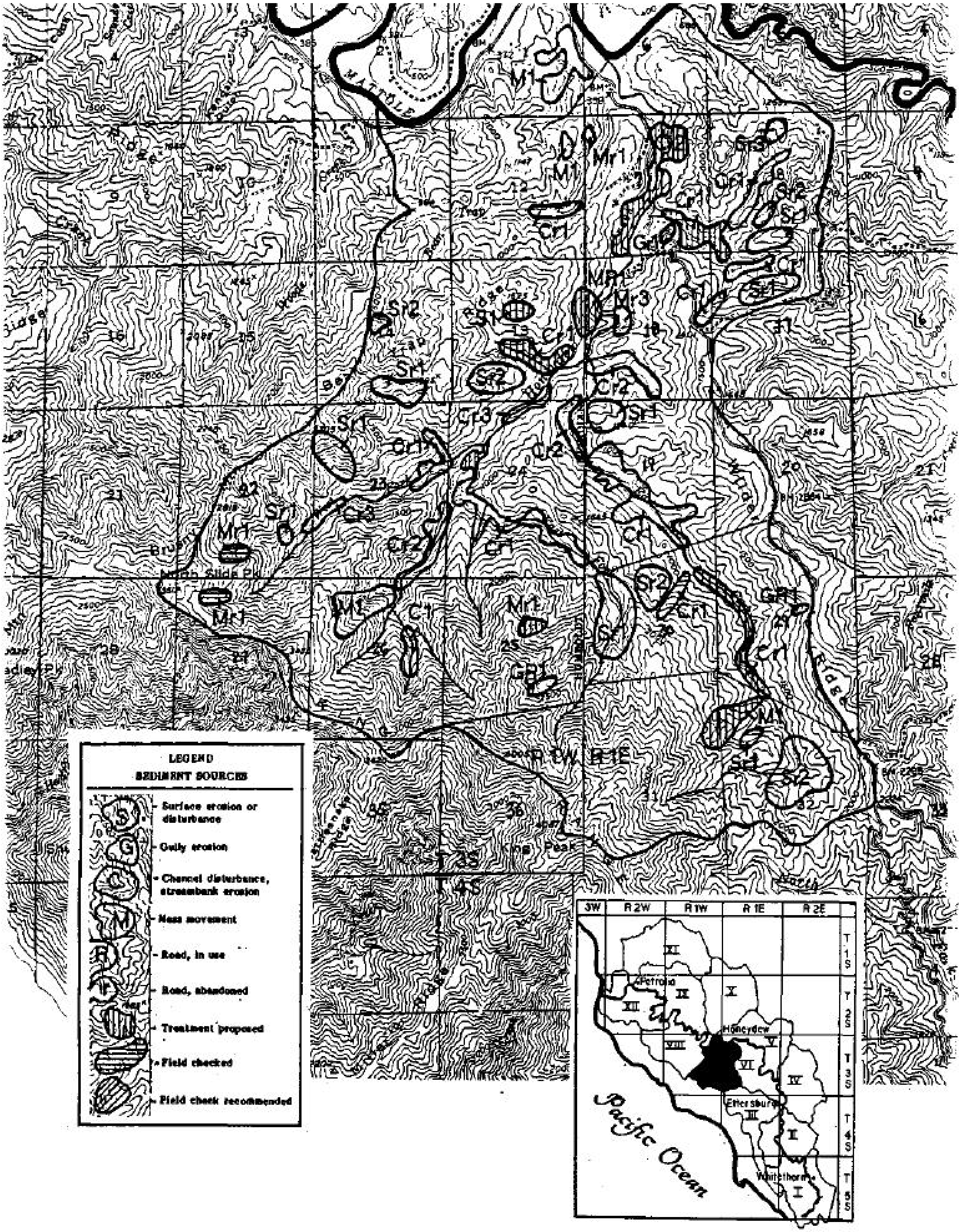
Historically, the stream channel maintained itself against the relatively more stable, less steep eastern bank of the valley, and was capable of storing and effectively transporting slide deposits from the periodic events. According to nearby resident Frank Landergen, the stream maintained its easterly configuration after the 1955 event. Between 1955 and 1964, the upper basin experienced tractor logging. The 1964 debris torrent, swollen and complicated by a massive input of woody debris, plugged the valley and diverted the stream against the unstable, highly erodible west bank, where the channel remains today. This configuration has eroded and oversteepened the western banks, keeping them in a constant state of destabilization and failure. Erosion potential here is estimated to be in excess of eighty thousand cubic yards.

Downstream, the effects of destabilized sediment transport equilibrium are apparent, with an abundance of woody debris in and adjacent to the active channel, extensive areas of streambank failure and scattered debris slides, and poor riparian vegetation. Two large logjams are located at about 1.1 and 1.3 miles above the confluence of the Lower East Fork with Honeydew Creek. The upper jam should be modified for fish passage. Salmonid rearing habitat can be substantially improved by selective cabling of logs and root wads in the active channel.

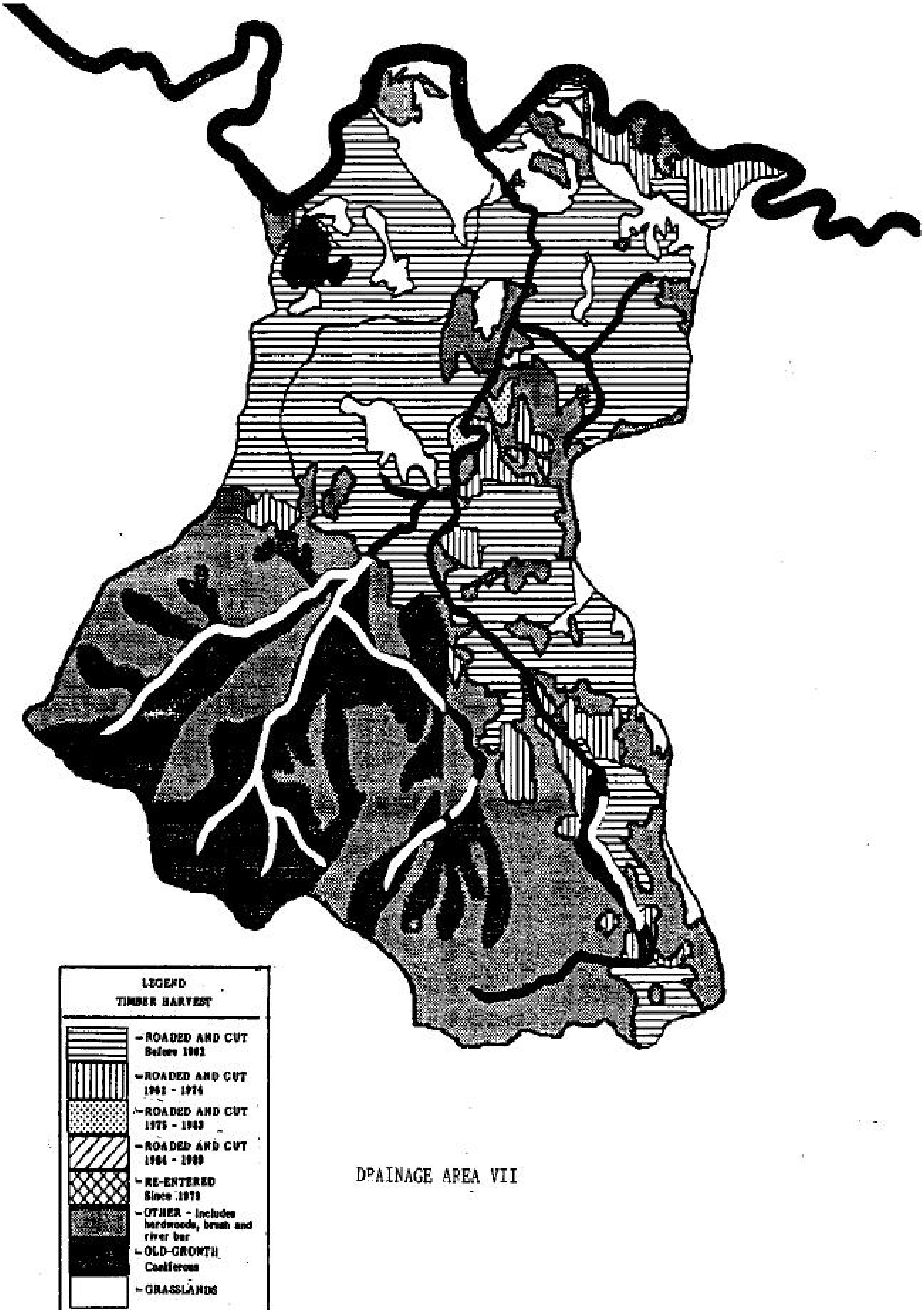
Recommended treatment: Using heavy equipment and on-site materials, stabilize banks of debris torrent channel and realign channel of Lower East Fork to east bank. Modify logjam downstream. Selectively retain large woody debris in channel by securing with cable in lower 1.5 miles of the creek. Revegetate the debris torrent channel area, the west bank, and downstream of the logjams. (Contracts for this work have been awarded to the MRC by DFG as of 10/89.)

Surveyors for Drainage Area VII
Tim Showen
Sue McClatchy
4138 Wilder Ridge Road
Garberville, CA 95440

Gary Peterson
c/o MWSSG
P.O. Box 188
Petrolia, CA 95558



LEGEND
SEDIMENT SOURCES
Surface erosion or disturbance
Gully erosion
Channel disturbance, streambank erosion
Mass movement
Road, in use
Road, abandoned
Treatment proposed
Field checked
Field check recommended
R 2W
R 1E
T 3S
T 4S
King Peak
Pacific Ocean
Petrolia
Honeydew
Ettersburg
Whitethorn



DRAINAGE AREA VII

DRAINAGE AREA VIII

Squaw Creek

SQUAW CREEK

Squaw Creek enters the Mattole River just upstream of A.W. Way county park, about fifteen river miles from the mouth of the Mattole, and about halfway between Petrolia and Honeydew.

The watershed rises from less than two hundred feet elevation at the mouth, to more than thirty-five hundred feet in the headwaters at North Slide Peak, about two miles from the ocean. It is generally steep, forested, mountainous terrain, although extensive grassland along the ridges comprises more than 15% percent of the acreage.

Squaw Creek is the fifth largest tributary of the Mattole, with a drainage area of sixteen square miles. Squaw Creek has more than twenty-five tributaries, ten of which are denoted "blue line" on the U.S.G.S. 7 1/2 minute topographic map for the Shubrick Peak quadrangle.

The main orientation of the creek is in a north/south direction, similar to other creeks in the Mattole that conform to the prevalent geologic formation.

More than 80% of Squaw Creek has been mapped as Hugo (812) soil series, a prevalent forest soil. More than 15% has been mapped as Kneeland (835), a grassland soil; and the remainder has been mapped as Usal (818), a forest soil, May men (872), a brushland soil, and Cahto (877), a woodland soil.

These soil types support a vegetation composition that is largely forestland with a strong grassland component. Over 1650 acres are natural grassland with the bulk of it found along two prominent ridge systems: Cooskie Ridge, with over 100 grassland acres, and Moody Ridge, with over 215 grassland acres.

Of the forestland, the vast majority is tanoak, madrone, Douglas-fir (TMD) stands, and variations with Douglas-fir dominant (DTM). Significant areas are pure stands of tanoak and madrone (TM), and pure stands of Douglas-fir (D), or Douglas-fir and tanoak (DT). Other species composing minor amounts of acreage are canyon live oak, Ceanothus, manzanita, huckleberry, and riparian vegetation such as maple, alder, willow, Pepperwood, and cottonwood.

To describe its geomorphology, Squaw Creek can be roughly divided into three sections. The upper watershed has significant amounts of bedrock channel, riparian forest, and old-growth forest groves. Solar aspect, the steep incised terrain, and riparian shading all make for cool water temperatures and high water quality. The middle section of the watershed has been largely converted from forest to grassland. Here the creek gradient levels out, with wide gravel bars, lack of riparian forest, and more open terrain leading to greater solar exposure and higher water temperatures. In addition, this middle section of Squaw Creek receives greater inputs of sediment from tributaries and slopes, and hillsides are grazed by cattle, which have access to watercourses. The lower section of the watershed along the creek becomes more canyon-like, with steeper bed gradient. The creek displays significant gravel bars, yet has retained a good deal of riparian forest and shade for the creek.

King salmon and steelhead have historically used ten of the eleven Squaw Creek stream length miles. Formerly abundant runs have been reduced to a few seldom-seen spawners. In the early 1980's this drainage was recognized by the Mattole Salmon Group as having underutilized king salmon habitat. Steps were taken to improve the situation by enlisting the assistance of the California Conservation Corps to modify logjams, and with the help of local residents, to install and operate a streamside hatchbox for raising and releasing king salmon fingerlings into Squaw Creek. The 1990 season marks the fifth year of the hatchbox's operation. More than fifty thousand native Mattole king salmon have been released into Squaw Creek through this program.

Every tributary of Squaw Creek has been damaged by accelerated erosion and sedimentation from timbering and related road construction. Sediment from the ridges and hillslopes of Squaw Creek now chokes the channels and causes peak water flows to jump out of the channel and eat away at the slopes, further triggering streambank failures and resultant cumulative impacts.

Historically, land ownership in Squaw Creek was mainly limited to a few ranching families with large holdings. In 1970 the King Range National Conservation Area (KRNCA) was formed under the authority of the Bureau of Land Management (BLM) to manage more than 50,000 acres for the public good. Approximately 3096 of Squaw Creek (mostly in the headwaters) is presently within the KRNCA.

The year 1964 brought two disasters to Squaw Creek. In September the Roberts' fire burned out of control. It began in Petrolia, burned upstream, and jumped the river in the vicinity of Shenanigan Ridge/Cooskie Mountain. It continued into Squaw Creek and burned to the ocean. The effect of this fire on the vegetation mosaic of Squaw Creek is still evident today, especially in the headwaters where it burned the ridges and left forested draws. The ridges have come back in thick brush juxtaposed against the remnant old-growth.

The second disaster, the flood of 1964, occurred just three months later. Although not as intense as the 1955 flood, the '64 was significant for Squaw Creek. The December flood, following so closely on the heels of the September fire, meant bare soil was exposed to extremely heavy rainfall. Subsequent erosion has led to aggraded stream conditions.

An additional source of sediment to Squaw Creek has been the extensive landslide of Cooskie Mountain. This landslide was active as long ago as 1941, as shown by old aerial photos. Assumed to be from natural causes, it has been exacerbated by road construction and continual grading and rerouting every few years. Dominated by a massive debris chute with advancing gullies, the forty plus acre slide continues unabated. This phenomenon probably accounts for the fact that Squaw Creek remains one of the largest contributors of sediment to the Mattole system.

Aside from this presently active landslide, most disturbances in Squaw Creek have subsided. In the early 1950's, predominant impacts were from present and previous conversion from forest to grassland by large scale burning and cutting, as well as widescale timber harvest and road construction. In many cases trees were cut and left on site to be burned. Prior to the 50's most impacts were along the more easily accessed ridges and slopes.

Today, previously damaged areas are slowly healing and the forest is regenerating. Significant stands of old-growth remain primarily in the headwaters. It is not surprising that the preferred location of spawning king salmon is in the vicinity of these remnant old-growth stands.

Numerous field trips since 1981 have been conducted in the Squaw Creek watershed to assess erosion problems and fishery habitat condition. As a result of this investigation, several erosion control projects have been completed in Squaw Creek, including more than thirty acres of reforestation, road stabilization measures, and broadcast seeding of unstable streambanks. For the current erosion control plan survey, four additional field trips were conducted during 1988-89.

Another field trip was chosen to view the central section of the Squaw Creek watershed where the dominant land use has been removal of forest cover and conversion to grassland by repeated burning and grazing. The stream gradient levels out somewhat in this area, and the creekbed contains wide gravel bars with little riparian forest. Aerial photos showed widespread surficial slope and channel disruptions. This would have been a preferred field trip site, but due to lack of landowner permission, this area was not surveyed.

Rehabilitation Prescriptions

T3S R2W Sec. 13, and T3S RIW Section 18 (Telegraph Ridge/Cooskie Sale Road) –

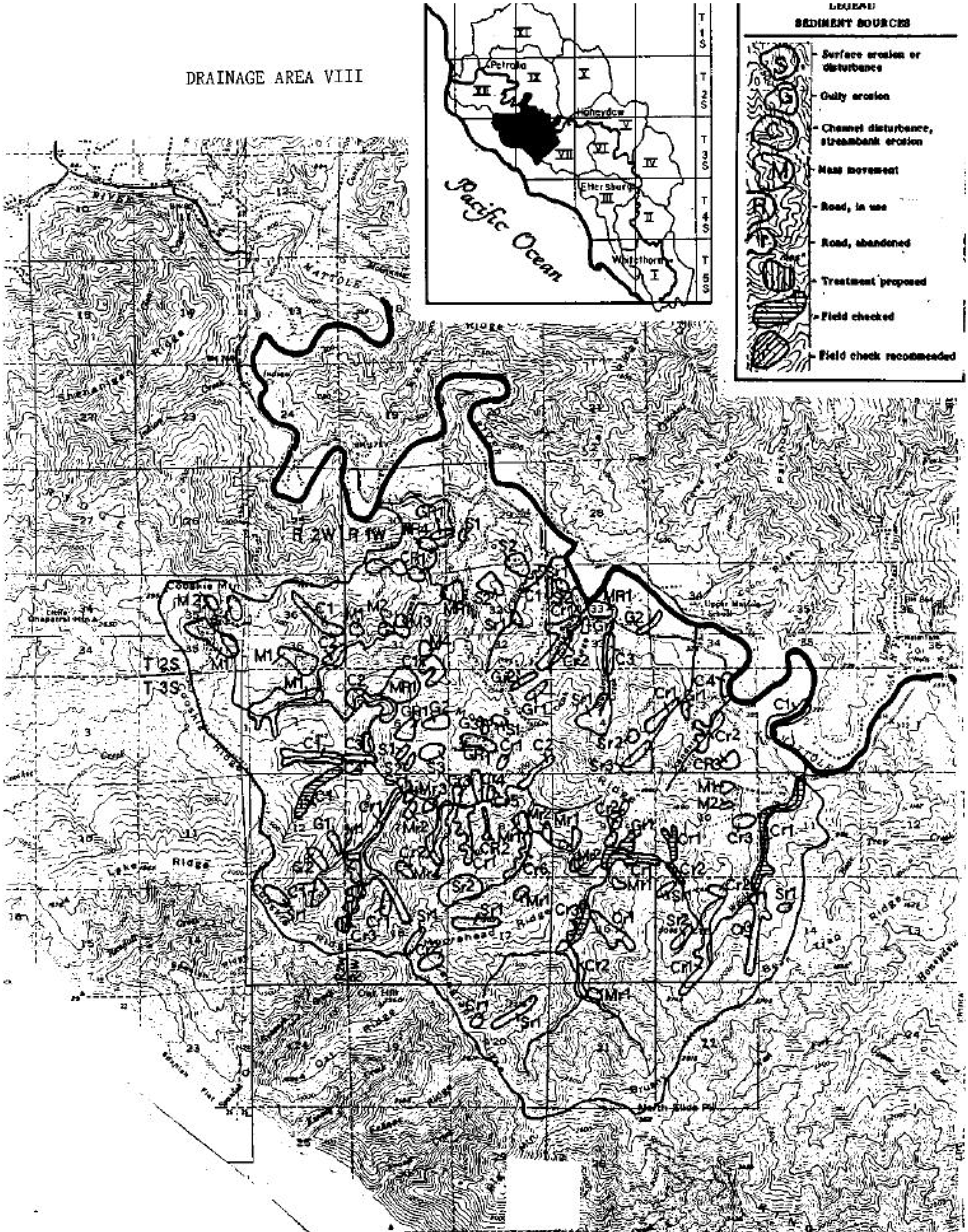
This site is within the BLM-managed KRNCA. At the junction of Lake Ridge Road and Cooskie Ridge Road, surveyors dropped down through a native prairie and contoured along the Squaw Creek side of the slope on an old timber skid road.

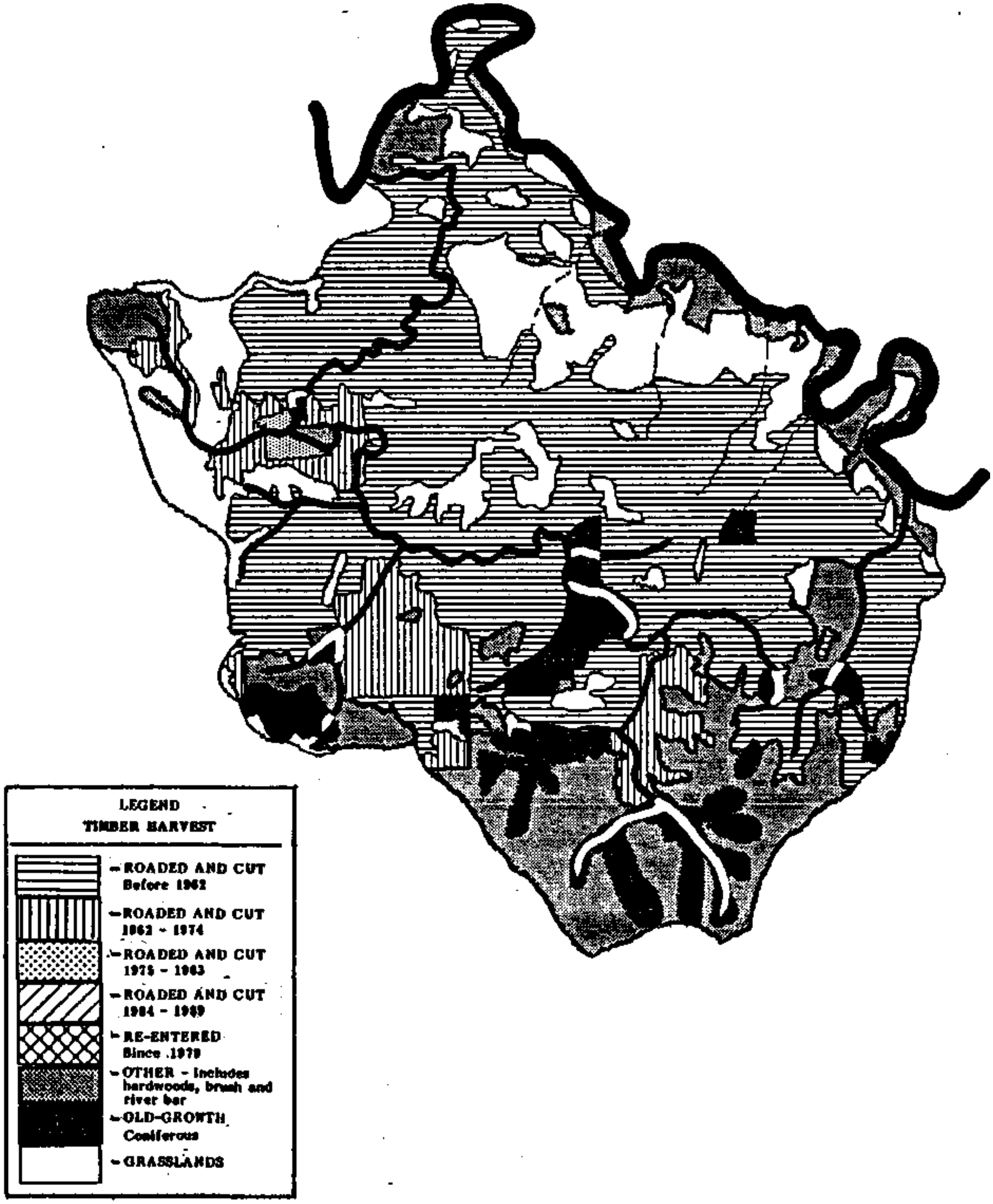
In general, this road network needs attention. Alterations in microdrainages have resulted in water gullying down the road and accelerating soil erosion. Ideally, heavy equipment would put the road system to bed. There is one stretch of road that has slipped away, so access for rehabilitation must be from each end. At a very minimum, the culverts should be opened and trash racks and energy dissipation provided. Work at this site can prevent major disruption of slope integrity at the headwaters of channel bowls, adjacent to significant stands of old-growth forest.

This prescription has been made available to BLM with the recommendation that this work be performed as part of BLM's erosion control plan for 1990.

Surveyors for Squaw Creek:
Janet Morrison
Randall Stemler
P.O. Box 122
Petrolia, CA 95558

DRAINAGE AREA VIII





DRAINAGE AREA VIII

DRAINAGE AREA IX

Unnamed Tributaries
Pritchett Creek
McGinnis Creek
Conklin Creek
Mill Creek East

UNNAMED TRIBUTARIES

T2S R1W Section 20
Gl - Inspected at the request of the landowner, this one thousand foot long gully was probably caused by artificial channelization of runoff on an alluvial flat. Gully downcutting probably also accelerated after upslope timber harvest. Although stable at its head, the gully continues to deepen and widen, approaching twenty feet in width and more than twelve feet in depth. Sides are calving off in large blocks. The most successful cost effective treatment is likely to be returning the gully sides to an angle of repose that can be revegetated, and establishing a bottom that would halt further downcutting. Benefits would accrue to the apple orchard adjacent to the gully by stopping the water table from sinking any further.

Surveyor for Unnamed Tributary:
Randall Stemler

PRITCHETT CREEK

This four-plus square mile wooded tributary was logged off entirely before 1975. No field inspection was made, but examination of aerial photos shows the likelihood of a higher than usual incidence of water diversion and concentration due to abandoned roads. Due to the length of time since active logging, however, it is likely that most active sedimentation is in the form of streambank erosion. Field survey along the channel is recommended. If significant points of sediment inputs are discovered, examine roads upslope.

Mapping for Pritchett Creek:
Janet Morrison

McGINNIS CREEK

The lower three miles of McGinnis Creek remain productive for steelhead despite channel aggradation and the near absence of riparian vegetation due to grazing. Should the land use change in this area, or should stock fencing become practical, riparian planting in this area would be very beneficial. Salmonid access ends at the first main fork of the creek, with a ten foot rock falls on the west fork, and a 4000 cubic yard logjam on the east. Due to the remoteness of the watershed, significant portions of it were not logged until the 1980's. A series of THP's were filed by Eel River Sawmills in 1984 and 1985 in areas upstream and upslope of the known salmonid habitat. It was decided to use what field time was available to inspect these plans post-harvest for erosion problems. Eel River Sawmills cooperated with this strategy by allowing MRC surveyors access in 1988.

T2S R1W Section 9

SR2 - A two-day field trip led by geologist David Steensen was used to examine in detail the potentials for failure along slightly less than a mile of haul road on THP 1-84-109, which had been logged in 1985. The timing was interesting in that the inspection took place three rather dry years after harvest, and surveyors were able to ascertain major potentials for mass wasting. The California Department of Forestry and Fire Protection generally accepts as a rule of thumb that almost all logging related erosion occurs within three years after harvest. It is also interesting to note that most of this potential for mass movement could have been avoided through one or two days of heavy equipment work by operators on their way out of the area at the end of the logging show.

In the interest of brevity we will not reproduce the entire prescription here, but only a geologist's summary with a general indication of costs. All prescriptive details are for cross-road drains, the removal of crossings, removal of fill, and the outsloping of roads: exactly the sorts of mitigations provided for in the California Forest Practice Rules. In fact, a good deal of this sort of work was performed by the operator, but it fell short of what would be required to keep the several hundreds of cubic yards of sediment out of the creek where in all probability it will wind up. To quote Steenson:

> In general both roads A & B are not affected by fluvial (running water) processes. However, the roads do present a danger of delivering moderate amounts of material to the active perennial tributaries of McGinnis Creek. The mechanism would be essentially the same as that of the post- road debris slide at 4A-1. Fill material perched on top of organics (common along most of this road system) becomes heavy with rains and crosses a threshold of stability. Considering the number of scarps along the road, and the light rainfall winters of the North Coast over the last three years, it seems that given a "normal" rainfall year, more debris slides are likely.

Steensen goes on to provide a detailed description of heavy equipment work needed to avoid these debris slides and costs them out at roughly $7,000 including on-the-ground supervision, but not including administrative costs. The point to be taken here is that the same work could have been performed by the original operator at perhaps a third of the cost with the additional supervision of a rehabilitation geologist. In general, inspection of recently completed timber harvest plans in the course of this survey revealed a similar pattern. Almost enough mitigation had been applied almost expertly enough to avoid most of the major road related erosion and mass movement problems. If adequate mitigations are provided at the time *of* harvest, non-catastrophic reading systems are possible, even on these steep and remote terrains. Attempting to treat the *same* problems as restoration problems some years after the fact most often demonstrates an unacceptable cost/benefit relationship.

Surveyor for McGinnis Creek:
Chris Woods
P.O. Box 118
Petrolia, CA 95558

CONKLIN CREEK

One tributary of Conklin Creek is producing the majority of active sedimentation at this time, and rehabilitation efforts should be concentrated here; this is the most western and most downstream of the major tributaries of the creek, draining Apple Tree Ridge.

Because of the proximity of various disturbances, and their linear arrangement on the tributary, their treatment will be most effectively considered as a single project.

T2S R1W Section 6

MR1 - A one-half acre mass wasting is crossed by an old skid road. A debris torrent has been triggered by road fill failure and scoured the entire drainage. Dewater the road, armor the toe, and revegetate.

GR2 - Although an earthflow and gully erosion are still active, debris does not seem to be reaching watercourses at this time. Keep under observation but do not include in treatment plan.

T2S R2W Section 1

Mrl - This is a one-half acre failure below an old skid road cut. Access is by foot only. Broadcast with Bacchoris seed, investigate armoring the toe with available materials.

Mr2 - Same as above.

Surveyor for Conklin Creek:
Dan Weaver
P.O. Box 190
Petrolia, CA 95558

MILL CREEK EAST

Oral accounts of the area tell of cattle raising on the flat area known as K.D. Flat, and the other flats to the east and south. Old-growth Douglas-fir covered the hills except for a few slopes which were grasslands originally. Douglas-fir grew right up to Mill Creek and its tributaries on the flat. In the 192 O's some ranchers began importing and raising sheep. One rancher grew vetch on the Mackey Ranch (which is presently the Lanini Ranch subdivision).

Harvesting of Douglas-fir began in the early fifties with the logging of a stand of old-growth on Apple Tree Ridge on what was then principally a dairy ranch on Lytel family property. The logging was limited to a few acres. Intensive logging on Apple Tree Ridge did not begin until 1973. Local residents report that up to 1964, there were good steelhead and silver salmon runs in Mill Creek East, as far up as "the crossing" which is located on the mainstem of the creek about 1.3 miles above the mouth.

1964 was critical for it was the year in which a control burn at the top of Apple Tree Ridge raged out of control because of a rapid drop in humidity and sudden increased winds. As the fire raced to the coast, the California Department of Forestry and Fire Protection used bulldozers to create a wide fire line on and below Apple Tree Ridge. No waterbars were cut either during or after the fire, and subsequent winter rains caused slides, bank failures, and sedimentation which eliminated the good spawning grounds. According to local accounts, the spawning runs stopped then and have only begun to recover in recent years.

In 1973, intensive logging began on Apple Tree Ridge and since then most of the old-growth has been removed. Only one sizable (roughly thirty acres) stand of old-growth remains on the highest point on that ridge. Though some care was taken to cut water bars, the roads were never "put to bed" and in subsequent years, road failures have contributed to numerous slides which added to the debris and sedimentation in the mainstem of Mill Creek East.

At present, the areas which were logged have become more stabilized. Large stands of Ceonothus have grown on cut-over slopes and second growth Douglas-fir have seeded in. Those areas are grazed, and they are slowly reverting to their pre-logging appearance, namely grassy meadow/pasture interspersed with stands dominated by Douglas-fir and Ceanothus. Steelhead have been reported up to "the crossing" at Crl in T1S R2W Section 2 on the mainstem of Mill Creek East.

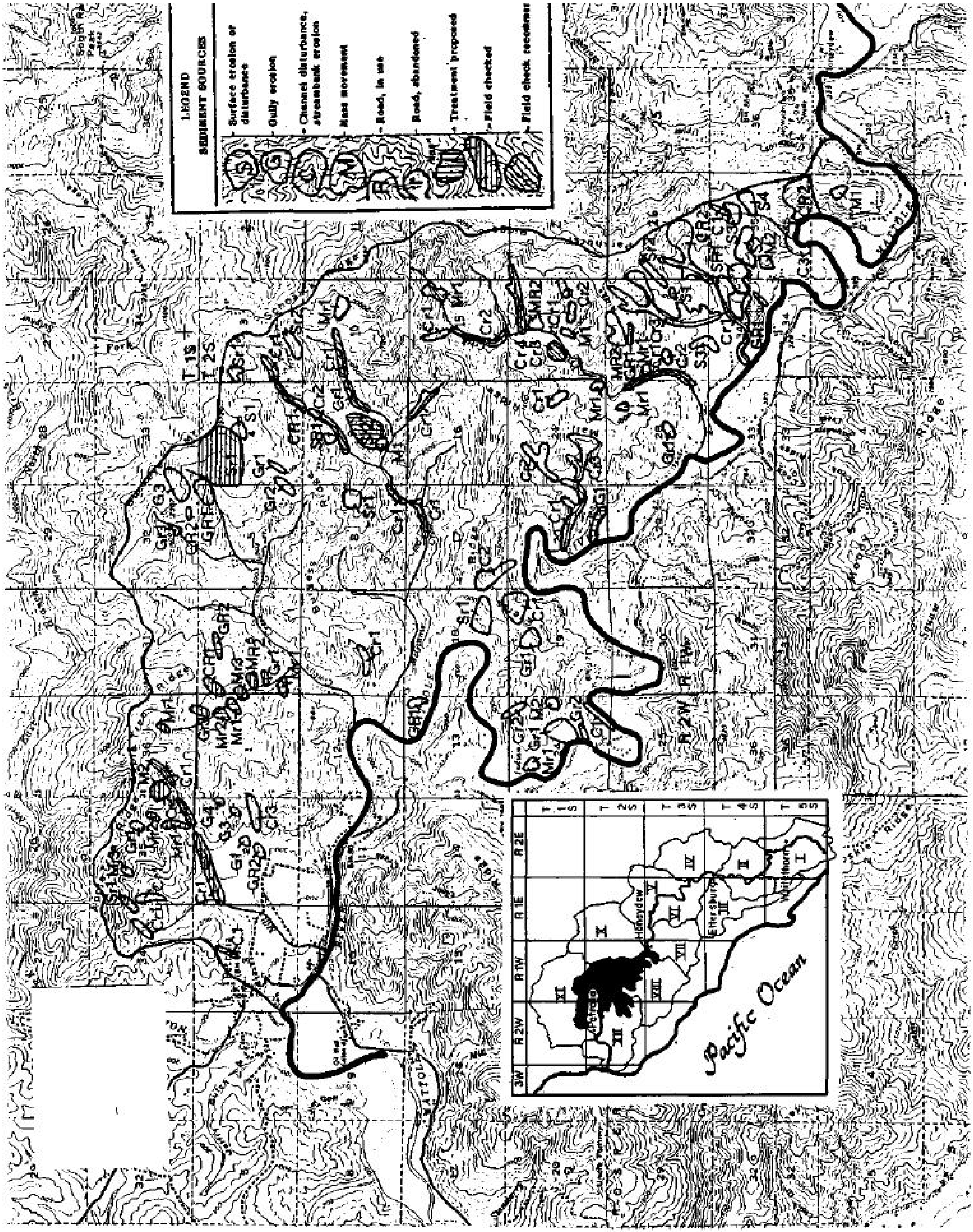
Field survey has indicated that for the most part, the major damage to Mill Creek East was in the past. Debris from various slides, gullies, and streambank failures will continue, but the rate has slowed considerably and the slopes and banks will continue to stabilize in the future.

Rehabilitation Prescriptions

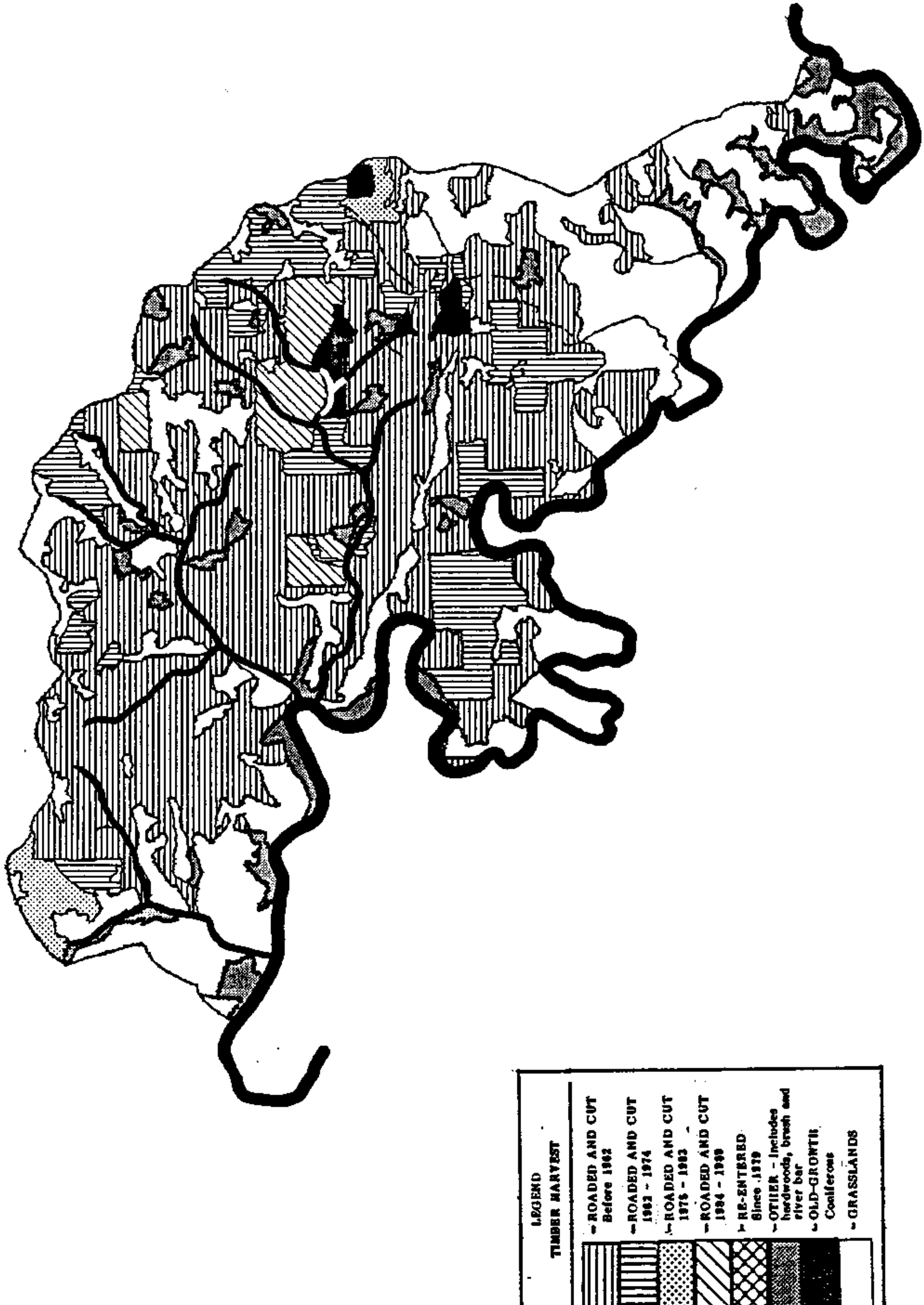
T1S R2W Section 35

Cr2 - (In consultation with geologist David Burnson) Construct catchment basin. The head of this disturbance lies at a definite break in slope and tends to serve as a storage area for sediment and debris from active disturbances upstream. The cost-effectiveness of treating several landslides upstream of Cr2 was considered likely to be poor due to difficulty of access. This is also the logical limit to the upstream migration of adult salmonids, and habitat downstream would be improved by locating a catchment basin here. Mill Creek East is atypical of streams in the Mattole in that it is a classic meadowland stream; most of the lower three-fourths of the watershed is flat terrain or gently rolling hills. Cr2 lies at the most upstream extension of this meadowland terrain, and a catchment basin located here would benefit an optimum area of the watershed.

Surveyor for Mill Creek East:
Paul Ehrlich
c/o MRC



DRAINAGE AREA IX



DRAINAGE AREA IX

DRAINAGE AREA X

The Upper North Fork

THE UPPER NORTH FORK

Twenty-six square miles in area, the Upper North Fork of the Mattole is the second largest tributary of the river, and has two major tributaries of its own: Oil Creek and Rattlesnake Creek. It drains areas of Rainbow Ridge (elevation 3542 feet) and Cathey's Peak (elevation 3070 feet) and enters the Mattole from the east downstream of Honeydew. Land ownership varies between older, large ranches and industrial timber holdings in the western portion of the watershed, and smaller homesteaded plots and forest and timber lands in the eastern portion. Of the 805 acres of old-growth forest remaining in the drainage, 690 are held by Maxxam Corporation in small parcels of 60 acres or less.

Long time residents report the presence of large numbers of salmonids in all parts of the basin in historical times. In recent times, poor pool-to-riffle ratios and high water temperatures, both of which are related to highly aggraded channels, have limited productive salmonid habitat to the more downstream reaches of the drainage. In 1984, salmonid redds were observed upstream of "the Gorge", approximately 3.5 miles upstream of the confluence of the Upper North Fork and the Mattole River.

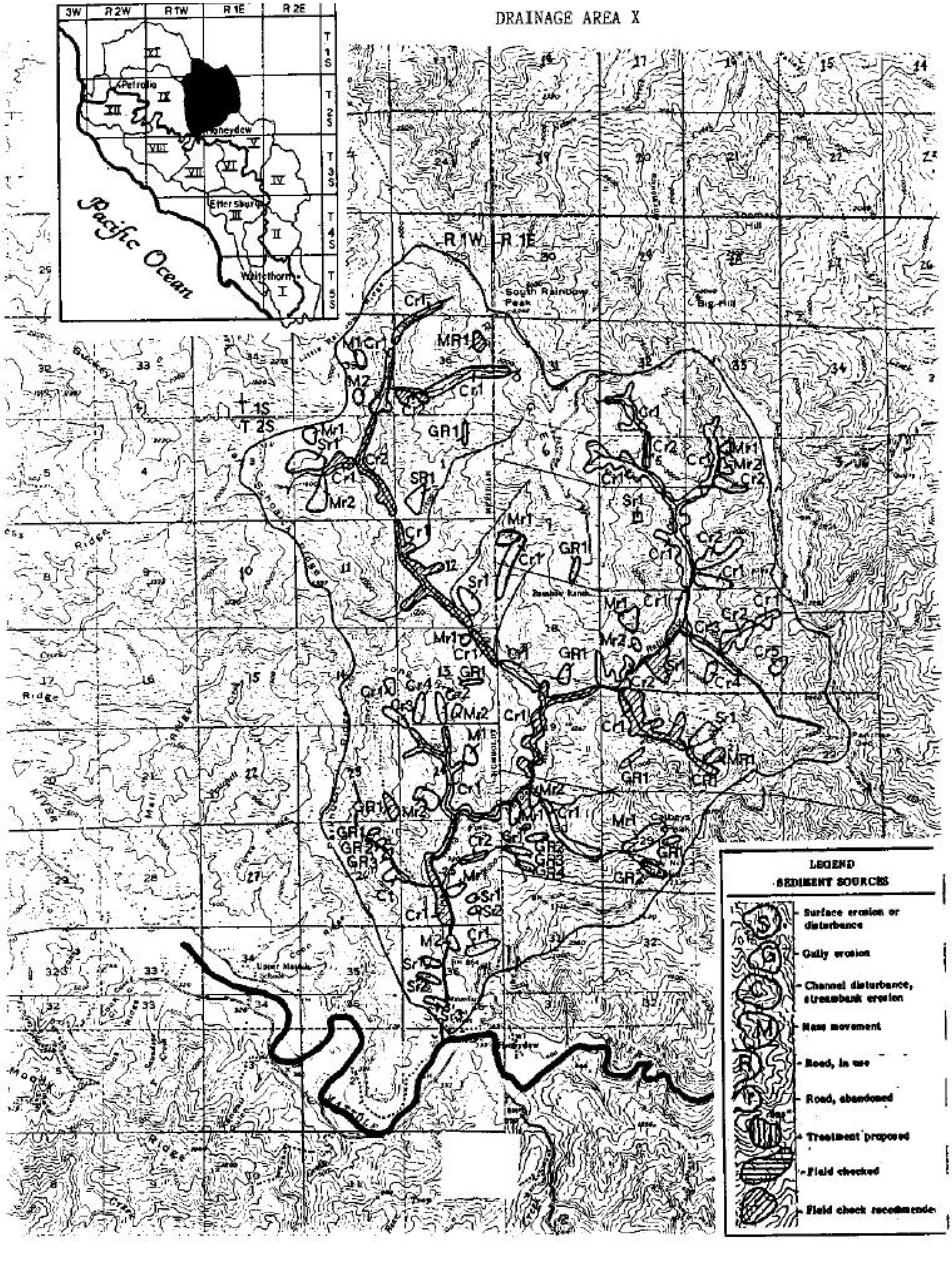
In 1984, the Mattole Watershed Salmon Support Group (MWSSG) assisted in planting 2,000 alders for slope stabilization on the upper mainstem. Between 1986 and 1989, significant projects in streambank armoring, gully control, and tree planting have been undertaken by neighboring landowners on the southwest face of Cathey's Peak, with the assistance of the State Coastal Conservancy, Redwood Community Action Agency, and MWSSG.

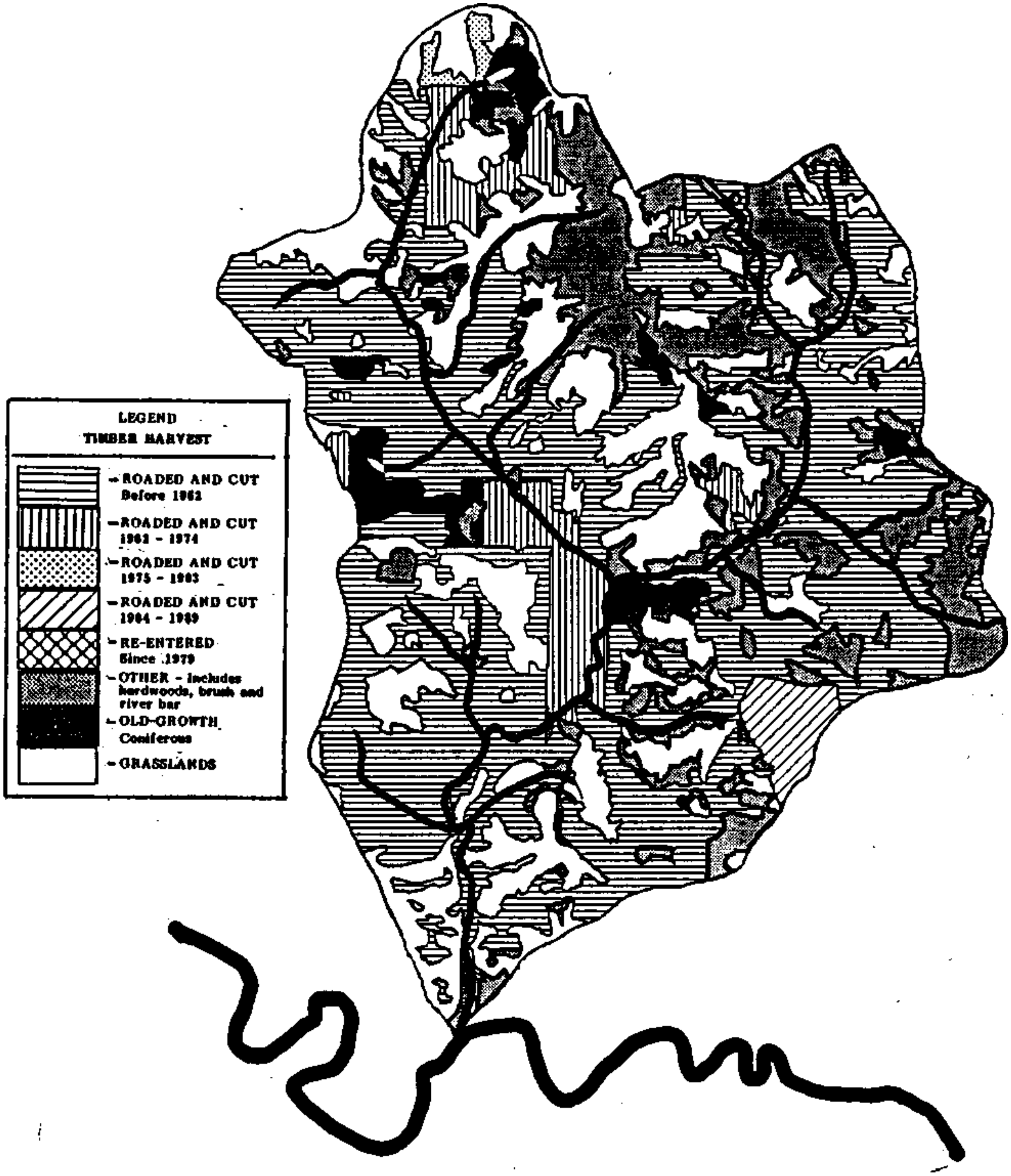
There are two road associations maintaining access for residents of the eastern portion in the Upper North Fork, on Cartwright Road and on Creighton Creek.

As in other tributaries of the Mattole, investigation of the aerial photographs has revealed that the largest part of sediments mobilized as a result of historical disturbances has already moved into the channels of the third and fourth order streams, which are highly aggraded. This 'aggradation has destabilized the creeks, and streambank erosion may at this point be contributing more sediment to the system than are the original sources. Portions of the two major tributaries, and a reach of the mainstem downstream of their confluence, have been targeted for field investigation with the assumption that many opportunities for streambank stabilization will be found. Maxxam Corporation, the largest single landowner in the Upper North Fork, has categorically refused access permission to erosion surveyors, and other problems related to remoteness and difficulty of physical access prevented further field work within the constraints of this survey.

Mapping for the Upper North Fork:
Peter Marshall
Box 47
Honeydew, CA 95545

DRAINAGE AREA X





DRAINAGE AREA X

DRAINAGE AREA XI

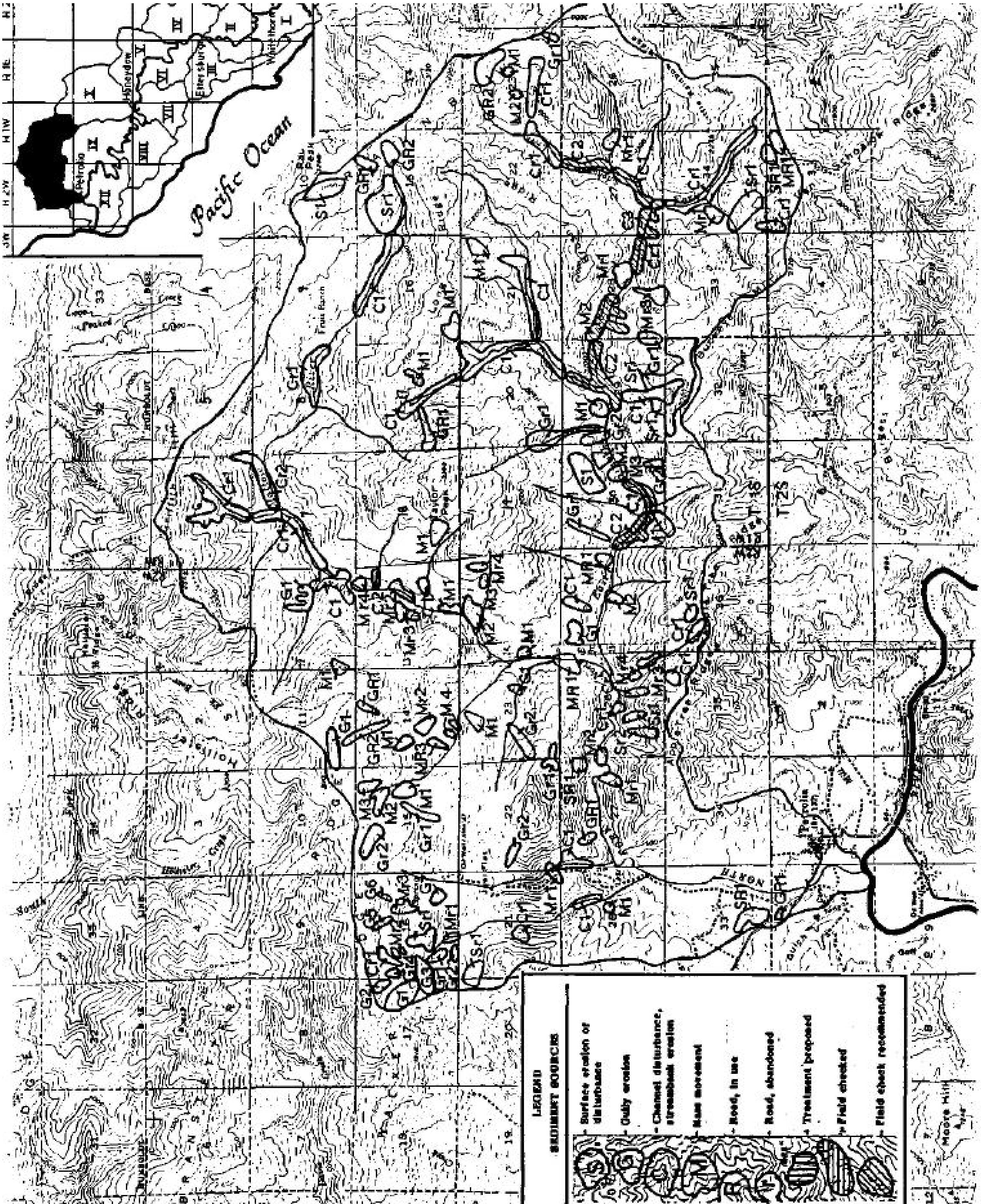
Lower North Fork

LOWER NORTH FORK

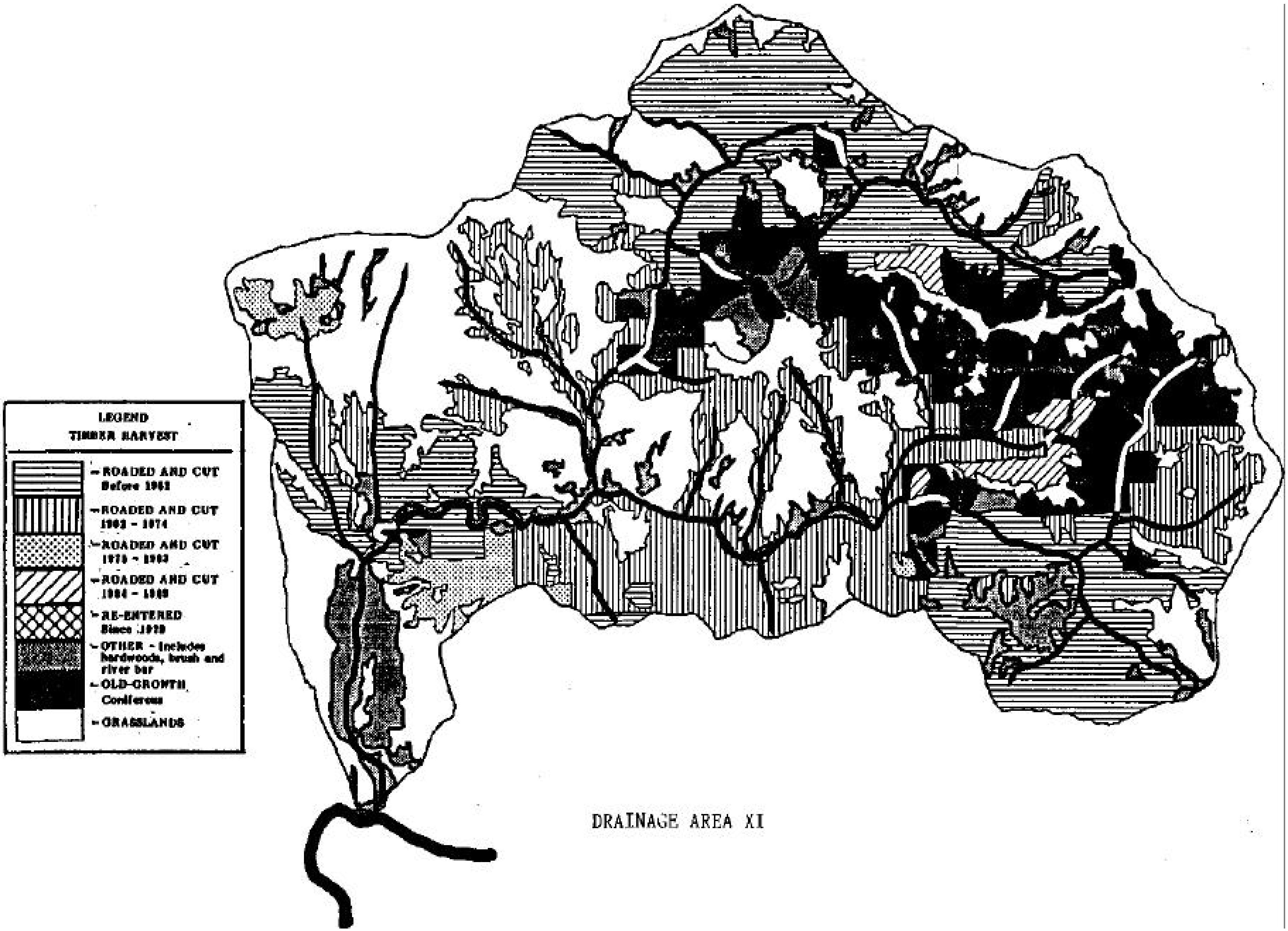
The Lower North Fork drains Taylor Peak (3374 ft.) and thirty-nine square miles of surrounding territory, making it the largest tributary of the Mattole. Although the mouth of the Lower North Fork enters the Mattole near the town of Petrolia, much of its terrain is remote and unroaded. Of the westernmost half of the drainage, more than 50% is in grasslands, the most extensive grassland ecology in the Mattole. On the eastern and southern slopes of Taylor Peak, and on the ridgelines of Sulfur Creek (a tributary of the East Branch), lie the most extensive stands of undisturbed old-growth forests in the Mattole River basin, some three thousand acres currently owned by Pacific Lumber Company/Maxxam Corporation.

Most of the mainstem of the Lower North Fork and the East Branch had been logged prior to 1964, and the flood of that year seems to have seriously impacted the drainage. Recovery processes have been slow and most major channels appear to be highly aggraded and poor in riparian vegetation still. A high predominance of active sedimentation is occurring in the channels themselves, and systematic surveys of the mainstem and especially of the East Branch could be very productive in terms of locating sites for effective rehabilitation. To date, only the lowermost reaches of the mainstem have been examined on the ground, as landowners in key upstream areas have chosen to withhold access permission for field surveys.

Mapping for Lower North Fork:
Garth Harwood
c/o MRC



DRAINAGE AREA XI



DRAINAGE AREA XI

DRAINAGE AREA XII

Indian Creek
Clear Creek
Mill Creek
The Estuary and Lagoon

As the river nears the ocean, water volume increases, gradients decrease, and velocities are reduced. The effects of aggradation seen on a smaller scale upstream can be observed here hugely magnified as suspended sediments settle to the channel bottom and bedloads are pushed further downstream. As the channel fills with sediment collected from the whole of the river system, the large flows jump the banks of the former channel and tear away at the alluvial plains, which calve off and add to the sediment load. Meadows that were pasture for dairy farms become the latest addition to the broad and cobbled floodplains which now extend a half mile across, downstream of Petrolia. The river whips and braids across the cobble and changes course from year to year, sometimes storm to storm.

Here the cumulative effects of upstream disturbances have nearly eliminated salmonid habitat. Potential spawning gravels are infused with compacted silt. Even if the female salmon could dig a shallow redd with her fragile tail, the eggs would choke for lack of oxygen, or would be buried by new deposits of gravel scoured out in the next big storm. Scant and shallow summer flows warm up to the high sixties and low seventies; great swimming, but near-lethal for juvenile salmonids. Pools six feet deep or more, which in a stable system can provide a temperature inversion and cool summer habitat for young salmonids, are mostly gone, or are formed one year and filled the next. (There were fewer deep pools in the lower river in 1989 than there were in 1982, and in 1982, there were only fourteen pools six feet or deeper between Honeydew and the Pacific.)

Upslope, the landforms vary between the high coastal prairie so attractive to the rancher, and short creeks cut down through relatively shallow canyons. The trees were mostly logged off before 1975, but a maritime climate which is largely fog-free favors the regeneration of Douglas-fir, and whole conifer forests are beginning to overtop the tanoak and *Ceanothus* brush which had sprung up after the logging. Quite a bit of forest land has been converted to pasture; small amounts are still being converted; some of the conversions have been maintained by semi-annual burning.

Sometime soon—probably within the next twenty years, perhaps in the next five—the silt will begin to be flushed out of these reaches faster than new sediment arrives from upstream. This will be an important point in the erosional history of the river, as it will signal that the system is on the upswing of recovery. Restoration work will begin to take on some of the attributes of rowing downstream (as compared to swimming up). It has become important to know what's moving on the channel bottom in the lower Mattole, and the Mattole Restoration Council (MRC) has since 1986 taken annual transect measurements at sixteen monumented cross sections in the mainstem between Honeydew Creek and Mill Creek. Four years of readings in dry years have so far proved inconclusive with regard to trends in channel aggradation/degradation.

For all the drama of the lower river as a site of accumulation of silts and gravels and cobbles, the sediment input from tributaries in the drainage area have been relatively small. Tributaries to the north of the river drain low elevation, low gradient rangelands, and erosion problems are largely the result of natural processes. Upstream and to the south and east, the terrain becomes more canyon-like, with steep headwalls and deep inner gorges. The scale of the drainages remains moderate to small, however, and the major disturbances have for the most part occurred twenty or more years ago, so that recovery processes are well advanced.

The estuary/lagoon system has suffered enormously as a sediment basin for the entire Mattole hydrological system, and in terms of erosional effects on biological diversity, it should receive the very highest priority for further study and rehabilitation work. This area will be discussed more extensively under its own heading.

INDIAN CREEK

Dry ridgetops in this drainage have been logged and converted to rangeland with relatively little contribution of sediments to waterways. Several large road related slides in the upper drainage appear to have stabilized. Overall, the mid-slopes show good natural regeneration. A largely undisturbed riparian zone has no doubt contributed to the fact that the channels of the creek remain stable and are carrying less sediment bedload than other creeks of similar size, gradient, and land use history.

Rehabilitation Prescriptions

T2S R2W Section 23

Sr2 - Tractor logging on this slope in the early eighties left a failing haul road which may still be contributing sediment into the mainstem. This slope should be field inspected for road failure. Near the base of this slope a landslide on the south side of the creek is being undercut and destabilized. Materials are available on site for bank armoring.

Surveyor for Indian Creek:
Bob Anderson
c/o MRC

Mapping for Indian Creek:
Janet Morrison
c/o MRC

CLEAR CREEK

Much of this small, steep drainage has been logged within the last fifteen years, and the last harvestable stand of old-growth was taken out over a period ending in 1989 near the confluence of the creek and the river (THP 1-84-630X Disturbances are still contributing significant sediments and the channel of the mainstem is heavily aggraded for its length. Slopes on the west side of the creek in sections 11 and 15 which were logged most recently should be reinspected for regeneration successes. A bedrock falls 25 feet high limits use of the creek by salmonids to the lower .7 miles of the mainstem and a long oversteepened culvert near the mouth makes access difficult for adult salmonids. Nevertheless, repeated surveys have shown an abundance of juvenile steelhead both above and below the culvert. Because of the preferred salmonid habitat here, and due to the extent and volume of sediment contribution potential, this drainage should be given the highest priority for rehabilitation work in Drainage Area XII

Rehabilitation Prescriptions

T2S R2W Section 11

Crl - The channel transport mechanism is beginning to reach equilibrium as sediment inputs are slowly reduced, and the lower reaches of the mainstem are beginning to degrade. Multiple streambank failures are still occurring and some instream structural work would divert flows away from sensitive banks. The west side would benefit from riparian planting. Abandoned skid and haul roads on the east side should be inspected for water diversion and potential for further failure.

The culvert through which Clear Creek flows under the county road is ninety feet long, ten feet in diameter, and is set at a gradient of four degrees. It is probably a partial velocity barrier to steelhead, and especially to silver salmon. A series of baffles, bolted or welded to the bottom of the culvert, would have the effect of reducing overall water velocity and providing resting areas for up-migrating fish.

Surveyor for Clear Creek:
Bob Anderson

Mapping for Clear Creek:
Janet Morrison

MILL CREEK

Mill Creek was logged in its entirety prior to 1975 with the exception of 210 acres which now constitutes the largest grove of old-growth habitat within ten linear miles. This grove, located on the west side of a middle reach of the creek, accounts for the relative stability of the lower reaches of the creek. The Mill Creek Watershed Conservancy (MCWC), a land trust, is attempting to acquire this parcel as an ecological reserve, partially with state funds generated by Proposition 70 passed by voters in 1988.

The Mattole Watershed Salmon Support Group (MWSSG) has done considerable salmon enhancement and watershed rehabilitation work in the drainage, and has restored to natural viability a run of silver salmon which had gone extinct due to a culvert misplaced after the 1964 flood. Logjam removal by California Conservation Corps (CCC) crews has increased the amount of spawning gravels available to salmonids by more than 100&. MWSSG crews have increased the quality of the habitat by building gravel collection weirs, armoring stream channels, and riparian planting. The approach to the culvert under the county road has been improved and the culvert has had baffles installed to ease salmon migration. For a period of six years following 1981, MWSSG incubated, reared, and released silver salmon into Mill Creek, and wild spawners have been observed every winter since 1986-87.

Rehabilitation Prescriptions

T2S R2W Section 21

Sr1- An abandoned haul road has failed as it crosses several Class III headwater tributaries of Mill Creek. Some of the failures are due to plugged inlets, where the stream has cut around the culvert and left it high and dry. In some cases, the diverted flow has contributed to a debris torrent downstream, and in other cases, water has been diverted onto the road and is still delivering sediment. Waterbars constructed with hand tools would be an effective method of routing seasonal flows into their original microdrainages.

T2S R2W Section 21

Grl - A large and complex gully (500 feet by 125 feet) with its toe in the stream, threatens to deliver a moderate amount of sediment into a Class n tributary which is proven rearing habitat for salmonids. Revegetation of lower sidewalls and base of gully would reduce sediment flow. A road on the opposite side of the tributary has failed at several points and could be waterbarred effectively. In general, geologist Terry Spreiter advises that rehabilitation work be focused on upper slopes.

Surveyor for Mill Creek:
Freeman House
c/o MCWC, Box 173
Petrolia, CA 95558

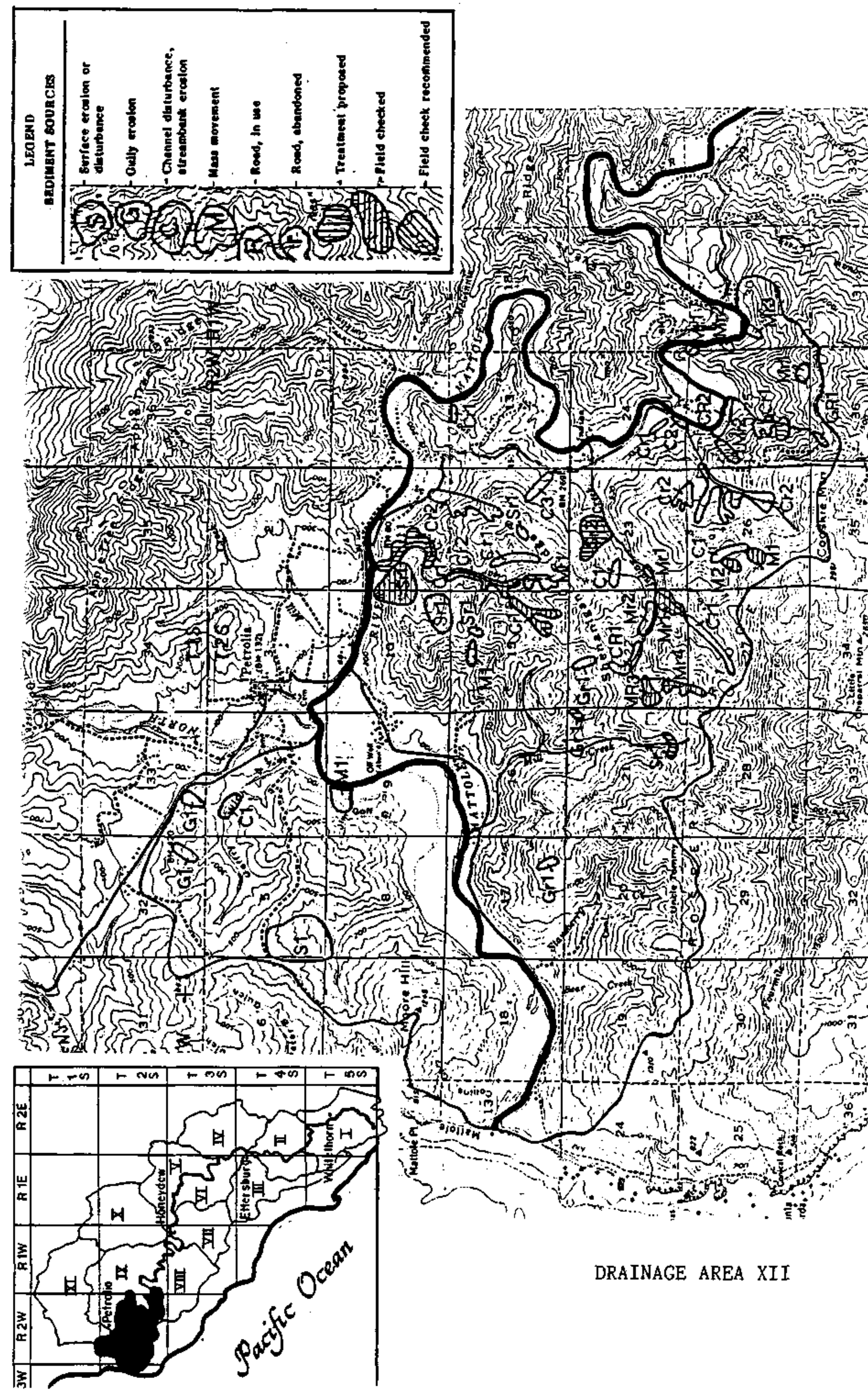
THE ESTUARY AND LAGOON

The estuary has a seasonal cycle, open to the ocean from fall to late spring, and closed by a sand berm during the summer and early fall. As the river mouth is closed by the berm, a small lagoon of approximately seven acres is formed. This variable wetland is rich in wildlife, and the lagoon serves a critical function in the life cycle of the king salmon.

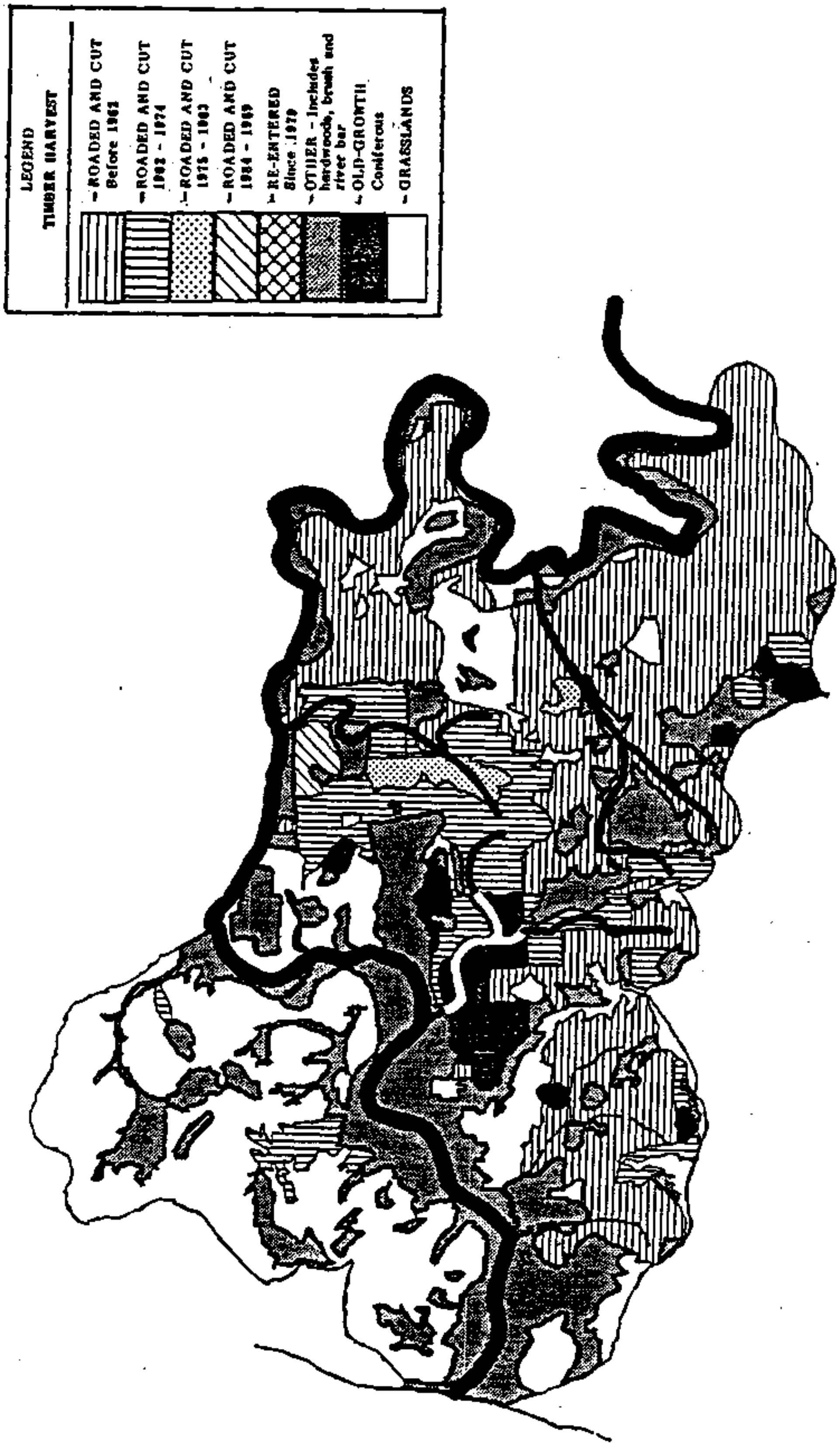
There is almost no documentation of the historical condition of the estuary and lagoon. Surveyor's notes from 1860 indicate that the lagoon area was of a width similar to today's, but gives no indication of depths or volumes of water, or the condition of the bottom. Today's lagoon is heavily aggraded, shallow, and quite dynamic with the river's channel continually shifting.

Salmonid population and growth studies conducted by the Bureau of Land Management (BLM), and Humboldt State University since 1984, have begun to demonstrate that the summer carrying capacity for salmonids in the lagoon is low—perhaps as low as fifty thousand. Twice during the period of study, massive ecological diebacks seem to have occurred, indicating that the summertime lagoon is a distinct bottleneck in the Mattole king salmon life cycle. The limits to population are not clearly understood, but are related to water temperature, diet, and predation, which are, in turn, related to the availability of riparian habitat and to the massive depositions of sediment at the bottom end of the hydrological system.

Recognizing the need for a clearer understanding of the hydrology of the estuary/lagoon area, the State Coastal Conservancy has contracted MRC to perform a two year study of these processes, with the goal of developing rehabilitation techniques which will augment recovery processes here without diminishing wildlife values. Meanwhile, MWSSG is contracted by DFG to perform small scale revegetation projects, and to anchor woody debris in place as scouring structures. These structures will use the force of high water flows to begin to scour deeper pools in this channel, in proximity to existing riparian vegetation on the southern side of the lagoon area. In gross terms, all ecological problems in the estuary/lagoon are related to its function as an endpoint of in-river storage of sediment. Any erosion control work which reduces the input of sediment into the river system will ultimately benefit the estuary/lagoon. Because native Mattole king salmon populations are diminished to a point where their viability remains in question, estuarine rehabilitation work aimed at increasing the summer carrying capacity of the lagoon in the short term, must assume equal importance with any upstream work to reduce sediment inputs.



DRAINAGE AREA XII



DRAINAGE AREA XII

A PRIMER OF
EROSION CONTROL TECHNIQUES

Erosional Features **—Surface Erosion**

—Gully Erosion

—Channel Disturbance

—Mass Movement

— Surface Erosion from raindrop impact, sheet wash or rilling involves subtle movement of individual soil particles downslope. It easily occurs when rain hits freshly exposed or unvegetated soil without a permanent channel for drainage. Oftentimes roads initiate surface erosion from rain hitting the road surface itself, and from freshly worked ground. It is the least significant erosional feature in terms of sediment production, yet is the most easily and successfully controlled. If it is not addressed, surface erosion may lead to gully formation. In the disturbance maps, this symbol is sometimes used to indicate that road systems have been abandoned with unknown effects.

Treatment Measures:

Application of mulch
Planting, transplanting
Broadcast seeding of appropriate species
Contour terracing
Water diversion

— **Gully Erosion**, characterized by downcutting and headward erosion, occurs where concentrated drainage cuts down through erodible soil, forming intermittent stream channels. Treatments commonly used to address active gullies involve dispersing concentrated water feeding the gully head, and stabilizing the headcut, channel bottom, and sides.

Treatment Measures:

- Water diversion
- Culverts with energy dissipation
- Headcut stabilization
- Checkdams
- Rock checkpoints, rock armoring
- Mulch
- Broadcast seeding
- Planting, transplanting

— **Channel Disturbance**, often a result of cumulative effects upstream, is characterized by disrupted perennial drainage channels, and occurs when natural watercourses have been altered by concentration of discharge, culvert failure, sidecast road fill, debris plugging, debris torrent, loss of riparian support, slope failure, erosion, or aggradation. Disrupted channels that direct water flows against raw banks contribute to future erosion potential.

Treatment Measures:

- Reconnecting altered drainage channels
- Removing soil and debris from channel
- Gabions (slope or in-stream)
- Cribwalls, revetments using woody debris
- Rock checkpoints, rock armoring
- Culverts with energy dissipation
- Mulching
- Broadcast seeding
- Planting appropriate species

— **Mass Movement**, associated with landslides, slumps, and earthflows, occurs when shear stress in the slope exceeds shear strength resulting in mass movement. Anything that reduces shear strength or increases shear stress contributes to this cause. Primary factors are removal of lateral support (by rivers or readouts), removal of vegetation, addition of moisture into the groundwater system (by altered drainage networks), and the addition of weight upslope (road fill or water saturation). If these factors combine with already unstable conditions that exist in the Mattole, then mass movement can easily be triggered.

Treatment Measures:

- Return of lateral support, weighting toe
- Drainage and diversion of water
- Removal of weight on slope
- Revegetation with appropriate species

REVEGETATION TECHNIQUES

MULCH

Mulch is an effective treatment for disturbed soil that has little or no vegetative cover. Effective rates of application vary depending on what type of mulch is being used. A rule of thumb for straw mulch is two to three tons per acre. Other types of mulch have been used effectively, for instance, leaf mulches held down with jute netting, or excelsior mulch with netting. It has been determined that the use of mulch encourages brush regeneration.

Mulch can be used on bare slopes to mitigate the effects of raindrop impact. Project sites often have slopes that have been worked, and need protection for the first few years until grass and woody vegetation can become established. Using mulch is a cost effective treatment for surficial erosion.

BROADCAST SEEDING

Broadcast seeding is an effective way to vegetate large areas quickly. Although most often used for grasses, this treatment is appropriate for brush and trees too. Some examples of seed other than grass include: legumes, coyote brush, and riparian trees such as alder, cottonwood, and willow. Selection of appropriate seed depends upon the environmental conditions of the site being treated. Often treatment areas are so remote that outplanting containerized vegetation is too difficult. Some sites may be too steep to stand on but could be broadcast seeded. Often it is cost efficient to gather large quantities of seed but difficult to acquire plants for the same cost. One drawback is that grass has difficulty becoming established fast enough after seeding to help much during the first few winter storms. Grass competes with establishment of woody vegetation. Locally, alder seed can be gathered in August, coyote brush from November through January.

TRANSPLANTING

Physical movement of plants found growing nearby, to the treatment site, is sometimes appropriate. Some species are best transplanted to a treatment area from a population able to withstand the loss. If it is a matter of simply spreading out the population in the vicinity of the area it can be an appropriate treatment, but care must be taken not to deplete the existing population.

PLANTING

Planting vegetation is a primary means for long-term restoration of the health of the watershed. Other treatments are temporary measures until vegetative cover can be restored. Planting consists of selecting appropriate species for the treatment area, and introducing them to a new site in such a way that they prosper and grow. Appropriate species are usually those found growing nearby. This treatment includes stem cuttings from plants such as willow, cottonwood, thimbleberry, coyote brush, or other species that are able to root when planted; as well as container grown, and bare root stock, such as alder, tanoak, Ceanothus, Douglas-fir, redwood, and grand-fir. Planting is appropriate for treatment of areas that are stable enough to offer a fair chance of survival. Correct choice of species is critical, as is proper planting technique.

STRUCTURAL TECHNIQUES

ROCK

Rock is probably the most important material for widescale use in restoration structures. It can often be found on or near the treatment site, it is a natural component of the watershed, and it has valuable qualities as a stabilizing agent. Unlike wood, rock tends to keep on working, even with changes through the seasons. Rock is used in the construction of check points, energy dissipation, and bank armoring. Rock checkpoints are similar to checkdams. They are points at which channel side and bottom cutting are halted by the placement of rocks. Rock armoring, riprap and revetment are techniques for stabilizing slopes, streamside banks or channels where strong resistance to the force of water is required. Often revetment is set at a one and one half to one slope. Weighting for lateral support is one of the few effective measures for treating deep-seated slumps, or landslides. Large quantities of big rock placed on the toe of the landslide helps return some lateral support. On-site rock must be sturdy enough for the treatment prescribed. Usually large quantities of big rock are required, although smaller rock can be used for filling gabion structures. Large rock can be moved by labor intensive approaches, but heavy equipment is often advised.

CONTOUR TERRACING

The use of contour terracing on slopes retards surface erosion by slowing runoff, and encourages infiltration, as well as providing a niche for vegetation. Often contour trenches or terraces can be combined with vegetal treatment to arrive at a biotechnical approach such as willow wattling. Contour terracing can be an effective treatment for shallow slumping, minor rilling, or gullying.

WATER DIVERSION

Water that is aggravating an erosional feature may need to be diverted to a more stable location. This can be done with waterbars, trenches, or by use of culverts. Wherever microdrainages have been concentrated, diversion may be required. Waterbars are simple diversions to deconcentrate runoff from roads. One of the few treatments for mass movement erosional features is to discourage water from entering at the top of the system. This can be accomplished by slope drainage diversion. Care must be taken to assure that diverted water does not destabilize new areas. An effective waterbar diverts the water, discharges the water onto a stable area, dissipates the energy, and is the proper distance from the next waterbar. Slope drainage diversion is necessary when dewatering an unstable area above a slump, landslide, or earthflow. Small hand dug trenches can be effective in some cases, or larger ones constructed with heavy equipment may be necessary.

HEAD CUT STABILIZATION

The stabilization of gully headcuts is critical for stopping headward erosion. By sloping the gully headcut back to the angle of repose, and with placement of sufficient rock, mulch, and seeding, waterfall erosion and resulting migration of the gully upslope can be halted. Rock and wire mattresses can be constructed to offer additional support to the headcut area. Anytime a gully is treated, the headcut must be addressed, or stabilization is unlikely.

HOOD CHECKDAMS

Wooden structures can be used for erosion control treatment, but they are expensive to build and maintain. Unless redwood is used, the life span can be relatively short. However, the use of wood may be attractive, especially if on-site materials exist. Construction is exacting and requires carpentry skills. Placement of the structures is critical. Checkdams can slow water velocity, and produce sediment flats for vegetation to grow in and stabilize. Checkdams are commonly used in intermittent gullys, or streams, when they can be well anchored.

REMOVAL OF SOIL AND DEBRIS

The removal of soil and debris involves transporting material to a suitably stable spot. Instances where this may be appropriate are when removing material from channels, removing side cast road spoil from the slope, or removing weight from an unstable hillslope. Moving large quantities of soil, gravel, and debris is difficult. Heavy equipment makes it easy, but access is not always available. Labor intensive techniques make it possible.

RECONNECT ALTERED DRAINAGE CHANNELS

Survey the original watercourse to determine the point of departure. Return water to the original channel at as close to the original grade as possible. This often involves removal of material. Rock armoring of new channel, and vegetal treatment may be necessary. Concentrated runoff can be relieved from an active or potential erosional feature by returning drainage to the original channel. Roads and skid trails are commonly associated with altered watercourses. Determination should be made as to whether they are abandoned and should be removed, or are used and just need culverts or waterbars.

PULL ROAD, PUT TO BED, OUTSLOPE

Common treatment is to outslope the road to remove the inboard drainage, cross drain where necessary, or even pull side cast fill material back up and place it in the road cut. Mulch and vegetal treatment may be necessary afterwards. Roads are put to bed when they have been abandoned and are contributing to current or potential erosional features. Sometimes partial outsloping is appropriate. Careful consideration should be given to pulling a road, especially if it is in relatively stable condition, or there is the likelihood that it may be used in the future. The cost of putting a road to bed is high, often higher than the original cost of construction. Some of the greatest potential for erosion can be removed when fill used in stream crossings is pulled back and the original gradient of the streambed and streambank is restored.

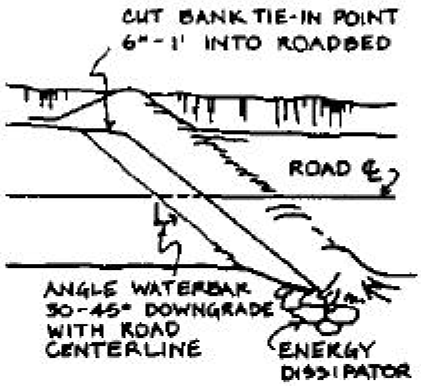
CULVERTS

Use of adequate size culverts allows roads to cross watercourses easily without severe impact. The more culverts that are used, the less the concentration of drainages out of natural channels. An important element for culverts is regular maintenance to make sure they are not in danger of becoming plugged, especially during peak storms. Another key element is that adequate energy dissipation be provided at the culvert outlet so that erosional features are not triggered. Sometimes existing culverts need to have trash racks constructed near the inlet to help reduce plugging and make the job of unplugging simpler. If the outlet discharges on erodible fill, or adequate energy dissipation is not already provided for an existing culvert, then an extension may be required so that water can be delivered to the break in slope. If a road is partially outsloped with no inboard drainage, then culverts are appropriate whenever the road crosses a watercourse. Otherwise, culverts are appropriate for major draws, intermittent creeks, and major streams, and whenever necessary to reduce concentrated runoff. Culverts can also be used to avoid sending water around the corner and into the next watershed. The most common cause of culvert failure, being undersize, is directly related to their high cost. If they can't handle the peak events, then they are too small. One solution is to use sturdy planks for bridging half-culverts made from corrugated roofing.

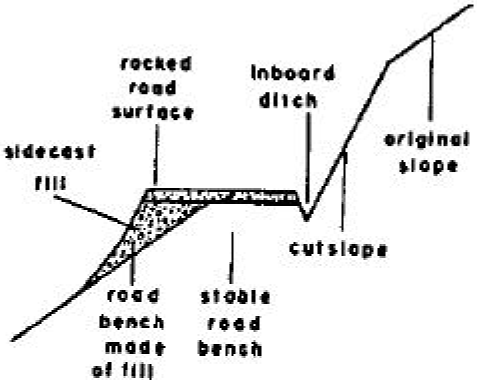
GABIONS

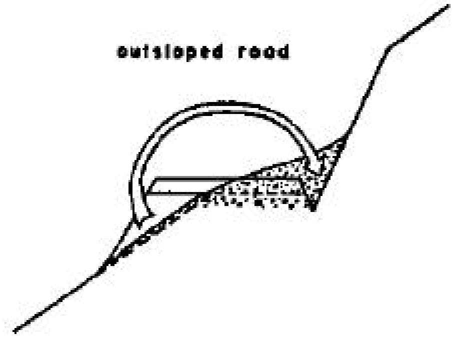
Gabions are rock filled baskets, made from thick gauge wire netting. They can be constructed in various shapes and sizes, depending on their use. In general, the rock used to fill them should be greater than four inches. Gabions can be used to form retaining walls, where other materials are not available. When placed across the foot of a slope to form a toe wall, gabion structures add lateral support through addition of weight and mass. In some instances, gabions can help stabilize mass movement by weighting the toe. When used instream, gabions can enhance spawning habitat by trapping and retaining suitable gravel. They can be placed in sediment choked reaches so that resulting increased water velocity cuts deeper channels. Rock and wire mattresses are similar to gabions, and can be used to stabilize gully headcuts and surficial erosion, as well as to provide energy dissipation for culvert outlets. Gabion weirs, wing deflectors, rock mattresses and other gabion structures must be well anchored in stable medium. Tiered structures, especially retaining walls with stairstep construction, should be slanted back into the slope to avoid toppling.

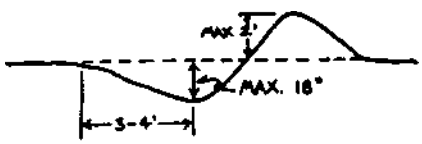
Randall Stemler



(A) TOP VIEW

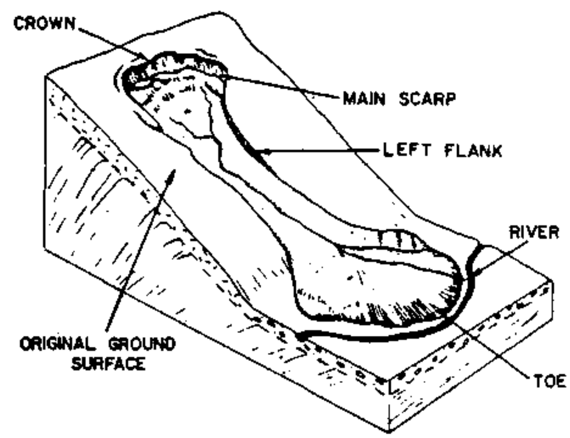




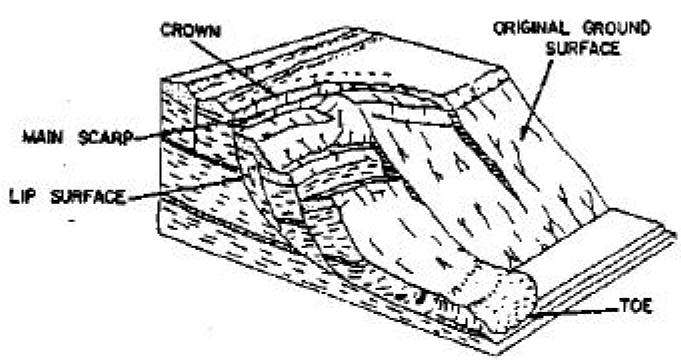


(B) CROSS SECTION

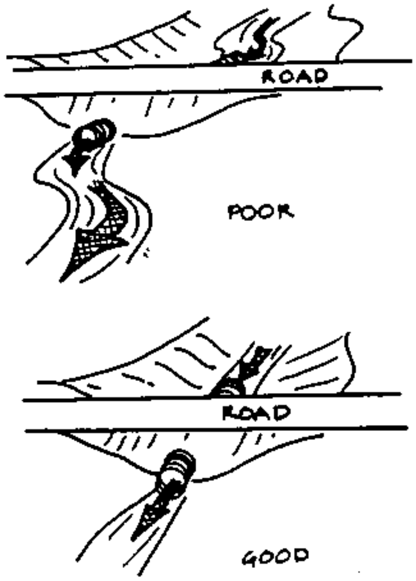
GR – Road related gully



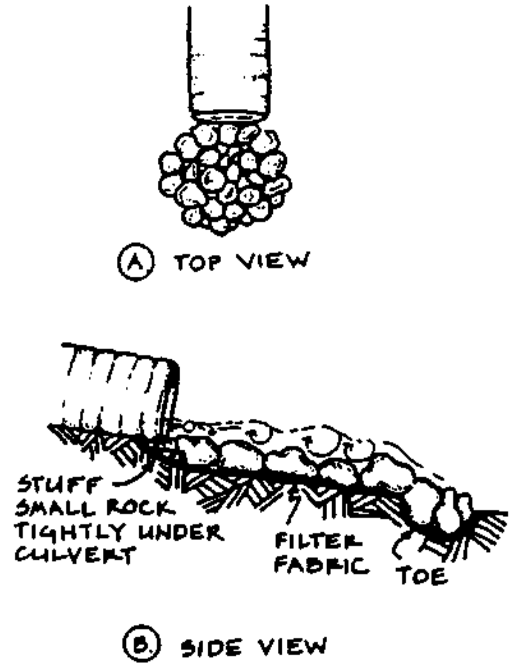
EARTH FLOW



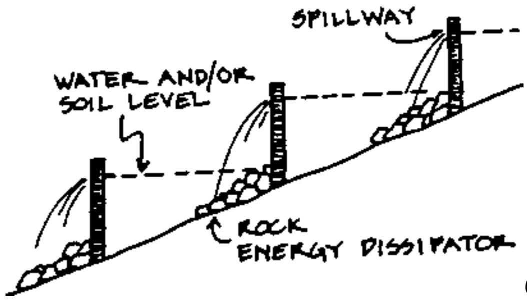
ROTATIONAL SLIDE



Culvert alignment

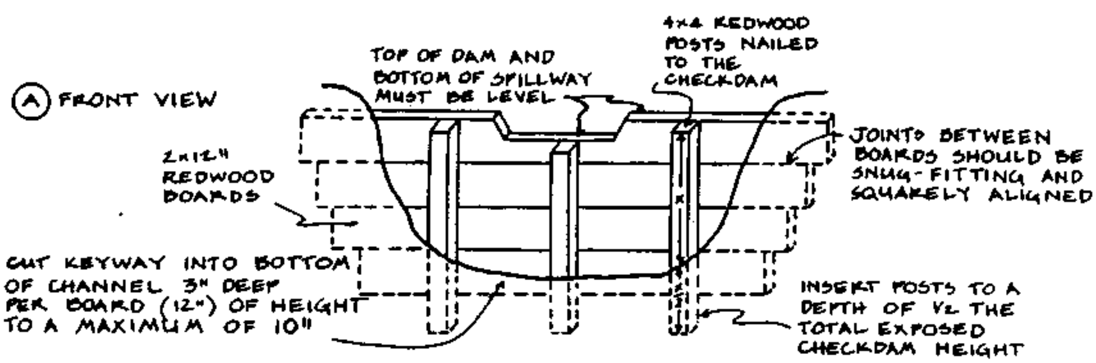


Rock energy dissipator



Checkdam placement

Redwood checkdam



GLOSSARY

AGGRADATION: Gravel, sand, and silt deposits accumulated in the stream channel. The process of sediment building up.

ALLUVIAL: Refers to sediment deposited by flowing water.

ANGLE OF REPOSE: That angle where a slope is at rest and no longer moves from being too steep. It is an angle that varies relative to conditions at the site, including climate, soil, and rock type.

ARMOR: Protective covering used to fortify streambanks from water current; usually provided by rock.

BACCHARIS: See COYOTE BRUSH

BAREROOT STOCK: Plants grown in bulk at a nursery, lifted from the soil while dormant, packed in a moist medium without soil around the roots, and provided to the planter for outplanting.

BEDLOAD: Gravel and other sediments carried and temporarily stored in the streambed.

BIOTECHNICAL: Erosion control methods that use a combination of plants and structures.

BREAK IN SLOPE: The point where the slope angle changes; often referring to the point where road fill meets the natural slope gradient.

CEANOTHUS: Generic name for a treelike shrub in the buckthorn family. There are several species, all of which are nitrogen fixers. Often found on dry hillsides. Common names include: blue blossom, buckbrush, whitethorn.

CHANNEL: The bed of a stream or waterway.

CHECKDAM: A structure placed in a watercourse to trap and store sediment and stop the downcutting action of water.

CHECKPOINT: Similar to a checkdam except that its function is not to trap sediment, but rather to firmly fix the base level of the watercourse. The sides and bottom of the checkpoint structure are set in, and more or less flush with the sides of the channel.

CONCENTRATED DRAINAGE: Water that originally flowed in several dispersed channels converges into one channel, often overloading it.

CONTAINERIZED VEGETATION: Plants that are container grown in bulk in a nursery. When the containers are removed, the material they were grown in remains bound around the roots.

COYOTE BRUSH: A hardy shrub of the Bacchoris genus. Stem cuttings will root. Germinates readily on harsh sites.

CROSS DRAIN: Construction of a trench across a road to drain water from the inside cut slope to the outside fill slope.

DEBRIS TORRENT: A violent, tumultuous flow of rock, earth, tree trunks, broken branches, root wads, and other flotsam and jetsam.

DEEP-SEATED: Massive earth movements like landslides and earth slumps often have a slippery surface that is very deep. It is along this deep-seated failure plane that the mass movement occurs.

DEGRADATION: Usually refers to a downcutting streambed level that is lowering by erosion. Opposite of aggradation.

DEWATERING: Removing water from saturated soil, or diverting water away from saturated soil by encouraging runoff, rather than infiltration. Vegetation can be effective in dewatering by transpiring moisture.

DOWNCUTTING: Erosive action whereby the channel bottom is dropping; often associated with gullies.

EARTHFLOW: A type of mass movement that is usually deep-seated, where soil and vegetation slowly creep downhill in large intact masses. A mud glacier.

ENERGY DISSIPATION: A process accomplished by use of a structure to break the force of water and thereby reduce the velocity and erosive capacity. Usually installed at the outlet of culverts or waterbars.

ERODIBLE FILL: During road construction fill dirt is often used to build up low spots. This material is very susceptible to slope erosion, especially if culverts discharge water onto it.

FLUVIAL: Produced by, or pertaining to, the running water of a river, stream, or creek.

GABION: A wire basket filled with small rocks to form building block-like structures for various uses both instream and on the slope.

GROUND WATER: Water that travels through underground pathways.

HEADCUT: The vertical cliff at the head of a gully where waterfall or headward erosion undermines the bank.

HEADWARD EROSION: The process of gully advancement upstream.

INBOARD: The uphill, inside, or cut slope side of a road; often referring to a drainage ditch that runs along that side of the road to capture water and direct it into a culvert that carries it under the road and discharges it downslope.

INFILTRATION: The process where water sinks into the ground rather than runs off over the surface.

INTERMITTENT STREAM: A channel that runs water only part of the time, usually seasonally.

LATERAL SUPPORT: The strength across the face of any particular slope due to internal friction and resistance to sliding. Removal of lateral support can trigger mass movement. Use of retaining walls, large heavy rock, or buttressing at the foot of slopes can add lateral support and provide some remedy.

MICRODRAINAGE: Subtle variations in slopes and draws where channels originate in headwater areas.

MITIGATE: To lessen the impact or effect of an erosional feature.

OUTSLOPE: The downhill, outboard side of a road; also referring to the process of constructing the road so that it is tipped that direction, without an inboard ditch.

PERENNIAL DRAINAGE: A channel that runs water year round.

RAINDROP IMPACT: A significant type of surficial erosion where individual raindrops splash bare soil particles downslope.

RAVEL: To come apart; a slope that erodes bit by bit. The pile of material at the base of a slope that has fallen from above.

REACH: A section of stream that has similar characteristics. Where a pool stops and a riffle begins, marks the end of one reach and the beginning of another.

RESTORATION: To revive, renew, heal, cure; to bring back from a state of injury; to reestablish after interruption.

REVETMENT: A general term for an armor facing placed on a slope or along a stream bank to resist erosion and help prevent mass movement.

RILLING: A type of surficial erosion where very small channels begin to form from water runoff. This leads to gully formation.

RIPARIAN: Situated on or near the edge of a river or stream.

RIPRAP: A type of revetment using boulder placement for bank protection.

ROAD SPOIL: Road fill or other material that has been pushed over the edge of the bank.

SEDIMENT: Clay, silt, sand, and gravel that is deposited in the watercourse.

SHEAR STRENGTH: The degree to which soil and rock particles stick together due to internal friction. The strength of the material forming the slope; cohesiveness. See LATERAL SUPPORT.

SHEET WASH: A surficial erosion feature where water erodes soil from the slope in thin layers, preceding rilling or gullying.

SIDECAST: Material pushed over the edge of the road. Similar to road spoil.

SLOPE FAILURE: The point reached where stability of the slope has been exceeded and an erosional feature has developed.

SLUMP: A type of deep-seated slope movement where masses of soil and vegetation slip downhill. Similar to an earthflow.

STEM CUTTINGS: Short sections of branches taken from species that root when planted, such as willow or coyote brush.

STEREO PAIRS: Overlapping photographs that, with the use of a stereoscope, allow the viewer to see the subject matter in three dimensions.

TECTONIC UPLIFT: Elevation of a part of the earth's crust due to the movement of large geographic plates.

TERRACING: Building a series of level benches along the contour of a slope.

TOE: The base of a slope or mass movement.

TRASH RACK: A device that is built around the inlet of a culvert to catch debris and prevent the culvert from getting plugged; and make it easier to clean out if it does get plugged.

WATERBAR: A soil berm or rolling dip constructed on a road at such an acute angle that it diverts the flow of water off the road and discharges it onto a stable area.

WATERSHED: The region or area drained by a particular stream or river, delineated by ridge lines.

WATER VELOCITY: The speed of water. When the speed of flowing water is doubled, the erosive or cutting ability is increased about 4 times, the quantity of material that can be carried is increased 32 times, and the size of a particle that can be transported by pushing or rolling is increased 64 times!

WATTLING: The process of tying bundles of flexible twigs or branches together, staking them in contour trenches to interrupt the flow of water down a slope, and partially covering the wattles with soil. The use of species that root from stem cuttings results in sprouting along the terraces.

WEIGHTING: A technique used to help stabilize mass movements by the addition of weight and mass to return lateral support to the toe. See LATERAL SUPPORT.

WEIR: An instream structure used to direct or modify the flow of water, and as a gabion-like erosion control device similar to a checkdam; also a fence or system of panels used to direct and trap fish.

WINDROW: Leaves, branches, hay or other material placed in rows on the contour of a slope to slow the action of runoff and reduce soil erosion; also rows of trees planted in such a way as to break the force of strong winds.

WING DEFLECTORS: In-stream structures designed to force flow away from unstable banks; usually used in a series around the outside bend of a river. Also called wing dams or groins.

Selected Bibliography
for Erosion Control in the Coast Range

Many of these texts are available for inspection at the Mattole Restoration Council library.

GENERAL

Margolin, M. 1986. *The Earth Manual*. Heyday Books, Berkeley, CA

Prunuske, L. 1987. Groundwork: a *handbook for erosion control in North Coastal California.* Marin Co. Resource Conservation District.

ROADS

Darrach, A.E., W.J. Saurerwein, C.E. Hally. 1981. Building *Water Pollution Control into Small Private Forest and Ranchland Roads.* USDA Forest Service, Soil Conservation Service. No. RG-SPF 0061980.

Dellberg, R.A. 1982. Road Building *for Small Private Roads.* Mendocino Co. Resource Conservation District, 405 Orchard Ave., Ukiah, CA 95482

Furniss, M.J., T.D. Roelofs. 1989. *Forest Roads and Anadromous Fish: how to have both.* American Fisheries Society, Maryland.

Garland, J.J. 1983. *Planning Woodland Roads* Circular 1118, *Designing Woodland Roads* Circular 1137, Road Construction on Woodland Properties Circular 1135, Maintenance *of Woodland Roads* Circular 1139. Oregon State University Extension Service, Corvallis, OR 97331

Gelonek, W.A., T.C. Ferrara, K.V. Henkel, et.al. 1984*. A Basic Guide on How to Plan, Construct, and Maintain Small Private Forest Roads.* California Dept. of Forestry and Fire Protection

Yee, C.S., T.D. Roelofs. 1980. *Planning Forest Roads to Protect Salmonid Habitat.* USDA Forest Service. Pacific NW Forest and Range Experiment Station.

GULLIES AND LANDSLIDES

Gray, D.H., A.T. Leiser. 1982. *Biotechnical Slope Protection and Erosion Control.* Van Nostrand Reinhold, New York, NY.

Heede, B.H. 1976. *Gully Development and Control.* USDA Forest Service RM169. Colorado.

Mendocino Co. Resource Conservation District. *Stream Channel and Gully Grade Stabilization Structures.* 405 Orchard Ave., Ukiah, CA 95482

Singer, S. 1980. Guidelines *for Gully Control.* Santa Cruz Co. Resource Conservation District, Aptos, CA 95003

Singer, S. 1982 *A Guide for the Control of Landslides.* Santa Cruz Co. Resource Conservation District, Aptos, CA 95003

Taylor, F. and E. Brabb. 1986. Landslide Inventory and Susceptibility Mapping in *California.* USGS Open file report 86-100 USGS Denver, CO 96225

Weaver, W.E., M.M. Hecktner, D.K. Hagens, et.al. 1987. An Evaluation *of Experimental Rehabilitation Work, Redwood National Park.* TR19. Redwood National Park, Arcata, CA 95521

VEGETATION MANAGEMENT

Chan, F.J., R.W. Harris, A.T. Leiser. 1977 Direct *Seeding Woody Plants in the Landscape.* UC Agriculture Leaflet 2577 Davis, CA 95616

Clary, R.F. 1983. *Planting Techniques and Materials for Revegetation of California Roadsides.* USDA Soil Conservation Service, Davis, Ca 95616

Hafenrichter, A.L., et.al. 1968. Grasses and Legumes *for Soil Conservation in Pacific Northwest and Great Basin States.* USDA Soil Conservation Service, Wash., D.C.

Singer, S. 1980. Groundcover: a planting guide *for erosion control in Santa Cruz County.* Santa Cruz Co. Resource Conservation District, 323 Spreckles Dr., Aptos, CA 95003

U.S. Dept. of Agriculture Forest Service. 1974. Seeds *of* Woody Plants in the *United States.* USDA Forest Service, Agricultural Handbook #450, Wash., D.C.

WILDLIFE

British Columbia Ministry of Environment. 1980. *Stream Enhancement Guide*. B.C. Minister of Environment, Fish and Wildlife Branch, Vancouver, B.C., Canada (out of print)

Seehorn, M.E. 1985 *Fish Habitat Improvement Handbook*. USDA Forest Service TP-R8-TP7

RANGE MANAGEMENT, GRAZING SYSTEMS

California Cooperative Extension Service, 1985. Preliminary Guidelines *for Managing California's Hardwood Rangelands.* Publication 21413. $5.00 Check local extension office.

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