CORRECTIVE WORK NEEDED FOR THE REHABILITATION OF THE HEADWATERS OF THE REDWOOD CREEK WATERSHED

By

David M. Burns & Perry Y. Amimoto

April 1977

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FOREWORD

This is a report of a study to develop a feasible and cost/effective rehabilitation program to reduce the accelerated erosion coming from numerous erosion sources created over the years in the upstream drainage of Redwood Creek Basin. This study was authorized by the Secretary of Resources Claire Dedrick and the Director of Conservation L. A. Moran and carried out under the direction of State Forester L. E. Richey.

This report describes the basic physical facts as they presently exist in the upper watershed of Redwood Creek Basin. No attempt was made to relate the physical problems to existing or past land ownership patterns. The land ownership has changed over the years since the first logging took place and there is not necessarily any correlation to the conditions on the ground and the present landowners' activities, nor is there any correlation in regard to the effects of current logging practices and past logging practices.

It should be noted that physical problems occurring in the upper Redwood Creek Basin are not unlike problems found in other drainages previously logged with similar geology and timber types in the North Coast Region. The study at this time has not covered the lower portion of Redwood Creek near the National Park in the redwood forest type.

We find that the comments received regarding the preliminary draft of this study generally corroborate the findings and do not substantially alter the estimated cost of rehabilitation of the watershed. It should be noted that this report did not include the mitigation of problems in the main Redwood Creek channel because this was being studied by others including U. S. Geological Survey.

This report was prepared by David Burns, California Department of Forestry, and Perry Amimoto, California Division of Mines and Geology, Department of Conservation.

Corrective Work Needed for the Rehabilitation of the Headwaters of the Redwood Creek Watershed

by
David M. Burns[1] & Perry Y. Amimoto[2]

I. Summary

The study concludes that the cost of rehabilitation work to reduce erosion in the upper watershed of Redwood Creek will be approximately $2,430,000 or about $50/acre. Comments on this study by the U. S. Geological Survey and the National Park Service are attached to this report.

II. Background

This study was authorized by State Forester L. E. Richey. The purpose was to look into the needs and feasibility of the rehabilitation of Redwood Creek and to make recommendations for cost effectiveness.

Meetings were held with representatives of the larger timber owners within the watershed. Representatives of the Redwood National Park and U. S. Geological Survey who have intimate knowledge of Redwood Creek were advised of the study and asked for their inputs. All representatives were invited to participate in the field work.

Since the Redwood Creek drainage is 154,000 acres, it was decided to block the drainage into 3 areas and sample within one area at a time. Of the three areas, two are north of State Highway 299, while the third study area, representing approximately one-third of the total drainage, is located in the headwaters of Redwood Creek south of State Highway 299. Other criteria for the study were: 1) selection of areas that had been logged or disturbed prior to January, 1975 (new Forest Practice Rules effective date); 2) land owner's approval or permission; and 3) accessibility and timing.

1/ Forester III, CDF

2/ Engineering Geologist, CDMG

Considering these criteria and the multiple law suits which were in progress involving the three major landowners, the study team was precluded from working on lands of the larger landowners. It was decided to start the rehabilitation study in the least controversial area. This was affirmed in the State Forester L. E. Richey's letter of September 7, 1976 to Director L. A. Moran in which the initial study area was limited to the headwaters of Redwood Creek south of State Highway 299.

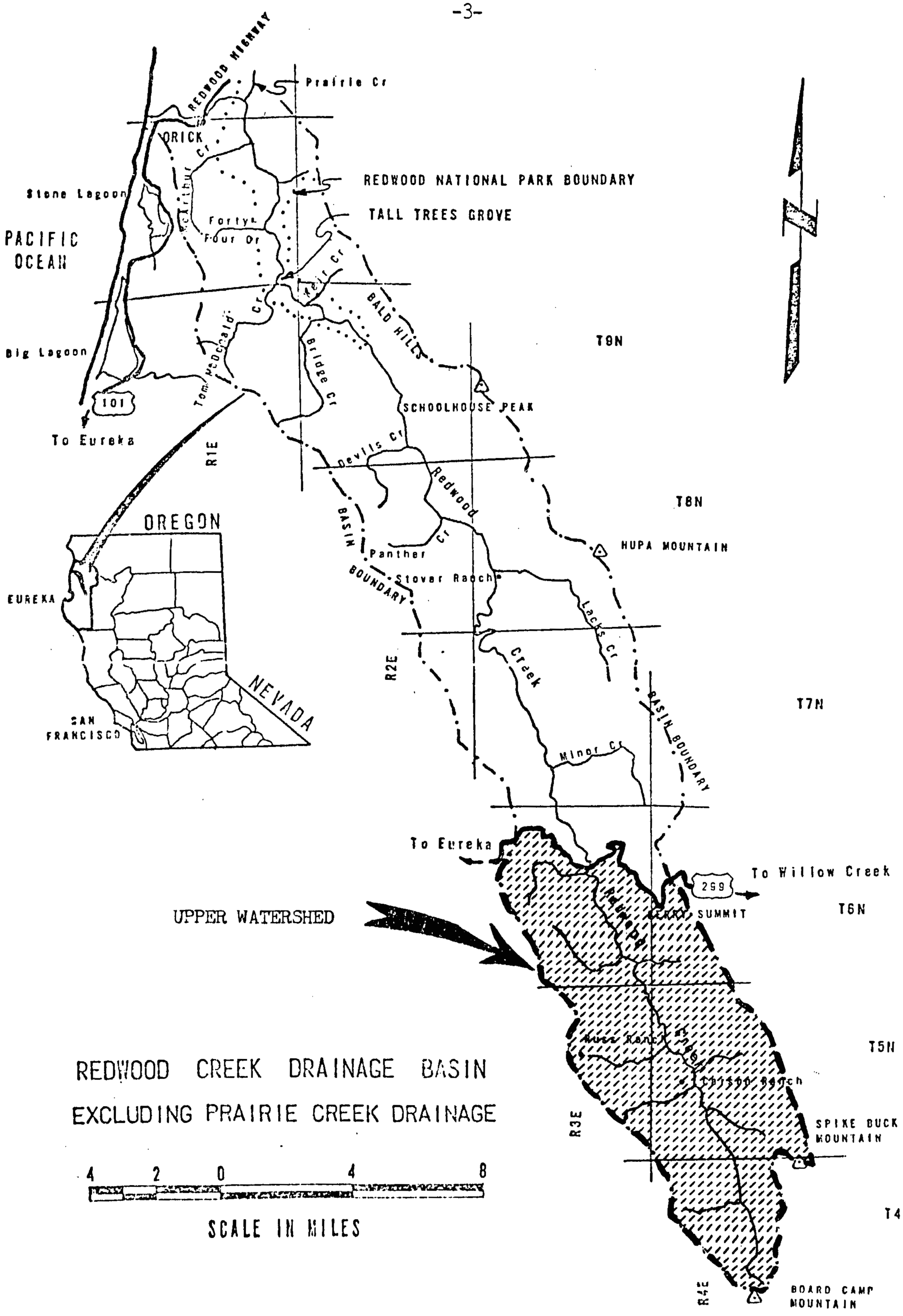
During the week of September 20, 1976, David Burns, Forester III of the California Division of Forestry, Perry Amimoto, Engineering Geologist of Division of Mines and Geology, Steven Veirs and Gary Lester of National Park Service studied and sampled subareas in the upper watershed of Redwood Creek. No company or industrial representatives accompanied the study team during this phase of the study.

III. Description of area

In general terms, the area studied consists of 48,400 acres. Based on aerial photos taken as late as September, 1975, the timber stand conditions in the study area were stratified as follows:

1.	Virgin timber (mostly U. S. Forest Service	13% of area
2.	Grasslands (prairie soils)	16% of area
3.	Oak woodland with grass and some Douglas-fir	17% of area
4.	Areas logged more than 7 years ago and having at least 80% revegetated	23% of area
5.	Areas logged more than 7 years ago and having	
6.	Areas logged within past 7 years using selection or seed tree cuts	3% of area
7.	Areas logged within past 7 years using clear-cut	5% of area

Elevations in the study area range from 980 feet to 5400 feet above sea level. Redwoods are present at the lower elevations; and true fir at the higher elevations.



REDWOOD CREEK DRAINAGE BASIN
EXCLUDING PRAIRIE CREEK DRAINAGE

IV. Source of Debris & Sediments

Roads, mass land movements, streams and logging skidroads were studied as sources of debris and sediments. The findings are as follows:

1. Roads are major sources of erosion and stream sediments. During high flows, many of the drainage facilities fail, resulting in road washouts and accelerated stream channel and bank erosion (Fig. 1). Several culverts are not functioning because of silted intakes, and very few culverts have energy dissipaters (Fig. 2). Also, many new culverts are needed to prevent erosion of the roadway and undercutting of the cut slopes. Old log bridges are deteriorating and causing stream blockages. "Humboldt crossings" (logs laid perpendicular to the road surface to act as culverts) are not doing an adequate job (Fig. 3).
2. Landslides and slope failures along roads and streams are major sources of erosion (Fig. 4).
3. Ephemeral streams are generally clogged with old logging debris (logs, chunks, and slash) which have acted as debris catchment basins (Fig. 5).
4. Considerable accelerated erosion of stream banks is occurring along intermittent streams (Fig. 6). Log jams have acted to trap sediments and divert waters into erodible stream banks, resulting in undercutting and slope failures.
5. Much of the older logging in the upper watershed started in the early 1950's. The skidroads in the older logging areas generally had few, if any, waterbreaks. However, most of the skid roads have stabilized or have been revegetated with grasses and forbs. (Fig. 7).

6. In areas logged within the past 7 years, many waterbreaks on the skid roads failed resulting in gully erosion (Fig. 8).
7. Non-logging areas include prairie soils, subdivisions, and public roads and right-of-ways. Areas which are considered prairie soils (grasslands) are actively moving and are very sensitive to water concentrations such as culvert outflows (Fig. 9).

There is in the planning stages a proposed subdivision which will involve about 2,000 acres from Redwood Creek near the State Highway 299 up the slope on the east side of the drainage and then southward along the ridge and extending down the major side ridges (Fig. 10). Lot sizes will range between 20 to 29 acres in size. Lots will be located on moving prairie soils and areas that have been converted from timberland to grass. This subdivision could cause very serious downslope accelerated erosion problems.

V. Mitigating Measures

Mitigating recommendations are as follows:

1. Corrective actions needed to mitigate erosion and sedimentation caused by roads include:
   a. Cleaning out sediments and logging debris from intake areas near culverts.
   b. Installing drop inlets and concrete headwells at some culvert inlets.
   c. Replacing and/or adding larger culverts at some locations.
   d. Adding new culverts where road surfaces or cut slopes are being undercut by excessive water.
   e. Installing energy dissipaters at outlets of all culverts.
   f. Replacing and installing new bridges or large arch culverts.

g. Removing all "Humboldt crossings" and replacing with culverts or bridges.

h. Installing downdrops on cuts, fills, and culverts when accelerated erosion is occuring.

i. Installing cribbing on road fills where it is the only feasible method of reducing road slipouts and washouts.

j. Line side ditches into culverts where excessive erosion of the fill material is occurring.

k. Grade roads for adequate drainage (outsloping and redirection of roadside drainageways are needed).

l. Rock road surfaces and roadway drainages.

m. Install interceptor ditches on top of road cuts where exposed cuts are subject to excessive surface runoff.

2. Corrective measures needed to reduce landsliding include installing or implementing the following:

   a. Lined interceptor ditches above the slide.

   b. Terraces to divert surface runoff.

   c. Pipe drops to convey runoff down the slope.

   d. Horizontal drainage wells.

   e. Revegetation of the landslide surface.

   f. Cribbing to buttress the toe of slides.

3. If the logging debris were to be removed from ephemeral streams, the large volumes of stored sediments would be released at one time, resulting in accelerated erosion. Therefore, it is generally recommended that debris from ephemeral streams not be removed at this time.

4. In intermittent streams, logs that cause bank erosion should be removed and revegetation of the stream channel undertaken where appropriate.

5. Areas logged prior to seven years ago generally do not require remedial treatment except where the remedial measures would cause a substantial and overall decrease in erosion. There are a few gullied skid roads where rehabilitation could be considered; however, the repair of such gullies by dozer work and waterbreaks might cause accelerated erosion. Since most skid roads are reasonably stablized, it is generally recommended that no corrective work be undertaken at this time. For areas logged less than seven years ago, it would be beneficial to repair or install new waterbreaks on the skid trails.

6. In non-logging areas the public and private entities should be encouraged to repair non-functioning erosion control measures and to install corrective devices.

VI. Cost of Rehabilitation Work

Estimated costs of rehabilitation work recommended in this report will be approximately $2,430,000. The separate costs are summarized in Table I. The methods of expanding the field data to the study area are as follows:

1. Roads - Estimated number of miles from 1975 aerial photographs.
2. Landslides - Estimated number of slides from "Erosional Land Form Map of the Redwood Creek Drainage Basin, Humboldt County, California 1947-74," by K. M. Nolan, D. R. Harden, and S. M. Colman, USGS July 1976.
3. Stream Log Jams - Estimated number from field observations.

Table I

COST ESTIMATES FOR CORRECTIVE WORK NEEDED FOR THE REHABILITATION OF THE UPPER ONE-THIRD OF THE REDWOOD CREEK WATERSHED

	No. Of Units	Materials	Equipment W/Operator	Labor	Overhead Supervision	Engineering Services	TOTAL
I. ROADS	170 miles	$	$	$	$	$	
A. Culverts Repair & Additional	460 ea.	187,600	65,700	24,200	65,000	25,000	367,500
B. Grading	170 miles	---	10,200	1,000	2,500	---	13,700
C. Bridges or Arch Culverts	13 ea.	325,000	26,000	32,500	9,000	6,000	398,500
D. Cribbing	13 ea.	32,500	7,500	2,500	10,000	3,000	55,500
E. Road Rock Base	6 mi.	10,000	3,000	400	1,000	500	14,900
F. Line side ditches to culverts	80 ac.	3,000	7,000	9,000	3,000	---	22,000
G. Revegetation	5 mi.	3,000	27,000	1,000	1,500	---	32,500
Subtotals		561,100	146,400	70,600	92,000	34,500	904,600
% of Subtotal Cost		62.02	16.19	7.81	10.17	3.81	100.00
II. LANDSLIDES							
A. Along Roads							
1. Interceptor ditches	4,000'	8,000	16,000	4,000	4,000	2,000	34,000
2. Down Drains	4,000'	24,000	4,000	4,000	4,000	2,000	38,000
3. Midslope collection ditches	4,000'	24,000	24,000	4,000	4,000	2,000	58,000
4. Horizontal Drains	3,000'	1,000	13,000	1,000	1,000	1,000	17,000
5. Hydroseeding	20 ac.	2,000	18,000	1,000	1,000	---	22,000
B. Along Stream Banks							
1. Interceptor Ditches	50,000'	100,000	200,000	50,000	25,000	25,000	400,000
2. Down Drain	88,000'	528,000	88,000	88,000	25,000	25,000	754,000
Subtotals		687,000	363,000	152,000	64,000	57,000	1,323,000
% of Subtotal Cost		52.04	27.50	11.52	4.85	4.09	100.00
III. STREAM LOG JAMS	90						
A. Cut & Remove logs		300	103,000	40,000	13,500	---	156,800
B. Revegetation of Stream Channel	27 ac.	2,700	---	1,500	2,500		6,700
Subtotals		3,000	103,000	41,500	16,000		163,500
% Subtotal Costs		1.83	63.00	25.38	9.79		100.00
IV. SKID TRAILS	4,000 ac.						
A. Waterbar Repair		---	25,000	2,000	7,000	---	34,000
B. Revegetation of Skidtrails		4,000	1,000	2,000	1,000		8,000
Subtotals		4,000	26,000	4,000	8,000		42,000
% Subtotal Costs		9.52	61.91	9.52	19.05		100.00
GRAND TOTALS		1,255,100	638,400	268,100	180,000	91,500	2,433,100
% of Total Cost		51.65	26.27	11.03	7.41	3.64	100.00

4. Skidroads - Estimated number of acres from preliminary photo interpretation of vegetation and land use conditions in the redwood creek basin as of September 1975 as provided by the National Park Service. The number of miles of skidroads per square mile by slope class was provided by Dr. J. M. Dodge based on recent soil erosion studies in the Redwood Creek Basin. Skidroad conditions were based on field observations.

VII. Cost/Benefits for Recommended Treatments

If all the corrective measures recommended in this report were to be accomplished, then a 52 percent reduction of active sediment production would result (see Table II). Active sediment production, as used in this table, means sediments and debris reaching water courses as differentiated from debris already in streams.

Table II. Cost/Benefits for Recommended Treatments

Sources of Sediments	% of Total Sediment by Source	Estimated Chance of Success of Treatment	Sediments Reduced by Treatment	Estimated Cost of Treatment	Estimated Cost Per % Sediment Reduction by Treatment
Roads	20 %	.80	16 %	$ 904,600	$56,530
Mass Land Movements	60	.30	18	1,323,000	73,330
Stream Bank & Log Jams	10	.90	9	163,500	18,170
Skid Roads	10	.90	9	42,000	4,670
TOTAL	100 %	---	52 %	$2,433,100	$46,730

The most cost effective treatment is on skidroads and landings; the next most cost effective treatment would be in streams and log jams; the third in the list of cost effectiveness treatment is road repair; and the least cost effective treatment would be the treatment of mass land movements.

For the projected work on skidroads and landings to be effective, the work should be done as soon as possible. Data developed during this study indicates that skidroad recovery is almost complete in twenty years, while 6 year old logging areas require additional repair work on 20 percent of the skidroads; and areas logged two years ago require up to 70 percent rehabilitation work of skidroads.

VIII. Lists of Participants and Sources of Information

Participants in the Field Evaluation Phase of this Study Were:

David Burns (Coordinator)	California Division of Forestry
Perry Amimoto	California Division of Mines & Geology
Steven Veirs, Jr.	National Park Service
Gary Lester	National Park Service

Persons Contacted for Assistance and Information Were:

James Denny	California Division of Forestry
Grant McClellan	California Division of Forestry
Jean Sindel	California Division of Forestry
Roy Ritchey	California Division of Forestry
Richard Forester	California Department of Fish & Game
Alfred Merrill	Louisiana Pacific Corporation
Lowell Chapman	Arcata Redwood Company
Herb Peterson	Simpson Timber Company
Carlton Yee Ph.D.	Consulting Professional Forester & Hydrologist
Einar Johnson	National Park Service
Richard Janda Ph.D.	U. S. Geological Service
Edward Lowe	California Department of Transportation
Charles Wagener	California Division of Forestry

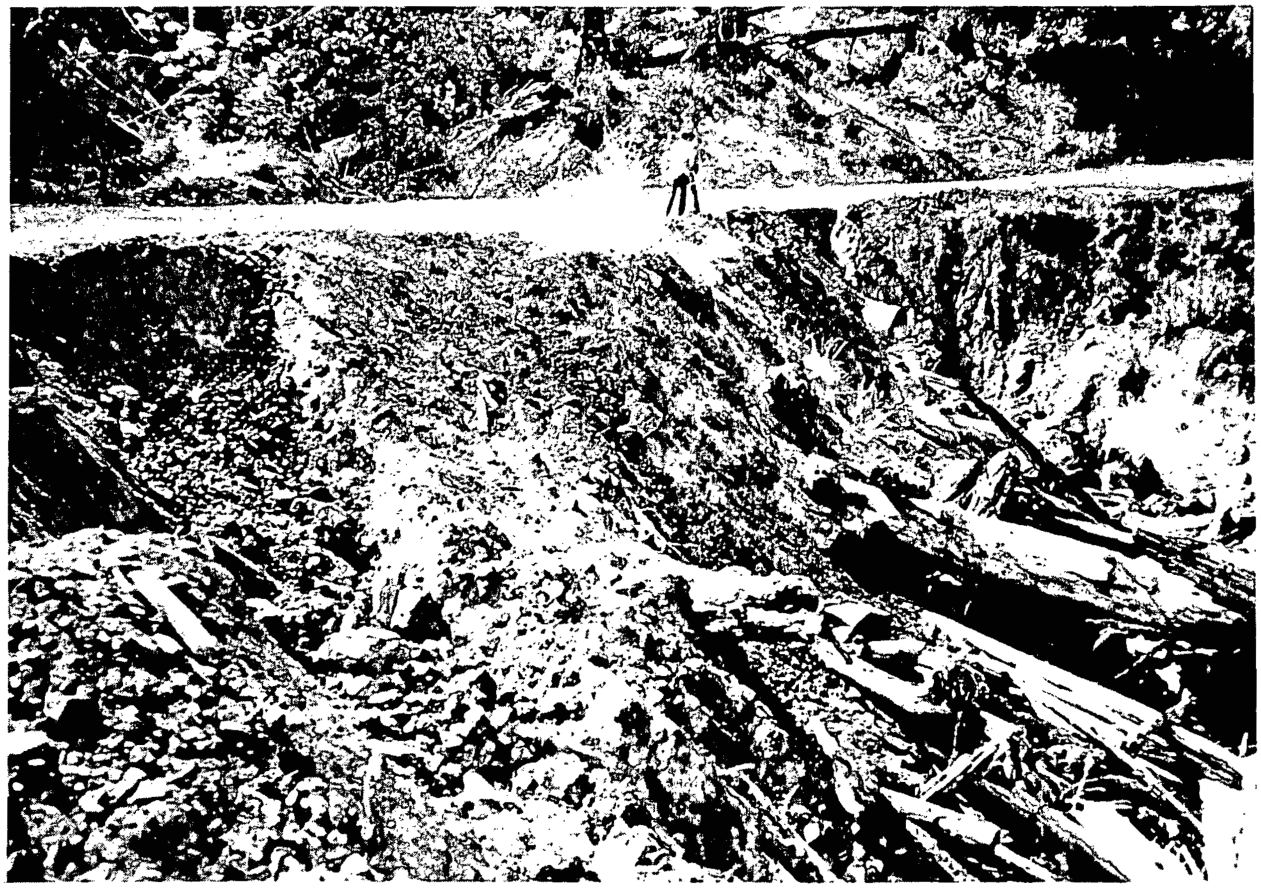


Fig. 1. During high flows many culverts fail, resulting in road washouts and accelerated stream channel and bank erosion..

Fig. 2. Erosion caused by a culvert outlet with no energy dissipater.

Fig. 3. An old log bridge which has collapsed and is causing stream blockages.

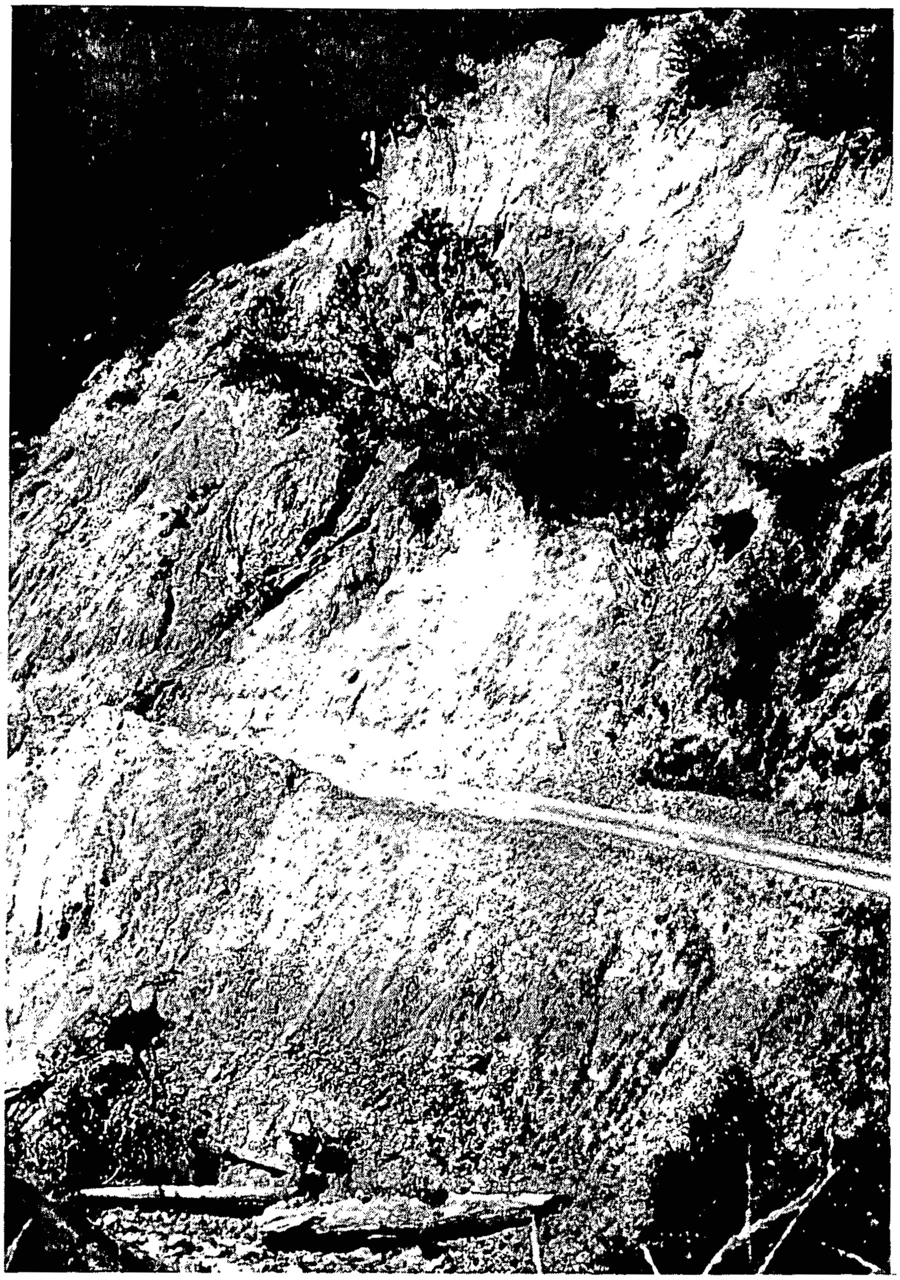


Fig. 4. Landslides and slope failures along roads and streams are major sources of erosion.

Fig. 5. Ephemeral streams are generally clogged with old logging debris which have acted as debris catchment basins.

Fig. 6. Log jams have acted to trap sediments and divert waters into erodible stream banks.

Fig. 7. The skidroads in the older logging areas generally had few, if any, waterbreaks. However, most of the skid roads have stabilized or have been revegetated with grasses and forbs.

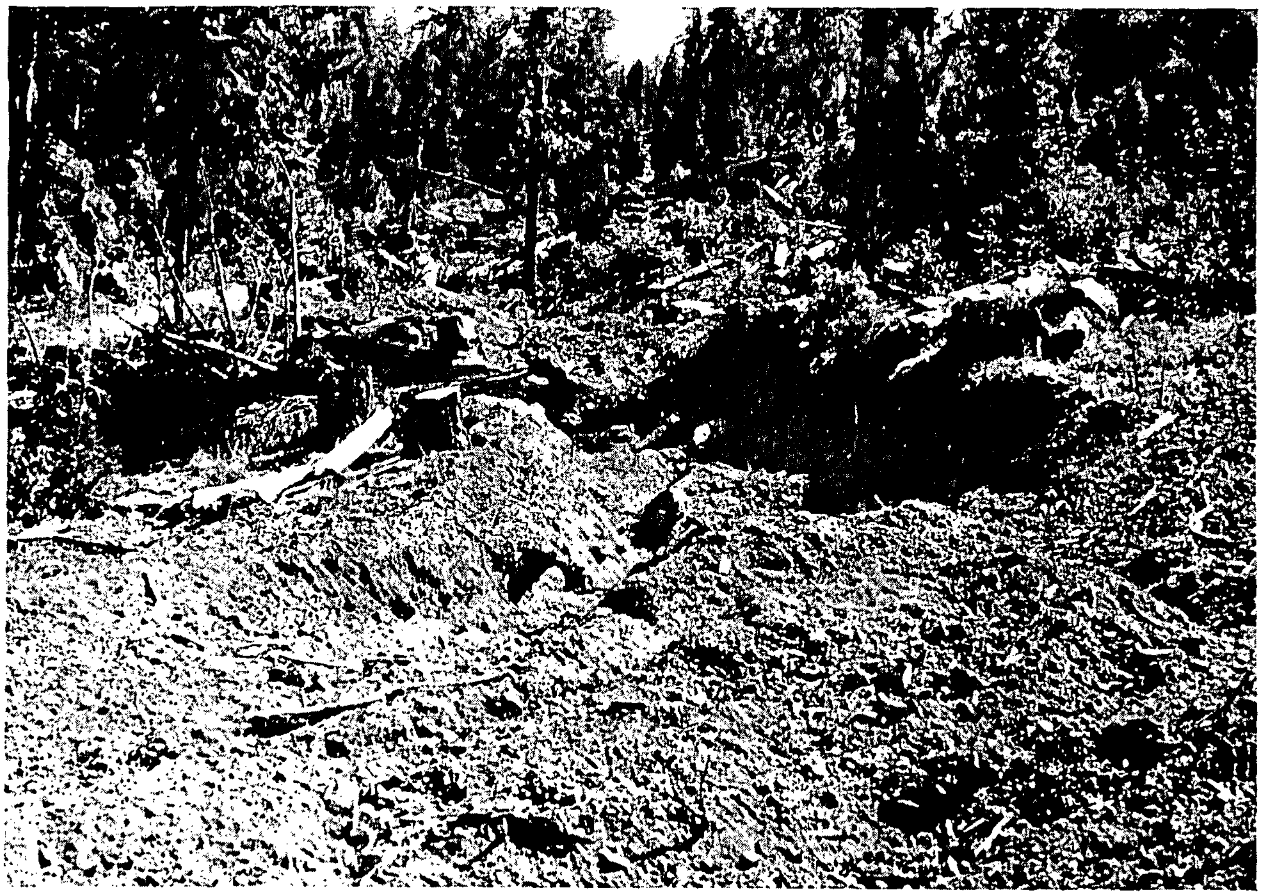


Fig. 8. In areas logged recently many waterbreaks on skid roads failed.

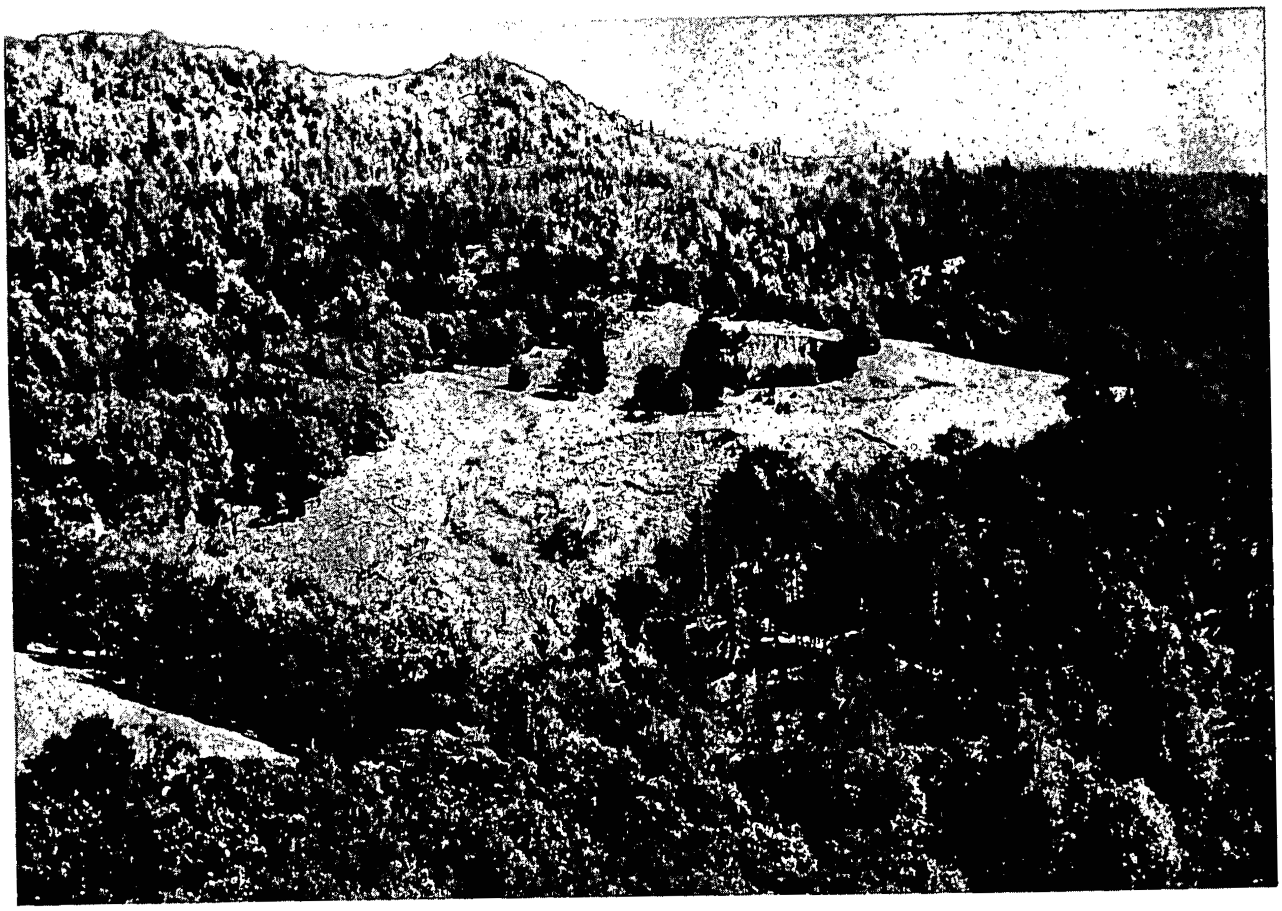


Fig. 9. Areas which are considered prairie soils (grasslands) are actively moving.

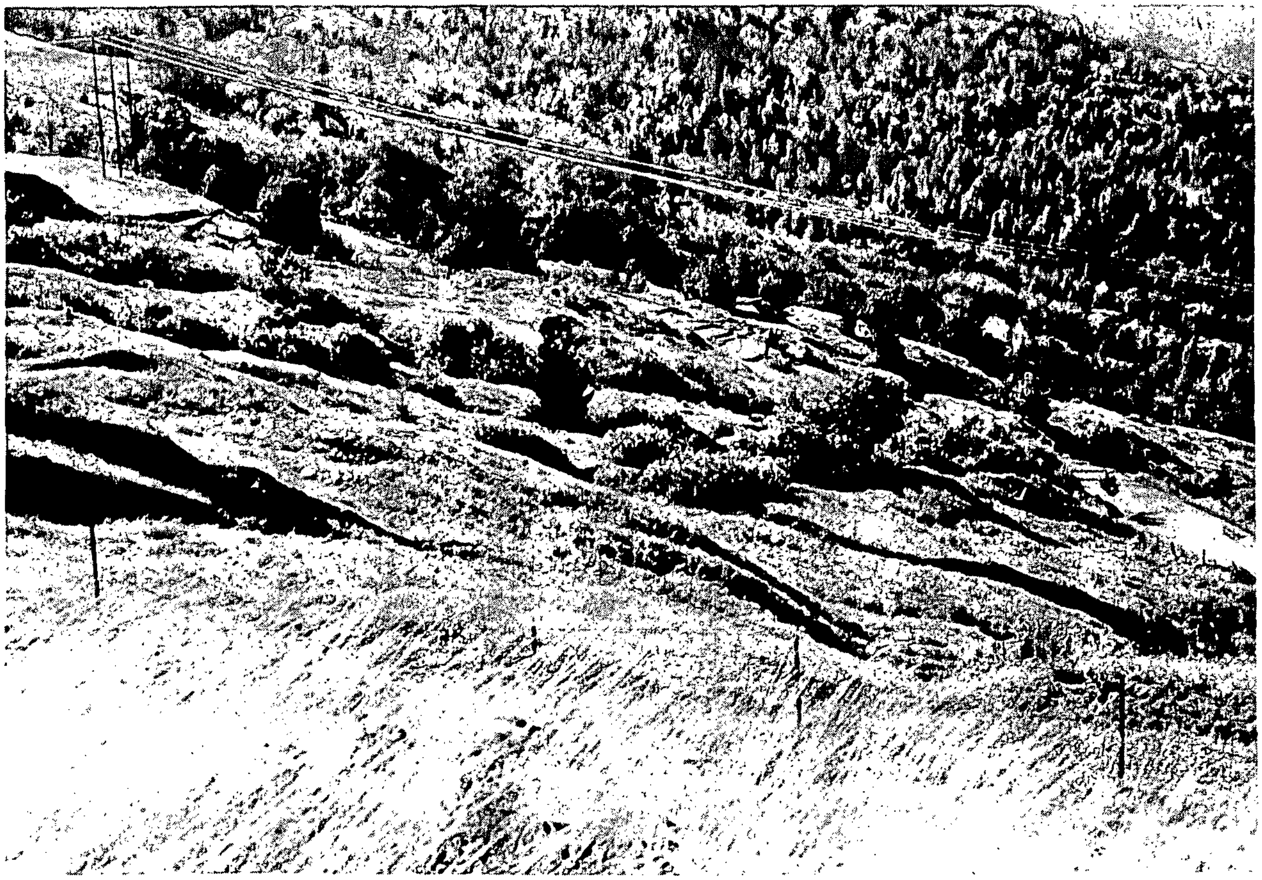


Fig. 10. A paved road in an area proposed for a subdivision is showing landslide cracks in this area of unstable prairie soils.

ATTACHMENT "A"

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
Water Resources Division
345 Middlefield Road
Menlo Park, CA 94025

January 31, 1977

Mr. David M. Burns
Forester III
California Division of Forestry
13760 Lincoln Way
Auburn, CA. 95603

Dear Dave,

Given the limited information and time available to you and Perry Amimoto, you did a thoroughly commendable job in establishing a working outline for the design of a rehabilitation program for the upper third of the Redwood Creek basin. However, from my particular perspective as a student of the natural and man-induced hillslope and stream channel processes, I would like to see that outline somewhat expanded and refined before it becomes the foundation for a specific action program. In the paragraphs that follow I shall discuss five general areas of concern that I have about your interim report. These concerns, in turn, lead me to suggest that you consider summarizing the entire proposed rehabilitation program in a map format with a scale of not less than 1:24,000 (one inch equals 2000 feet) before funding and work schedules are firmly established. Sixteen more specific comments are keyed by number to the actual text. Congratulations on initiating a potentially exciting demonstration of some of the ecologic and economic benefits associated with watershed rehabilitation in northwestern California.

Thank you for encorporating into this draft the editorial change that Carl Hauge forwarded to you concerning the citation of the photographic information used to stratify the upper basin with regard to timber stand condition. Again, I should like to apologize for being unable to accompany you during your field inspection of the study area. I further apologize for being so slow in getting these comments to you.

My first concern about your interim report is that some key elements in your data base may not be developed in sufficient depth and detail to allow for accurate estimation of the true magnitude of the required rehabilitative effort. I am particularly concerned about two forms of largely photointerpretive map information developed by the Geological Survey at a scale of 1:62,500 (one inch equals approximately 1 mile) and utilized in your interim report--(1) an erosional landform map released to the open-file in July of 1976, and (2) a working draft of a map of vegetation and land-use conditions which was forwarded to the Park Service and others familiar with these conditions for their review and comment before we developed a final map for public release. Scale limitations associated with the erosional landform map may result in grossly underestimating the number of landslides that could be included in the rehabilitation program. Landslides less than 200 feet in width are either included within the "unstable streambanks" category on the erosional landform map or are not portrayed at all. Although none of these small slides individually produce a large quantity of sediment, their aggregate contribution is quite large. Moreover, the probability of successfully stabilizing many of these relatively small landslides may be significantly greater than that associated with some of the larger, more complex landslides. In passing, I should like to say that you may also be able to improve your estimate of the amount of effort that could be directed toward landslide stabilization, if you were to subdivide your slide category into more tighter defined subcategories such as deep-seated translational-rotational slides, earthflows, shallow-seated debris slides, etc. Such a subdivision would also allow you to sharpen your estimate of the probable success of proposed stabilization measures.

Many of the limitations associated with our preliminary land and vegetation conditions map are indicated on its accompanying explanation; a copy of this explanation is enclosed for your reference. The map units were selected in part in an attempt to contrast vegetation conditions in 1968, at the time Redwood National Park was established, with those conditions that exist "today" (i.e., 1975). Unfortunately, 1968 photographs were not available for the upper basin. The point to be stressed here is that the map units in the upper basin (i.e., the area of immediate concern in your interim report) were separated on the basis of interpretations of the time significance of the degree of vegetation and ground surface disruption within different harvest units visible on 1970 aerial photographs. Thus, to turn the argument around and to infer that little disruption remains after seven years approaches circular reasoning.

The map units do indeed separate areas characterized by differing levels of disruption and may, therefore, be useful in the early planning phases of a rehabilatative effort. However, the units are defined primarily in terms of the percent of an area covered by bare mineral soil; they are not defined in terms of type or intensity of erosion within those bare soil areas. Thus, the map units address themselves more to the issue of re-stocking and revegetation than to the issue of erosional stabilization. These two issues, while closely related, are not identical because a relatively large amount of erosion can occur in a relatively small unvegetated area. Our experience suggests that even immediately following timber harvest, erosion tends to be concentrated in discrete areas of limited extent (for example, gullied skid trails, sloughed road cuts, debris avalanche tracks, etc.) rather than being widely distributed over the entire harvested area. Moreover, these areas of concentrated erosion tend to be areas that are most slowly revegetated. Therefore, areas that are 80% or more revegetated, may still be actively eroding as a consequence of timber harvest-induced ground surface disruption. Another factor to consider is that much of the earlier logging was carried out in a more disruptive manner than that associated with more recent logging. These considerations lead me to suggest that by restricting rehabilitative efforts on skid trails to only the approximately 8% of the total area (4000 acres) that was "logged within the past 7 years" and neglecting the 46% of the total area that was "logged more than 7 years ago", you may be underestimating the amount of rehabilitative effort that could be directed towards reducing skid trail erosion. I believe that rehabilitative efforts could profitably be carried out within much of the 23% of the total area that was apparently logged more than 7 years ago and is still less than 80% revegetated.

Two possible areas of rehabilitative work that are not included in your report, but that I believe could substantially reduce long-term sediment yields from the upper Redwood Creek basin are (1) stabilization of landslides and gullies attributable to State Highway 299, and (2) removal of selected accumulations of woody debris and trapped sediment along Redwood Creek and other perennial streams. Similarly, stabilization of man-induced gullies in prairies does not appear to have been given as much emphasis as the importance of this sediment-producing process would warrent.

Another area of concern is that your interim report does not address itself to the timing of the various proposed work activities. If the rehabilitative program is to reduce successfully the long-term sediment yield from the upper basin, and at the same time not cause an undesirably large impact upon present stream sediment loads, the proposed activities should be dispersed in both space and time. Therefore, I think that your report should address itself to the following questions: Over what time period will the program be carried out? In what sequence should particular activities be carried out? How will the rehabilitative effort be carried out in relation to other land management activities such as conversion of remaining old growth, re-logging, thinning, hardwood control, etc.?

A potential pitfall in attempting to plan a rehabilitative effort on the basis of limited sampling of examples of different vegetation map units is that a substantial number of the anticipated problems may occur at sites that are not readily accessible by functioning roads. In these situations, one must then struggle with a group of closely related questions. Is the reopening of a previously established road or the construction of a new road likely to cause more erosion than that associated with presently inaccessible erosion problems targeted for rehabilitation? Will a new or re-opened road be required anyway in order to carry out some other management objective such as hardwood control or thinning? Given the complex pattern of ownership in the upper basin, it might be profitable to consider establishing an integrated roadnet that would serve the needs of all land and timber owners and still minimize the total miles of roads in the basin.

If your final recommendations are made on a more site specific basis, and summarized in the map format that I suggested earlier, I believe that the total estimated cost of rehabilitation would go up dramatically, and that many more opportunities for hand labor would emerge. In assessing the feasibility of presenting the rehabilitation plan in a map format, it may be useful to realize that our Topographic Division does have for public distribution preliminary 7-1/2 minute 1:24,000 topographic maps of the entire upper Redwood Creek basin. Perhaps one or two quadrangles could be used as a demonstration.

My numbered comments and a xerox copy of your report are enclosed as separate attachments.

I hope that these comments are useful and that they do not open too many "cans of worms" for you. If you think that I could be of some help in putting some of those "worms" on their proper hooks, please write.

Sincerely yours,

Richard J. Janda
Geologist

Enclosures

cc: Perry Y. Amimoto
Larry E. Richey

COMMENTS KEYED BY NUMBER TO TEXT

Note: Some additional remarks are written directly on the page margins.

1.) It would be desirable early in the report to present an explicit statement of the report and program objectives. The report implies to me that the objective of the proposed program is to enhance the productivity of commercial timber land and to lessen the long-term sediment yield from upper Redwood Creek while at the same time not significantly adding to the presently high stream sediment loads.

2.) You may want to refer to these three companies not as "major" landowners, but rather as "the three ownerships immediately adjacent to the park" because two ownerships within your upstream study area are actually considerably larger than ARCO.

3.) You may want to mention that your Category 7 (our Categories 9 and 10) includes relogging operations.

4.) Redwoods occur only as a few scattered trees in the downstream end of your study area. I believe that, although your description does not mention the Douglas-fir-dominated timber type, it is the most prevalent timber type within your study area. Additionally, while it is true that true firs (in particular white fir) do occur at higher altitudes within the basin, they are never the dominant vegetation form, rather they occur along with incense cedar, Douglas-fir, and other conifers. Perhaps a more correct designation for the inland timber type is "mixed conifer".

In discussing the setting of the area, I think that it would be helpful to add some brief comments about the bedrock, soils, and hillslope and channel morphology because these features place constraints on the types of desirable rehabilitative efforts.

5.) You may also want to allude to erosion from road surfaces and drainage ditches in that maintenance, wet weather use, and freeze-thaw cycles tend to make these impacts on stream sediment loads quite persistent.

Perhaps you should discuss erosion induced by the old and new routes of State Highway 299 as separate from that induced by timber access and ranch roads.

Some discussion of maintenance of existing, rehabilitated, and proposed roads would also be useful because without proper continuous maintenance much of the road rehabilitation program would be futile.

6.) I think that you may able to estimate more precisely the magnitude of the proposed rehabilitative effort for landslides, if your broad category of landslides is subdivided. Such a subdivision may also lead to a more complete estimate of the likelihood of success for

6.) continued-- various proposed activities. Some of the subdivisions may be (1) deep translational or rotational slides, (2) earthflows, (3) shallow streamside debris slides, (4) road-related debris slides and avalanches, and (5) road drainage-related debris torrents.

7.) Although this is described as a "sink" rather than as a source, these debris jams could well become a major source of sediment in the future as they become rotten or are physically removed by storm runoff. Perhaps, it would be wise to inspect and inventory the condition of the major jams; then you may want to consider periodic removal of selected jams so as to result in a controlled, timed release of the stored sediment. Such a controlled release would substantially lessen the potential for a dramatic, damaging sudden release of stored sediment.

8.) When all the functions of the various jams are considered, it will probably suggest that some jams should remain in place. For example, some jams have had a stabilizing influence in that they have attenuated the debris associated with debris torrents, and have dissipated flood energy (velocity). Others provide stable habitat nitches for benthic organisms and shelter for fish.

9.) While it is true that "most" of the skid trails are now stable, it is also important to realize that some of the skid trails that develop the most serious erosion problems are still actively eroding. Even in recently harvested areas the erosion is usually concentrated along a few skid trails rather than being dispersed evenly throughout the entire unit.

10.) I agree, and these areas are indeed major sources of sediment to the creek. However, they are not included in Section V, Table 1. This could probably be a very cost-effective program.

11.) It may be appropriate, if not here then in Section V, to indicate ways of mitigating the potential impact of the proposed subdivision.

12.) In many cases adding more culverts would be useful in order to minimize drainage concentration.

13.) Much of this work could be coordinated with other types of management activity.

14.) A few general comments and reactions to Table 1. (a) The road mileage and areas of streambanks needing revegetation seem low. (b) There seems to be a strong bias towards use of heavy equipment. (c) What about addressing rehabilitation of former landings? (d) What is the basis for the numbers presented in the second and third column of Table 2 on Page 9? I probably would have chosen slightly different values. (e) Costs are computed for treating skid trails on only 8 percent of the total area whereas some treatment could profitably be addressed to an additional 23 percent of the area.

15.) In designing your sediment reduction program and assessing the cost-effectiveness of that program, I think that some more consideration should be directed towards all the various types of mass movement activity, and the ways in which they deliver sediment to the creek.

16.) What is the time frame over which this reduction will be effective? I think that the program may reduce the long-term sediment loads of the creek but nonetheless it is important to realize that while work is in progress there may be a significant short-term increase in sediment yield, at least on a local basis.

17.) I do not consider myself competent to address myself to any of the dollar issues involved in your proposal.

xerox one copy

STATE OF CALIFORNIA

THE RESOURCES AGENCY
DEPARTMENT OF CONSERVATION
DIVISION OF FORESTRY

Interim Report

CORRECTIVE WORK NEEDED FOR THE REHABILITATION OF THE HEADWATERS OF THE REDWOOD CREEK WATERSHED

By

David M. Burns & Perry Y. Amimoto

December
1976

TABLE OF CONTENTS

FORWARD

This is an interim report of a study to develop a feasible and cost/effective rehabilitation program to reduce the accelerated erosion coming from numerous erosion sources created over the years in the upstream drainage of Redwood Creek Basin. This study was authorized by the Secretary of Resources Claire Dedrick and the Director of Conservation L. A. Moran.

This report describes the basic physical facts as they presently exist in the upper watershed of Redwood Creek basin. No attempt was made to relate the physical problems to existing or past land ownership patterns. The land ownership has changed over the years since the first logging took place and there is not necessarily any correlation to the conditions on the ground and the present landowners' activities, nor is there any correlation in regard to the effects of current logging practices and past logging practices.

It should be noted that physical problems occuring in the upper Redwood Creek Basin are not unlike problems found in other drainages previously logged with similar geology and timber types in the North Coast Region. The study at this time has not covered the lower portion of Redwood Creek near the National Park in the redwood type.

This report was prepared under the direction of David Burns, California Division of Forestry, and Perry Amimoto, California Division of Mines and Geology.

L. E. RICHEY
State Forester

Interim Report: Corrective Work Needed for the Rehabilitation of the Headwaters of the Redwood Creek Watershed

By

David M. Burns[1] & Perry Y. Amimoto[2]

I. Summary

The study concludes that the cost of rehabilitation work to reduce erosion in the upper watershed of Redwood Creek will be approximately $2,430,000 or about $50/acre.

II. Background

This study was authorized by State Forester L. E. Richey. The purpose was to look into the needs and feasibility of the rehabilitation of Redwood Creek and to make recommendations for cost effectiveness.

Meetings were held with representatives of the larger timber owners within the watershed. Representatives of the Redwood National Park and U. S. Geological Survey who have intimate knowledge of Redwood Creek were advised of the study and asked for their inputs. All representatives were invited to participate in the field work. (1)

Since the Redwood Creek drainage basin is 154,000 acres, it was decided to block the drainage into 3 areas and sample within one area at a time. Of the three areas, two are north of State Highway 299, while the third study area, representing approximately one-third of the total drainage, is located in the headwaters of Redwood Creek south of State Highway 299. Other criteria for the study were: 1) selection of areas that had been logged or disturbed prior to January, 1975 (new Forest Practice Rules effective date); 2) land owner's approval or permission; and 3) accessibility and timing.

Why this limitation? Seems unwarranted

May have been unrealistic

Considering these criteria and the multiple law suits which are in progress involving the three major landowners, the study team was precluded from working on lands of the larger landowners. It was decided (2)

---

[1] Forester III, CDF

[2] Engineering Geologist, CDMG

to start the rehabilitation study in the least controversial area. This was affirmed in the State Forester L. E. Richey's letter of September 7, 1976 to Director L. A. Moran in which the initial study area was limited to the headwaters of Redwood Creek south of State Highway 299.

During the week of September 20, 1976, David Burns, Forester III of the California Division of Forestry, Perry Amimoto, Engineering Geologist of Division of Mines and Geology, Steven Veirs and Gary Lester of National Park Service studied and sampled subareas in the upper watershed of Redwood Creek. No company or industrial representatives accompanied the study team during this phase of the study.

III. <u>Description of Area</u>

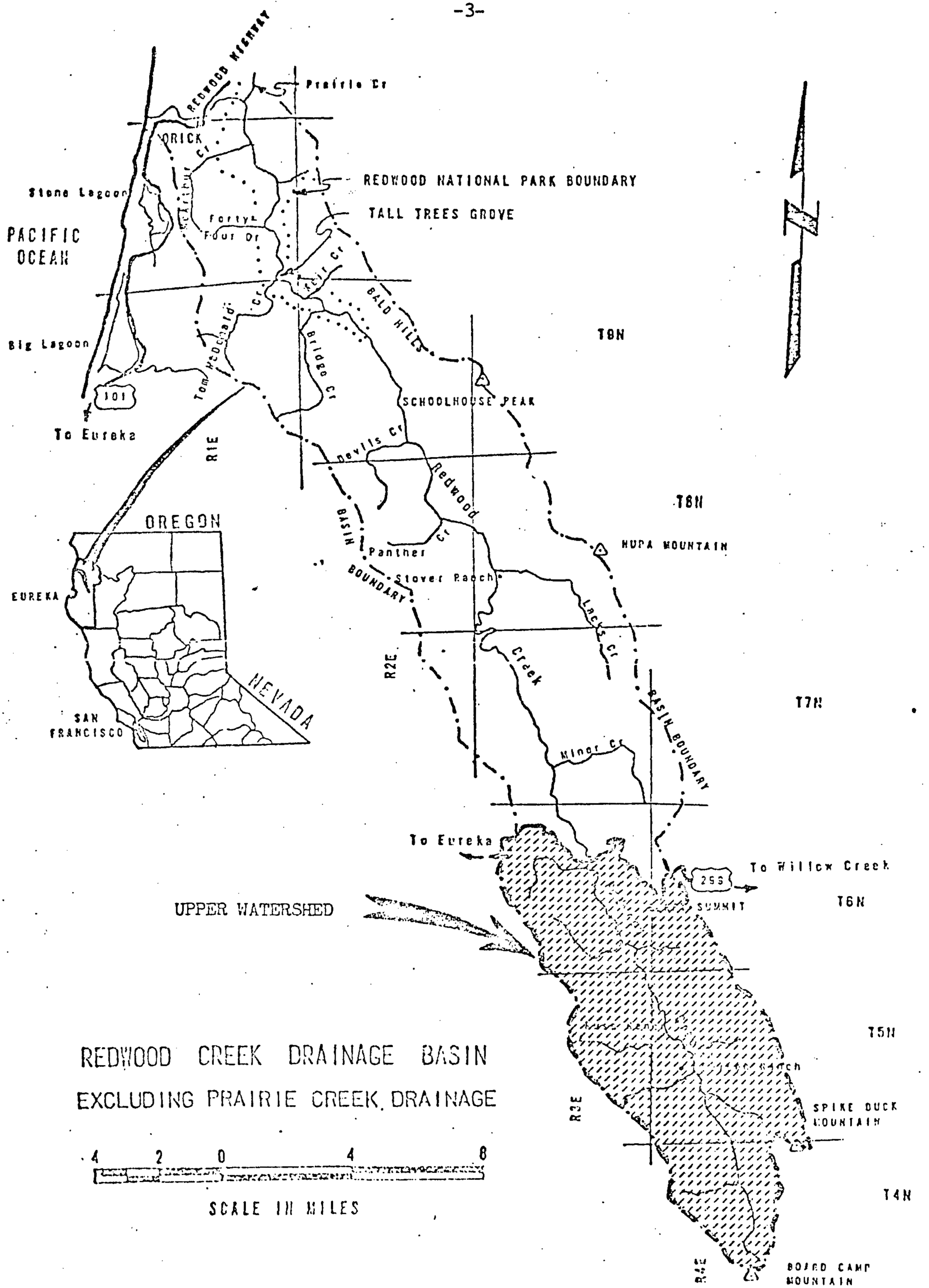
In general terms, the area studied consists of 48,400 acres. Based on aerial photos taken as late as September, 1975, the timber stand conditions in the study area were stratified as follows:

			Map Explanation
1.	Virgin timber (mostly U. S. Forest Service	13% of area	1
2.	Grasslands (prairie soils)	16% of area	2
3.	Oak woodland with grass and some Douglas-fir	17% of area	3
4.	Areas logged more than 7 years ago and having at least 80% of the area revegetated	23% of area	4+5
5.	Areas logged more than 7 years ago with less than 80 percent revegetation.	23% of area	6+7
6.	Areas logged within past 7 years using selection or seed tree cuts	3% of area	8
7.	Areas logged within past 7 years using clear-cut	5% of area	9+10

(3)

Elevations in the study area range from 980 feet to 5400 feet above sea level. Redwoods are present at the lower elevations; and true fir at

(4) the higher elevations.


REDWOOD HIGHWAY
Prairie Cr
ORICK
REDWOOD NATIONAL PARK BOUNDARY
TALL TREES GROVE
Stone Lagoon
PACIFIC
OCEAN
Big Lagoon
101
To Eureka
BALD HILLS
T9N
SCHOOLHOUSE PEAK
Tom McDonald Cr
Bridge Cr
Devils Cr
Redwood
R1E
T8N
OREGON
EUREKA
NEVADA
SAN
FRANCISCO
BASIN
Panther
BOUNDARY
Stover Ranch
HUPA MOUNTAIN
Lacks Cr
Creek
R2E
T7N
BASIN BOUNDARY
Minor Cr
To Eureka
299
To Willow Creek
SUMMIT
T6N
UPPER WATERSHED
T5N
REDWOOD CREEK DRAINAGE BASIN
EXCLUDING PRAIRIE CREEK DRAINAGE
SPIKE BUCK
MOUNTAIN
R3E
4 2 0 4 8
SCALE IN MILES
T4N
BOARD CAMP
MOUNTAIN

IV. Source of Debris & Sediments

Roads, mass land movements, streams and logging skidroads were studied as sources of debris and sediments. The findings are as follows:

Also erosion below roads because of drainage concentration.

(5)

1. Roads are major sources of erosion and stream sediments. During high flows, many of the drainage facilities fail, resulting in road washouts and accelerated stream channel and bank erosion (Fig. 1). Several culverts are not functioning because of silted intakes, and very few culverts have energy dissipaters (Fig. 2). Also, many new culverts are needed to prevent erosion of the roadway and undercutting of the cut slopes. Old log bridges are deteriorating and causing stream blockages. "Humboldt crossings" (logs laid perpendicular to the road surface to act as culverts) are not doing an adequate job (Fig. 3).

use more general term

(6)

2. Landslides [~~and slope failures~~] (redundant) along roads and streams are major sources of erosion (Fig. 4).

(7)

3. Ephemeral streams are generally clogged with old logging debris (logs, chunks, and slash) which have acted as debris catchment basins (Fig. 5).

This is described more as a sink than as a source.

(8)

4. Considerable accelerated erosion of stream banks is occurring along intermittent streams (Fig. 6). Log jams have acted to trap sediments and divert waters into erodible stream banks, resulting in undercutting and slope failures.

I dislike the implication that bank erosion reflects only debris jams.

(9)

5. Much of the older logging in the upper watershed started in the early 1950's. The skidroads in the older logging areas generally had few, if any, waterbreaks. However, most of the skid roads have stabilized or have been revegetated with grasses and forbs. (Fig. 7).

6. In areas logged within the past 7 years, many waterbreaks on the skid roads failed resulting in gully erosion (Fig. 8).

7. Non-logging areas include prairie soils, subdivisions, and public roads and right-of-ways. Areas which are considered prairie soils (grasslands) are actively moving and are very sensitive to water concentrations such as culvert outflows (Fig. 9).

(10)

There is in the planning stages a proposed subdivision which will involve about 2,000 acres from Redwood Creek near the State Highway 299 up the slope on the east side of the drainage and then southward along the ridge and extending down the major side ridges (Fig. 10). Lot sizes will range between 20 to 29 acres in size. Lots will be located on moving prairie soils and areas that have been converted from timberland to grass. This subdivision could cause very serious downslope accelerated erosion problems.

(11)

V. <u>Mitigating Measures</u>

Mitigating recommendations are as follows:

1. Corrective actions needed to mitigate erosion and sedimentation caused by roads include:

   a. Cleaning out sediments and logging debris from intake areas near culverts.

   b. Installing drop inlets and concrete headwells at some culvert inlets. Statement of reasoning may also be usefull. Drop inlets + trash racks to minimize opportunity for plugging, and concrete headwalls + realignment to increase efficiency.

   c. Replacing and/or adding larger culverts at some locations.

(12)

   d. Adding new culverts where road surfaces or cut slopes are being undercut by excessive water. Also enlarged channels

   e. Installing energy dissipaters +/or non erodible substrate at outlets of all culverts.

   f. Replacing ineffective drainage structures and installing new bridges or large arch culverts.

g. Removing all "Humboldt crossings" and replacing with culverts or bridges.

h. Installing downdrops [spouts?] on cuts, fills, and culverts when accelerated erosion is occuring.

i. Installing cribbing on road fills where it is the only feasible method of reducing road slipouts and washouts.

j. Line side ditches into culverts where excessive erosion of the fill material is occurring.

k. Grade roads for adequate drainage (outsloping and redirection of roadside drainageways are needed).

l. Rock road surfaces and roadway drainages.

m. Install interceptor ditches on top of road cuts where exposed cuts are subject to excessive surface runoff.

n)? What about vegetation to reduce raindrop impact, sheet wash, and freeze-thaw erosion from cut and fill surfaces,

2. Corrective measures needed to reduce landsliding include installing or implementing the following:

a. Lined interceptor ditches above the slide.

b. Terraces to divert surface runoff.

c. Pipe drops to convey runoff down the slope.

d. Horizontal drainage wells.

e. Revegetation of the landslide surface.

f. Cribbing to buttress the toe of slides.

g.) In case of some slides related to strm-undercut or roadcuts, shaping of cross-section to change stress distribution could help.

3. If the logging debris were to be removed from ephemeral streams, [working definition would help reader understand limitations,] the large volumes of stored sediments would be released at one time, resulting in accelerated erosion. Therefore, it is generally recommended that debris from ephemeral streams not be removed at this time. But these could be released over a period of years and such action would (1) enhance the areas ability to transmit storm runoff and (2) lessen the potential for sudden release of stored sediment due to flood induced failure of rotted check dams.

4. In intermittent streams, logs that cause bank erosion should be removed and revegetation of the stream channel undertaken where appropriate.

5. Areas logged prior to seven years ago generally do not require remedial treatment, ~~except where the~~ remedial measures would cause a substantial and overall decrease in erosion. There are a few gullied skid roads where rehabilitation could be considered, however, the repair of such gullies by dozer work and waterbreaks might cause accelerated erosion. Since most skid roads are reasonably stablized, it is generally recommended that no corrective work be undertaken at this time. For areas logged less than seven years ago, it would be beneficial to repair or install new waterbreaks on the skid trails.

6. In non-logging areas the public and private entities should be encouraged to repair non-functioning erosion control measures and to install corrective devices.

VI. Cost of Rehabilitation Work

Estimated costs of rehabilitation work recommended in this report will be approximately $2,430,000. The separate costs are summarized in Table I. The methods of expanding the field data to the study area are as follows:

1. Roads - Estimated number of miles from 1975 aerial photographs.

2. Landslides - Estimated number of slides from "Erosional Land Form Map of the Redwood Creek Drainage Basin, Humboldt County, California 1947-74," by K. M. Nolan, D. R. Harden, and S. M. Colman, USGS July 1976.

3. Stream Log Jams - Estimated number from field observations.

Table I

COST ESTIMATES FOR CORRECTIVE WORK NEEDED FOR THE REHABILITATION OF THE UPPER ONE-THIRD OF THE REDWOOD CREEK WATERSHED

	No. Of Units	Materials	Equipment W/Operator	Labor	Overhead Supervision	Engineering Services	TOTAL
ROADS	170 miles	$	$	$	$	$	
Culverts Repair & Additional	160 ea.	187,600	65,700	24,200	65,000	25,000	
Grading	170 miles	---	10,200	1,000	2,500	---	
Bridges or Arch Culverts	13 ea.	325,000	26,000	32,500	9,000	6,000	
Cribbing	13 ea.	32,500	7,500	2,500	10,000	3,000	
Road Rock Base	6 mi.	10,000	3,000	400	1,000	500	
Line side ditches to culverts	80 ac.	3,000	7,000	9,000	3,000	---	
Revegetation	5 mi.	3,000	27,000	1,000	1,500	---	
Subtotals		561,000	146,400	70,600	92,000	34,500	904,500
% of Subtotal Cost		62.02	16.19	7.81	10.17	3.81	100.00
LANDSLIDES							
Along Roads							
1. Interceptor ditches	4,000'	8,000	16,000	4,000	4,000	2,000	
2. Down Drains	4,000'	24,000	4,000	4,000	4,000	2,000	
3. Midslope collection ditches	4,000'	24,000	24,000	4,000	4,000	2,000	
4. Horizontal Drains	3,000'	1,000	13,000	1,000	1,000	1,000	
5. Hydroseeding	20 ac.	2,000	16,000	1,000	1,000	---	
Along Stream Banks							
1. Interceptor Ditches	50,000'	100,000	200,000	50,000	25,000	25,000	
2. Down Drain	88,000'	528,000	80,000	85,000	25,000	25,000	
Subtotals		687,000	363,000	152,000	64,000	54,000	1,320,000
% of Subtotal Cost		52.04	27.50	11.52	4.85	4.09	100.00
STREAM LOG JAMS	90						
Cut & Remove logs		300	103,000	40,000	13,500	---	
Revegetation of Stream Channel	27 ac.	2,700	---	1,500	2,500		
Subtotals		3,000	103,000	41,500	16,000		163,500
% Subtotal Costs		1.83	63.00	25.38	9.79		100.00
SKID TRAILS	4,000 ac.						
Waterbar Repair		---	25,000	2,000	7,000	---	
Revegetation of Skidtrails		4,000	1,000	2,000	1,000		
Subtotals		4,000	26,000	4,000	8,000		42,000
% Subtotal Costs		9.52	61.91	9.52	19.05		100.00
GRAND TOTALS		1,255,000	638,400	268,100	180,000	88,500	2,430,000
% of Total Cost		51.65	26.27	11.03	7.41	3.64	100.00

14

low?

why area?

tree planting

What about landings? removing fill?

4. Skidroads - Estimated number of acres from preliminary photo interpretation of vegetation and land use conditions in the redwood creek basin as of September 1975 as provided by the National Park Service. The number of miles of skidroads per square mile by slope class was provided by Dr. J. M. Dodge based on recent soil erosion studies in the Redwood Creek Basin. Skidroad conditions were based on field observations.

VII. Cost/Benefits for Recommended Treatments

If all the corrective measures recommended in this report were to be accomplished, then a 52 percent reduction of active sediment production would result (see Table II). Active sediment production, as used in this table, means sediments and debris reaching water courses as differentiated from debris already in streams.

(14)

Table II. Cost/Benefits for Recommended Treatments

(16) what time reference (long or short term?)

Sources of Sediments	% of Total Sediment by Source	Estimated Chance of Success of Treatment	Sediments Reduced by Treatment	Estimated Cost of Treatment	Estimated Cost Per % Sediment Reduction by Treatment
Roads	20 %	.80	16 %	$ 904,500	$56,530
(15) Mass Land Movements	60 High?	.30	18	1,320,000	73,330
Stream Bank & Log Jams	10 low?	.90 High?	9	163,500	18,170
Skid Roads	10	.90 High?	9	42,000	4,670
TOTAL	100 %	---	52 %	$2,430,000	$46,730

?? Basis ??

Perhaps distinguish between mass erosion and fluvial erosion from landslide areas. The fluvial component is often sizeable and persistent!

The most cost effective treatment is on skidroads and landings; the next most cost effective treatment would be in streams and log jams; the third in the list of cost effectiveness treatment is road repair; and the least cost effective treatment would be the treatment of mass land movements.

For the projected work on skidroads and landings to be effective, the work should be done as soon as possible. Data developed during this study indicates that skidroad recovery is almost complete in twenty years, while 6 year old logging areas require additional repair work on 20 percent of the skidroads; and areas logged two years ago require up to 70 percent rehabilitation work of skidroads.

VIII. Lists of Participants and Sources of Information

Participants in the Field Evaluation Phase of this Study Were:

David Burns (Coordinator)	California Division of Forestry
Perry Amimoto	California Division of Mines & Geology
Steven Veirs, Jr.	National Park Service
Gary Lester	National Park Service

Persons Contacted for Assistance and Information Were:

James Denny	California Division of Forestry
Grant McClellan	California Division of Forestry
Jean Sindel	California Division of Forestry
Roy Ritchey	California Division of Forestry
Richard Forester	California Department of Fish & Game
Alfred Merrill	Louisiana Pacific Corporation
Lowell Chapman	Arcata Redwood Company
Herb Peterson	Simpson Timber Company
Carlton Yee Ph.D.	Consulting Professional Forester & Hydrologist
Einar Johnson	National Park Service
Richard Janda Ph.D.	U. S. Geological Service
Edward Lowe	California Department of Transportation
Charles Wagener	California Division of Forestry

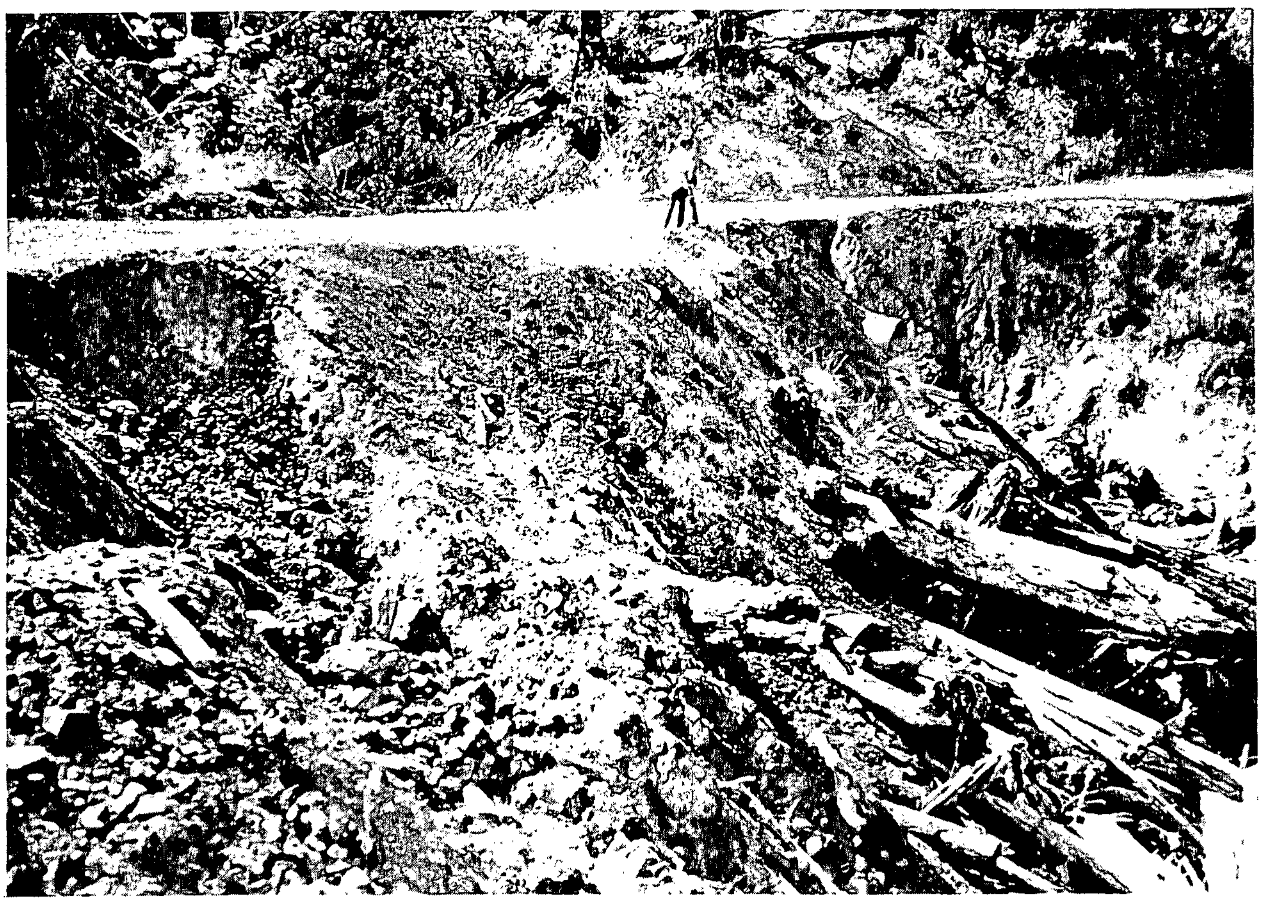


Fig. 1. During high flows many culverts fail, resulting in road washouts and accelerated stream channel and bank erosion..

Fig. 2. Erosion caused by a culvert outlet with no energy dissipater.

Fig. 3. An old log bridge which has collapsed and is causing stream blockages.

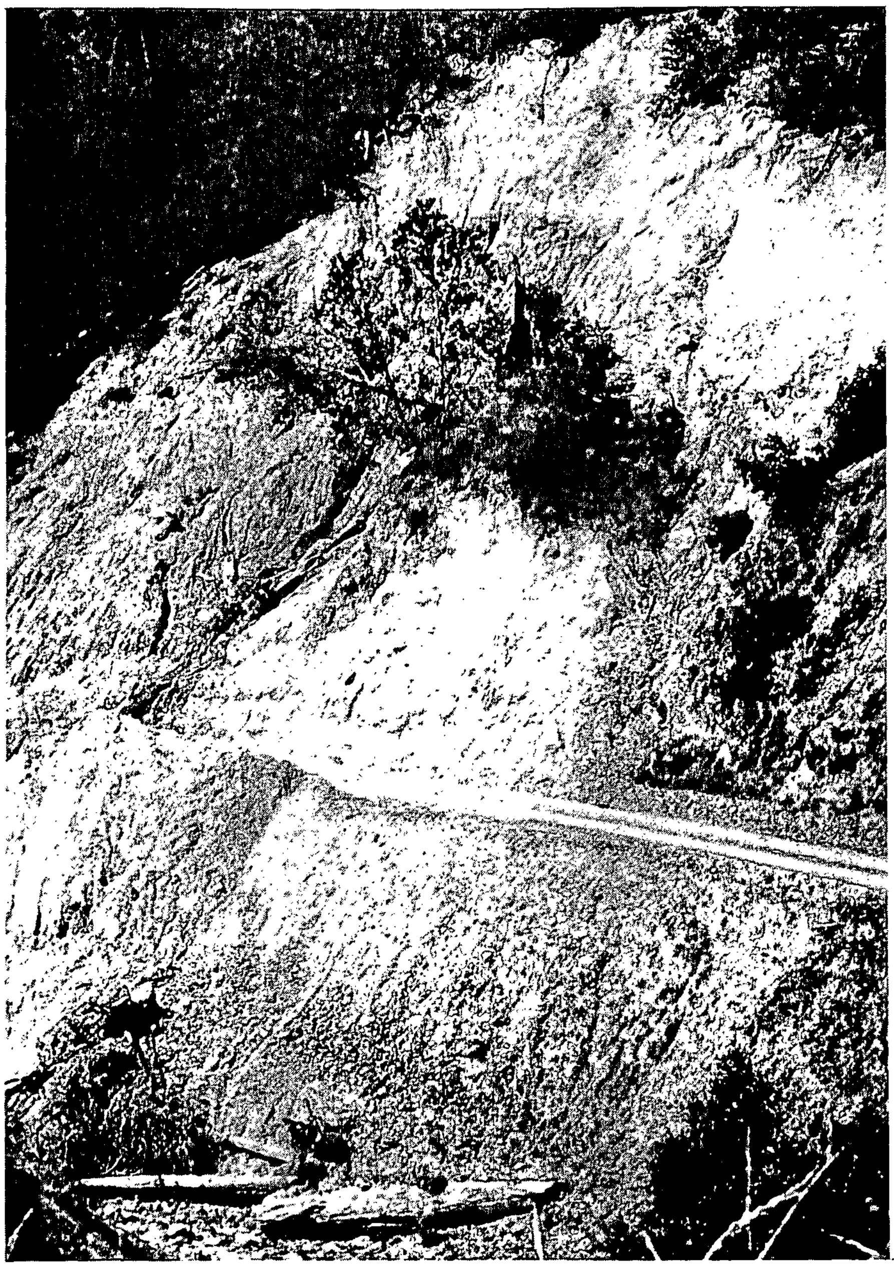


Fig. 4. Landslides and slope failures along roads and streams are major sources of erosion.

Fig. 5. Ephemeral streams are generally clogged with old logging debris which have acted as debris catchment basins.

Fig. 6. Log jams have acted to trap sediments and divert waters into erodible stream banks.

Fig. 7. The skidroads in the older logging areas generally had few, if any, waterbreaks. However, most of the skid roads have stabilized or have been revegetated with grasses and forbs.

Fig. 8. In areas logged recently many waterbreaks on skid roads failed.

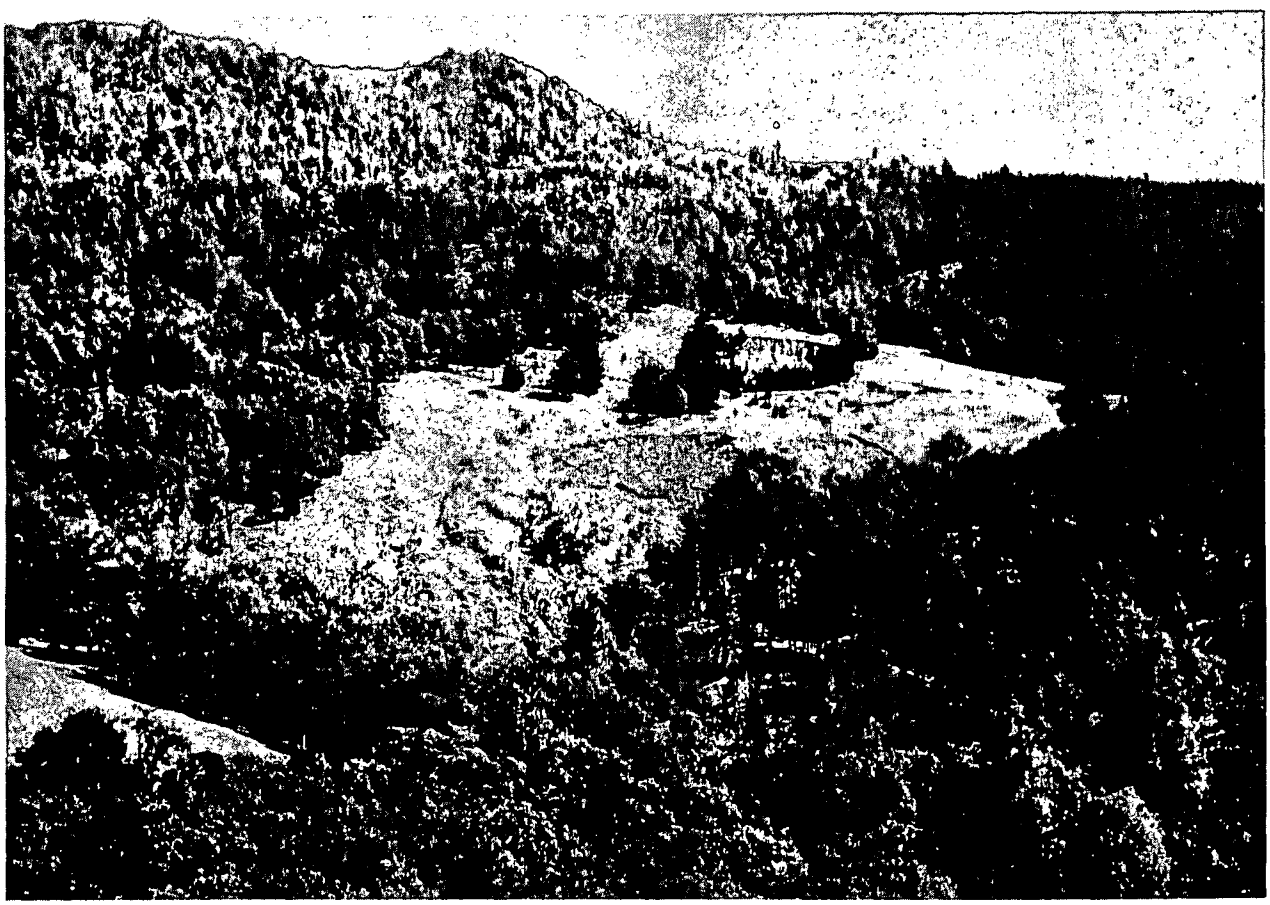


Fig. 9. Areas which are considered prairie soils (grasslands) are actively moving.

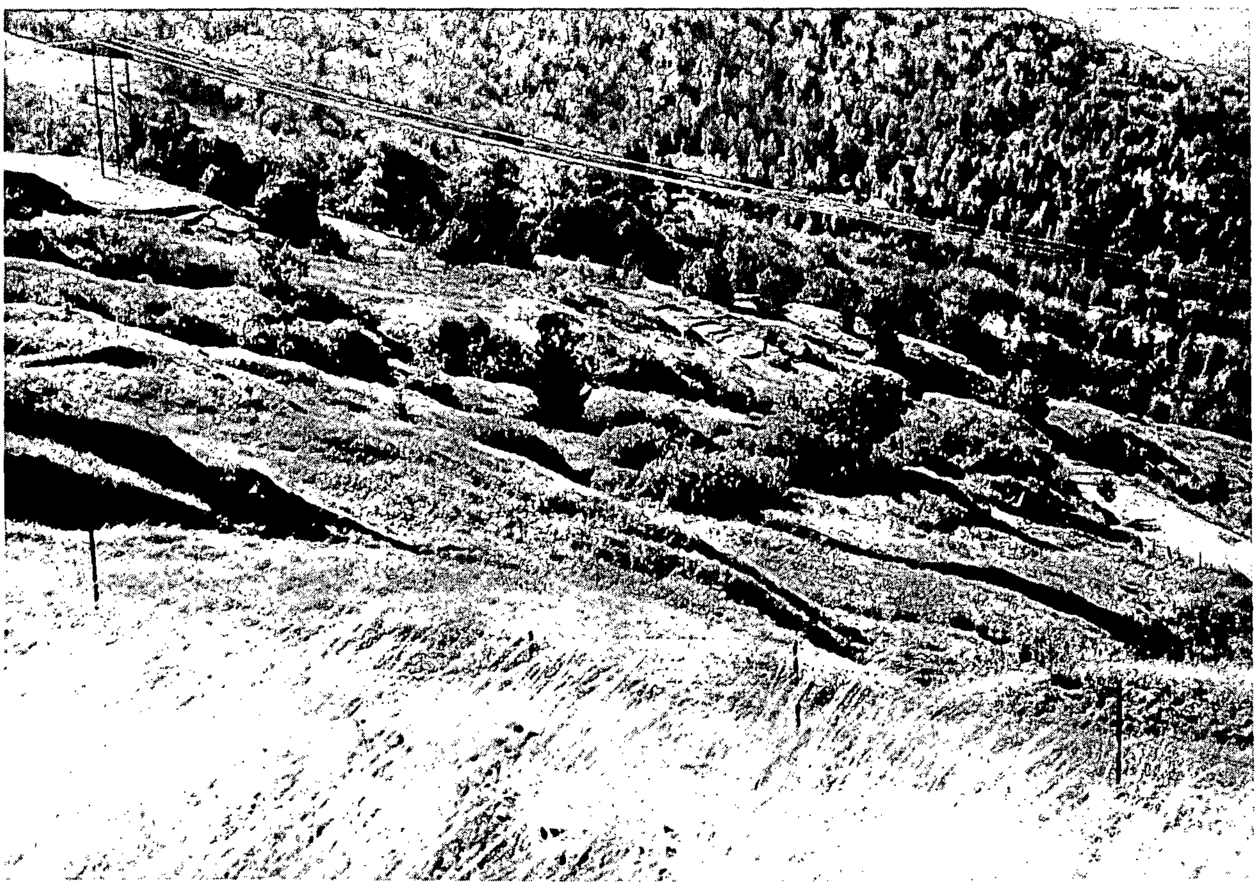


Fig. 10. A paved road in an area proposed for a subdivision is showing landslide cracks in this area of unstable prairie soils.

ATTACHMENT "B"

United States Department of the Interior

NATIONAL PARK SERVICE
WESTERN REGION
450 GOLDEN GATE AVENUE, BOX 36063
SAN FRANCISCO, CALIFORNIA 94102

IN REPLY REFER TO:

(WR)RNR

February 1, 1977

Ms. Claire Dedrick
Secretary, California Resources Agency
1416 Ninth Street
Sacramento, California 95814

Dear Ms. Dedrick:

We were pleased to receive a copy of the interim report on "Corrective Work Needed for the Rehabilitation of the Headwaters of the Redwood Creek Watershed", by David M. Burns and Perry Y. Amimoto. We have also strongly urged that watershed rehabilitation begin in the Redwood Creek watershed, to enhance the productivity of upstream forest land as well as to protect the downstream resources of Redwood National Park. We appreciate the efforts of the Resources Agency in tackling this difficult problem.

Our comments can be segregated into two types: (1) comments of the material in the report, and (2) the relation of the proposed rehabilitative work to other future land use practices in the basin. In general, we feel that the report should adopt a more specific approach, and that any rehabilitative work should be integrated spatially and temporally with impacts from other likely land treatments in the upper basin. The issues are discussed in this order.

Comments on the Report

The comments are generally in page order, although some cross-referencing is necessary. Due to the difficulty of assigning accurate estimates of sediment production by source, our review comments are qualitative and subjective more than quantitative.

AMERICAN REVOLUTION BICENTENNIAL 1776-1976

The report would benefit from a more precise statement of objectives. This is especially important in light of the fact that the rehabilitation program will not be taking place in a vacuum but must be part of an overall watershed management program.

Under Background, it would be appropriate to include Highway 299 in the headwaters area. The Description of Area should note that the predominant timber type is Douglas-fir. Redwoods and true fir are mentioned but redwood is sparsely represented and white fir is confined to the higher elevations. Tan oak, madrone, and western red cedar are the common tree species associated with Douglas-fir in the study area.

The section on Source of Debris and Sediment would benefit from a reorganization of the findings. For instance, item 3 as described is not now an active source of sediment; it describes areas in which debris and sediment have become stored and at least temporarily withheld from further transport. It would be appropriate to add an item related to debris jams in perennial streams. Items 1 through 6 refer to timber harvest related sources while item 7 and the following paragraph introduce partly natural sources and potential impacts of future development. While such development must be considered in future watershed management coordination, it is a separate item from the rehabilitation program. Reorganization of this section would permit the mitigating measures discussed in the next section to be related to the corresponding problems under Sources. It would also be useful to estimate volumes of sediment now in stream channel storage, as a means of relating active sediment sources to the average annual sediment load (1954-75) at the Redwood Creek near Blue Lake station, which is 780,000 tons per year (18 tons/acre/yr).

The Mitigative Measures section, as well as the Sources section, ignore the problems associated with debris jams and aggradation in perennial streams. A substantial number of landslides adjacent to perennial streams in the Redwood Creek basin are, at least in part, the result of log and logging-related debris jams and associated stream channel diversions. An estimate of the need for perennial stream rehabilitation should be made a part of the study report. Of course, site-specific determinations will have to be made to determine if removal or partial removal is feasible or desirable at this time.

The mitigating measures should also recognize the sediment increases that will be caused by realteration of this disturbed landscape. For example, removal of an old bridge or log jam is going to release stored sediment that will be transported downstream. Additionally, there are bound to be rehabilitative failures, even with the best of planning. New problems will in some instances be inadvertently created by diverting drainage from unstable areas into "stable" areas. While the increase in sediment associated with successful and unsuccessful treatments should not be overwhelming, it should be recognized in the report as an unavoidable short-term consequence of the program.

The Cost of Rehabilitation Work would benefit from a greater amount of detail regarding the estimates presented in Table I. Under the "Roads" category, the use of "ea." under "no. of units" is unclear. Item 1. F., lining side ditches, is quantified by acres when a linear measure is probably more appropriate. It would be helpful under "Landslides" to identify the number or area of landslides to be treated. Inasmuch as 60 percent of all sediment is attributed to landslides (from Table II) a greater amount of detail supporting rehabilitative estimates would be desirable.

The hydroseeding unit cost is estimated to be more than $1,000 per acre. This figure seems much higher than the normal hydroseeding cost. In addition, hydroseeding landslide surfaces to annual plants has very limited return in terms of erosion control.

The item on repair of skid trails appears to underestimate the amount of work required, in view of the available data base and our observations. The proposed 4,000-acre treatment is only slightly more than the 3,872 acres of recently cutover land. However, there are an additional 22,264 acres logged more than seven years ago, and half of this acreage is less than 80 percent revegetated. A substantial portion of this area is continuing to produce sediment, especially through gullies along skid trails, and warrants a greater amount of rehabilitation work. This work will involve a much greater amount of hand labor, and hand labor assisting equipment, than the currently budgeted amount which is equivalent to perhaps one person for one dry season.

In our judgment, the costs as estimated for the project are considerably below what will actually occur if a 50 percent reduction in total sediment yield is to be achieved. This is, of course, a subjective judgment, due both to the need for estimation and the lack of detail in the report. We suggest that as a test case, the authors should select one or more tributary watersheds, map the actual rehabilitative work at a large scale, and re-estimate the cost involved. This approach would lend more substance to the report and allow validation or amendment of the present cost figures. We would be pleased to assist the Resources Agency team in developing such an approach.

The cost/benefit analysis should clearly show the partitioning of total sediment by source as estimated percentages, which may or may not approximate actual values. They also intermingle recent man-induced erosional rates with natural rates, as when a new road reactivates an old landslide.

Comments on Relation to Other Watershed Uses

* 2/7 - J. Davis called to give correction.

There is *an obvious need to implement the rehabilitative program in coordination with a wide range of other land treatments if the goal of reducing sediment is to be achieved. While the list below is not meant to be complete, it indicates that there is a high probability for sediment yields from many sources:

- rehabilitation work
- harvest of 5,000 acres of old growth (most publicly-owned)
- removal of residual timber
- thinning young growth
- hardwood conversion to commercial conifer species
- grazing
- potential subdivision near Highway 299

In some cases, the rehabilitative work needed could be coordinated with an activity like hardwood conversion or residual tree removal to reduce costs and eliminate the need to disturb an area twice in succession. Much of the road work could be done in conjunction with obtaining access for various purposes, and perhaps developing an integrated road network.

The timeframe over which all these activities take place is extremely important. In order to space out the temporary sediment impacts associated with well-planned activities, and avoid overconcentration of impact in any portion of the basin, the rehabilitative effort must be only one part of a larger land use plan. This plan will eventually have to encompass the middle and lower portions of the Redwood Creek basin. Rehabilitation may eventually be phased out and replaced by an active maintenance of stream channels, roads, landslides, and disturbed areas, as appropriate. Not all of the rehabilitative work could or should be done in one season; the eventual timeframe will depend on effective coordination of all basin activities.

The Burns-Amimoto report is a good start towards rehabilitation of the headwaters of Redwood Creek. We have suggested that it be strengthened by a more detailed, site-specific approach and that these activities be coordinated with other expected basin activities. While our comments focus on areas of the report that need strengthening, we nonetheless fully appreciate the efforts of the California Resources Agency in developing the report, and generally concur with its approach. We would be pleased to provide further assistance in this complex project involving various elements of the public and private sectors.

Thank you again for requesting our comments. We hope they will be of value in preparing the final report.

Sincerely yours,

for Howard H. Chapman
Regional Director,
Western Region

cc:
Chairman, State Board of Forestry