STATUS OF NATURAL RESOURCES IN REDWOOD CREEK BASIN, REDWOOD NATIONAL PARK

A REPORT TO THE DIRECTOR
OF THE
NATIONAL PARK SERVICE
FROM
A SCIENTIFIC EVALUATION TEAM:

Milton Kolipinski, Team Moderator
Ed Helley
Luna Leopold
Steve Veirs
Gerard Witucki
Robert Ziemer

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INTRODUCTION

Redwood Creek drains a 280 square mile basin which is located in a region of high winter rainfall and high natural rates of erosion. Forests of commercial quality formerly covered about 238 square miles of the basin. Parklands, including a portion of Redwood National Park, occupy approximately 10% of the lower basin and include, among other values, several of the world's tallest trees.

Substantial timber harvest and associated road construction began in the basin in the early 1950's and intensified during the 1960's. Over the last 25 years 182 square miles of timberland have been harvested, using tractor logging techniques. This represents 65% of the basin and 75% of the forested land within the basin. Few examples exist of such extensive and intensive disturbance in a large watershed.

A vast store of information shows that when vegetation is removed from a watershed, erosion rates and runoff peaks increase. In the last 30 years or so hydrologists have come to this conclusion from experimental studies and from studies of plots and instrumented watersheds in the United States and elsewhere. Redwood Creek is no exception.

ALTERATION OF EROSION AND RUNOFF IN REDWOOD CREEK BASIN

A scientific team (See Appendix) identified recent increases in erosion and runoff by altered processes as being consequential to the resources of Redwood National Park. This conclusion is based on observations of increased sediment loads and runoff as discussed below.

EROSION IN REDWOOD CREEK BASIN

Erosion problems within Redwood Creek Basin are discussed from two aspects: 1) main channel and 2) tributaries.

Erosion in main channel of Redwood Creek

The major sediment source in Redwood Creek and one indirectly influenced by timber harvest is that of stream bank cutting and streamside slides. These two processes are accelerated by increased storm runoff which may be correlated with cutover areas. Stream bank cutting and sliding accounts for about half of the sediment load transported by Redwood Creek itself.

Mass movement processes are visually apparent, but they contribute less than 30 percent of the long-term sediment load measured at the farthest downstream data-collection station in Redwood Creek, near Orick, California. Mass movement was likely the most important source of stream-borne sediment before logging began in the basin. Data collected by the U. S. Department of Agriculture suggest total sediment contributed to Redwood Creek from this source would be no more than 1,260 tons per square mile per year. But the U. S. Geological Survey believes 1,950 tons per square mile per year to be an upper limit. This latter figure represents about one-fourth of the long-term average suspended sediment load computed for Redwood Creek near Orick.

The remaining percentage of sediment load, from sources other than mass movement or stream bank cutting and sliding, is attributable to small tributaries.

Evidence for accelerated erosion of Redwood Creek's main channel comes from:

A. Comparison of aerial photographs taken in 1936 and 1947 with more recent aerial photography indicates extensive widening of the unvegetated gravel plain and associated bank erosion. Similar photographic comparison for the interval between 1947 and 1973 shows an increase in the number of slides along Redwood Creek from 30 to 341.

B. Historical observations for over 20 years show bed elevations have increased by as much as 15 feet near the U. S. Highway 299 bridge, and 5 to 8 feet at the Tall Trees Grove. Coarse overbank deposits are now occurring in areas that previously received only fine grained sediments.

C. Data collection began at monumented cross-sections at 48 stream sites over two years ago. The data demonstrate:

1. Lateral shifting of the low-water channel (thalweg) occurs frequently during winter runoff and results in repeated stirring of streambed materials to a depth of several feet.

2. Bank erosion is pervasive.

3. Aggradation (deposition of sediments) is the prevalent streambed change throughout the basin.

4. Aggradation is most pronounced during and immediately following major flood events.

5. In the lower part of the basin, sediment deposition is elevating the altitude of the channel. Below are two examples:
   --- In the case of the low-water channel, up to four feet of sediment have been deposited in the two-year study period; however, the amount is generally on the order of one foot.
   --- Recent coarse-grained flood deposits are commonly more than ten feet thick and presently building up.

Erosion in tributaries of Redwood Creek

Small scale but widely distributed gully, rill and sheet erosion on disturbed tributary basins is a significant source of sediment introduced into the stream systems. Evidence for sediment increases due to logging from tributary basins follows:

A. Simultaneous (synoptic) observations on selected tributaries. Suspended sediment measured from basins that were heavily logged since establishment of the park ranged up to 80 times that measured from unlogged basins during eight periods of synoptic sampling. This is supported by measurements of suspended sediment transported in seven small tributaries during two storm events. During the two storms when rainfall plus the antecedent precipitation index (API)* was less than three inches, sediment carried by streams draining recently cutover areas ranged from 19 to 81 times** that carried by streams draining uncut areas. Suspended sediment loads from regenerating areas ranged from 1.7 to 6.7 times** those in uncut areas.

In five events where storm rainfall plus API ranged from 6 to 10 inches, suspended sediment loads in recently cut areas ranged from 4.7 to 23.5 times** those in uncut areas. Suspended sediment loads from regenerating areas ranged from 1.7 to 3.4 times** those in uncut areas.

Although some slight variability in basin parameters exists, the surface forms of these study basins are closely similar. This similarity would not exist if the observed differences in erosion rates persisted for long.

B. Single event (non-synoptic) observations made in March 1973. In one storm of about 5.2 inches of rainfall in a 24-hour period an uncut area produced only 27 tons of suspended sediment per square mile.

In comparison, during a smaller storm with only about 2.5 inches of rainfall, the uncut basin produced only 19 tons of sediment per square mile. Two recently logged areas produced 130 and 171 tons of sediment per square mile.

C. Bedload production and movement. Bedload movement has been observed in all basins studied. But typically it is greater in recently cutover basins than it is in uncut areas. For example, during a period of extensive sampling, bedload production in three recently logged basins varied from 0.15 to 1.5 tons per square mile for the event. In contrast no movement occurred in uncut basins for the same event.

Complete suspended sediment data are available for Redwood Creek at Orick from 1971 through 1975. During these five years the creek transported about 8,000 tons per square mile per year of suspended sediment. This amount represents the greatest measured load per area of any stream of comparable size in the conterminous United States.

*API is a standard measure of pre-storm soil moisture conditions.

**This range of values results partly from differences in pre-storm soil moisture conditions.

RUNOFF IN REDWOOD CREEK BASIN

The team also assessed the effect of timber harvesting on runoff in Redwood Creek basin. The team considered both the results of basin-wide model studies and studies of tributaries.

Basin-wide runoff.

Modeling techniques have widespread use among hydrologists. Using a modeling approach, the U. S. Geological Survey's Water Resources Division examined the relationship between basin-wide storm runoff measured at Orick and daily rainfall measured at Prairie Creek. Model data indicate a 20 percent increase in storm runoff occurred in the early to middle 1960's. The increase in runoff correlates in time with a marked intensification of timber harvesting within the basin.

A runoff comparison was made for the periods before and after intensive logging began. Amount of runoff is similar in the two periods for both high and low pre-storm soil moisture conditions. But runoff increases substantially when pre-storm soil moisture is moderate. Moderate pre-storm soil moisture conditions coincide with most winter storms and are more common than the extremes of wet or dry. This change in runoff appears to be related to changes in soil moisture retention parameters. This relationship agrees with hydrologic principles that deal with the generation of runoff.

Tributary runoff.

Runoff per unit area of surface water was compared for seven small tributary basins during eight periods of synoptic sampling. As in the case of suspended sediment load, data were collected during eight storms over a two-year period. The variability in basin parameters makes it difficult to demonstrate specific statistical differences. However, comparison of recently logged basins with unlogged and regenerating basins suggests the following:

1) logging increases the total volume of surface-water runoff from storms;
2) logging increases the volume of water flowing at the flood "peak";
3) these changes in runoff are greatest when soil moisture conditions in the study basins are moderate.

During two storms when rainfall plus API was less than four inches, runoff in cut-over areas ranged from 2.5 to 3.2 times* that in uncut areas. Runoff from regenerating areas ranged from 1 to 51 times* that in uncut areas.

*This range of values results partly from differences in pre-storm soil moisture conditions.

In five cases when storm rainfall plus API ranged from 6 to 10 inches, runoff from cut areas ranged from 1.6 to 15 times* that from uncut areas. Runoff from regenerating areas ranged from 1.4 to 2.0 times* that from uncut areas. These trends are compatible with the U. S. Geological Survey's modeling predictions made for the basin as a whole. Also these trends are consistent with a large body of data from paired experimental watersheds including those from the Alsea and H. J. Andrews experimental watersheds in Oregon.

*This range of values results partly from differences in pre-storm soil moisture conditions.

SUMMARY AND CONCLUSION

Data cited in this report confirm the existence of accelerated erosion within Redwood Creek basin. The team attributes this erosion to large-scale, tractor-yarded, clear-cut timber harvesting and associated road construction. The consequences of these man-induced changes in hydrologic characteristics go against National Park Service policies for natural area management and the language of the act establishing Redwood National Park.

These consequences include:

1) direct tree losses from accelerated bank erosion;
2) tree mortality from overbank deposition of sediments;
3) filling of pools resulting in loss of low flow aquatic habitat;
4) filling of gravels suitable for spawning anadromous fishes by fine sediments.

Accelerated erosion in Redwood Creek basin coincides with a period of intensive and extensive land disturbance. In comparable basins elsewhere researchers have observed serious adverse effects 6 to 15 years after timber harvesting ceased. Consequently, Redwood Creek watershed may not yet have reached its highest level of alteration. Considerable timber remains on highly erosive sites. Remaining old growth is concentrated on sites that are most susceptible to man-induced accelerated erosion.

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APPENDIX

PURPOSE AND SCOPE OF THIS REPORT

The Director of the National Park Service recently asked the Director of the Western Region in San Francisco to assemble a temporary team of scientific experts to evaluate the status of resources in Redwood Creek basin. The assembled team of Federal scientists met for an accelerated work session on November 19 and 20, 1975 with Dr. Richard Janda because of his broad geological and hydrological knowledge of the basin. Dr. Janda and his research associates of the U. S. Geological Survey are nearing the completion of a three-year study program in Redwood Creek basin for the National Park Service. Dr. Janda provided background information for the scientific team by reviewing program data and results obtained to date. The scientific team based its considerations on reports and scientific evidence about changes in natural processes that have occurred, especially within the past few decades. References the team used in its analysis are listed at the end of this report. This report summarizes the team's findings.

The scientific team consisted of members having considerable depth and breadth of scientific knowledge of Redwood Creek basin and with Redwood National Park. The team members were: Dr. Ed Helley, Geomorphologist, U. S. Geological Survey, Menlo Park; Dr. Luna Leopold, Hydrologist, University of California at Berkeley and part-time U. S. Geological Survey employee, Menlo Park; Dr. Robert Ziemer, Research Hydrologist, U. S. Forest Service, Arcata; Mr. Steve Veirs, Plant Ecologist, National Park Service, Redwood National Park; Mr. Gerard Witucki, Hydrologist; and Dr. Milton Kolipinski, Aquatic Biologist and Team Moderator, both with the National Park Service, San Francisco. This report does not necessarily reflect the views or policies of the employing agencies of the team members.

The goal of the scientific team was to analyze the present condition of the forests and streams in Redwood Creek basin, particularly that part of the basin in Redwood National Park. The team reviewed scientific evidence dealing with the processes that originally shaped the natural resources of the basin. The team considered how and to what extent timber harvesting has altered these processes.

The scientific team thanks the following for helping to analyze the situation in Redwood Creek basin: William Werrell, Hydrologist, and O. L. Wallis, both with the National Park Service in San Francisco; K. Michael Nolan, Hydrologist, and Deborah R. Harden, Hydrologist, both with the U. S. Geological Survey in Menlo Park, California. Also, the team thanks Trudy Allen of the National Park Service for typing review drafts and the final copy of this report.