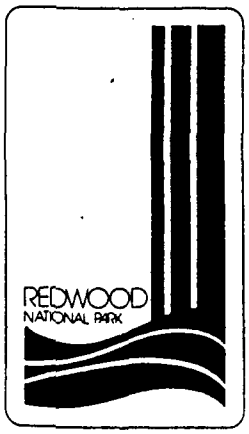
THE REDWOOD NATIONAL PARK WATERSHED REHABILITATION PROGRAM:

A PROGRESS REPORT AND PLAN FOR THE FUTURE



REDWOOD NATIONAL PARK

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climate was typical of the climate which characterized the past 3,000 years. Therefore, major storms typical of the period 1950-1975 should occur more frequently during the next few years than would be predicted based upon the climate of the last decade. For example, (using a long term climatological perspective) the major storm of December 1964 probably has a recurrence interval of 45-50 years. Similarly the storms of 1955, 1972, and 1975 have recurrence intervals of 30,10 and 10 years respectively.

Fluvial Erosion: Gully erosion was assessed on 32 study plots located in cutover lands in the Redwood Creek watershed. These surveys showed virtually all gully erosion was associated with roads, and the largest roads were the greatest sediment source. Stream diversions were the most important single cause of erosion. The most important gully erosion preventive measure was careful construction practices used on major logging haul roads. Oak-woodland and grassland soils were found to be more susceptible than forest soils to gully erosion from road caused stream diversion.

Landsliding: Total landslide contribution to the Redwood Creek basin between 1954 and 1980 was 6,415,600 m^3, of which 82 percent occurred either during or before the December 1964 flood. Aerial photo interpretation showed most of this landsliding occurred during this storm. There were two high landslide volume reaches along the 100 km length of Redwood Creek. One was located along the uppermost 30 km, the other extended from the downstream end of Redwood Valley to Bridge Creek. Low landslide occurrence reaches became areas of maximum sediment storage due to their lower gradient and greater valley width. Sandstone slopes were more prone to large landslides than schist slopes.

B. Fish and Wildlife

1. Role and Function

Fish and wildlife staff study the nature, function, and dynamics of aquatic and terrestrial ecosystems and determine man's influence upon these systems and their biologic components. Studies and monitoring of fish and wildlife communities, populations and the park environment are undertaken to provide basic resource information needed to effectively manage and protect the park's fish and wildlife. Information is provided for park management and other division staff to foster understanding and appreciation of park fish and wildlife to guide park developments, to avoid harm to park visitors and to provide for restoration and protection of park resources. Staff prepare management plans to provide for a balanced, diverse, naturally functioning and self-perpetuating biological park community which provides adequate protection for threatened or endangered species and their habitat.

2. Summary

Research begun during 1980 within the Redwood Creek estuary revealed the value of the estuary for downstream migrating juvenile salmonid fish and the adverse effects of channelization and construction of flood control levees on the function of the embayment. Short term management was implemented following public review and an assessment of various short and long term alternatives. Water levels were maintained high enough to provide suitable habitat for downstream fish migrants, but low enough to prevent flooding of adjacent pastures.

Tracking of black bears within the park yielded valuable information on bear behavior, home range, selective utilization of cutover and old growth forests, seasonal physical condition, reproduction, and bear population age and sex composition.

Aquatic invertebrates of the Redwood Creek watershed were studied to assess the impacts of watershed restoration activities within small streams on downstream aquatic biological resources.

Other studies included: Cold pool formation and use by fish as sanctuaries during warm summer months; elk management planning; fishery impacts of the proposed 101 bypass highway; fish habitat management planning; Redwood Creek salmonid nursery area surveys and river otter research. See Table 8 for the status of fish and wildlife projects.

3. Accomplishments

Aquatic Invertebrate Surveys: Aquatic invertebrates represent the major source of food for juvenile anadromous fish and have been used as indicators of stream quality. Species identification and abundance were measured to observe stream changes over time. Surveys were initiated to determine aquatic invertebrate species distribution and abundance in streams of the Redwood Creek watershed.

The first objective of the aquatic invertebrate study was a qualitative survey of larger park streams in the Redwood Creek basin. Bridge Creek, Devils Creek, Tom McDonald and Emerald Creeks were sampled April through October 1980. The survey duplicated objectives of the USGS efforts during their 1973-1975 survey, except improved sampling techniques were employed. The survey resulted in an aquatic invertebrate species list and a description of their relative abundance. These examples will be used to describe baseline stream conditions for comparison with the results from future samplings. In order to use aquatic invertebrate monitoring as a resource management tool, a quantitative technique was developed to sample small streams. A small artificial substrate basket was designed which could sample streams as shallow as 5 cm. without disturbing the substrate (many conventional sampling devices require the substrate to be disturbed as part of the collection process). The sampler collected a lower number

TABLE 8

Fish and Wildlife Project Status

Project Title/Objective	Year Initiated	Status
Aquatic Invertebrate Surveys - Determine species and abundance of fish food organisms in Redwood Creek streams.	80	Surveys completed. Samples still being processed. Preliminary species list available.
Evaluation of techniques for collection/analysis of aquatic invertebrate communities.	81	Field work completed. Masters thesis produced. Draft technical report prepared. "New" sampler developed. Technical paper prepared.
Determination of aquatic community impacts resulting from watershed rehabilitation.	81	Initial field work completed. Draft report prepared. Management recommendations prepared. Follow-up field work to be conducted.
Redwood Creek Estuary Research - To determine feasibility of developing rehabilitation alternatives for the Redwood Creek estuary.	80	Initial geologic work completed and Masters thesis produced. Technical papers prepared. Management Alternatives for the Redwood Creek Estuary prepared Public meetings conducted. Management alternatives developed and implemented. Fisheries Research continuing.
River Otter Research - Determine status and effects of logging on distribution/abundance of otters.	80	Field work completed FY83. Data analysis underway. Target completion date in FY84.
Redwood Creek Salmonid Nursery Area Study - Determine quantity, quality and distribution of juvenile salmonid nursery areas in Redwood Creek basin.	81	Field work completed FY82. Technical paper prepared. Data analysis continuing. FY84 target completion date.

TABLE 8 (continued)

Fish and Wildlife Project Status

Project Title/Objective	Year Initiated	Status
Black Bear Research - Determine habitat selection patterns and distribution of black bear in the cutover redwood forest ecosystem. Develop comprehensive Bear Management Plan.	81	Field work continuing. Nine bears radio-collared. Draft bear management plan prepared. Technical paper prepared. Target completion FY86.
Roosevelt Elk Management - Assist Department of Fish and Game in alleviating elk depredation on property adjacent to park.	81	Prepared assessments for 1982 and 1983 relocation efforts. 24 elk relocated. Assist in developing interagency regional elk management plan. Ongoing.
Fisheries Habitat Management Plans - Develop stream specific habitat management plans for fisheries enhancement.	81	Preliminary work begun in Bridge Creek. Permanent monitoring sites established. Ongoing.
Evaluation of Impacted from Proposed construction of U.S. 101 highway bypass.	80	Field work completed necessary for predictive information. Impact analysis prepared. Technical paper prepared. Evaluations should continue during and following construction phase of project.
Cold Pool Research - Determine distribution, abundance and importance of cold pools as critical rearing habitat to juvenile salmonids. Develop management recommendations for enhancing/ creating new cold pools.	82	Cold pools for two summers located/mapped. Two technical papers prepared. Research continuing and ongoing.
Roosevelt Elk Research - Determine habitat selection patterns and distribution of Roosevelt elk in the cutover redwood forest ecosystem Develop alternatives for management.	83	Study plan being developed. Field work to begin FY84. Target completion date 1989.

of total individuals but a comparable number of taxa. The result was an invertebrate sampler which could be more readily transported for use in wildland situations and which produced representative samples of the aquatic community at a much lower cost.

During the summer of 1981, the immediate effects of road crossing excavation on the downstream aquatic community was studied on two second order streams within the park. The results of the investigation indicated the standard practice to divert streamflow around road crossing excavations was neither practical nor necessary. Due to the morphology of such streams, sediment produced by rehabilitation work either settled out quickly or did not produce a significant change in the aquatic community.

Another study was conducted to monitor the colonization of a new stream channel during the first summer following excavation and to observe biological recovery after one year. As part of the colonization study, drift organisms were sampled hourly over a 24-hour period to determine availability of colonizing organisms. This study showed high numbers of aquatic invertebrates colonized the channels during the first summer following the excavation, but that community composition changed. One year after the excavation, there was no significant difference between the aquatic community of the new channel and a section of channel upstream from the rehabilitation worksite.

Redwood Creek Estuary: Studies were initiated to determine the feasibility of developing rehabilitation alternatives for the Redwood Creek estuary. The estuary was modified as a result of channelization and flood control levees completed in 1968. Data on both physical and biological estuarine processes to determine seasonal timing and distribution of fish and fish food organisms in the estuary, determine seasonal changes in water quality and analyze and compare present-day patterns of inundation, estuarine morphology and sedimentation.

Preliminary research was used to develop short term management alternatives to minimize fisheries resource impacts. Continued studies will refine information on fish use of the estuary, on estuarine productivity and on feasible long term rehabilitation alternatives. The estuary's importance to anadromous fish has been established. Until the flood control levees are modified to restore former circulation patterns within the embayment, the overall effectiveness of erosion control rehabilitation efforts occurring upstream and restoration of the fishery resources of the Redwood Creek watershed cannot be realized.

Research results were presented in technical presentations at symposia and in Management Alternatives for the Redwood Creek Estuary. Public meetings were conducted to disseminate research findings and to receive public comments on proposed alternatives.

Redwood Creek Nursery Area Study: Depending upon species, juvenile salmonids spend a rearing period in freshwater before entering the

ocean. The availability and quality of nursery habitat determines the ability of fish to survive this rearing period. A study was undertaken to determine the quantity, quality and distribution of nursery habitat in the Redwood Creek basin. It was found that many tributary streams were not available to anadromous salmonids. Natural barriers to upstream migration occur near their mouths. Within park boundaries only three Redwood Creek tributary streams (excluding Prairie Creek and its tributaries) were free of such barriers.

Fisheries Habitat: Erosion and sedimentation damages fish spawning and rearing habitat in different ways and to varying degrees within individual tributary streams. Therefore, rehabilitation/management alternatives effective in one stream may not be so in another. Specific rehabilitation/management plans should be developed for each stream. Accordingly, stream surveys were conducted to identify potential spawning sites, rearing area availability, type and quality of cover and fish food availability. Permanent sampling sites were established for long-term monitoring of stream conditions. Complete physical and biological characteristics and stream stability of sampling sites were recorded. Stream stability was an extremely important characteristic affecting the duration and cost-effectiveness of management measures. Investigation revealed widely used fish enhancement measures like gabion weirs or egg hatch boxes would not effectively improve fisheries in Redwood Creek. Likewise, some streams were unstable, having constantly readjusting channel, riffle and pool locations. Streams proposed for rehabilitation/management planning would emphasize restoration of rearing habitat. Development of a Bridge Creek habitat management plan was begun.

Highway 101 Bypass: Data on fish and wildlife resources within the impact area of the proposed highway's alternative routes were unavailable when project planning began. Studies were begun, concentrating on aquatic resources, that would provide the information necessary to predict impacts from highway construction. Data collected were used in preparation of draft and final environmental documents. The potential for significant impacts was identified which resulted in abatement measure committments and mitigation money from the California Department of Transportation. A new technique, developed in concert with the California Department of Fish and Game, was used to assess fishery values of project affected streams. A technical paper was prepared which describes the procedure. Studies to monitor impacts will resume during project construction.

Cold Pool: During Redwood Creek fishing habitat studies, cold pools which serve as summertime habitat for juvenile salmonids were discovered. When the mixing of cold groundwater with mainstem water was retarded by a gravel bar or large organic debris, a cold pool formed. During summertime low flow conditions, mainstream temperatures increased to levels harmful to juvenile fish. Cold pools provided sanctuaries from elevated summertime water temperatures and therefore provided important nursery habitat. Cold pool research was designed to

investigate the distribution, abundance and use by fish of natu occurring cold pools. This research revealed conditions favoring pool formation occurred infrequently. During Summer 1982, only cold pools were found in the lower 18 miles of Redwood Creek. Be of elevated mainstem temperatures, these cold pools encompassed a all the quality nursery habitat available in the creek mainstem. either producing additional cold pools or enhancing existing cold p summer rearing habitat could be significantly increased.

River Otter: River otters are dependent on aquatic resources, w have been severely damaged by intense land use in northern Califor Research objectives were to determine the status, distribution abundance of river otters in Redwood Creek. The study was conducte Humboldt State University.

Live-trapping, radio transmitter implantations and subsequent trac of two otters provided abundance and distribution data. Otters found to utilize various habitats in Redwood Creek, ranging from estuary to small tributary streams.

Black Bear: There has been a conspicuous lack of bear/human problem Redwood National Park. Prior to 1978, the National and State pa comprised a coastal band of old growth forest stretching north f Orick to the Smith River. Compared to cutover land with its increa bear food production, old growth forests represented relatively p bear habitat. As a result bear density was greater in cutover la which surrounded the parks. Hunting occurred in these areas an natural fear of humans was reinforced. Visitors to the parks had sm likelihood for bear encounters as bears were concentrated in cuto lands and avoided humans. Park expansion in 1978 encompassed la areas of cutover land and prime bear habitat was added to the park. development of trails and campgrounds occurs, people will be encoura to visit these areas.

Cutover areas represent a mosaic of habitat types in various stages successional revegetation. How bears select habitats and how th habitats change with vegetative succession are being investigated. T information can be used when planning visitor facilities such t reliable predictions can be made about bear/human conflicts.

Objectives of the park's bear research included: Habitat selection a distribution patterns, population age and sex structure and season nutritional status of black bears in the cutover redwood ecosystem Techniques used to obtain information include live-trapping, radio-tel metry, detailed vegetation analysis and blood hematology and chemistr Research documented black bears denning in north coastal Californi Blood chemistry, hematology and physical measurements indicate a peri of physiological stress for bears during spring and summer. Habit evaluations showed this corresponds to low natural food availabilit During this period it would be especially important to prevent be access to human foods. Also during this period bears utilized tree ba

cambium as a food resource. Radio-telemetry allowed delineation of bear seasonal home ranges. For example, females with cubs utilized cutover areas but were closely associated with old growth stands for denning and cover. Younger less dominant animals use cutover lands for a larger proportion of time.

The park's bear research enabled development of a comprehensive bear management plan, which provides the park with a unique opportunity to deal with potential bear/human interactions before they become a problem.

Roosevelt Elk: Roosevelt elk residing in and around the Orick-Prairie Creek area have reportedly caused depredation of adjacent private property, resulting in claims of substantial annual economic loss by landowners. As vegetative succession proceeds on cutover land, elk distribution will change, likely increasing depredation problems or stressing local groups of animals. No scientific data was available, however, that would allow development of management alternatives which would be effective in dealing with depredation problems while not adversely affecting local elk herds. Research will be carried out to identify habitat selection and distribution patterns of elk in the cutover redwood forest.

C. Cultural Resources

1. Role and Function

The park archaeologist assists park management in carrying out National Park responsibilities to preserve cultural resources. Functions include compliance with applicable statutes, regulations and policies, location, evaluation and protection of historic and prehistoric resources and protection of places of importance to local Native Americans.

An active, parkwide cultural resource management program plan is maintained. The archaeologist provides close coordination of park activities with the State Historic Preservation Office and with Native American Heritage Advisory Committees. Prehistoric and historic artifacts are preserved and archived. Appropriate clearances for park management actions which may affect park cultural resources are acquired.

2. Summary

To date, 29,600 acres (27.9%) of park lands have been subjected to archaeological reconnaissance. Fifty eight cultural resources were recorded. Of park lands within the Redwood Creek basin, 14,500 acres or 28.9% have been subjected to complete archaeological reconnaissance. Outside of the Redwood Creek basin, 7,000 acres (24%) of park lands have been surveyed. However surveys undertaken outside the basin were cursory, that is, lands were spot checked.

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B. BIBLIOGRAPHY OF REDWOOD NATIONAL PARK PUBLICATIONS

Redwood National Park Technical Report Series

Madej, M. A., H. Kelsey, and W. Weaver. 1980. An Evaluation of 1978 Rehabilitation Sites and Erosion Control Techniques in Redwood National Park. Redwood National Park Technical Report Number 1. National Park Service, Redwood National Park. Arcata, California. 113 pp.

Kelsey, H. and P. Stroud. 1981. Watershed Rehabilitation in the Airstrip Creek Basin. Redwood National Park Technical Report Number 2. National Park Service, Redwood National Park. Arcata, California. 45 pp.

Kelsey, H., M.A. Madej, J. Pitlick, M. Coghlan, D. Best, R. Belding and P. Stroud. 1981. Sediment Sources and Sediment Transport in the Redwood Creek Basin: A Progress Report. Redwood National Park Technical Report Number 3. National Park Service, Redwood National Park. Arcata, California. 114 pp.

Sacklin, John A. 1982. Wolf Creek Compost Facility, Operation and Maintenance Manual. Redwood National Park Technical Report Number 4. Second Edition. National Park Service, Redwood National Park. Arcata, California. 61 pp.

Reed, Lois J. and M.M. Hektner. 1981. Evaluation of 1978 Revegetation Techniques. Redwood National Park Technical Report Number 5. National Park Service, Redwood National Park. Arcata, California. 70 pp.

Muldavin, Esteban H., J.M. Lenihan, W.S. Lennox and S.D. Veirs, Jr. 1981. Vegetation Succession in the First Ten Years Following Logging of Coast Redwood Forests. Redwood National Park Technical Report Number 6. National Park Service, Redwood National Park. Arcata, California. 69 pp.

Lenihan, James M., W.S. Lennox, E.H. Muldavin, and S.D. Veirs, Jr. 1982. A Handbook for Classifying Early Post-Logging Vegetation in the Lower Redwood Creek Basin. Redwood National Park Technical Report Number 7. National Park Service, Redwood National Park. Arcata, California. 40 pp.

Pitlick, John. 1982. Sediment Routing in Tributaries of the Redwood Creek Basin: Northwestern California. Redwood National Park Technical Report Number 8. National Park Service, Redwood National Park. Arcata, California. 67 pp.

Coghlan, M. 1984. A Climatologically - Based Analysis of the Storm and Flood History of Redwood Creek. Redwood National Park Technical Report Number 10. National Park Service, Redwood National Park. Arcata, California. 47 pp.

Bibliography of Redwood National Park Publications

Technical Reports in Progress (1984 - 1985 Publishing Date)

Walter, Tom. Gully Erosion on Prairies of the Redwood Creek Basin, Northwestern California.

Varnum, Nicholas. Significance of Channel Changes at Cross Sections in the Mainstem of Redwood Creek, California During the 1982 Water Year.

Madej, Mary Ann. Recent Changes in Channel-Stored Sediment in Redwood Creek, California.

Best, David. Recent Land Use History of Redwood Creek, California.

Best, David. Contribution of Fluvial Erosion to the Sediment Load of Redwood Creek, California.

Kelsey, H. M., M. Coghlan, J. Pitlick, and D. Best. Geomorphic Analysis of Streamside Landsliding in the Redwood Creek Basin.

Best, D. W., H. M. Kelsey, D.K. Hagans, and M. Alpert. Role of Fluvial Hillslope Erosion and Road Construction in the Sediment Budget of Garrett Creek, Humboldt County, California.

Selected Publications on Watershed Rehabilitation

by Redwood National Park Staff

Bundros, Gregory J., T. Spreiter, K. Utley and E. Wosika. 1981. Erosion Control in Redwood National Park, 1980. Proceedings, Symposium on Watershed Rehabilitation in Redwood National Park and Other Coastal Areas. August 24-28, 1981. Arcata, California. Center for Natural Resource Studies of the John Muir Institute. Berkeley, California. pp. 273-282.

Coghlan, M. and M. A. Madej. 1981. Main Channel Response to Increased Sediment Supply, Upper Redwood Creek, California. Transactions American Geological Union, Abstracts, Vol. 62, Number 45, p. 858.

Hagans, D. K., W. E. Weaver and M. Alpert. (in preparation) Land Use as an Independent Variable Affecting Fluvial Erosion in the Redwood Creek Basin, Northern California. Abstract in: Proceedings, Symposium on Effects of Forest Land Use on Erosion and Slope Stability, May 7-11, 1984, Honolulu, Hawaii. Union of Forestry Research Organizations. Published by the Forest Research Institute, New Zealand Forest Service. Christchurch, New Zealand.

Bibliography of Redwood National Park Publications

Selected Publications on Watershed Rehabilitation (Continued)

Hektner, Mary, L. Reed, J. H. Popenoe, R. J. Mastrogiuseppe, D. Vezie, N. G. Sugihara and S. D. Veirs, Jr. Review of Revegetation Treatments Used in Redwood National Park: 1977 to Present. Proceedings, Symposium on Watershed Rehabilitation in Redwood National Park and Other Coastal Areas. August 24-28, 1981. Arcata, California. Center for Natural Resource Studies of the John Muir Institute. Berkeley, California. pp. 70-77.

Hofstra, Terrence D. 1981. Aquatic Resources Rehabilitation Program, Redwood National Park. Proceedings, Symposium on Watershed Rehabilitation in Redwood National Park and Other Coastal Areas. August 24-28, 1981. Arcata, California. Center for Natural Resource Studies of the John Muir Institute. Berkeley, California. pp. 56-58.

Hofstra, Terrence D. 1982. Management Alternatives for the Redwood Creek Estuary. National Park Service, Redwood National Park. Arcata, California. 50 pp.

Kelsey, H. M. and W. Weaver. 1979. Watershed Rehabilitation for Erosion Control on Logged Lands in Redwood National Park. Guidebook for Geological Society of America Field Trip, April 12-14, 1979. A Field Trip to Observe Natural and Management-Related Erosion in Franciscan Terrane of Northern California. pp. XII-1 to XII-14.

Kelsey, H. M., W. Weaver and M. A. Madej. 1979. Geology, Geomorphic Processes, Land Use and Watershed Rehabilitation in Redwood National Park and Vicinity, Lower Redwood Creek Basin. Guidebook for Geological Society of America Field Trip, April 12-14, 1979. A Field Trip to Observe Natural and Management-Related Erosion in Franciscan Terrane of Northern California. pp. XIII-1 to XIII-18.

Kelsey, H. M., W. E. Weaver and G. Bundros. 1979. An Evaluation of Erosion Control Devices Used in Gullies Within Redwood National Park. Geological Society of America, Abstracts With Programs, Vol. 11, Number 3.

Kelsey, H., M. A. Madej, J. Pitlick, P. Stroud, and M. Coghlan. 1981. Major Sediment Sources and Limits to the Effectiveness of Erosion Control Techniques in the Highly Erosive Watersheds of North Coastal California. In: Proceedings of a Symposium on Erosion and Sediment Transport in Pacific Rim Steeplands. January 25-31, 1981. Christchurch, New Zealand. IAHS-AISH Publication Number 132. International Association of Hydrological Sciences. Washington, D.C. pp. 493-510.

Bibliography of Redwood National Park Publications

Selected Publications on Watershed Rehabilitation (Continued)

Klein, R. D. (In preparation) Channel Adjustments Following Logging Road Removal in Small Steepland Drainages. Abstract in: Proceedings, Symposium on Effects of Forest Land Use on Erosion and Slope Stability, May 7-11, 1984, Honolulu, Hawaii. Union of Forestry Research Organizations. Published by the Forest Research Institute, New Zealand Forest Service. Christchurch, New Zealand.

LaHusen, R. G. (In preparation) Characteristics of Management Related Debris Flows, Northwestern California. Abstract in: Proceedings, Symposium on Effects of Forest Land Use on Erosion and Slope Stability, May 7-11, 1984, Honolulu, Hawaii. Union of Forestry Research Organizations. Published by the Forest Research Institute, New Zealand Forest Service. Christchurch, New Zealand.

Larson, James P., C. L. Ricks, and T. J. Salamunovich. 1981. Alternatives for Restoration of Estuarine Habitat at the Mouth of Redwood Creek, Humboldt County, California. Proceedings, Symposium on Watershed Rehabilitation in Redwood National Park and Other Coastal Areas. August 24-28, 1981. Arcata, California. Center for Natural Resource Studies of the John Muir Institute. Berkeley, California. pp. 236-245.

Lenihan, James M., W. S. Lennox, E. H. Muldavin and S. D. Veirs, Jr. 1981. Redwood Forests in Their Initial Stages of Secondary Succession Following Logging and the Application to Forest Rehabilitation. Proceedings, Symposium on Watershed Rehabilitation in Redwood National Park and Other Coastal Areas. August 24-28, 1981. Arcata, California. Center for Natural Resource Studies of the John Muir Institute. Berkeley, California. pp. 56-68.

Madej, M. A. and H. Kelsey. 1981. Sediment Routing in Stream Channels: Its Implications for Watershed Rehabilitation. Proceedings, Symposium on Watershed Rehabilitation in Redwood National Park and Other Coastal Areas. August 24-28, 1981. Arcata, California. Center for Natural Resource Studies of the John Muir Institute. Berkeley, California. pp. 17-25.

Madej, M. A. (In Press). Channel Storage in Redwood Creek, Northern California. Transaction American Geophysical Union.

Pitlick, John. 1981. Organic Debris in Tributary Stream Channels of the Redwood Creek Basin. Proceedings, Symposium on Watershed Rehabilitation in Redwood National Park and Other Coastal Areas. August 24-28, 1981. Arcata, California. Center for Natural Resource Studies of the John Muir Institute. Berkeley, California. pp. 177-190.

Selected Publications on Watershed Rehabilitation (Continued)

Pitlick, John. 1981. Sediment Routing in Tributaries of the Redwood Creek Basin, Northern California. Transactions, American Geophysical Union, Abstracts. Vol. 62, Number 45. p. 858.

Popenoe, James H. 1981. Effects of Grass Seedings, Fertilizer and Mulches on Vegetation and Soils of the Copper Creek Watershed Rehabilitation Unit: The First Two Years. Proceedings, Symposium on Watershed Rehabilitation in Redwood National Park and Other Coastal Areas. August 24-28, 1981. Arcata, California. Center for Natural Resource Studies of the John Muir Institute. Berkeley, California. pp. 87-95.

Sonnevil, R. A., and W. E. Weaver. 1981. The Evolution of Approaches and Techniques to Control Erosion on Logged Lands, Redwood National Park, 1977-1981. Proceedings, Symposium on Watershed Rehabilitation in Redwood National Park and Other Coastal Areas. August 24-28, 1981. Arcata, California. Center for Natural Resource Studies of the John Muir Institute. Berkeley, California. pp. 258-272.

Teti, Patrick. 1981. Rehabilitation of a 290 Hectare Site in Redwood National Park, 1980. Proceedings, Symposium on Watershed Rehabilitation in Redwood National Park and Other Coastal Areas. August 24-28, 1981. Arcata, California. Center for Natural Resource Studies of the John Muir Institute. Berkeley, California. pp. 283-297.

United States Department of the Interior. 1978. Proceedings of a Workshop on Techniques of Rehabilitation and Erosion Control in Recently Roaded and Logged Watersheds, With Emphasis to North Coastal California. March 13-14, 1977. National Park Service, Redwood National Park, Resources Management Division. Arcata, California. 89 pp.

Veirs, Stephen D., Jr., and W. Lennox. 1981. Rehabilitation and Long-Term Park Management of Cutover Redwood Forests: Problems of Natural Succession. Proceedings, Symposium on Watershed Rehabilitation in Redwood National Park and Other Coastal Areas. August 24-28, 1981. Arcata, California. Center for Natural Resource Studies of the John Muir Institute. Berkeley, California. pp. 50-55.

Weaver, W. E., H. M. Kelsey and M. A. Madej. 1979. General History of Redwood National Park: Guidebook for Geological Society of America Field Trip, April 12-14, 1979. A Field Trip to Observe Natural and Management-Related Erosion in Franciscan Terrane of Northern California. pp. IX-1 to IX-3.

Selected Publications on Watershed Rehabilitation (Continued)

Weaver, W. E., H. M. Kelsey, M. A. Madej, D. Hagans and G. Bundros. 1979. Minimizing Concentrated Runoff, Surface Erosion, and Mass Slope Movement in Redwood National Park by Removing Former Logging Haul Roads. Geological Society of America. Abstracts with Programs, Vol. 11, Number 3.

Weaver, W. and M. Seltenrich. 1980. Summary Results Concerning the Effectiveness and Cost-Effectiveness of Labor-Intensive Erosion Control Practices Used in Redwood National Park, 1978-1979. Unpublished memorandum report, on file, Redwood National Park. 20 pp.

Weaver, W. and M. A. Madej. 1981. Erosion Control Techniques Used in Redwood National Park, Northern California, 1978-1979. In: Proceedings of a Symposium on Erosion and Sediment Transport in Pacific Rim Steeplands, January 25-31, 1981. Christchurch, New Zealand. IAHS-AISH Publication Number 132. International Association of Hydrological Sciences. Washington, D. C. pp. 640-645.

Weaver, W. E., A. V. Choquette, D. K. Hagans and J. Schlosser. 1981. The Effects of Intensive Forest Land Use and Subsequent Landscape Rehabilitation on Erosion Rates and Sediment Yield in the Copper Creek Drainage Basin, Redwood National Park. Proceedings, Symposium on Watershed Rehabilitation in Redwood National Park and Other Coastal Areas. August 24-28, 1981. Arcata, California. Center for Natural Resource Studies of the John Muir Institute. Berkeley, California. pp. 298-312.

Weaver, W. E., M. S. Seltenrich, R. A. Sonnevil, and E. M. Babcock. 1981. The Use of Cost-Effectiveness as a Technique to Evaluate and Improve Watershed Rehabilitation for Erosion Control, Redwood National Park. Proceedings, Symposium on Watershed Rehabilitation in Redwood National Park and Other Coastal Areas. August 24-28, 1981. Arcata, California. Center for Natural Resource Studies of the John Muir Institute. Berkeley, California. pp. 341-360.

Weaver, W. E. and R. A. Sonnevil. (In preparation) Relative Cost-Effectiveness of Forest Land Rehabilitation, Redwood National Park, Northern California. Abstract in: Proceedings, Symposium on Effects of Forest Land Use on Erosion and Slope Stability. May 7-11, 1984. Honolulu, Hawaii. Union of Forestry Research Organizations. Published by the Forest Research Institute, New Zealand Forest Service. Christchurch, New Zealand.

Bibliography of Redwood National Park Publications

Redwood National Park Papers Published in the Proceedings of the First Biennial Conference of Research in California's National Parks September 9-10, 1982. University of California at Davis. Davis, California

Geology/Hydrology

Status of the Emerald Creek Landslide, Redwood National Park
E. M. Babcock, R. G. LaHusen, R. D. Klein, R. A. Sonnevil, W. E. Weaver, D. K. Hagans

Comparison of Slope Treatments for Reducing Surface Erosion on Disturbed Sites at Redwood National Park
K. J. Kveton, K. A. Considine, E. M. Babcock, R. G. LaHusen, M. S. Seltenrich, R. A. Sonnevil, W. E. Weaver

Vegetation

The Bald Hills Prairies of Redwood National Park, California
M. M. Hektner, R. W. Martin, D. R. Davenport

The Forest Associations of the Little Lost Man Creek Research Natural Area, Redwood National Park
J. M. Lenihan

Guidelines for Classifying Early, Post-Logging Vegetation in the Lower Redwood Creek Basin of Redwood National Park
J. M. Lenihan, W. S. Lennox, E. H. Muldavin, S. D. Veirs, Jr.

Stand Composition and Diameter Distribution in Sixty-Year-Old Second-Growth Coast Redwood Forests
W. S. Lennox

Artificial and Biological Control of Tansy Ragwort, Sencecio jacobaea L., in Redwood National Park, California
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Water Quality and Productivity of the Redwood Creek Estuary
J. Larson, J. McKeon, T. Salamunovich, T. D. Hofstra

Redwood Creek Estuary Flood History, Sedimentation and Implications for Aquatic Habitat
C. Ricks

Determining the Economic Value of Aquatic Resources Within the Impact Area of Proposed Highway Construction
R. Wood, California Department of Fish and Game, Eureka, California
T. Hofstra, Redwood National Park, Arcata, California
D. McLeod, California Department of Fish and Game, Eureka, California

Bibliography of Redwood National Park Publications

Papers Now Being Prepared by National Park Service Staff for Inclusion in a U.S. Geological Survey Professional Paper on Research in Redwood National Park

Summary of Scientific Involvement in the Redwood Creek Basin
S. Veirs, Jr. and R. J. Janda

Geology and Descriptive Geomorphology of the Redwood Creek Basin
S. M. Cashman, H. M. Kelsey and D. R. Harden

A Climatological Analysis of the Response of Redwood Creek to Extreme Storms
M. Coghlan

Recent Land Use History in the Redwood Creek Basin
D. Best

Magnitude and Causes of Gully Erosion in the Lower Redwood Creek Drainage Basin
W. E. Weaver and D. K. Hagans

Role of Fluvial Hillslope Erosion and Road Construction in the Sediment Budget of Garrett Creek, Humboldt County, California
D. K. Hagans, H. Kelsey, D. Best, and M. Alpert

Sediment Routing in Tributaries of the Redwood Creek Basin: Northwestern California
J. Pitlick

Recent Changes in Channel Stored Sediment in Redwood Creek Basin
M. A. Madej

Geomorphic Analysis of Streamside Landslides in the Redwood Creek Basin
H. Kelsey, M. Coghlan, J. Pitlick and D. Best

Summer Cool Pools in Redwood Creek Near Orick, California
E. Keller, T. Hofstra and C. Moses

The Estuary of Redwood Creek: Impacts of Recent Drainage Basin Changes on Aquatic Habitat
C. Ricks

Bibliography of Redwood National Park Publications

Management Reports

U.S. Department of the Interior. 1975. Environmental Assessment, Management Options for Redwood Creek, Redwood National Park. National Park Service, Western Region. San Francisco, California. 31 pp.

U.S. Department of the Interior. 1979. Draft Environmental Statement, General Management Plan, Redwood National Park. Volume 1 of 3, NPS 1433. National Park Service, Denver Service Center. Denver, Colorado. 247 pp.

U.S. Department of the Interior. 1980. General Management Plan, Redwood National Park. NPS 1661. National Park Service, Denver Service Center. Denver, Colorado. 51 pp.

U.S. Department of the Interior. 1981. Environmental Assessment, K & K Road Relocation, Redwood National Park. National Park Service, Denver Service Center. Denver, Colorado. 51 pp.

U.S. Department of the Interior. 1981. Watershed Rehabilitation Plan, Redwood National Park, Del Norte and Humboldt Counties, California. National Park Service, Denver Service Center. Denver, Colorado. 92 pp.

U.S. Department of the Interior. 1982. Redwood National Park Resources Management Plan and Environmental Assessment. National Park Service, Redwood National Park. Crescent City, California. 275 pp.

U.S. Department of the Interior. 1982. Redwood National Park Resources Management Plan. National Park Service, Redwood National Park. Crescent City, California. 72 pp.

U.S. Department of the Interior. 1982. Redwood Information Center Environmental Assessment. National Park Service, Denver Service Center. Denver Colorado. 35 pp.

U.S. Department of the Interior. 1984. Backcountry Trail Plan: Redwood and Skunk Cabbage Creeks, National Park Service, Redwood National Park. Arcata, California. 50 pp.

U.S. Department of the Interior. 1984. Redwood National Park Revised Resources Management Plan. National Park Service, Redwood National Park. Crescent City, California.

U.S. Department of the Interior. 1984. Statement for Management, Redwood National Park. National Park Service, Redwood National Park. Crescent City, California. 65 pp.

Publications List (Partial) for Research Carried Out in Cooperative USGS - NPS Watershed Studies, Redwood National Park

Bradford, Wesley L., and Rick T. Iwatsubo. 1978. Water Chemistry of the Redwood Creek and Mill Creek Basins, Redwood National Park, Humboldt and Del Norte, Counties, California. Water Resources Investigations 78-115, U.S. Geological Survey, Menlo Park, CA

Harden, Deborah R., Richard J. Janda, and Michael Nolan. 1978. Mass Movement and Storms in the Drainage Basin of Redwood Creek, Humboldt County, California - A Progress Report. Open-File Report 78-486, U.S. Geological Survey, Menlo Park, CA

Iwatsubo, Rick T., K. Michael Nolan, Deborah R. Harden, and G. Douglas Glysson, 1976. Redwood National Park Studies, Data Release Number 2, Redwood Creek, Humboldt County and Mill Creek, Del Norte County, California. Open-File Report 76-678, U.S. Geological Survey, Menlo Park, CA

Iwatsubo, Rick T., K. Michael Nolan, and Deborah R. Harden. 1975. Redwood National Park Studies Data Release Number 1, Redwood Creek, Humboldt County, California. Open-File Report, U.S. Geological Survey Menlo Park, CA

Janda, Richard J. 1975. Recent Man-Induced Modifications of the Physical Resources of the Redwood Creek Unit of Redwood National Park, California, and the Processes Responsible for Those Modifications. Open-File Report, U.S. Geological Survey, Menlo Park, CA

Janda, Richard J., K. Michael Nolan, Deborah R. Harden, and Steven M. Colman. 1975. Watershed Conditions in the Drainage Basin of Redwood Creek, Humboldt County, California as of 1973. Open-File Report, U.S. Geological Survey, Menlo Park, CA

Janda, Richard J. 1976. Testimony Prepared for Presentation in San Francisco, California on September 18, 1976 at the Subcommittee on Conservation, Energy, and Natural Resources of the U.S. House of Representatives Committee on Government Operations' Public Hearing Concerning the Special Need for Federal Action to Preserve and Protect the Resources of Redwood National Park. Open-File Report 76-718, U.S. Geological Survey, Menlo Park, CA 24 pp.

Janda, Richard J. 1977. Summary of Watershed Conditions in the Vicinity of Redwood National Park, California. Open-File Report 78-25, U.S. Geological Survey, Menlo Park, CA

Lee, K. W., G. W. Kapple, and D. R. Dawdy, 1975. Rainfall-Runoff Relation for Redwood Creek Above Orick, California. Open-File Report, U.S. Geological Survey, Menlo Park, CA

Nolan, K. Michael, D. R. Harden, and S. M. Colman, 1976. Erosional Landform Map of the Redwood Creek Drainage Basin, Humboldt County, California, 1947-74. Water-Resources Investigations 76-42, Open-File Report, U.S. Geological Survey, Menlo Park, CA

Nolan, K. Michael, and Deborah R. Harden, 1976. Graphic and Tabular Summaries of Water and Suspended-Sediment Discharge for Two Periods of Synoptic Storm Sampling During 1975 in the Mill Creek Drainage Basin, Del Norte County, California. Open-File Report 76-473, U.S. Geological Survey, Menlo Park, CA 13 pp.

Nolan, K. Michael, Deborah R. Harden, and Richard J. Janda, 1976. Graphic and Tabular Summaries of Recent Changes in Stream-Channel Cross Sections for Redwood Creek and Selected Tributaries, Humboldt County, California. Open-File Report 76-392, U.S. Geological Survey, Menlo Park, CA

CULTURAL RESOURCES REFERENCES

Baker, S. 1981. An Archaeological Survey of Eleven Inventory Units, Redwood National Park, Humboldt County, California.

Baker, S. and S. Salzman. 1982. An Archaeological Survey of Seven Inventory Units, Redwood National Park, Humboldt County, California.

Bearss, E.C. 1969. History Basic Data, Redwood National Park, Del Norte and Humboldt Counties, California. (Reprinted 1982)

Benson, J. R. 1978. An Excavation and Reinterment of a Burial at 4-DNO-15 in Del Norte County, California.

Benson, J. R. 1981. Archaeological Test Excavation of CA-HUM-442, Redwood National Park, California.

Benson, J. R. 1983. Archaeological Test Excavations at Four Sites in Redwood National Park, Humboldt County, California.

Bickel, P. McW. 1979. A Study of Cultural Resources in Redwood National Park.

Bickel, P. McW. and A. G. King. 1980. A Research Design for Anthropological Work in Redwood National Park, California.

Greene, L. W. 1980. Historic Overview of the Redwood Creek Basin and the Bald Hills Regions of Redwood National Park, California.

Hayes, J. F, et al. 1980. Description and Analysis of Prehistoric Artifacts from Archaeological Sites within Redwood National Park, California.

King, A. G. 1980. Archaeological Reconnaissance of Two Rehabilitation Units: The Lower K & K Road Unit and the Devils Creek Y-2 Road Slope Unit and Archaeological Testing at CA-HUM-484, Redwood National Park, California.

King, A. G. and Bickel, P. McW. 1980. Resource Evaluation at Nine Archaeological Sites, Redwood Creek Basin, Redwood National Park, California.

Moratto, M. J. 1973. A Survey of Cultural Resources in and Near Redwood National Park, California.

Salzman, S. S. 1979. Redwood National Park Archaeological Survey of Proposed Rehabilitation Road Route and Airstrip Creek Rehabilitation Unit with Comments on Survey of Logged Land Areas.

Salzman, S. S. and Bickel, P. McW. 1979. Archaeological Survey in Rehabilitation Units in Redwood National Park, California.

Shoup, L. H. 1983. An Interpretation and Assessment of the Significance of the Historic Cultural Properties of Redwood National Park.

Soulliere, L. E. 1978. Architectural Survey and Evaluation, Redwood National Park, California. (Final 1982).

OTHER REFERENCES CITED

Everhart, W. C., 1983. The National Park Service. Westview Press. Boulder, Colorado 197 pp.