



The North Coast region provides more than one-third of California's water.

Managing Forests on Unstable Lands

The redwood and Douglas-fir region of the Coast Range and Klamath Mountains in northwestern California covers an area extending from the California Oregon border south to about 100 miles above San Francisco. The area provides more than 40 percent of California's timber products, 37 percent of its streamflow, and the most valuable habitat for salmon and steelhead trout in the State. But management of these important resources presents major problems. One difficulty is that natural landslides commonly occur, eroding slopes and depositing enormous amounts of sediment in streams. The role that logging and its associated roadbuilding may play in contributing to this

natural erosion and sedimentation needs to be better understood. Sedimentation is a threat to the high quality of water in the numerous small streams that interlace the region. These waterways provide some 7,000 miles of habitat for king and silver salmon and steelhead trout. Conducting timber harvesting operations in such a way that water quality will not be impaired is a major challenge to forest managers.

Obtaining regeneration is also a problem, particularly on hot, south-facing slopes, on landslide scars, road cuts and fills, or similar harsh sites. Sometimes cutover sites have to be replanted as many as three times in attempts to get an adequate stand established.

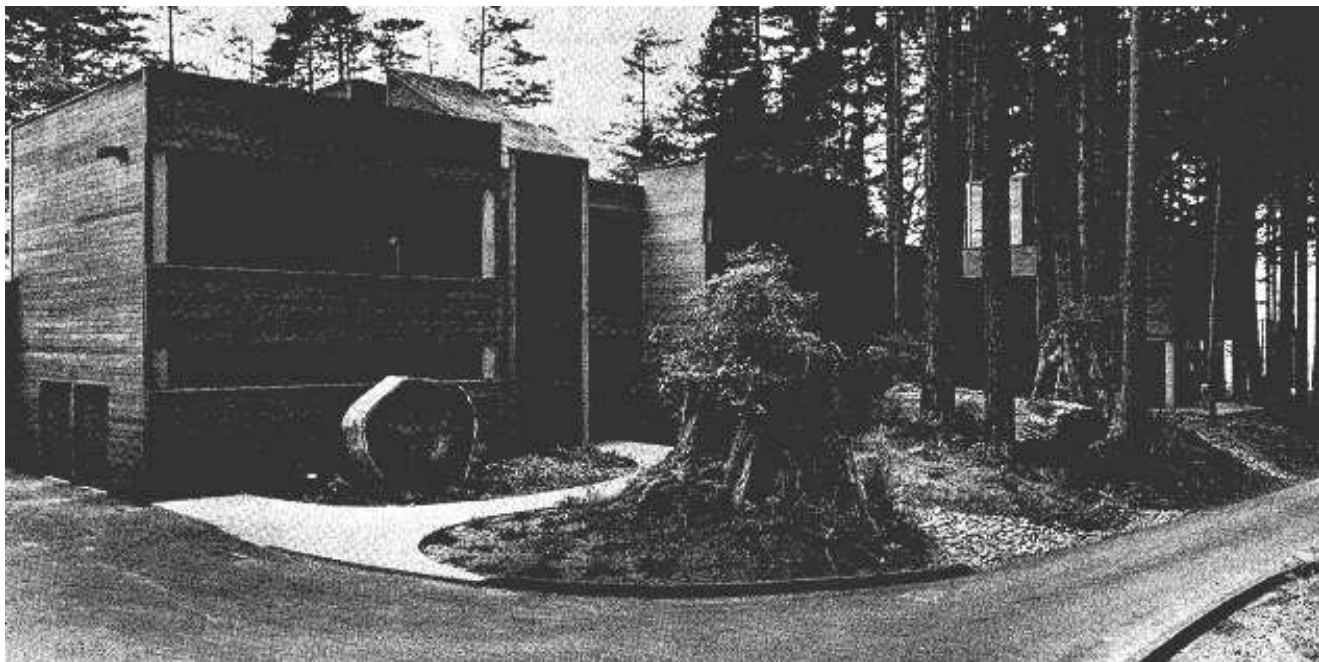
Researchers at the Pacific Southwest Station's Redwood Sciences Laboratory in Arcata, California, are concentrating on resource problems of this complex ecosystem. The staff works in cooperation with Humboldt State University (where the Laboratory is located), and with forest managers throughout northwestern California. Results of the research are applicable not only in this area, but also in portions of Oregon, Washington, Alaska, Idaho, and British Columbia, where geological, biological, and climatic conditions are similar to those of the North Coast.

Much of the research on the effects of road construction and logging on water quality and flood peaks has been done in the Caspar Creek drainage on Jackson State Forest, a site that is representative of other watersheds of second-growth redwood and Douglas-fir in northwestern California. Streamflow and sediment loads of both the North Fork and South Fork of the drainage have been monitored for the past 14 years. The North Fork has not been logged during that period; in the South Fork, 62 percent of the timber was harvested after 4 miles of logging roads were built.

Preliminary results show that the road-building did not affect flood peaks, but it did increase sedimentation. The records showed that over the 4-year period between the beginning of road construction and the beginning of timber cutting, the South Fork watershed produced 1,340 cubic yards more sediment per square mile of drainage area than predicted. Logging increased the suspended sediment loads four times more than road construction-about 6,150 cubic yards per mile of drainage.

These sedimentation levels are not excessive, however. According to Raymond M. Rice, principal hydrologist at the Laboratory, "The overall effect on site quality, as measured by soil loss, was not of the magnitude to warrant the concern of forest managers. Although 14 percent of the eroded material left the watershed, prorated over an entire rotation, this is about one-seventh of one percent of the total soil mass lost each year. A timber harvest such as the South Fork operation would not cause unacceptable damage."

At the request of the State Board of Forestry, researchers are examining 102 sites



Research at the Redwood Sciences Laboratory, Arcata, is designed to improve management of the redwood and Douglas-fir forests in northwestern California. (Karl Riek photo courtesy California Redwood Association.)

throughout the coast redwood region that have recently been logged, to determine if there is any relationship between the type of logging operation (tractor or cable), site characteristics (such as slope, soil, and rainfall), and the erosion associated with a timber harvest. Sites on both National Forests and privately owned land are being studied. Preliminary results from the Forest Service sites show that in the tractor-yarded areas, more soil displacement occurred during the actual yarding operations than during subsequent storms. On the Forest Service plots that were cable-yarded, the results were the opposite: less than half of the logging-related soil displacement occurred during yarding.

Robert B. Thomas, mathematical statistician at the Laboratory, is trying to improve the techniques that are used to sample and monitor sedimentation. The data gathered under these improved techniques can be used in statistical or mathematical models of the processes involved in sedimentation. When completed, these models can be used to predict the results of proposed management activities.

In the Douglas-fir forests that lie east of the redwood belt, researchers are studying the problems associated with logging on steep, granitic batholiths. Here, landslides-especially debris avalanches-frequently occur as a result of logging. Geologist Philip B. Durgin has found that landslide susceptibility changes as the parent material weathers. "Landslides are most frequent when granitic rock is at an intermediate stage of weathering," Durgin explains. "In the early stages, there is not enough mobile material for there to be much of a landslide problem. In the later stages, the aggregation of clay and soil produces cohesion that promotes slope stability." Durgin regards a site's weathering stage as an important clue to its engineering properties. "An engineering geologist who is able to identify the weathering stage of a site will be better able to predict how a proposed management plan might affect the stability of slopes in the area," he says.

Raymond Rice and Norman H. Pillsbury (California Polytechnic State University, San Luis Obispo) have developed an equation

foresters can use to predict landslide risk on granitic sites. In their research, they used photos of a portion of the Klamath National Forest, taken before patchcutting, after cutting, and after severe storms triggered landslides throughout the area. They compared characteristics of cut sites that had failed with those that had not, and found that steepness of slope and density of crown cover and understory cover were key factors. Tests of their equation showed that it correctly predicted 91 percent of the failures and 75 percent of the instances in which sites remained intact. In areas similar to that used in the study, the equation can be used in evaluating the slide hazard of proposed timber harvests.

Hydrologist Robert R. Ziemer is leading a study to determine how logging affects the role that roots play in maintaining slope stability. Roots reinforce unstable slopes by tying the soil mantle to the parent material and by providing lateral support to the soil mass. "The increase in landslides that often occurs following logging may be related to the death and gradual decay of root systems in the harvested areas," Ziemer says. As part of this research, roots excavated from sites in California, Oregon, and Alaska that were logged 2 to 70 years previously have been weighed, measured, grouped into size classes, and tested for shear strength (their ability to resist the shear stress that is continually acting upon slopes). At some sites, a portable shear apparatus, developed by Ziemer, was used to measure shear strength of the soil-root matrix at the excavation sites. Preliminary results suggest that 6 years after logging, roots have deteriorated to the extent that they have only 10 percent of the soil-holding capacity they had before logging.

Regeneration

The root strength studies point up the importance of establishing a new stand as soon as possible after harvesting. Laboratory scientists are looking for ways to improve natural and artificial regeneration of redwood and Douglas-fir on a variety of sites. A



Although coast redwood is internationally famous, more needs to be known about how to grow, harvest, and regenerate this species. Research foresters at the PSW Station are developing guidelines for redwood management.

study conducted by Research Forester James L. Lindquist will show how growth of redwood sprouts is influenced by different levels of overstory stocking or by the diameter of the parent stump. "Redwood is unique among western commercial conifers in its ability to sprout many vigorous new stems from the stump shortly after harvesting," Lindquist says. "Sprouts are just as important as seedlings, if not more so, in redwood reproduction: trees of sprout origin may comprise as much as 55 percent of a young stand after old-growth is harvested, and stands that develop after the harvesting of young-growth could have an even higher percentage of sprout-originated crop trees." For the study, young-growth stands have been thinned to either 25, 50, or 75 percent of

the original basal area of the plot. Stumps were classified according to their size, and will be checked periodically after thinning to determine the number of sprouts produced per stump, and the mean height and diameter growth of the tallest sprouts.

At other sites, Research Forester Rudolph O. Strothmann is testing the response of previously unthinned stands of commercial-sized young-growth redwood and Douglas-fir to repeated thinnings. Several well-stocked, 40-year-old stands were thinned to 25, 50, and 75 percent of the basal area of the control plots. The stands will be thinned again at age 45, 50, and 60, and will be harvested at age 70. At each thinning interval, the basal area and cubic and board foot volume will be recorded, to see how much these measurements have increased since the previous thinning. The study is needed because few formal thinning trials have been conducted for young-growth redwood, despite the fact that these stands make up the largest acreage of commercial redwood.

In another study, Strothmann will be comparing growth of containerized redwood seedlings with that of bare-root stock. "With the increasing interest in planting coast redwood, there is a definite need for field tests to learn about the relative merits of the two types of planting stock," he explains. The test, which he believes is the first of its kind for coast redwood, will involve measuring the survival and growth, over a 5-year-period, of about 200 seedlings that have been planted on a clearcut site.

In other research, scientists are developing tables for estimating future growth and yield of young, even-aged Douglas-fir stands of various densities. They will later develop tables for forests that have undergone routine thinning or cutting operations.

Fish habitat

Fish habitat research at Arcata is focused on the effects logging, roadbuilding, and other forest management activities have on physical parameters of fish habitat, such as the configuration of stream channels, the movement of suspended sediment, and the location and quality of areas for feeding,

hiding, resting, and spawning. In one investigation, streamflow and the rates at which heavy (bedload) sediment is transported are being compared in a logged and an unlogged drainage. Another investigation will determine the current and projected rates at which North Coastal streams are recovering from the depositing of huge loads of sediment that occurred during the 1964 and 1975 floods.

A separate study will investigate sedimentation of riffles and pools. The fastwater riffles provide the best feeding and cover areas for young fish (fry), while the deeper, current-free pools are the best rest areas for migrating adults. The ideal habitat, which has both riffles and pools, can be degraded by sedimentation.



Scientists are studying the long-range effects that erosion has on the quality of water in small forest streams.

The Laboratory is sponsoring several cooperative studies of forest management effects on fish habitat. Carlton S. Yee (Humboldt State University) is studying movement of gravel in the beds salmon use for spawning. Some movement is beneficial, because it removes fine sediment. The sediment could otherwise clog gravel interstices, slow down oxygen delivery to the eggs in the gravel nests, or form a physical barrier to the recently hatched fish that are trying to emerge from the gravel. But, too much movement can crush the eggs or fry. Yee's study will show when and how much gravel movement occurs, and what variations in streamflow trigger the movements.

A cooperative study with William V. Allen (Humboldt State University), concerns chemoreception-the process by which salmon detect odor signatures of trace amounts of organic compounds. The fish use these signatures during migration to find their way back to their home stream. Allen's intent is to find out if decomposition of needles, bark, and other debris that may fall into streams during logging, interferes with chemoreception. The study involves periodic sampling of streamwater in logged and unlogged drainages to determine variations in the composition and concentration of the compounds that are important in chemoreception.

In all these North Coast studies, researchers are dealing with a unique and highly productive ecosystem. The region's coast redwoods are the world's fastest-growing conifers. Its streams are major sources of water and are valuable habitat for fish. Its problems-fragile soils, unstable slopes, and rivers with some of the highest sedimentation rates of any in North America-are as impressive as its assets. Scientists at the Redwood Sciences Laboratory are helping land managers to meet this region's challenges and to fulfill its potentials.

*-by Marcia Wood,
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A list of recent publications about the North Coast studies is available from the PSW Station. For copies, write to: Publications Section, PSW Station, P.O. Box 245, Berkeley, CA 94701, and ask for the "Forestry Research" list of Redwood Sciences Laboratory publications. Researchers named in this story can be contacted by phone at (707) 822-3691 (FTS: 461-5318) or by writing to them at the Redwood Sciences Laboratory, 1700 Bayview Drive, Arcata, CA 95521.