Watershed Restoration

For more than 30 years, the Redwood Creek watershed has been the testing ground for innovative restoration practices. The goal at the beginning remains true today: to minimize erosion caused by past land management activities and to encourage the recovery of the natural ecosystems to their predistubance conditions.

Bond Creek, a tributary of Redwood Creek, in 1978. The web of "skid" roads provided access to individual trees. Once a tree was cut down, a bulldozer dragged (skidded) the log to the nearest landing on a haul road (visible at the top and bottom of this photo).

Lower Redwood Creek in 1983. This section of the watershed has been preserved since 1968 when Redwood National Park was created. Timber harvesting continues upstream of the park and sediment from eroding slopes travels into protected parklands.

WATERSHEDS

The Redwood Creek Legacy

A watershed consists of all of the land that drains into a river, lake, or other body of water. **Healthy watersheds support a rich diversity of species, including humans, whose lives depend on the complex interactions between water, geology, soils, vegetation, and wildlife.**

Throughout the Redwood Creek watershed, the ancient forests, oak woodlands, and grasslands form a mosaic of habitats that support numerous fish and wildlife species. The forests and grasslands act as a watershed sponge by intercepting rainfall and absorbing soil moisture. Streamside vegetation provides cover, shade, and nutrients for insects, amphibians, fish, and wildlife. However, logging of ancient redwoods and Douglas-fir from Redwood Creek's steep slopes dramatically altered these watershed processes.

Several faults and steep inner gorges govern the network of streams within Redwood Creek. Road construction interrupted their natural course by covering some streams with road fill and logs. Eventually intense rainstorms washed out logging roads and diverted streams, which caused severe gullying and landslides.

While gravel, sand, and silt are a normal part of Redwood Creek, **today the gravel bars are higher and wider due to many tons of sediment and debris being deposited into the creek during past floods.** This sediment buried spawning beds and deep pools that shelter young salmon. Warm, summer waters and high sediment loads in the winter replaced the cool, clear, oxygen-rich environment. Juvenile salmon die in water above 77 degrees Fahrenheit. They have difficulty detecting food or predators in murky waters and silt can suffocate newly laid eggs.

The primordial forest is gone from most of the watershed except for that found in Redwood National and State Parks and on some public lands. Life supported by the watershed has been compromised, including humans who rely on clean and abundant water for drinking, agriculture, and recreation.

Yet, Redwood National and State Parks' challenge of restoring the watershed by removing old roads and reestablishing native vegetation is beginning to show progress. As sediment loads have moved downstream since the 1964 flood, portions of the creek are recovering. **As long as restoration continues, there is hope that the watershed will recover to the support the diversity of life that depends on it — hope for bears, butterflies, birds, and all future generations.**

From Protecting Redwoods to Restoring a Watershed

Redwood Creek flows from its headwaters at 5,000 feet northwest for 67 miles to the ocean at Orick. At one time, timber companies owned most of the land in the watershed. In 1968, a half-mile wide stretch along nine miles of lower Redwood Creek became part of Redwood National Park. The new park's purpose was to preserve ancient streamside redwood groves.

However, logging and road construction continued upstream and on the slopes above the new park. Intense winter rains on the new roads and freshly disturbed, bare slopes resulted in severe erosion. The sediment washed downslope and accumulated in stream channels, filling pools, burying stream habitat, and threatening the streamside redwoods. Consequently, efforts to enlarge the park and protect its resources started soon after the park was created.

Ten years later, 48,000 acres were added to Redwood National Park, of which 38,000 acres had been logged. A Park Protection Zone (see map on page 6) of about 33,000 acres of private land upstream of the park was also established. Congress directed the National Park Service to develop a program to reduce erosion and sedimentation and restore the disturbed land.

Roads are Primary Cause of Erosion

Studies identified roads as the primary cause of erosion. Standards for logging methods and road construction did not exist prior to enactment of the California Forest Practice Act of 1973. The old roads in the new parklands posed numerous problems. Many had inadequate drainage structures, such as culverts sized too small to carry heavy winter flows; roads washed out and triggered severe gully and landslide erosion. The skid roads that bulldozers used to drag logs from hillsides to roads became the new drainage network. These former practices seriously altered the topography and hydrology of the Redwood Creek watershed.

The restoration program began by testing erosion control methods in search of a cost-effective way to restore the land. After considerable experimentation with hand labor techniques, such as planting willows on barren slopes and building "check dams" to slow run-off, park scientists realized that the best way to remove roads was to use the same equipment that had once built them.

Heavy Equipment Reshapes the Land

Today, bulldozers and excavators remove culverts, reexposing the original streambeds, and take out road fill, uncovering the original topsoil. Tree stumps unearthed in the process convey the original contours of the land. In many areas, the natural shape of streams and hillsides is restored. Woody debris is scattered over the finished surfaces to reduce erosion, add organic matter to the soil, and provide cover for small wildlife. Within a few months, native forest species establish themselves on the finished slopes, and within a few years the recovery of the forest is underway.

The creation of Redwood National Park changed the concept that National Park Service lands should be pristine examples of nature. As a result, an effort to protect the world's tallest trees has led to a deeper understanding of ecosystems and watershed processes and to the development of techniques to restore disturbed lands.

Above: Logging road crossing on Emerald Creek just prior to excavation.

Above: Emerald Creek during storm one year after restoration. Below: Emerald Creek six years later.

Fine Tuning the Process

Watershed restoration at Redwood National and State Parks has been a process of finding the best approach over three decades as scientists better understand watershed processes.

The restoration program began in 1978 in search of a cost-effective way to restore the land. Early efforts used backhoes to remove road fill from stream crossings and unstable areas. Then hand labor workers built small wooden dams to slow the water and hold back sediment. Workers planted willows on bare wet areas. Thousands of redwood and Douglas-fir trees were planted in the hopes that a new forest would eventually stabilize the eroding landscape.

Lead geologist Terry Spreiter worked at Redwood from 1980 to 2007, "We thought that simply reestablishing vegetation on the bare slopes would stop erosion. But we needed to address the drainage and slope stability problems on the old logging roads."

After further studies and considerable experimentation with hand labor techniques, park scientists realized that the best way to remove roads was to use the same equipment that had once built them. Careful experimentation with large bulldozers and excavators eventually proved that roads could be completely removed and natural topography and runoff patterns restored. Many of the heavy equipment contractors used during this time had seen the land before it was logged and were instrumental in developing cost-effective restoration methods.

As equipment techniques improved, another significant discovery occurred. The topsoil and stream channel beds that had been buried during road construction could be successfully uncovered. Rather than designing excavations according to engineered specifications, the equipment operators and park geologists worked together as a team to find and uncover the natural shape and features of the land.

Restoring nature's landscape design brings back natural hillslope and stream channel processes. Reexposed topsoil is rich in nutrients, organic matter, and native seed. In a few years, road removal effects begin to fade from view as trees take root in a natural setting. Spreiter's conclusion, "The best roads are those that no one, including Mother Nature, knows were ever there."

Topsoil Makes the Difference

A logging road one year after removal. Topsoil uncovered from beneath the road allows the area to revegetate naturally.

The same area four years later. Native forest species are reestablished in the rich topsoil.

Saving a Watershed, Saving Jobs

The Redwood Expansion Act of 1978 initiated the most expensive acquisition of land in the National Park Service's history. In an unprecedented move, the almost $2 billion transaction included not only the value of the land, but revenues that the timber companies would lose from future harvests.

Geologists and heavy equipment operators work together as a team to ensure that they leave a naturally functioning ecosystem after road removal.

To assist with the restoration of an entire watershed, park staff hired local woods workers, timber contractors, and local American Indian tribe members. In fact, some of the heavy equipment operators who helped build 450 miles of logging and 3,500 miles of skid roads now help to remove roads and restore the watershed. From 1979 to 1987, more than $103 million in benefits covered severance pay, retraining programs, and relocation packets for more than 2,850 timber workers.

In addition, the Redwood Region Economic Development Commission (RREDC) was established to mitigate job loss and to award federal funds, contributing to environmentally-sound development throughout the region. RREDC distributed more than $10 million for public works, technical assistance projects, and loans to qualifying businesses, creating new jobs in Humboldt and Del Norte counties.

Not only has the Redwood Creek watershed been dramatically altered in the last five decades, but the nature of the surrounding communities has changed as well. Some of the larger projects that have enhanced the region and led to new jobs include: the expanded Eureka-Arcata airport; a new marina, a boat repair shop, and fish processing plant for Humboldt Bay; improved streets for the historic city of Ferndale; an industrial park in the City of Arcata; and expansion of Crescent City/Del Norte County harbor.

Unexpected economic opportunities continue to grow from the Redwood Creek program, a watershed restoration model for land managers and foresters locally, nationally, and internationally. **New jobs and careers in erosion control techniques and natural resource conservation have developed to meet the challenges of protecting some of the world's remaining fragile resources.**

The care of rivers is not a question of rivers, but of the human heart. ~ Tanaka Shozo

Partnerships Help Restoration Happen

Gazing at the seemingly unspoiled waters of Redwood Creek as it flows by ancient stands of redwoods can be misleading to those unfamiliar with the creek's story. The water travels for over 60 miles through land owned by timber companies, ranchers, and federal agencies. The waterway connects not only a 280-square mile watershed, but also the many uses occurring on those lands and the people involved in their management.

Prior to 1850, a dense coniferous forest covered Redwood Creek basin. Settlement of the region led to harvesting of old-growth Douglas-fir and coast redwood and by the mid-1960s over half the trees were cut and hundreds of miles of logging roads crisscrossed the landscape. Changes in land use within the watershed were imminent.

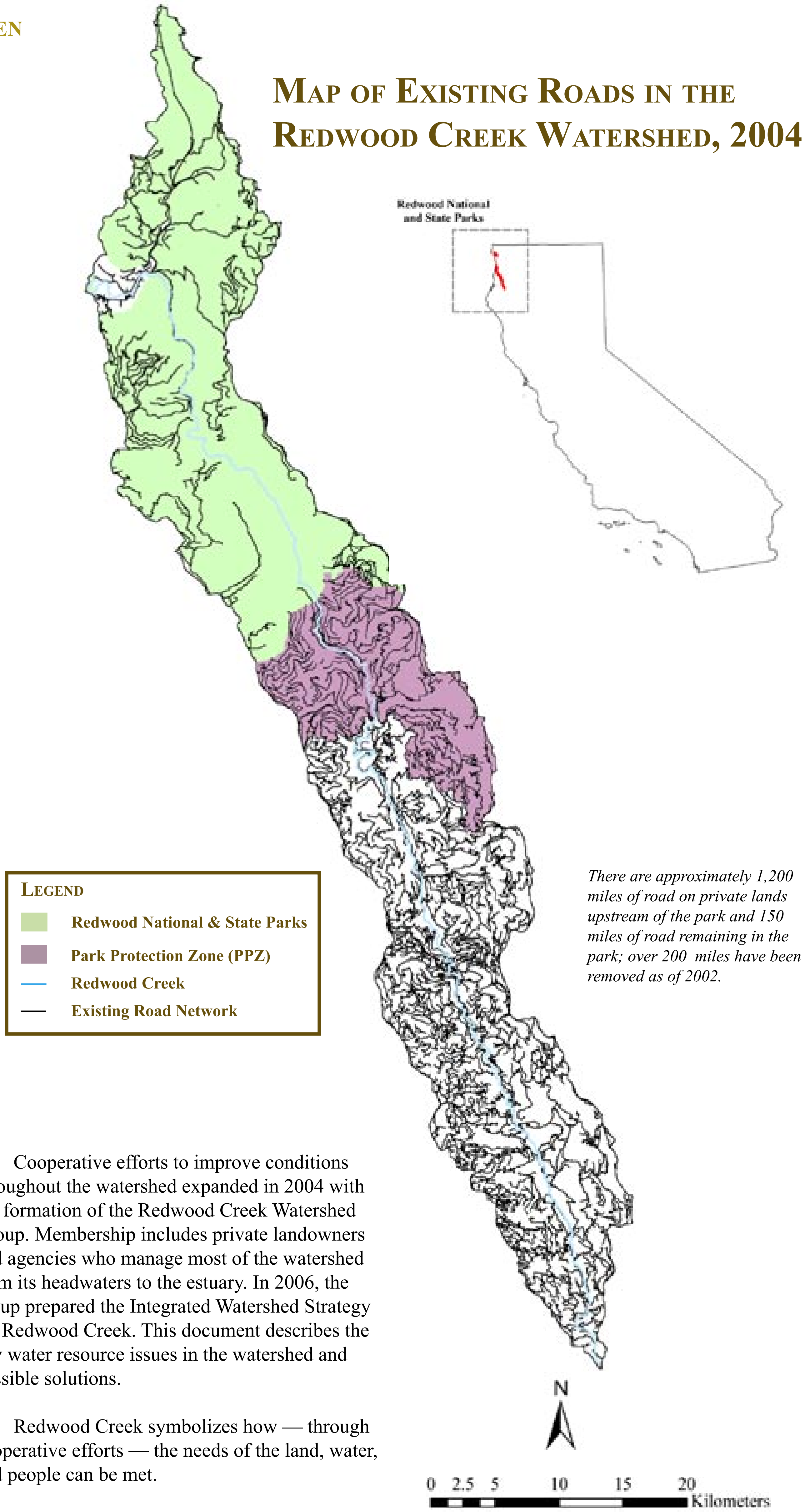
National Park designation in 1968, followed by park expansion 10 years later, protected the lower one-third of the watershed from further timber harvest. The 1978 legislation acknowledged that erosion and sedimentation from logging activities upstream were a significant threat to old-growth redwood groves within the park and to the aquatic ecosystem of Redwood Creek.

The middle third of the watershed was designated as a Park Protection Zone (PPZ). Initial efforts at erosion control with private landowners in areas upstream of the park focused on review of timber harvest plans with the goal of reducing sediment entering Redwood Creek. Park staff and private landowners recognized that a cooperative approach to erosion control was needed to address the potential threat from aging logging roads on private lands.

Discussions in the mid-1990s with landowners led to a cooperative effort to control and prevent erosion from logging roads on private lands. Park geologists and a non-profit organization now work with private landowners to assess the potential for erosion and to plan the upgrade or removal of logging roads. Funding, staffing, and equipment for projects are obtained through the combined efforts of landowners, the National Park Service, state agencies, and non-profit organizations.

A watershed-wide assessment of logging roads upstream of the park was completed in 2004. Analyzed data identifies the areas in greatest need of treatment to prevent erosion. Results form the basis for funding requests that implement erosion control and prevention on lands upstream of the parks. This coordinated approach benefits and protects park resources by reducing sediment from upstream sources and benefits upstream landowners through improved management of their lands.

Map of Existing Roads in the Redwood Creek Watershed, 2004



There are approximately 1,200 miles of road on private lands upstream of the park and 150 miles of road remaining in the park; over 200 miles have been removed as of 2002.

Cooperative efforts to improve conditions throughout the watershed expanded in 2004 with the formation of the Redwood Creek Watershed Group. Membership includes private landowners and agencies who manage most of the watershed from its headwaters to the estuary. In 2006, the group prepared the Integrated Watershed Strategy for Redwood Creek. This document describes the key water resource issues in the watershed and possible solutions.

Redwood Creek symbolizes how — through cooperative efforts — the needs of the land, water, and people can be met.

"It should not be so hard to mesh the needs of the lands and waters and the people . . . in the last analysis, they are the same." ~ Charles Wilkinson

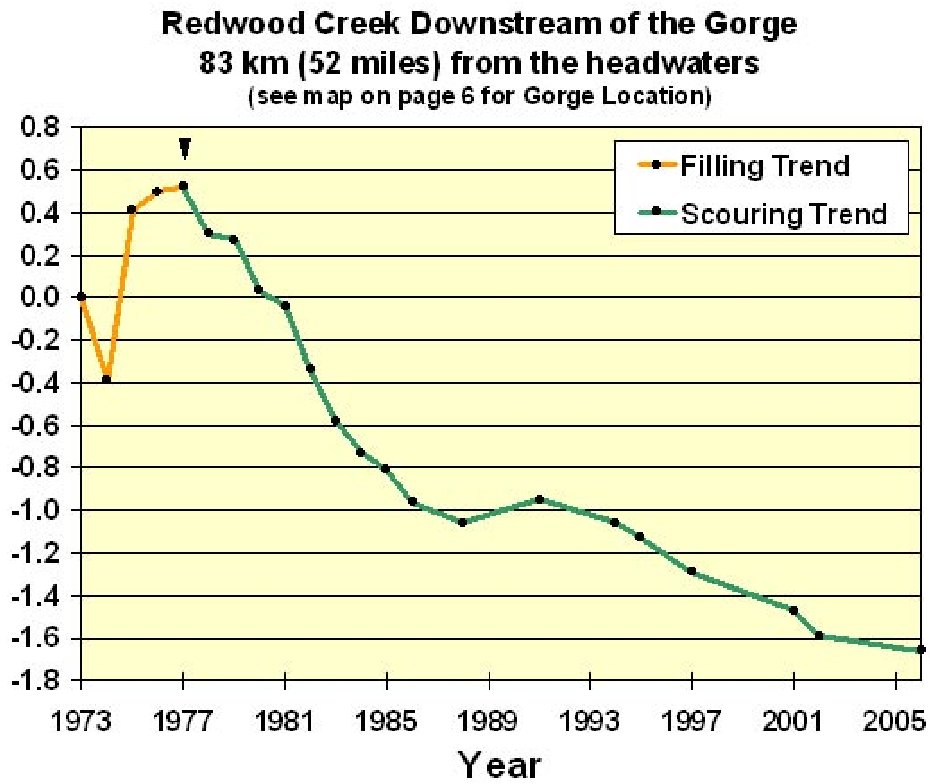
Sediment Wave Study

During the last five decades a series of floods, combined with widespread timber harvesting and road building, caused extensive erosion and deposited large volumes of sediment (silt, sand, and gravel) into Redwood Creek and its tributaries. Long term channel monitoring initiated in 1973 has tracked a "slug" of sediment traveling from the headwaters to the estuary.

History:
Prior to the 1950s, Redwood Creek traveled a narrow and sinuous path with large old-growth conifers along its banks. Floods in 1955, 1964, 1972, and 1975 caused extensive logging road failures, gullying, and landslides throughout the watershed. The flood of 1964 resulted in 20 feet of sediment burying the channel near the creek's headwaters. Initial impacts were most extensive in the upstream half of the watershed where storms and logging activity had been the most intense. Consequently, the channel widened, pools used by salmon and steelhead filled, and the channel bed material became finer.

Sediment Study:
A sediment study was initiated in 1973 to document long-term response and trends in channel width, bed elevation, scour and fill along the channel, pool depth, and pool frequency. Fifty-eight cross sections have been surveyed annually or after moderate floods. Longitudinal streambed profiles showing bed elevations were surveyed in 1977, 1983, 1986, 1995, and 1997.

Trend in Streambed Elevation (meters)



Results:
Results from the study documented that the sediment deposited in the upper portions of the creek during the 1964 flood was flushed downstream by the 1972 and 1975 floods and high winter flows. As the sediment made its way downstream, it spread out over space and time, which resulted in slower movement. In 1977, a streambed profile showed that the channel in lower Redwood Creek was generally flat and featureless and pools were less than two feet deep. It took more than 20 years for the slug of sediment to move from the base of the gorge downstream to Elam Creek (see map on page 6 for locations). By the mid-1990s, the slug of sediment had peaked near Elam Creek and since then lower Redwood Creek channel has begun to recover. By 1995, most of the channel in the upper watershed had recovered to pre-flood elevations and the average pool depths above Tall Trees Grove were nearly six times deeper than in 1977. However, a moderate flood in 1997 set pool recovery back to conditions similar to those in the early 1980s.

Conclusions:
Long term monitoring provides invaluable information on the status and change in park ecosystems. After almost 30 years, sediment impacts from past land use and floods are still impacting the aquatic and riparian resources of Redwood Creek. Many, many life cycles of steelhead and salmon have been affected. The channel remains wider than pre-1964 conditions and riparian areas lack large conifers (which regulate summer water temperatures) and provide large logs in the channel. The U.S. Environmental Protection Agency utilized the parks' sediment data as a basis for listing Redwood Creek as "sediment impaired" — this listing was achieved in 2002.

Above, during the flood of 1964 more than 20 feet of sediment dumped into upper Redwood Creek, killing old-growth streamside trees. Since 1964, Redwood Creek has flushed much of that sediment downstream. The reexposed trees on the right died from being buried by sediment.

Top left, during the winter, a plume of sediment emanates from the mouth of Redwood Creek, altering life cycles of salmon, steelhead trout, marine mammals, and seabirds that depend on the river estuary for food, growth, and migration.

Ancient Drama, Restored Future

I stopped hiking to peer into the creek. A movement caught my eye in the narrow tributary. A large salmon swayed in a pool at a bend in the creek. How had it gotten there — blocked by shallow water and gravel bars? Surely, this salmon's travels were over and successful spawning would not occur.

Steelhead trout and salmon are anadromous fish. They hatch in freshwater streams, then migrate as juveniles to the ocean to grow into adults. At sexual maturity, in two to six years, instinct triggers the need to spawn and fish return to the freshwater stream of their birth. The journey upstream is arduous, requiring incredible strength and stamina to overcome barriers and waterfalls.

In a burst of renewed energy and determination, the salmon surged upstream through the shallow water and over the gravel bar. Significantly more of the fish was out of the water than in. It continued to propel itself toward the next small pool where it rested before making its next push forward.

Most salmonids die after spawning, leaving organic material that is critical for the survival of other plants and animals in the watershed. Loss of salmon carcasses would drastically change the entire redwood forest ecosystem.

Steelhead trout and salmon are in decline for many reasons. Over fishing in the ocean has taken an enormous toll. Timber harvesting, road construction, dams, and large floods have negatively impacted salmonids by changing water quality and transforming winter and summer stream habitat. Alterations to a stream can have disastrous results because salmon have specific requirements for the survival of juveniles (cool water) and for reproduction (quality spawning gravels). Their ability to adapt to change is limited.

In life, salmon represent strength and stamina. I had renewed hope for the success of this salmon. Can similar conviction be found for the Chinook and coho salmon and steelhead trout of northern California?

Watershed restoration is one of many actions that humans can take to help with the survival of these species. Restoring watersheds gives them hope.

Salmon Status in Redwood:

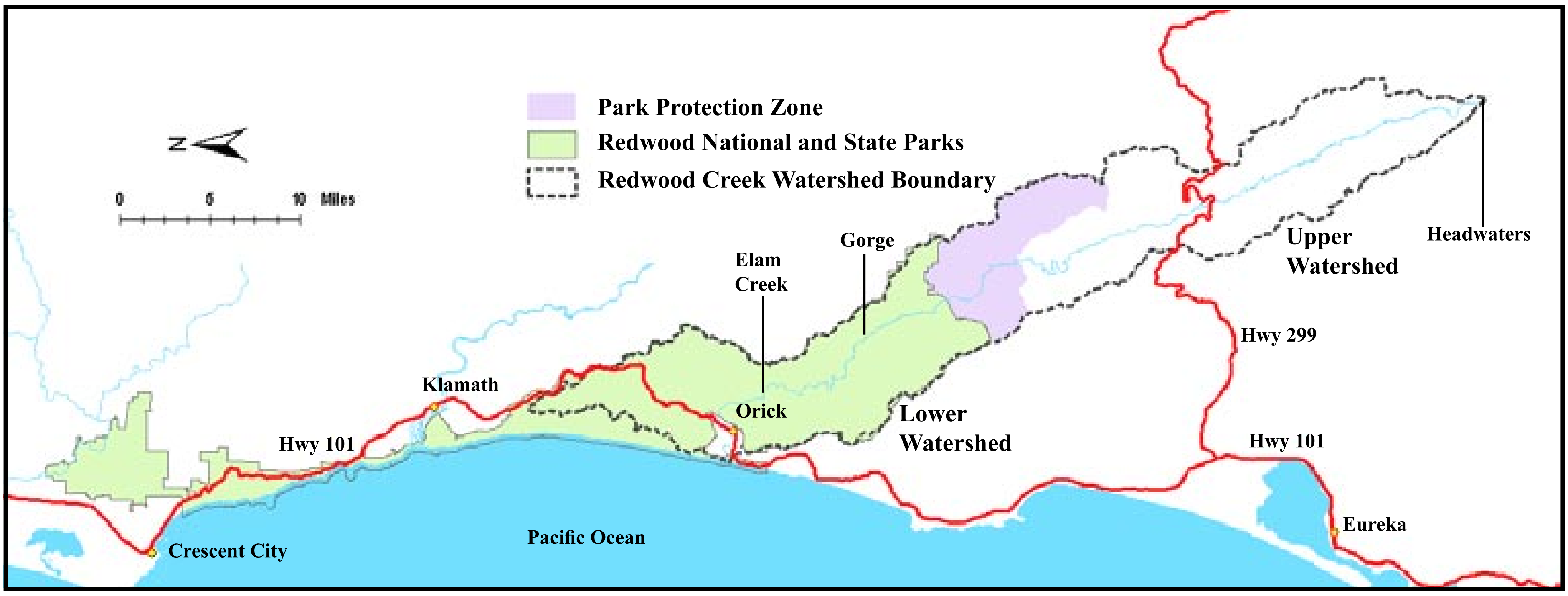
Chinook and coho salmon and steelhead trout are federally listed as threatened. Threatened status means the species are likely to become at risk of extinction in the foreseeable future.

"So powerful are the ties between humans and salmon that even in rivers and streams where salmon are still running—but in numbers severely diminished—the ghosts of salmon are rising. Salmon resides in the hearts of humans: for many, even the imminence of its absence creates an active ghost."

Totem Salmon by Freeman House

Sediment delivered to Redwood Creek during floods in the last five decades has significantly altered fish habitat and water quality. While the stream habitat is recovering from these past events, water quality is still impaired from high stream temperatures and heavy sediment loads. Salmon such as this adult coho require clean, pea to fist-sized gravels for spawning.

Redwood National and State Parks and Redwood Creek Watershed

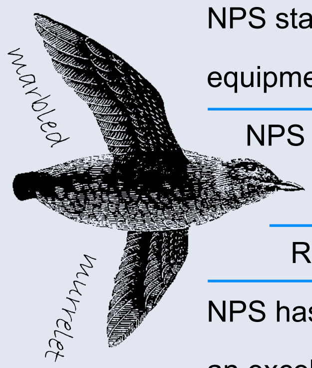


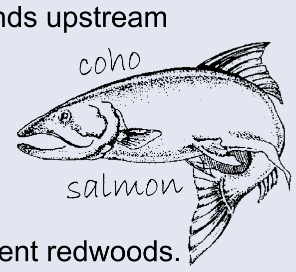
Logging of the Redwood Creek watershed began in the mid-1940s and continues on private land in the upper watershed. The flood of 1964 washed tons of sediment from the bare slopes into the channel. During the floods of 1972 and 1975, the sediment was flushed down the channel, and by 1980, had reached the gorge above the Tall Trees Grove. It has taken more than 20 years for the wave of sediment to move from the gorge to Elam Creek, where it resides today.

 To cherish what remains of the Earth and to foster its renewal is our only legitimate hope of survival. ~ Wendell Berry

WATERSHED RESTORATION CHRONOLOGY

1955/64	Floods and storms cause massive erosion from slopes into Redwood Creek.
1966	55 percent of the old-growth timber in Redwood Creek watershed is gone due to timber harvesting.
1968	Congress establishes Redwood National Park to preserve the streamside redwood forest, including 22,500 acres in lower Redwood Creek and the Tall Trees Grove.
1968-1978	Timber harvest rate on private lands upstream of original park boundaries accelerates.
1972	Another flood. USGS initiates erosion and sedimentation studies; data contribute significantly to efforts to expand the park.
1973	California State Legislature establishes timber harvest rules for privately owned land: California Forest Practices Act. Statewide standards for timber harvesting and logging road construction did not exist prior to this time.
1975	Two floods in quick succession flush more sediment downstream. By 1980, a wave of sediment reaches the gorge (see map on page 6) above the Tall Trees area, a natural bottleneck.
1978	Congress expands Redwood National Park by 48,000 acres, including 38,000 acres of logged lands in Redwood Creek watershed and establishes a Park Protection Zone (PPZ) of about 33,000 acres of private land upstream of park. Congress mandates a restoration program and erosion and sedimentation studies for both the park and private lands.
1978	National Park Service (NPS) and California Department of Forestry (CDF) sign an agreement allowing NPS to review and comment on Timber Harvest Plans in the Park Protection Zone.
1978-1979	Experimental erosion control and watershed restoration work begins by trying labor intensive methods: (1) planting willows to stabilize barren slopes, (2) building wooden water ladders to slow runoff, (3) using small equipment such as backhoes to remove road fill (soil) from streams, (4) installing check dams and rock armor to prevent post-excavation erosion.
1980	NPS staff recognize that heavy equipment, primarily bulldozers and excavators, is needed to treat roads effectively. Early heavy equipment treatment can be viewed along the Dolason Trail (see map page 8).
1981	NPS develops Watershed Rehabilitation Plan that identifies more than 300 miles of log hauling roads and 3,500 miles of skid roads in the park pose the greatest erosion threat to resources.
1987	Restoration partners remove Little Bald Hills Road and convert it to a trail (see map on page 8).
1995	NPS has treated approximately 150 miles of roads in the park. Restoration partners remove Ah Pah Road and create Ah Pah Trail, an excellent example of complete restoration techniques in an old-growth setting (see map on page 8).
1995	NPS and largest industrial landowners in Redwood Creek sign Memorandum of Understanding to “cooperate to identify, prioritize, and correct, where economically feasible, potential sediment sources in the Redwood Creek basin.”
1997	First major storm in more than 20 years causes substantial erosion to more than 120 sites on remaining park roads.
1999	Park staff and a non-profit corporation implement a watershed-wide assessment of the road network on lands upstream of the park. Funds come from California Department of Fish and Game, NPS, and private landowners.
1999	Restoration partners restore Mill B and the associated log deck into a vibrant wetland; now called Elk Meadow Day Use Area (see map on page 8).
2000	NPS begins treatment of road system in Lost Man Creek to protect its high quality salmon habitat and ancient redwoods.
2003	More than half the logging roads on parklands in Redwood Creek have been treated, reducing erosion and restoring the natural hydrologic process. Work continues on remaining park roads not needed for visitor or administrative use.
2004	Watershed-wide assessment of roads completed on lands upstream of the park and data analyzed to identify high priority treatment areas.
2004	Redwood Creek Watershed Group formed to address water quality and aquatic habitat issues throughout the watershed.
2006	Redwood Creek Watershed Group completes the *Integrated Watershed Strategy for Redwood Creek*.
Future	(1) Continue restoration of parklands and erosion control on private lands, (2) continue Timber Harvest Plans reviews, (3) continue to □ agencies, implement projects described in the *Integrated Watershed Strategy for Redwood Creek*.





Restoration Glossary

ANADROMOUS - referring to fish that spend part of their lives in the ocean but migrate into freshwater to spawn

CABLE YARDING - logs are attached by cable to a spar pole or "yarder" located on the landing, then hauled uphill (generally used on slopes greater than 50 percent)

HAUL ROAD - a road used by logging trucks to transport logs; often 35 to 50 feet in width, so that trucks can travel and pass efficiently

HUMBOLDT CROSSINGS - during road construction, logs (rather than culverts) were placed in a stream channel and covered with dirt

LANDING - logs are yarded to this location where they are loaded onto a truck and transported to a mill

LAYOUT - mounds of soil pushed up to cushion the fall of a tree

RIPARIAN - area of vegetation along a stream or wetland

SEDIMENT - sand, silt, and gravel

SKID ROADS - secondary dirt roads used by tractors and bulldozers to drag logs to landings where they are loaded onto trucks; typically 15 to 20 feet wide

SPECIAL TREATMENT AREAS - locations within 200 feet of national, state, regional, county, or municipal park boundaries, or key habitat areas of federal or state designated threatened, rare, or endangered species

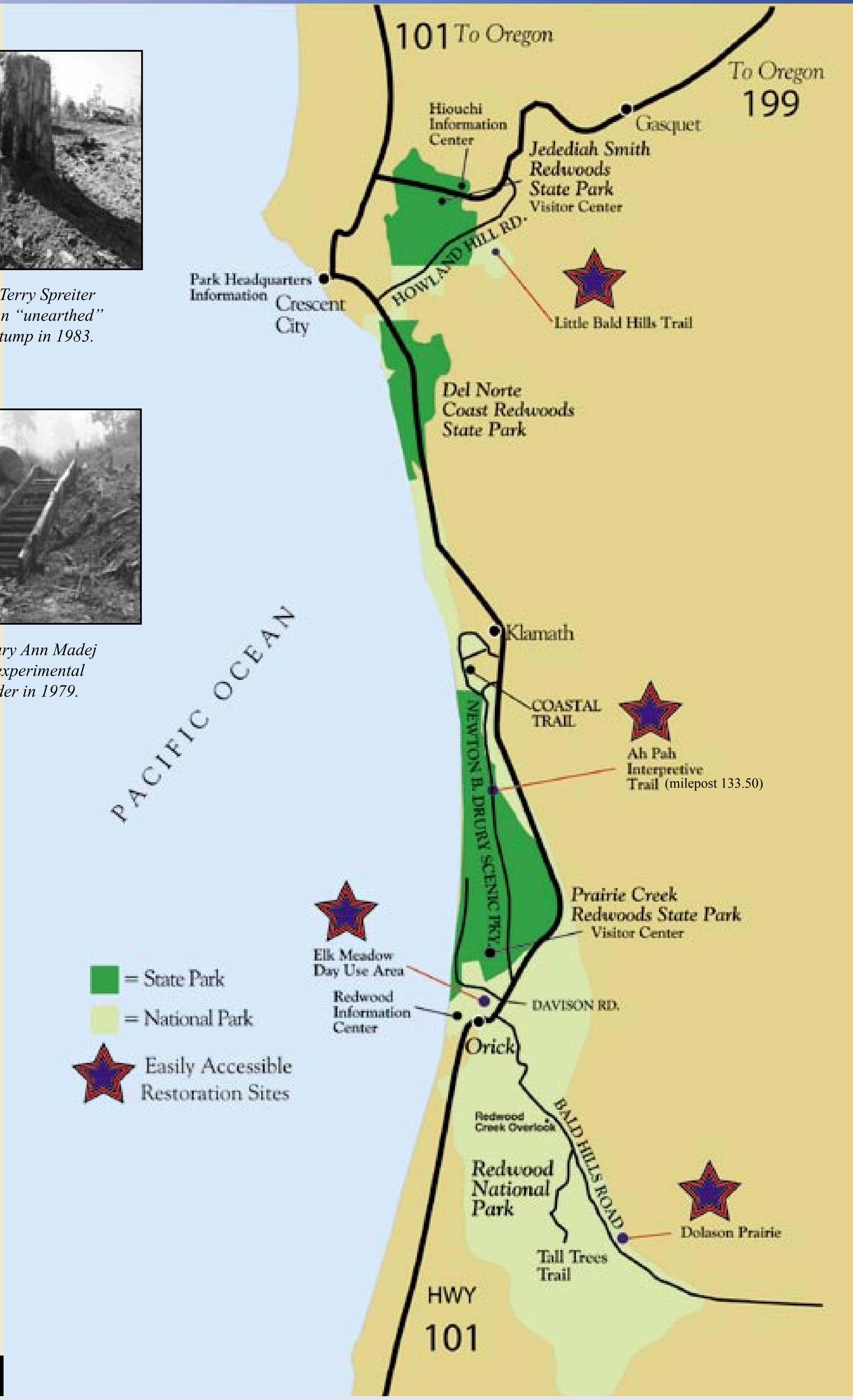
TIMBER HARVEST PLANS - a plan that specifies how a site, typically on private land, will be logged, including road construction and harvesting methods. The plan, governed by the California Forest Practice Rules, is reviewed by various agencies and the public.

TRACTOR YARDING - logs are dragged by a tractor or bulldozer to a landing, leaving a dense network of skid roads on the slopes (generally used on slopes less than 50 percent)

Geologist Terry Spreiter in front of an "unearthed" redwood stump in 1983.

Geologist Mary Ann Madej beside an experimental water ladder in 1979.

Easy to Visit Restoration Sites



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***Totem Salmon* quote used with permission by Freeman House.**

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For more information, contact the parks at (707) 464-6101. Visit our website at www.nps.gov/redw.