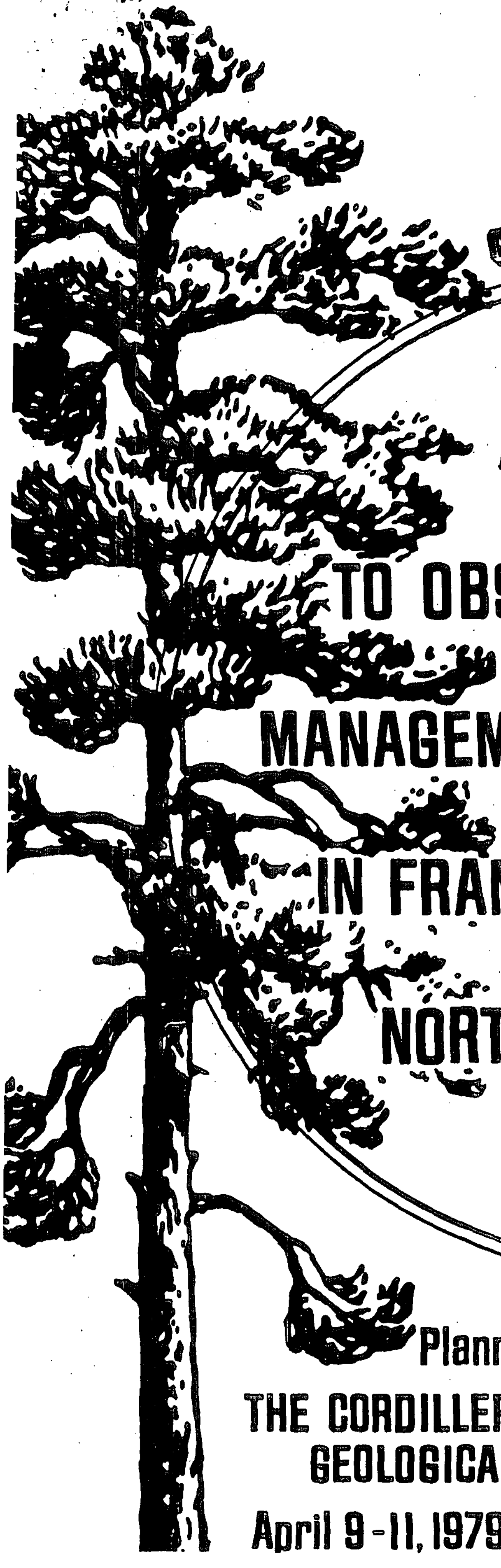
1979, Kelsey Road Log Day 2



GUIDEBOOK FOR

A FIELD TRIP TO OBSERVE NATURAL AND MANAGEMENT-RELATED EROSION IN FRANCISCAN TERRANE OF NORTHERN CALIFORNIA

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THE CORDILLERAN SECTION OF THE
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ROAD LOG - Day No. 2

GEOLOGY, GEOMORPHIC PROCESSES, LAND USE, AND WATERSHED REHABILITATION IN REDWOOD NATIONAL PARK, AND VICINITY LOWER REDWOOD CREEK BASIN

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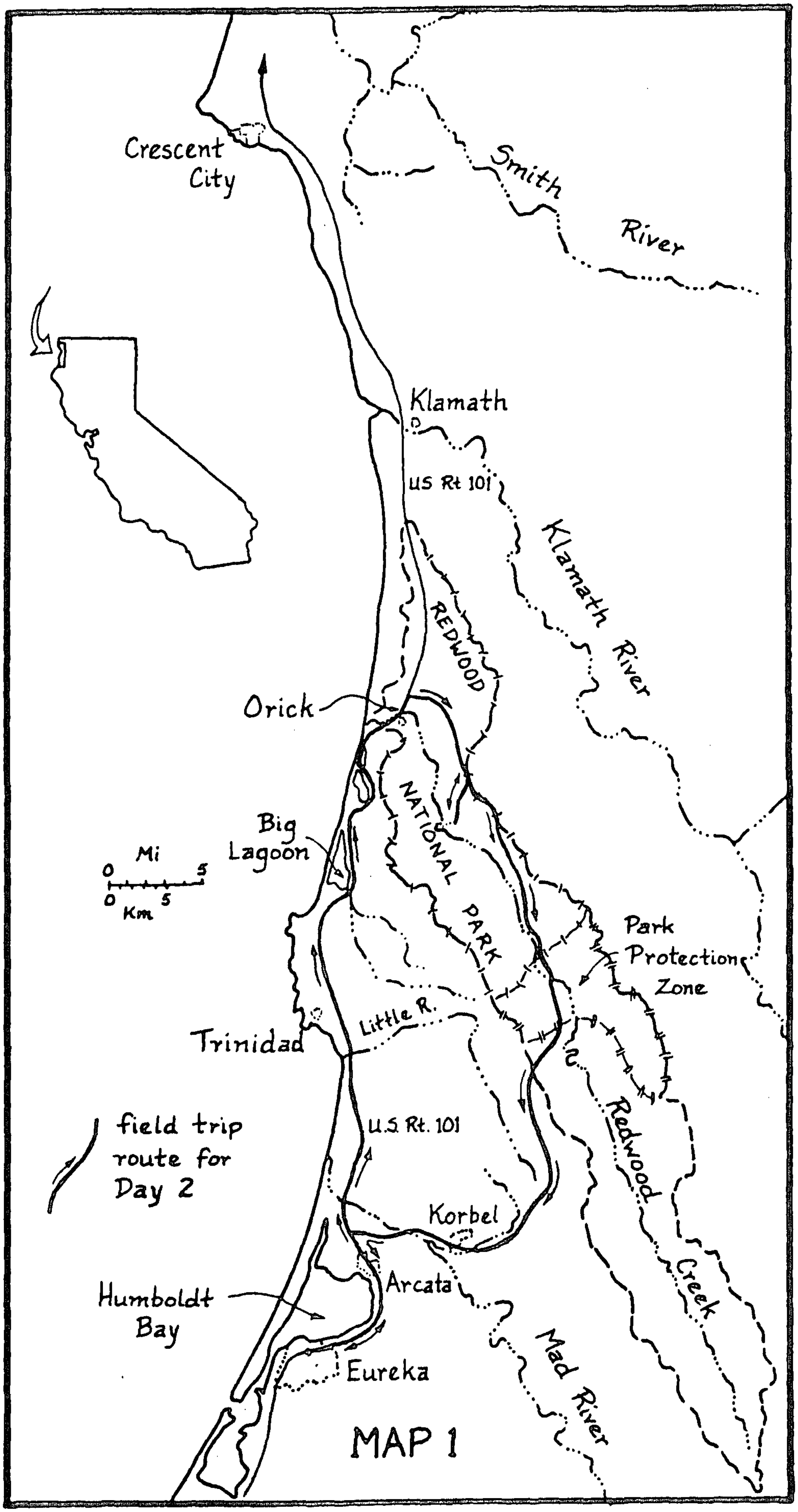
INTRODUCTION

The field trip will broadly cover the geology, geomorphology, and land use of the lower Redwood Creek basin; most of the field trip stops will be in the recently acquired (March, 1978) portion of the Redwood National Park. The field trip will be a loop route north to Redwood Creek via Highway 101 which follows the coast and the return trip will be on an inland route which passes through the private lands of the Simpson Timber Company (field trip route shown on Map 1).

START - Eureka to Orick via U.S. Highway 101

The trip will proceed north by bus from Eureka along U.S. 101 to Orick. The road first follows along the east margin of Humboldt Bay, through the town of Arcata, and then onto the floodplain of the Mad River. U.S. 101 crosses the Mad River and then climbs onto a marine terrace where the town of Mc-Kinleyville sits. After 2 miles, U.S. 101 again drops to sea level affording an excellent view to the north of Clam Beach and the shoreline northward. Along Clam Beach the highway follows the alignment of an old railroad grade which connected numerous lumber mills in the Arcata-Eureka areas with the coastal redwood forests to the north. After U.S. 101 crosses the Little River, the road again climbs onto marine terraces in the vicinity of Trinidad. The marine terraces near Trinidad are the best preserved multiple sequence of terraces between Fort Bragg to the south, and the Oregon border to the north.

Several miles north of Trinidad, U.S. 101 drops down to Big Lagoon, the largest of three coastal lagoons along the trip route. The next lagoon to the north is Stone Lagoon. The water levels in Big and Stone Lagoons can fluctuate tens of feet as the coastal drainages fill the lagoons until they overtop their sand spits, and then they rapidly empty into the ocean. Ocean waves then build up the breached sand spit and the process is repeated. For example, in November, 1977, Big Lagoon breached its sand spit at the north end, and in



Crescent City
Smith River
Klamath
US Rt 101
Klamath River
REDWOOD
Orick
NATIONAL PARK
Big Lagoon
Mi
0
5
0
5
Km
Park Protection Zone
Little R.
Trinidad
field trip route for Day 2
U.S. Rt. 101
Redwood Creek
Korbel
Arcata
Humboldt Bay
Eureka
Mad River
MAP 1

less than six hours the lagoon dropped 17 feet as it emptied into the ocean. It took roughly four weeks for coastal processes to reseal the opening. In a winter or normal rainfall, the lagunal sand spits breach and rebuild two or three times. The last and smallest lagoon, Freshwater Lagoon, no longer breaches because it is connected to the ocean by a culvert under U.S. 101.

Just north of Freshwater Lagoon sits the town of Orick in the floodplain of Redwood Creek. In both December, 1955 and December, 1964, Orick was severely damaged by major floods; now the town is protected by a levee built after the 1964 flood by the U.S. Army Corps of Engineers. The levee is clearly visible from the highway bridge which crosses Redwood Creek. This bridge also is the site of a U.S.G.S. stream-sampling station.

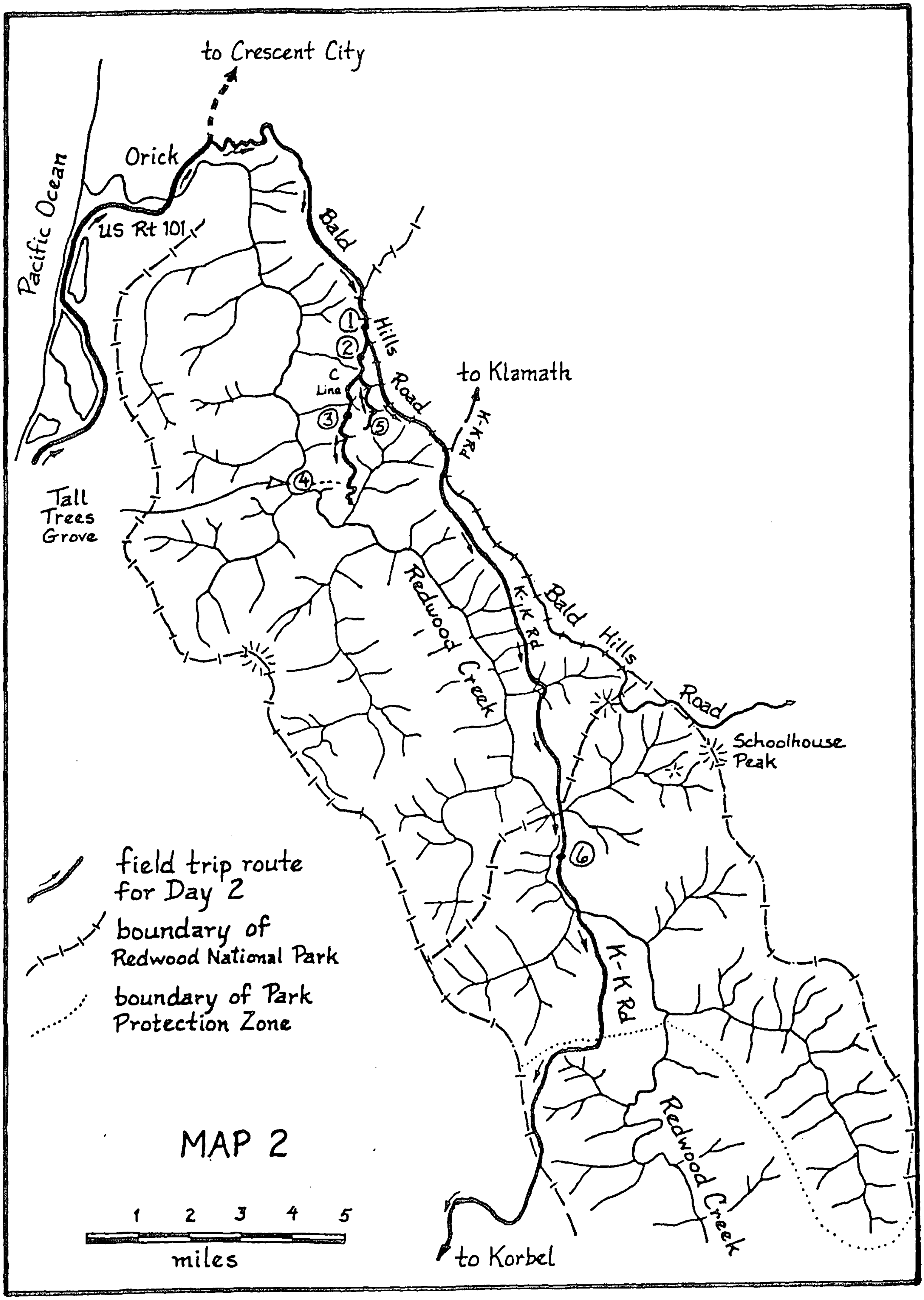
From Orick, the trip proceeds a mile further north on U.S. 101 to the Bald Hills Road (Map 2), which leads into Redwood National Park, and the Redwood Creek basin. At the junction of U.S. 101 and the Bald Hills Road stands a lumber mill of the Arcata Redwood Company, which once owned a large amount of land now in the National Park. The presence of this lumber mill directly adjacent to the present National Park boundary illustrates the close physical tie between timber harvesting and Redwood National Park. Between the logging mill and Stop 1, the route goes entirely through National Park lands.

STOP 1 - Redwood National Park Overlook

The large flat area on this stop is a log landing where logs were loaded onto trucks to be hauled to the mills. This log landing is at the top of a clear-cut slope from which the logs were hauled by cables suspended from a large truck-mounted spar that stood on the landing.

All the land in the Redwood Creek watershed visible from this overlook is now part of the Park. The virgin, unlogged redwood/Douglas-fir forest that dominates the view from the overlook represents a large portion of the lands included in the original Redwood National Park, established in 1968. A short reach of Redwood Creek is also visible in the valley bottom. To the left and directly below the landing are logged areas that were cut after initial Park acquisition, but prior to 1978.

From this vantage point, the results of two silvicultural practices can be seen. On the lower slopes across the valley isolated old-growth redwoods still stand on an area which was cut in the late 1950's. Up until the 1960's many timber companies practiced this "seed tree method" in which scattered trees were left to naturally reseed the adjacent, harvested land. In roughly 10 to 15 years these trees would be cut and removed leaving an area fully stocked with a young regrowth of conifer trees. The upper slopes, across the valley, as well as the 1975 cut block directly below the overlook, were harvested by the clearcut method in which all the trees are removed at one time. With the advent of aerial seeding and the increased efficiency of



to Crescent City
Orick
Pacific Ocean
US Rt 101
Bald Hills Road
C Line
to Klamath
K-K Rd
Tall Trees Grove
Redwood Creek
Bald Hills Road
Schoolhouse Peak
K-K Rd
field trip route for Day 2
boundary of Redwood National Park
boundary of Park Protection Zone
MAP 2
1 2 3 4 5
miles
to Korbel
Redwood Creek

hand planting with containerized seedlings, the clearcutting technique has been almost exclusively used since the late 1960's. The boundary of the old 1968 Park can be roughly discerned by the clearcut timber harvesting boundaries just upslope from the Redwood Creek channel.

From Stop 1, the route will continue south on the Bald Hills Road to the junction with the C-line, a former major logging road of the Arcata Redwood Company that is now a main access road to the logged portion of the National Park on the east side of the Redwood Creek basin. The route will follow the C-line down into the basin (Map 2).

STOP 2 - Exposure of Franciscan Sandstone and View Showing Effects of Different Logging Techniques on the Landscape

Stop 2 affords both a close-up look at the bedrock in the area and (on the opposite side of the road) an excellent overview of the effects on the landscape of timber harvesting practices. The large outcrop consists of Franciscan (Jurassic through earliest Tertiary) massive sandstones with interbeds of sandy siltstone and siltstone. The exposure is typical of the more coarse-grained, unmetamorphosed Franciscan marine sediments that underlie the eastern half of the Redwood Creek basin. The sediments are intensely faulted and folded and there is no stratigraphic continuity to the beds.

The discontinuity of the entire outcrop is evident at its western edge, where the sandstone block abruptly ends--one gets the impression of a large block of relatively coarse-grained sandstone enclosed in a finer-grained matrix. The structure and lithology of the Franciscan sediments on the east side of Redwood Creek suggest that the unit has been pervasively sheared and faulted so that the larger competent massive sandstone blocks (and locally blocks of greenstone and chert) now exist in isolated knobs and prominent ridges on hillslopes that are mostly underlain by finer-grained sediments. These massive sandstones that form the prominent topographic features are probably severed, sheared remnants of once laterally contiguous massive sandstone beds. The prairies on the ridge tops (between Stops 5 and 6) are locations where the Franciscan sediments are fine grained and pervasively sheared and prone to rapid soil creep or earthflow which, in combination with climatic influences, discourage growth of trees.

The sandstone outcrop has recently been used as a borrow pit to provide rock to surface the logging roads. Extensive excavation is apparent near the top of the outcrop.

On the logged hillslopes across the road from the outcrop, the effects of two different timber harvesting techniques are apparent (Photo 1). The steeper, upper slope was cable logged, and then burned in 1977. Barely discernable shallow skid trails caused by the dragging of log butts during cable yarding form a fan-shaped pattern that converges upslope at the site of the log landing.

These shallow skid trails do not concentrate runoff downslope and generally do not become erosional problems. In contrast, the adjacent logged unit on the lower, more gently sloping ground was logged by Caterpillar tractors in 1974. Tractor logging involves a high density of tractor skid roads necessary to drag the logs downhill to a landing. These skid roads frequently make deep cuts into the hillslope and can intercept and concentrate runoff. The tractor roads converge downslope and frequently become gully systems that cause severe erosion. The vast majority of the cutover lands in the Park were tractor logged, and it is these tractor-logged slopes, as well as the main roads, that presently pose the major erosional problems.

The remaining unlogged timber stands in the vicinity occur mainly on the steepest and most inaccessible slopes and would have been the most difficult to log. Throughout the Park, the remaining timber occurs in similar sites, and at the time of Park expansion, logging was proceeding on the most erosionally sensitive terrain.

PHOTO 1. (December 1978): View to north looking across the Cloquet Creek drainage at the patterns of ground disturbance created by two different logging methods. The steeper slope on the right (east) was logged by cable yarding, and the more gently sloping terrain on the left (west) was logged by Caterpillar tractors that build numerous skid roads (see text).

The wide portion of the road at this stop is one of the many log landings along the trip route. These landings are composed of loose soil, rock, logs, and small organic debris, all of which is compacted by heavy equipment. The outer edge of these landings is frequently oversteepened, and the rotting organic debris in conjunction with seasonal, heavy rains cause many of these landings to eventually fail.

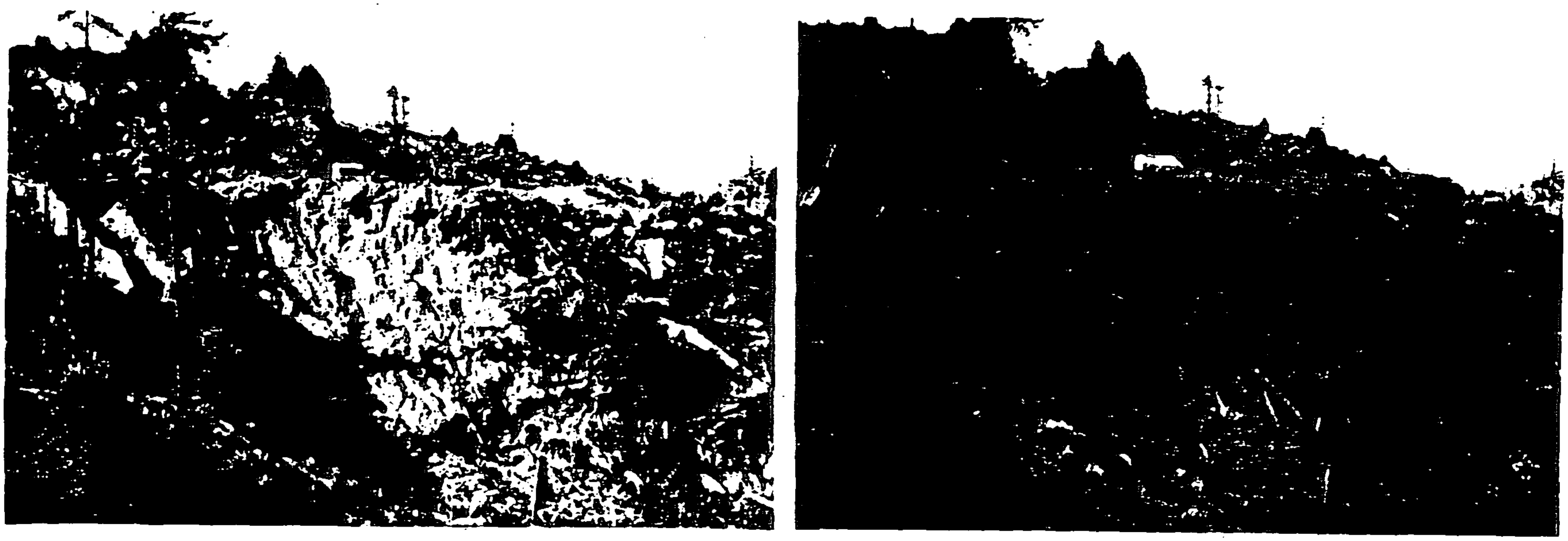
Below and to the left of the landing is a second-order stream that runs through the clearcut unit. The channel is clogged with logging slash in amounts far greater than the normal organic debris load for a second-order stream. Excessive amounts of logging slash in these streams trap sediment in temporary debris basins and alter stream habitat for micro fauna, and frequently increase erosion by deflecting flow against previously stable stream banks.

From Stop 2, the route continues south down the C-line towards Redwood Creek (Map 2). The C-line is a major road with large cutbanks and fill slopes. Bare cutbank and fill slopes are ubiquitous on the roads throughout the logged portion of the Park. Rilling is prevalent on the cutbanks and fills, and becomes a persistent erosional problem because these slopes do not readily revegetate. Establishing an adequate vegetative ground cover on slopes laid bare by road construction will be one of the projects of the rehabilitation. Also visible along the road are young Monterey pines (Pinus radiata) planted by the timber companies to provide a fast-growing scenic shield from the logged hillslopes. The pines are an exotic species, and to restore the forest to its native composition, the pines will be eventually removed from Park lands.

STOP 3 - Rehabilitation Work on a Slope Failure at a Log Landing, and Exposure of the Grogan Fault

At this stop, the road cutbanks expose the Grogan Fault and at the log landing, just across the road, one of the initial erosion control projects is clearly visible.

The outer edge of the log landing at Stop 3 catastrophically failed about 5 years ago, sending tons of sediment and organic debris into the stream channel below. As of spring 1978, the remainder of the landing was precariously perched above the stream (Photo 2). In September, 1978, a track-mounted, drag-line crane pulled back the perched debris on the landing and recontoured the slope to a more stable configuration (Photo 3). A Caterpillar tractor redistributed the removed fill onto adjacent stable skid trails. After the heavy equipment work, manual labor crews under contract to the Park Service performed erosion control work which included the installation of willow wattles and planter boxes, as well as planting shoots of sprouting plant species (for a description of willow wattles and planter boxes, see accompanying article). The willow wattles are buried in contour trenches, and the small contour terraces formed by the wattling both provide a physical barrier to rilling and/or ravelling, and encourage rapid revegetation of



PHOTOS 2 and 3. (September and December, 1978): Log landing in the Miller Creek drainage on the C-line before and after rehabilitation by heavy equipment and manual labor crews. The outer part of the landing failed about 5 years ago and left a perched scarp of soil and organic debris above the stream. Heavy equipment removed the perched material, recontoured the slope, and manual labor crews then planted and wattled the slope (see text).

the slope when the sprouting plant species in the wattles start to grow. The planter boxes at the base of the recontoured slope provide a protected, stable substrate for plants on an otherwise steep and difficult-to-revegetate area.

Across the road from the landing is an exposure of the Grogan Fault, the major fault in the Redwood Creek basin which trends NNW, and runs along the creek for much of its length. The fault separates unmetamorphosed Franciscan sandstone and siltstone on the east side of the basin from Franciscan schist on the west side of the basin. Where the fault intersects the Pacific coastline, approximately 9.5 miles NNW of Stop 3, the fault offsets Plio-Pleistocene marine sediments indicating post-Pliocene displacement; however, latest movement of the fault at this locality is not known. The small borrow pit to the east of the fault shows massive fractured sandstone in the cutbank. Directly across from the wattles, the cut slopes expose the fault gouge in what appears to be rocks transitional in metamorphic grade between the sandstone and the schist. Schist exposures occur approximately 100 yards further down the road to the west.

The Franciscan schists are well-foliated, highly-deformed quartz-mica or quartz-mica-feldspar schists with lesser amounts of graphitic schists and infrequent exposures of metavolcanic and metachert rocks (Janda, 1975). Because of the highly deformed and well-foliated nature of these rocks, and the seasonally large amounts of rainfall (50 to 100"), soil creep is a ubiquitous process uniformly affecting most all schist slopes and therefore has played a major role in slope morphology on the schist slopes in the west side of the Redwood Creek basin.

Starting 3.2 miles to the SSW of this exposure, Redwood Creek roughly flows along the trace of the Grogan Fault for the rest of its length upstream, and the sheared incompetent nature of the rocks in proximity to the fault make the stream banks of Redwood Creek especially susceptible to mass slope failure. Many streamside debris slides along the Grogan Fault zone in the upper half of the basin have been caused by heavy rainfall in conjunction with lateral corrasion by the Creek during flood discharges. Much of the recent aggradation in the Creek, which will be discussed at the next stop, is attributed to sediment delivered to the channel by such landslides.

The deep red soils derived from schist parent rock are visible in the road cuts as we drive from Stop 3 to Stop 4. These red schist-derived soils are common on the more stable slopes in the Redwood Creek basin to the west of the Grogan Fault.

STOP 4 - Hike to Tall Trees Grove and Discussion of Channel Processes and Recent Channel Changes; and a View of the Headscarp of the Elbow Creek Landlside

The hike down to the Tall Trees Grove is along a bulldozer-constructed trail built by Arcata Redwood Company in the early 1960's to allow tourists access to the trees. Once logging in the basin became politically controversial in the late sixties, visitor access to the trees was discontinued.

Roughly half way to the Tall Trees Grove the trail crosses the east fork of Elbow Creek and the head of the Elbow Creek landslide. Several small failure scarps are visible in the trail surface and numerous trees in the areas are bowed or leaning. A short detour downslope reveals the headscarp of a large streamside landslide which extends some 900 feet up from Redwood Creek.

There is poor channel development in Elbow Creek with surface and subsurface flow occurring alternately because slope mobility defeats the development of a stable channel. Larger trees near the channel are leaning and many stems have fallen. Major breaks in the topography and stepped soil surfaces indicate the presence of several ancient slumps along this drainage. Slope failure generally increases in magnitude downslope towards Redwood Creek.

The position of the toe of the Elbow Creek slide at the outside of the first meander above the Tall Trees Grove distinguishes it as perhaps the most threatening mass movement feature of the Tall Trees. Below is a summary of the history of this slide as derived from sequential aerial photography.

PHOTO DATE	PHOTO DATA
1936	Identified in first aerial photos of the basin as two smaller slides, Numbers 9 and 10. (Colman, 1973)
1958	Slide 9 greatly increased in activity.
1962	Slide 10 showing activity.
1966	Increase in area of both slides.
1970	Two discrete masses merge as a single unit.
1972-75	Crown area shows greatly increased activity.

The slide mass currently extends approximately 1000 feet upslope and 500 feet along its base at Redwood Creek. The greatest activity in the slide occurs near the rapidly retreating crown scarp for a downslope distance of roughly 300 to 400 feet.

Several hundred feet further downslope this distinct slide merges with another that heads in the next drainage to the west. From where the two slides join, downslope to 100 feet above the intersection with Redwood Creek, active movement appears less pronounced than near the crown region and the toe. It is likely that erosion at the base of the hillslope by Redwood Creek may have initiated the formation of the slide mass in the past, but the most recent activity currently is occurring in the upslope areas.

The trail descends approximately a half a mile from the headscarps of the Elbow Creek landslide to the river bottom and the tall trees. The Tall Trees Grove consists of a majestic stand of coast redwoods (Sequoia sempervirens), including the world's tallest tree, which is situated on an alluvial flat of about 15 acres adjacent to Redwood Creek. Since the passage of the 1968 Congressional Act establishing Redwood National Park, protecting the large redwoods in the Tall Trees Grove has been the focus of attention of many people and of many disciplines. Three of the world's six tallest trees are growing here, and they may be threatened by land use practices and stream channel changes which have occurred in the last 40 years (see accompanying article on History of Redwood National Park).

The redwoods in the Tall Trees Grove average 600 years in age, and the tallest tree is also near 600 years old. The Grove is the lowest of at least three distinct alluvial terrace levels at this locality. The Tall Trees Grove is periodically inundated by large floods, and on occasion is significantly altered by stream erosion. The outer edge of the meander loop that encloses the Grove was severely eroded more than 150 years ago, as evidenced by the ages of younger trees in this locality.

Redwood Creek currently flows in a broad, active channel adjacent to the Grove. Stream gradients in this reach range from 0.0015 to 0.008 and average about 0.002. Pools are scarce. The channel bed is composed of pebbly sand and gravel with mean sediment size (D_{50}) of 4mm. Large gravel bars deposited by floods in the last 15 years are present on the insides of river bends along the creek upstream of the Tall Trees Grove, and gravel deposition has also occurred within alluvial groves located intermittently along the creek starting about a mile above the Tall Trees Grove. In addition, recent silt deposits from overbank flooding can be seen throughout the Grove.

Periodic flood inundation and silt deposition in these groves is a normal occurrence, and trees become progressively more buried after each major flood. On the south side of the Grove, stumps of trees cut by miners en route to the Klamath and Trinity mines in the 1860's (age based on 110-year-old age of tree sprouts from the stumps) have ax marks only 1-2 feet above the ground. Assuming these ax marks were made at waist height, at least 2 to 3 feet of silt deposition has occurred in this part of the Grove in the last 110 years. The streamside position of some of these axed trees, which were used for log river crossings, as well as the root morphology of living streamside trees, suggests the right bank of Redwood Creek above the tallest tree has been stable for the past 400 to 500 years (Steve Veirs, oral communication, December, 1978).

The earliest documentation of the Grove and Redwood Creek are 1936 aerial photos. Subsequent air photos, surveyed channel cross sections, sediment sampling, groundwater monitoring, and interviews with local residents have provided much additional information on the Grove. During the last 40 years, timber harvest and road building have accelerated rapidly throughout most of the basin and have increased the sediment load of Redwood Creek. Five major floods (*i.e.*, flood peaks of at least 45,000 cubic feet/second or 162 cubic feet/second/sq. mile) have occurred since 1953, and have also affected sediment routing and storage.

The large contributions of sediment to Redwood Creek by landsliding and fluvial erosion during the 1955 and 1964 floods, and during other large runoff events, as well as sediment contributions by erosion of slopes disturbed by logging have substantially modified stream channels. Due to recent sediment contributions, several feet of aggradation have occurred in many reaches of Redwood Creek, large gravel bars have been deposited, the Redwood Creek channel has become wider, and the sediment size appears to have become finer (Janda, 1978). Upstream from the Park, 15 feet of aggradation occurred at two channel cross sections after the 1964 flood. The bed of Tom McDonald Creek, directly across from the south side of the Tall Trees Grove, has aggraded 10 to 12 feet since 1952, based on channel infilling below a logging bridge built at that site. Since 1952, Redwood Creek in the vicinity of the grove has aggraded on the order of five feet (Nolan, *et al.*, 1976).

Aggradation poses a threat to riparian vegetation in the alluvial groves in several ways. Bank erosion directly threatens steamside trees and some trees have already toppled into the Creek due to bank retreat. Deposition of coarse gravel limits redwood seedling establishment and organic matter in flood deposits may harm trees by depletion of oxygen. Rapid channel aggradation increases the height of the water table and rapid groundwater rises may flood the root zone and drown the trees. Increased bed elevations cause coarser clasts of sediment to move through alluvial flats during floods, which may damage the trees by physical abrasion or undermine them through channel avulsion. In Redwood Valley, 19 stream miles above the Tall Trees, aggradation has already buried and killed streamside groves of hardwood and conifer that were once growing on upper flood plains (Janda, *et al.*, 1975).

In 1973 the amount of aggradation in Redwood Creek was greatest above Harry Wier (Emerald) Creek (one mile above the Tall Trees Grove). More recently, the leading edge of aggradation seems to have moved farther downstream, and Redwood Creek has begun to cut down through gravel deposits in some upstream reaches. Barring another major storm which again delivers massive quantities of coarse sediment to Redwood Creek, the channel will continue to gradually degrade as the present coarse sediment load is moved further downstream. Locally, however, aggradation may continue in some Park reaches as bedload sediment moves through various channel segments. Although no direct measurements of sediment discharge have been made at the Tall Trees Grove, annual sediment transport through this reach can be estimated from sediment sampling stations upstream and downstream from the Grove. Approximately 155,000 to 375,000 tons of bedload per year (or 775 to 1,875 tons/mi^2/yr) are transported through this reach, and the total sediment loads are approximately 1,600,000 t/yr (8,000 tons/mi^2/yr) (James Knott, written communication, 1975).

Sediment movement adjacent to the Grove has been disturbed by human activities in the past. From 1951 to 1968, Georgia-Pacific Lumber Co. excavated gravel from channel bars in Redwood Creek at the Tall Trees Grove for road surfacing. Excavation occurred in summer months to a depth of 6 to 7 feet and 200,000 to 800,000 tons of gravel were removed in the 17-year operation.

Extraction of gravel from the Redwood Creek channel is one of several alternatives to the aggradation problem in the Park. Aesthetically and logistically, such an operation would be impractical at the Tall Trees Grove, although upstream of the Grove in the more accessible Redwood Valley reach of the basin, gravel excavation would be possible. The aggradation problem could also be treated symptomatically by installing bank revetment on alluvial flats to protect streamside trees from bank erosion. Another management alternative is to leave the main channel alone and concentrate on reducing sediment input from disturbed lands in the watershed. The rehabilitation project in the Redwood Creek basin places emphasis on this last alternative.

From Stop 4, we will hike back to the trailhead and travel up the C-line to the C-10 road--one of the major arterial logging roads off the C-line (Map 2). The C-10 road is a dead-end logging spur road and is the site of one of the initial watershed rehabilitation projects conducted in 1978.

STOP 5 - Watershed Rehabilitation Site on the C-10 Road in the Upper Miller Creek Drainage

This stop is a visit to one of the three major watershed rehabilitation sites completed in Redwood National Park in the latter part of 1978. It consists of the terminal section of a major logging haul road, and the tractor-logged hillslopes above this road segment.

The C-10 road served as a haul road when this area was logged in 1971. The road was heavily rocked to withstand traffic, and culverts were placed in the major drainages. The road fell into disrepair after logging was completed, and in the years that followed, there had been major culvert washouts on the stream crossings, carrying much fill material into the stream channels. In addition, fill material from roads and landings had failed, and in many localities, further fill failures were imminent. In short, the road was contributing a large quantity of sediment to Miller Creek. The last 3500 feet of road, where erosion problems were the greatest, was selected as a rehabilitation project for the summer and fall of 1978 (see accompanying article on watershed rehabilitation techniques).

In August, 1978, a D-8 tractor ripped the entire road surface to a depth of 24 to 30 inches to disaggregate the compacted, rocked surface. A drag-line crane excavated fill material from the six tributary channels crossing the C-10 road. The drag-line also pulled back fill and organic debris from landings and from the outside edge of the road fills. A bulldozer worked with the drag-line to recontour the fill that was placed on the inside, stable portion of the road such that the road bench was "outsloped" or sloped downhill. The net result is that drainages now have gently sloping banks, abrupt breaks in slope on the road edges are now smoothed, and the road is now inclined such that drainage runs off the road rather than along it. (See photos of the C-10 road rehabilitation in the accompanying article on watershed rehabilitation techniques.)

The heavy equipment work exposed large areas of soil. In addition, the logged hillslopes above the C-10 road had numerous problems where runoff was eroding gullies along tractor skid roads. To improve these conditions, a contract was awarded to a labor-intensive group to revegetate the bare soils, stabilize gullies and stream banks, and divert runoff into natural channels through construction of waterbars on eroding skid roads.

On steep slopes along the C-10 road where fill was pulled back, willow wattling has been installed. This is the same technique that was used on the C-line landing (Stop 3). Planter boxes, sprig planting, and grass seeding were also used on this site to hasten revegetation of bare slopes.

Check dams are now in place in two major drainages that cross the C-10 road in order to prevent these streams from downcutting, thereby helping to stabilize the banks. Sediment deposited behind the check dams not only promotes stability of adjacent streambanks, but acts as a substrate for vegetation. The streambanks and channel were planted heavily with cuttings from sprouting plant species, and seeded with grass so vegetation would quickly take hold on the stabilized channel slopes.

At three sites upslope and downslope of the road, water ladders were placed in drainages where water must be conducted across steep slopes without downcutting. They were installed where check dams are impractical due to steep, unstable slope conditions. Sufficient energy dissipation is a necessity at the outlet of water ladders to prevent undercutting of the structures.

The application of three types of mulch on bare soils along the pulled road alignment is clearly visible. The experimental mulch plots will test the effectiveness of non-living ground cover in preventing soil loss. The three types of mulch are: (1) redwood bark, twigs, and leaves; (2) cuttings from brushy species overlain by jute netting (a loosely woven hemp fabric); and (3) straw. Grids of erosion pins are set up in each plot and on control slopes to determine if differences in soil loss (if any) are significant.

The rest of this road log was prepared in part from materials provided by the U.S. Geological Survey.

From Stop 5 the field trip returns to the Bald Hill Road (see Map 2) and proceeds south-southeast along the ridge between the Klamath River and the Redwood Creek drainage basins. The road passes several naturally occurring, unnamed grass-braken fern prairies which have since the mid-19th century been sites of cattle grazing and other agricultural activities. The forest at the edge of these prairies has locally been cleared one or more times. Most of the prairies are presently bordered by young stands of oak and (or) Douglas-fir. The prairies along the ridge may partly reflect the generally low moisture levels and fire history of these sites, whereas the prairies at mid-slope locations and adjacent to Redwood Creek appear to be associated with areas of active mass movement underlain by pervasively sheared rocks.

After about three miles, the travel route turns right onto the Klamath to Korbel Road (K-K Road) which gradually descends the hillslopes down to Redwood Creek.

Roadcuts along the K-K Road provide numerous exposures of the regolity and relatively unmetamorphosed Franciscan sedimentary rocks on the eastern side of the Redwood Creek Basin. The prairie soils tend to have thicker, more mollic (darker) A-horizons than the forest soils (haploxeralfs and xerochrepts). Additionally the forest soils near the drainage divide tend to be deeper and more oxidized (browner) than the forest soils near Redwood Creek. Variations in lithology and structural competence of the Franciscan rocks in this part of the basin help account for the diversity of landforms and erosion processes than can be observed from the K-K Road. The geologic controls on geomorphic form and process here are similar to those controls previously observed by field trip participants in the Russian and Eel River Basins. Relatively competent sandstones that crop out near the Bald Hills Road and in the vicinity of Slide Creek lack stratigraphic continuity, but nonetheless are less pervasively sheared and associated with less mudstone than the sheared sequences of sandstone and mudstone that crop out in Counts Hill Prairie and near Redwood Creek.

The sandstone areas typically bear redwood-Douglas-fir forest and display sharp rocky ridge crests, v-shaped stream valleys, and smooth straight hillslopes that are generally steeper than hillslopes underlain by sheared mudstone in the same physiographic setting. These areas appear to have been naturally sculpted by a combination of (1) persistent stream downcutting by high order streams and (2) infrequent shallow-seated debris slides and avalanches that deliver large quantities of debris directly to both intermittent and perennial streams. Within the sandstone areas, tractor-yarded, clearcut timber harvest and road construction appear to have accelerated fluvial erosion significantly more than mass movement.

The pervasively sheared sandstone and mudstone areas typically display a complex mosaic of vegetation with (1) grass prairie or grass-oak woodland in areas of vigorous mass movement, (2) dense stands of young oaks and (or) Douglas-fir at the margins of the prairies, and (3) mature redwood-Douglas-fir forest on intact landslide blocks and relatively stable areas. The hillslopes are generally more irregular than those underlain by competent sandstone. The degree of surface irregularity and surface disruption depends upon the rate and type of mass movement activity. These areas appear to have naturally been sculpted primarily by relatively persistent, deep-seated (depths to failure surfaces generally greater than 3 m and commonly greater than 10 m) mass movement processes, including soil creep, earthflow, and slumping. Gully erosion is also an important process in some of the more active earthflows.

Near Dolason Hill Prairie and Counts Hill Prairie, the roadside vegetation is low enough to allow field trip participants to look southwest across the valley of Redwood Creek and to see the checker-board pattern of recent clearcut timber harvest units south of the mouth of Bridge Creek. This dispersed harvest pattern is the result of the Z'Berg-Nejedley Forest Practices Act of 1972 and special negotiations between the National Park Service, U.S. Department of Justice, and the original timber owner. The intent is to avoid the concentrated impact that field trip participants observed along the C-line. The lower six cable-yarded patch cuts are immediately adjacent to the former (1968) boundary of Redwood National Park.

As the K-K Road descends toward Redwood Creek and the Grogan Fault, the relatively unmetamorphosed rocks exposed in roadcuts become progressively more sheared and finer grained. By the time the road crosses Copper Creek (see fig. 1, page XI-2) and starts up Redwood Creek, the rocks are penetratively sheared and contain abundant clay and disaggregated sandstone. The hillslopes in this area are ubiquitously unstable and numerous natural and road-induced landslides and gullies supply enormous volumes of sediment directly to Redwood Creek. Field trip participants will be able to view two earthflows where the U.S. Geological Survey is studing times and rates of surficial earthflow movement--Raingage Earthflow and Devils Creek Earthflow (Harden and others, 1978; Nolan and others, this guidebook).

STOP 6 - Rain Gage Earthflow

The morphology and recent history of movement of Raingage Earthflow are summarized by Nolan, Janda, and Duls (this guidebook, pages XI-1 to XI-10). The overall morphology and amount of ground surface disruption shown by this earthflow are typical of many earthflows in Franciscan broken formation and melange. However, recent surfacial movement rates are considerably less than rates documented for similar earthflows elsewhere in the Redwood Creek and Van Dussen Basins (Kelsey, 1977; Harden and others, 1978).

Field trip participants will be able to view (1) the transverse stakelines discussed by Nolan and others, (2) longitudinal stakelines used to estimate volumes of sediment delivered directly to Redwood Creek from the toe of this earthflow, (3) stake arrays designed to give weekly movement rates and (4) stream sediment sampling apparatus designed to estimate volumes of sediment delivered to Redwood Creek by gully erosion on the earthflow surface.

Leave STOP 6 and continue south on the K-K Road toward Korbel. The road soon crosses the Grogan Fault which is wider and structurally more complex here than where field trip participants observed it in the Miller Creek Basin. The zone of intense brecciation associated with the fault is commonly several hundred meters wide, but in the area between STOP 6 and Panther Creek the fault contact between relatively unmetamorphosed sedimentary rocks (texture zone 1 of Blake and others, 1967) and schist (texture zone 3 of Blake and others, 1967) is generally quite sharp. Locally, such as near the mouth of Coyote Creek, discontinuous lenses of transitional metamorphic rocks (texture zone 2 of Blake and others, 1967) occur along the fault. Transitional rocks are always present along the Grogan Fault upstream from Garrett Creek. The outcrop belt of transitional rocks near Highway 299 is as much as 1.3 km wide. The transition, however, is usually incomplete, and the schist appears to have been largely derived from finer grained rocks than the relatively unmetamorphosed sandstones.

The southern boundary of Redwood National Park crosses Redwood Creek between STOP 6 and the mouth of Coyote Creek (see Maps 1 and 2). The central part of the Redwood Creek Basin between the southern park boundary and the tributary drainage basin of Lacks Creek has been formally designated by Congress as a Park Protection Zone (PPZ) in which the Secretary of Interior has the authority and responsibility to monitor closely landuse activities and to assess whether those activities have the potential to affect adversely downstream park resources. The eastern slope of the PPZ and the streamside corridor along Redwood Creek are areas of unstable hillslopes and high sediment yields similar to the area through which the trip just passed.

Between Coyote Creek and one mile past Panther Creek, the K-K Road goes through a series of timber harvest units that have been yarded in a number of innovative ways in order to minimize ground surface disturbance in this naturally unstable streamside corridor.

After crossing Redwood Creek near the mouth of Panther Creek the K-K Road slowly climbs the western valley wall of the Redwood Creek basin. The exposed schist becomes progressively less sheared, and the soils become progressively deeper, clayier, and redder. Roadcuts on the broad drainage divide between Redwood Creek and Little River expose bright red clayey soils and saprolite (haplohumults and tropohumults) more than 6 m thick. These soils are locally associated with stream gravels and may have developed on an old erosion surface.

Roadcuts along the K-K Road in the headwaters of the Little River basin expose some meta-graywacke which is considerably coarser grained than most of the schist.

Near the Little River-Mad River drainage divide, the K-K Road leaves the schist and passes into relatively unmetamorphosed sandstones. The contact is the Bald Mountain Fault which lacks the transition zone rocks and wide zone of intense brecciation associated with the Grogan Fault.

The K-K Road then descends down the North Fork of the Mad River towards Korbel. Roadcut exposures are primarily of deeply weathered sandstone, but some volcanic rocks, including pillow basalt, are also present. The old growth forest in the North Fork basin was harvested 10 to 40 years ago. Most of the basin now bears dense young growth stands, some of which have recently been commercially thinned.

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