

SUMMARY REPORT

**REHABILITATION UNIT 82-2:
C-20 ROAD & SLOPE AND C-LINE LANDING #2**

**Resource Management Division
Redwood National Park**

by

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TABLE OF CONTENTS

	<u>Page</u>
Introduction	1
Unit Description	1
Pre-Rehabilitation Road Conditions	1
Rehabilitation Work-Summary	3
Logging History	4
Geomorphology and Erosion Features	4
Geomorphology	4
Man-Induced Erosion Features	7
Erosion-Control Rehabilitation Work	9
Introduction	9
Procedures	9
Objectives	9
Heavy Equipment Phase	13
Heavy Equipment Application	13
Heavy Equipment Sequencing	16
Heavy Equipment Costs	16
Rock Distribution	24
Labor Intensive Phase	26
Conclusions	28
Conclusions	28
Prescription and Treatments	28
Heavy Equipment Application	28
Labor Intensive Application	29
References	30

LIST OF FIGURES

	<u>Page</u>
Figure 1. Location Map of Rehabilitation Unit 82-2	2
Figure 2. Logging History Map	5
Figure 3. Gemorphic Features Map	6

LIST OF TABLES

	<u>Page</u>
Table 1. Erosion Potential Summary	10
Table 2. Sequence of Events	12
Table 3. Summary Costs of Erosion-Control Work	14
Table 4. Summary of Heavy Equipment Types and Costs	15
Table 5. Summary of Average Heavy Equipment Costs	17
Table 6. Miscellaneous Heavy Equipment Costs	19
Table 7. Summary of Haul Road Crossings	20
Table 8. Road Reaches	22
Table 9. Landings	23
Table 10. C-Line Landing #2	25
Table 11. Rock Pit Costs	27

INTRODUCTION

Unit Description

Rehabilitation Unit 82-2: C-20 Road and slope, and C-Line landing #2, occurs on eastern slopes draining into Redwood Creek just downstream of the Tall Trees Grove (Fig. 1). The C-20 Road and slope section of the unit encompasses the upper slopes of Larson and Cloquet Creeks drainage basins. The C-Line landing #2 is located in the Miller Creek drainage basin about a half mile downslope of the C-20 area along the C-Line Road (Fig. 1). The rehabilitation work performed at the C-Line landing #2 was relatively minor and so was incorporated into the nearby C-20 work area.

The entire hydrologic area across which the C-20 Road traverses is about 1,444 acres, extending from Redwood Creek to the drainage divide along Bald Hills Road. Of this area approximately 713 acres are uncut, old growth forest (redwood and Douglas-fir), mostly downslope of the C-20 Road (Fig. 1). Of the 731 acres of cutover land, the 444 acres adjacent to the C-20 and below the C-Line were either treated or eliminated from further rehabilitation work.

Total relief is about 2,000 feet from Redwood Creek (100 feet) to Bald Hills Road (2,082 feet). The C-20 Road traversed the slopes dropping in elevation from about the 1,200 to 900 foot level to the north. Hillslopes are highly variable with most being moderately steep (20-50 percent) with localized steeper slope (100 percent or more) and gentle (0-20 percent) benches and ridges. Main stream channels are well incised while smaller ephemeral channels are only slightly incised.

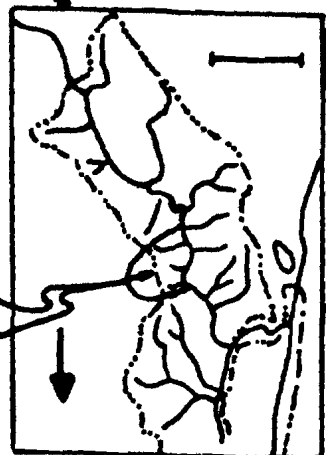
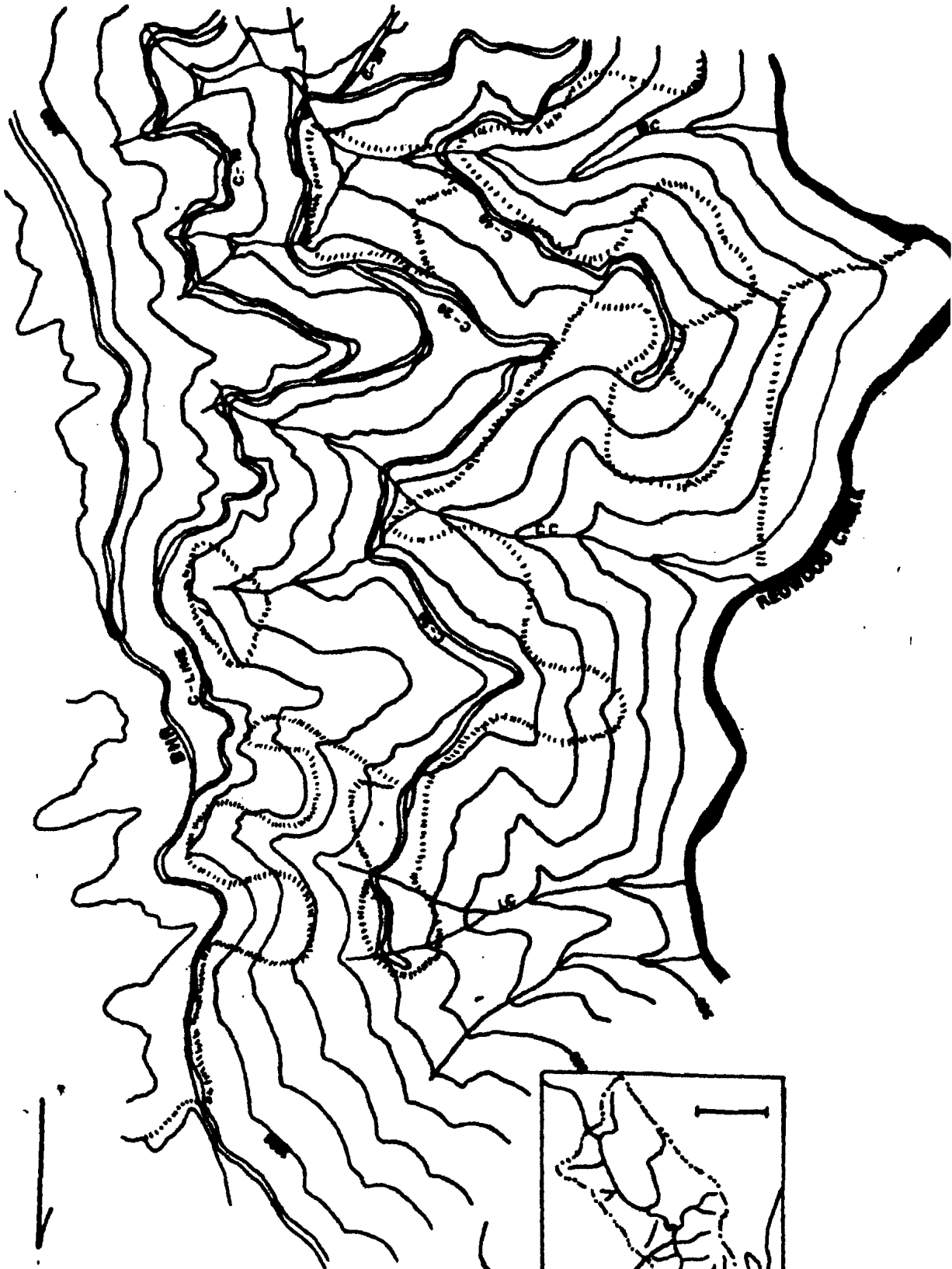
Bedrock geology under the rehabilitation unit is exclusively Jurassic to Cretaceous Franciscan assemblage (Harden and other, 1981). From below the C-20 Road up to the divide, the predominate lithologies are incoherent to coherent, un-metamorphosed sandstones, siltstones and mudstones with discontinuous bedding (KJf1 and KJfc of Harden and others, 1981). Localized outcrops of sandy conglomerates occur upslope of the C-20 Road. Below these units, a zone of highly sheared, metamorphosed sandstone and mudstone occurs associated with the Grogan Fault zone (KJfg and Harden and others, 1981). On the lower hillslopes occur the schist of Redwood Creek (KJfr of Harden and others, 1981).

Localized colluvial deposits occur on benches and below more resistant ridges particularly where conglomerate exists. Along major ridges, thick well developed soils are present. Mass movement deposits and topography occur at several locations on the hillslopes. More detailed geomorphic descriptions of certain areas are given in a later section (Geomorphology and Erosion Features).

Pre-Rehabilitation Road Conditions

The C-20 Road was the major haul road access for timber harvest of the hillslopes prior to park expansion. The road was rocked and had inboard ditches. Culverts had been placed at major stream crossings, but most were undersized for the calculated runoff of a 25-year storm event. The road crossing of the mainstem of Cloquet Creek was a redwood log bridge.

C-Line
Landing #2



The road was passable in December 1981, although rough at an incipient road failure area (R-6; Plate 1), and at a six inch scarp across the road at a landing (L-3, Plate 1). The remainder of the road was in excellent condition with a few minor problems. Two incipient road failures with scarps less than six inches high occurred on separate road reaches (R-8 and R-9; Plate 1). At one, a small cutbank landslide had occurred partially blocking the road. The most northern end of the road was soft and appeared to have been ripped by the logging company. Also on this road reach (R-1; Plate 1) a major spring area draining down the road surface caused gradual failure of a portion of the outer edge of the road.

During the course of the winter (January-April 1982), the failure on road reach R-6 continued to slump, blocking the road. Scarp displacement at winters end was about 4-6 feet. Part of this activity was caused by a small debris slide down the cutbank which blocked an upslope road culvert causing the collected inboard ditch flow to drain onto the slump area. At landing L-3, scarp heightening blocked inboard ditch flow and caused ponding of water on the back side of the landing. This water drained across the landing in a shallow drain during major storm events and flowed subsurface the rest of the time. By winters end, the scarp had heightened to 3-4 feet.

C-Line landing #2 occurs at an elevation of about 1,050 feet and was perched about the south stem of Miller Creek (Fig. 1). The landing was constructed, along with others, along the C-Line during upslope tractor-yarded timber harvest in 1971. The landing had minor scarps across its surface prior to the winter of 1982. During the winter, which had higher precipitation than recent years, the scarps expanded to 2-3 feet in height. The landing was perched above a perennial stream and considered possible to cause slope stability problems which would enter sediment into the stream. Because of the proximity with the C-20 Road and slope area, the C-Line landing #2 was included within the work of that unit.

Rehabilitation Work - Summary

The purpose of the rehabilitation work on this unit was to examine, document, analyze, and, where possible, treat areas of erosion or potential erosion which had been caused or enhanced by land-use practices. Also, because of the units visibility to C-Line and the shuttle bus route to the Tall Trees Grove, the unit posed potential use as a demonstration of watershed rehabilitation techniques for park visitors.

The rehabilitation work on this unit removed 2.1 miles of the C-20 Road. This consisted of removing 3,648 cubic yards of material from 5 haul road crossings; excavating 7 skid trail crossings; outsloping and/or ditching 12 landings; and outsloping or cross-road draining 6,742 feet of road. The 15.3 acres of ground disturbed by the rehabilitation work was mulched with straw to protect against surface erosion and to enhance revegetation.

At the C-Line landing #2, 451 dump truck loads of material or 3,157 cubic yards were removed from the failing landing and used to outslope an old rock quarry.

Logging History

The logging of C-20 hillslopes occurred exclusively in the period 1971-1977 (Fig. 2). The C-Line was constructed sometime in the late 1960's. The C-20 Road was constructed to L-1 by 1973 and the large 1971-73 tractor yarded clearcut units above the road were completed. During construction of the road a several hundred foot wide area below the road alignment was logged apparently as a right-of-way. The road was extended to the north to the then existing park boundary probably in 1974, and the small, upslope tractor-yarded units harvested. The three cable-yarded clearcuts below the road were completed in 1975-76. The three cable-yarded clearcuts off the C-Line and at 'Devastation Point' were completed in 1975-77 (Fig. 2). Timber harvest was ceased in the area by the 1978 Park Expansion Act.

GEOMORPHOLOGY AND EROSIONAL FEATURES

Geomorphology

A number of interesting geomorphic features are exhibited on the hillslopes of the rehabilitation unit. These include: variation in hillslope morphology based on bedrock lithology; ancient, large-scale, mass movement features; and stream channel configurations.

Variation in Hillslope Morphology - One aspect of the hillslopes is that all three major bedrock lithologies of Redwood Creek basin occur within individual tributary hydrologic units. Along both Cloquet and Larson Creeks, the variation in hillslope morphology in response to bedrock type is discernable. The upper portion of the hillslopes are underlain by unmetamorphosed Franciscan sandstones and mudstone. Stream gradients, hillslopes, and stream channel sidebanks are steep. Main streams are well incised, infiltration is relatively high, and hillslopes are dry with little emergent ground water. The middle portion of the hillslope is underlain by highly sheared Franciscan associated with the Grogan Fault zone. Hillslopes and stream gradients are somewhat gentler. Stream channels are less incised, infiltration is low, and hillslopes are wetter from emerging groundwater. The lower hillslopes are underlain by schist of Redwood Creek. Hillslopes and stream gradients are gentle to moderately steep. Main streams are well incised, and the hillslope is probably wetter from emergent groundwater. However, most of these features are obscured by the remaining old growth forest on the lower hillslopes. The hillslopes therefore exhibit both the hillslope characteristics of the east side (unmetamorphosed Franciscan and sheared Grogan Fault zone) and the west side (schist terrain) of Redwood Creek drainage.

Ancient Mass Movement Features - Some of the most striking geomorphic features on the hillslope are interpreted to be ancient, inactive landslides or mass movement features. At least four large, inactive mass-movement features are discernable on the logged hillslopes (Fig. 3). Others may be present downslope hidden by the old growth forest. All of these features exhibit similar characteristics: an extremely steep (90 percent plus) upslope area interpreted as the headscarp below which a gentle (0-20 percent) bench. Below the top most bench a pattern of alternating steep slopes and benches extends downslope. This 'staircase' like topography has been termed in the park as "tread and riser".

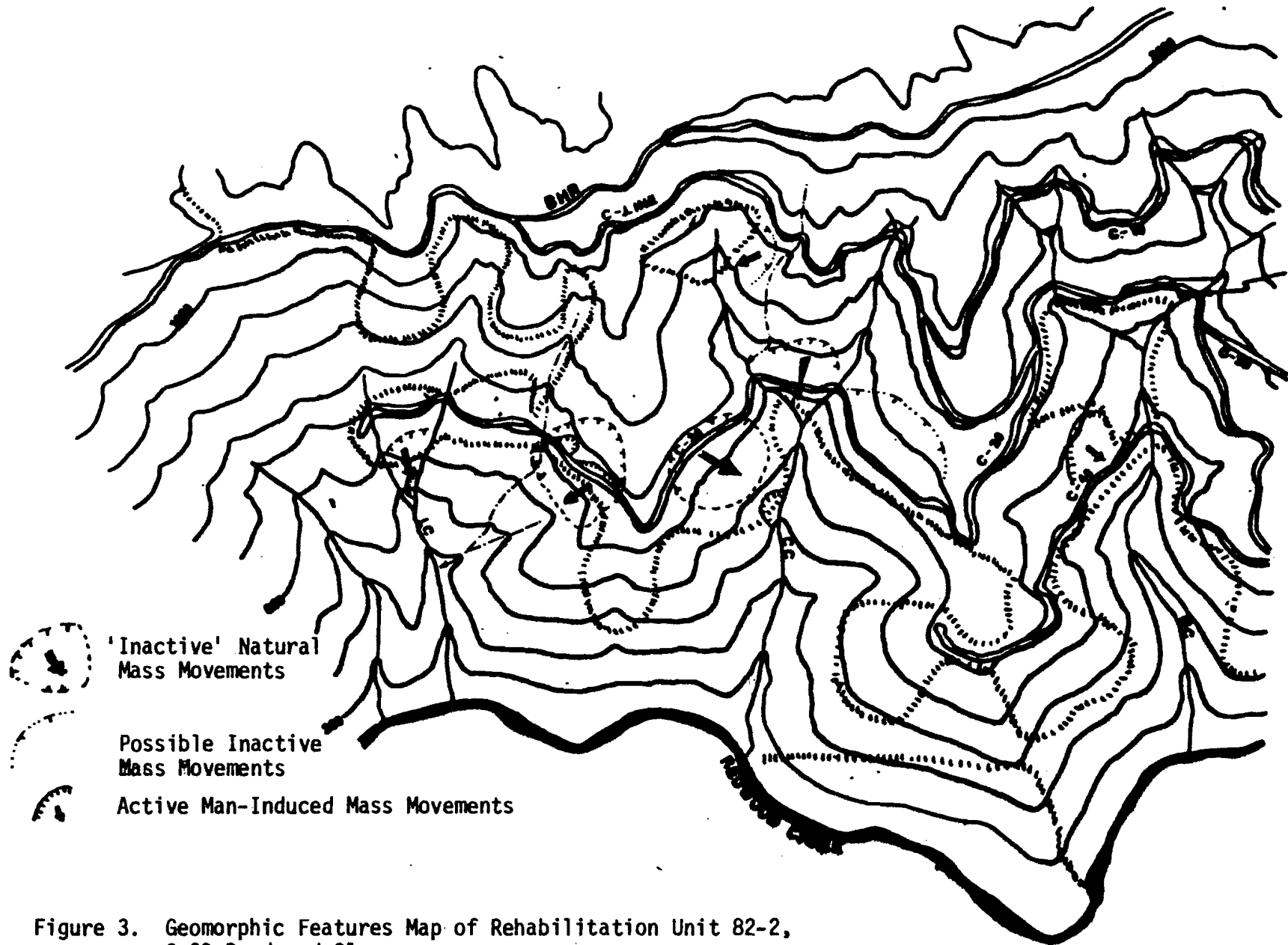


Figure 3. Geomorphic Features Map of Rehabilitation Unit 82-2, C-20 Road and Slope.

At the downslope terminus, these features may end in an incised stream valley where large boulders may represent lag deposits which the stream is incapable of removing. Some features blend downslope into the general hillslope trend before reaching a main stream. Infrequently will bulbous 'toes' of these large mass-movements be preserved. I believe examples of each of these types of downslope terminus are present on this hillslope (Fig. 3).

I feel, the types of motion exhibited by mass movements was predominated by a slumping nature with some earth flowage or complex slumping/gliding occurring downslope. Additionally, the rate of movement on the features was probably very slow with activity occurring over several decades or possibly centuries. The age, duration, and specific details of these mass movements are not known, and detailed geomorphic studies would be required to answer these questions. None of the mass movements on the unit are noticeably active at present. However, local areas on some do show either present natural or man-induced activity (Fig. 3).

Stream Channel Configuration - Several unusual stream configurations exist on the units hillslopes. Possibly the most obvious are along a tributary to the north stem of Cloquet Creek (Fig. 3). The stream crosses the C-Line in a well-incised, narrow valley with a relative gradient. The stream appears to be graded across a more resistant channel location underlain by massive sandy conglomerate. The north drainage ridge separates the stream from a much steeper slope. The stream is now 'perched' topographically higher than the ground to one side of it.

Downstream the same channel steepens and becomes poorly incised as it flows down the presumed headscarp of one of the ancient mass movements. As the stream flows onto a bench below the presumed headscarp, the channel makes a sharp bend to flow into the north stem of Cloquet Creek. This stream reach is very poorly incised. Stream flow goes subsurface in the perched reach above the headscarp. Only during major storms does runoff appear to flow down the steep headscarp reach as evidenced by only minor erosion of skid trail crossings. The stream channel on the bench at the end of the headscarp reach shows little evidence of flow since timber harvest. However, several large springs occur downslope apparently fed by the subsurface stream flow. The interpretation for this directional change in the stream channel configuration is the capture of the stream along the headscarp of a mass movement at some time in the past.

Several other stream channel configurations present possible evidence of modification by past mass movements along the stems of Larson Creek although not as dramatically as the above. Also the configuration and density of tributaries to both Larson and Cloquet Creeks have anomalous arcuate patterns which need to be examined in greater detail in order to be explained.

Man-Induced Erosion Features

Unlike most logged hillslopes within the Redwood Creek area of the park, the units hillslopes have relatively few and these only minor, man-induced erosion features. The reasons for the lower degree of erosion are: lack of upslope roads causing drainage diversions and concentrations; smaller cut blocks; cable-yarded headwater regions; improved forest practices; few skid trail crossings of perennial streams; rapid revegetation; and most of the logged hillslope has undergone only one or two major storm events.

The 1971-1972 tractor-yarded units show the most man-induced erosion features. Particularly in the 1971 cut, little regard was shown for preserving ephemeral stream channels or maintaining drainage patterns. Waterbars were relatively few and poorly constructed. Numerous skid trail crossings of ephemeral drainages have totally destroyed the channels and excessive ground disturbance occurred. Fortunately, because of the small drainage areas, the main erosion features were a series of small gullies, and numerous rills on skid trails. Rapid conifer regrowth has healed most of these problems and the slope features are mostly inactive.

A similar pattern is seen on the large 1972-1973 tractor-yarded cut areas: drainage disruption by skid trails; small rills and gullies; and eroded skid trail crossings. The forest practices used on these hillslopes were somewhat better than on the 1971 cut. Most incised ephemeral drainages were avoided as much as possible, sidecast into the channels were minimal, and the amount of ground disturbance was less than older practices. However, poorly defined ephemeral drainages were mostly ignored and little regard for drainage patterns observed. This was particularly noticeable at the northern end of the large cut unit where past movements had obscured surface drainage patterns. Additionally, nearly all of the waterbars on these cut units were improperly constructed. Most were made simply as a dam across the skid trails with no thought for drainage off the trail. As a result many breached causing minor gullying and rilling.

The younger tractor units at the end of the C-20 Road and the various cable-yarded units caused little erosion because of their size, location or time in relation to major storms.

A main erosional problem on the unit was the style of construction of the C-20 Road. A broad 100 yard wide right of way was logged downslope of the road and little care was paid to this area in terms of skid trail location and drainage patterns preservation. Additionally, numerous large decks or landing were constructed along the road. Skid trails concentrated water towards these landings and decks, but no effort was made to allow water to drain across. While many landings posed no erosional threat, several (L-8, 9 and 3; Plate 1) eroded or were predicted to become sediment sources.

The most poorly located section of road along the C-20 was that between L-3 and L-5 (Fig. 3; Plate 1). This section traverses across large, inactive mass movement feature and locally steep slopes. Ephemeral streams crossing the road were either not identified or ignored during construction. Hillslopes above the road were tractor clearcut logged before road construction and complete destruction of the subtle drainage patterns resulted. The incoherent mass movement material, steep slopes, disrupted drainages, and high cutbanks resulted in gradual road failure and cutbank slumping. Because of the size of the feature and the fact that little of the failing material could enter stream channels, minimal rehabilitation work was done on this area. However future continual slumping may cause the ultimately disturbed area to be quite large. The possibility exists that a portion of the older, larger mass movement may become reactivated because of the logging of this hillslope and road construction.

While the actual erosion which had and was occurring on this unit was minimal, the potential erosional impact for several areas was deemed high. Table 1 summarizes the potential erosion predicted for the major work sites (Plate 1).

EROSION-CONTROL REHABILITATION WORK

Introduction

Procedures

The method of approach to the rehabilitation work passes through four sequential phases: evaluation, heavy equipment, labor intensive, and winter maintenance phase. The evaluation phase begins with the selection of the hillslopes and roads which will be encompassed within the general unit. This is followed by reconnaissance aerial-photograph interpretation, and field surveys of road conditions and erosional problems. Detailed field mapping of geomorphic, erosional, and land use features is then accomplished during the winter rainy months. Included in this phase period is the evaluation of erosion potential at possible worksites. The final portion of the evaluation phase performed in the spring is the prescription of treatments to be performed to reduce erosion, remove sediment sources and correct drainage patterns. This includes identifying worksites, formulating a sequence of work, and documenting pre-work conditions by establishing photo-point locations. At this point a projection of cost is made, and the proposed prescriptions are reviewed in the field with other Redwood National Park geologists. Questions, problems, and discussions from this field review are resolved and a finalized prescription plan is made. From this plan, a cost projection is made and required heavy equipment rentals are procured.

The heavy equipment phase involves performing the actual erosion-control work on the unit. Partially concurrent with this is the labor intensive phase of erosion-control work performed by labor crews. These phases take place in the summer to early fall dry season. The winter maintenance phase is the follow-up work performed in the fall and early winter to correct developing problems from the first storms. Post heavy-equipment measurements are made to determine volumes of excavated fill and disturbed ground, and the taking of post-rehabilitation photo-documentation. Also included is the analysis of work performed and the writing of a summary report. Table 2 summarizes this unit's work.

Objectives

Although the C-20 Road and slope unit did not have any major active sediment sources, the potential for future erosion at various sites was considered very high. The isolation of areas by road failures, declining road maintenance and major storm events would probably cause major sediment sources to develop in the future. One main objective of the rehabilitation work was to remove the large erosion potential associated with the two large stream crossings which had become isolated by road failure at R-6 (Plate 1). Also considered significant was correction of diverted spring flow causing road slumping along R-1 (Plate 1).

Table 1. EROSION POTENTIAL SUMMARY

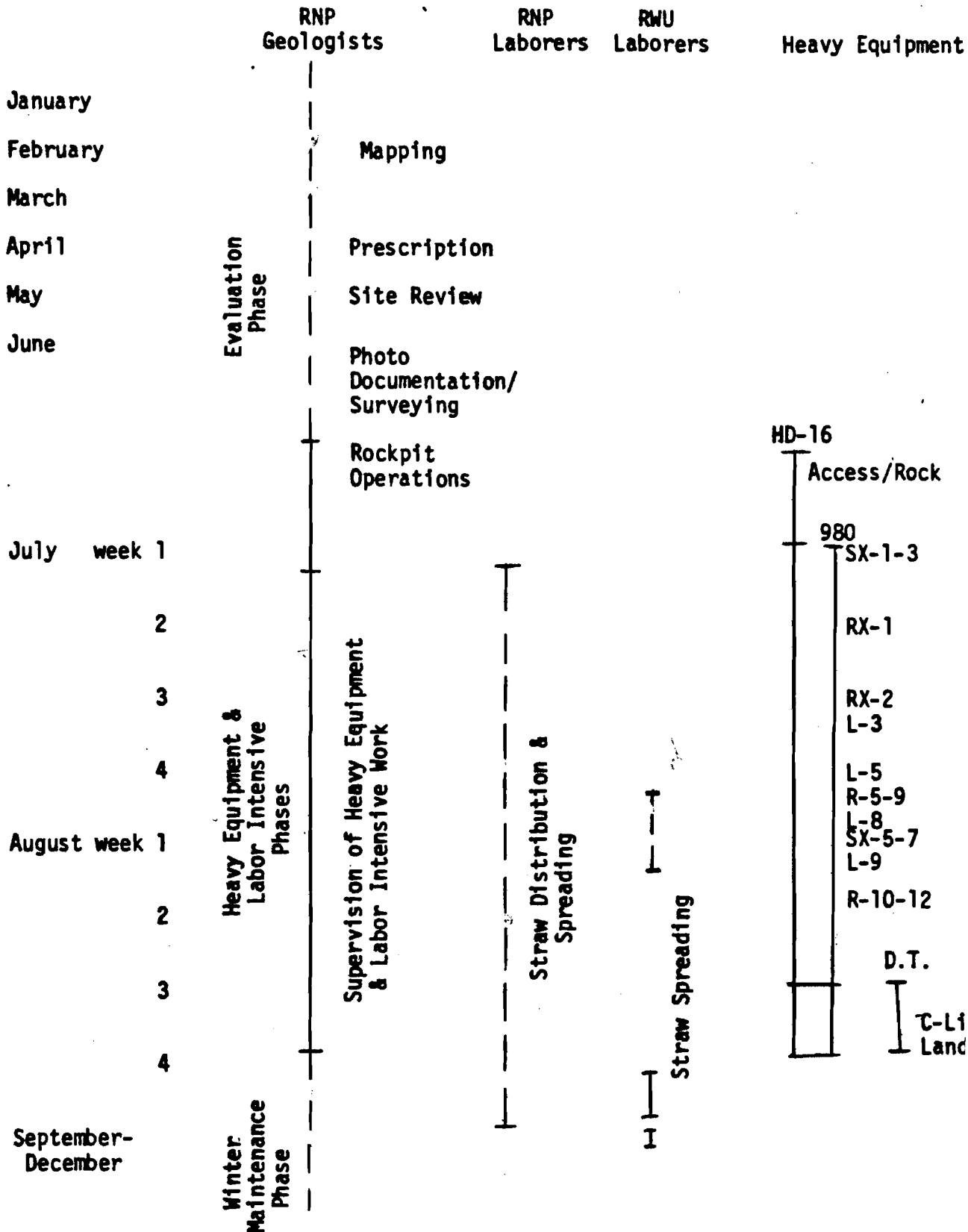
<u>Worksite</u>	<u>Erosion Potential Index</u>	<u>Erosion Potential Description</u>
R-1	Low-moderate	Possible slope stability problems; may evolve into mass movement sediment source by spring diversion.
Rx-1	Moderate; (1000 yd ³ +) Moderate-high diversion potential	Culvert failure; possible diversion of channel within local drainage area; erosion of fill and natural ground.
R-2	Low-moderate	Low potential most of reach, except where perched above channel of Rx-2.
L-1	Low	Possible debris slide of outer edge into stream channel; ground disruption likely.
Rx-2	Moderate-high (1000+) high diversion potential	Erosion of fill probable; channel diversion probable with gully erosion and cutbank failure (2000+)
R-3	None-slight	
L-2	Slight	Continued ground disruption; no sediment generated.
R-4	None	Inboard ditch concentration; slight rilling or gully.
Rx-3	Moderate-high (200+) high diversion potential	Culvert failure; possible diversion onto R-4; erosion could be considerable.
L-3	Unknown	Continued failure may cause sediment delivery to stream, diversion of Rx-3 onto area or toe possible.
R-5	Slight	
L-4	Unknown	Continued failure; ground disruption; sediment generated may be localized.
R-6	Unknown	Continued failure; some sediment generated to streams.
R-7	Slight	Failure likely; possibly little sediment generated to streams.
L-5	High	L-5w may fail by debris torrent down steep headwater, cable-yarded area below; large sediment probable.
R-8	None to slight	
L-6	None to slight	
R-9	None to slight	

Table 1. EROSION POTENTIAL SUMMARY - cont'd

<u>Worksite</u>	<u>Erosion Potential Index</u>	<u>Erosion Potential Description</u>
L-7	Moderate-high	Partial failure into stream likely.
Rx-4	Slight	Bridge approach collapse gradual; bridge collapse long-term feature.
L-8	High-extreme	Failure of landing fill directly into stream has occurred and will continue in future (2000+ yd ³).
R-10	None to slight	
L-9	Moderate	Partial failure into stream probable
Rx-5	Moderate - no diversion potential	Culvert failure; fill erosion.
L-10	Slight	Landing failure, no - little sediment generated.
R-11	Slight	
L-11	Moderate	Landing failure, ground disruption, some sediment generation.
Rx-6	Slight - no diversion potential	Fill erosion.
L-12	Slight	Landing failure, ground disruption.
R-12	High	Road fill failure by debris avalanching probable; questionable sediment generation; high ground disturbance.

TABLE 2. SEQUENCE OF EVENTS, REHABILITATION UNIT 82-2

C-20 Road & Slope/C-Line Landing #2



The highly disrupted road section between L-3 and L-5 (Plate 1) was decided to be untreatable due to the scale of the mass movement, and pose little actual or potential sediment threat. The objective in this area was to eliminate drainage diversions caused by the road, and to allow the mass movement to evolve naturally.

Another major objective of the rehabilitation work was to eliminate or minimize the erosion potential associated with continued failure of the large volumes of fill at landing L-7 and L-8 (Plate 1). Also, removal of the large volumes of fill at stream crossing Rx-5 and L-9 was deemed necessary. The high potential for debris sliding along R-12 warranted treatment by road outslipping.

The removal of several small, but eroding skid trail crossings (Sx-1-4; Plate 1) on ephemeral drainages was considered beneficial. Skid trail crossings removal (Sx-5-7) and waterbar construction was desirable in an area of poorly defined drainage and potential stream diversion.

The remainder of the C-20 Road was considered to pose only minor erosion potential, although its removal as a hydrologic barrier was considered appropriate. The prescribed treatment for most of the road was slight outslipping and cross road draining to remove the road as a hydrologic barrier and to lessen the road as a visual scar. Also, the interpretive value of the road removal to visitors along C-Line was considered highly desirable. Panoramic photographs before, during, and after rehabilitation work were taken for future information.

At the C-Line landing #2, the main objective was to attempt to stabilize the failing landing from evolving into a sediment source. The prescription was to remove as much of the perched landing material as possible to decrease the loading of the hillslope. A limit on the prescription was not to cause failure of the C-Line Road, or to narrow it to an unsafe width. If the landing area continues to fail, at least the removed volume could not be eroded and therefore decrease the potential size of the sediment source.

Finally, one general objective on the unit was to reduce erosion or potential erosion so as to minimize the sediment load which could effect the relatively undisturbed lower reaches of the streams passing through the old growth forests.

Cost Summary - Table 3 summarizes the costs involved in performing the erosion control rehabilitation work on this unit. As in previous years the major expenditure was on heavy equipment to perform the actual erosion-control work. Labor-intensive, secondary treatment work has been greatly reduced from previous years.

Heavy Equipment Phase

Heavy Equipment Application

Three pieces of heavy equipment performed all of the rehabilitation work on this unit: one crawler tractor with rippers (D-8), a crawler tractor with winch (HD-16C) and a hydraulic excavator (980B). Several rubber-tired loaders and a fleet of dump trucks were used to load and transport the rock for channel protection treatment. Two dump trucks were used during the excavation of the C-Line landing #2. Table 4 summarizes the equipment specifications, cost and hours.

Table 3. SUMMARY COSTS OF EROSION-CONTROL WORK, REHABILITATION UNIT 82-2,
C-20 ROAD & SLOPE AND C-LINE LANDING #2

	RNP Geologists	RNP Laborers	Heavy Equipment Rental	Redwoods United	Total Task Costs	% Grand Total	Phase Total	Phase %
PHASE								
Mapping	\$4,846.40 ¹				\$4,846.40 ✓	5.0%		
Prescription	2,582.40 ¹				2,582.40	3.0%	\$7,428.80	8.0%
PHASE								
Primary Treatment	10,277.28 ^{1,2} ✓		\$52,495.64		62,772.92	71.0%		
Secondary Treatment			7,667.27 ³		7,667.27	9.0%	73,935.19	84.0%
Miscellaneous			3,495.00 ⁴		3,495.00	4.0%		
SIVE COSTS								
Secondary Treatment	1,141.92 ¹ ✓	\$3,567.20		\$2,117.81	6,826.93	8.0%	6,826.93	8.0%
Miscellaneous								
TOTALS	\$18,848.00 ✓	\$3,567.20	\$63,657.91	\$2,117.81				
% of GRAND TOTAL	21.4%	4.0%	72.2%	2.4%	\$88,190.92 - GRAND TOTAL			

¹ Estimated cost.

² Covers all of heavy equipment.

³ \$6,476.02 rock acquisition costs.

⁴ Includes move in/move out costs.

Table 4. SUMMARY OF HEAVY EQUIPMENT TYPES AND COSTS
REHABILITATION UNIT 82-2

Equipment Type	Owner/Operator	Make/Model	Year	Rate/Hour	Total Hours
Hydraulic excavator	Kjers/Charles Giannini	Case 980B w/1 1/4 yd ³ bucket	1980	\$85.00	318.0
Crawler tractor	W.W. Stockton	Allis Chalmers HD-16C	1973	\$50.00	341.5
Crawler tractor	Dutra/Tom Robert	Caterpillar D-8H 46A w/rippers	1968	\$75.00	122.5
Dump truck	Keith Parker	International/G.M.C.	1959	\$33.94	43.5
Dump truck	Diamond R Logging/ Danny Nunes	International	1963	\$33.00	43.5

On this unit, the D-8 tractor was used to do the initial excavation of fill from the larger haul road crossings and at landing L-8. The D-8 tractor outsloped road reach R-7 entirely and did some preliminary work on several landings. Also the D-8 tractor ripped the entire road and all landing surfaces.

The hydraulic excavator was used to complete the larger haul-road crossings and to excavate the smaller road crossings and skid trail crossings. The excavator also did much of the road outsloping by removing the outboard edge of the road so that the HD-16 could complete the outsloping. The excavator also pulled back the edge of all the landings and constructed the drainage ditches across them. All of the rock armor was placed by the excavator at the several worksites which received rock. At C-Line landing #2, the excavator removed all of the material from the landing and loaded it into dump trucks.

The HD-16 tractor supported both the D-8 and 980 by removing and spreading fill which they were excavating. The HD-16 also finished outsloping the roads and the landings. Some skid trail crossings were excavated exclusively by the HD-16. Additionally, the HD-16 would open up access routes and construct trails for the 980.

Heavy Equipment Sequencing

The sequencing of heavy equipment use was straight forward on the unit. Work began on the sequence of skid trail crossing Sx-1-4 and then moved to the end of the C-20 Road (R-1). Work then progressed out the road with the excavator and HD-16 outsloping the road and landings as the D-8 excavated the larger crossings to the maximum extent. The excavator and HD-16 then completed the crossing as the D-8 ripped the next length of road to the next major worksite. Initially, this posed some problems as the excavator and HD-16 caught up with the D-8 working on a crossing, and they would have to be moved to a landing to work. After the initial week or so this resolved itself as the D-8 got far enough ahead.

With the departure of the D-8, the excavator and HD-16 completed the road from Rx-4 to the end of R-12 by themselves. Once the C-20 Road was complete, the two pieces of equipment walked down the C-Line to the C-Line landing #2.

Heavy Equipment Costs

Table 5 summarizes the average cost of heavy equipment for the treatment performed on the rehabilitation unit. Primary treatment costs are those entailed in removing potentially erodible material from stream crossings and landings, and restoring drainage patterns by outsloping roads and constructing drainage channels. Secondary treatment costs are those entailed in protecting stream channel excavations with rock armor. Because the secondary treatment on this site was limited, the cost of placing rock armor is incorporated within the primary treatment tasks on Table 5, but all secondary treatments are summed at the bottom.

Table 5. SUMMARY OF AVERAGE HEAVY EQUIPMENT COSTS

Treatment	# of	Total Quantity	Total Cost	Avg. Cost/ Worksite	Avg. Cost/ Quantity	Range In Cost Quantity
Haul Road, Crossings ¹	6	3,648 yd ³	\$10,568.75	\$1,761.46	\$2.88/yd ³	\$1.31-2.96/yd
Skid Trail Crossings	7	790 yd ³	\$3,291.25	\$470.18	\$4.17/yd ³	\$1,061.25-42.50/each
Road Reaches	12	6,742 l.f.	\$9,045.00	\$753.75	\$1.34/l.f. \$7,083.59/mi.	\$.66-3.93/l.f.
Landings	12	--	\$19,395.00	\$1,616.25	--	\$135-5,730/each
Rip Roads	--	6,742 l.f. 15.6 Acre	\$2,062.50	\$.31/l.f. \$132.21/Acre	--	--
Deep Dishes	3	--	\$932.50	\$310.83	--	--
C-Line Landing #2	--	3,157 yd ³	\$8,396.89	\$2.66/yd	--	--
Miscellaneous	--		\$3,495.00			
Rock Acquisition		624 yd ³	\$6,471.02	\$10.37.yd ³		

	<u>Cost</u>	<u>% of Total H.E Costs</u>
Total Primary Treatment Cost	\$52,495.64	82.5%
Total Secondary Treatment Costs	\$7,667.27	12.0%
Total Miscellaneous Costs ²	\$3,495.00	5.5%
TOTAL HEAVY EQUIPMENT COSTS	<u>\$63,657.91</u>	

¹Includes excavation (primary treatment) and rock placement (secondary treatment; not cost of rock acquisition. 17

Miscellaneous costs include a variety of small primary and secondary treatment tasks, access clearance, move in and out costs, and several others. See Table 6 for a detail listing of various elements of miscellaneous costs.

Haul Road Crossings - Table 7 shows the costs for the treatment of haul road crossings. Excluding rock delivery cost, Rx-1 and 2 accounts for 79.5 percent of the cost. At both of these crossings, part of the cost was the necessity of pushing fill several hundred feet along the road and around a bend to a stable location away from the stream channel. This required both tractors to work together during initial excavations. At Rx-1 both tractors and the excavator were working simultaneous on the operation. At both stream crossings the cost of rock delivery was several times the cost of rock placement. The main problems at both of these crossings were: the limited work space; the depth of excavation; lack of storage space immediately adjacent to the crossings; and all fill had to be removed in one direction.

The remaining haul road crossings were insignificant with the exception of Rx-5. This was a broad, gentle channel with space for the tractors to remove fill and with spoil locations immediately adjacent. The lower cost per cubic yard is a reflection of the ease of this excavation.

Road Reaches - Table 8 shows the cost of road removal on the unit. The wide range in costs (\$.66-\$3.93/lin.ft) reflect variations in the degree of treatment and the equipment used. For slight outsloping with drains by the excavator and HD-16, the cost range is \$0.66-\$1.59 for seven road reaches. For moderate outsloping with drains by excavator and HD-16, the costs are \$2.14 and \$3.93/linear foot. For complete outsloping by D-8, the cost on the one road reach was \$0.81/linear foot.

The main objective in the treatment of road reaches was to remove the hydrologic barrier formed by the inboard ditch and road surface. It was decided that slight outsloping in combination with cross road drains for wetter locations would meet this objectives and be the least expensive. One additional factor for slight outsloping was the extensive regrowth of young (1/2 - 8 foot) conifers on the outer edge of the road and on the cutbank. More extensive outsloping was deemed unnecessary hydrologically and excessively destructive to the existing regrowth. Alternatively, simple cross-road drain construction was considered not as desirable hydrologically because of maintaining the inboard ditch and resulting concentration of runoff. In addition, the lack of fine grained material on the rocked road surface might inhibit vegetative regrowth.

Landings - The treatment of landings was the largest individual expenditure on the unit (Table 9). However of the \$19,395 spent in treating 12 landings, \$8,308.75 or 42.8 percent of the total was spent on landings L-8 and L-9 (Table 9). These two landings had high erosion potential. Landing L-3 had a large drainage ditch constructed across it in an attempt to stabilize the landing failure. L-5w was perched above steep slopes and had potential for debris-flow failure. L-7 was perched above the major stream of Cloquet Creek and was deemed a potential sediment source. L-10, 11 and 12, had less erosion potential but required large or multiple drains constructed to direct flow across them.

Table 6. MISCELLANEOUS HEAVY EQUIPMENT COSTS

Task	Equipment	Hours	Cost	Total Cost
Waterbar construction	980	.75	\$63.75	\$238.7
	HD-16	3.5	175.00	

Moving	980	2.25	191.25	278.75
	HD-16	1.0	50.00	
	D-8	.5	37.50	

Road access - D-Line	HD-16	5.0	250.00	950.0
	C-30	5.0	250.00	
	C-20	9.0	450.00	

Safety	980	1.0	85.00	135.0
	HD-16	1.0	50.00	

Downtime	980	.5	42.50	67.5
	HD-16	.5	25.00	
Misc. lost time	980	.5	42.50	67.5
	HD-16	.5	25.00	
Rock access	HD-16	15.0	750.00	800
	Straw	1.0	50.00	

Sum total:	980	5.0	425.00	2,537.5
	HD-16	41.5	2,075.00	
	D-8	.5	37.50	

Move In/Out Costs:				
Move in/out to Cal-Pac	980		168.75	957.5
Move in/out to Cal-Pac	HD-16		232.50	
Move in	D-8		293.75	
Out to Redwood Creek	D-8		112.50	
Move out	D-8		150.00	

TOTAL MISCELLANEOUS HEAVY EQUIPMENT COST:

\$3,495.0

Table 7. SUMMARY OF HAUL ROAD CROSSINGS

Worksite	Task	Equipment	Hours	Cost	Task Total	% of Total Site Cost	Cost/ Yd ³
Rx-1 (1304 yd ³)	Excavate	D-8	18.5	\$1,387.50			
	Excavate	980	12.25	1,041.25	\$2,428.75		
	Fill	HD-16	21.5	1,075.00			
	Fill	D-8	5.0	375.00	1,450.00		
				Primary Treatment Cost	\$3,875.00	53%	\$2.97
	Rock placement	980	8.25	701.25			
	Rock placement	D-8	1.5	112.50	813.75		
	Rock delivery				2,654.78		2.66
				Secondary Treatment Cost	\$3,468.53	47%	\$13.55
Total Cost Rx-1					\$7,343.53		
Rx-2 (1441 yd ³)	Excavate	D-8	17.0	\$1,275.00			
	Excavate	980	16.0	1,360.00	\$2,635.00		
	Fill	HD-16	18.25	912.50	912.50		
				Primary Treatment Cost	\$3,547.50	56%	\$2.46
	Rock placement	980	2.0	170.00	\$170.00		
	Rock delivery				2,654.78		
Secondary Treatment Cost					\$2,824.78	44%	
Total cost Rx-2					\$6,372.28		\$4.42
Rx-3 (120 yd ³)	Excavate	980	2.0	170.00			
	Excavate & fill	HD-16	1.75	87.50	\$257.70		
Primary Treatment Cost					\$257.50		\$2.15

Table 7. SUMMARY OF HAUL ROAD CROSSINGS

Worksite	Task	Equipment	Hours	Cost	Task Total	% of Total Site Cost	Cost/ Yd ³
Rx-4	Excavate	980	3.0	\$255.00	\$255.00		
				Primary Treatment Cost	\$255.00		
Rx-5 (583 yd ³)	Excavate	D-8	5.75	\$431.25			
	Excavate	980	6.5	552.50			
	Excavate & fill	HD-16	8.0	400.00	\$1,383.75		
				Primary Treatment Cost	\$1,383.75		\$2.37
Rx-6 (200 yd)	Excavate	980	2.5	\$212.50			\$1.31
	Excavate & fill	HD-16	1.0	50.00	\$262.50		
				Primary Treatment Cost	\$262.50		
SUMMARY -		<u>Equipment</u>	<u>Hours</u>	<u>Primary Treatment</u>	<u>Secondary Treatment</u>	<u>Equipment Cost</u>	
		980	52.5	\$3,591.25	\$871.25	\$4,462.50	
		HD-16	50.5	2,525.00		2,525.00	
		D-8	47.75	3,468.75	112.50	3,581.25	
		Heavy Equipment Total Cost		\$9,585.00	\$983.75	\$10,568.75	
		Rock delivery cost			\$5,309.56	\$5,309.56	
		TOTALS		\$9,585.00	\$6,293.31	\$15,878.31	
		% of TOTAL		60%	40%		

Table 8. ROAD REACHES

Site	Treatment	Equipment	Hours	Cost	Road Length (L.F.)	Cost/ L.F.
R-1	Moderate O.S. w/drains	980 HD-16	13.5 18.0	\$2,047.50	521	\$3.03
R-2	Fillsite/Moderate O.S.	980 HD-16	7.5 8.5	1,062.50	502	\$2.12*
R-3	Fillsite	980 HD-16	4.0 3.0	490.00	492	\$1.00*
R-4	Slight O.S. w/drains	980 HD-16	2.5 3.25	375.00	526	\$0.71
R-5	Slight O.S. w/drains	980 HD-16	3.0 3.0	405.00	330	\$1.23
R-6	Slight O.S. w/drains	980 HD-16	3.5 4.5	522.50	330	\$1.58
R-7	Complete O.S.	D-8	5.0	375.00	462	\$0.81
R-8	Slight O.S. w/drains	980 HD-16	5.0 4.5	650.00	954	\$0.68
R-9	Slight O.S. w/drains	980 HD-16	2.0 2.0	270.00	409	\$0.66
R-10	Slight O.S. w/drains	980 HD-16 D-8	1.0 1.75 1.0	247.50	317	\$0.78
R-11	Slight O.S. w/drains	980 HD-16	7.0 4.0	795.00	501	\$1.59
R-12	Moderate O.S. w/drains	980 HD-16	13.0 14.0	1,805.00	845	\$2.14
SUM TOTAL		980 HD-16 D-8	620 665 6.0	\$5,270.00 \$3,325.00 \$450.00		
TOTAL				\$9,045.00		

*Disregard Cost/L.F. - fillsites from road crossings.

Table 9. LANDINGS

Site	Treatment	Equipment	Hours	Cost	Total Cost
L-1		980	8.5	\$722.50	
		HD-16	12.5	625.00	\$1,347.50
L-2		980	3.0	255.00	
		HD-16	5.5	275.00	
		D-8	4.0	300.00	830.00
L-3	Ditch	980	8.5	722.50	
	Rock placement	980	2.5	212.50	
	Outslope	980	4.0	340.00	
		HD-16	11.0	550.00	1,825.00
L-4		980	1.0	85.00	
		HD-16	1.0	50.00	135.00
L-5w		980	6.25	531.25	
		HD-16	7.5	375.00	
		D-8	3.5	262.50	1,168.75
L-5e		980	3.5	297.50	
		HD-16	1.5	75.00	372.50
L-6		980	5.0	425.00	
		HD-16	3.25	162.50	587.50
L-7		980	10.5	892.50	
		HD-16	1.5	75.00	
		D-8	10.0	750.00	1,717.50
L-8		980*	33.0	2,805.00	
		HD-16	26.25	1,312.50	
	Excavate	D-8	18.0	1,350.00	
	Fill	D-8	3.5	262.50	5,730.00
L-9		980	18.5	1,572.50	
		HD-16	17.5	875.00	
		D-8	1.75	131.25	2,578.75
L-10		980	9.5	807.50	
		HD-16	10.5	525.00	1,332.50
L-11		980	3.5	297.50	
		HD-16	7.0	350.00	
					1,770.00
L-12		980	8.5	722.50	
		HD-16	8.0	400.00	
SUM TOTALS		980	125.75	\$10,688.75	
		HD-16	113.0	5,650.00	
		D-8	40.75	3,056.25	\$19,395.00

Landing L-8 was the most complex landing treated on the unit. Initially, the D-8 excavated as much material as possible until the ground became saturated. The hydraulic excavator and HD-16 then excavated additional yardage off the slope from a series of contoured tractor trails. The excavator would excavate from the lowest trail and pass the fill to the above road where the HD-16 would push it away. The failed portion of the landing which remained blocking the stream channel was excavated until an apparently stable layer of large organic debris was encountered.

After the slope was completed, I re-examined the configuration and decided the following day that additional excavation was needed. New contoured tractor trails were constructed and the entire surface was lowered an additional 3-4 feet. Wet ground conditions made it necessary for the excavator to handle the material at least twice in order to get it to dry ground so the HD-16 could remove it. The removed material was pushed away by the tractor and outsloped on a stable portion of the landing. As a final task, the excavator placed rock near the bottom of the slope to be placed by labor crews during the winter.

C-Line Landing #2 - The rehabilitation treatment on the C-Line landing #2 was to remove as much of the failing landing fill material as possible. The two constraints on this operations were: not to destabilize the C-Line Road itself; and all removed fill had to be end-hauled by dump truck to a small rock pit about 200 feet up the C-30 Road. One logistical problem during this operation was the shuttle bus to the Tall Trees Grove traveling through the center of the worksite. Constant caution and traffic direction had to be maintained to avoid vehicular accidents. However, much interest was shown by the visitors while viewing the rehabilitation heavy equipment in action.

The actual operation was relative straight-forward. The excavator removed fill from the edge of the landing and loaded it into dump trucks. The trucks took the material to the rock pit and the HD-16 tractor outsloped the cutbank of the rock pit. Table 10 shows the hours and costs involved in this operation.

A total of about 451 dump truck loads were removed or at an average of 7 cubic yards per load a total of 3,157 cubic yards. At about 1 ton per cubic yards this is about 3,157 tons or 6,314,000 pounds of weight removed from the landing.

While an additional dump truck could have increased the rate of excavation by the excavator, the negative effect of increased traffic probably would have offset any benefit. The other inefficient element in the operation was the HD-16 spreading fill in the rock pit. This was actually a part-time job, but was required at intervals throughout the day. No other additional work was available nearby to better utilize the equipment time.

Rock Distribution

One costly operation performed during the rehabilitation work was the distribution of rock armor to the various C-20 units work sites and other rehabilitation units. The total cost of this operation was \$19,478.87 of which

Table 10. C-LINE LANDING #2

Equipment	Hours	Cost	# of Dump Truck Loads
980	41.0	\$3,485.00	
HD-16	40.0	2,000.00	
K.P.-D.T. ¹	39.5	1,340.63	228
Move in/out	4.0	135.76	
D.R.-D.T. ²	39.5	1,303.50	223
Move in/out	4.0	132.00	
TOTALS		\$8,396.82 \$2.66 yd ³	451

¹K.P.-D.T. - \$33.95/hour.

²D.R.-D.T. - \$33.00/hour.

\$6,471.02 was charged to the C-20 unit (Table 11). Approximately 78 dump truck loads (8 cubic yards per load) or 624 cubic yards of rock were delivered to the unit. The total cost per yard was \$10.37. However, the actual cost of delivery was \$5,051 or \$8.11/yd³. The remaining \$1,410.03 was a proportion of the move in/move out costs and the standby costs incurred during the first day of operation (Table 11).

The rock distribution operation began with several problems. A front-end loader broke down several times in the first few hours. By noon, the loader became inoperable and the entire operation was shut down. However, total equipment cost for this day, which produced about six loads of rock was \$2,212.30. A replacement loader was brought in the following day by the contractor and a second loader was rented from a different contractor. This second loader (Cat 950; rubber-tired) was exceptionally good for loading the rock and extremely well operated. The first loader (Case W-18), and the replacement (Case W-20) were not as productive as the Cat 950, lacking weight and digging power.

Once the operation got underway, things went relatively smoothly, although two dump trucks which had been contracted were not available. Because of fewer dump trucks, the loaders had extended periods of waiting time between loading trucks. As in previous years, the rock delivery costs are high because of logistical problems, travel time, the relatively small volume of rock involved and the complications of trying to manage a large number of dump trucks going to a variety of places.

Labor Intensive Phase

The major task performed by labor crews on this unit was that of spreading straw mulch on the ground disturbed by the heavy equipment during rehabilitation. This was performed by Redwood National Park laborers, Redwoods United, Inc., personnel, and a youth group. Table 12 summarizes the person hours and costs for this operations. A variety of minor primary and secondary treatments were performed by RNP laborers, such as log jam removal below Rx-5, and rock distribution on Rx-1 and 2 are not shown.

In all a total of 15,76 acres were covered with straw mulch. Discounting the area worked by the youth group which was not a cost to the project, the total cost per acre was \$408.41/acre. Approximately half of the RNP laborers time was spent in distribution of straw. The cost of actually spreading the straw was about \$280/acre.

As in previous years, Redwoods United costs include transportation and travel time to the site, and a fixed percentage (18 percent) administrative charge. These costs are reflected in the cost per acre of the mulch spreading. However, Redwoods United remains the simplest method for mulch operation available to the park.

Table 11. ROCK PIT COSTS

Equipment	Hours	Trans. Cost	Cost
Loader W18/W20	33.5	\$475.00	\$2,083.00
CAT 950	50.5	514.50	3,140.50
DT 1	60.5	2.5 hrs	2,147.50
DT 2	50.5	3.0 hrs	1,775.00
DT 3	63.0	3.0 hrs	2,252.50
DT 4	61.0	3.0 hrs	2,074.50
DT 5	60.0	3.0 hrs	2,098.00
DT 6	52.0	3.0 hrs	
DT 7	59.0	3.0 hrs	3,903.85
Total Cost			\$19,474.84

Task	Cost		
6/30 equipment problems	\$2,212.30		
Transportation	1,690.92		
Lost time	340.00		
Rock Delivery To Units ¹ :	\$4,243.22		
C-30	5,329.92	%	
C-20	5,061.00	35%	C-30
D-Line	4,840.73	33%	C-20
		32%	D-Line
	\$19,474.87		
		Total Cost ¹ To Each Unit	
			\$6,814.62
			6,417.02
			6,189.23
			\$19,474.87

¹See Summary Reports of each unit for cost breakdown.

²Cost divided up proportional to each unit.

CONCLUSIONS

Conclusions

Prescription and Treatments

The prescriptions which were made and the treatments which were performed on this unit appear to have been appropriate for the erosion potentials as perceived. The worksites with the highest erosion potentials received the maximum treatment while worksites of moderate to low erosion potential received corresponding less degree of treatment. For example, worksites Rx-1, Rx-2 and L-8 had the highest erosion potential on the unit and received the maximum treatment. Worksites L-5w, L-7, L-9, Rx-5 and R-12 had moderate erosion potentials and received intermediate degree of treatment. The remaining worksites had lower erosion potentials and received minimum treatment.

Certain worksites probably received higher treatments than their erosion potential warranted. For example, the end of R-1, R-2 and DD-1, L-1 and L-2. This was because of the inexperience of the excavator operator during the early phase of work, a delay in the arrival of the D-8, and using the excavator and HD-16 on sites longer than prescribed while the D-8 completed work at major worksites (Rx-1 and Rx-2). Another area which may have received more treatment than the erosion potential warranted was worksites between R-5 and L-7. These worksites had slight to no erosion potential, but received slight outslowing and cross road drains. The treatments were prescribed however, with the factor of the areas high visibility from the C-Line shuttle bus route in mind. A similar section of road without high visitor visibility probably would have received less treatment.

Heavy Equipment Application

The types of heavy equipment and the tasks they were used to perform on the unit appear to have been, for the most part, appropriate. The hydraulic excavator remains the most versatile piece of equipment for most treatments. The track-mounting, 360 degree swing radius, and large bucket capacity makes the excavator most useful in steep terrain, on rough roads, and in restricted worksite locations. The excavator can remove stream crossings, move large organic debris, place channel armor, outslope road and landings, and excavate cross road drains.

The HD-16 tractor was used largely to assist the excavator and D-8 by removing and disposing of their excavated fill. As such, its medium size and weight and pushing capacity are necessary. While working with the excavator on stream crossings, the HD-16 could readily handle the rate of spoil (fill) produced. While the pair were doing slight outslowing the HD-16 spent some time waiting for sufficient spoil. When working with the D-8, the HD-16 could not keep up with the volume of spoil generated, especially where long pushing distances were involved. Overall, the HD-16 was probably under-utilized on the unit, except at the major worksites (Rx-1, 2, & 5; L-8).

A D-8 tractor on the unit could have been utilized more on the unit. It was not because this machine was in only fair condition and could not (or would not) be worked to its maximum capacity. On the worksites it was used at, it removed about the volume expected although more time was required than anticipated. A different D-8, in better condition and with a better operator, would probably have removed more volume in less time. However, because of the low hourly rental rate, the lack of D-8 ripper tractors availability, and the short time of use, it was decided to do as much of the most critical work as possible and then release the machine.

The one worksite where the equipment used on the site was deficient was at L-8. Because of the large volume of fill to be removed, the long slope distance involved, and the saturated ground conditions encountered, the excavator had to move the same fill several times to reach a dry enough location so that the tractors could push it away. A dragline crane would have been able to work this site much easier and probably would have removed more fill, more rapidly.

Labor Intensive Application

The only major labor intensive treatment on the unit was the spreading of straw mulch on ground disturbed by heavy equipment during rehabilitation work. The cost benefit of this treatment remains in question. From an erosional view the benefit is probably negligible. From a vegetative viewpoint, the benefits are not clear. Further definition of benefits are necessary to determine if the treatment should be continued.

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VEGETATION REPORT

REHABILITATION UNIT 82-2:
C-20 ROAD & SLOPE AND C-LINE LANDING #2

RESOURCE MANAGEMENT DIVISION
REDWOOD NATIONAL PARK

By
Bonnie C. Griffith

May 1983

Rehabilitation Site 82-2

Site Description

Rehabilitation Unit 82-2, C-20 Road and slope and C-Line Landing #2, is located on the East side of Redwood Creek basin (Fig. 1). The C-20 Road and slope is located in the Larson and Cloquet Creek drainages at an elevation range of 900 to 1200 feet with a WSW Aspect (Fig. 2). C-Line Landing #2 lies at the southern end of the Miller Creek drainage, one-half mile down-slope of the C-20/C-Line junction at an elevation of 1050 feet. The entire unit covers 1444 acres, of which 713 acres is uncut old growth redwood and Douglas-fir forest found down slope of the C-20. The C-20 Road was a major haul road for logging prior to park expansion. The slopes above the C-20, comprise the remaining 731 acres, which were tractor yarded from 1971 to 1974. The area below the road was cable yarded from 1975 to 1976 (Fig. 3).

Heavy equipment prescriptions rehabilitated 2.1 miles of road surface. This resulted in the removal of 3648 cubic yards of material from five haul road crossings (RX), excavation of seven skid trail crossings, outsloping of 12 landings and the outsloping of 6742 feet of road. To stabilize and prevent C-Line Landing #2 from turning into a sediment source, 3, 157 cubic yards of material was removed from the failing landing. A total of 15.8 acres of ground was disturbed, most of which was straw mulched (application rate of 4000 lbs/acre) to minimize surface runoff and enhance seedling development.

Soil Description

The soils of the C-20 Road and slope belong to two orders, Alfisols and Inceptisols. The Alfisols are primarily derived from shale and have profiles with brown clay loams over mottled, olive gray clays. These soils are somewhat poorly to moderately well drained and make up a major soil component in drainage areas. The Inceptisols are well drained and occur on ridges and uniform to convex slopes. These soils, derived from sedimentary rocks, range from brown loam to gravelly loam over light brown gravelly clay to clay loam.

Vegetation Description

Prior to logging, the C-20 unit supported an old growth redwood forest (*Sequoia sempervirens*) and its associates. These include *Pseudotsuga menziesii*, Douglas-fir; *Lithocarpus densiflora*, Tan bark-Oak; *Arbutus menziesii*, madrone; *Tsuga heterophylla*, Western hemlock; *Abies grandis*, grand fir; *Rhododendron macrophyllum*, California rose-bay; *Gautheria shallon*, salal; *Whipplea modesta*, Yerba de Selva; *Polystichum munitum*, sword fern; and *Vaccinium ovatum*, Californ huckleberry. In the drainages the slopes are dominated by *Alnus oregona*, red alder, *Salix* sp., willow; *Petasites palmatus*, Western Coltsfoot; and sword fern

The logging of west to southwest facing slopes exposed the understory to a warmer and drier environment. The species which now dominate the slopes reflect this change. In general, the vegetation of the yarded units is comprised of

second growth Douglas-fir, resprouting redwood and to a lesser extent second growth redwood. The two dominant shrubs species are Baccharis pilularis var. Consanguinea, coyote brush, and Ceanothus thyrsiflorus, Blue brush, intermixed with California rose bay, California huckleberry, and sword fern (in moist areas).

In general the vegetation directly adjacent to the road side is a mixture of second growth Douglas-fir, blue brush, and coyote brush. Logging has also increased the number of exotic species, i.e. Cortaderia selloana, Pampas grass and Cytisus scoparius, Scotch broom and the occurrence of some natives such as, Lupinus rivularis, Riverbank Lupine.

The vegetation immediately downslope of the C-Line Landing #2 is dominated by second growth Douglas-fir, resprouting redwood, coyote brush, pampas grass and alder and willow are found in the wet areas.

General Vegetation Prescription

The main objective of planting with conifers and shrubs is to accelerate the revegetation and the stabilization of rehabilitated slopes, haul roads, and crossings. Planting stock consisted of two-year, bareroot Douglas-fir (purchased from Arcata Lumber Company, Smith River), one-year, tubestock redwood (purchased from Simpson Lumber Company, Korbell), one-year, tubestock alder (purchased from Randy Stemler, Petrolia and grown by Simpson Lumber Company, Korbell), and coyote brush and Yerba de Selva (propagated by Randy Stemler, Petrolia).

Willow stem cuttings were utilized to line drainage areas on L-10, RX-5 and in a few wet areas. Willows were cut on site with a minimum diameter of 1/2 inch and length of 18-24 inches. At least half the length of the cuttings were pushed into the ground by hand or with the aid of a dibble. Laborers were instructed to orient the stem cuttings with nodes in the upright position. These areas will be monitored for survival.

Planting was accomplished between February 2 to 15, 1983 by RNP laborers and a Redwoods United, Inc. crew. Overall an average of three conifers was planted for every alder for the unit (Table 1). Alder, one to two foot spacings, was planted along channels of RX-1, RX-3, L-3, RX-5, L-10, R-11, SX-1 and SX-2. Side slopes of RX-1, RX-3, RX-5, SX-1 and SX-2 were planted with redwood on three foot spacings. A total of twelve hundred coyote brush seedlings were planted at two foot spacings on the side slopes of RX-1. At SX-1 and SX-2 Yerba de Selva on the side slopes were planted at 1 foot spacings. Most road reaches and landings were planted with Douglas-fir and redwood at eight to ten foot spacings. Planting of R-6, R-7, and R-9 was deferred due to narrowness of the outsloped area and the abundant seed source available from the surrounding area. In general most landings were planted with Douglas-fir, redwood and alder on eight to ten foot spacings. R-8 was treated with Douglas-fir and Coyote brush on eight foot spacings. L-6 was planted exclusively with Douglas-fir on eight foot spacings due to its WSW exposure.

C-Line Landing #2 was planted with 100 Douglas-fir and 80 redwood at 10 foot spacings and 50, 3 year red alder (acquired from Red Alder Bio-Assay Experiment Station, J; Plant Ecologist - RNP) at 15 foot spacings.

To evaluate the effects of fertilizer pellets and compost on one-year, tubestock redwood an experiment was established on February 2, 1983 on R-12 by Jim Popenoe, Plant Ecologist - RNP (See Appendix I).

On April 5, 1983 a study to determine the effects of slow release fertilizer tablets (20-10-5) on two-year, bareroot Douglas-fir was established at L-6. Fertilizer tablets were planted six to eight inches up slope from twenty-five trees. An additional twenty-five trees will serve as controls. Height and girth measurements were recorded for all trees.

Cost Analysis

Table 2 shows the cost for planting stock which amounts to 53% of the total cost of the vegetation prescription. Labor costs represent 47% of the total costs. Average cost per tree was \$0.38. An additional \$0.006 should be included in the total cost per tree for transportation of the seedlings to Orick Operations Center. Table 2 does not include the 60 hours (\$9.19/hour) required to map and execute the vegetation prescription for this site by the Biological Technician.

TABLE 2. PLANTING COST C-20 ROAD AND SLOPE

Average Unit Cost/Hour

Labor	Hours	Wage	Transportation	Administration	Average Cost/Hr.	Tot Cos
RNP Laborers	123	9.08 ¹	9.52			117
Redwoods United	172	5.68	7.58 ²	8.94 ³		153
Total	295					<u>270</u>
Total Average Cost/Hour		<u>7.10</u>	<u>8.39</u>		<u>9.18</u>	

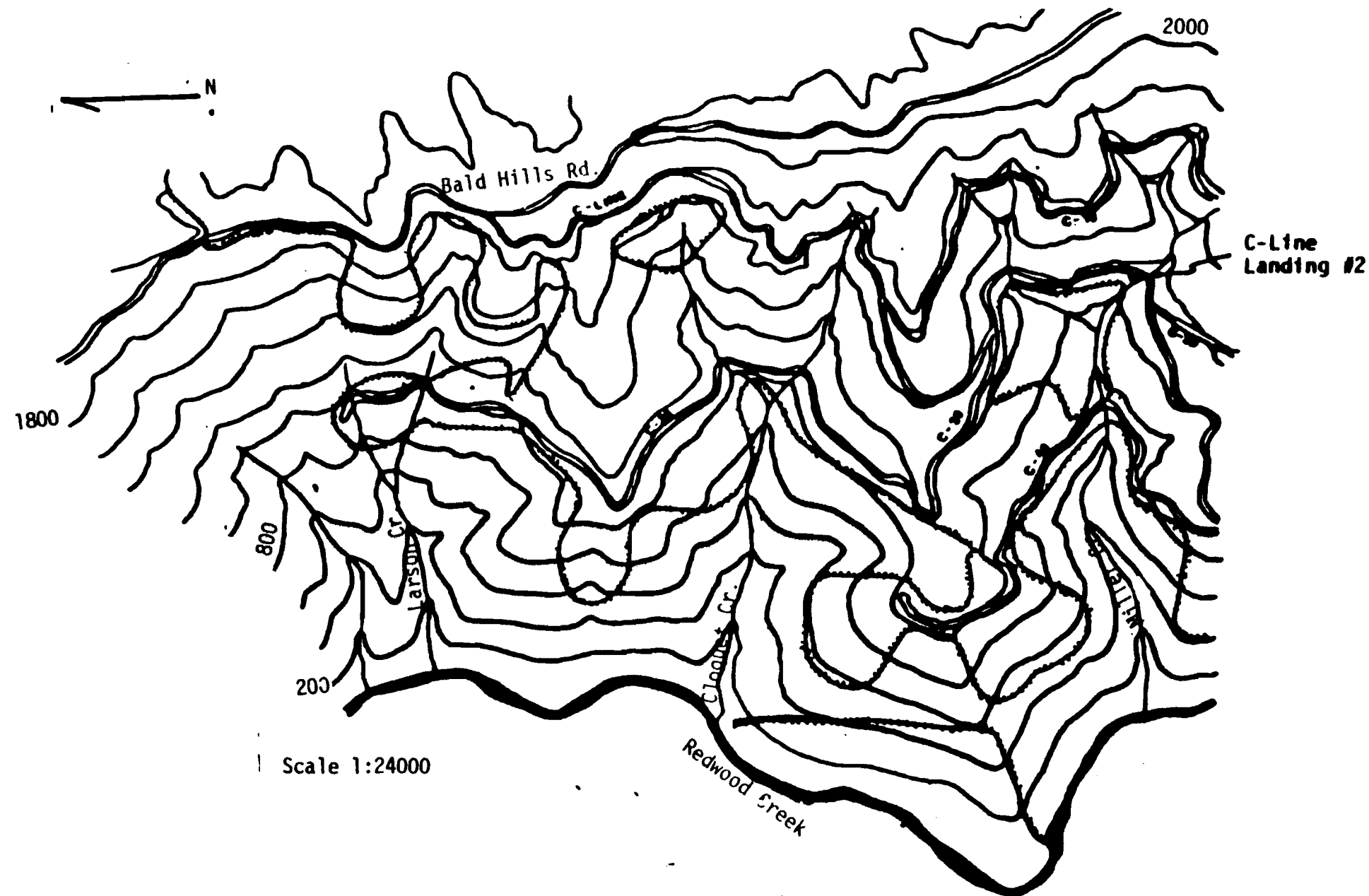
Plant Stock	Number Planted	Purchase Cost/Tree	
Douglas-fir	4249	.105	44
Redwood	4285	.15	64
Alder	2586	.30	77
Yerba de Selva	885	.48	42
Coyote brush	2100	.34	71
Total	<u>15186</u>		<u>300</u>
Average Cost/Plant		<u>.20</u>	
GRAND TOTAL			<u>571</u>
Average Cost/Hour			<u>19.36</u>
Total cost/Tree ⁴		<u>.38</u>	

- 1 Wages include 7% for government benefits.
- 2 \$50/day plus 2 hours overtime for driver.
- 3 18% Administration charge on wages plus transportation.
- 4 Average cost per tree including wages.

Figure 1. Location of Rehabilitation Site 82-2.



Figure 2. Rehabilitation Site 82-2: C-20 Road & Slope; C-Line Landing #2.



APPENDIX 1

FIELD EVALUATION OF FERTILIZER PELLETS AND COMPOST TO IMPROVE GROWTH OF REDWOOD TREES ON THE PULLED C-20 ROAD

Jim Popenoe
February 15, 1983

This experiment was established on February 2, 1983, on the pulled C-20 Road. The site is a gently NW-facing slope near the top of a ridge. The planting medium is mixed native C horizon, crushed saprolite and crushed bedrock with very little actual soil. The upsloped road was strawed. The experimental design is as follows:

Test plants are 1-0 redwoods. Alders are planted two feet away on the south side of each redwood with the objective of providing shade and fixed N after 2 to 3 years. The redwoods are protected by vexar tubes. Treatments are:

1. Control (Tag #s 301-325)
2. Fertilizer pellet (Tag #s 326-350)
3. Compost + fertilizer (Tag #s 351-368)
4. Topsoil + fertilizer (Tag #s 369-378)

The compost treatment consists of three 5 1/2" pots of compost mix (1/3 by volume compost with subsoil) placed in the planting hole.

The topsoil treatment consists of three 5 1/2" pots of soil collected from the surface 6" at sites in old growth redwood forest.

The height and girth of each tree was measured initially and will be measured again annually.

The control and fertilizer-pellet treatments are being duplicated also without the vexar tubes.

Bonnie Griffith and Dave Vezie are assisting on this project.

SUMMARY REPORT

REHABILITATION UNIT 82-2:
C-20 ROAD & SLOPE AND C-LINE LANDING #2

Resource Management Division
Redwood National Park

by
Kenneth W. Utley
W. David Burns
Paul E. Routon

February 1983

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TABLE OF CONTENTS

	<u>Page</u>
Introduction	1
Unit Description	1
Pre-Rehabilitation Road Conditions	1
Rehabilitation Work-Summary	3
Logging History	4
Geomorphology and Erosion Features	4
Geomorphology	4
Man-Induced Erosion Features	7
Erosion-Control Rehabilitation Work	9
Introduction	9
Procedures	9
Objectives	9
Heavy Equipment Phase	13
Heavy Equipment Application	13
Heavy Equipment Sequencing	16
Heavy Equipment Costs	16
Rock Distribution	24
Labor Intensive Phase	26
Conclusions	28
Conclusions	28
Prescription and Treatments	28
Heavy Equipment Application	28
Labor Intensive Application	29
References	30

LIST OF FIGURES

	<u>Page</u>
Figure 1. Location Map of Rehabilitation Unit 82-2	2
Figure 2. Logging History Map	5
Figure 3. Gemorphic Features Map	6

LIST OF TABLES

	<u>Page</u>
Table 1. Erosion Potential Summary	10
Table 2. Sequence of Events	12
Table 3. Summary Costs of Erosion-Control Work	14
Table 4. Summary of Heavy Equipment Types and Costs	15
Table 5. Summary of Average Heavy Equipment Costs	17
Table 6. Miscellaneous Heavy Equipment Costs	19
Table 7. Summary of Haul Road Crossings	20
Table 8. Road Reaches	22
Table 9. Landings	23
Table 10. C-Line Landing #2	25
Table 11. Rock Pit Costs	27

INTRODUCTION

Unit Description

Rehabilitation Unit 82-2: C-20 Road and slope, and C-Line landing #2, occurs on eastern slopes draining into Redwood Creek just downstream of the Tall Trees Grove (Fig. 1). The C-20 Road and slope section of the unit encompasses the upper slopes of Larson and Cloquet Creeks drainage basins. The C-Line landing #2 is located in the Miller Creek drainage basin about a half mile downslope of the C-20 area along the C-Line Road (Fig. 1). The rehabilitation work performed at the C-Line landing #2 was relatively minor and so was incorporated into the nearby C-20 work area.

The entire hydrologic area across which the C-20 Road traverses is about 1,444 acres, extending from Redwood Creek to the drainage divide along Bald Hills Road. Of this area approximately 713 acres are uncut, old growth forest (redwood and Douglas-fir), mostly downslope of the C-20 Road (Fig. 1). Of the 731 acres of cutover land, the 444 acres adjacent to the C-20 and below the C-Line were either treated or eliminated from further rehabilitation work.

Total relief is about 2,000 feet from Redwood Creek (100 feet) to Bald Hills Road (2,082 feet). The C-20 Road traversed the slopes dropping in elevation from about the 1,200 to 900 foot level to the north. Hillslopes are highly variable with most being moderately steep (20-50 percent) with localized steeper slope (100 percent or more) and gentle (0-20 percent) benches and ridges. Main stream channels are well incised while smaller ephemeral channels are only slightly incised.

Bedrock geology under the rehabilitation unit is exclusively Jurassic to Cretaceous Franciscan assemblage (Harden and other, 1981). From below the C-20 Road up to the divide, the predominate lithologies are incoherent to coherent, un-metamorphosed sandstones, siltstones and mudstones with discontinuous bedding (KJf1 and KJfc of Harden and others, 1981). Localized outcrops of sandy conglomerates occur upslope of the C-20 Road. Below these units, a zone of highly sheared, metamorphosed sandstone and mudstone occurs associated with the Grogan Fault zone (KJfg and Harden and others, 1981). On the lower hillslopes occur the schist of Redwood Creek (KJfr of Harden and others, 1981).

Localized colluvial deposits occur on benches and below more resistant ridges particularly where conglomerate exists. Along major ridges, thick well developed soils are present. Mass movement deposits and topography occur at several locations on the hillslopes. More detailed geomorphic descriptions of certain areas are given in a later section (Geomorphology and Erosion Features).

Pre-Rehabilitation Road Conditions

The C-20 Road was the major haul road access for timber harvest of the hillslopes prior to park expansion. The road was rocked and had inboard ditches. Culverts had been placed at major stream crossings, but most were undersized for the calculated runoff of a 25-year storm event. The road crossing of the mainstem of Cloquet Creek was a redwood log bridge.

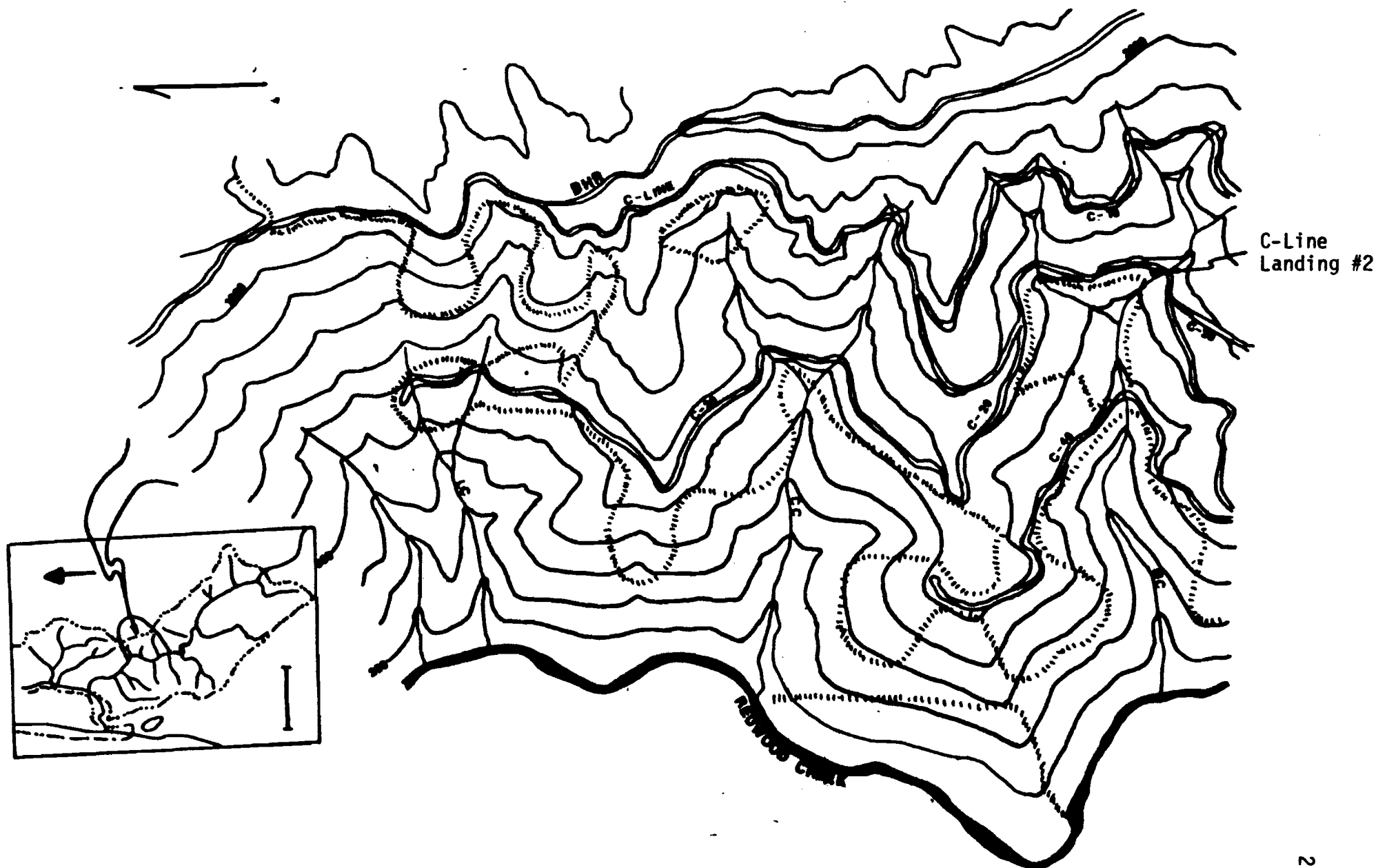


Figure 1. Location Map of Rehabilitation Unit 82-2, C-20 Road & Slope and C-Line Landing #2. Scale 1:24,000. Contour interval is 200 feet. Hatchured pattern defines limit of uncut forest. BHR = Bald Hills Road; CC = Cloquet Creek; LC = Larson Creek; MC = Miller Creek.

The road was passable in December 1981, although rough at an incipient road failure area (R-6; Plate 1), and at a six inch scarp across the road at a landing (L-3, Plate 1). The remainder of the road was in excellent condition with a few minor problems. Two incipient road failures with scarps less than six inches high occurred on separate road reaches (R-8 and R-9; Plate 1). At one, a small cutbank landslide had occurred partially blocking the road. The most northern end of the road was soft and appeared to have been ripped by the logging company. Also on this road reach (R-1; Plate 1) a major spring area draining down the road surface caused gradual failure of a portion of the outer edge of the road.

During the course of the winter (January-April 1982), the failure on road reach R-6 continued to slump, blocking the road. Scarp displacement at winters end was about 4-6 feet. Part of this activity was caused by a small debris slide down the cutbank which blocked an upslope road culvert causing the collected inboard ditch flow to drain onto the slump area. At landing L-3, scarp heightening blocked inboard ditch flow and caused ponding of water on the back side of the landing. This water drained across the landing in a shallow drain during major storm events and flowed subsurface the rest of the time. By winters end, the scarp had heightened to 3-4 feet.

C-Line landing #2 occurs at an elevation of about 1,050 feet and was perched about the south stem of Miller Creek (Fig. 1). The landing was constructed, along with others, along the C-Line during upslope tractor-yarded timber harvest in 1971. The landing had minor scarps across its surface prior to the winter of 1982. During the winter, which had higher precipitation than recent years, the scarps expanded to 2-3 feet in height. The landing was perched above a perennial stream and considered possible to cause slope stability problems which would enter sediment into the stream. Because of the proximity with the C-20 Road and slope area, the C-Line landing #2 was included within the work of that unit.

Rehabilitation Work - Summary

The purpose of the rehabilitation work on this unit was to examine, document, analyze, and, where possible, treat areas of erosion or potential erosion which had been caused or enhanced by land-use practices. Also, because of the units visibility to C-Line and the shuttle bus route to the Tall Trees Grove, the unit posed potential use as a demonstration of watershed rehabilitation techniques for park visitors.

The rehabilitation work on this unit removed 2.1 miles of the C-20 Road. This consisted of removing 3,648 cubic yards of material from 5 haul road crossings; excavating 7 skid trail crossings; outslowing and/or ditching 12 landings; and outslowing or cross-road draining 6,742 feet of road. The 15.3 acres of ground disturbed by the rehabilitation work was mulched with straw to protect against surface erosion and to enhance revegetation.

At the C-Line landing #2, 451 dump truck loads of material or 3,157 cubic yards were removed from the failing landing and used to outslope an old rock quarry.

Logging History

The logging of C-20 hillslopes occurred exclusively in the period 1971-1977 (Fig. 2). The C-Line was constructed sometime in the late 1960's. The C-20 Road was constructed to L-1 by 1973 and the large 1971-73 tractor yarded clearcut units above the road were completed. During construction of the road a several hundred foot wide area below the road alignment was logged apparently as a right-of-way. The road was extended to the north to the then existing park boundary probably in 1974, and the small, upslope tractor-yarded units harvested. The three cable-yarded clearcuts below the road were completed in 1975-76. The three cable-yarded clearcuts off the C-Line and at 'Devastation Point' were completed in 1975-77 (Fig. 2). Timber harvest was ceased in the area by the 1978 Park Expansion Act.

GEOMORPHOLOGY AND EROSIONAL FEATURES

Geomorphology

A number of interesting geomorphic features are exhibited on the hillslopes of the rehabilitation unit. These include: variation in hillslope morphology based on bedrock lithology; ancient, large-scale, mass movement features; and stream channel configurations.

Variation in Hillslope Morphology - One aspect of the hillslopes is that all three major bedrock lithologies of Redwood Creek basin occur within individual tributary hydrologic units. Along both Cloquet and Larson Creeks, the variation in hillslope morphology in response to bedrock type is discernable. The upper portion of the hillslopes are underlain by unmetamorphosed Franciscan sandstones and mudstone. Stream gradients, hillslopes, and stream channel sidebanks are steep. Main streams are well incised, infiltration is relatively high, and hillslopes are dry with little emergent ground water. The middle portion of the hillslope is underlain by highly sheared Franciscan associated with the Grogan Fault zone. Hillslopes and stream gradients are somewhat gentler. Stream channels are less incised, infiltration is low, and hillslopes are wetter from emerging groundwater. The lower hillslopes are underlain by schist of Redwood Creek. Hillslopes and stream gradients are gentle to moderately steep. Main streams are well incised, and the hillslope is probably wetter from emergent groundwater. However, most of these features are obscured by the remaining old growth forest on the lower hillslopes. The hillslopes therefore exhibit both the hillslope characteristics of the east side (unmetamorphosed Franciscan and sheared Grogan Fault zone) and the west side (schist terrain) of Redwood Creek drainage.

Ancient Mass Movement Features - Some of the most striking geomorphic features on the hillslope are interpreted to be ancient, inactive landslides or mass movement features. At least four large, inactive mass-movement features are discernable on the logged hillslopes (Fig. 3). Others may be present downslope hidden by the old growth forest. All of these features exhibit similar characteristics: an extremely steep (90 percent plus) upslope area interpreted as the headscarp below which a gentle (0-20 percent) bench. Below the top most bench a pattern of alternating steep slopes and benches extends downslope. This 'staircase' like topography has been termed in the park as "tread and riser".

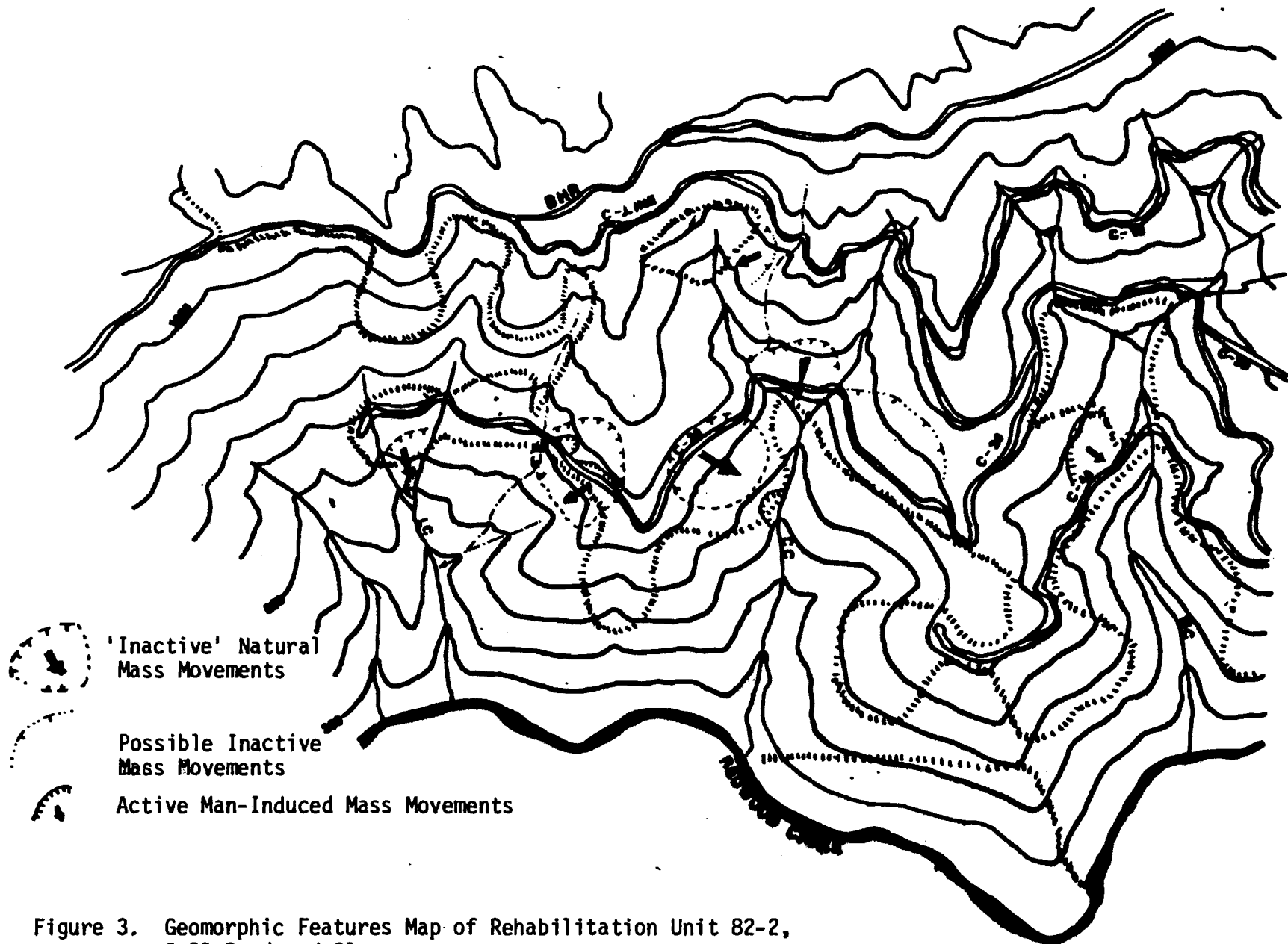


Figure 3. Geomorphic Features Map of Rehabilitation Unit 82-2,
C-20 Road and Slope.

At the downslope terminus, these features may end in an incised stream valley where large boulders may represent lag deposits which the stream is incapable of removing. Some features blend downslope into the general hillslope trend before reaching a main stream. Infrequently will bulbous 'toes' of these large mass-movements be preserved. I believe examples of each of these types of downslope terminus are present on this hillslope (Fig. 3).

I feel, the types of motion exhibited by mass movements was predominated by a slumping nature with some earth flowage or complex slumping/gliding occurring downslope. Additionally, the rate of movement on the features was probably very slow with activity occurring over several decades or possibly centuries. The age, duration, and specific details of these mass movements are not known, and detailed geomorphic studies would be required to answer these questions. None of the mass movements on the unit are noticeably active at present. However, local areas on some do show either present natural or man-induced activity (Fig. 3).

Stream Channel Configuration - Several unusual stream configurations exist on the units hillslopes. Possibly the most obvious are along a tributary to the north stem of Cloquet Creek (Fig. 3). The stream crosses the C-Line in a well-incised, narrow valley with a relative gradient. The stream appears to be graded across a more resistant channel location underlain by massive sandy conglomerate. The north drainage ridge separates the stream from a much steeper slope. The stream is now 'perched' topographically higher than the ground to one side of it.

Downstream the same channel steepens and becomes poorly incised as it flows down the presumed headscarp of one of the ancient mass movements. As the stream flows onto a bench below the presumed headscarp, the channel makes a sharp bend to flow into the north stem of Cloquet Creek. This stream reach is very poorly incised. Stream flow goes subsurface in the perched reach above the headscarp. Only during major storms does runoff appear to flow down the steep headscarp reach as evidenced by only minor erosion of skid trail crossings. The stream channel on the bench at the end of the headscarp reach shows little evidence of flow since timber harvest. However, several large springs occur downslope apparently fed by the subsurface stream flow. The interpretation for this directional change in the stream channel configuration is the capture of the stream along the headscarp of a mass movement at some time in the past.

Several other stream channel configurations present possible evidence of modification by past mass movements along the stems of Larson Creek although not as dramatically as the above. Also the configuration and density of tributaries to both Larson and Cloquet Creeks have anomalous arcuate patterns which need to be examined in greater detail in order to be explained.

Man-Induced Erosion Features

Unlike most logged hillslopes within the Redwood Creek area of the park, the units hillslopes have relatively few and these only minor, man-induced erosion features. The reasons for the lower degree of erosion are: lack of upslope roads causing drainage diversions and concentrations; smaller cut blocks; cable-yarded headwater regions; improved forest practices; few skid trail crossings of perennial streams; rapid revegetation; and most of the logged hillslope has undergone only one or two major storm events.

The 1971-1972 tractor-yarded units show the most man-induced erosion features. Particularly in the 1971 cut, little regard was shown for preserving ephemeral stream channels or maintaining drainage patterns. Waterbars were relatively few and poorly constructed. Numerous skid trail crossings of ephemeral drainages have totally destroyed the channels and excessive ground disturbance occurred. Fortunately, because of the small drainage areas, the main erosion features were a series of small gullies, and numerous rills on skid trails. Rapid conifer regrowth has healed most of these problems and the slope features are mostly inactive.

A similar pattern is seen on the large 1972-1973 tractor-yarded cut areas: drainage disruption by skid trails; small rills and gullies; and eroded skid trail crossings. The forest practices used on these hillslopes were somewhat better than on the 1971 cut. Most incised ephemeral drainages were avoided as much as possible, sidecast into the channels were minimal, and the amount of ground disturbance was less than older practices. However, poorly defined ephemeral drainages were mostly ignored and little regard for drainage patterns observed. This was particularly noticeable at the northern end of the large cut unit where past movements had obscured surface drainage patterns. Additionally, nearly all of the waterbars on these cut units were improperly constructed. Most were made simply as a dam across the skid trails with no thought for drainage off the trail. As a result many breached causing minor gullying and rilling.

The younger tractor units at the end of the C-20 Road and the various cable-yarded units caused little erosion because of their size, location or time in relation to major storms.

A main erosional problem on the unit was the style of construction of the C-20 Road. A broad 100 yard wide right of way was logged downslope of the road and little care was paid to this area in terms of skid trail location and drainage patterns preservation. Additionally, numerous large decks or landings were constructed along the road. Skid trails concentrated water towards these landings and decks, but no effort was made to allow water to drain across. While many landings posed no erosional threat, several (L-8, 9 and 3; Plate 1) eroded or were predicted to become sediment sources.

The most poorly located section of road along the C-20 was that between L-3 and L-5 (Fig. 3; Plate 1). This section traverses across large, inactive mass movement feature and locally steep slopes. Ephemeral streams crossing the road were either not identified or ignored during construction. Hillslopes above the road were tractor clearcut logged before road construction and complete destruction of the subtle drainage patterns resulted. The incoherent mass movement material, steep slopes, disrupted drainages, and high cutbanks resulted in gradual road failure and cutbank slumping. Because of the size of the feature and the fact that little of the failing material could enter stream channels, minimal rehabilitation work was done on this area. However future continual slumping may cause the ultimately disturbed area to be quite large. The possibility exists that a portion of the older, larger mass movement may become reactivated because of the logging of this hillslope and road construction.

While the actual erosion which had and was occurring on this unit was minimal, the potential erosional impact for several areas was deemed high. Table 1 summarizes the potential erosion predicted for the major work sites (Plate 1).

EROSION-CONTROL REHABILITATION WORK

Introduction

Procedures

The method of approach to the rehabilitation work passes through four sequential phases: evaluation, heavy equipment, labor intensive, and winter maintenance phase. The evaluation phase begins with the selection of the hillslopes and roads which will be encompassed within the general unit. This is followed by reconnaissance aerial-photograph interpretation, and field surveys of road conditions and erosional problems. Detailed field mapping of geomorphic, erosional, and land use features is then accomplished during the winter rainy months. Included in this phase period is the evaluation of erosion potential at possible worksites. The final portion of the evaluation phase performed in the spring is the prescription of treatments to be performed to reduce erosion, remove sediment sources and correct drainage patterns. This includes identifying worksites, formulating a sequence of work, and documenting pre-work conditions by establishing photo-point locations. At this point a projection of cost is made, and the proposed prescriptions are reviewed in the field with other Redwood National Park geologists. Questions, problems, and discussions from this field review are resolved and a finalized prescription plan is made. From this plan, a cost projection is made and required heavy equipment rentals are procured.

The heavy equipment phase involves performing the actual erosion-control work on the unit. Partially concurrent with this is the labor intensive phase of erosion-control work performed by labor crews. These phases take place in the summer to early fall dry season. The winter maintenance phase is the follow-up work performed in the fall and early winter to correct developing problems from the first storms. Post heavy-equipment measurements are made to determine volumes of excavated fill and disturbed ground, and the taking of post-rehabilitation photo-documentation. Also included is the analysis of work performed and the writing of a summary report. Table 2 summarizes this unit's work.

Objectives

Although the C-20 Road and slope unit did not have any major active sediment sources, the potential for future erosion at various sites was considered very high. The isolation of areas by road failures, declining road maintenance, and major storm events would probably cause major sediment sources to develop in the future. One main objective of the rehabilitation work was to remove the large erosion potential associated with the two large stream crossings which had become isolated by road failure at R-6 (Plate 1). Also considered significant was correction of diverted spring flow causing road slumping along R-1 (Plate 1).

Table 1. EROSION POTENTIAL SUMMARY

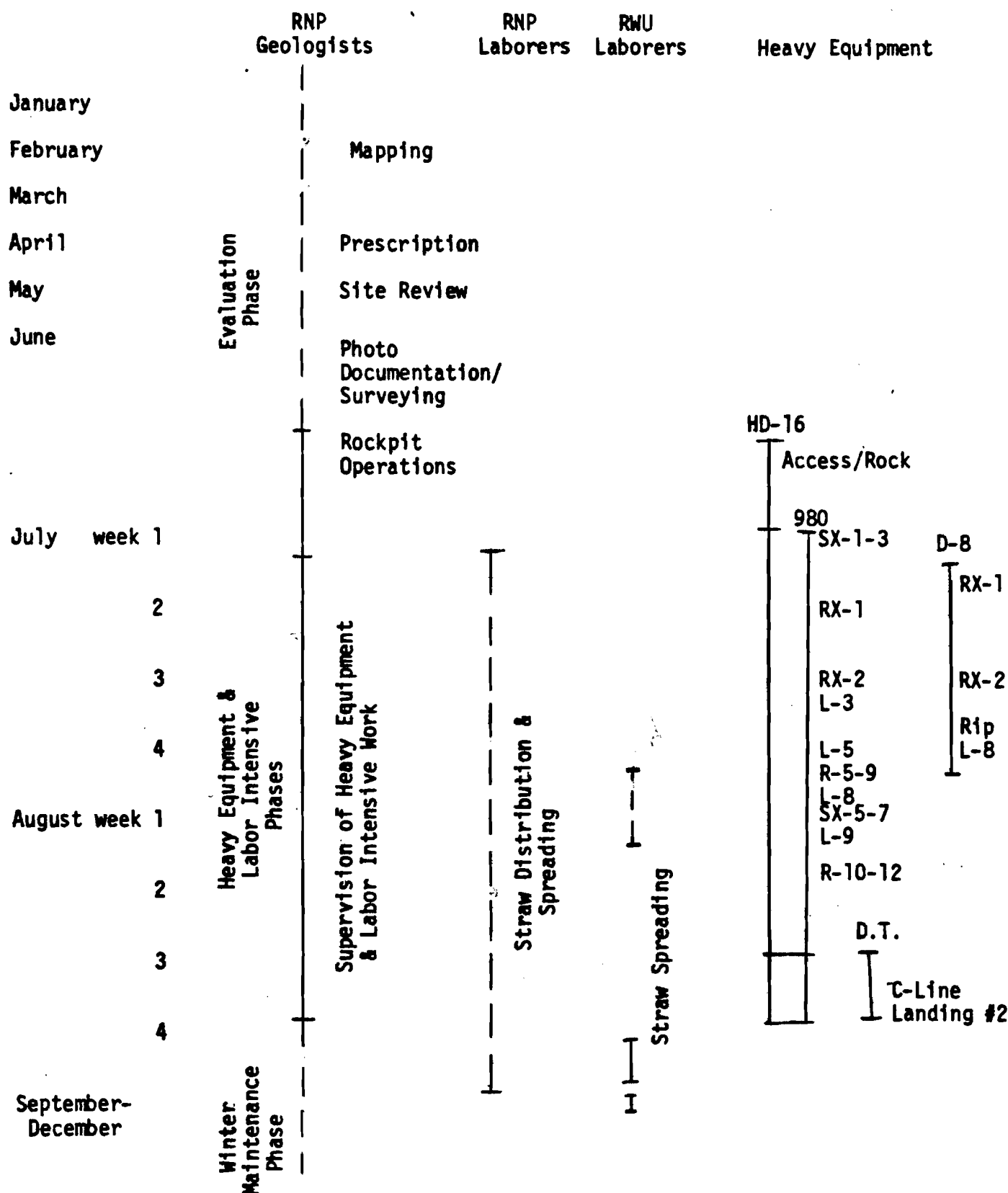
<u>Worksite</u>	<u>Erosion Potential Index</u>	<u>Erosion Potential Description</u>
R-1	Low-moderate	Possible slope stability problems; may evolve into mass movement sediment source by spring diversion.
Rx-1	Moderate; (1000 yd ³ +) Moderate-high diversion potential	Culvert failure; possible diversion of channel within local drainage area; erosion of fill and natural ground.
R-2	Low-moderate	Low potential most of reach, except where perched above channel of Rx-2.
L-1	Low	Possible debris slide of outer edge into stream channel; ground disruption likely.
Rx-2	Moderate-high (1000+) high diversion potential	Erosion of fill probable; channel diversion probable with gullying erosion and cutbank failure (2000+)
R-3	None-slight	
L-2	Slight	Continued ground disruption; no sediment generated.
R-4	None	Inboard ditch concentration; slight rilling or gullying.
Rx-3	Moderate-high (200+) high diversion potential	Culvert failure; possible diversion onto R-4; erosion could be considerable.
L-3	Unknown	Continued failure may cause sediment delivery to stream, diversion of Rx-3 onto area or toe possible.
R-5	Slight	
L-4	Unknown	Continued failure; ground disruption; sediment generated may be localized
R-6	Unknown	Continued failure; some sediment generated to streams.
R-7	Slight	Failure likely; possibly little sediment generated to streams.
L-5	High	L-5w may fail by debris torrent down steep headwater, cable-yarded area below; large sediment probable.
R-8	None to slight	
L-6	None to slight	
R-9	None to slight	

Table 1. EROSION POTENTIAL SUMMARY - cont'd

<u>Worksite</u>	<u>Erosion Potential Index</u>	<u>Erosion Potential Description</u>
L-7	Moderate-high	Partial failure into stream likely.
Rx-4	Slight	Bridge approach collapse gradual; bridge collapse long-term feature.
L-8	High-extreme	Failure of landing fill directly into stream has occurred and will continue in future (2000+ yd ³).
R-10	None to slight	
L-9	Moderate	Partial failure into stream probable.
Rx-5	Moderate - no diversion potential	Culvert failure; fill erosion.
L-10	Slight	Landing failure, no - little sediment generated.
R-11	Slight	
L-11	Moderate	Landing failure, ground disruption, some sediment generation.
Rx-6	Slight - no diversion potential	Fill erosion.
L-12	Slight	Landing failure, ground disruption.
R-12	High	Road fill failure by debris avalanching probable; questionable sediment generation; high ground disturbance.

TABLE 2. SEQUENCE OF EVENTS, REHABILITATION UNIT 82-2

C-20 Road & Slope/C-Line Landing #2



Dashed Lines = Part time work on unit
 Solid Lines = Full time work on unit

The highly disrupted road section between L-3 and L-5 (Plate 1) was decided to be untreatable due to the scale of the mass movement, and pose little actual or potential sediment threat. The objective in this area was to eliminate drainage diversions caused by the road, and to allow the mass movement to evolve naturally.

Another major objective of the rehabilitation work was to eliminate or minimize the erosion potential associated with continued failure of the large volumes of fill at landing L-7 and L-8 (Plate 1). Also, removal of the large volumes of fill at stream crossing Rx-5 and L-9 was deemed necessary. The high potential for debris sliding along R-12 warranted treatment by road outslipping.

The removal of several small, but eroding skid trail crossings (Sx-1-4; Plate 1) on ephemeral drainages was considered beneficial. Skid trail crossings removal (Sx-5-7) and waterbar construction was desirable in an area of poorly defined drainage and potential stream diversion.

The remainder of the C-20 Road was considered to pose only minor erosion potential, although its removal as a hydrologic barrier was considered appropriate. The prescribed treatment for most of the road was slight outslipping and cross road draining to remove the road as a hydrologic barrier and to lessen the road as a visual scar. Also, the interpretive value of the road removal to visitors along C-Line was considered highly desirable. Panoramic photographs before, during, and after rehabilitation work were taken for future information stops.

At the C-Line landing #2, the main objective was to attempt to stabilize the failing landing from evolving into a sediment source. The prescription was to remove as much of the perched landing material as possible to decrease the loading of the hillslope. A limit on the prescription was not to cause failure of the C-Line Road, or to narrow it to an unsafe width. If the landing area continues to fail, at least the removed volume could not be eroded and therefore decrease the potential size of the sediment source.

Finally, one general objective on the unit was to reduce erosion or potential erosion so as to minimize the sediment load which could effect the relatively undisturbed lower reaches of the streams passing through the old growth forests.

Cost Summary - Table 3 summarizes the costs involved in performing the erosion control rehabilitation work on this unit. As in previous years the major expenditure was on heavy equipment to perform the actual erosion-control work. Labor-intensive, secondary treatment work has been greatly reduced from previous years.

Heavy Equipment Phase

Heavy Equipment Application

Three pieces of heavy equipment performed all of the rehabilitation work on this unit: one crawler tractor with rippers (D-8), a crawler tractor with winch (HD-16C) and a hydraulic excavator (980B). Several rubber-tired loaders and a fleet of dump trucks were used to load and transport the rock for channel protection treatment. Two dump trucks were used during the excavation of the C-Line landing #2. Table 4 summarizes the equipment specifications, cost and hours.

Table 3. SUMMARY COSTS OF EROSION-CONTROL WORK, REHABILITATION UNIT 82-2,
C-20 ROAD & SLOPE AND C-LINE LANDING #2

		RNP Geologists	RNP Laborers	Heavy Equipment Rental	Redwoods United	Total Task Costs	% Grand Total	Phase Total	Phase %
EVALUATION PHASE	Mapping	\$4,846.40 ¹				\$4,846.40 ✓	5.0%		
	Prescription	2,582.40 ¹				2,582.40	3.0%	\$7,428.80	8.0%
HEAVY EQUIPMENT PHASE	Primary Treatment	10,277.28 ^{1,2} ✓		\$52,495.64		62,772.92	71.0%		
	Secondary Treatment			7,667.27 ³		7,667.27	9.0%	73,935.19	84.0%
	Miscellaneous			3,495.00 ⁴		3,495.00	4.0%		
LABOR INTEN- SIVE COSTS	Secondary Treatment	1,141.92 ¹ ✓	\$3,567.20		\$2,117.81	6,826.93	8.0%	6,826.93	8.0%
	Miscellaneous								
	TOTALS	\$18,848.00 ✓	\$3,567.20	\$63,657.91	\$2,117.81				
	% of GRAND TOTAL	21.4%	4.0%	72.2%	2.4%	\$88,190.92 - GRAND TOTAL			

¹ Estimated cost.

² Covers all of heavy equipment.

³ \$6,476.02 rock acquisition costs.

⁴ Includes move in/move out costs.

Table 4. SUMMARY OF HEAVY EQUIPMENT TYPES AND COSTS
REHABILITATION UNIT 82-2

Equipment Type	Owner/ Operator	Make/ Model	Year	Rate/ Hour	Total Hours
Hydraulic excavator	Kjers/Charles Giannini	Case 980B w/1 1/4 yd ³ bucket	1980	\$85.00	318.0
Crawler tractor	W.W. Stockton	Allis Chalmers HD-16C	1973	\$50.00	341.5
Crawler tractor	Dutra/ Tom Robert	Caterpillar D-8H 46A w/rippers	1968	\$75.00	122.5
Dump truck	Keith Parker	International/G.M.C.	1959	\$33.94	43.5
Dump truck	Diamond R Logging/ Danny Nunes	International	1963	\$33.00	43.5

On this unit, the D-8 tractor was used to do the initial excavation of fill from the larger haul road crossings and at landing L-8. The D-8 tractor outsloped road reach R-7 entirely and did some preliminary work on several landings. Also the D-8 tractor ripped the entire road and all landing surfaces.

The hydraulic excavator was used to complete the larger haul-road crossings and to excavate the smaller road crossings and skid trail crossings. The excavator also did much of the road outsloping by removing the outboard edge of the road so that the HD-16 could complete the outsloping. The excavator also pulled back the edge of all the landings and constructed the drainage ditches across them. All of the rock armor was placed by the excavator at the several worksites which received rock. At C-Line landing #2, the excavator removed all of the material from the landing and loaded it into dump trucks.

The HD-16 tractor supported both the D-8 and 980 by removing and spreading fill which they were excavating. The HD-16 also finished outsloping the roads and the landings. Some skid trail crossings were excavated exclusively by the HD-16. Additionally, the HD-16 would open up access routes and construct trails for the 980.

Heavy Equipment Sequencing

The sequencing of heavy equipment use was straight forward on the unit. Work began on the sequence of skid trail crossing Sx-1-4 and then moved to the end of the C-20 Road (R-1). Work then progressed out the road with the excavator and HD-16 outsloping the road and landings as the D-8 excavated the larger crossings to the maximum extent. The excavator and HD-16 then completed the crossing as the D-8 ripped the next length of road to the next major worksite. Initially, this posed some problems as the excavator and HD-16 caught up with the D-8 working on a crossing, and they would have to be moved to a landing to work. After the initial week or so this resolved itself as the D-8 got far enough ahead.

With the departure of the D-8, the excavator and HD-16 completed the road from Rx-4 to the end of R-12 by themselves. Once the C-20 Road was complete, the two pieces of equipment walked down the C-Line to the C-Line landing #2.

Heavy Equipment Costs

Table 5 summarizes the average cost of heavy equipment for the treatment performed on the rehabilitation unit. Primary treatment costs are those entailed in removing potentially erodible material from stream crossings and landings, and restoring drainage patterns by outsloping roads and constructing drainage channels. Secondary treatment costs are those entailed in protecting stream channel excavations with rock armor. Because the secondary treatment on this site was limited, the cost of placing rock armor is incorporated within the primary treatment tasks on Table 5, but all secondary treatments are summed at the bottom.

Table 5. SUMMARY OF AVERAGE HEAVY EQUIPMENT COSTS

Treatment	# of	Total Quantity	Total Cost	Avg. Cost/ Worksite	Avg. Cost/ Quantity	Range In Cost Quantity
Haul Road ₁ Crossings	6	3,648 yd ³	\$10,568.75	\$1,761.46	\$2.88/yd ³	\$1.31-2.96/yd
Skid Trail Crossings	7	790 yd ³	\$3,291.25	\$470.18	\$4.17/yd ³	\$1,061.25-42.50/each
Road Reaches	12	6,742 l.f.	\$9,045.00	\$753.75	\$1.34/l.f. \$7,083.59/mi.	\$.66-3.93/l.f.
Landings	12	--	\$19,395.00	\$1,616.25	--	\$135-5,730/each
Rip Roads	--	6,742 l.f. 15.6 Acre	\$2,062.50	\$.31/l.f. \$132.21/Acre	--	--
Deep Dishes	3	--	\$932.50	\$310.83	--	--
C-Line Landing #2	--	3,157 yd ³	\$8,396.89	\$2.66/yd	--	--
Miscellaneous	--		\$3,495.00			
Rock Acquisition		624 yd ³	\$6,471.02	\$10.37.yd ³		

	<u>Cost</u>	<u>% of Total H.E Costs</u>
Total Primary Treatment Cost	\$52,495.64	82.5%
Total Secondary Treatment Costs	\$7,667.27	12.0%
Total Miscellaneous Costs ²	\$3,495.00	5.5%
TOTAL HEAVY EQUIPMENT COSTS	<u>\$63,657.91</u>	

¹Includes excavation (primary treatment) and rock placement (secondary treatment; not cost of rock acquisition. 17

²See Table 6 for miscellaneous cost breakdown.

Miscellaneous costs include a variety of small primary and secondary treatment tasks, access clearance, move in and out costs, and several others. See Table 6 for a detail listing of various elements of miscellaneous costs.

Haul Road Crossings - Table 7 shows the costs for the treatment of haul road crossings. Excluding rock delivery cost, Rx-1 and 2 accounts for 79.5 percent of the cost. At both of these crossings, part of the cost was the necessity of pushing fill several hundred feet along the road and around a bend to a stable location away from the stream channel. This required both tractors to work together during initial excavations. At Rx-1 both tractors and the excavator were working simultaneous on the operation. At both stream crossings the cost of rock delivery was several times the cost of rock placement. The main problems at both of these crossings were: the limited work space; the depth of excavation; lack of storage space immediately adjacent to the crossings; and all fill had to be removed in one direction.

The remaining haul road crossings were insignificant with the exception of Rx-5. This was a broad, gentle channel with space for the tractors to remove fill and with spoil locations immediately adjacent. The lower cost per cubic yard is a reflection of the ease of this excavation.

Road Reaches - Table 8 shows the cost of road removal on the unit. The wide range in costs (\$.66-\$3.93/lin.ft.) reflect variations in the degree of treatment and the equipment used. For slight outsloping with drains by the excavator and HD-16, the cost range is \$0.66-\$1.59 for seven road reaches. For moderate outsloping with drains by excavator and Hd-16, the costs are \$2.14 and \$3.93/linear foot. For complete outsloping by D-8, the cost on the one road reach was \$0.81/linear foot.

The main objective in the treatment of road reaches was to remove the hydrologic barrier formed by the inboard ditch and road surface. It was decided that slight outsloping in combination with cross road drains for wetter locations would meet this objectives and be the least expensive. One additional factor for slight outsloping was the extensive regrowth of young (1/2 - 8 foot) conifers on the outer edge of the road and on the cutbank. More extensive outsloping was deemed unnecessary hydrologically and excessively destructive to the existing regrowth. Alternatively, simple cross-road drain construction was considered not as desirable hydrologically because of maintaining the inboard ditch and resulting concentration of runoff. In addition, the lack of fine grained material on the rock road surface might inhibit vegetative regrowth.

Landings - The treatment of landings was the largest individual expenditure on the unit (Table 9). However of the \$19,395 spent in treating 12 landings, \$8,308.75 or 42.8 percent of the total was spent on landings L-8 and L-9 (Table 9). These two landings had high erosion potential. Landing L-3 had a large drainage ditch constructed across it in an attempt to stabilize the landing failure. L-5w was perched above steep slopes and had potential for debris-flow failure. L-7 was perched above the major stream of Cloquet Creek and was deemed a potential sediment source. L-10, 11 and 12, had less erosion potential but required large or multiple drains constructed to direct flow across them.

Table 6. MISCELLANEOUS HEAVY EQUIPMENT COSTS

Task	Equipment	Hours	Cost	Total Cost
Waterbar construction	980	.75	\$63.75	\$238.75
	HD-16	3.5	175.00	
Moving	980	2.25	191.25	278.75
	HD-16	1.0	50.00	
	D-8	.5	37.50	
Road access - D-Line	HD-16	5.0	250.00	950.00
	C-30	5.0	250.00	
	C-20	9.0	450.00	
Safety	980	1.0	85.00	135.00
	HD-16	1.0	50.00	
Downtime	980	.5	42.50	67.50
	HD-16	.5	25.00	
Misc. lost time	980	.5	42.50	67.50
	HD-16	.5	25.00	
Rock access	HD-16	15.0	750.00	800-
Straw	HD-16	1.0	50.00	
Sum total:	980	5.0	425.00	✓ 2,537.50
	HD-16	41.5	2,075.00	
	D-8	.5	37.50	
Move In/Out Costs:				
Move in/out to Cal-Pac	980		168.75	957.50
Move in/out to Cal-Pac	HD-16		232.50	
Move in	D-8		293.75	
Out to Redwood Creek	D-8		112.50	
Move out	D-8		150.00	
TOTAL MISCELLANEOUS HEAVY EQUIPMENT COST:				\$3,495.00

Table 7. SUMMARY OF HAUL ROAD CROSSINGS

Worksite	Task	Equipment	Hours	Cost	Task Total	% of Total Site Cost	Cost/ Yd ³
Rx-1 (1304 yd ³)	Excavate	D-8	18.5	\$1,387.50			
	Excavate	980	12.25	1,041.25	\$2,428.75		
	Fill	HD-16	21.5	1,075.00			
	Fill	D-8	5.0	375.00	1,450.00		
	Primary Treatment Cost				\$3,875.00	53%	\$2.97
	Rock placement	980	8.25	701.25			
	Rock placement	D-8	1.5	112.50	813.75		
	Rock delivery				2,654.78		2.66
	Secondary Treatment Cost				\$3,468.53	47%	\$13.55
	Total Cost Rx-1				\$7,343.53		
Rx-2 (1441 yd ³)	Excavate	D-8	17.0	\$1,275.00			
	Excavate	980	16.0	1,360.00	\$2,635.00		
	Fill	HD-16	18.25	912.50	912.50		
	Primary Treatment Cost				\$3,547.50	56%	\$2.46
	Rock placement	980	2.0	170.00	\$170.00		
	Rock delivery				2,654.78		
	Secondary Treatment Cost				\$2,824.78	44%	
	Total cost Rx-2				\$6,372.28		\$4.42
Rx-3 (120 yd ³)	Excavate	980	2.0	170.00			
	Excavate & fill	HD-16	1.75	87.50	\$257.70		
	Primary Treatment Cost				\$257.50		\$2.15

Table 7. SUMMARY OF HAUL ROAD CROSSINGS

Worksite	Task	Equipment	Hours	Cost	Task Total	% of Total Site Cost	Cost/Yd ³
Rx-4	Excavate	980	3.0	\$255.00	\$255.00		
				Primary Treatment Cost	\$255.00		
Rx-5 (583 yd ³)	Excavate	D-8	5.75	\$431.25			
	Excavate	980	6.5	552.50			
	Excavate & fill	HD-16	8.0	400.00	\$1,383.75		
				Primary Treatment Cost	\$1,383.75		\$2.37
Rx-6 (200 yd)	Excavate	980	2.5	\$212.50			\$1.31
	Excavate & fill	HD-16	1.0	50.00	\$262.50		
				Primary Treatment Cost	\$262.50		
SUMMARY -		<u>Equipment</u>	<u>Hours</u>	<u>Primary Treatment</u>	<u>Secondary Treatment</u>	<u>Equipment Cost</u>	
		980	52.5	\$3,591.25	\$871.25	\$4,462.50	
		HD-16	50.5	2,525.00		2,525.00	
		D-8	47.75	3,468.75	112.50	3,581.25	
		Heavy Equipment Total Cost		\$9,585.00	\$983.75	\$10,568.75	
		Rock delivery cost			\$5,309.56	\$5,309.56	
		TOTALS		\$9,585.00	\$6,293.31	\$15,878.31	
		% of TOTAL		60%	40%		

Table 8. ROAD REACHES

Site	Treatment	Equipment	Hours	Cost	Road Length (L.F.)	Cost/ L.F.
R-1	Moderate O.S. w/drains	980 HD-16	13.5 18.0	\$2,047.50	521	\$3.03
R-2	Fillsite/Moderate O.S.	980 HD-16	7.5 8.5	1,062.50	502	\$2.12*
R-3	Fillsite	980 HD-16	4.0 3.0	490.00	492	\$1.00*
R-4	Slight O.S. w/drains	980 HD-16	2.5 3.25	375.00	526	\$0.71
R-5	Slight O.S. w/drains	980 HD-16	3.0 3.0	405.00	330	\$1.23
R-6	Slight O.S. w/drains	980 HD-16	3.5 4.5	522.50	330	\$1.58
R-7	Complete O.S.	D-8	5.0	375.00	462	\$0.81
R-8	Slight O.S. w/drains	980 HD-16	5.0 4.5	650.00	954	\$0.68
R-9	Slight O.S. w/drains	980 HD-16	2.0 2.0	270.00	409	\$0.66
R-10	Slight O.S. w/drains	980 HD-16 D-8	1.0 1.75 1.0	247.50	317	\$0.78
R-11	Slight O.S. w/drains	980 HD-16	7.0 4.0	795.00	501	\$1.59
R-12	Moderate O.S. w/drains	980 HD-16	13.0 14.0	1,805.00	845	\$2.14
SUM TOTAL		980 HD-16 D-8	620 665 6.0	\$5,270.00 \$3,325.00 \$450.00		
TOTAL				\$9,045.00		

*Disregard Cost/L.F. - fillsites from road crossings.

Table 9. LANDINGS

Site	Treatment	Equipment	Hours	Cost	Total Cost
L-1		980	8.5	\$722.50	
		HD-16	12.5	625.00	\$1,347.50
L-2		980	3.0	255.00	
		HD-16	5.5	275.00	
		D-8	4.0	300.00	830.00
L-3	Ditch	980	8.5	722.50	
	Rock placement	980	2.5	212.50	
	Outslope	980	4.0	340.00	
		HD-16	11.0	550.00	1,825.00
L-4		980	1.0	85.00	
		HD-16	1.0	50.00	135.00
L-5w		980	6.25	531.25	
		HD-16	7.5	375.00	
		D-8	3.5	262.50	1,168.75
L-5e		980	3.5	297.50	
		HD-16	1.5	75.00	372.50
L-6		980	5.0	425.00	
		HD-16	3.25	162.50	587.50
L-7		980	10.5	892.50	
		HD-16	1.5	75.00	
		D-8	10.0	750.00	1,717.50
L-8		980*	33.0	2,805.00	
		HD-16	26.25	1,312.50	
	Excavate	D-8	18.0	1,350.00	
	Fill	D-8	3.5	262.50	5,730.00
L-9		980	18.5	1,572.50	
		HD-16	17.5	875.00	
		D-8	1.75	131.25	2,578.75
L-10		980	9.5	807.50	
		HD-16	10.5	525.00	1,332.50
L-11		980	3.5	297.50	
		HD-16	7.0	350.00	
					1,770.00
L-12		980	8.5	722.50	
		HD-16	8.0	400.00	
SUM TOTALS		980	125.75	\$10,688.75	
		HD-16	113.0	5,650.00	
		D-8	40.75	3,056.25	\$19,395.00

Landing L-8 was the most complex landing treated on the unit. Initially, the D-8 excavated as much material as possible until the ground became saturated. The hydraulic excavator and HD-16 then excavated additional yardage off the slope from a series of contoured tractor trails. The excavator would excavate from the lowest trail and pass the fill to the above road where the HD-16 would push it away. The failed portion of the landing which remained blocking the stream channel was excavated until an apparently stable layer of large organic debris was encountered.

After the slope was completed, I re-examined the configuration and decided the following day that additional excavation was needed. New contoured tractor trails were constructed and the entire surface was lowered an additional 3-4 feet. Wet ground conditions made it necessary for the excavator to handle the material at least twice in order to get it to dry ground so the HD-16 could remove it. The removed material was pushed away by the tractor and outsloped on a stable portion of the landing. As a final task, the excavator placed rock near the bottom of the slope to be placed by labor crews during the winter.

C-Line Landing #2 - The rehabilitation treatment on the C-Line landing #2 was to remove as much of the failing landing fill material as possible. The two constraints on this operations were: not to destabilize the C-Line Road itself; and all removed fill had to be end-hauled by dump truck to a small rock pit about 200 feet up the C-30 Road. One logistical problem during this operation was the shuttle bus to the Tall Trees Grove traveling through the center of the worksite. Constant caution and traffic direction had to be maintained to avoid vehicular accidents. However, much interest was shown by the visitors while viewing the rehabilitation heavy equipment in action.

The actual operation was relative straight-forward. The excavator removed fill from the edge of the landing and loaded it into dump trucks. The trucks took the material to the rock pit and the HD-16 tractor outsloped the cutbank of the rock pit. Table 10 shows the hours and costs involved in this operation.

A total of about 451 dump truck loads were removed or at an average of 7 cubic yards per load a total of 3,157 cubic yards. At about 1 ton per cubic yards this is about 3,157 tons or 6,314,000 pounds of weight removed from the landing.

While an additional dump truck could have increased the rate of excavation by the excavator, the negative effect of increased traffic probably would have offset any benefit. The other inefficient element in the operation was the HD-16 spreading fill in the rock pit. This was actually a part-time job, but was required at intervals throughout the day. No other additional work was available nearby to better utilize the equipment time.

Rock Distribution

One costly operation performed during the rehabilitation work was the distribution of rock armor to the various C-20 units work sites and other rehabilitation units. The total cost of this operation was \$19,478.87 of which

Table 10. C-LINE LANDING #2

Equipment	Hours	Cost	# of Dump Truck Loads
980	41.0	\$3,485.00	
HD-16	40.0	2,000.00	
K.P.-D.T. ¹	39.5	1,340.63	228
Move in/out	4.0	135.76	
D.R.-D.T. ²	39.5	1,303.50	223
Move in/out	4.0	132.00	
	TOTALS	\$8,396.82	451
		\$2.66 yd ³	

¹K.P.-D.T. - \$33.95/hour.

²D.R.-D.T. - \$33.00/hour.

\$6,471.02 was charged to the C-20 unit (Table 11). Approximately 78 dump truck loads (8 cubic yards per load) or 624 cubic yards of rock were delivered to the unit. The total cost per yard was \$10.37. However, the actual cost of delivery was \$5,051 or \$8.11/yd³. The remaining \$1,410.03 was a proportion of the move in/move out costs and the standby costs incurred during the first day of operation (Table 11).

The rock distribution operation began with several problems. A front-end loader broke down several times in the first few hours. By noon, the loader became inoperable and the entire operation was shut down. However, total equipment cost for this day, which produced about six loads of rock was \$2,212.30. A replacement loader was brought in the following day by the contractor and a second loader was rented from a different contractor. This second loader (Cat 950; rubber-tired) was exceptionally good for loading the rock and extremely well operated. The first loader (Case W-18), and the replacement (Case W-20) were not as productive as the Cat 950, lacking weight and digging power.

Once the operation got underway, things went relatively smoothly, although two dump trucks which had been contracted were not available. Because of fewer dump trucks, the loaders had extended periods of waiting time between loading trucks. As in previous years, the rock delivery costs are high because of logistical problems, travel time, the relatively small volume of rock involved, and the complications of trying to manage a large number of dump trucks going to a variety of places.

Labor Intensive Phase

The major task performed by labor crews on this unit was that of spreading straw mulch on the ground disturbed by the heavy equipment during rehabilitation. This was performed by Redwood National Park laborers, Redwoods United, Inc., personnel, and a youth group. Table 12 summarizes the person hours and costs for this operations. A variety of minor primary and secondary treatments were performed by RNP laborers, such as log jam removal below Rx-5, and rock distribution on Rx-1 and 2 are not shown.

In all a total of 15.76 acres were covered with straw mulch. Discounting the area worked by the youth group which was not a cost to the project, the total cost per acre was \$408.41/acre. Approximately half of the RNP laborers time was spent in distribution of straw. The cost of actually spreading the straw was about \$280/acre.

As in previous years, Redwoods United costs include transportation and travel time to the site, and a fixed percentage (18 percent) administrative charge. These costs are reflected in the cost per acre of the mulch spreading. However, Redwoods United remains the simplest method for mulch operation available to the park.

Table 11. ROCK PIT COSTS

Equipment	Hours	Trans. Cost	Cost
Loader W18/W20	33.5	\$475.00	\$2,083.00
CAT 950	50.5	514.50	3,140.50
DT 1	60.5	2.5 hrs	2,147.50
DT 2	50.5	3.0 hrs	1,775.00
DT 3	63.0	3.0 hrs	2,252.50
DT 4	61.0	3.0 hrs	2,074.50
DT 5	60.0	3.0 hrs	2,098.00
DT 6	52.0	3.0 hrs	
DT 7	59.0	3.0 hrs	3,903.85
Total Cost			\$19,474.84

Task	Cost		
6/30 equipment problems	\$2,212.30		
Transportation	1,690.92		
Lost time	340.00		
Rock Delivery To Units ¹ :	\$4,243.22		
		Total Cost ¹ To Each Unit	
C-30	5,329.92	%	
C-20	5,061.00	35% C-30	\$6,814.62
D-Line	4,840.73	33% C-20	6,417.02
		32% D-Line	6,189.23
	\$19,474.87		\$19,474.87

¹See Summary Reports of each unit for cost breakdown.

²Cost divided up proportional to each unit.

CONCLUSIONS

Conclusions

Prescription and Treatments

The prescriptions which were made and the treatments which were performed on this unit appear to have been appropriate for the erosion potentials as perceived. The worksites with the highest erosion potentials received the maximum treatment while worksites of moderate to low erosion potential received corresponding less degree of treatment. For example, worksites Rx-1, Rx-2 and L-8 had the highest erosion potential on the unit and received the maximum treatment. Worksites L-5w, L-7, L-9, Rx-5 and R-12 had moderate erosion potentials and received intermediate degree of treatment. The remaining worksites had lower erosion potentials and received minimum treatment.

Certain worksites probably received higher treatments than their erosion potential warranted. For example, the end of R-1, R-2 and DD-1, L-1 and L-2. This was because of the inexperience of the excavator operator during the early phase of work, a delay in the arrival of the D-8, and using the excavator and HD-16 on sites longer than prescribed while the D-8 completed work at major worksites (Rx-1 and Rx-2). Another area which may have received more treatment than the erosion potential warranted was worksites between R-5 and L-7. These worksites had slight to no erosion potential, but received slight outslloping and cross road drains. The treatments were prescribed however, with the factor of the areas high visibility from the C-Line shuttle bus route in mind. A similar section of road without high visitor visibility probably would have received less treatment.

Heavy Equipment Application

The types of heavy equipment and the tasks they were used to perform on the unit appear to have been, for the most part, appropriate. The hydraulic excavator remains the most versatile piece of equipment for most treatments. The track-mounting, 360 degree swing radius, and large bucket capacity makes the excavator most useful in steep terrain, on rough roads, and in restricted worksite locations. The excavator can remove stream crossings, move large organic debris, place channel armor, outslope road and landings, and excavate cross road drains.

The HD-16 tractor was used largely to assist the excavator and D-8 by removing and disposing of their excavated fill. As such, its medium size and weight and pushing capacity are necessary. While working with the excavator on stream crossings, the HD-16 could readily handle the rate of spoil (fill) produced. While the pair were doing slight outslloping the HD-16 spent some time waiting for sufficient spoil. When working with the D-8, the HD-16 could not keep up with the volume of spoil generated, especially where long pushing distances were involved. Overall, the HD-16 was probably under-utilized on the unit, except at the major worksites (Rx-1, 2, & 5; L-8).

A D-8 tractor on the unit could have been utilized more on the unit. It was not because this machine was in only fair condition and could not (or would not) be worked to its maximum capacity. On the worksites it was used at, it removed about the volume expected although more time was required than anticipated. A different D-8, in better condition and with a better operator, would probably have removed more volume in less time. However, because of the low hourly rental rate, the lack of D-8 ripper tractors availability, and the short time of use, it was decided to do as much of the most critical work as possible and then release the machine.

The one worksite where the equipment used on the site was deficient was at L-8. Because of the large volume of fill to be removed, the long slope distance involved, and the saturated ground conditions encountered, the excavator had to move the same fill several times to reach a dry enough location so that the tractors could push it away. A dragline crane would have been able to work this site much easier and probably would have removed more fill, more rapidly.

Labor Intensive Application

The only major labor intensive treatment on the unit was the spreading of straw mulch on ground disturbed by heavy equipment during rehabilitation work. The cost benefit of this treatment remains in question. From an erosional viewpoint, the benefit is probably negligible. From a vegetative viewpoint, the benefits are not clear. Further definition of benefits are necessary to determine if the treatment should be continued.

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VEGETATION REPORT

REHABILITATION UNIT 82-2:
C-20 ROAD & SLOPE AND C-LINE LANDING #2

RESOURCE MANAGEMENT DIVISION
REDWOOD NATIONAL PARK

By
Bonnie C. Griffith

May 1983

Rehabilitation Site 82-2

Site Description

Rehabilitation Unit 82-2, C-20 Road and slope and C-Line Landing #2, is located on the East side of Redwood Creek basin (Fig. 1). The C-20 Road and slope is located in the Larson and Cloquet Creek drainages at an elevation range of 900 to 1200 feet with a WSW Aspect (Fig. 2). C-Line Landing #2 lies at the southern end of the Miller Creek drainage, one-half mile down-slope of the C-20/C-Line junction at an elevation of 1050 feet. The entire unit covers 1444 acres, of which 713 acres is uncut old growth redwood and Douglas-fir forest found down slope of the C-20. The C-20 Road was a major haul road for logging prior to park expansion. The slopes above the C-20, comprise the remaining 731 acres, which were tractor yarded from 1971 to 1974. The area below the road was cable yarded from 1975 to 1976 (Fig. 3).

Heavy equipment prescriptions rehabilitated 2.1 miles of road surface. This resulted in the removal of 3648 cubic yards of material from five haul road crossings (RX), excavation of seven skid trail crossings, outsloping of 12 landings and the outsloping of 6742 feet of road. To stabilize and prevent C-Line Landing #2 from turning into a sediment source, 3, 157 cubic yards of material was removed from the failing landing. A total of 15.8 acres of ground was disturbed, most of which was straw mulched (application rate of 4000 lbs/acre) to minimize surface runoff and enhance seedling development.

Soil Description

The soils of the C-20 Road and slope belong to two orders, Alfisols and Inceptisols. The Alfisols are primarily derived from shale and have profiles with brown clay loams over mottled, olive gray clays. These soils are somewhat poorly to moderately well drained and make up a major soil component in drainage areas. The Inceptisols are well drained and occur on ridges and uniform to convex slopes. These soils, derived from sedimentary rocks, range from brown loam to gravelly loam over light brown gravelly clay to clay loam.

Vegetation Description

Prior to logging, the C-20 unit supported an old growth redwood forest (*Sequoia sempervirens*) and its associates. These include *Pseudotsuga menziesii*, Douglas-fir; *Lithocarpus densiflora*, Tan bark-Oak; *Arbutus menziesii*, madrone; *Tsuga heterophylla*, Western hemlock; *Abies grandis*, grand fir; *Rhododendron macrophyllum*, California rose-bay; *Gautheria shallon*, salal; *Whipplea modesta*, Yerba de Selva; *Polystichum munitum*, sword fern; and *Vaccinium ovatum*, California huckleberry. In the drainages the slopes are dominated by *Alnus oregona*, red alder, *Salix* sp, willow; *Petasites palmatus*, Western Coltsfoot; and sword fern.

The logging of west to southwest facing slopes exposed the understory to a warmer and drier environment. The species which now dominate the slopes reflect this change. In general, the vegetation of the yarded units is comprised of

second growth Douglas-fir, resprouting redwood and to a lesser extent second growth redwood. The two dominant shrubs species are Baccharis pilularis var. Consanguinea, coyote brush, and Ceanothus thyrsiflorus, Blue brush, intermixed with California rose bay, California huckleberry, and sword fern (in moist areas).

In general the vegetation directly adjacent to the road side is a mixture of second growth Douglas-fir, blue brush, and coyote brush. Logging has also increased the number of exotic species, i.e. Cortaderia selloana, Pampas grass and Cytisus scoparius, Scotch broom and the occurrence of some natives such as, Lupinus rivularis, Riverbank Lupine.

The vegetation immediately downslope of the C-Line Landing #2 is dominated by second growth Douglas-fir, resprouting redwood, coyote brush, pampas grass and alder and willow are found in the wet areas.

General Vegetation Prescription

The main objective of planting with conifers and shrubs is to accelerate the revegetation and the stabilization of rehabilitated slopes, haul roads, and crossings. Planting stock consisted of two-year, bareroot Douglas-fir (purchased from Arcata Lumber Company, Smith River), one-year, tubestock redwood (purchased from Simpson Lumber Company, Korbelt), one-year, tubestock alder (purchased from Randy Stemler, Petrolia and grown by Simpson Lumber Company, Korbelt), and coyote brush and Yerba de Selva (propagated by Randy Stemler, Petrolia).

Willow stem cuttings were utilized to line drainage areas on L-10, RX-5 and in a few wet areas. Willows were cut on site with a minimum diameter of 1/2 inch and length of 18-24 inches. At least half the length of the cuttings were pushed into the ground by hand or with the aid of a dibble. Laborers were instructed to orient the stem cuttings with nodes in the upright position. These areas will be monitored for survival.

Planting was accomplished between February 2 to 15, 1983 by RNP laborers and a Redwoods United, Inc. crew. Overall an average of three conifers was planted for every alder for the unit (Table 1). Alder, one to two foot spacings, was planted along channels of RX-1, RX-3, L-3, RX-5, L-10, R-11, SX-1 and SX-2. Side slopes of RX-1, RX-3, RX-5, SX-1 and SX-2 were planted with redwood on three foot spacings. A total of twelve hundred coyote brush seedlings were planted at two foot spacings on the side slopes of RX-1. At SX-1 and SX-2 Yerba de Selva on the side slopes were planted at 1 foot spacings. Most road reaches and landings were planted with Douglas-fir and redwood at eight to ten foot spacings. Planting of R-6, R-7, and R-9 was deferred due to narrowness of the outsloped area and the abundant seed source available from the surrounding area. In general most landings were planted with Douglas-fir, redwood and alder on eight to ten foot spacings. R-8 was treated with Douglas-fir and Coyote brush on eight foot spacings. L-6 was planted exclusively with Douglas-fir on eight foot spacings due to its WSW exposure.

C-Line Landing #2 was planted with 100 Douglas-fir and 80 redwood at 10 foot spacings and 50, 3 year red alder (acquired from Red Alder Bio-Assay Experiment, Popenoe, J; Plant Ecologist - RNP) at 15 foot spacings.

To evaluate the effects of fertilizer pellets and compost on one-year, tubestock redwood an experiment was established on February 2, 1983 on R-12 by Jim Popenoe, Plant Ecologist - RNP (See Appendix I).

On April 5, 1983 a study to determine the effects of slow release fertilizer tablets (20-10-5) on two-year, bareroot Douglas-fir was established at L-6. Fertilizer tablets were planted six to eight inches up slope from twenty-five trees. An additional twenty-five trees will serve as controls. Height and girth measurements were recorded for all trees.

Cost Analysis

Table 2 shows the cost for planting stock which amounts to 53% of the total cost of the vegetation prescription. Labor costs represent 47% of the total costs. Average cost per tree was \$0.38. An additional \$0.006 should be included in the total cost per tree for transportation of the seedlings to Orick Operations Center. Table 2 does not include the 60 hours (\$9.19/hour) required to map and execute the vegetation prescription for this site by the Biological Technician.

TABLE 2. PLANTING COST C-20 ROAD AND SLOPE

<u>Average Unit Cost/Hour</u>						
Labor	Hours	Wage	Transportation	Administration	Average Cost/Hr.	Total Cost
RNP Laborers	123	9.08 ¹	9.52			1170.69
Redwoods United	172	5.68	7.58 ²	8.94 ³		1537.51
Total	295					<u>2708.20</u>
Total Average Cost/Hour		<u>7.10</u>	<u>8.39</u>		<u>9.18</u>	

Plant Stock	Number Planted	Purchase Cost/Tree	
Douglas-fir	4249	.105	446.15
Redwood	4285	.15	642.75
Alder	2586	.30	775.80
Yerba de Selva	885	.48	424.00
Coyote brush	2100	.34	714.00
Total	<u>15186</u>		<u>3002.70</u>
Average Cost/Plant		<u>.20</u>	

GRAND TOTAL		<u>5710.90</u>
Average Cost/Hour		<u>19.36</u>
Total cost/Tree ⁴	<u>.38</u>	

1 Wages include 7% for government benefits.

2 \$50/day plus 2 hours overtime for driver.

3 18% Administration charge on wages plus transportation.

4 Average cost per tree including wages.

TABLE. 1. REHABILITATION SITE 82-2: VEGETATION PRESCRIPTION

Worksite	Acreage	Douglas- Fir	Redwood	Alder	Coyote Brush	Yerba de Selva	Willows
R-1	.52						
RX-1 Rt	.14				900		
Lt	.14						
R-2	.79	700	765	440**			
L-1	.53						
RX-2 to L-2	.50						
L-2	.59						
R-4	.3						
RX-3	.07						
L-3	.36	800	800				
R-5 to L-5	1.20			500			
L-5	1.02						
R-8	.79	308			1200		
L-6	.57	300					
R-9	.29	N/T					
L-7	1.15	350	300				
Skid to/includes SX-1 and SX-2	.63	245	250	250**		840	
RX-4	Bridge	N/T					
L-8	1.03	350					
R-10	.41	200		**			
L-9 to RX-5 (Rt)	1.03	200		**			*
RX-5 (Lt) to L-10	.4	300	1887	1240**			*
L-10	.6			**		45	*
R-11	.49	70		**			
L-11	.28	124					
L-11 to L-12	.21	50					
L-12	.3	100	100				
R-12	1.0	52	103				
Subtotal	15.34			156	2100	885	
C-Linelanding #2	.43	100	80	50 ¹			
Total	15.77	4249	4285	2586	2100	885	

R - Road Reach

RX - Road Crossing

L- Landing

SX - Stream Crossing

* - Willow Stem cuttings

** - Alder planted at channels and crossings
1 - 2' spacings

N/T - No treatment

1 - 3-year alder from Bio-Assay Experiment

Figure 1. Location of Rehabilitation Site 82-2.

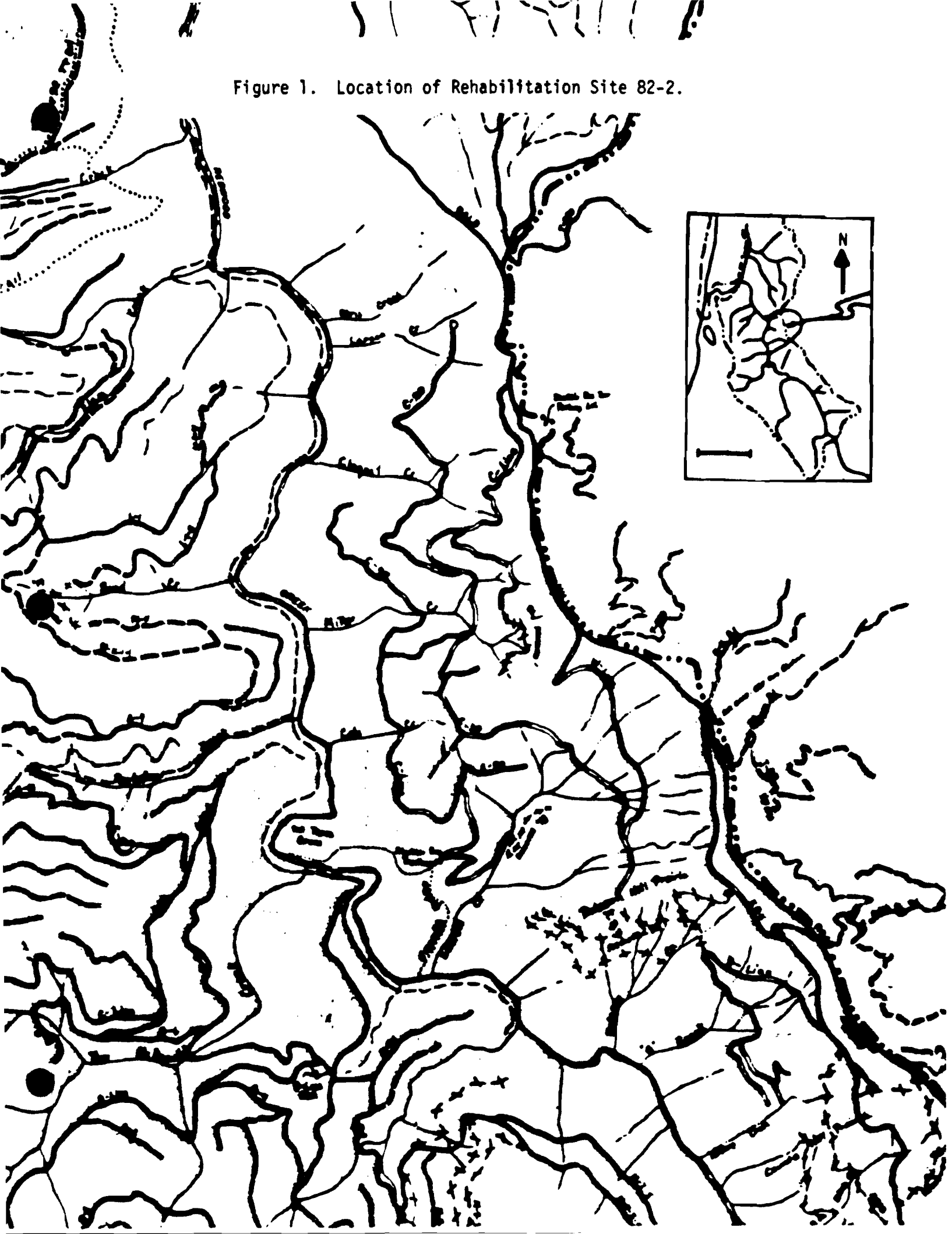
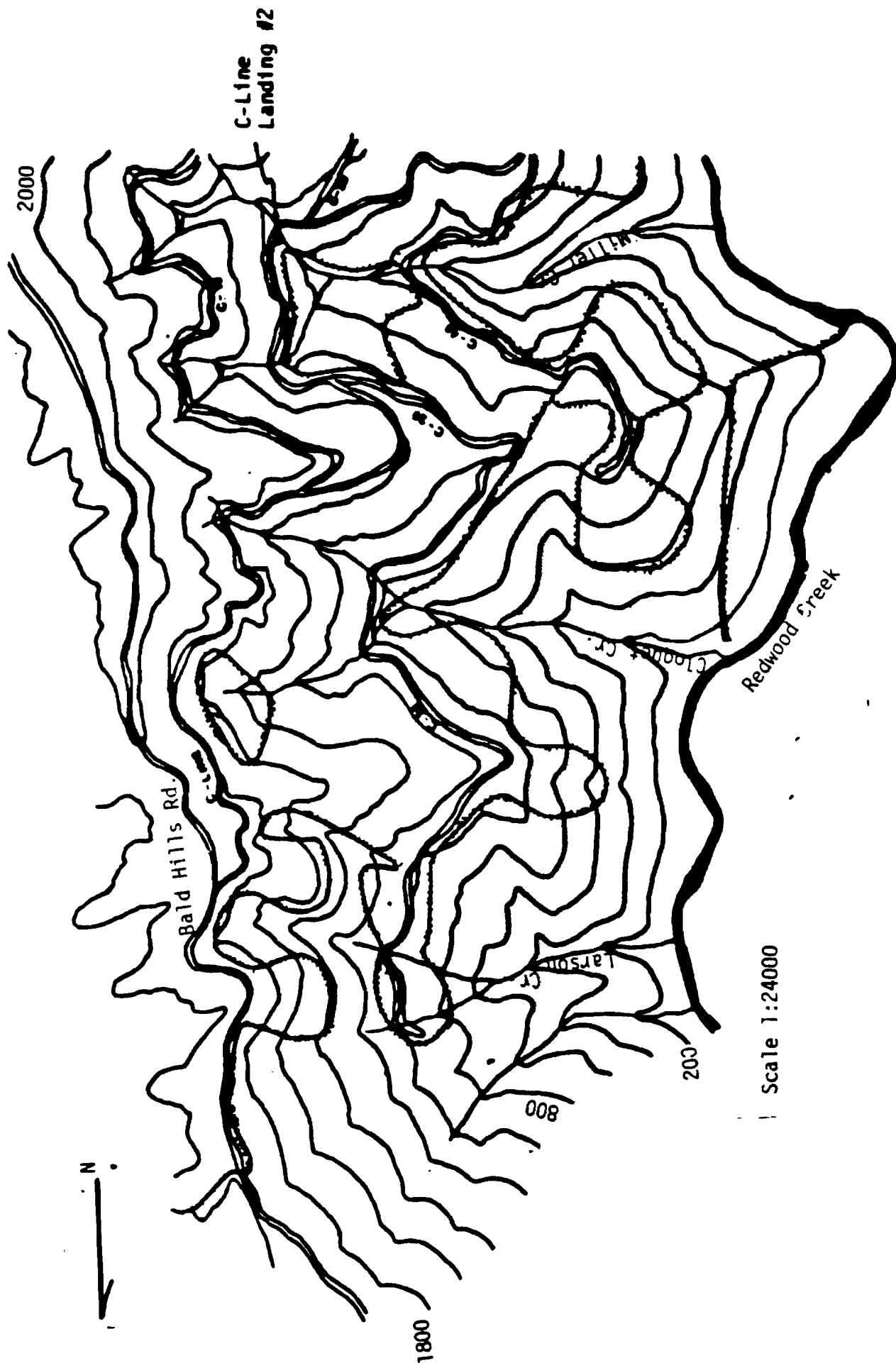


Figure 2. Rehabilitation Site 82-2: C-20 Road & Slope; C-Line Landing #2.



APPENDIX 1

FIELD EVALUATION OF
FERTILIZER PELLETS AND COMPOST
TO IMPROVE GROWTH OF REDWOOD TREES
ON THE PULLED C-20 ROAD

Jim Popenoe
February 15, 1983

This experiment was established on February 2, 1983, on the pulled C-20 Road. The site is a gently NW-facing slope near the top of a ridge. The planting medium is mixed native C horizon, crushed saprolite and crushed bedrock with very little actual soil. The outsloped road was strawed. The experimental design is as follows:

Test plants are 1-0 redwoods. Alders are planted two feet away on the south side of each redwood with the objective of providing shade and fixed N after 2 to 3 years. The redwoods are protected by vexar tubes. Treatments are:

1. Control (Tag #s 301-325)
2. Fertilizer pellet (Tag #s 326-350)
3. Compost + fertilizer (Tag #s 351-368)
4. Topsoil + fertilizer (Tag #s 369-378)

The compost treatment consists of three 5 1/2" pots of compost mix (1/3 by volume compost with subsoil) placed in the planting hole.

The topsoil treatment consists of three 5 1/2" pots of soil collected from the surface 6" at sites in old growth redwood forest.

The height and girth of each tree was measured initially and will be measured again annually.

The control and fertilizer-pellet treatments are being duplicated also without the vexar tubes.

Bonnie Griffith and Dave Vezie are assisting on this project.



Unit: 82-2 1-A 6/16/82 PP#21B Pre H.E. W.D.B.



Unit: 82-2 1-B 11/1/82 PP#21B Post H.E. W.D.B.



Unit: 82-2 2-A 6/16/82 PP#28 Pre H.E. W.D.B.



Unit: 82-2 2-B 11/1/82 PP#28 Post H.E. W.D.B.



Unit: 82-2 2-C 8/16/82 PP#28 G.M.L.