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SUMMARY OF EROSION-CONTROL REHABILITATION WORK

UNIT 81-1

NORTH COPPER CREEK AND MANEZE PRAIRIE

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INTRODUCTION

Unit Description

Rehabilitation Unit 81-1, North Copper Creek and Maneze Prairie, is located near the southern boundary of the Redwood Creek Unit of Redwood National Park (Fig. 1). The unit encompasses the northern slopes of the drainage basin of Copper Creek, a large perennial tributary flowing westward to Redwood Creek. These hillslopes may be divided into three smaller sections. The lower basin is those slopes which drain into Copper Creek between its mouth and about the 800 foot contour line crossing (Fig. 1). The middle basin drains slopes between the 800 and 1500 foot contour line crossings, and the upper basin drains the remaining slopes up to Schoolhouse Peak (Fig. 1).

Total relief in the basin is about 2700 feet from the mouth of Copper Creek (360 feet) to Schoolhouse Peak (3097 feet). Relief in the tributary drainages is a maximum of about 1700 feet in the lower basin, an average of about 1100 feet in the middle basin, and about 800 feet in the upper basin. Hillslopes are moderately steep (20-50 percent) with local slopes up to 100 percent or more. Only a few small areas along drainage divides have slopes below 20 percent.

Physiographically and vegetatively, the northern slopes are divisible into two types: prairie/oak woodlands, and conifer forested lands (Fig. 1). Prairie/oak woodlands are dominated by naturally occurring grassland prairies devoid of all trees, or thick stands of oaks with an understory of grasses. The oak woodlands occur either downslope of prairies, or extend as finger-like protrusions into the prairies along stream channels. Topographically, the prairies and oak woodlands are very similar, being highly irregular and composed of alternating steep slopes and gentler benches. This staircase-like topography (tread and riser) and hummocky ground indicate some form of mass-movement processes (i.e. slumping or earthflowage) are, or have been, active on these areas. Stream channels on the prairies are only slightly incised while in the oak woodlands they tend to be moderately incised. The causes for the existence of these prairie/oak woodlands whether geologic, pedologic, hydrologic, geomorphic, vegetation succession, or combinations of factors, are not known.

The upper half of the lower basin is prairie with minor oak woodlands (Fig. 1). This area is known as Maneze Prairie. The upper two-thirds of the middle basin is prairie with about 25 percent oak woodlands and is named Child's Hill Prairie. In the upper basin, only about 10 percent of the area is conifer forested lands and the remainder is dominated by oak woodlands with 25 percent prairies. The prairie/oak woodlands grade downslope through a transitional zone of young Douglas-fir and oak into the conifer forested lands. This zone is often marked by extremely steep slopes (70-100+ percent).

The conifer forested lands were originally covered with a mature, old growth forest of mixed Douglas-fir and redwood trees. However, logging in the past thirty years has completely removed this forest, and the area is covered with thick brush, stump sprouts, and seedlings. The forested lands tend to be somewhat more smooth sloped and regular than the prairie/oak woodlands.

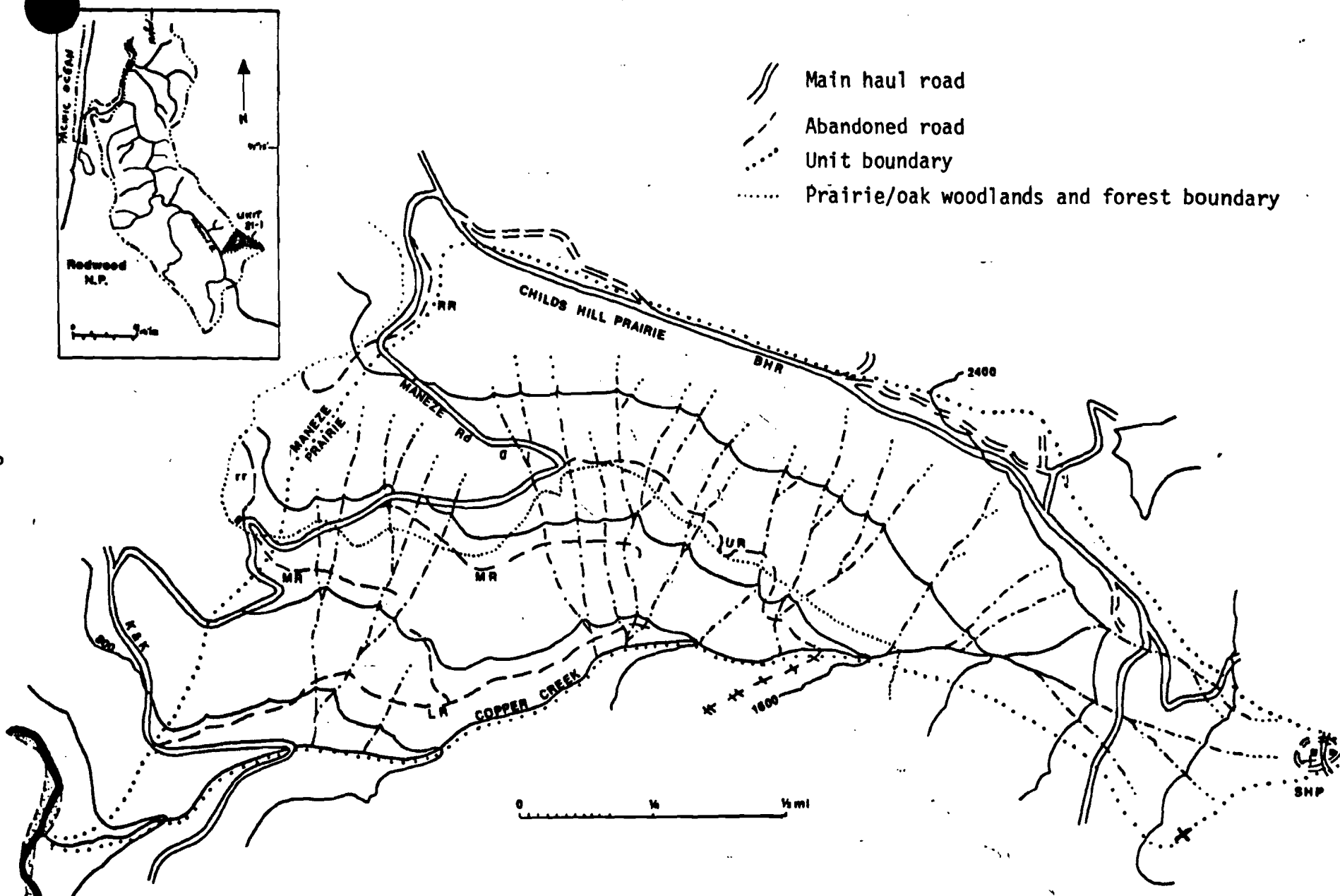


Figure 1. Location and description map - Rehabilitation Unit 81-1, North Copper Creek and Maneze Prairie.

UR - upper road, MR - middle roads, LR - lower road, RR - ridge road, rr - ranch road,
BHR - Bald Hills Road, SHP - Schoolhouse Peak.

Some relict staircase-like topography exists indicating past mass movement features. Adjacent to Copper Creek, a steeper-sloped "inner gorge" surface exists from the mouth to about the 1600 foot contour line crossing indicating possibly recent downcutting. Tributary streams which have large collection areas on the prairies are generally well incised across the forested lands. Smaller drainages with collection areas mostly within the forested lands are only slightly incised. This is particularly noticeable in the lower and the middle basins. The consequences of this will be examined in the erosion features section later in this report.

The rehabilitation unit was defined to encompass the entire hydrologic area of all hillslopes draining from the north into Copper Creek. This area of 1010 acres was geomorphically mapped at a scale of 1:1200 (Utley and Burns, 1981a), except upslope of Bald Hills Road around Schoolhouse Peak where a base map was not available. However, this area was examined and mapped at a larger scale of 1:6000. Of the total acreage, 663 acres were of prairie/oak woodlands and the remaining 347 acres were conifer forested land.

Road Network

Four road systems had been constructed on these hillslopes to facilitate timber harvest (Fig. 1). The removal of these roads was of primary importance to the erosion control work. Traversing Maneze Prairie, Maneze Road was a major, rocked haul road with intact culverts and inboard ditch and had been maintained continuously since its construction. Erosion features caused by the road and potential erosion problems were noted along the entire road. From Maneze Road, two minor spur roads existed: the Ridge Road and Ranch Road. Both of these were unrocked secondary haul roads with no inboard ditch and small fill crossings.

The remaining three road systems were informally termed the lower, middle, and upper roads from their position on the hillslope. The lower road was an unrocked secondary haul road with only limited areas with an inboard ditch. The road was blocked by a gully at the second intermittent stream crossing. The remainder of the lower road was moderately to heavily overgrown by brush. All of the road's stream crossings were eroded to varying degrees and none of the culverts were functioning. Erosion problems were noted along the entire road and will be discussed in more detail in a later section (Erosion Features).

The middle road system was comprised of short road segments (Fig. 1). Both of these were minor, unrocked haul roads with no inboard ditches and Humboldt crossings. The lower middle road was heavily overgrown by brush and nearly unrecognizable on aerial photographs. The road had caused drainage diversions and gullies, and will be discussed in a later section. The upper middle road was impassable by eroded crossings just as it left Maneze Road. The rest of the road was heavily overgrown by conifers and brush. All road crossings had eroded in part, but several remained as sediment sources.

The upper road, an unrocked secondary haul road with no inboard ditch, was blocked by the first stream crossing which had eroded. All the crossings along the road were either fill crossings or Humboldt crossings and had eroded in part. More detailed discussions of the erosion problems associated with all these roads are given in the Erosion Features section later in this report.

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 by land use practices. The procedures and objectives of this work is discussed in more detail in a later section of this report (Erosion-Control Rehabilitation Work).

The rehabilitation work removed 3.1 miles of haul roads on the hillslope. This was done by excavating 37 stream crossings, constructing 42 cross road drains, outsliping 11,400 feet of prairie/oak woodlands, and stabilizing 3 landings. Straw mulch was spread on 22.9 acres of ground disturbed by the rehabilitation work to inhibit surface erosion and to promote revegetation. Additionally, 13 skid trail crossings were excavated to restore drainage patterns. Fifteen gullies were treated on Maneze Prairie by various methods.

Land Use History

Timber Harvest History

The timber harvest of this unit occurred in four periods: 1954-55, 1959, 1962, and 1970-71 (Fig. 2). The earliest logging occurred in 1954 and 1955 in the upslope margins of the forested lands of the lower and middle basins just below the prairie/oak woodlands. Tractor logging methods were used and apparently was a selective clearcut in that nearly all of the old growth was removed. The 1959 cut was immediately adjacent to the K & K and Maneze Road (Fig. 2). Tractor methods and selective cut was used. In 1963, most of the remaining lower basin was logged by tractor selective clearcut.

In 1970, virtually the entire uncut middle basin was tractor clearcut logged (Fig. 2). Additionally, much of the earlier units were salvaged logged of residuals. In 1971, the remaining old growth of the middle and upper basins were tractor clearcut and the earlier units below the lower road were salvaged logged of residuals.

Road Construction History

The following history of road construction on the unit has been established from readily available aerial photographs and topographic map information. The date of construction of Bald Hills Road and its older counterpart is not known. The older road existed pre-1952 and was straightened to the present Bald Hills Road route in 1962-1968. Maneze Road appears to have been constructed in 1952-1954 to gain access to the early timber harvests in the mid-1950's. The road was constructed down to the bottom of Maneze Prairie to the present barn site. The Ranch Road was probably constructed at this time. The Ridge Road was probably constructed in the same period and may post date Maneze Road. An older Maneze Road or trail may have been constructed earlier than 1952 for cattle tending and access to the old barn site, but this is not known. Neither a trail nor the old barn are shown on the topographic map which had been revised in 1952. The lower middle road was constructed in 1954 and timber harvest had occurred that summer. The upper middle road was constructed in 1955 and timber harvest occurred. Both the middle roads were probably abandoned immediately following timber harvest.

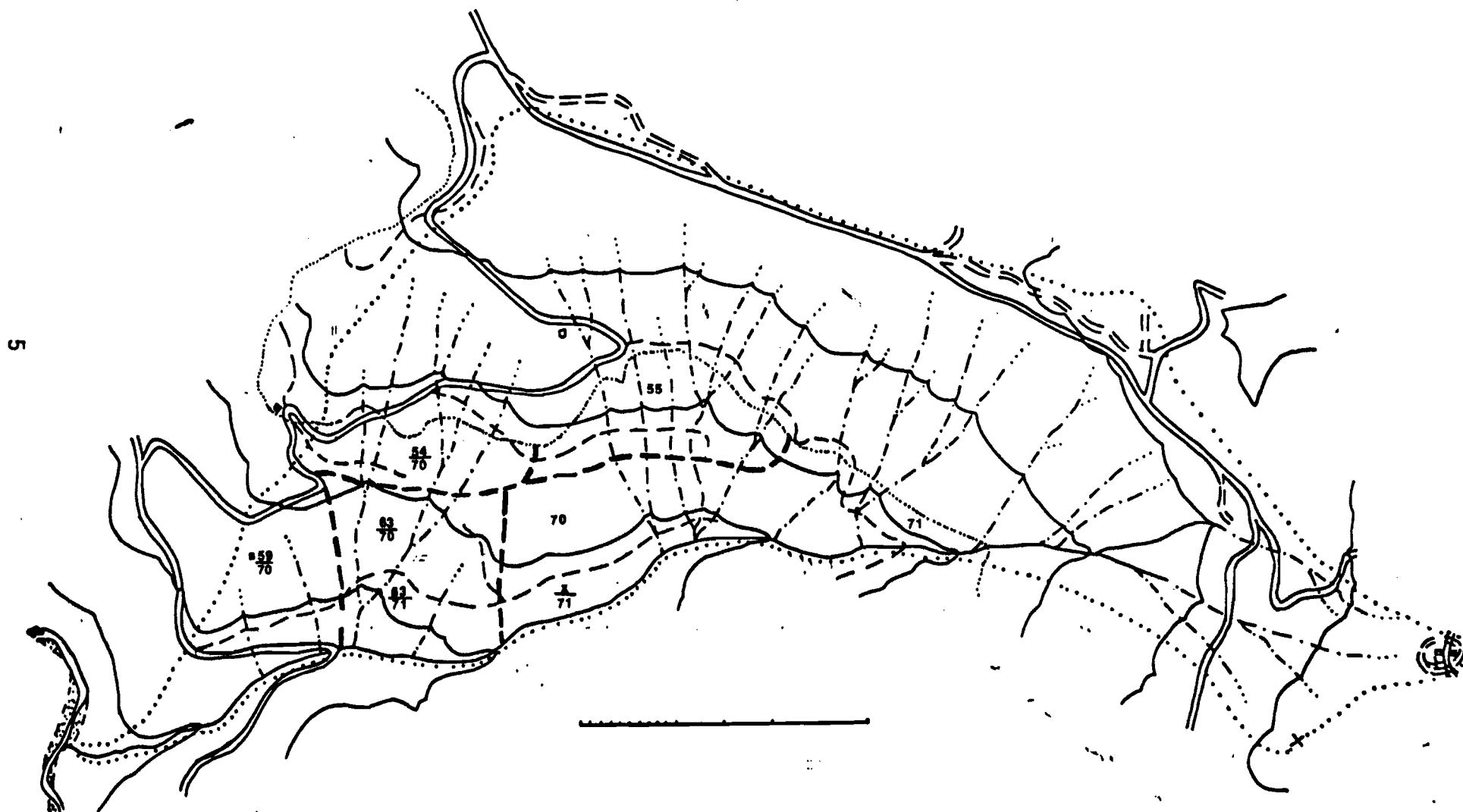


Figure 2. Logging History Map of Rehabilitation Unit 81-1, North Copper Creek and Maneze Prairie.

The K & K Road was constructed through the Copper Creek area in 1956-1959. Maneze Road was extended to connect with the K & K probably in 1958-1959 as access for timber harvest.

The lower road is not evidenced in the 1962 photos indicating that the 1959 logging was done from the K & K and Maneze Road. Most of the lower road in the lower basin was constructed in 1963 for that years timber harvest. The remainder of the lower road was probably constructed in 1969-1970 for access to the extensive 1970-71 harvests.

The upper road was apparently constructed in 1970-71 for access to the upper basin harvest. This road may have been used to allow empty logging trucks to enter from Maneze Road and exit loaded through the road system on the south side of Copper Creek. A similar pattern may have existed for the lower road also. Both the upper and lower roads appear to have been abandoned immediately following completion of timber harvest in 1971.

EROSION FEATURES

The following section describes the erosional features and processes found on the rehabilitation unit. This information was collected during the detailed field mapping (Utley and Burns, 1981a). The erosion history for the unit was compiled from these field observations and the use of aerial photographs taken in 1954, 1962, 1966, 1968, 1972, 1973, and 1978.

Types of Features

Four main types of erosion features were observed occurring on the unit. These were mass movements, eroded stream channels, eroded stream fills, and gullies. Most of these features were attributed to land use practices which caused landscape modifications. Specifically, these practices were timber harvest and road construction. Some of the features may be in whole or part naturally occurring and will be discussed in more detail later. However, few features within the forested lands can be discerned to be naturally occurring. This is in part due to the inability to see these features while covered with old growth forest, and also because of the degree of landscape modification caused by timber harvest.

Mass Movements

Mass movements on the unit ranged from large features (earthflows, slumps) to small features (fill failures, debris avalanches, streambank slides). The two largest features are earthflow/slumps at the top of Maneze Prairie and just west of Schoolhouse Peak (Fig. 3). Both of these features preserve earthflow topography, but it is not clear whether they are naturally occurring or man-induced. Both appear to be presently inactive. Elsewhere on the prairies, widespread evidence of previous mass movements exist. These features were probably of a complex earthflow, slump and creep nature.

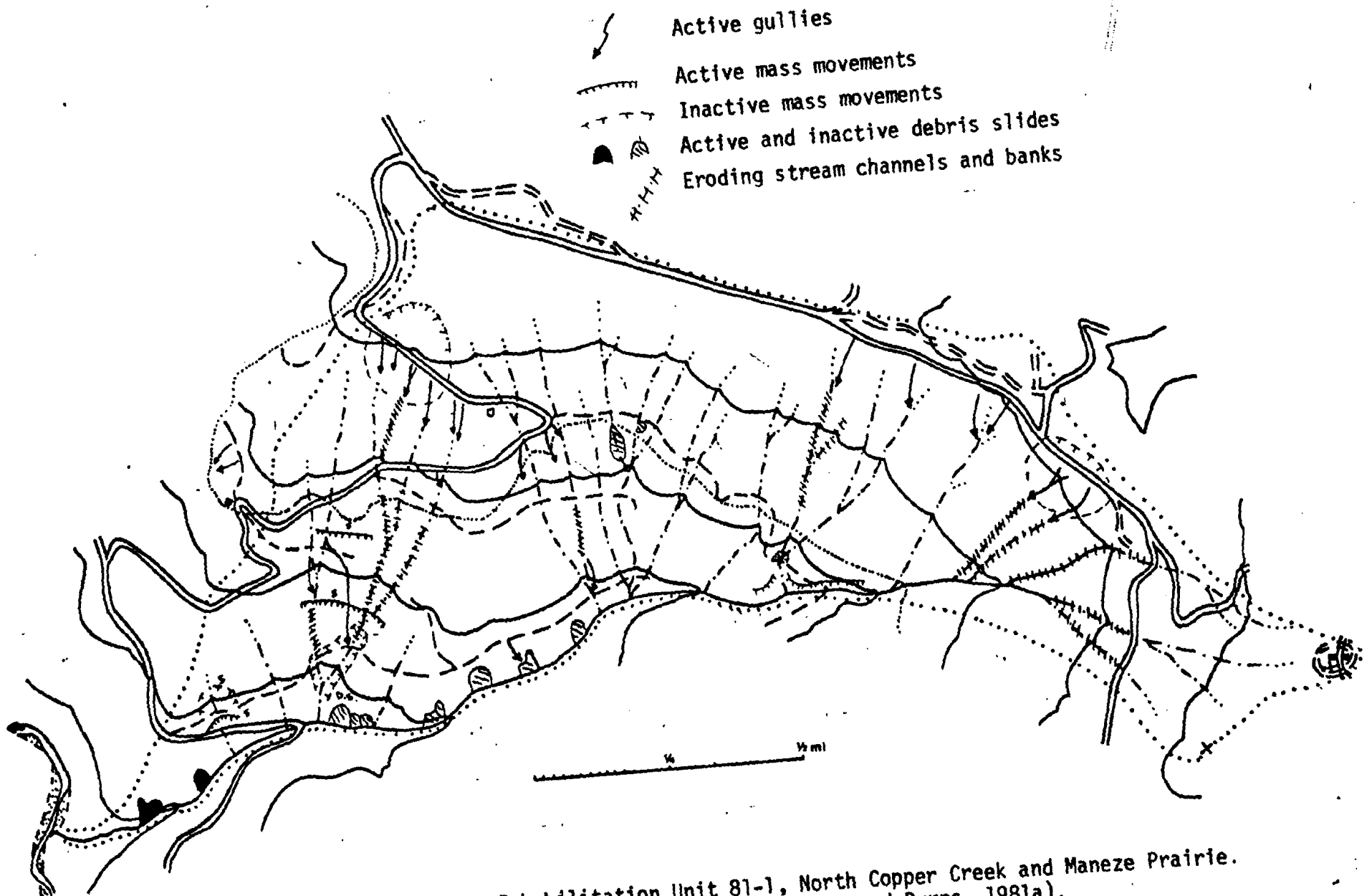


Figure 3. Erosion features, Rehabilitation Unit 81-1, North Copper Creek and Maneze Prairie.
Based on 1:12000 detailed geomorphic maps (Utley and Burns, 1981a).

In the forested lands, several areas show presently active mass movement. An area of slumping occurs below the first stream crossing along the lower road (Fig. 3). The causes of this feature are not clear, but may be related to an older road failure which occurred downslope along the K & K. A large area adjacent to and between the two stems of the third intermittent tributary to Copper Creek is undergoing complex slumping and debris sliding (Utley and Burns, 1981a). The causes of these features may have been drastic landscape and drainage modification upslope created by the 1954 timber harvest. Further upslope along these tributaries, additional slumping is occurring near the prairie/oak woodlands boundary (Fig. 3). This also appears to have been induced by landscape and drainage alteration caused by the 1954 timber harvest.

The largest and most erosive mass movement area is adjacent to Copper Creek in the middle and upper basin (Fig. 3). Large scale slope instability occurs as slumping and compound debris sliding (Utley and Burns 1981a). This appears to have been induced by extensive landscape modification and timber removal from a very steep, unstable hillslope.

Smaller mass movement features occur across the unit ranging from sidecast-fill slumps along haul roads and landings, to larger debris slides from steep, stream-bank slopes (Fig. 3; Utley and Burns, 1981a). Numerous of these slides occur along the steep slopes of the "inner gorge" of Copper Creek. Most appear to have been induced by landscape modification, timber removal, and log jam formation.

Eroded Stream Channels

Stream channels which have experienced downcutting or side bank erosion are wide spread on the unit. Nearly every intermittent stream channel exhibits some erosion of either type (Utley and Burns, 1981a). Copper Creek has numerous side channel and downcutting erosion features. Some of these may be erosion of terrace deposits and also related to log jams. The tributary streams in the forested lands show an extensive sidebank erosion generally caused by skid trail construction or by organic debris sidecast into them. Some channels show downcutting by upslope headcut migration generally from a road or skid trail crossing where the headcut originated. Generally, it appears that increased runoff caused by forest removal and ground disturbance has caused most stream channel erosion in the forested lands.

On the prairies, nearly all stream channels show evidence of downcutting and side bank erosion (Utley and Burns, 1981a). This may, in part, be a natural process on prairies, but some headscarp formation by cattle trail crossings was readily evidenced. Extensive stream channel erosion is evidenced in the upper basin. Some, if not all, of this erosion appears to have been caused by runoff concentration by Bald Hills Road.

Eroded Stream Crossings

All of the stream crossings along the upper, middle, and lower roads had eroded to some degree. In some instances, erosion was slight and in others nearly the entire road fill had been removed. Nearly all of the stream crossings on the upper and middle roads had stabilized and were undergoing only minor erosion. Several crossings along the lower road had stabilized, but several others continued to be eroded. For a more detailed discussion of these crossings as sediment sources see a later section (Sediment Sources).

All of these stream crossings had eroded for similar reasons. Fill crossings along the upper road had eroded once storm runoff flow overtopped them. Middle road crossings were Humboldt-type and failed with high storm runoff. Lower road crossings with culverts eroded once the culvert plugged with trash or sediment, or runoff exceeded the capacity of the culvert size. Several stream crossings of small ephemeral streams along the lower road had slumped, although little evidence of surface runoff was shown. Stream diversion by the lower road had also occurred prior to the erosion of the crossing at several locations.

Nearly all of the skid-trail stream crossings had eroded in part or total on the unit. Exceptions to this were crossings on small ephemeral streams near their headwaters, and crossings with large organic debris which served as knickpoints or base levels. Nearly all of the skid trail crossings on the unit were only slightly actively eroding.

Gullies

Gullies are less dominant erosion features on this unit than on the south side of Copper Creek. The reason for this is probably because the headward collection areas of the streams occur on the prairies which were not disturbed by road construction and timber harvest. The streams are moderately to well incised when they enter into the forest lands, and the roads were contoured into the stream valleys. Because of these factors drainage disturbance and diversions which cause gullying were less than on the south side of Copper Creek. The exception to this is along the small tributaries which form the third drainage area in the lower basin (Fig. 3). These streams have relatively minor prairie collection areas, and are only slightly incised when they enter the forested lands. When this area was logged in 1954, extensive landscape modifications occurred and little regard to drainage patterns were made. As a result extensive gully systems were formed in this area.

Elsewhere in the forested lands, a single, large, active gully occurs in the middle basin (Fig. 3). This was caused by a skid-trail diversion of a stream following 1970 timber harvest. Several inactive gullies occur upslope of this area below Maneze Road.

Gullies on Maneze Prairie have been caused by inboard ditch concentration and diversions of streams by Maneze Road. Most of these gullies were only slightly active and only minor sediment sources by 1980. Below Bald Hills Road several gullies were formed by inboard ditch concentration.

EROSION HISTORY

The following section describes the erosion history of the unit. The information was obtained from the 1952 topographic map, and aerial photographs taken in 1954, 1962, 1966, 1968, 1972, 1973, and 1978. A major factor related to the erosion history was the occurrence of six major storm events during the past thirty years. These storms were: January 1953, December 1955, December 1964, January 1972, March 1972, March 1975 (Harden and others, 1978). Since that time no major storms have occurred.

Erosion Features - 1954

Unfortunately, the 1954 photographs post date the construction of Bald Hills Road and Maneze Road. Because of this the relationship between these roads and the two earthflows, eroded stream channels and gullies on the prairie lands is not known. By August of 1954, the upper Maneze Road and lower middle road had been constructed and some timber harvest had occurred (Fig. 4). No major erosion problems had appeared on the cutover land, since the rainy season had not occurred. Several gullies and eroded stream channels and the earthflow were already in existence on Maneze Prairie. At least two gullies were in existence on the upper hairpin turn of Maneze Road.

Gullies and eroded stream channels existed below the old alignment of Bald Hills Road just west of Schoolhouse Peak. The earthflow in this area was present and several small gullies extended downslope from it. The remainder of the basin remained in old growth forest with no obvious erosional features visible through the forest canopy. Presumably, in the summer of 1955 the other middle road was constructed and timber harvest occurred (Fig 4). In December 1955, a major storm occurred.

Erosion Features - 1962

The erosional features presumable brought on by the December 1955 storm are visible in the 1962 photos. On the prairies, gullies continued to erode and several new gullies were formed (Fig. 5). A small slump had occurred on the prairie just below the future alignment of the upper road. This apparently was a naturally occurring feature. In the 1954 and 1955 logged areas, stream channel erosion was occurring upslope of the lower middle road. A stream was being diverted down this road and possibly forming gullies into the old growth below as evidenced by down timber and linear breaks in the canopy. The upper middle road showed few erosional features although the stream crossings may have eroded in part. Some gully or stream channel erosion may have occurred on one stream (Fig. 5).

Maneze Road had been extended downslope to connect with the K & K which had been constructed through the area in the late 1950's. The 1959 selectively logged area showed no signs of major erosion features and only skid trails had been constructed into the area.

Downstream from the K & K on Copper Creek several debris slides had occurred (Fig. 5).

Erosion Features - 1968

In December 1964, the next major storm occurred across northern California and the results are visible on the 1966 and 1968 photos. Just prior to this storm (Summer 1963) the remaining old growth was harvested from the lower basin. Part of the lower road had been constructed for access to this area (Fig. 6).

The single most obvious effect of this storm on the prairie lands was the extensive erosion in two gullies on the earthflow below Bald Hills Road. Another gully was formed below Maneze Road by a stream diversion at a road crossing. Elsewhere on the prairies, some stream channel and gully erosion occurred but is less conspicuous.

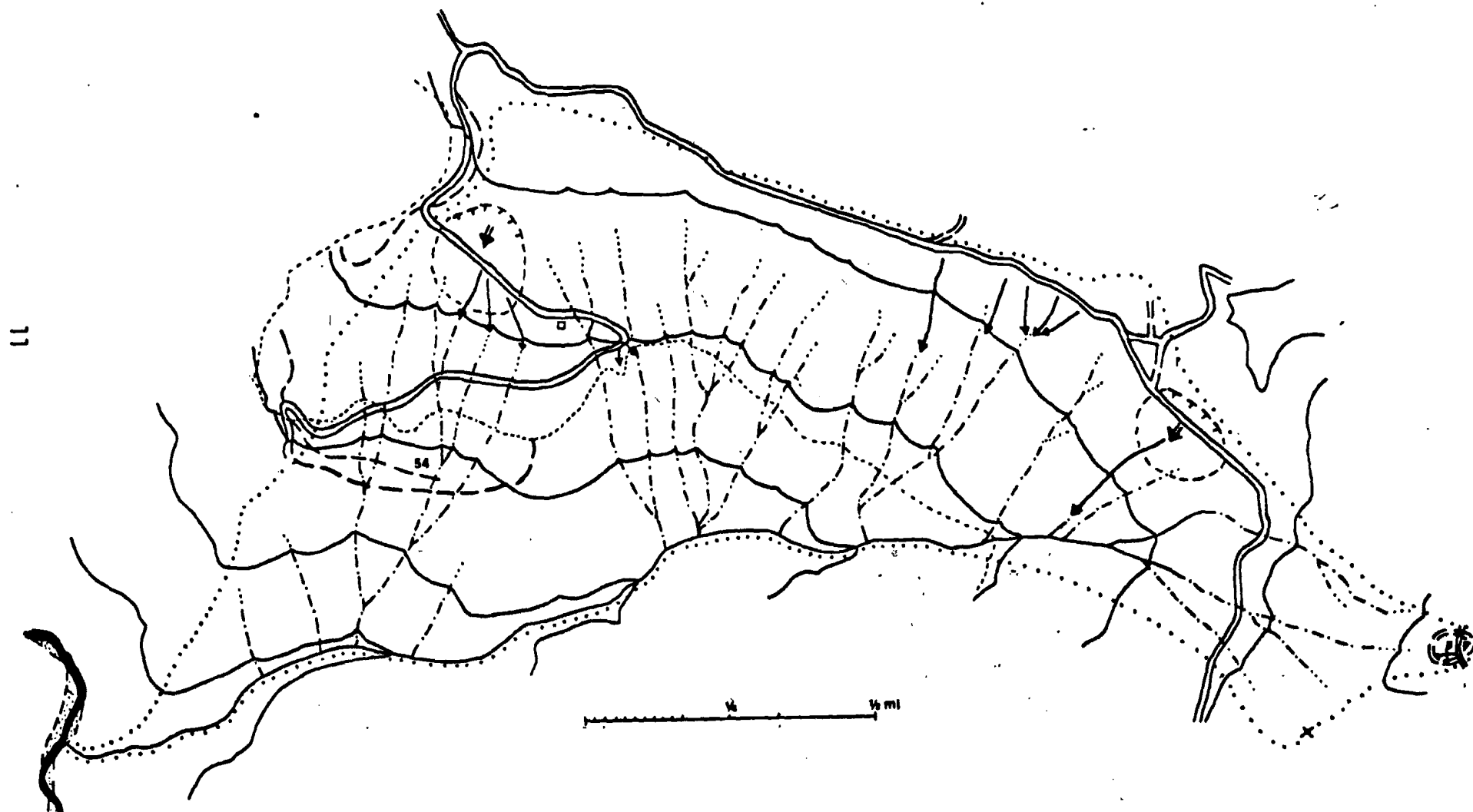


Figure 4. Erosion features 1954 - Rehabilitation Unit 81-1, North Copper Creek and Maneze Prairie. From aerial photographs August 1954 and topographic map information.

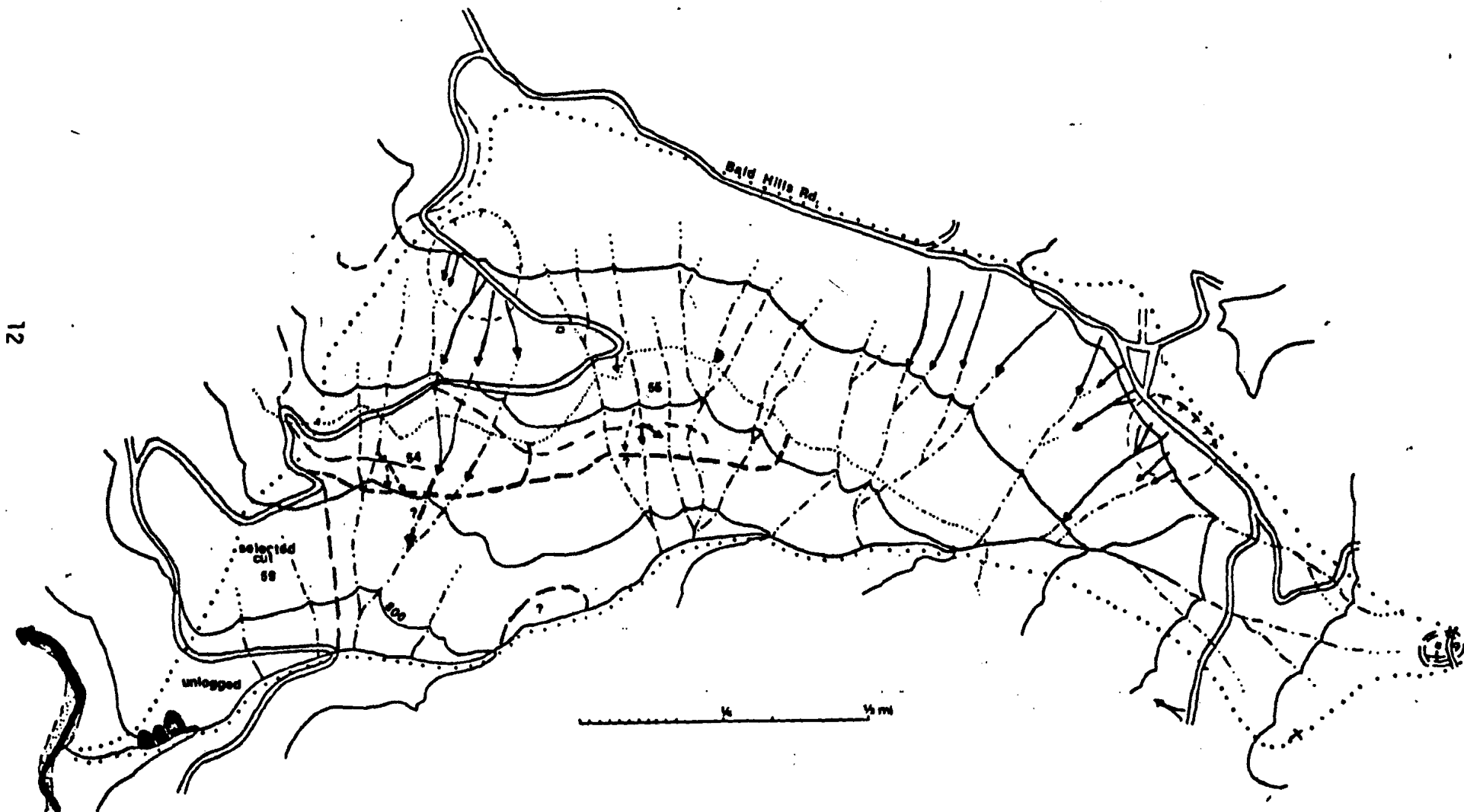


Figure 5. Erosion features 1962 - Rehabilitation Unit 81-1, North Copper Creek and Maneze Prairie. Shows effects of 1950's logging and major storm of December 1955. From aerial photographs 1962.

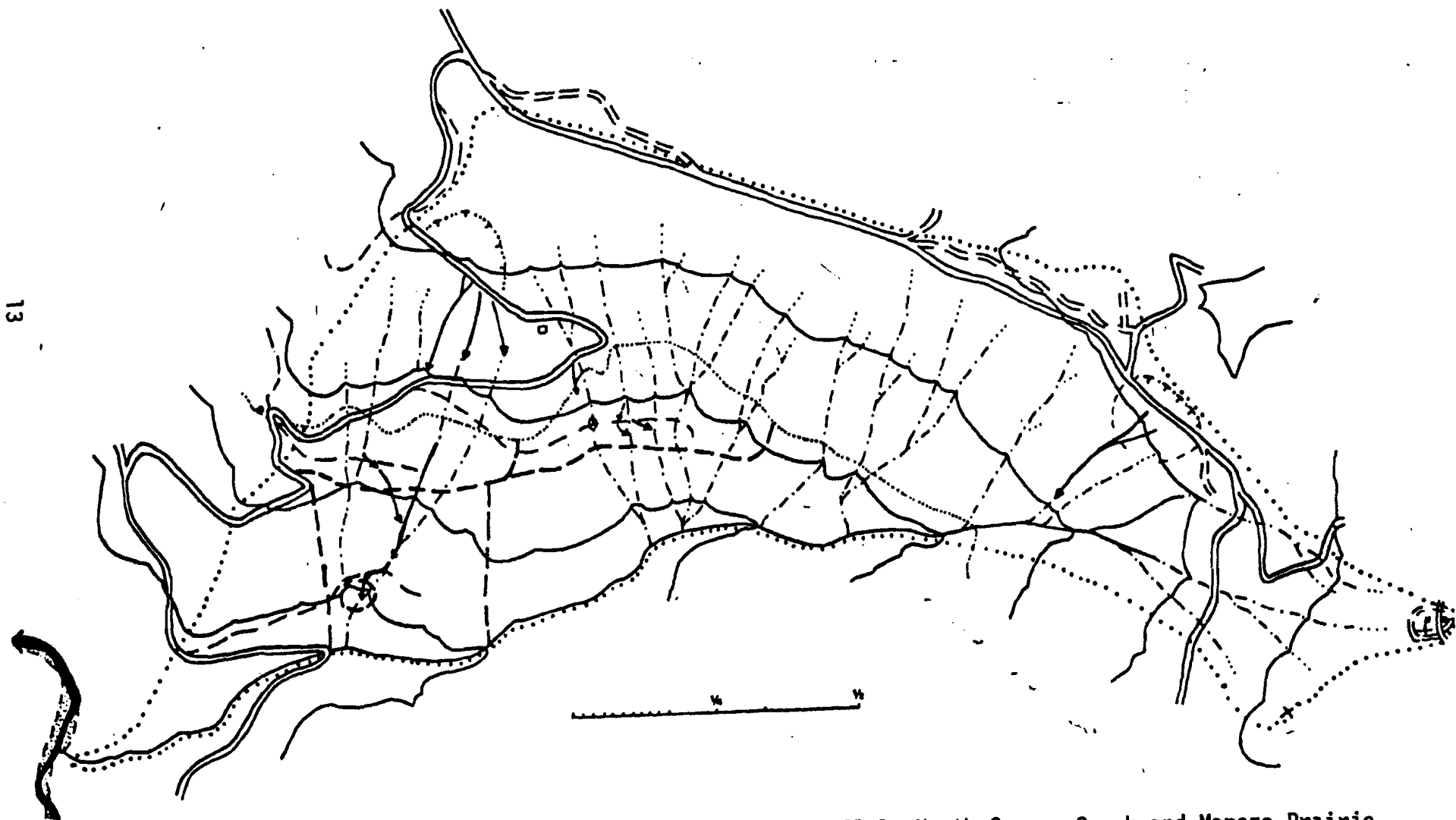


Figure 6. Erosion features 1968 - Rehabilitation Unit 81-1, North Copper Creek and Maneze Prairie. Shows effects of logging and major storm of , 1964. From aerial photographs 1966 and 1968.

Along the upper middle road all of the stream crossings were eroded in part. The pre-existing stream diversion and gullies at the one crossing appears to have continued. Along the lower middle road, the stream diversion down the road continued and the gully system continued to enlarge. The stream channel into which the gully flowed was extensively eroded. This stream downslope was diverted at the lower road gullying the road and further downslope. In the uncut portion of the area, little obvious evidence is visible although some streambank erosion probably occurred along Copper Creek.

Erosion Features - 1973

In 1970 and 1971, the remaining old growth was clearcut logged from the rest of the unit. Additionally, residual logging of nearly all of the earlier harvest areas was done. The rest of the lower road and landing spur and upper road were constructed to access these timber harvests.

In January and again in March of 1972, major storms occurred. The effects of these storms are visible on 1972 and 1973. Especially on the 1972 photos, which were taken only a few days after the March storm, are the erosional features apparent. Not only are the large features visible but extensive small gully erosion on skid trails and roads is readily apparent. This storm was the most damaging one to the site, probably in part because of the large area and extent of landscape modification caused by the 1970-71 timber harvest.

The prairie lands were the least impacted, showing only continued gully erosion on the earthflow below Bald Hills Road (Fig. 7). All of the road-stream crossings on the upper road were eroded, although without any stream diversions. Some extensive stream bank channel erosion occurred below two crossings along the upper road. Stream bank erosion occurred along the large gullied channel on Maneze Prairie.

In the forested land, widespread channel and bank erosion occurred on most streams in the middle basin (Fig. 7). One stream was diverted by a skid trail and eroded a large gully. In the lower basin, stream channel and bank erosion was extensive. The stream diverted by the lower middle road eroded a large gully system down to and across the lower road (Fig. 7). Large debris slides occurred in the drainage below the lower road. All road crossings along the lower road were eroded to varying degrees. Many debris slides both large and small occurred along the "inner gorge" slopes of Copper Creek (Fig. 7). A large area of many interrelated slides occurred in the upper basin destabilizing a large stretch of stream side slopes (Fig. 7).

Erosion Features - 1980

In the period 1973-1980 (when field mapping was done) few additional changes had occurred although a major storm occurred in March 1975. Channel bank erosion and gullies persisted below Maneze Road. Stream bank failures continued along several streams below the upper road. The skid trail gully from the diverted stream in the middle basin remained active through mostly by sidebank erosion and not downcutting further. Stream channel erosion and gully erosion in the lower basin continued above the lower road in the third drainage basin. Additionally, slope stability problems had appeared upslope slump scarps and debris slides. Extensive debris slides were active on this drainage below the lower road.

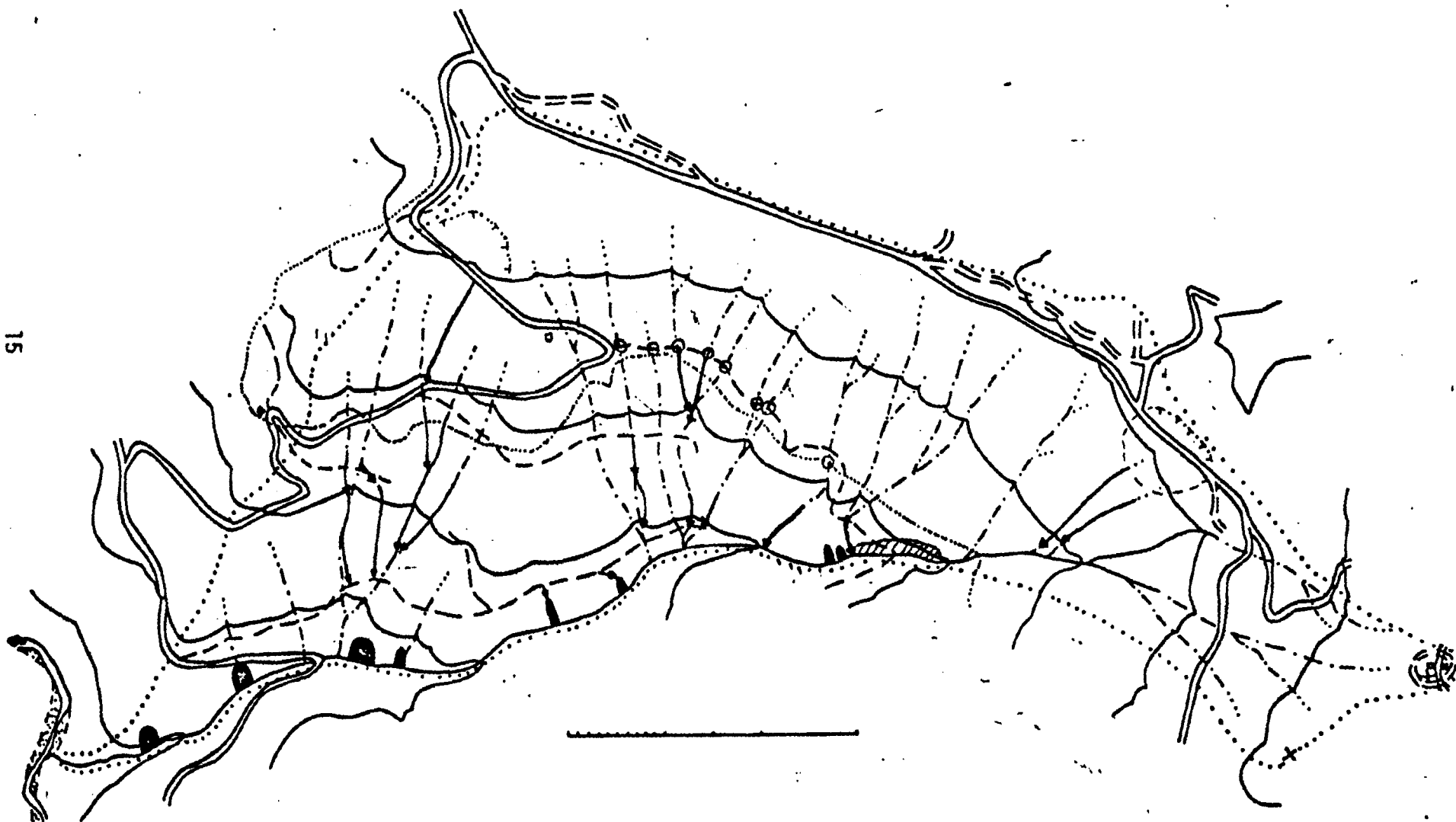


Figure 7. Erosion features 1973 - Rehabilitation Unit 81-1, North Copper Creek and Maneze Prairie. Shows effects of logging and major storms of January and March 1972. From aerial photographs 1972 and 1973.

Slumpage was occurring above and below the lower road in the first drainage due to ground saturation. Elsewhere, stream bank slides along Copper Creek remained partially active, although some had stabilized and begun to revegetate. The extensive area of slumping and debris slides along Copper Creek in the middle and upper basins remained active. Extensive stream channel erosion was occurring along the upper basin drainage (Fig. 8).

Sediment Sources - 1980

From the detailed field mapping, the major sediment sources on the unit were inventoried (Fig. 8). These could be divided into two classes: active and potential sources. Active sediment sources were those which were undergoing erosion or would undergo erosion during a storm event. Potential sediment sources were those which could undergo or cause extensive erosion during major storm events in the future.

Some features may be small erosion sources but qualify as major potential sediment sources because of the erosion which they could cause. An example would be a small skid trail crossing which could cause a stream diversion and extensive gully erosion. The prediction of potential sediment sources is in part a subjective decision by the geologists based on field conditions and experience. Quantifying erosion potential can be difficult in terms of predicting the amount and extent of erosion, and even more difficult in the time frame over which the erosion could occur.

Along the upper road on this unit, all of the haul road crossings were determined to be only small potential sediment sources (Fig. 8). However, the large skid trail crossing at the end of the road (SX-1) was established as a large active sediment source and even larger potential source.

Along the upper middle road all of the crossings were assessed to be small potential sources, except for RX-13 and RX-14 which were predicted as medium and large potential sources. RX-14 would be from continued fill erosion and RX-13 from potential gully erosion by stream diversion.

On the lower road, haul road crossings RX-20, 21, 22, 23, and 24 were established to be active sediment sources and predicted to be large potential sources (Fig. 8). All of the potential erosion was predicted to be of continued fill crossing erosion. Additionally, along the lower road large potential sources were predicted at a landing (L-2) and two road segments (R-16 and 18) by debris sliding directly into Copper Creek (Fig. 8). In each of these cases, several thousand cubic yards of material was predicted to be ultimately eroded. Also at landing L-6, active gully erosion and potential gully and mass movement erosion were predicted of several thousand yards.

Along Maneze Road large potential sediment sources were predicted at several crossings by culvert failure and gullies caused by subsequent stream diversions (Fig. 8). Several others were predicted to cause large potential sources by erosion of the road crossing fill (Fig. 8). Even with continued road maintenance, large gully erosion was predicted during future major storms because of the highly erodible nature of the prairie soils. In addition to these predicted road-related gullies, the large gully (G-6) would remain active by side bank erosion for a considerable time.

Road Crossing Sediment Sources

- Active Small • ○ Small
- Medium ● ○ Medium
- Potential ○ Large
- Active gullies
- Eroding stream channels and banks
- Active mass movements
- Potential mass movements

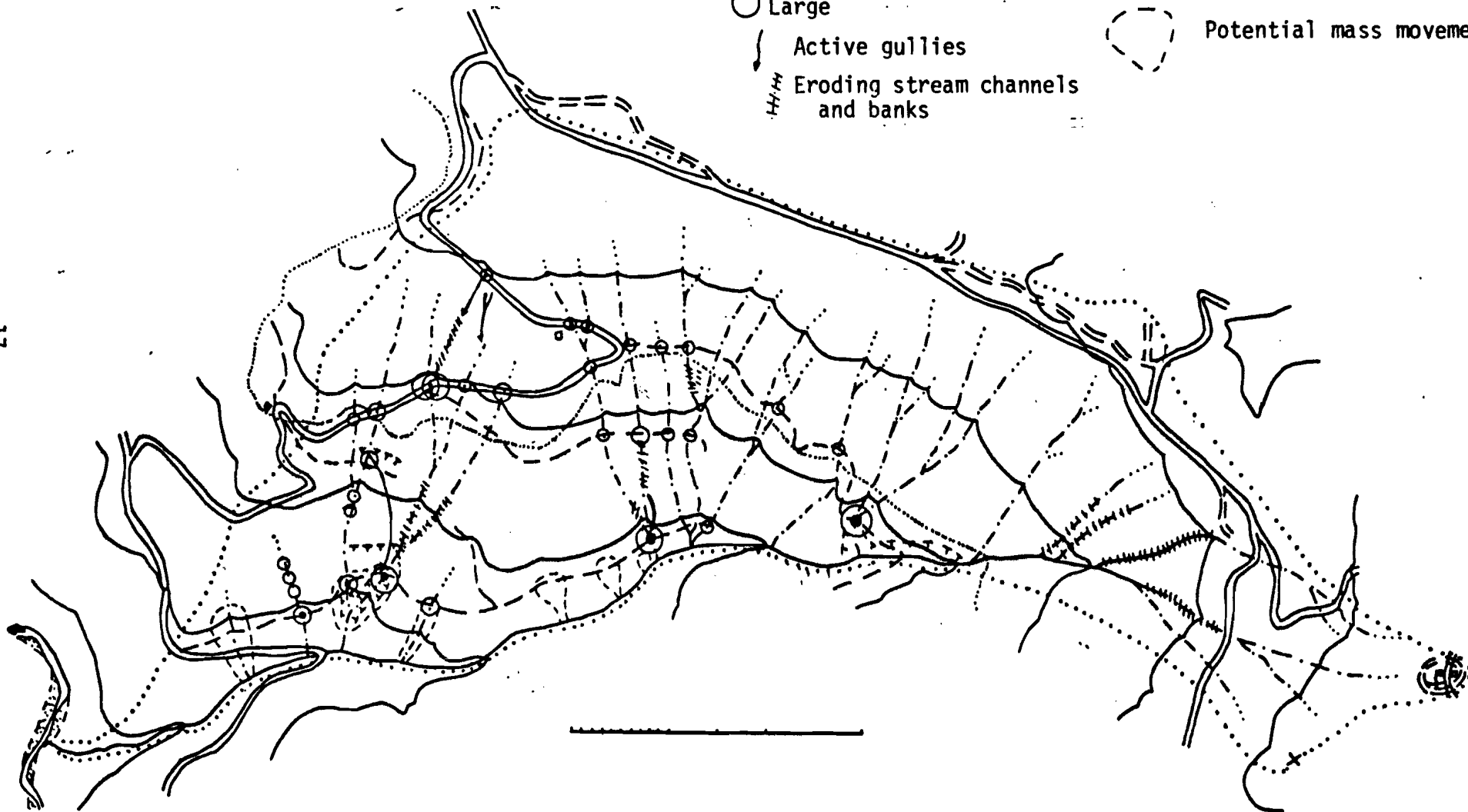


Figure 8. Sediment sources - Rehabilitation Site 81-1, North Copper Creek and Maneze Prairie. From aerial photographs 1978 and detailed field mapping 1980-1981. Shows active and potential sediment sources both natural and man-caused.

All of the active and potential sediment sources mentioned above were treated and, at least in part, removed as sediment sources by the rehabilitation work. As seen in Figure 8, several large active and potential sediment sources were not deemed treatable. The gullies and eroding stream channels below Bald Hills Road were inaccessible to heavy equipment. The area of unstable, steep slopes adjacent to Copper Creek in the middle and upper basins, also was deemed untreatable because of its size and degree of development. The active gully upslope of RX-20 was untreated because of lack of stable channel course and degree of gully development.

The complex gully system and mass movement features in the third drainage area in the lower basin was treated indirectly by skid trail crossing clearance and haul road crossing excavation along the lower road. The objective of the work in this area was to re-establish and improve drainage patterns and allow natural revegetation to stabilize the mass movements.

EROSION-CONTROL REHABILITATION WORK

Introduction

Procedures

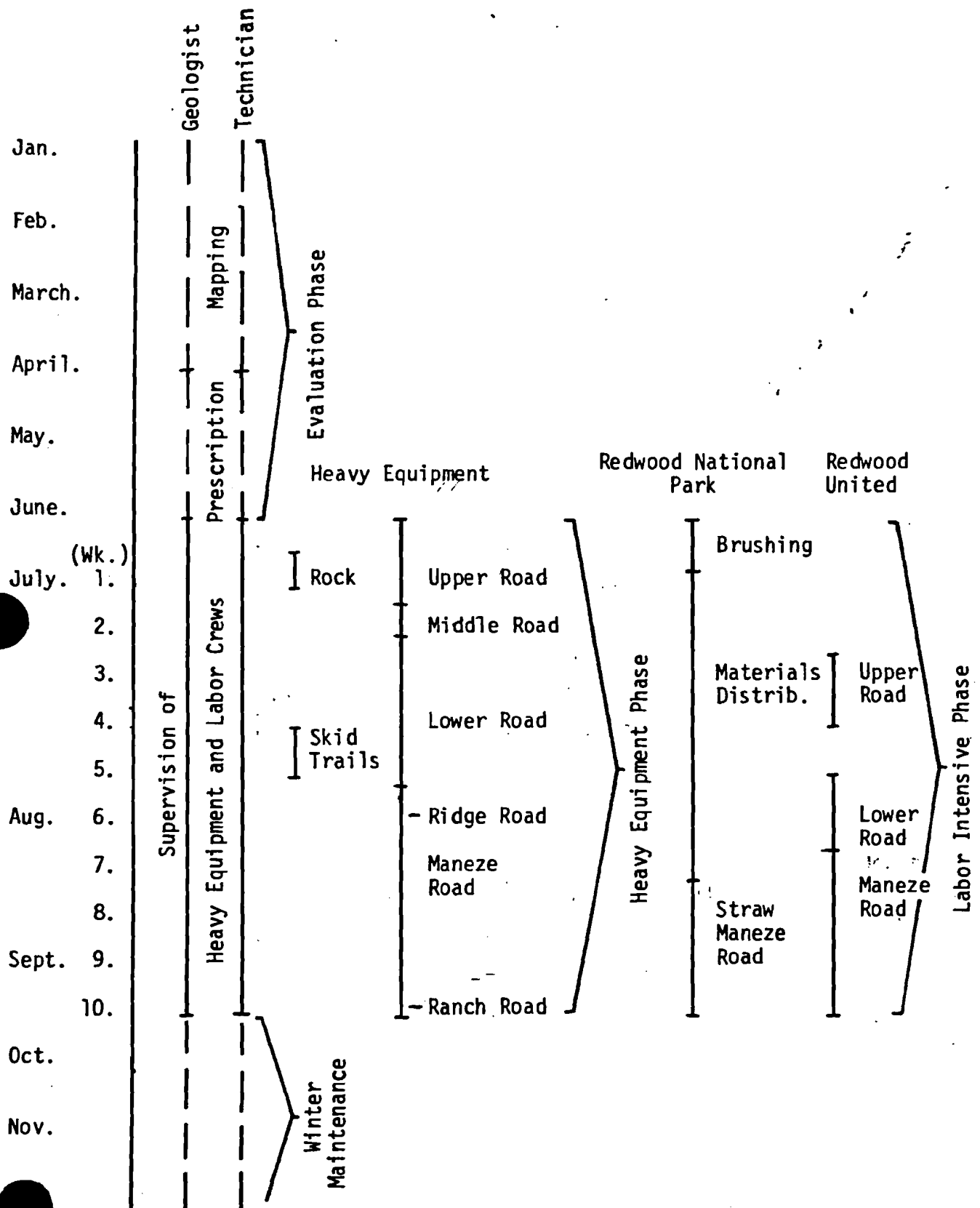
The method of approach to the rehabilitation work passes through four sequential phases: evaluation, heavy equipment, labor intensive, and winter maintenance phases. The evaluation phase begins with the selection of the hillslope and roads which will be encompassed within the unit. This is followed by reconnaissance aerial photograph interpretation field surveys of road conditions and erosion problems. Detailed field mapping of geomorphic, erosional, and land use features is then accomplished during the winter rainy months. Included in this period is the evaluation of erosion potential at possible worksites. The final portion of the evaluation phase is the prescription of treatments to be performed to reduce erosion, remove sediment sources, and to 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 rental of equipment is procured.

The heavy equipment phase is performing the actual erosion-control work on the unit with the heavy equipment. Partially concurrent with this is the labor intensive phase of performing erosion control work with labor crews. The winter maintenance is follow-up work performed in the fall and early winter months to correct problems developing from the first rains. Also included is the analysis of the work performed and writing a summary report. Table 1 lists the sequence of the phases as performed on the 81-1 North Copper Creek Unit.

Objectives

The objectives of work on this unit was to remove, correct, or stabilize land use induced erosion which was occurring on these hillslopes. This was to be accomplished by removing eroding fills of road crossings, correcting drainage patterns on skid trails, stabilizing gully systems on prairies, and, as much as possible, removing the physical scars created by road construction.

TABLE 1. SEQUENCE OF REHABILITATION WORK PHASES ON UNIT 81-1,
NORTH COPPER CREEK AND MANEZE PRAIRIE



On the upper road the main objective was to remove the large sediment source posed by the skid trail at its end (Fig. 8; SX-1). The rest of the road was to merely remove the small road crossings and the physical scar of the road itself. On the upper middle road, the objectives were to remove the two remaining potential sediment sources at RX-13 and 14 (Fig. 18), and the physical scar of the road on Maneze Prairie.

On the lower road, the objective was to treat the large potential sediment sources of the haul road crossings and potential mass movements on landings and road segments. Additionally, drainage improvement across the road bench was desired by minor outsliping and cross road draining the road. Of particular importance, was the removal of the lower road in the third drainage area in the lower basin. This in conjunction with skid trail removal upslope was directed towards stabilizing the gully systems and mass movement features in this drainage area.

The importance of this work was that if left untreated the active and potential sediment sources would continue to evolve and deliver sediment into Copper Creek. With the continued deterioration of the roads and natural revegetation, increased costs and impacts would have been involved in allowing more time to pass, if work was deemed necessary in the future. In simpler terms, the longer the work was left uncompleted, the greater would be the sediment eroded, the greater would be the cost of work, the higher the impact on the revegetation, and the less would be the effectiveness of the erosion control work.

On Maneze Road and Prairie, the potential erosion was deemed to remain until the road was removed. The main objectives of the work was to remove the causes of these potential sediment sources (Fig. 8). These causes were analysed as the concentration of flow by the inboard ditch and diversion potential of streams at road crossings. Additionally, the removal of the road as a visual scar across Maneze Prairie was deemed aesthetically desirable. Also the stabilization and visual removal of the gully scars caused by the road were desirable to restore a more natural scene.

Cost Summary

Table 2 summarizes the costs involved in performing the erosion-control rehabilitation work on this unit. Approximately 9.1 percent of the total cost was entailed in the evaluation phase of mapping erosional features and prescribing erosion control treatments. About 74.6 percent was spent in implementing the erosion control work with heavy equipment, and the remaining 16.3 percent was spent in labor intensive secondary treatment work.

Heavy Equipment Phase

Heavy Equipment Application

Three pieces of heavy equipment performed most of the rehabilitation work on this unit: two crawler tractors (HD-15, D-7E), and a hydraulic excavator (980B). Two other crawler tractors and several dump trucks were used briefly also. Table 3 summarizes the equipment specifications, costs, and hours.

TABLE 2. SUMMARY COSTS OF EROSION-CONTROL WORK ON REHABILITATION UNIT 81-1

		RNP Employees		Heavy Equipment Rental	Redwoods United Inc.	Total Task Costs	% Grand Total Cost	Phase Total	Phase % Grand Total Cost
		Geologists	Laborers						
Evaluation Phase	Mapping	\$6,257.62 ¹	--	--	--	\$6,257.62	5.8%	\$9,888.88	9.1%
	Prescript.	\$3,631.26 ¹	--	--	--	\$3,631.26	3.4%		
Heavy Equipment Phase	Access		--	\$3,739.40	--	\$3,739.40	3.6%	\$80,658.30	74.6%
	Primary Treatment	\$6,321.30 ²	--	\$60,874.63	--	\$67,195.93	62.0%		
	Secondary Treatment		--	\$6,145.52	--	\$6,145.52	5.7%		
	Misc.		--	\$3,577.45	--	\$3,577.45	3.3%		
Labor Intensive Phase	Secondary Treatment	\$1,264.26 ¹	5629.41 ^(*) ~~\$5,519.01~~	--	\$8,426.92	~~\$15,210.19~~ 15320.87	14.0%	17697.67 ~~\$17,587.27~~	16.3%
	Misc.	--	\$1,555.40	--	\$821.68	\$2,377.08	2.2%		
TOTALS		\$17,474.44	\$7,074.41	\$74,337.00	\$9,248.60	\$108,134.45			
% of Grand Total		16.2%	6.5%	68.7%	8.6%	GRAND TOTAL		108244.85 ~~\$108,134.45~~	

¹Estimated cost.^(*) COST OF ROCK DISTRIBUTION (\$110⁰⁰) WAS NOT INCLUDED²Covers all of heavy equipment work.

TABLE 3. SUMMARY OF EQUIPMENT TYPES AND COSTS

Equipment Type	Make/Model	Year	Rate	Total Hours
Hydraulic Excavator	Case 980B w/1 1/4 yd ³ bucket	1979	\$77.60/hr. ¹	444.5
Crawler ² Tractor	Allis Chalmers HD-16C	1973	\$45.00/hr.	434.5
Crawler ² Tractor	Allis Chalmers HD-16C	1968	\$45.00/hr.	49
Crawler Tractor	Catepillar D-7E w/manual angle blade	1967	\$67.50/hr. ¹	177.5
Crawler Tractor	Catepillar D-8 w/rippers	1963	\$80.00/hr.	20

¹Price includes prompt payment discount.

²The 1968 HD-16 was substituted for the 1973 HD-16 for 111 hours by the contractor due to mechanical problems.

Briefly, the hydraulic excavator was the primary excavation equipment actually digging fill from road crossings, outsloping landings and roads on the steeper slopes, and "pulling back" the edges of the largest gullies. The HD-16 crawler tractor removed the spoil away from the excavation, did preliminary excavation on worksites, outsloped roads and landings on low slopes, and opened access routes into worksites. Additionally an HD-16 excavated small skid trail crossings which were inaccessible to the hydraulic excavator. The D-7 crawler was used almost exclusively on Maneze Road and Prairie to do the final out-sloping of roads, contour the outsloping into the hillslope, "walk-in" mulch, contour gullies, and outslope roads on low slopes. The D-8 crawler tractor ripped a short portion of the lower road and all of Maneze Road.

Heavy Equipment Sequencing

The sequencing of heavy equipment use was to begin at the end of the upper road and work out to Maneze Road. The prairie portion of the upper middle road was removed next, and equipment then moved to the lower road. The lower road was opened to the end and the equipment used a skid trail to gain access to the forested portion of the upper middle road. After the two crossings were completed on the middle road, the equipment worked its way back along the lower road to the K & K. As the road was being removed a crawler tractor used skid trails for access to excavate the skid trail crossings in the lower basin.

The equipment then moved to the top of Maneze Road and removed the Ridge Road. Work then proceeded down the Maneze Road with adjacent gully work. The final work was to remove the Ranch Road and associated gullies. The reasoning behind this sequence of work was to allow Maneze Road to remain open as long as possible, and to insure that the more critical work on the lower hillslopes was completed prior to work on Maneze Prairie.

Heavy Equipment Costs

Table 4 summarizes the average costs for heavy equipment of the treatments performed on the rehabilitation unit. Access costs, in this report, are those entailed in bringing the equipment to the unit, opening the roads to do the work, moving the equipment between roads on the unit, installing a temporary bridge across Redwood Creek, and removing the equipment from the unit at the end of the work. Primary treatment costs are those entailed in removing potentially erodible material from stream channels, landings and roads, or of restoring drainage patterns disrupted by past land-use practices.

Secondary treatment costs are those entailed in protecting stream channel excavations and mulch covered areas. The placing of rock as channel armor was used only on three sites on the unit. This was due to the inaccessibility of the worksites in the forested area, and the aesthetically undesirable and unnatural appearance of such armor on the prairies. Where rock was placed was in highly unstable excavations where substantial erosion was predicted without some form of channel protection. The exposed nature of the prairies indicated the possibility of mulch removal by strong winds. Because of this reasoning, it was prescribed to "walk-in" the mulch after being spread by having the a crawler tractor repeatedly drive over it across the slope contour.

TABLE 4. SUMMARY OF AVERAGE COSTS OF HEAVY EQUIPMENT TREATMENTS, REHABILITATION UNIT 81-1

Treatment ⁴	# of	Total Quantity	Total Cost	Avg. Cost Worksite	Avg. Cost Quantity	Range in Cost/Quant.	Remarks
Haul Road Crossings	37	5,916 yd ³	\$25,201.85	\$681.13	\$4.25/yd ³	\$1.59-\$6.41	
Skid Trail Crossings	13	¹ 893 yd ³	\$3,604.45	\$277.27	\$4.03/yd ³	\$2.07-\$5.99	
Outslope Prairie Roads	30	² 10,218 lf (1.94 mi)	\$16,869.75	\$562.33	\$1.65/lf \$8,695.75/mi	see later table	Total outsloping
CRD/O.S. Forest Road	9	44 CRD 3,920 lf	\$4,392.25	\$488.03	\$99.82/CRD \$1.12/lf	see later table	Cross road drain with slight out-sloping
²⁴ Rip Roads	1.2 mi ¹	1.2 mi 6,300 ft.	\$1,000.00	\$833.33/mi \$.16/lf	\$833.33/mi	--	
Prairie Gullies	15	4,220 lf 59,159 yd ²	\$6,257.58	\$417.17	\$1.48/lf \$1.06/yd ²	see later table	
Landings	5	¹ 1,000	\$3,420.75	\$684.15	\$3.42/yd ³	\$38-\$1463/Landing	
Waterbars	20	--	\$128.00	\$6.40/each	--	--	
Total Cost Primary Treatments			\$60,874.63				

TABLE 4. (CONTINUED)

Treatment	# of	Total Quantity	Total Cost	Avg. Cost Worksite	Avg. Cost Quantity	Range in Cost/Quant.	Remarks
<u>Secondary Treatments</u>							
Channel Armor	3	200 yd ³	\$640.55	\$213.52	\$3.20/yd ³		
Armor Acquisition	3	230 yd ³	\$3,767.40	\$1,255.80	\$16.38/yd ³		
Mulch Walk-in	15	13.8 acres	\$1,738.12	\$115.87	\$125.95/acre		
Total Cost			\$6,145.52				
Access			\$3,739.40				
Misc.			\$3,577.45				
Heavy Equipment Cost exluding rock			\$70,569.60				
TOTAL HEAVY EQUIPMENT COSTS			<u>\$74,337.00</u>				

¹Estimated quantity.

²lf - linear feet.

Miscellaneous costs include a variety of tasks including waterbar construction on unrehabilitated roads, removal of logs from the prairie, downtime, block-aging off the top of Maneze Road, etc.

Haul Road Crossings -- The three most expensive heavy equipment treatments performed on this unit were excavating haul road crossings, outsloping prairie roads, and stabilizing prairie gullies. The haul road crossings on the unit are divisible into two types: forest crossings and prairie crossings. These are classes by volume of fill into small, medium, and large crossings (Table 5). Crossings show a wide range of cost per yard but in general, show somewhat higher costs for larger crossings. Also, prairie crossings appear to be slightly less expensive than forested road crossings. This is probably caused by more large organic debris in the forested crossings, and more room for maneuvering on the prairie crossings making the excavation easier. One point to be noted is that the three largest crossings entailed 42 percent of the total cost of all haul road crossings.

Outsloping Prairie Roads -- The prairie roads on the unit can be classed according to the average roadbed width. Small roads are about 10-12 feet wide and include the upper, middle Ridge, and Ranch roads. Maneze Road had an average width of about 20 feet. Additionally the slope of the land over which the road was constructed indicates the cutbank height, steepness of fill, and equipment needed to perform rehabilitation work. Low slopes are less than 15 percent, moderate slopes are 15-30 percent, and steep slopes are greater than 30 percent. Roads on low slopes could be outsloped completely by crawler tractors. On moderate slopes, the hydraulic excavator had to perform partial removal of the outboard fill edge after which the crawler tractor could complete outsloping. Roads on steep slopes required extensive fill removal by the hydraulic excavator before the crawler tractor could finish the outsloping.

Table 6 shows the costs of outsloping various classes of prairie roads. The general trend is that small roads cost less than larger roads to remove probably because of the smaller amount of fill needed to be moved. For the larger road it appears that those on steeper slopes are more costly to remove. The cause of this is probably the greater excavator work required on steeper roads which raised the cost. A few additional features reflected in the costs are: the middle road in a certain area consisted of two parallel roads; the upper road passed through prairie and oak woodlands and was not completely outsloped in the oak woodlands; and Maneze Road on moderate slopes included pushing large volumes of fill away from road crossings to be able to completely outslope the cutbanks.

Prairie Gullies -- A variety of treatments were performed on the gullies on Maneze Prairie. The three basic treatments were: infilling inactive gullies, contouring flowing gullies, and sloping active gully sidebanks. For inactive gullies with minor or no flow, a crawler tractor infilled the gully by breaking down the sidebanks and compacting the fill. The infilled gully was then contoured into the surrounding landscape as much as possible. This proved an inexpensive treatment (average \$.60/linear foot), but cost was dependent on the cross-sectional area of the gully (Table 7).

TABLE 5. SUMMARY OF AVERAGE COSTS OF HAUL ROAD CROSSING, REHABILITATION UNIT 81-1

Type & Size ¹ of Crossing	# of Worksites	Quantity	Equipment	Avg. Cost Worksite	Range in Cost	Avg. Cost yd ³	Range
<u>Prairie Roads:</u>							
Oak woodland ² small	10	10-108 yd ³ (455 yd ³)	980 + HD-16	\$153.18	\$11-295	\$3.37	\$1.11-5.55
Small	12	10-157 yd ³ (977 yd ³)	980 + HD-16 + D-7E	\$360.13	\$390-507	\$4.42	\$1.84-6.37
Medium	3	775 yd ³		\$2,723.60	\$850-1,009	\$3.51	\$2.87-3.95
Large	RX-10	587 yd ³		\$1,779.65		\$3.03	--
<u>Forested Roads:</u>							
Small	7	20-185 yd ³ (662 yd ³)	980 + HD-16	\$419.83	\$11-743	\$4.44	\$0.56-10.19
Medium	RX-21	463 yd ³	980 + HD-16	\$1,954.60	--	\$4.22	--
Large	RX-20	922 yd ³	980 + HD-16	\$3,711.40	--	\$4.02	--
	RX-23	721 yd ³	980 + HD-16	\$4,321.65	--	\$5.99	--
	RX-24	665 yd ³	980 + HD-16	\$2,580.80	--	\$3.88	--
TOTAL	37	2,308 yd ³		\$10,613.85 (\$3,537.95)		\$4.60	

¹Small crossing <200 yd³; Medium crossing 200-500 yd³; Large crossing 500-1000 yd³.

²Upper Road.

TABLE 6. SUMMARY OF AVERAGE COSTS OF PRAIRIE ROAD REMOVAL,
REHABILITATION UNIT 81-1

Slopes ¹	Linear Feet	Area	Total Cost	Cost/ Linear Ft.	Cost/ Acre
<u>Small Roads:</u>					
Low - Ridge	650	1.0	\$941.20	\$1.45	\$941.20
Middle	900	1.0	\$1,125.10	\$1.25	\$1,125.10
Moderate - Upper	2815	2.2	\$1,862.30	\$0.66	\$846.50
Steep - Ranch	1350	1.5	\$1,464.40	\$1.09	\$976.27
<u>Maneze Road:</u>					
Low	1698	2.4	\$2,910.84	\$1.71	\$1,212.85
Moderate	1280	1.8	\$3,222.42	\$2.52	\$1,790.23
Steep	1815	3.3	\$4,895.78	\$2.70	\$1,483.63

¹Low - <15%; Moderate - 15-30%; Steep - >30%.

TABLE 7. SUMMARY OF COSTS OF PRAIRIE GULLY TREATMENT
REHABILITATION UNIT 81-1

Gully	Avg. Cross Section Area (Ft.)	Length (Ft.)	Equipment	Total Cost	Cost/ Linear Ft.
<u>Inactive Gullies - Infilled</u>					
G-15	2	305	D-7	\$33.75	\$0.11
G-2	16	290	D-7	\$151.88	\$0.52
G-7	27	180	D-7	\$67.50	\$0.38
G-0	48	240	HD-16	\$67.50	\$0.28
G-12	59	355	D-7	\$337.50	\$0.35
G-13	133	<u>245</u>	D-7	<u>\$303.75</u>	<u>\$1.24</u>
	TOTALS	1615		\$961.88	\$0.60
<u>Contoured Gully - Flowing</u>					
G-10	7	365	D-7	\$168.75	\$0.46
G-11	7	455	D-7	\$185.62	\$0.41
G-8	13	460	D-7	\$253.12	\$0.55
G-1	26	160	D-7	\$33.75	\$0.21
G-17	?	105	D-7	\$101.25	\$0.96
G-16	?	<u>145</u>	D-7	<u>\$270.00</u>	<u>\$1.86</u>
	TOTALS	1690		\$1,012.48	\$0.70
<u>Sloped Gullies</u>					
G-5	120	275	980+HD-16 +D-7	\$249.45	\$0.91
G-14	40	105	980+HD-16 +D-7	\$410.85	\$3.91
G-6	400	<u>535</u>	980+HD-16	<u>\$3,622.90</u>	<u>\$6.77</u>
	TOTALS	915		<u>\$4,283.20</u>	\$4.68

For gullies which had significant flow, the treatment was to use a crawler tractor to contour the gully into the landscape. This was done by shaping the sidebanks and partially infilling the gully. The gully course was left as a gentle, defined channel at the end of the treatment to contain the known flow. This also was an inexpensive treatment, but was done only on relatively small gullies.

For large, steep-walled gullies the treatment was to use the hydraulic excavator to slope the sidewalls to a lower angle. This removed the over-steeped sidebanks as continual sediment sources and contoured the gully into the landscape. Fill was contoured away from the gully and blended into the landscape. No material was intentionally added to the gully bottom which had already reached a stable gradient. This was the most expensive gully treatment because of the slower nature of the hydraulic excavator. However, the end result appears both visually satisfying and is lessened as a sediment source (Fig. 9).

Evaluation of Heavy Equipment and Application

The heavy equipment used on this unit for the most part proved excellent. The machinery was either relatively new or well maintained as evidenced by only a few minor on-site breakdowns. A large part of the success of this unit's work goes to the equipment operators, who were of immense help with their experience, suggestions, encouragement, and attitudes.

The hydraulic excavator remains the most versatile excavation-type equipment used in comparison with dragline cranes and backhoes. The mobility of the excavator in steep and rugged terrain is a necessity for this type of work. The large bucket capacity and swivel ability are highly advantageous. This type of excavator (Case 980B) is excellent also because of a seven-degree tilt ability for the cab, allowing work on slopes and excavation at an angle.

The Allis Chalmers' crawler tractors (HD-16) used on the site showed the advantages of medium-sized, but heavy, powerful machines. The large pushing capacity and horsepower allowed extensive use of these machines for fill removal and outsloping. Particularly useful was the tilt ability of the bulldozer blade. The D-7E crawler tractor proved not as versatile as the other tractors. This was a result of its lower weight, lesser horsepower, and manual-angle blade. These decreased its pushing power and capacity. However, the D-7 proved particularly useful for contouring and compacting the outsloped areas on Maneze Road. The operator had an excellent eye for shaping the disturbed ground into the landscape, and also had the patience to keep at this boring task for long hours. The D-7 also walk-in all of the straw mulch on the prairies.

The treatment prescriptions appeared to be appropriate in terms of erosion control and the equipment used. Obviously, unknown conditions encountered in excavation changes the end product. The single most common problem in the prescriptions were for large haul road crossings. The necessary excavations proved deeper than anticipated, and in several cases, still did not reach completely to original grade. Some crossings were believed to be at grade but were not. Several crossings had reached the limit of equipment to excavate fill from the crossings, and were still above grade. The cause of this is probably the irregular and steep nature of the original channel, combined with the channel changes caused by the landscape modification.

The treatment prescriptions on the prairies appear to have been very appropriate and the equipment could readily do this work. The removal of Maneze Road as a visual scar and potential erosion source proceeded very well with few problems. The treatment of the gullies produced results better than anticipated, although several years will be required to evaluate the final results. The extensive use of crawler tractors to contour and compact the fill is of prime importance for best results. Larger, heavy tractors are especially useful in both pushing capacity and weight.

Labor Intensive Phase

Labor Intensive Application

Two types of labor intensive personnel were used on this unit: Redwood National Park laborers and Redwoods United, Inc., employees. Redwoods United, Inc., is a non-profit, Samoa, California, based organization for the handicapped, which is specifically mentioned in the legislature establishing the 1978 Park Expansion. The labor intensive personnel were used for secondary treatments, the principal of which was spreading straw mulch on disturbed ground along the roads (Table 8). A variety of miscellaneous tasks of related, but non-secondary treatment nature were performed mostly by Redwood National Park laborers.

The sequencing of labor intensive work paralleled the heavy equipment sequence: upper road, lower road, and Maneze Road from the top (Table 1). The distribution of mulch (straw bales) was completed prior to the heavy equipment work because the access trails opened by the equipment were used. In some instances, the straw bales were being distributed literally within feet of the heavy equipment.

Labor Intensive Costs

As shown in Table 8, the distribution and spreading of straw mulch was the single largest cost of the labor intensive phase. A total of \$13,835.53 was spent on this treatment of which \$2,194.26 (16 percent) was for distribution and the remainder for the actual spreading. The average unit cost of this treatment was \$814/acre. Some of the reasons for this high a unit cost were the inaccessibility of the worksites which required hiking; the density of spread straw, especially on the prairies; and the high temperature on the exposed prairies. Additionally, the necessity of using a four-wheel drive pick-up to distribute straw bales to the upper and lower roads, and the areas off of Maneze Road increased costs. Not included in the distribution costs were the use of Redwood National Park's 2 1/2 ton, flat-bed truck and laborers to distribute some straw along Maneze Road. Also, the necessity of a laborer to work in conjunction with Redwoods United crews contributed to higher costs.

The miscellaneous tasks were used to give some variety and to break up the boredom for the Redwood National Park laborers. This was effective for keeping the morale of the personnel up and such tasks should be planned for this reason.

TABLE 8. SUMMARY OF LABOR INTENSIVE TREATMENT COSTS
REHABILITATION UNIT 81-1

Treatment	Type	Person Hours	Avg. Cost Per. Hrs.	Cost	Total Cost	Area (Acres)	Cost/ Area
<u>Mulch Spreading:</u>							
Upper Rd.	RNP	50	\$7.83	\$377.30	\$2,002.29	2.7	\$741.58
	RWU	237		\$1,624.99			
Lower Rd.	RNP	95	\$7.83	\$727.95	\$2,086.06	2.7	\$772.61
	RWU	195		\$1,358.11			
Upper Maneze ¹	RNP	105	\$7.83	\$842.05	\$2,900.64	4.3	\$674.57
	RWU	265		\$2,058.59			
Lower Maneze ²	RNP	140	\$7.83	\$1,100.40	\$3,663.58	7.3	\$501.86
	RWU	345		\$2,563.18			
Ridge Rd.	RNP	25	\$7.83	\$192.55	\$576.82	1.0	\$576.82
	RWU	55		\$384.27			
G-6	RNP	10	\$8.45	\$84.50	\$522.28	1.0	\$522.28
	RWU	60		\$437.78			
Total					\$11,751.67	17	\$691.27
<u>Material Distribution:</u>							
Upper & Lower Rds.	RNP	103.5	\$7.52	\$774.16	\$2,194.26		
Maneze Rd.	RNP	190	\$7.52	\$1,420.10			
Total Mulch Costs					\$13,945.93	17	\$820.34
Rock	RNP	15	\$7.36	\$110.40	\$110.40		
Total Secondary Treatment					\$14,056.33		
<u>Miscellaneous:</u>							
Fence	RNP	20	\$8.45	\$169.00	\$990.28		
Removal	RWU	120	\$7.24	\$821.28			
Access	RNP	80	\$7.52	\$601.20	\$601.20		
Photo-Points	RNP	35	\$7.52	\$263.80	\$263.80		
Oak Removal	RNP	20	\$7.52	\$150.30	\$150.30		
Seeding	RNP	20	\$7.52	\$150.30	\$150.30		
Various	RNP	30	\$7.36	\$220.80	\$220.80		
Total Miscellaneous Costs					\$2,376.68		
TOTAL LABOR INTENSIVE COSTS					\$16,433.01		

¹Upper Maneze is from top to junction with upper road and adjacent gully areas.

²Lower Maneze includes from upper road to Barn and Rand, middle roads, and all adjacent gullies.

The hidden cost in the labor intensive treatments is the non-productive time spent in commuting to the rehabilitation unit. For the Redwood National Park laborers this entailed a two hour travel time per day. Therefore, roughly 20 percent of the Redwood National Park's laborers cost is entailed in travel time. For Redwoods United employees, travel time was from Samoa and averaged about four hours per person per day. Therefore, 40 percent of Redwoods United costs are involved in travel. This changes the average cost per productive person hours (Table 9). Additionally, the administrative and vehicle charges are shown in relation to the wages paid to Redwoods United employees (Table 9). The total cost of Redwoods United per productive person hour is therefore \$12.07. A comparable or slightly higher cost is probably realistic if the transportation and administrative costs of Redwood National Park laborers were calculated.

Evaluation of Labor Intensive Application

The only significant labor intensive treatment on this unit was the spreading of straw mulch on disturbed areas. On the prairie lands, this appears to be desirable from the viewpoint of decreasing surface erosion, and possibly for enhancement of grass re-establishment. Additionally, the mulch gives an aesthetically more pleasing finished appearance to prairie work. In the oak woodland areas where there is a canopy cover the necessity is less and may have negative impacts on grass re-establishment. On roads within the forested lands, it appears that road surface application is of only limited value. The exception may be the application of mulch to stream channel excavations to enhance surface stability and inhibit some surface erosion.

The cost of this labor treatment is relatively high in relationship to the possible benefits. Major elements of these costs are the logistical distribution of necessary materials, travel time to get to the unit, and the inaccessibility of worksites. Predictions of these factors and costs must be involved in the prescriptions and weighed against the expected benefits of the treatment.

TABLE 9. ANALYSIS OF COST/HOUR FOR REDWOODS UNIT

	Total Person Hours	Non-Prod. Travel Time	Wages	Avg. Wage	Avg. Cost Prod. ¹ Per. Hr.	Trans.	Admin.	Cost/ Hour	Cost/ Prod. Per.Hr.	Total Cost	Cost/ Per. Hour.	Cost/ Prod. Per. Hour
RNP Laborers	923.5	185 ²	\$7,074.41	\$7.83	\$9.58	--	--	--	--	--	--	--

Redwoods United	1277	511 ³	\$6,661.21	\$5.22	\$8.70	\$1,175.00 \$0.92/hr	\$1,411.99 \$1.11/hr.	\$2.03	\$3.38	\$9,248.20	\$7.24	\$12.07

¹Productive Person Hour = hours spent in field working.

²At 2 hours per day.

³At 4 hours per day.

Conclusion

Most of the erosional features observed on this unit (Figure 3; Utley and Burns, 1981a) have been related to landscape modifications caused during timber harvest and road construction. These modifications have caused:

1. runoff concentration by roads;
2. drainage diversion by roads or skid trails;
3. drainage pattern destruction by tractor yarding methods;
4. increased surface runoff and ground saturation by timber removal; and
5. stream channel obstruction by sidecast material or road crossing construction.

The effects of these have been:

1. gully erosion;
2. streambank and channel erosion;
3. mass movements caused by ground saturation; and
4. fill erosion at haul road and skid trail crossings.

Many of the erosional features which have resulted from landscape modification have been interpreted as occurring immediately following the initial disturbance and have since stabilized. However, certain features have persisted long after the original disturbance and remained active sediment sources to the present. The most dramatic example of this is the drainage disturbance and gullies in the lower basin caused by the 1954 timber harvest. The cumulative effect of which has been widespread slope instability and large scale erosion features. The persistence and evolution of the effects of a relatively minor modification of drainage patterns over nearly thirty years indicates the care which must be exercised in causing modifications and in analyzing their results. In this case minor preventative measures (i.e., waterbars and swales) could probably have negated the cumulative impact. On this site, the most persistent and largest potential sediment sources are man-induced mass movement features, most of which have evolved to the point of being untreatable.

Additionally, the continued erosion or potential erosion associated with even well maintained or constructed roads is demonstrated by Maneze and Bald Hill roads. Along Maneze Road, high erosion potentials existed for all of the stream crossings as long as the road existed. Along Bald Hill Road, continued erosion caused by the road has evolved to the point of being untreatable or inaccessible for treatment. These indicate the necessity of careful design and construction of roads, and the mitigation of initial problems to prevent cumulative impacts.

The erosion-control rehabilitation work on this unit has demonstrated, as previous work within the park, that some effective but highly expensive corrective work can reduce sediment sources; for example, removing haul road and skid trail crossing fills. However, the most effective treatments are preventative in nature such as removing stream diversion potentials along Maneze Road. The most frustrating erosion features are those which are cumulative results which have evolved in complexity or scope to an untreatable degree. Doubly frustrating is the ability to see where minor preventative measures in the past could readily have mitigated the entire impact. Such preventative measures include preserving or restoring drainage patterns following timber harvest, or determining areas unsuitable for timber harvest to be left as forest preserves, or more careful design of roads and log-landing locations.



Unit: 81-1 PP#2 6/23/81



Unit: 81-1 PP#2 9/3/81



Unit: 81-1 PP#2 7/7/82



Unit: 81-1 PP#18A 6/23/81



Unit: 81-1 PP#18A 9/3/81



Unit: 81-1 PP#18A 9/14/83



Unit: 81-1 PP#22 6/30/81



Unit: 81-1 PP#22 9/1/81



Unit: 81-1 PP#22 9/7/83



Unit: 81-1 PP#24B 6/30/81



Unit: 81-1 PP#24B 9/1/81



Unit: 81-1 PP#24B 8/8/84



Unit: 81-1 1-A 6/30/81 PP#34 RX-21 Pre H.E. K.W.U.



Unit: 81-1 1-B 9/1/81 PP#34 Post H.E. W.D.B.



Unit: 81-1 1-C 7/7/82 PP#34 RX-21 R.G.L.



Unit: 81-1 1-D 9/8/83 PP#34 RX-21



Unit: 81-1 1-E 8/7/84 PP#34 RX-22 L.T.



Unit: 81-1 2-A 8/6/81 PP#61A Pre H.E. W.D.B.



Unit: 81-1 2-B 9/3/81 PP#61A RX-21 Post H.E. W.D.B.



Unit: 81-1 2-C 10/27/82 PP#61A RX-21 L.T.



Unit: 81-1 2-D 7/18/83 PP#61A L.T.