THE CASPAR CREEK EXPERIMENTAL WATERSHED

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The Caspar Creek Experimental Watershed was set up as a traditional paired watershed to investigate the effects of logging and road construction on erosion and sedimentation. Research participants have come from the California Division of Forestry, the Pacific Southwest Forest and Range Experiment Station, the California Department of Water Resources, the California Division of Mines and Geology, the California Department of Fish and Game, and Humboldt State University. The primary objectives of the project are to measure the sediment produced by a. North Coastal watershed in an undisturbed condition and to measure the degree to which water quality, flood peaks, suspended sediment, and bedload are affected by road construction and logging when practices are designed to minimize excessive runoff and erosion. Presently the North Fork of Caspar Creek (1,228 acres) serves as a control in comparison to the treated South Fork of Caspar Creek (1,047 acres). (Fig. 1)

Cretaceous sedimentary rocks including sandstone and weathered coarse-grained shale underlie the basin. An advanced second growth forest of redwood, douglas-fir, hemlock, and grand fir has become established following clear-cutting and burning in the late 1800's. The area.receives about 40 inches of rain per year predominantly between October and April. Hillslopes tend to steepen toward stream channels; the average slope is approximately 30%.

A calibration period preceeded road construction and logging in the South Fork. About 3.7 miles of, haul road were built. Following a measurement period for this treatment, 96% of the South Fork drainage was selectively logged and yarded by tractor. These effects are presently being monitored prior to the logging of the North Fork drainage in a few years. The following table outlines the project history:

1961-1967	Calibration,period for the two untreated watersheds
1967	Construction of road network in the South Fork drainage
1967-1971	Measurement period for impacts of road construction
1971-1973	Logging of the South Fork drainage
1973-present	Measurement period for impacts of logging
1980-1984	Logging of the North Fork drainage

In 1961, recording gaging stations were established at V-notch weirs at the, outlets of each watershed. At these stations suspended sediment concentration is measured periodically, and frequently during

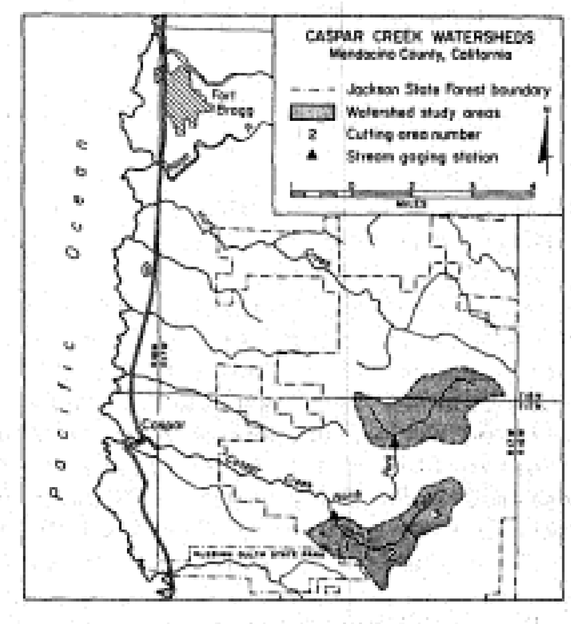

Figure 1-The two experimental watersheds in the Caspar Creek study are the North and South Forks on the Jackson State Forest, in northern California.

(Krammes and Burns, 1973)

storms. Sedimentation by bedload material and finer fractions in debris basins behind the weirs is monitored annually by surveyed cross-sections. Precipitation is measured by a series of rain gauges set up in and aroung the watersheds. In 1976, erosion in the South Fork watershed was measured over seven plots. Along transects in each plot, cross sectional areas of rills, gullies, ruts and cuts for skid trails or roads were measured to estimate the erosion within the basin caused by logging and road construction. A total of 94 acres was sampled amount ing to 9% of the watershed. During this same year, landslides were surveyed over the entire South Fork watershed. The volume of landslides was then estimated.

Before reviewing the status of information gleaned from this project, it would be enlightening to put our results in the context of logging impacts in North Coastal California. Fate has asserted some amendments to the original study design. This has both qualified our comparisons of the treated and control watersheds and had reinforced some new insights .into the nature of logging-related erosion.

An investigation of erosion found in logged, areas in northwestern California (Datzman, 1978) included 102 sites where surface and site conditions and erosion and ground disturbance were measured. These plots were stratified by slope, mean annual precipitation, geologic type, time since logging, and yarding method. Multiple regression was run to determine the importance of variables on erosion. It was found that two variables, yarding method and size of timber, were most important. Cable yarding created less disturbance and erosion than tractor yarding. Logging of old-growth redwood with sizes several times larger than other timber types and second-growth stands created significantly more erosion. The data, however, were dominated by a few erosion extremes which are attributed to the unpredictable "operator" variable. The site's with greatest erosion included a wide range of inherent erodibility. The erosion was unduly caused by the operator.

The disturbance and site conditions of the South Fork are similar to tractor-yarded second growth logging operations in this, study. The South Fork, however; suffered nearly four times as much erosion. Two-thirds of the erosion was from a failed landing unwisely located on the toe of a rotational mass movement feature. Without the results of the other study, we might conclude that a confusing quirk had complicated our experiment. In another light, one of the characteristic and important conditions of the "real world" is represented in our treatment. In conclusion, we believe that the logging and erosion and site factors of the South Fork of Caspar Creek are representative of other second growth tractor-yarded logging units in Northwestern California.

STREAMFLOW

Flows greater than 40 cfs in the South Fork, occur only one per cent of the time, but carry 26% of the flow volume and 81% of the sus pended sediment. Robert Ziemer (in prep.) has analyzed the streamflow records to see if logging has affected the volume of storm flows in the South Fork. He has found that the first three or four storms of each rainy season produce higher hydrograph peaks in the South Fork than predicted from the calibration data, but the difference becomes in significant later in the season. He reasons that loss of evapotrans porative stress from logging has caused the soil moisture in the South Fork to be higher during the beginning of the rainy season, producing more runoff for a given amount of precipitation. Later in the season, an equilibrium of saturation conditions with rainfall persists over the landscape more or less independent of the vegetative cover. Because much of the precipitation during the first storms goes into saturating hillslopes, the peak flows are usually not as great as during the later saturated period.

EROSION

Net soil loss from logged areas averaged 147 yd^3/ac. Assuming that the average soil depth is four feet, that the cutting cycle is 50 years, and that under undisturbed conditions natural erosion rate equals soil replenishment rate, logging-related erosion would remove the entire soil horizon in 4,700 years. Sediment measurements indicate that 14% of the eroded material since logging and road construction has left the watershed. Most of the eroded soil, therefore, would remain in the watershed (at a lower elevation and perhaps in a zone of higher transport) for a period much greater than 4,700 years. This analysis does not account for other types of soil depletion important to productivity, such as loss of nutrients.

The landslide survey yielded an estimated 100 yd^3/ac of soil displacement. Eighty-five percent of the slides were associated with road construction and skid trails.

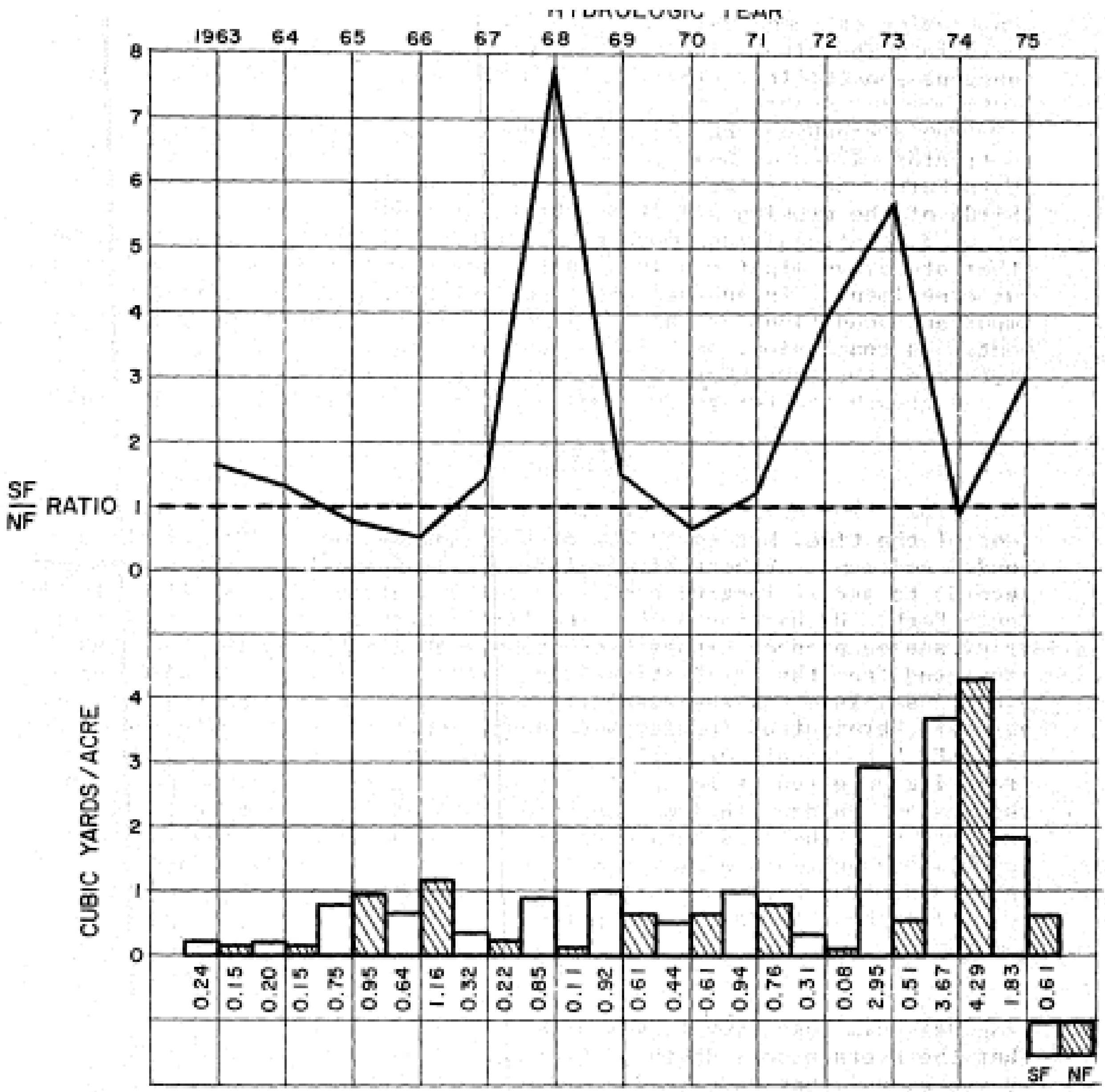

FIGURE 2 - SUSPENDED SEDIMENT COMPARISON FOR.. NORTH FORK (NF) AND SOUTH FORK (SF) CASPER CREEK WATERSHED, 1963-1975

(Tilley & Rice, .1977)

SEDIMENTATION

Measurement of sediment in streams is often used to monitor the erosion of the watershed as a whole. Because of the usual low delivery ratio, erosion measured in this way is but a small fraction of the total soil displacement. Once fine sediment reaches the drainage network, it is quickly tranported through the system and becomes a sensitive parameter of erosion as well as an important condition of water quality. Coarser sediment moving as bedload moves more slowly through the system and thus is more difficult to attribute to a particular hydrologic or erosional event.

Following road construction, suspended sediment ocncentration rose in 1967 to 3.7 times the level predicted. In 1969 and 1970, concentrations declined. (Fig. 2) Presumably, these levels fell in a short period because most of the roads were constructed within a few hundred feet of the South Fork channel. Displaced soil thus moved rapidly to the channel. In total, over four years, construction of 3.7 miles of roads in the South Fork produced 2.04 yd^3/ac of sediment which arrived at the South Fork weir.

In 1967, immediately after road construction, a log splash dam failed in the South Fork releasing 925 yd^3 of sediment or 43% of the total sediment derived from road construction. The dam had been storing sediment for approximately 80 years. A major stream crossing of the main haul road, approximately three hundred feet upstream, was the likely cause of the dam failure. In 1967, deposition in the debris basin was 50% greater than predicted. In 1971, flows in excess of 200 cfs contributed four times as much sediment as predicted. Most likely this sediment was derived from the splash dam failure and road construction.

LOGGING

The logging operator gave little consideration to erosion control or the maintenance of natural water sources. Water bars were infrequent and often misplaced. Landings were often located without due consideration of local slope hydrology or slope stability.

Several factors complicated the use of calibration period data to assess the sediment yield from logging. Some of the highest and lowest amounts of precipitation fell in the years during and following logging. In 1974, slides entered each of the North Fork and South Fork riparian areas. Material from the North Fork slide, 4,324 yd^3, directly entered the stream channel. The South Fork slide, 727 yd^3, bridged the stream so that little of the sediment entered the channel. Allowing for these complications, our upper estimate of the suspended sediment derived by logging equals 7.5 yd^3/ac and our lower estimate is 3.7 yd^3/ac. We believe the upper estimate is more accurate.

The sediment load of the stream depends upon the stream power available to transport it and the sediment supply. In a stream with little sediment supply, the sediment load is supply dependent because

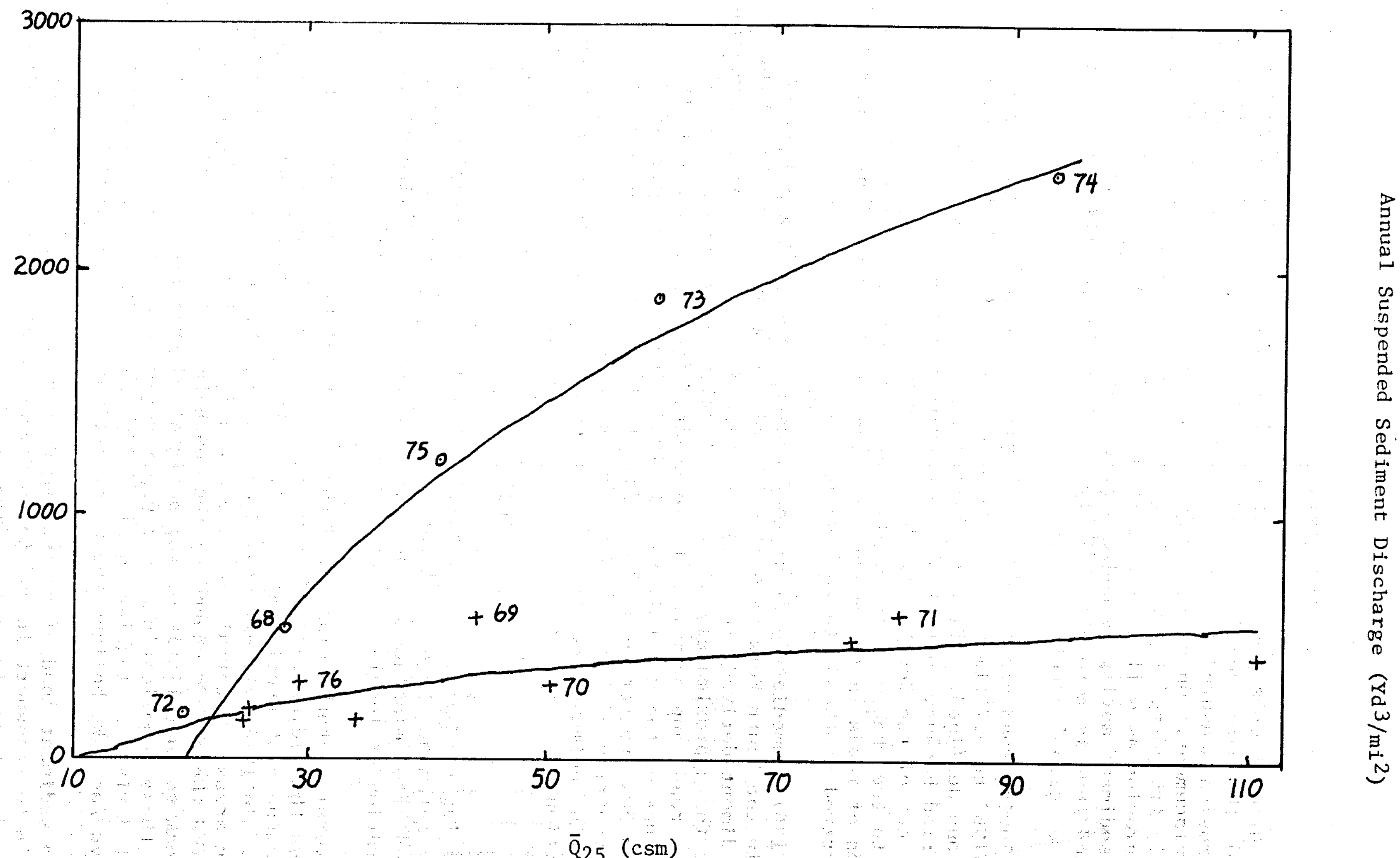

Figure 3. Sediment Discharge of South Fork of Caspar Creek as a function $\bar{Q}_{25}$ (the mean discharge of the flow volume). (Rice, et. al., 1978)

⊙ "Disturbance" years

\+ "Non-disturbance" years

at even high flows (high stream power), the stream tray carry little sediment. On the other hand, if sediment is abundant the sediment load depends on the stream power (or discharge) capable of carrying it, i.e., the load is stream power dependent. Considering the relationship between annual suspended sediment yield versus the mean discharge for the top 25% of the flow volume ($\overline{Q}_{25}$) for the South Fork (Fig. 3), logging has caused a change in the sediment load from being supply dependent to stream power dependent.

INTERPRETATIONS

Total sedimentation resulting from logging and road construction from 1967 to 1976 is estimated at 8.5 yd^3/ac of suspended sediment plus 0.99 yd^3/ac of debris basin deposits, totaling 9.5 yd^3/ac of sediment reaching the South Fork weir. The erosion control measures employed with logging and road construction were below the state of the art at the time and certainly below the standards set by the current California Forest Practice rules.

The rate of soil loss attributed to logging in the South Fork is equivalent to an average erosion of the land surface of 0.85 feet per 1,000 years or approximately the erosion rate of North Coast basins for the last several million years (Wahrhaftig, 1975). In the South Fork, ten percent of the watershed was made less productive because of the disturbance, but half of this area is in road prisms. Even with twice the natural erosion rate, one could conclude that the projected depletion of the soil resource is not immediate enough to influence long-range management decisions.

The most important impact was on water quality. The first and fourth largest values for $\overline{Q}_{25}$ occurred during the calibration period. Despite this, suspended sediment concentrations during six of the nine post-calibration years exceeded any of the concentrations during the calibration years for the South Fork. This means that if the cutting cycle is every 50 years, ten percent of the time suspended sediment concentrations will be above the level expected from natural variability. Can the aquatic ecosystem maintain productivity and diversity under this great a change in physical conditions? In eight of the nine post-calibration years, suspended sediment concentrations in the South Fork exceeded the water quality standards of the North Coast Regional Water Quality Board (no increases beyond 20% of the background).

FUTURE PLANS

The North Fork watershed will be selectively logged between 1980 and 1984. Most of the area will be cable-yarded except for upper gentler slopes which will be tractor-yarded. In addition to the variables measured up to now, bedload transport rate will be measured before and after logging. Channel cross-sections will be periodically surveyed in order to follow the movement of the coarse stream sediment through the drainage network. In an adjoining watershed, plans are underway to measure the nutrient depletion created by logging.

THE FIELD TRIP

Long drives over narrow roads restrict us from seeing representative stream channels and hills lopes of both watersheds. We will first visit the South Fork weir and then drive toward the headwater area to see the tractor-yarded area and some cable-yarded units outside of the experimental watersheds.

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