

Streamflow and Sediment Response to Logging, California, USA

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1. INTRODUCTION

Streamflow, suspended sediment, and bedload have been monitored since 1962 in the 473-ha North Fork and the 424-ha South Fork of Caspar Creek. These watersheds are about 7 km from the Pacific Ocean, on the Jackson Demonstration State Forest, 10 km south of Fort Bragg, California, USA (Ziemer et al. 1996).

The watersheds have a southwest orientation. Uplifted marine terraces deeply incised by antecedent drainages characterize the youthful topography. Hillslopes are steepest near the stream channel and become gentler near broad, rounded ridgetops. About 35% of the slopes are less than 17° and 7% are steeper than 35°. Elevation ranges from 37 to 320 m. The soils of the basins are well-drained clay-loams, 1 to 2 m in depth, and are derived from Franciscan graywacke sandstone and weathered, coarse-grained shale of Cretaceous Age. The soils have high hydraulic conductivity and subsurface stormflow is rapid, producing saturated areas of only limited extent and duration.

The climate is typical of low-elevation watersheds on the central North American Pacific coast. Winters are mild and wet, while summers are moderately cool and dry. About 90% of the average annual precipitation of 1200 mm falls from October through April. Snow is rare and rainfall intensities are low.

Prior to treatment, the watersheds supported a 90-year-old second-growth forest composed of coast redwood (*Sequoia sempervirens* (D. Don) Endl.), Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), western hemlock (*Tsuga heterophylla* (Raf.) Sarg.), and grand fir (*Abies grandis* (Dougl. ex D. Don) Lindl.). Stem wood volume averages about 700 m³ha⁻¹. From 1963 to 1967, both forested watersheds were measured in an “untreated” condition. In 1967, logging roads were built in the South Fork. From 1971 through 1973, about 65% of the stand volume was selectively cut from the South Fork watershed, while the North Fork remained as an untreated control. Logging began in the North Fork in 1985 and ended in 1991. The timber volume removed from the North Fork watershed approximated that cut from the South Fork in the early 1970's, but clearcutting rather than selective harvest was used. The size of clearcut blocks in the North Fork ranged from 9 to 60 ha and occupied 35% to 100% of individual tributaries.

2. RESULTS

2.1 WINTER PEAKFLOW

Logging-induced changes in the South Fork's peak streamflow were greatest for the first storms following lengthy dry periods. There was no significant

change in the largest peakflows (>10-year return interval) after selectively logging the South Fork (Wright et al., 1990). Peak streamflows following clearcut logging in the North Fork behaved similarly. There was a mean increase of 17% for the class of peakflows with return intervals >0.45-year ($>0.004 \text{ m}^3 \text{ s}^{-1} \text{ ha}^{-1}$).

2.2 ANNUAL RUNOFF

Annual runoff in the South Fork increased between 9% and 30% for the first 5 years after selective logging. This is equivalent to an average increase in water yield of $900 \text{ m}^3 \text{ ha}^{-1}$. The increased annual water yield slowly returned to prelogging levels over the following 15 years. After clearcut logging in the North Fork, annual water yield increase varied from 9% to 58% in the first 7 years, with an average increase of $945 \text{ m}^3 \text{ ha}^{-1}$. This result is similar to that observed following the removal of about the same volume of trees from the South Fork. However, 7 years after clearcutting, there is still no trend of return to prelogging levels.

2.3 SUMMER LOWFLOW

Selection logging of the South Fork increased summer lowflow by about $0.3 \text{ l-s}^{-1} \text{-km}^{-2}$ for each of the first 3 years after logging, an increase of about 80% from that predicted by the pre-logging regression. This increased summer flow declined with regrowth of the vegetation so that within 7 to 8 years after logging, summer lowflow had returned to pre-logging levels. Clearcut logging about 50% of the North Fork produced minimum summer flows averaging $0.4 \text{ l-s}^{-1} \text{-km}^{-2}$ (146%) larger than predicted. The increased flow was greatest (250%) during the first 2 years after clearcutting, but 7 years after cutting, summer flow was still 112% above prelogging levels.

2.4 SEDIMENT DISCHARGE

Annual suspended sediment loads in the South Fork increased by almost 400% ($130 \text{ m}^3 \text{ km}^{-2}$) relative to the predicted load in the winter following roadbuilding and increased by between 100% ($30 \text{ m}^3 \text{ km}^{-2}$) and 500% ($460 \text{ m}^3 \text{ km}^{-2}$) of the predicted loads in the five winters after logging. South Fork sediment loads returned to pre-logging levels about 7 years after logging was completed. To date, the effect of logging in the North Fork has been much smaller than that following logging in the South Fork. The greatest increase in suspended loads in the North Fork in the 6 years since clearcutting has been $56 \text{ m}^3 \text{ km}^{-2}$.

About one-third of the total sediment load consists of bedload. Sediment deposited in debris basins immediately upstream of the North and South Fork gauging stations typically include bedload plus about 40% of the suspended load. No changes in debris basin deposits were detected after roadbuilding or logging in either watershed.

REFERENCES

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