The Role of Stored Historic Sediment in Short-Term Sediment Production, South Fork Noyo River, Jackson State Demonstration Forest, California

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Introduction

The South Fork Noyo River (SFNR) watershed (Photo 1) in northern coastal California has been heavily impacted by widespread clearcut logging over the last century (Photo 2). As a consequence, large volumes of sediment have been delivered to watercourses within the basin. Historically, large populations of anadromous fish reproduced in the river. However, drastically declining fish populations over the past several decades has raised concerns over the cumulative impacts of sediment on water quality, fish habitat, and the aquatic environment. In 1999, the U.S. Environmental Protection Agency established a Total Maximum Daily Load (TMDL) for the SFNR, and determined sediment loading allocations aimed at improving water quality criteria for sediment. The EPA acknowledged that the office-based sediment budget assessments used in the TMDL were incompatible with field geomorphic relations. Prior to this study, very little data existed on sediment storage volumes and transport rates in the SFNR.

The overall goal of this assessment was to use geomorphic field mapping and data collection techniques to assess long- and short-term sediment storage and transport within the SFNR. Specific objectives of this investigation were to:

(1) collect baseline data on the volume of sediment stored and transported within the SFNR watershed over the past approximately 110 years;
(2) collect present-day stream flow and sediment transport data from the main stem SFNR and its major tributaries; and
(3) evaluate long- and short-term storage and transport within the SFNR watershed.

This effort contributes to the evaluation of how forest management practices have affected the past and present distribution of sediment within the basin. The results of this research address the uncertainties in sediment budget analysis and provide a broader basis for understanding long-term watershed processes in the SFNR watershed and other watersheds throughout northwestern California.

Figure 1

Drainage map of the South Fork Noyo River watershed showing detailed geomorphic mapping locations, reconnaissance mapping reaches, suspended sediment sampling locations, cross section locations, watershed boundary, and property boundary of Jackson State Demonstration Forest.

Photo 2

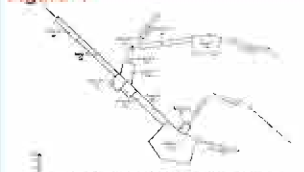
[illegible]

[illegible]

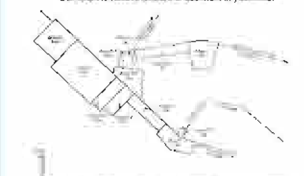
Photo 3

A) Photo showing sawed log embedded within historic terrace deposit in map Area C. Pre-historic terrace is visible in the background and gravel bar is in the foreground. Field map board is on log for scale. B) Photo showing historic terrace deposit in Area C. In both photos, dashed line indicates approximate back edge of historic deposit.

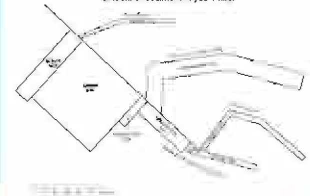
Figure 4



Box diagram showing total volume of historic terrace storage per river mile in the South Fork Noyo basin. Box width is relative amount of sediment in yds³/mile.



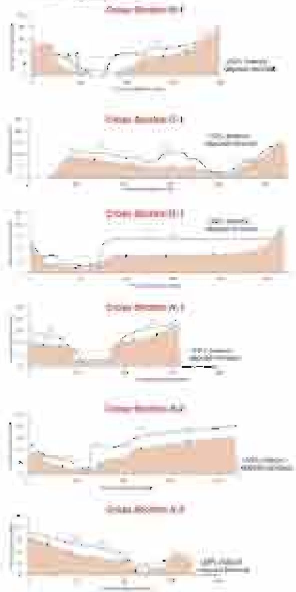
Box diagram showing total volume of active channel deposits per river mile in the South Fork Noyo basin. Box width is relative amount of sediment in yds³/mile.



Box diagram showing total suspended sediment in tons for each sampling station.

Figure 5

Cross sections surveyed in each detailed mapping area (Figure 1). Dashed lines represent probable maximum thickness of historic aggradation used to estimate the amount of material removed by fluvial processes since the time of terrace deposition.



Methods and Approach

- We performed detailed geologic mapping and surveying to quantify the volumes of sediment associated with pre-historic terraces, historic terraces, and the active channel along four stream reaches. We also collected reconnaissance-level data along three stream reaches in the SFNR watershed.
- We assessed the present-day hydrology and sediment transport within the major sub-watershed areas in the SFNR watershed by establishing ten streamflow and suspended sediment sampling locations within the study area. These stations were monitored for water year 2001.
- The sediment transport data was then compared to the distribution of stored historic sediment identified by field mapping to assess the influence of historic sediment on present-day suspended sediment yield.

Figure 2

Schematic sketch of typical South Fork Noyo River channel showing valley margin, prehistoric terrace, historic terraces, gravel bar, and channel. Historic terrace deposits are observed on bedrock in some locations (left) and on channel deposits in other locations (right). Old growth redwood stumps are diagnostic of prehistoric deposits and embedded chain-sawed logs are diagnostic of historic deposits. Prehistoric terraces typically support second growth redwood trees and ferns; historic terraces typically support alder trees and grasses.

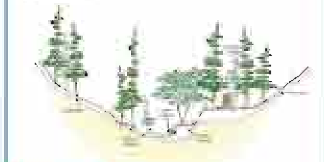
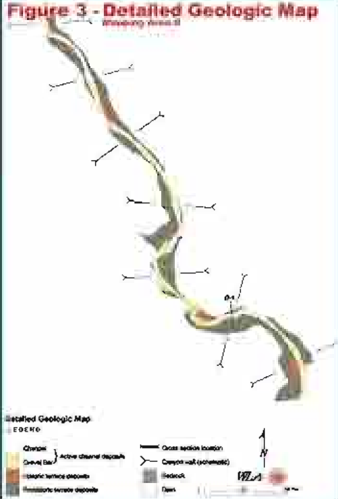


Figure 3 - Detailed Geologic Map

(Mapping Area B)



Results

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Pre-historic terraces, historic terraces, and active channel deposits were delineated in four study areas along the SFNR (Figures 1 and 3). Pre-historic terraces were identified by the presence of old-growth redwood stumps in growth position on the terrace surface. This map unit approximates the terrace configuration in the SFNR watershed prior to the initiation of logging in the late 1800's. Historic terraces were delineated based on the presence of chainsawed logs within terrace deposits, and an absence of old-growth stumps (Photo 3). We infer that these historic terraces represent the maximum amount of channel aggradation that has occurred since the initiation of logging. Based on the presence of chainsawed logs found in the channel, we infer that the active channel deposits are a product of post-logging erosion and transport of historic sediment. Figure 2 is a schematic cross section of a typical SFNR channel, showing map unit relations.

We schematically show the distribution of sediment stored in channels and historic terraces as well as the total volume of suspended sediment measured for water year 2001 in Figure 4. These data suggest that there is significantly more sediment stored in the channel downstream of mapping Area B. From these reasons, we infer that there has been sufficient time since the logging operations and subsequent terrace deposition to erode the historic terrace deposits and redistribute this material downstream.

Photo 1

Photo shows the South Fork Noyo River watershed (view northwest). The Pacific Ocean near Fort Bragg is in the background.

[illegible]

- Detailed channel mapping performed during the project confirms that there is significant amounts of stored historic sediment in the channels of the SFNR and that this sediment likely is mobilized during winter storm flows. We identified 138,000 yds³ of sediment stored in the active channel and 68,000 yds³ of sediment stored in historic terraces (Table 1).
- By analysis of the six channel cross sections (Figure 5) we speculate that approximately 45% to 75% of the historic sediment that once existed in the SFNR watershed has been eroded and transported downstream. These relations suggest that the sediment generated by logging in the SFNR watershed is being transported through the system but has not yet been flushed out of the system. We speculate that the remaining post-logging sediment in the SFNR channel will take tens to hundreds of years to flush through to the watershed mouth.
- A large increase in suspended sediment transport occurred downstream from mapping Area B. This implies that significant sources of readily accessible sediment are located along this stream reach. This readily accessible sediment is most likely the active channel sediment identified downstream of mapping Area B.
- The addition of suspended sediment trapped in channel and historic terrace storage locations to watercourses appears to result in dramatic increases in the overall suspended sediment load. Therefore, areas that contain large amounts of sediment stored in active channels and/or historic terrace deposits likely are large contributors to the suspended sediment measured during present-day high-discharge events. Clearly, a distinction must be made between the amount of sediment introduced to the system over the short-term and the amount of sediment reintroduced to the system from long-term channel storage locations.
- Future field-based sediment budget analyses for the SFNR and other coastal watersheds will benefit greatly from accurate mapping and quantification of channel deposits. An understanding of the volume and timing of sediment stored in the channel is necessary for any study attempting to relate upstream management practices to suspended sediment production. By not addressing long-term sediment storage and relying solely on present-day suspended sediment sampling, suspended sediment load entering the watercourse by modern management practices can be significantly over-estimated.

Table 1

Total volume of sediment stored in active channel deposits, historic terrace deposits, and pre-historic terrace deposits for each detailed mapping area (Area A-1 to Area D) and reconnaissance mapping area (Area E to Area G).

Stream Reach	[illegible]	Active Channel Deposits			[illegible]	[illegible]
		Gravel Bar [illegible]	Channel [illegible]	[illegible]		
Area A-1	[illegible]	[illegible]	5,367	[illegible]	[illegible]	8,350
Area A-2	0.35	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Area B-1	0.47	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Area B-2	0.38	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Area B-3	0.45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Area C	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Area D	2.1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Area E	2.2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Area F-1	0.4	[illegible]	[illegible]	[illegible]	1,091	[illegible]
Area F-2	0.24	[illegible]	[illegible]	[illegible]	0	[illegible]
Area F-3	1.66	[illegible]	[illegible]	[illegible]	4,201	[illegible]
Area G	1.5	[illegible]	[illegible]	[illegible]	7,397	[illegible]
Total	[illegible]	[illegible]	[illegible]	[illegible]	67,992	[illegible]

[illegible]

Conclusions

- The detailed maps and cross sections produced in this research provide a snapshot of the distribution of stored sediment within SFNR and represent a baseline datum from which to monitor future channel recovery.
- The streamflow and suspended sediment transport data provide estimates of suspended sediment transport for WY 2001. This data can be used in the future to monitor sediment contributions related to upslope management practices on a sub-watershed basis.
- This research shows that sediment trapped in long-term storage along the SFNR channel is transported downstream in high-discharge events. This sediment increases the overall suspended sediment load and can lead to an overestimation of the sediment generated by upslope management practices.

Future sediment transport studies designed to assess the sediment contribution from upslope forest management should include an assessment of in-channel storage and transport. A clear understanding of the distinction between these two sediment sources is necessary to properly evaluate sediment budget analyses.

Acknowledgements

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