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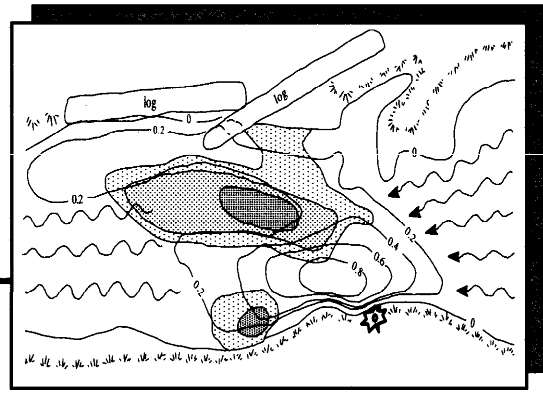

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Fine sediment in pools: an index of how sediment is affecting a stream channel

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One of the basic issues facing managers of fisheries watersheds is how inputs of sediment affect stream channels. In some cases we can measure and even roughly predict effects of land use on erosion and delivery of sediment from hillslopes to streams. But we are at a loss about how a given increase in sediment load will affect channel morphology, flow conditions, and substrate. As a result, we are unable to relate watershed processes to productivity of fish habitat. The method described here is meant to begin to fill this gap. Measurement of the relative volume of fine sediment in pools serves as a sensitive index of a channel's response to the volume of sediment delivered to it. The hypothetical mechanism behind this response is as follows: as more sediment is added to a stream, the bed becomes more mobile at a given discharge. At high flow, sand and small pebbles become abundant over most of the surface of the bed, and bedload transport rates of all grain sizes are greater than they would be if the supply of sediment were smaller. As flow wanes and transport rates decrease after a flood, this finer sediment is winnowed from areas of the bed where boundary shear stress is high, such as riffles, and deposited in areas of low shear stress, such as pools. Thus riffles and much of the rest of the bed become armored while pools are blanketed with a layer of fine sediment. In channels with a low sediment load and a less mobile bed, less fine sediment is available for winnowing from riffles--thus deposits of fines in pools are smaller. Therefore, the fraction of pool volume filled with fine sediment, which we call V*, is directly related to the supply of sediment and the mobility of the channel as a whole.

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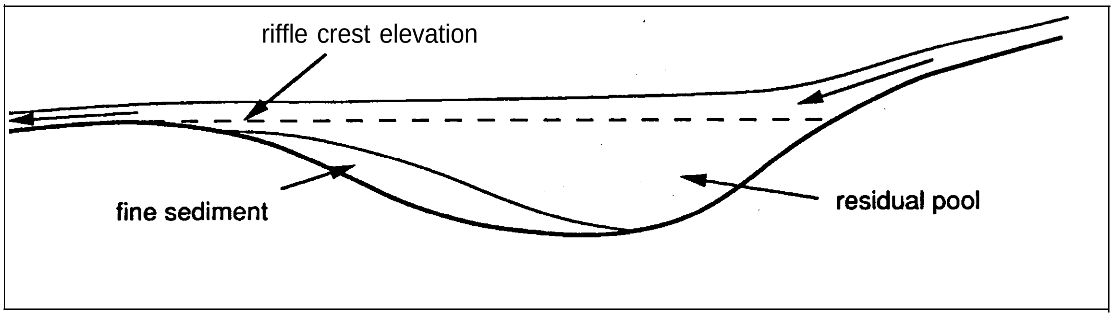

Figure 1. Kepresentative pool in Three Creeks, a tributary to Willow Creek in Six Rivers National Forest

The Method

Fine sediment is characteristically deposited non-uniformly in pools (Figure 1). Deposits are thickest under eddies and backwaters, around the periphery of pools, and behind large boulders or large woody debris. Deposits are commonly absent under the thalweg. Fines occupy 30 percent of the volume of the pool shown in Figure 1. The grain size of the fine sediment varies from stream to stream. In most cases, it consists of sand and small pebbles. but silt and medium to large nebbles may also be present. Fines are distinguished from the coarser substrates in pools by being unarmored, distinctly finer than the rest of the bed, and easily penetrable with a metal rod. We measure the residual water volume (see Lisle, 1989) and fine sediment volume in a number of pools in a reach of stream (Figure 2). Fifteen or so clearly definable pools are selected in a reach that has a relatively low gradient (which favors both large pools and much sediment in storage) and no intervening large tributaries or sources of sediment. Measurements should be made during low flow. Our three person crew can complete work in a one kilometer reach of a third or

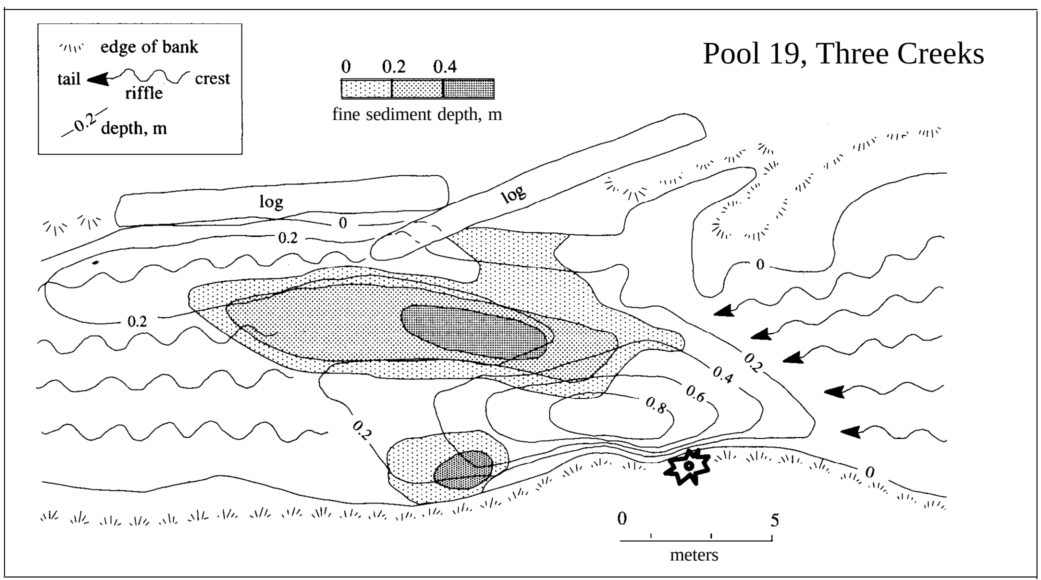

Figure 2. Longitudinal section of a pool showing delineation of fine sediment and residual pool volumes.

fourth order tributary in about three days; larger rivers requiring rafts take approximately twice as long. Our procedure for each pool is outlined below. We will publish a more detailed description of the method soon, and until then we are available for help in getting started.

1. Locate the riffle crest and measure the mean thalweg depth. Sketch a map of the pool.

2. Over five to eight transects placed at measured intervals along a longitudinal tape, measure water depth and fines thickness (if present) at a total of 30 to 60 locations in the pool.

3. At locations along these transects where there are fines, place a metal rod (one-half inch in diameter x four ft. or longer in length) on the bed surface and push by hand or gently tap with a hand sledge until you detect the, buried armor layer. Measure the depth of penetration. Additional transects may be added to cover deposits of fines in sufficient detail. Transects and soundings should be closely spaced over distinct deposits of fines.

4. Compute the residual pool volume (Vr) and fines volume (Vf) within the residual pool. Scoured pool volume (Vsp), the residual pool volume if fines were removed, equals the sum of residual pool volume and fines volume. The fraction of pool volume filled with fines (V*) equals the fines volume divided by the sum of fines volume and residual pool volume:

$$V^* = Vf/(Vf+Vr) = Vf/Vsp$$

Volumes are computed by summing the volumes between adjacent transects. These unit volumes are computed by multiplying the mean cross sectional area of each pair of transects by the distance between them. We have a Minitab program that is available which can be easily adapted to other systems, to perform these

	Sediment Yield	Average V*	# of pools sampled
Big French	low	0.040	13
Bear	moderate	0.069/a	20
Rattlesnake	moderate	0.12	20
N. Rattlesnake	moderate	0.11	15
Three Creeks	high	0.27	19
Grouse	high	0.26	17
Grass Valley	extreme	0.50	17

/a not including the reach downstream of a mine, described on pg. 5

Table 1. Perceived sediment yield and fraction of pool volume filled with fine sediment (V*) in tributaries of the Trinity River. Streams are listed in order of perceived sediment supply.

calculations. We compute a weighted average value of V* for the entire reach simply by dividing the total fines volume of all of the pools by the total scoured pool volume.

Applications

Inventory--comparing streams with different sediment toads

To test the accuracy and practicality of measuring fine sediment volume in pools to assess sediment loads, we ranked and rated the perceived sediment loads of eight tributaries of the Trinity River in northwestern California. We then measured fines volume and residual volume in 13 to 20 pools in a reach of each stream, ranging between 230 and 1400 meters in length. Perceived sediment loads were categorized before we began field work as low, moderate, high, and extreme based on erosivity of bedrock, area and intensity of logging and road building, and narratives of watershed specialists of the Shasta-Trinity and Six Rivers National Forests. Median values of V* correlated well with category and rank of sediment load (Table 1). Big French Creek, which drains resistant metamorphic rocks in the Trinity Alps Wilderness Area, ranked lowest in sediment production and contained the least fine sediment (V*=0.04). Grass Valley Creek, which drains extensively disturbed, deeply weathered granite, ranked highest in sediment production and contained the most sediment (V*=0.50). Values of fine sediment volume for the remainder fell in approximate order of sediment production.

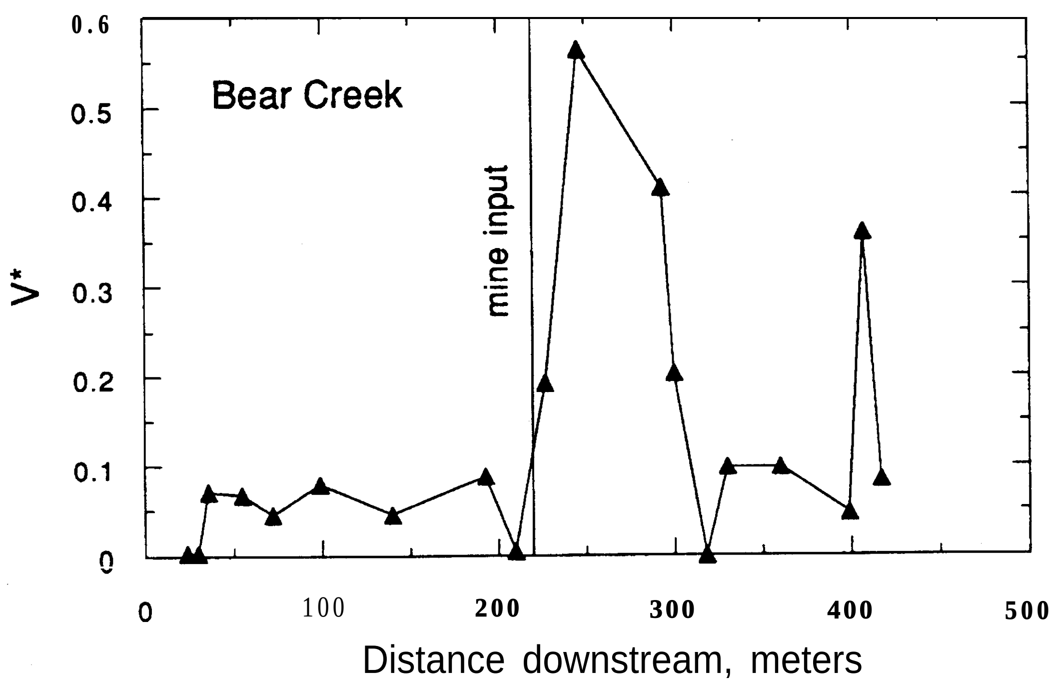

Figure 3. Downstream variation of V* in Bear Creek, a tributary to Hayfork Creek in the Shasta-Trinity National Forest. "Mine input" indicates location of input of fine sediment from a mine.

Detection and evaluation of sediment sources

In addition to indexing sediment load, we found that a sequence of measurements of V* down a channel can be used to reveal sediment sources in a stream network and to evaluate the magnitude and extent of their effect. The relative volume of fine sediment in pools of Bear Creek increased sharply at 250 m downstream of the start of the study reach, and then decreased rapidly within the next 100 m (Figure 3). At the point of increase, we discovered an illegal mining operation upslope and out of sight of the channel. Values of V* were among the lowest of the study streams upstream of the mine and among the highest immediately downstream. These results suggest that sediment sources such as tributaries, landslides, fires, or human related disturbance can be evaluated by measuring fines in pools both upstream and downstream of the sources.

Monitoring

We have only begun to repeat these measurements annually in a particular reach of stream, but the method seems appropriate for monitoring. For this purpose, we suggest that more intensive measurements be made in a smaller number of simple, large pools than as in the study described above. We are in the process of refining our methodology for a variety of applications. We do not recommend the method for unstable channels. Extensive bank erosion, migrating bars, and active braiding also diminish pool volume and even cause pools to disappear, but this is due more to ineffective and unstable structure than to secondary filling of stable pools with fine sediment.

Relations to fiih habitat

Pools are important components of habitat for many fish species and other aquatic organisms. Filling by fines affects pool habitat by reducing volume, particularly during drought conditions, and obliterating substrate cover. Similarly, V* may be linked to bed mobility and sediment transport and thereby to spawning habitat through scour of redds or sedimentation by fines. Fine sediment in pools is transported first as flow increases and could infiltrate redds constructed immediately downstream. Deposition of fines in pools, however, cannot be linked quantitatively at this point to habitat suitability or productivity of fish. Relationships between pool conditions and habitat requirements need to be better developed in order to determine thresholds of concern based on the volume of fine sediment in pools.

Current Status

We are preparing two manuscripts, one to describe results from our Trinity basin study and another to describe our methodology in detail.

We are also training hydrologists and fisheries biologists from Klamath and Six Rivers National Forests. The Klamath National Forest will use the method to investigate sediment problems and monitor recovery in the Salmon River drainage following recent fires and timber salvage. For further information contact us at (707) 822-3691; (DG S27L01A).

Acknowledgments

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FHR Currents...Purpose

The Fish Habitat Relationship (FHR) Program of R-5 USFS has been established to research and develop information on fish ecology and to coordinate effective applications of this knowledge in managing and protecting our fisheries. By relating life stage requirements of specific species to physical habitat parameters, we are aiming at our main objective: developing a methodology to manage fisheries through the management of habitat.

If you wish to submit a paper for publication in the FHR Currents, please write Jerry Boberg, Dave Fuller (Technical Editors) or Stephanie Gomes (Editor) for information and guidelines:

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