The Importance of Wood in Headwater Streams of the Oregon Coast Range

Although headwater streams comprise the majority of stream length in mountainous regions, little is known about their form and function in comparison to higher-order rivers. A better understanding of the role of headwater streams in routing water, wood, and sediment is needed to clarify the physical and biological connections among uplands, riparian zones, and downstream reaches.

Debris flows in steep, **headwater streams** often convey sediment and wood to downstream reaches, leaving behind a channel that has been **scoured** to bedrock. The erosion of a channel to bedrock provides a unique opportunity to measure the rate at which wood and sediment accumulate, and to gain insight into the processes that refill a channel and rebuild channel structure. As part of the Cooperative Forest Ecosystem Research (CFER) program, USGS scientists Christine May and Robert Gresswell examined the processes and rates of sediment and wood replenishment to headwater streams in the Oregon Coast Range. Their objectives were to: (1) quantify the rate of wood and sediment accumulation in **low-order streams** that were prone to erosion by debris flows; (2) identify the mechanisms for sediment storage in these steep, low-order channels; and (3) assess the potential of low-order streams to serve as storage sites for hillslope-derived sediment.

In the Oregon Coast Range, debris flows are one of the dominant sediment transport processes in headwater catchments. These episodic disturbances have the potential to scour sediment and wood that have been stored in small streams for decades to centuries and deliver this material downstream to larger rivers. Because the quality of downstream habitats is determined, in part, by how often such disturbances occur and how much material is delivered downstream, it is important to understand the dynamics of sediment and wood accumulation in headwater streams during the interval between debris flows. To gain a better understanding of the role of headwater streams in routing wood and sediment throughout the stream network, May and Gresswell used **dendrochronology** to estimate the time since the previous debris flow in two unlogged, third-order basins, Skate and Bear creeks, in the central Oregon Coast Range (Figure 1). Within these two basins they examined sediment and wood accumulation in 13 tributaries that ranged from 4 to 144 years post disturbance. All wood in contact with the channel or valley floor with an average diameter >20 cm and length >2 m was measured. The volume of sediment in the channel network was also measured, including the proportion of sediment that was directly stored behind wood and boulders.

Although a high degree of variability of in-stream wood abundance was observed, the volume of wood was found to be strongly correlated with the time since the previous debris flow (Figure 2). Sediment accumulation rates had less variation; however, the sediment volume increased out of proportion to time. Lower accumulation rates were observed immediately following a debris flow, whereas higher accumulation rates were observed as the time since the previous debris flow increased (Figure 3). May and Gresswell interpreted this pattern as an increased ability of the channel to store sediment over time. After a channel is scoured by a debris flow, newly acquired sediment is quickly transported downstream. As wood

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US Department of the Interior
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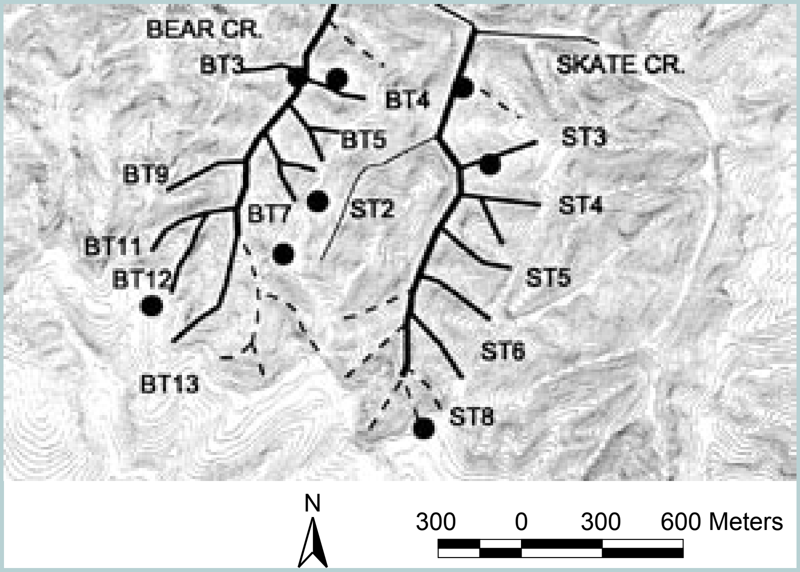


Figure 1. Site map of Skate and Bear creeks, Siuslaw River drainage in the central Oregon Coast Range. Dark solid lines represent channels investigated for wood and sediment storage. Dashed lines represent tributaries impacted by timber harvest and not investigated. Thin solid line (ST2) is only tributary with no evidence of delivering debris flows to the mainstem. Solid circles represent sample sites for the dendrochronology-based fire history reconstruction. Contour interval = 10m.

accumulates in the channel through time; however, the capacity of the channel to store sediment increases, initiating a series of positive feedbacks. Sediment that accumulates behind wood in the channel increases the streambed **roughness**, decreases the local slope of the channel, and further reduces the capacity for sediment transport. On average, 73% of the sediment in these steep, debris flow prone channels is stored directly behind wood. Because headwater streams occupy the majority of the channel length, they have the potential to store large volumes of hillslope-derived sediment. In an intensive investigation of Skate Creek, May and Gresswell found that 72% of sediment in the entire drainage network was stored in debris flow prone tributaries.

Based on their observations, the researchers created a conceptual diagram that depicts the changes in channel morphology that occur in headwater streams following a debris flow (Figure 4). Immediately following the disturbance, the channel is predominantly bedrock, with almost no sediment or wood in storage. During the following 50 years, small discrete patches of sediment are stored behind individual logs, but the channel remains predominantly bedrock. One hundred years after the debris flow almost half of the channel length is still exposed bedrock. By 144 years, the maximum age of channels investigated by May and Gresswell, discrete patches of sediment had coalesced to form larger, more contiguous patches. These changes in channel morphology are largely attributable to wood accumulation, which provides the cornerstone for sediment storage in channels that would otherwise remain in a bedrock state.

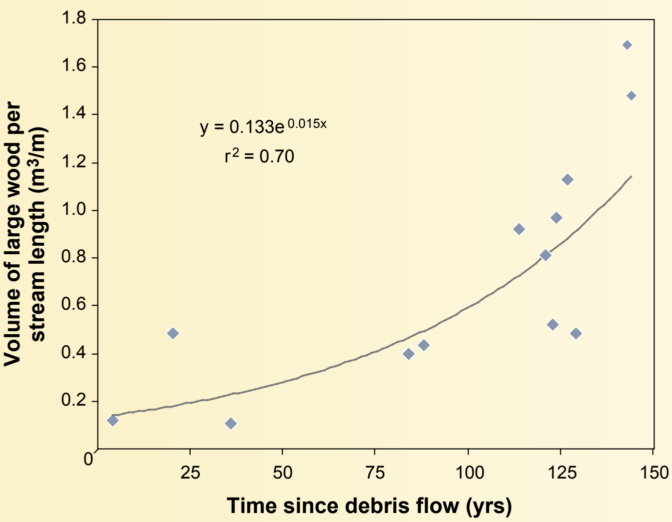


Figure 2. Volume of large wood in the study streams based on the time since the previous debris flow as estimated by dendrochronology.

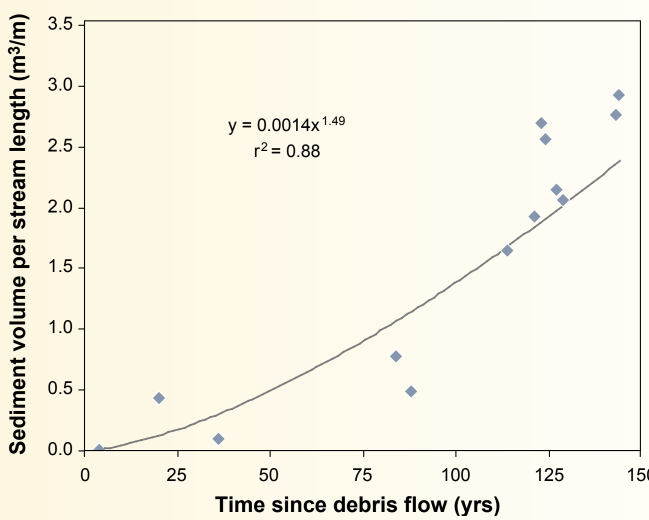
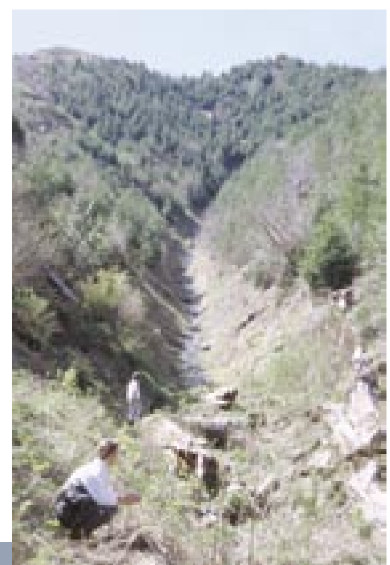


Figure 3. Sediment accumulation in the study streams based on the time since the previous debris flow as estimated by dendrochronology.

Figure 4. Conceptual illustration of the changes in channel morphology in steep headwater streams, based on the time since the previous debris flow.

With an adequate supply of in-stream wood, small streams have the potential to store large volumes of sediment in the interval between debris flows and can function as one of the dominant storage reservoirs for sediment in mountainous terrain. May and Gresswell warn that if these low-order streams are depleted of present or future sources of wood, the sediment storage capacity of the basin may be drastically reduced. Without the input of wood, channels that have been scoured to bedrock by a debris flow may persist in a bedrock state for a greater length of time. Because there is no sediment storage in bedrock channels, these channels become an effective conveyor of sediment delivered from the adjacent hillslopes. This continual sediment transport would represent a major shift in processes, with headwater streams becoming a chronic source of sediment to downstream areas instead of an episodic source.



In a companion study, May and Gresswell (2003b) investigated the processes associated with wood recruitment to channels of different size and topographic position. They found that landslides contributed the majority of wood to small headwater streams. In contrast, larger channels received the majority of wood from wind throw in the adjacent forest stands. Consequently, small headwater streams received wood from farther upslope than larger streams that flowed through alluvial valleys. This information may be useful for developing forest management strategies that aim to protect the sources of wood to streams.

Glossary

Debris flow A channelized mass movement where there is a rapid downslope flow of a saturated mass of sediment and wood.

Dendrochronology The science of dating events and variations in the environment in former time periods by comparative study of growth rings in trees and aged wood.

Headwaters First- and second-order stream channels that drain steep hillsides. These streams include permanently flowing non-fish-bearing streams and seasonally flowing (intermittent) streams.

Low-order streams Small streams with no or few tributaries (i.e., first- and second-order streams).

Roughness The unevenness of streambed material (i.e., gravel, cobbles) that contributes resistance to stream flow.

Scour A concentrated erosive action that mobilizes material from the bed or banks of a channel.

Research Highlights

- Wood and sediment accumulation rates in the channel were strongly correlated with the time since the previous debris flow.
- Large wood was the focal point for sediment accumulation because it provided a physical obstruction to sediment transport.
- Sediment that was stored behind wood in the channel increased the streambed roughness, decreased the local slope of the channel, and further reduced the capacity for sediment transport.
- With an adequate supply of wood, small streams have potential to store large volumes of sediment in the interval between debris flows and can function as one of the dominant storage reservoirs for sediment in mountainous terrain.

This factsheet is one in a series of information products developed by the Cooperative Forest Ecosystem Research (CFER) program on the production and function of large wood in the riparian zone. Funding for this research was provided to the CFER program by the Bureau of Land Management, USGS Forest and Rangeland Ecosystem Science Center, the Oregon Department of Forestry, and Oregon State University.

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For Further Reading

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