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Stream channel response to the removal of large woody debris, Larry Damm Creek, northwestern California

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Wherever large woody debris (LWD) is a significant component of channel roughness, its removal has the potential to alter all aspects of local channel morphology. The resulting channel form is then controlled by remaining randomly distributed large roughness elements (LRE's), as described by Lisle (1986); these remaining LRE's may be bends, exhumed or newly introduced woody debris, or bedrock outcrops. In Larry Damm Creek, the net result of removal of LWD accumulations has been a tendency for the channel pattern to evolve toward a more "alluvial" state, stabilized by bends at bedrock outcrops and woody debris-defended banks.

Removal of woody debris from channels is an important management technique in rivers and streams with adjacent forests. It has been done repeatedly to improve navigation and to increase channel conveyance by reducing instream roughness (Shields and Nunnally, 1984). Removal of debris introduced by timber harvest activities is mandated by forest practice regulations in several states and provinces in North America; often, pre-existing woody debris is removed at the same time (Bilby, 1984). Finally, woody debris is removed to eliminate streambank erosion or facilitate the in-channel movement of fish (Pitlick, 1982). Historically, little consideration has been given to the effects of debris removal on local and downstream channel conditions and to whether the benefits are sufficient to offset potential channel degradation.

To examine the mechanisms by which LWD controls local energy expenditure, and consequent patterns of water depth, velocity, and sediment storage, 70 m^3 of LWD were removed from Larry Damm Creek, a third-order (A_d = 3.9 km^2) tributary in the Redwood Creek watershed. In the 300-m-long study reach, channel slope is moderate (S_w = 0.014), characteristic width is 8.2 m, and the morphologic bankfull flow (Q_{bf}) is 3.5 m^3 s^{-1}. The bulk of the two debris accumulations removed in the experiment had been in the channel for a minimum of 68 years based on the age of a nursed tree; however, some of the smaller pieces were introduced after timber harvest activities in the late 1950's through the mid-1960's. Travel time of water through the "Pull" reach was measured before and after debris removal at low to moderate flows ($Q \leq 30\%\ Q_{bf}$). Changes in channel cross sections and the long profile were noted for 100 m along this reach, and for 100 m reaches up- and downstream. In addition, substrate size was systematically sampled throughout the entire study reach before and after debris removal.

The most notable effects of debris removal were (1) the local increase (up to 250%) in water velocity through the vicinity of the debris jams at measured discharges as a result of displaced channel roughness and decreased sinousity of the low flow thalweg, (2) ~100 m^3 of sediment that was entrained solely from within the affected reach in the first year after debris removal, and (3) the creation or deepening of pools at bends above and below the two debris jams at the expense of numerous scour pools within the jams.

A sediment routing model based on measured scour and fill was used to describe the movement of fine-grained, debris-stored sediment (trapped behind the physical barriers of the jams and as backwater deposits upstream) into new storage sites. Within the "Pull" reach, the dominant storage site after debris removal was a prominent point bar. Much of the sediment that moved into this reach from upstream (50 m^3 in the first year, 30 m^3 in the second year after removal) was deposited in this bar, whereas finer debris-stored sediment was deposited lower in the "Pull" reach. Furthermore, roughly 30 m^3 of debris-stored sediment moved entirely out of the "Pull" reach and was deposited above debris jams farther downstream. Bed material size is now coarser above and through the area of the removed debris jams and finer downstream, suggesting the sort of balance that must be evaluated when removing debris accumulations to improve fish habitat.

Channel morphology has stabilized around the following LRE's: major bends in the channel above and below the former location of the debris jams, sediment deposits associated with these bends, and a small amount of the original debris-stored sediment that was stabilized with vegetation prior to channel disturbance. At low flows, the net roughness of the reach surrounding the debris jams is therefore not significantly lower than it was prior to debris removal. This is due to the combined effects of higher grain roughness, a slight decrease in bed slope, and the two bends. Data from adjacent LWD-laden reaches suggest that this pattern probably persists at discharges up to bankfull as well.

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