Effects of Forest Harvesting on Large Organic Debris in Coastal Streams

By: Christopher G. Surfleet[1] and Robert R. Ziemer[2]

(1) Formerly; Hydrologic Technician, Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture, Arcata, CA.
(2) Hydrologist; and Principal Research Hydrologist, Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture, Arcata, CA.

Abstract

Large organic debris (LOD) was inventoried in two coastal streams to assess the impacts of forest harvesting on LOD recruitment in 90-year-old second-growth redwood and fir stands on the Jackson Demonstration State Forest in northern California. One stream, North Fork of Caspar Creek, drained a 508-ha watershed that had been 60% clear-cut, with riparian buffer strips left, four years earlier. The second stream, South Fork of Caspar Creek, drains a 424-ha catchment that 60% of the timber volume had been selectively harvested and the stream cleared of LOD twenty five years earlier. Results from these two study reaches were compared to a LOD study in the North Fork prior to logging. LOD levels increased following harvest because residual trees were left adjacent to the stream or in streamside buffer strips. Windthrow of fir provided the largest input of LOD in these second-growth redwood and fir stands due to the stand age and structure of the residual trees adjacent to the stream. Residual old-growth LOD pieces still play a major role in streams running through a mixed second-growth redwood and fir stand, this important element of stream LOD will continue to decline and must be compensated for in the future. Stream clearing can significantly reduce LOD levels for more than twenty five years.

Introduction

Large Organic Debris (LOD, woody debris greater than 10 cm in diameter) in streams is widely recognized as an important part of the aquatic ecosystem (Swanson and Lienkaemper, 1978). LOD has been recognized as a vital component of high quality habitat for anadromous fish (Bisson et al, 1987). LOD provides an organic energy source for aquatic organisms, controls the routing of sediment through stream systems, and provides stability to the streambed and banks (Swanson and Lienkaemper, 1978; Bilby and Likens, 1979). Previous management actions in streams focused on the removal of LOD to allow fish passage and remove potential damage to bridge and stream structures. These actions along with forest management activities have raised recent concern over depletion of LOD in coastal streams and prompted study to determine activities affecting LOD in streams.

Study Areas

The study areas are in the North and South Forks of Caspar Creek experimental watershed on the Jackson Demonstration State Forest. Both drainages support stands of mixed second growth Redwood (*Sequoia sempervirens*) and Douglas-fir (*Pseudotsuga menziesii*). Historically both drainages were clear-cut and burned in the late 1800's (Tilley and Rice, 1977). Splash dams were used in both reaches of the North and South Forks during this historic logging. The flushing of the stream channel from the splash dams leads to the assumption that present day LOD is a result of accumulations from the return of the current second-growth forest (O'Connor and Ziemer, 1989) and residual stumps from historic logging. The North and South Forks of Caspar Creek have been harvested since the first entry in late 1800's. The South Fork had 60% of timber volume selectively harvested and the stream cleared between 1967-1973. The North Fork was 60% clear cut, with riparian buffer strips left, between 1989-1991.

Methods

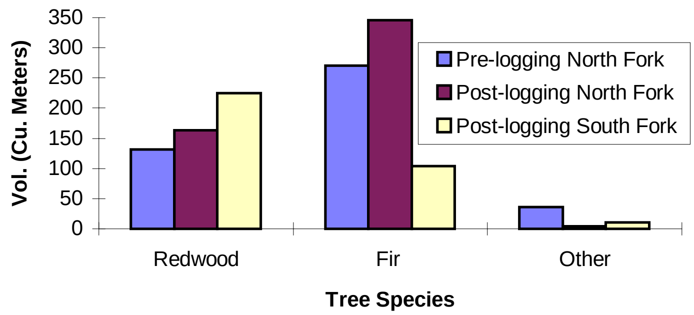
Results from two studies are presented and compared: 1) one study was of LOD in pre-logged conditions of the North Fork of Caspar Creek (O'Connor and Ziemer, 1989) 2) the second and most recent study was of LOD after logging in the North and South Forks of Caspar Creek. Both studies used the same methodology.

The LOD was sampled from a 1800 meter stream length along both the North and South Forks of Caspar Creek. LOD is discussed for two stream zones: 1) effective zone, within the annual high water flow of the stream, and 2) potential zone, spanning above the stream or within 1 meter of the annual high water flow. LOD sources identified with the LOD were: windthrow, bank erosion, landslide, wind fragmentation, logging debris and unknown. Tree species were grouped into three categories: 1) redwood, 2) fir, consisting of Douglas-fir and a little grand fir and hemlock, and 3) other, all other minor species of the area, predominately hardwoods or unidentifiable LOD. To determine if significant differences occurred between measured parameters Fisher's least significant difference analysis of variance test was used at 95% confidence level.

Results and Discussion

LOD characteristics differed between the North and South Forks of Caspar Creek. The differences in LOD levels following harvest comes in the effective and potential zones (Figure 1 & 2).

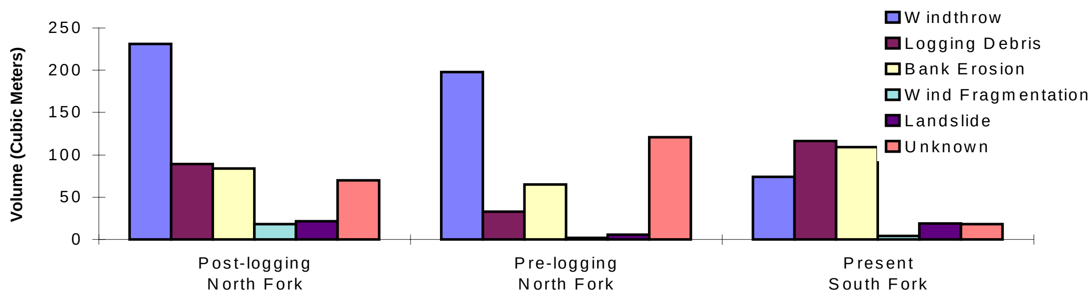
Figure 1. Combined Effective and Potential Zone LOD Volume by Tree Species



Fir is the tree species contributing the greatest LOD component for the North Fork of Caspar Creek. Redwood LOD was higher in the South Fork, however, this was due to high residual old growth stumps near the stream. Stream clearing activities related to the harvesting in 1967 did not remove the large residual stumps. When these large residual pieces are removed from analysis, recent accumulations of LOD in the South Fork are predominately fir.

The higher amount of fir is attributed to the age and relative vigor of the stand and individual tree species. The 100 year old fir is beginning to naturally deteriorate. This deterioration of the fir element is occurring before any decline in health of the long-lived redwood trees. The deteriorating firs are finding there way to the stream channels of the forest, attributing to the high proportion of fir LOD.

Figure 2. Combined Effective and Potential Zone LOD Volume by Input Process



Windthrow and bank erosion are the largest natural contributors of LOD in the North and South Forks of Caspar Creek (Figure 2). Logging debris is a high contributor, however, much of the logging debris is large residual stumps and logs from historic logging, not from recent harvest activities. Landslides and wind fragmented trees or snags offer little significant input of LOD.

To understand the potential for future LOD, the residual old growth LOD created from historic logging must be removed from the analysis. After exclusion of residual old growth LOD fir was found to be the highest tree type of LOD for both study streams. Windthrow is the largest LOD source in both study areas (Table 2). Logging debris was still the second highest in the South Fork of Caspar Creek while it was third highest in the North Fork. Bank erosion was probably not as high a contributor in the South Fork of Caspar Creek because of the stream clearing during harvest operations.

Table 2. Input Sources of Combined Effective and Potential Zone LOD Volume for Post-logging North and South Forks of Caspar Creek After exclusion of Residual Old Growth Logging Debris.

	North Fork of Caspar Creek	South Fork of Caspar Creek
Windthrow	48%	40%
Bank Erosion	18%	15%
Logging Debris	12%	22%
Wind Fragmentation	4%	2%
Landslide	4%	11%
Unknown	14%	10%

The current LOD volume for the effective zone of the South Fork of Caspar Creek is significantly lower than the post-harvest North Fork's effective zone at 95% confidence. Because much of the stream channel LOD was cleared twenty five years before, lower LOD in the South Fork does suggest that stream clearing significantly affects LOD recruitment even twenty five years after its application.

Pool associated and debris jam associated LOD was found to be significantly higher at 95% confidence in the post-harvest North and South Fork of Caspar Creeks than the pre-harvest North Fork conditions. This increase may be caused from numerous factors. Increases in channel LOD that followed harvesting increases the chance of LOD providing conditions suitable for pool formation. Increased debris jams provide greater stability to otherwise mobile LOD pieces. This stability along with their aggregated size promote more channel scouring and damming. Possible increases in flow following harvesting at critical times could increase stream energy causing increased scour and pool formation.

Summary and Conclusion

LOD in coastal streams is affected by management activities. From the results and discussion of the LOD data for Caspar Creek some generalizations were found which can be utilized for improvement of LOD levels in coastal streams subject to forest management activities. These are:

- LOD levels are found to increase following harvesting if trees are left in streamside buffers.
- Windthrow and bank erosion of trees are the largest natural contributors of stream channel associated LOD in second growth redwood and fir forests. Promoting and providing an element of older, more decadent trees, along stream courses will help LOD recruitment in coastal streams.
- Fir trees provide the most LOD in 90 year old second growth redwood and fir stands of Caspar Creek,. Fir trees become decadent much quicker than long-lived and shade tolerant redwood.
- Residual old growth logs played a major role in current LOD levels in the second growth forest of Caspar Creek, although there is much less LOD than in an old-growth forested stream. Over the next century this residual LOD element will disappear. Riparian management needs to compensate for the loss of this residual LOD in managed coastal watersheds over time.
- Pool associated LOD increased following harvesting. LOD in fish-bearing streams should be retained and emphasized after harvest as it provides greater habitat potential.
- Stream clearing of LOD greatly lowers LOD levels for a long time. The South Fork was cleared and even after twenty five years of LOD recruitment levels are well below those observed in the pre-harvest North Fork of Caspar Creek.

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Acknowledgments

I wish to acknowledge the participation and support of the United States Forest Service Pacific Southwest Research Station and the staff of the Jackson Demonstration State Forest. Particularly, Liz Keppeler and Norm Henry. I could never have done this work without their help.