SEDIMENT STORAGE IN SMALL, STEEP STREAMS IN EASTERN WASHINGTON FORESTS

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Introduction

During the Ahtanum watershed analysis, a process of discovery about cumulative effects of land use practices on public resources, there was lack of consensus about channel sensitivity to instream wood functions. Long-term monitoring (300 years, similar to the Milan Cathedral construction effort) began to quantify the roles of wood in small, steep streams. The monitoring analysis approach to support decision-making involves comparisons between channel conditions in managed and unmanaged sites. The two critical monitoring questions for this project are: (1) How much riparian vegetation is needed for adequate wood input to the channel? (2) How much functional in-channel wood is needed to maintain and improve channel performance?

Methods

Eighteen stream channels (7 unmanaged, 11 managed) were selected and measured during 1997, 1998, and 1999. All channels selected met these criteria: small (<5m bankful width), steep (10-30% gradient), confined (valley width <8m), wooded, cobbly-bouldery (not bedrock controlled), alluvial channels, fish-bearing and non-fish-bearing. Data were collected in digital form on channel geometry, channel longitudinal profile, in-channel wood, sediment obstructions, and riparian vegetation. Error free digital data collection was enabled using FieldWorker Pro software (Browne and Browne, 1998), running on reliable Apple Newton hardware in punishing conditions. The measurement sites have permanent plots installed in channels and streamside forest. Each riparian forest plot (two total, left and right side) measures 23m x 46m (total 0.21 ha). Each stream channel plot measures 46-52m in length.

Results

Overall, 5819 trees were tagged and measured. In channels, 2079 small woody debris (SWD) pieces were measured, 300 sediment wedges, and 395 pieces of large woody debris (LWD).

Riparian Forest

Mean values for trees per hectare in four size classes (TPA <8cm dbh, TPA 8-23cm, TPA 23-50cm, TPA >50cm) were 2.7, 1.6, 1.7, and 2.2 times greater in unmanaged sites compared to managed sites.

Channel Wood

Comparing mean values from unmanaged (n=7) and managed (n=10) sites: (a) mean zone 1 wood volume was 3.0 times greater in unmanaged sites, zone 2 was similar, zone 3 was 3.5 times greater in unmanaged sites, and zone 4 was 2.4 times greater in unmanaged sites than managed sites; (b) mean SWD volume was twice greater in unmanaged sites than managed sites; (c) mean LWD volume was 2.7 times greater in unmanaged sites than managed sites; (d) mean SWD and LWD piece counts were 1.7 and 2.4 times greater in unmanaged sites; (e) mean SWD drop and LWD drop in 100% wood faces were 1.6 and 1.3 times greater in unmanaged sites than managed sites; and(f) mean drop in 100% rock faces was 1.8 times higher in managed sites than unmanaged sites.

Steps and Obstructed Sediment
Changes in bed elevation associated with steps are believed to be important in terms of energy dissipation, hydraulic roughness, habitat differentiation, and grain sorting. Comparing mean values from five unmanaged and ten managed sites, mean step to bed drop was slightly greater in unmanaged sites. Four measurement sites had step to bed drop percentages exceeding 100%; five sites had percentages >85%. Considering step face composition, SWD plays an important role for step creation and maintenance: six of sixteen sites had >15% of step drop due to faces composed of >70% SWD. In contrast, six of sixteen sites had >15% of step drop due to faces composed of >70% LWD. Mean SWD drop and LWD drop in 100% wood faces were 1.6 and 1.3 times greater in unmanaged sites than managed sites. Mean drop from 100% rock faces was 1.8 times higher in managed sites. In addition, in unmanaged sites, the mean number of 100% wood steps was 2.1 times higher, and the mean number of wood pieces in steps was 1.8 times higher than in managed sites. Mean sediment wedge volume was 1.5 times higher in unmanaged sites, and mean number of steps per bankful width was 1.8 times higher in unmanaged sites.

Discussion
From this initial dataset, channel measurement sites in unmanaged forests have higher wood volumes and piece counts, regardless of piece size. This is consistent with higher stem densities in riparian forests surrounding unmanaged sites, particularly in large trees with numerous branch whorls. Branches are a major source of SWD. Fallen trees in densely shaded stands are often quite branchy; these branches can act as tines that comb out floating debris (rafts) or create wood piles. Branch wood was commonly found in many step faces.

Riparian stands recently disturbed by logging create structural conditions that can t produce channel wood until processes such as senescence, mortality, branch shedding, wind throw, bank erosion, wood decay, root rot, disease and insect effects can act on standing trees and cause wood to enter or fall into or near stream channels. Managed stands create structural conditions that maximize solar gain to canopies, reduce shading and competition for soil moisture, and maximize width and height growth rates. Without shading that occurs in stands with dense canopies, fewer branches senesce, die, and fall to produce small woody debris for in-channel functions.

Data from these initial point-in-time measurements suggest that wood of various sizes is an important structural element in stepped channel morphologies. The durability of rock steps versus wood steps is hypothetical and untested. Repeat measurements will directly evaluate the change in step face composition and obstruction volume over time. More steps equate to more obstructed sediment volume if obstruction shapes are similar (ratios of height:length are similar overall), though the differences in sediment volume and step count are minor.

Performance Specifications for Self-Replenishing Wood for Channels
Overall, these performance criteria for self-replenishing channel wood are based on information gathered on seven unmanaged reference sites, and seven managed sites with little significant alteration by human activity, and four managed sites affected by human activity in the Ahtanum, Cowiche, and Tieton basins. Extrapolation of these results to other mountainous forests requires

prudence and caution. The assumptions underlying WISSP and CRSN may not apply to other situational categories.

Riparian forest characteristics ~ stem class ratio 1:2:4:8 among four diameter classes

- TPH >51cm dbh, 50-125
- TPH 23-51cm dbh, 170-270
- TPH 8-23cm dbh, 400-500
- TPH <8cm dbh, 500-1000

Channel Wood

- Total wood volume, m^3/bfw: 0.28-0.68 (zones 1, 2, 3, and 4)
- Z3+Z4: TOTAL ratio: 0.60-0.85
- Z1+Z2: TOTAL ratio: 0.15-0.40
- Zone 1 volume: 0.04-0.08 m^3/bfw
- Zone 2 volume: 0.06-0.11 m^3/bfw
- Zone 3 volume: 0.06-0.17 m^3/bfw
- Zone 4 volume: 0.17-0.45 m^3/bfw
- SWD pieces/bfw: >3; LWD pieces/bfw: 1.5-3

Step Quantity (# per 10-20 BFWs)

- >2, for channel gradients >20%
- 1-2, for channel gradients 10-20%
- 0.5-1, for channel gradients 5-10%
- step to bed drop % >70%

Step Quality

- percent of step face drop in 100% LWD: 15-50%
- percent of step face drop in 100% SWD: 5-15%
- percent of step face drop in 100% rock (boulders, cobbles): 10-25%

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