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Steep slopes literature abstracts (Updated 4 Nov 2024)

For 8 November IRST meeting

Barrett, S.W.; Reilly, M. 2017. Literature Review: Effects of Salvage Logging on Riparian Zones in Coniferous Forests of Eastern Washington and Adjacent Regions. Cooperative Monitoring Evaluation and Research Report CMER 17-100. Olympia, WA: Washington State Forest Practices Adaptive Management Program. Washington Department of Natural Resources. https://www.dnr.wa.gov/publications/fp_cmer_17_100.pdf

ABSTRACT: This report provides an overview of the goals, objectives, methods, and results of the project. We reviewed 75 relatively recent publications that provide information about potential effects of salvage logging on riparian areas for eastside forests and comparable forests elsewhere in the Pacific Northwest. A major finding from the review is that the literature provides relatively little specific information about the effects of salvage logging in riparian areas. This lack of data applies not only to Washington eastside forests, but for riparian forests elsewhere in the western U.S. The lack of riparian-specific research is likely related to the fact that most modern-day fires have occurred on federal lands, where salvage logging and salvage-related research have been largely absent. Otherwise, the literature contains a wide range of information about the possible effects of salvage logging on adjacent upland forests, which can be useful for developing riparian management strategies. Examples of recent salvage-related research include studies investigating possible effects on soils (e.g., erosion, compaction, hydrophobicity), and studies documenting the effects of various management practices such as differing harvesting methods and equipment, erosion mitigation practices, and varying silvicultural prescriptions. A considerable amount of literature also describes research on post-salvage regeneration issues, and on fuels management practices. Conversely, less information exists about potential effects of salvage logging on riparian ecosystem structure and function, such as stream temperature regimes, water quality issues, aquatic biota, and the effectiveness of forest buffer retention zones. Topics such as salvage effects on soil processes (e.g., nutrient cycling, soil biota), riparian wildlife habitat, riparian restoration, and modern-day riparian fire regimes are also less well represented in the literature. Therefore, after describing the state of relatively recent research on salvage logging in relation to riparian areas, this report concludes by listing some current research gaps that have been identified by various study authors and other professionals. In addition to this Synthesis Report, the literature review project produced the following products: 1) an Excel database housing key data elements for the literature (e.g., authors, publication years, summaries), 2) a User Guide that explains how to efficiently locate and summarize information in the Excel database, and 3) a literature collection

composed of downloadable digital copies (pdf files) of each piece of literature reviewed during the project.

REVIEW NOTES

- Links to other potentially relevant literature
- Produced an Excel database which might serve as a model

Chesney, Charles (2000) Functions of Wood in Small, Steep Streams in Eastern Washington: Summary of Results for Project Activity in the Ahtanum, Cowiche, and Tieton Basins. TFW Effectiveness Monitoring Report.
https://www.dnr.wa.gov/publications/fp_tfw_mag1_00_002.pdf

A long term, ecological monitoring asset associated with the Channel Reference Site Network and the Wood in Small Streams Project was created in Eastern Washington. The monitoring goal is to describe the functional roles of wood in small, steep streams, and to document the relationship between riparian vegetation and in-channel wood. Detailed measurements were taken of both small and large woody debris, as well as channel morphometry, steps, sediment obstructions, and riparian stand conditions. Repeat measurements will test hypotheses about the roles of SWD in step face construction, hypotheses about sediment supply, step durability, and step functions over time, and hypotheses about the usability and information value of several experimental indicators (e.g., height:length ratios of sediment obstructions).

- Comparing mean values from unmanaged (n=5) and managed (n=10) sites:
- Mean zone 1 wood volume was 3.5 times greater in unmanaged sites, zone 2 was similar, zone 3 was 4.2 times greater in unmanaged sites, and zone 4 was 1.8 times greater in unmanaged sites than managed sites.
- Mean SWD volume was 1.4 times greater in unmanaged sites than managed sites.
- Mean LWD volume was 2.5 times greater in unmanaged sites than managed sites.
- Mean SWD and LWD piece counts were 1.9 and 2.1 times greater in unmanaged sites
- Mean SWD drop and LWD drop in 100% wood faces were 1.7 and 1.3 times greater in unmanaged sites than managed sites.
- Mean drop in 100% rock faces was 1.4 times higher in managed sites than unmanaged sites.

From this initial dataset, it's evident that 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.

Fitzgerald, J.; Clifton, C. 1997. Flooding, land use, and watershed response in the Blue Mountains of northeastern Oregon and southeastern Washington. In: Inland Northwest

Water Resources Conference, Program and abstracts.
https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5208929.pdf

The northern Blue Mountains sustained heavy rain and rapid snowmelt in November 1995 and rapid snowmelt over frozen soil in February 1996. The result was multiple record flood events, with February peak flows being more wide-spread and of higher magnitude. In addition to flooding, the storms triggered debris flows and slides on the Umatilla National Forest. These features commonly occurred in the rain-snow transition zone, in saturated loam-clay-ash soil, and on steep slopes (30-80 percent). Debris flows or torrents were the dominate feature, starting as an earthslide and then transporting debris sometimes over a mile. Roading and logging were associated with 37 percent of the observed mass wasting features. High flows and mass wasting combined to produce a variety of channel responses including: scouring of substrate and banks; aggradation of sediment; accumulation of large woody debris; and, lateral channel migration. Fluvial responses appear to differ with elevation and land use intensity. Flood discharge of National Forest streams was estimated using the indirect, slope-area method based on post-flood field evidence. Flood frequencies were then estimated using U. S. Geological Survey regional flood equations. Flood magnitude and frequency varied by watershed with some areas experiencing one or more "100 year" events (Umatilla and Walla Walla) and others experiencing less than a "25 year" event (Tucannon and Wenaha). Flood effects on National Forest investments (instream fish habitat structures and road-stream crossings) were also assessed. Results from field inventories indicate a high rate (73 percent) of instream fish habitat structure survival. Anchored rock weirs had the highest success rate. In roaded watersheds, a sample of culverts at stream-road crossings indicated about 50 percent of the culverts failure. The failure rate varies by watershed, however, from 23 to 95 percent. Culverts failed because of plugging with sediment often causing additional flood damage to roads and streams. Preliminary results indicate variability in watershed response to flooding which is partly attributed to different watershed characteristics and land use intensities. The post-flood assessments will be used to improve understanding of watershed response to extreme hydrologic events and to improve management practices to reduce damage from future high flows.

Herrera Environmental Consultants Inc. (2004) Review of the Available Literature Related to Wood Loading Dynamics in and around Streams in Eastern Washington Forests.
https://www.dnr.wa.gov/publications/fp_cmer_03_308.pdf

New forest practice rules recently established and based on the Forests and Fish Report (F&FR 1999) are subject to monitoring to evaluate their effectiveness. Monitoring and determination of the effectiveness of the new rules is the responsibility of the Department of Natural Resources' (WDNR) Cooperative Monitoring, Evaluation, and Research (CMER) committee made up of representatives from tribes, state and federal agencies, and industry. CMER has designated a standing committee, called the Scientific Advisory Group – Eastside (SAGE) to develop study approaches and implement evaluations regarding eastside riparian rules. SAGE initiated this project to identify the current state of knowledge regarding instream wood, wood recruitment and fluxes, and the function of wood in streams of eastern Washington. The project focus is to assess available quantitative information for eastern Washington on 41 research questions (provided in Appendix A) that pertain to the following nine topics:

1. Wood loading (channel wood characteristics)
2. Wood distribution in streams
3. In-stream manipulation of wood
4. Decay rates of wood in streams
5. Transport of wood in streams
6. Role of wood in pool formation in streams
7. Role of wood in bedload transport and sediment sorting
8. Riparian and channel conditions
9. Wood recruitment and mortality.

McGreer, D.J.; Sugden, B.D.; Schult, D.T. 1998. Surface Erosion and Mass Wasting Assessment and Management Strategies for Plum Creek's Native Fish Habitat Conservation Plan. Native Fish Habitat Conservation Plan Technical Report #3. Columbia Falls, Montana: Plum Creek Timber Company. [no web link found]

Since one of the important habitat elements for salmonids is the substrate in which they spawn and rear, the Native Fish Habitat Conservation Plan (NFHCP) must address erosion associated with Plum Creek's forest management activities. This report is intended to serve as a technical foundation upon which specific NFHCP strategies can be developed and their benefits evaluated. As the plan is under development, this paper does not provide specific commitments; it is intended to serve as a foundation upon which an intelligent plan can be based. For various surface and mass erosion processes, this report will: 1) summarize the impacts of historical logging and road construction management practices; 2) discuss current regulations and the protection they provide; 3) evaluate the effectiveness of current state Best Management Practices (BMP's) in controlling erosion; and 4) present general strategies and opportunities for the NFHCP to better address erosion on Plum Creek Timber Company lands in the NFHCP area.

REVIEW NOTES

- Most relevant document found
- Reviews and summarizes state reports (watershed analyses) on surface and mass erosion processes in relation to forest harvesting and roading
- Provides tabular summaries of mass wasting and debris flow densities for a number of eastside vs westside locations

Nowakowski, A.; Wohl, E. 2008. Influences on wood load in mountain streams of the Bighorn National Forest, Wyoming, USA. ENVIRONMENTAMANAGEMENT. 42(4): 557–571. https://doi.org/10.1007/s00267-008-9140-4

We documented valley and channel characteristics and wood loads in 19 reaches of forested headwater mountain streams in the Bighorn National Forest of northern Wyoming. Ten of these reaches were in the Upper Tongue River watershed, which has a history of management including timber harvest, tie floating, and road construction. Nine reaches were in the North Rock Creek watershed, which has little history of management activities. We used these data to test hypotheses that (i) valley geometry correlates with wood load, (ii) stream gradient correlates with

wood load, and (iii) wood loads are significantly lower in managed watersheds than in otherwise similar unmanaged watersheds. Statistical analyses of the data support the first and third hypotheses. Stream reaches with steeper valley side slopes tend to have higher wood loads, and reaches in managed watersheds tend to have lower wood loads than reaches in unmanaged watersheds. Results do not support the second hypothesis. Shear stress correlated more strongly with wood load than did stream gradient, but statistical models with valley-scale variables had greater explanatory power than statistical models with channel-scale variables. Wood loads in stream reaches within managed watersheds in the Bighorn National Forest tend to be two to three times lower than wood loads in unmanaged watersheds.

Puntenney-Desmond, K.C.; Kevin D. Bladon; Uldis Silins 2020. Runoff and sediment production from harvested hillslopes and the riparian area during high intensity rainfall events. Journal of Hydrology. https://doi.org/10.1016/J.JHYDROL.2019.124452

Forest harvesting often decreases soil infiltration capacity, leading to rapid and increased delivery of surface runoff, shallow subsurface runoff, and sediment to streams. While the general harvest area is typically the largest area of disturbance, relative to forest roads or skid trails, less is known about the degree to which the general harvest areas act as sources or sinks for runoff and sediment transport. This includes a need to improve understanding of the potential for runoff and sediment delivery from harvest areas through riparian buffers to streams during infrequent, high intensity precipitation events, which are predicted to increase due to climate change. In this study, we used rainfall simulations to investigate surface/shallow subsurface runoff, and sediment transport from plots during extreme precipitation events within a steep, headwater catchment in the Rocky Mountains. Simulations consisted of one hour of high intensity rainfall (I60: 70–80 mm h−1), representative of an ~100 year, or greater, storm event for the northern Rocky Mountain region. Our objectives were to compare runoff rates, sediment concentrations, and sediment yields between the general harvest area, along the edge of the riparian buffer at the interface with the harvested area, and within the riparian buffer. Surface/shallow subsurface runoff rates were greatest in the riparian buffer relative to the harvest area, especially when soil conditions were dry. Mechanical soil disturbance during forest harvesting appeared to result in higher infiltration rates and vertical, preferential flow relative to the riparian buffer. However, sediment concentrations in runoff from plots in the general harvest area were ~15.8-times greater than in the riparian buffer and ~4.2-times greater than at the harvest-riparian edge. Comparatively, sediment yields in the general harvest area were ~2.0-times greater than in the riparian buffer and ~1.2-times greater than at the harvest-riparian edge. Quantitative and qualitative evidence suggests differences in runoff and sediment between the harvest area, harvest-riparian edge, and riparian buffer were due to site differences in hydrophobicity, surface roughness, soil water content, and sediment supply. While we observed moderately high variability with only modest replication, the spatial patterns in the amount and timing of runoff, sediment production, and their relationships with soil moisture were consistent and monotonic along the gradient from harvested areas through riparian buffers. This highlights the need for additional research to explore if similar patterns appear evident after forest harvesting in other hydro-climatic settings.

Richardson, J.; Naiman, R.; Swanson, F.; Hibbs, D. 2005. Riparian communities associated with Pacific Northwest headwater streams: Assemblages, processes, and uniqueness. JOURNAOF THE AMERICAN WATER RESOURCES ASSOCIATION. 41(4): 935–947. https://doi.org/10.1111/j.1752-1688.2005.tb04471.x

Riparian areas of large streams provide important habitat to many species and control many instream processes – but is the same true for the margins of small streams? This review considers riparian areas alongside small streams in forested, mountainous areas of the Pacific Northwest and asks if there are fundamental ecological differences from larger streams and from other regions and if there are consequences for management from any differences. In the moist forests along many small streams of the Pacific Northwest, the contrast between the streamside and upslope forest is not as strong as that found in drier regions. Small streams typically lack floodplains, and the riparian area is often constrained by the hillslope. Nevertheless, riparian-associated organisms, some unique to headwater areas, are found along small streams. Disturbance of hillslopes and stream channels and microclimatic effects of streams on the riparian area provide great heterogeneity in processes and diversity of habitats. The tight coupling of the terrestrial riparian area with the aquatic system results from the closed canopy and high edge-to-area ratio for small streams. Riparian areas of the temperate, conifer dominated forests of the Pacific Northwest provide a unique environment. Forest management guidelines for small streams vary widely, and there has been little evaluation of the local or downstream consequences of forest practices along small streams.

REVIEW NOTES

- good synthesis of headwater streams processes & habitat values
- most focus on mesic environments, no distinction of drier ecoregions

Wu, G.; Liu, Y.; Cui, Z.; Liu, Y.; Shi, Z.; Yin, R.; Kardol, P. 2020. Trade-off between vegetation type, soil erosion control and surface water in global semi-arid regions: A meta-analysis. JOURNAOF APPLIED ECOLOGY. 57(5): 875–885. https://doi.org/10.1111/1365-2664.13597

Abstract

1. Soil erosion control and water resource protection can closely interact during restoration of terrestrial ecosystems. In semi-arid ecosystems, an urgent issue is how vegetation restoration can achieve the goal of soil erosion mitigation and water conservation, which in turn, feeds back to ecosystem functioning.

2. We reviewed 78 articles from 22 countries in semi-arid areas to evaluate the effects of vegetation type (i.e. forest, grassland and scrubland) on runoff and sediment yields across different environmental conditions (i.e. vegetation coverage, rainfall intensity, slope gradient and soil texture).

3. Our meta-analysis shows that runoff and sediment reduction both increased as the vegetation coverage increased, and tended to be stable when vegetation coverage exceeded 60%. Vegetation provided a greater benefit for sediment reduction than for runoff control under intense rainfall. Grasslands were generally more effective in reducing sediment than other vegetation types. Forests, grasslands and scrublands were most efficient in soil erosion control on 20°–30°, 0°–25° and 10°–25° slopes respectively. Grasslands and scrublands generally performed better with respect to soil erosion control on moderately coarse soils, whereas forests were most effective on medium-textured and moderately fine soils.

4. Synthesis and applications. Effective restoration and soil erosion control in semiarid ecosystems strongly depends on the selection of vegetation type. Our study further indicates that, for land managers, it is critical to consider local slope, and soil texture, and maintain appropriate vegetation coverage to achieve ecosystem sustainability. Grasslands might be particularly suitable to optimize the trade-off between soil erosion control and surface water resource in semi-arid regions.

Yang, J.; Guo, L.; Liu, Y.; Lin, P.; Du, J. 2024. Reforestation WilLead to a Long-Term Downward Trend in the Water Content of the Surface Soiin a Semi-Arid Region. FORESTS. 15(5) https://doi.org/10.3390/f15050789

The spatial distribution of soil moisture is a critical determinant for the success of vegetation restoration initiatives in semi-arid and arid regions. The Qilian Mountains, situated within a semi-arid zone in China, have been subject to significant water-induced soil erosion, which has led to extensive restoration activities, predominantly utilizing the species P. crassifolia. However, the interconnections between soil moisture and various land cover types within this region remain unclear, presenting challenges to effective woodland rehabilitation. This study examines the surface soil moisture dynamics in afforested areas with varying ages of plantation to determine the influence of tree planting on the moisture content of the upper soil layer. It investigates the characteristics and temporal patterns of surface soil moisture as the age of the plantation increases. The findings indicate that: (1) soil moisture levels follow a descending sequence from natural forest, through shrubland and grassland, to planted forest and mixed forest, with statistically significant differences observed between natural and mixed forests ($p < 0.05$); (2) young afforested areas (less than 50 years old) have lower soil moisture levels compared to natural forests, shrublands, or grasslands, and the ecohydrological impacts of afforestation become apparent with a temporal delay; and (3) the analysis using Generalized Additive Mixed Models (GAMM) and the application of Kriging interpolation to determine the spatial distribution of soil moisture reveals that in semi-arid and arid regions, several factors have a pronounced a non-linear relationship with the moisture content of the surface soil. These factors include the duration of afforestation, the position on the lower slope, the presence of shade on the slope, and the scale at which the study is conducted. Therefore, a comprehensive understanding of the dynamics of soil water content is essential to prevent the potential failure of artificially established forests due to inadequate soil moisture in their later stages.