WATERSHED ANALYSIS EFFECTIVENESS MONITORING:

A SUMMARY OF PROJECT ACTIVITY AND RESULTS

FOR CENTENNIAL CLEAN WATER GRANT 9600333

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1 Introduction

1.1 Purpose

The purpose of this document is to describe and summarize results of a project to monitor the effectiveness of Watershed Analysis prescriptions in achieving water quality and resource protection goals in selected watersheds. The project was initiated by the TFW Monitoring Program in 1996 in response to the need for information on the effectiveness of the State of Washington's Watershed Analysis process. Funding was provided by a Centennial Clean Water Fund grant from the Washington Department of Ecology (WDOE) to the Northwest Indian Fisheries Commission.

1.2 Background on the Watershed Analysis Prescription Process

Watershed Analysis (WSA) is a scientific and regulatory process instituted by the Washington State Forest Practices Board in 1992 to assess and prevent cumulative effects on aquatic resources from forest practices conducted on state and private forest lands under the jurisdiction of the State Forest Practices Act. The WSA process is described in section 222-22 of the Washington Forest Practices Rules (WFPB, 1995a). Watershed Analysis is conducted on individual Watershed Administrative Units (WAUs), which are watersheds between 15,000 and 50,000 acres in size. Watershed Analysis can be initiated by the Washington Department of Natural Resources (WDNR) or by forest landowners with significant holdings in the WAU. Participants typically include representatives of the state resource agencies (WDNR, WDOE, and Department of Fish and Wildlife), forest landowners, Indian Tribes, and consultants.

The process begins with a series of scientific assessments conducted by qualified analysts who evaluate the status of the key watershed input processes (i.e. mass wasting, surface erosion, riparian LWD recruitment, riparian shade, hydrology) and the condition of resources (i.e. stream channels, fish habitat and populations, water quality and public capital improvements). Information gathered during the assessments is used to identify situations where forest practices cause adverse changes to aquatic resources or capital improvements by altering inputs of sediment, peak flows, large woody debris (LWD), and thermal energy to stream channels. During synthesis, a report is developed for each causal mechanism. Each causal mechanism report identifies areas of resource sensitivity, (i.e. locations where the causal mechanism is likely to be initiated), channel response reaches (i.e. locations where channel or aquatic resource effects are likely to occur), and the types of forest practices and specific triggering mechanisms that initiate changes in the input process (WFPB, 1995b).

The causal mechanism reports are passed on to a prescription team that is responsible for developing prescriptions for each area of resource sensitivity. The goal of the prescriptions is to prevent or minimize the potential resource effects identified in each causal mechanism report. The prescriptions typically specify how forest practices should be conducted within the area of resource sensitivity to avoid initiating the triggering mechanisms. Prescriptions may prohibit some types of activities within the areas of resource sensitivity in some cases. Once prescriptions are reviewed and adopted by WDNR, they become site-specific regulations governing how forest practices are conducted within the areas of resource sensitivity.

1.3 Role of Monitoring in Evaluating Watershed Analysis

The WSA rules require periodic evaluation of the prescriptions for each WAU. Review typically occurs five years after the date of adoption in a process known as the five-year review, but can also occur following natural disasters or when deterioration in the condition of aquatic resources is documented. Although the five-year review is mandatory, monitoring is voluntary and is initiated at the discretion of the WSA team for each WAU. The five-year review process utilizes monitoring information if it is available, but is not dependent on it. If no monitoring data is available, the five-year review is based on professional judgement or information gained by repeating selected assessment procedures.

1.4 Challenges in Implementing Watershed Analysis Monitoring

The TFW Monitoring Program was charged with providing assistance to WSA teams in preparing and implementing WSA monitoring plans for their WAUs. In the first several years after the WSA processes was adopted, contact was made with many of the teams that were completing Watershed Analysis prescriptions, and assistance was provided to teams interested in developing monitoring plans. However, after several years it became apparent that few teams were developing monitoring plans, and fewer yet were following through to conduct monitoring. A number of reasons for this were identified (Schuett-Hames and Pleus, 1996), including:

- Some managers were not willing to devote staff time or dollars to monitoring because they saw no compelling reason to monitor or benefit from doing so.
- Some managers believed that devoting resources to monitoring would divert resources needed to complete WSA in other areas.
- Some team members appeared confident that the analysis and prescriptions were on target and had identified no monitoring issues or concerns.
- Many team members were unaware of the 5-year review and had not considered how monitoring data would contribute to a meaningful and successful review process.
- Some team members who were interested in monitoring did not follow through because they were too busy to initiate additional projects.
- Most teams disbanded after the prescription process and moved on to other projects or to work postponed during the analysis process.
- Some teams became engulfed in conflict and suspicion during the prescription process and did not have the necessary working relationships to develop a cooperative monitoring plan.
- Some teams who were interested in monitoring did not have the technical expertise to develop monitoring plans.

1.5 Project Description

1.5.1 Goals

The purpose of this grant was to promote and support the efforts of WSA teams to monitor the effectiveness of their Watershed Analyses by addressing several obstacles to monitoring. The project was designed to:

- Increase awareness of the need for, and benefits of, monitoring including its use in the five-year review process.
- Provide training and technical assistance to WSA teams in developing and implementing monitoring plans and activities.
- Encourage teams to initiate monitoring by providing funding to WSA teams for pilot monitoring projects.
- Produce information to evaluate the effectiveness of WSA prescriptions in achieving water quality and resource protection objectives and to identify the strengths and weaknesses in the process so that improvements can be made.

1.5.2 Tasks and Activities

A number of tasks and activities were completed to accomplish the project goals.

Workshops to Increase Awareness and Provide Training

Several informational workshops were carried out around the state to discuss the need for Watershed Analysis monitoring, to identify important monitoring issues, and to offer technical assistance to help WSA teams conduct monitoring projects. TFW Monitoring Program staff also provided training in developing WSA monitoring plans at WSA training workshops conducted by WDNR.

Funding for WSA Teams to Conduct Effectiveness Monitoring

To help WSA teams overcome the obstacle presented by lack of funding, the TFW monitoring program provided funding to WSA teams to support WSA monitoring projects. A Request for Proposals was circulated to WSA team members, asking them to design projects and submit proposals for monitoring projects. Over 20 monitoring proposals were received. Most proposals were generated by analysts who were involved in the assessment and synthesis processes rather than by prescription team members. Most came from WAUs where WSA had recently been completed, rather than those approaching five-year review. The proposals were reviewed by the TFW Monitoring Advisory Group (MAG). Selection criteria included: 1) regional or statewide relevance, 2) consistency with TFW Monitoring Program, 3) clarity in identifying monitoring questions, 4) feasibility and technical merit, 5) support and participation of stakeholders, and 6) matching contributions from participants.

Eight proposals were selected to receive funding. Six of them addressed riparian issues and two addressed sediment delivery issues. Six were located in western Washington and two were in eastern Washington.

Technical Assistance

Monitoring plans for each project were developed under guidance of the TFW Monitoring Program. The monitoring plans identified project objectives, monitoring questions and hypotheses, parameters, evaluation procedures, sampling design, data collection procedures, data analysis and evaluation procedures, quality assurance and project organization. Each monitoring plan was reviewed by MAG, TFW Monitoring Program staff, and WDOE, and revised to address the comments received. Once the plans were approved, the monitoring projects were implemented. The TFW Monitoring Program provided technical assistance including training and quality assurance surveys.

After data collection was completed, data was entered and analyzed and reports that presented the project results were prepared. The TFW Monitoring Program provided technical support during data analysis and report preparation where requested by project proponents. Reports were reviewed by MAG, TFW Monitoring Program staff, and WDOE, revised to address comments, and approved. Individual project reports are available from the WDNR Forest Practices Division.

2 Summaries of Monitoring Projects Conducted by WSA Teams

This section provides a brief description of each project conducted by WSA teams. See Appendix A for the project report abstracts and TFW document numbers.

2.1 Riparian Projects

2.1.1 Streamside buffers and large woody debris recruitment in the North Cascades Region. Jeff Grizzel, Myla McGowan, Devin Smith and Tim Beechie.

This project was designed to evaluate the effectiveness of WSA riparian LWD prescriptions in providing large woody debris recruitment (Smith et al., 1998). Ten sites where riparian prescriptions had been implemented during the last five years in the North Cascades physiographic region were selected from a pool of potential monitoring sites in the Deer Creek, Griffin-Tokul Hansen, Hazel, Hutchinson Creek, Jordan-Boulder, Lake Whatcom, Skookum, and Tolt WAUs. Sampling sites were stratified by buffer width and stream gradient. Data were gathered using the TFW riparian stand inventory procedure and the TFW LWD and habitat unit survey procedures.

Project results were presented by Grizzel et al. (2000). Buffer widths and tree mortality since harvest were documented for all sites. Effectiveness was evaluated by comparing debris frequency to targets based on WSA resource condition indices and regressions from unmanaged stands (Bilby and Ward, 1989) and geometric mean debris diameter with targets based on regressions from unmanaged stands (Bilby and Ward, 1989). Debris recruitment rates from sites in three buffer width classes were compared. Forest stand growth was modeled to estimate the number of years necessary to produce trees that would meet the target diameter.

Buffers at all study sites exceeded the prescription buffer width requirements. Mean buffer widths ranged from 16-39 meters. Post-harvest mortality ranged from 3-57% of stand basal area and 5-61% of stem density. Qualitative observations suggest that most mortality was due to windthrow following timber harvest. Nine of ten sites rated good for in-channel LWD frequency based on the WSA resource condition indices, but only four sites rated good based on key piece criteria. Seven of ten sites met the Bilby and Ward target for debris frequency. The average diameter of debris recruited from buffers was below target at all sites but average length exceeded targets. This indicates that while most sites are meeting LWD frequency targets, a disproportionate number of long, small diameter pieces are being recruited. Growth modeling suggests that only trees in close proximity to the stream will meet debris diameter targets within the next 25 years. Continued mortality in the form of wind damage is likely to reduce the capacity of these sites to recruit an adequate supply of target-sized debris in the future.

2.1.2 Onion Creek LWD recruitment. Rick Shumaker and Domoni Glass.

This project was designed to examine riparian LWD recruitment processes and stand dynamics in three types of riparian stands in the Onion Creek WAU (Schumaker et al., 1998). Onion Creek is located near Colville in Stevens County, within the Northern Rockies eco-region of northeast Washington. The objectives of the project were to: 1) generate information on LWD recruitment including tree fall rates and fall direction to improve models to estimate recruitment over time, 2) to document current stand conditions and recruitment rates during normal years and episodic events, and 3) to determine the persistence and function of recruited wood. Data were collected using the TFW riparian stand inventory procedure and the TFW LWD and habitat unit surveys. Baseline data on standing trees, down wood and in-channel wood were collected at three sites, a mixed-conifer, second-growth western red cedar, and mature western red cedar (Schumaker and Glass, 1999). Sites were initially visited in 1998 and again in 1999 to begin documenting stand mortality and LWD recruitment rates. Follow-up surveys one year after the initial surveys documented few changes resulting from natural processes. Iterative monitoring of stand conditions and recruitment over time is recommended.

2.1.3 The effects of the intentional addition of LWD to stream channels in the Upper Coweeman river basin. Storm Beech.

This project was designed to examine the effectiveness of riparian LWD prescriptions for adding LWD to stream channels in the Coweeman WAU, located in the Cascades eco-region near Vancouver. The objectives of the project were: 1) to document the characteristics of the wood added to the channel; 2) to determine if an initial, quantifiable response in channel morphology occurred (pool formation and sediment storage); and 3) to determine if the added pieces were stable and continue to function over time (Beech, 1998). Data were collected at four sites adjacent to harvest units where pieces were placed in the channel. Three techniques were used to place wood in the stream including, 1) yarding unmerchantable wood into the channel, 2) directional falling of trees during harvest operations, and 3) demolition of a log bridge with old-growth stringers. Sites were visited immediately after the wood was placed, and one year later after the sites had been subjected to winter high flows to document changes in LWD loading and channel response.

Project results are reported in Beech (1999). LWD stocking rates increased in all five sites after the LWD prescription was applied. Increases in total LWD piece counts ranged from 4-24%, and in-channel volume increased from 1-263%. The largest increases were at the bridge demolition site. The goal of achieving one function piece per four channel widths was not met at any of the harvest sites but was achieved at the bridge demolition site. LWD that was yarded into stream channels tended to have a greater volume placed within the bankfull channel (67%) than LWD that was felled into the channel (22%), presumably because cable yarding provides greater control in placing pieces. The added LWD pieces were stable at the sites with small, low-energy channels, but in the larger, high-energy mainstem sites between 50-80% of the pieces were transported out of the survey reaches during the first winter. Little change in pool habitat and sediment storage was observed in association with the added pieces after one year.

2.1.4 Function of wood in small, steep streams in eastern Washington. charles chesney.

This project was designed to monitor riparian stand conditions and wood quantity and function in small, steep stream channels in the Ahtanum, Cowiche and Tieton WAUs near Yakima in the East Cascades eco-region. The project objectives were: 1) to determine the function of both large and small wood in small streams, and 2) to determine the type of forest stand conditions needed to provide adequate amounts of wood to provide those functions (chesney, 1999). Ten managed (harvested) sites were compared with five unmanaged sites. Data were collected on riparian stand density and composition, channel wood abundance, and the function of wood in forming "steps" (obstructions that store sediment and dissipate energy).

The values for mean trees per acre in each of the four diameter classes were higher in the unmanaged stands. On average, the unmanaged forest sites had higher piece counts and volume of large and small woody debris than the managed sites. Mean small woody debris (SWD) volume and mean large woody debris (LWD) volume were also greater for the unmanaged sites (1.4 and 2.5 times greater respectively). The number of sediment retaining steps and estimated volume of stored sediment were higher (18% and 13%, respectively) in the unmanaged sites. Recommendations for prescription performance targets to maintain riparian stands that supply self-replenishing supplies of wood to small headwater channels are provided (chesney, 2000).

2.1.5 A watershed-scale baseline inventory of LWD in the Upper Coweeman WAU. Greg Volkhardt

This project was designed to establish a baseline for monitoring changes in LWD abundance on a watershed-scale. The project objectives were: 1) to document current LWD loading levels throughout the Coweeman WAU; 2) to document LWD loading levels adjacent to units scheduled for harvest within five years; and 3) to examine the relationship between current riparian stand condition and current LWD loading levels (Volkhardt, 1998). The study design involved a watershed-scale sampling scheme that placed all stream segments in the WAU into 15 strata based on five stream gradient classes and three confinement classes. Fifty to seventy percent of the segments in each strata (51 of the 91 segments in the WAU) were sampled for LWD size and abundance and riparian stand condition. Forty to fifty percent of the length of each selected segment was systematically sampled.

Survey results are presented in Volkhardt (1999). The survey resulted in a count of total and key piece LWD for each of the reaches surveyed, estimates of wood density for segments, and estimates of total and key piece wood loading at the segment, strata and WAU scales. Precision of WAU scale estimates for total and key piece LWD was 15% and 27% respectively. Post-study analysis showed no benefit from stratification by channel gradient, confinement or current riparian stand condition, as higher precision was achieved for estimates made without stratification. A better system for stratifying segments or a higher sampling rate would be necessary to achieve +/- 10% precision. Future monitoring should repeat surveys in the same segments and reaches prior to the five-year review to document trends in LWD loading throughout the WAU over time and evaluate the riparian LWD prescriptions.

2.1.6 Assessing the effectiveness of LWD prescriptions in the Acme Watershed. Alan Soicher.

This project was designed to establish a baseline for monitoring changes in LWD abundance and Watershed Analysis riparian prescription effectiveness in the Acme WAU (North Cascades-west eco-region). The project objectives were: 1) to document current LWD loading in fish-bearing streams and determine changes in LWD loading over time response to the riparian prescriptions; 2) to determine how timber harvest on Type 5 waters affects LWD recruitment and loading; and 3) to determine how the wood budget in a small sub-basin responds to management under WSA prescriptions compared to one where harvest activity is not occurring (Soicher, 1999a).

Project results are reported in Soicher (1999b). Surveys were conducted on 6.3 km of fish-bearing streams and 3.2 km of non-fish bearing stream. In general, fish-bearing streams were below WSA targets for LWD loading. Seven of ten fish-bearing segments rated poor, two rated fair and one good for LWD abundance. All but two of the fish-bearing segments received a riparian function assessment of RF4, below target in-channel wood loading and inadequate recruitment potential. In contrast, wood loading on the steeper non-fish bearing waters was moderate to high, but many of the Type 5 streams that were visited had poor short-term LWD recruitment potential due to past timber harvest.

2.2 Sediment Projects

2.2.1 Road drainage and erosion initiation in four west-Cascade Watersheds. Curt Veldhuisen and Periann Russell.

This project was designed to examine the effect of road drainage and relief culvert spacing on initiation of mass wasting and surface erosion at culvert outlets. The objectives were to: 1) determine if standards for culvert spacing and drainage guidelines are effective for preventing erosion at culvert outlets; and 2) determine if Watershed Analysis identifies situations where erosion at culvert outlets is likely to occur and addresses them appropriately (Russell and Veldhuisen, 1999). Four west side WAUs representing a range of geographic, climatic and landform conditions were selected for study, including Deer Creek, Mashel, Upper Chehalis and Hoko. A total of seventeen road segments ranging in length from 0.5-2.2 miles were sampled. In each segment, all drainage features (e.g. culverts, waterbars) were visited to determine culvert spacing and contributing road surface area and to identify and measure erosion features.

Results of the monitoring project are reported in Veldhuisen and Russell (1999). Gullies were found at 35% of the drainage outfall sites, and landslides were observed at 15%. The prevalence of erosion features tended to increase with hillslope gradient at the drainage release point. Gullies were found across the range of slope gradients, while the majority of landslides occurred when slopes were 80% or steeper. Erosion features (primarily gullies) on slopes <60% often occurred at sites where sub-surface flow was intercepted by the road cut. The contributing road surface area appeared to influence erosion initiation on slopes greater than 60%. Erosion initiation occurred at 66% of the sites where drainage was released on slopes 80% or steeper, suggesting that steep hillslopes are fairly sensitive to release of road run-off. Present forest practices rules, designed to prevent erosion within the roadway, were generally found to be ineffective at preventing erosion below drainage release sites along monitored roads. Watershed Analysis erosion assessments did not specifically identify the extent of road-drainage erosion features observed. Monitoring data were used to develop recommendations for revising drainage spacing guidelines and identifying sensitive locations.

2.2.2 Assessing the effectiveness of mass wasting prescriptions in the Acme Watershed. Alan Soicher.

This project was designed to evaluate the effectiveness of Watershed Analysis mass wasting prescriptions in the Acme WAU. The objectives were to determine: 1) if sediment delivery from management-induced mass wasting decreases over time in the WAU under the prescriptions; 2) if the prescriptions for road construction in sensitive areas prevent delivery of sediment from mass wasting: 3) if the mass wasting buffers adjacent to inner gorges are effective in preventing mass wasting and windthrow in the buffer; and 4) if prescriptions for selective harvest in the ground-water recharge zone of deep seated landslides are effective in preventing re-activation of the slides (Soicher, 1999a).

Results are presented in Soicher (1999c). This study provides a baseline for monitoring future trends that can be used to evaluate the effectiveness of the mass wasting prescriptions for the Acme WAU. Preliminary results from three site visits to locations where roads were rebuilt in mass wasting map units indicate that sediment delivery to the adjacent stream occurred at one site. The WSA aerial photo mass wasting inventory was repeated, and several failures were identified that appeared to be associated with windthrow along the boundary of recent harvest units. Additional data are being collected on windthrow and sediment delivery over time at mass wasting buffer sites in the Acme WAU.

3 Conclusions

3.1 Monitoring results and recommendations

Many of these projects were designed to establish a baseline from which to monitor changes associated with implementation of the WSA prescriptions over time. In addition, a number of the projects generated preliminary results about the effectiveness of the WSA riparian and sediment prescriptions. Following is a summary of important results and conclusions.

The project to evaluate streamside buffers and LWD recruitment in the North Cascades (Grizzel et al., 2000) identified an issue with windthrow of RMZ leave trees following timber harvest. Although many wind-thrown trees fell into or over the channel, most of the wood recruited was smaller than the target diameter and is not likely to function as well as larger pieces. Sites where many trees died because of windthrow before reaching a functional size will have fewer trees available for future recruitment. Consequently, it was learned that the prescriptions need to be improved to reduce windthrow mortality immediately after harvest of the adjacent stand in order to allow trees to reach a functional size before being recruited into the channel.

The project on road drainage and erosion initiation in four west-Cascade watersheds (Velhuisen and Russel, 1999) identified an issue with mass wasting and road surface erosion prescriptions that failed to address hazards and triggering mechanisms associated with drainage outfalls. The WSA mass wasting and surface erosion assessment procedures do not explicitly address gully erosion and mass wasting at drainage outfall sites. The project also identified a need for improvement in prescriptions for road construction and maintenance to address erosion initiation at drainage outfalls. Specific recommendations include:

1) identifying locations where the road cut intercepts sub-surface flow and installing drainage relief culverts regardless of road or hillslope gradient;
2) revising culvert spacing guidelines to reduce drainage contributing area where slopes exceed 60%; and
3) exercising extreme caution and careful placement of runoff when hillslope gradient exceeds 80%.

The project to assess the effectiveness of mass wasting prescriptions in the Acme WAU (Soicher, 1999c) identified an issue with the road construction prescriptions for inner gorge areas in the Acme WAU. In at least one case, more careful implementation of the road reconstruction project according to the site-specific geo-technical recommendations may have prevented sediment delivery. Continued monitoring and evaluation of the road construction prescriptions for inner gorge areas in the Acme WAU is advised.

The project on assessing effects of the intentional addition of LWD to stream channels in the Upper Coweeman WAU (Beech, 1999) identified several ways LWD addition prescriptions could be improved. First, more pieces need to be added to meet the prescription goals for LWD abundance at each of the harvest unit sites. In addition, at the sites with small, low-energy stream channels, a greater proportion of each piece should be placed within the bankfull channel in order to increase the likelihood of sediment retention or pool formation. Yarding was the more effective technique for placing pieces so they intruded into the bankfull channel while pieces added by felling were more likely to span the channel. Consequently, the prescription can be improved by encouraging the use of yarding or by providing better guidance on felling techniques so more stems intrude into channel rather than spanning over it. At high-energy mainstem channel sites, the majority of LWD pieces were transported downstream out of placement reach. To increase the on-site channel response at these sites, more care needs to be taken to increase piece stability by selecting large pieces and deploying them in stable configurations such as jams.

The project on the function of wood in small, steep streams in eastern Washington (chesney, 2000) concluded that riparian prescriptions are needed for steep headwater streams in the Ahtanum, Cowiche and Tieton WAUs. These prescriptions should be designed to achieve riparian stand conditions that provide an adequate supply of both large and small pieces of wood to form and maintain the obstructions that store sediment.

Changes in the status of WSA in the emergency forest practices rule package adopted by the Forest Practice Board in January 2000 makes the use of this information to improve the prescriptions and the assessment products somewhat problematic. The WSA riparian prescriptions are being superceded by the new riparian rules, and new road maintenance plans will be required for all forest roads. Mass wasting prescriptions will stay in effect. It now appears that there is limited incentive for WDNR or landowners to initiate WSA. However, the effectiveness of riparian and sediment reduction prescriptions continues to be a critical issue under the new rules. Consequently, information generated by these projects remains relevant to future adaptive management.

3.2 Conclusions concerning cooperative effectiveness monitoring

As a result of these projects, the TFW Monitoring Program was able to evaluate the feasibility of cooperative monitoring projects. These projects demonstrated that TFW participants can collect valuable monitoring data if funding is available. There are a number of advantages in working with local cooperators to implement a statewide monitoring program. They are located near study areas, are familiar with local conditions and people, and can provide efficient oversight and supervision of field projects. The cooperative approach also generated significant contributions of money and in-kind services. While the cooperative approach appears to be a feasible way to implement a statewide monitoring effort, several constraints were identified that need to be addressed to create an effective cooperative monitoring program. First is the need for technical assistance in study design. Most cooperators had not developed or implemented monitoring plans before and required technical assistance and guidance from the TFW Monitoring Program. Identifying clear objectives, focused monitoring questions, testable hypotheses, and rigorous analytical procedures was challenging for many project proponents. Based on our experience, this issue can be addressed most efficiently by developing statewide or regional monitoring plans that identify effectiveness monitoring questions, hypotheses and analytic procedures, avoiding the need to have each cooperator develop a separate monitoring study design. Statewide or regional monitoring plans would allow regional cooperators to engage in monitoring that contributes to a larger framework in a coordinated, consistent fashion. Local monitoring plans can then focus on identifying and selecting suitable sites, and the logistics of data collection. Collection of field data was handled well by local cooperators. Technical assistance provided by the TFW Monitoring Program in the form of training and quality assurance visits insured data quality.

Skill in processing and analyzing data, drawing conclusions and writing reports was variable. Having a monitoring plan that provided clear, detailed guidance in data analysis procedures facilitated data analysis and interpretation of results. Most of the monitoring plans could have been improved by increasing the level of detail and clarity in the portion of the plan that described the testable hypotheses and analytic procedures. In particular, greater involvement of a biometrician or statistician in data analysis proved to be beneficial in projects where the analytical procedures were complex. The NWIFC provided this service in several cases where cooperators did not have access to this type of expertise. In addition, because a high level of technical writing and organizational skill is required to present complex monitoring information in written reports, assistance was sometimes needed. Involvement in the writing and document review process by TFW Monitoring Program staff and other technical reviewers proved to beneficial in producing the technical documents.

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5 Appendix A. Citations and Abstracts

This appendix provides citations and abstracts for each project report, organized alphabetically by the last name of the primary author.

5.1 The effects of the intentional addition of LWD to stream channels in the Upper Coweeman river basin.

Citation

Beech, S. 1999. The effects of the intentional addition of large woody debris to stream channels in the upper Coweeman River basin: Baseline survey results. TFW-MAG1-99-004. DNR #122. Washington Department of Natural Resources. Forest Practices Division. Olympia.

Abstract

Five stream reaches within the Upper Coweeman Watershed Administrative Unit, Cowlitz County, Washington were surveyed where the intentional addition of LWD to the channels had occurred. The surveys were conducted as part of a study effort to evaluate the effectiveness of a watershed prescription process in which LWD is intentionally added to stream channels. Cable yarding, directional felling, and heavy machinery were used to add LWD to the channels. LWD, channel habitat and channel reference point data were collected utilizing Washington State Timber Fish and Wildlife (TFW) Monitoring Program guidelines. Initial surveys were conducted immediately after LWD addition occurred in the summer of 1998. Surveys were repeated in the summer of 1999. Parameters estimated include abundance and quality of natural and added LWD, channel habitat unit quantity and quality and location of added LWD relative to established streambank reference points. A total of 43 logs (177 cubic meters of volume) were added to the study sites, at a mean rate of one log for every 9.7 bankfull channel widths. 69% of added logs were transported various distances downstream. Log stability at the five sites ranged from all volume being exported out of the established reach to no instability occurring at all. The only alterations to channel morphology quantifiable at the reach scale occurred at a site where added debris was placed in a jam configuration. When logs were yarded into channels, 67% of the volume was placed within the bankfull channel cross section. Directional felling and bridge demolition placed 22% and 31% within the channel, respectively.

5.2 Functions of wood in small, steep streams in eastern Washington.

Citation

chesney, c. 2000. Functions of wood in small, steep streams in Eastern Washington. TFW-MAG1-00-002. DNR #127. Washington Department of Natural Resources. Forest Practices Division. Olympia.

Abstract

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.

Unmanaged stands have more trees in each of the four size classes that create conditions suitable for wood entry to channels. Mean values for trees per acre in four size classes (TPA <3" dbh, TPA 3-9", TPA 9-20", TPA >20") were 2.2, 1.6, 1.9, and 2.9 times greater in unmanaged sites compared to managed sites. 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 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 and shed to produce small woody debris for in-channel functions.

While dense, unmanaged stands create 2.4 times more in-channel and near-channel wood volume (zones 1-2-3-4 mean volumes) per bankful width, sediment wedge volume (cubic

yards per bankful width) and step quantity (number of steps per bankful width) are similar in unmanaged sites (n=5) compared to managed sites (n=10). Mean sediment wedge volume is nearly the same- 13% higher- in unmanaged sites compared to managed sites. Mean step quantity is only slightly higher- 18% higher- in unmanaged sites than in managed sites.

Crude methods used in measuring and calculating stored sediment volume may bias the initial results by forcing the assumption that all sediment obstructions are geometrically simple wedge shapes with simple-to-calculate obstruction volumes. Imperfect step measurement methods are likely to improve with repeat measurements and benefit from improvements in monitoring techniques and comprehension of fluvial processes.

The following performance targets are based on stand conditions providing self-replenishing supplies of wood to channels unaffected by land use activities:

Riparian forest characteristics:

TPA>20" dbh, 20-50;
TPA 9-20" dbh 70-110
TPA 3-9" dbh, 160-200
TPA <3" dbh, 200-400
Ratio of ~1:2:4:8 among the four diameter classes

Wood

A range of 7 to 13 SWD pieces/bfw and a range of 1-2 LWD pieces/bfw are needed to retain sediment in small, steep streams. In terms of wood volumes, a range of 0.20-0.30 ft^3/bfw of SWD (all 4 zones), and a range of 7 to 18 ft^3/bfw of LWD (all four zones) are needed for sediment retention. For zones 1 and 2 (in-channel LWD and SWD), data indicates that a range of 3 to 5 ft^3/bfw provide functional sediment retention.

Overall, these performance criteria are based on information gathered on five 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.

5.3 Streamside buffers and large woody debris recruitment in the North Cascades region.

Citation

Grizzel, J., M. McGowan, D. Smith and T. Beechie. 2000. Streamside buffers and large woody debris recruitment: evaluating the effectiveness of Watershed Analysis prescriptions in the North Cascades Region. TFW-MAG1-00-003. DNR #128. Washington Department of Natural Resources. Forest Practices Division. Olympia.

Abstract

Forest management prescriptions implemented as part of Washington's Watershed Analysis process have resulted in the retention of streamside buffer strips that afford a greater degree of stream protection than earlier practices. A primary objective in establishing these buffers is to recruit large woody debris to create and maintain fish habitat. In this study, we evaluated the effectiveness of Watershed Analysis prescriptions in recruiting large woody debris by examining 10 streamside buffers in Washington's North Cascades. We evaluated effectiveness in three ways: 1) be comparing debris frequency to targets derived from Watershed Analysis resource condition indices (Washington Forest Practices Board 1997) and a channel-width dependent regression equation (Bilby and Ward 1989); 2) by comparing the size of debris recruited from buffers to targets based on channel-width dependent regression equations (Bilby and Ward 1989); and 3) by comparing debris recruitment between three buffer width classes. In addition, related to 2) above, we modeled forest stand growth to estimate time-to-recruitment of target-sized debris for sites currently below the target diameter.

Habitat quality at nine of 10 sites rated "good" based on the Watershed Analysis debris frequency targets while seven of 10 sites met the Bilby and Ward target for debris frequency. However, only four sites rated "good" based on "key" piece frequency targets for Watershed Analysis. This indicates that while most sites are meeting frequency targets, there is a disproportionate number of small debris pieces relative to larger, more stable pieces. The average diameter of debris recruited from buffers was below the Bilby and Ward target at all sites, however, the average length exceeded the target at all sites. An evaluation of average piece volume indicated that longer piece lengths did not compensate for deficits in piece diameters, as seven of 10 sites failed to meet the debris volume target. Growth modeling suggests that due to bole taper, only trees in close proximity to the stream will meet debris diameter targets within the next 25 years (stand age 75 years). Trees further from the stream will require one to two decades additional growth before meeting the diameter target (stand age 85 t0 100 years).

Buffers in the 20-30 m and >30 m class contributed 19 and 28 percent of debris pieces, respectively outside 20 meters from the stream. This suggests a substantial portion of the total debris load is recruited from the outer margins of these wider buffers and narrower buffers limit debris recruitment. Buffer orientation with respect to the direction of damaging winds influenced the probability of debris recruitment. Trees in buffers oriented perpendicular to the direction of damaging winds (i.e. east-west) had a higher likelihood of being recruited relative to buffers oriented parallel to damaging winds (i.e. north-south). Post-harvest buffer mortality, primarily as a result of wind damage, ranged from 2.9 to 56.8 percent of stand basal area and 4.8 to 60.5 percent of stem density. Continued mortality in the form of wind damage is likely to reduce the capacity of these sites to recruit an adequate supply of target-sized debris in the future.

This study demonstrates that short-term post-harvest debris recruitment from streamside forest buffers is heavily influenced by windthrow. The quantity and quality of debris recruited will be a function of windthrow magnitude, buffer orientation, and stand characteristics. From a fish habitat perspective, accelerated rates of windthrow should be minimized to maintain stand density and allow for the continued growth and development of streamside buffer trees. Ideally, debris recruitment from the buffer would mimic the natural or background rate to ensure a continuous supply of debris over the long term. In order to achieve these objectives, natural resource managers must gain a better understanding of the factors influencing windthrow patterns at local and regional levels and implement management practices aimed at minimizing its occurrence.

5.4 Onion Creek watershed large woody debris recruitment

Citation

Schumaker, R. and D. Glass. 1999. Onion Creek watershed large woody debris recruitment. TFW-MAG1-00-001. DNR #126. Washington Department of Natural Resources. Forest Practices Division. Olympia.

Abstract

A riparian survey was conducted in the Onion Creek Watershed, in Stevens County, Washington, to obtain baseline data and establish permanent plots that can be used to track future rates of large woody debris recruitment during "normal" years and episodic events.

A total of twelve permanent plots were established during summer of 1998 at three sites corresponding to mixed conifer, western redcedar, and mature western redcedar stands. Plots were 30 meters long and 50 meters wide centered on the creek. All three streams were small, (Type 3) with bankfull widths ranging from 2 to 3 meters. Average stream gradients ranged from 8% to 20%, and average site hillslopes ranged from 26% to 44%.

Standing wood, down, wood, and instream wood were measured at each plot. Over 1250 standing trees and instream wood were marked with aluminum tags for future reference. Various information such as tree height, dbh, species, condition, and lean azimuth was recorded for standing trees. The size of down wood (pieces and trees with rootwads) was also recorded, along with the location and fall direction of trees. Instream wood was characterized and counted as well.

Overall, trees were predominantly western redcedar (60%), Grand fir, and western hemlock (fir and hemlock together making up 24%). Average stand densities ranged from 825 to 1055 stems/ha. The majority of the trees were small (<30cm dbh), with the greatest number of large trees in the mature redcedar stand. On average, the tallest trees were also located in the mature redcedar stand. Eight to 12% of the trees at a stand were either stressed or snags. Twelve to 20% of the trees in a stand were leaning, with 2% more leaning toward the creek than away. Trees were generally well distributed throughout the plots. The western redcedar stand had the most trees close to the creek; the mature redcedar had the most trees farther up the hillslope.

The most common species of down wood was western redcedar. There were about twice as many down pieces of wood than down trees with rootwads. The mixed conifer stand had the most down wood. Most of the down wood was small (<30cm) in diameter and between 5 and 15 meters long. The down trees with rootwads were more decayed than the individual pieces. Most of the trees that fell originated away from the creek, between 10 and 20 meters slope distance. Of the down wood, 11% was recruited to bankfull, 7% was spanning, and 20% was suspended over the stream channels (however, much of this suspended wood was found in just two of the twelve plots).

Most instream wood was very small (<20 cm diameter). Accounting for all wood in the channel (bankfull, spanning or suspended), recruitment was 1 piece/bankfull width. Most of these pieces were <5 meters long. Almost all of the wood functioning to form pools was small or medium sized; most was small. The mixed conifer stand had the most wood recruited to the bankfull channel (1.1 pieces/bankfull width). No debris jams were found in the study plots.

5.5 *Assessing the effectiveness of LWD prescriptions in the Acme watershed.*

Citation

Soicher, A. 1999. Assessing the effectiveness of large woody debris prescriptions in the Acme watershed: Phase 1 - Baseline data collection. TFW-MAG1-99-002. DNR #120. Washington Department of Natural Resources. Forest Practices Division. Olympia.

Abstract

A monitoring project designed to assess the effectiveness of forest practice prescriptions for Large Woody Debris (LWD) was initiated in the Acme Watershed, Whatcom County, Washington. Prescriptions were developed under watershed analysis, a state program to assess aquatic conditions and develop rules for protecting identified Areas of Resource Sensitivity. The watershed assessment found that salmon habitat and water quality conditions in the Acme watershed are severely degraded, largely due to channel manipulations, riparian clearing, and mass wasting. Phase I monitoring conducted in 1998 provides baseline reference conditions for future assessment of prescription effectiveness. Continued data collection under subsequent phases will help establish trends in watershed protection and habitat recovery.

The monitoring effort provides information to help answer the following questions:

- Question LWD1. What are current LWD loading levels in anadromous fish bearing waters and how will they change over time under the watershed analysis prescriptions.
- Question LWD 2. How does riparian harvest on and along Type 5 waters affect LWD recruitment and subsequent loading?
- Question LWD 3. How does the overall wood budget (loading levels) in a basin respond to management under Acme watershed analysis prescriptions as compared with a geomorphically similar basin that has not been recently clearcut?

LWD surveys were conducted in seven fish bearing streams in the Acme Watershed over a total length of 6.3 kilometers. An additional 3.2 kilometers of non fish bearing stream channels were surveyed in three basins. Phase I Monitoring has documented that LWD loading in the Acme watershed appears consistent with that reported in the Acme watershed analysis, that fish bearing creeks are wood impoverished and streamside conifer recruitment potential is low to moderate. Non fish bearing channels in the upper watershed vary in wood loading, with some above and some below targets. Although some moderately healthy riparian stands remain along fish bearing streams, most LWD recruitment in the short-term will be transported, perhaps catastrophically, from upstream. The protection of upland riparian forests will ensure an adequate supply of LWD (including key pieces) to upland and lowland reaches over the short and long term.

LWD prescription effectiveness will take many years to assess (on the order of decades). The effectiveness of prescriptions in protecting riparian leave areas may be a reasonable short-term indicator of long-term recruitment potential. Riparian stand surveys would complement data already available on in-stream wood loading around the watershed. Over time, repeat in-stream LWD surveys will help gage the success of habitat recovery measures in the Acme watershed.

5.6 Assessing the effectiveness of mass wasting prescriptions in the Acme watershed.

Citation

Soicher, A. 1999. Assessing the effectiveness of mass wasting prescriptions in the Acme watershed: Phase 1 - Baseline data collection. TFW-MAG1-99-003. DNR #121. Washington Department of Natural Resources. Forest Practices Division. Olympia.

Abstract

This report describes a monitoring project designed to assess the effectiveness of forest practice prescriptions in the Acme Watershed, Whatcom County, Washington. Rule calls of *Prevent or Avoid* for mass wasting produced a set of prescriptions aimed at protecting identified Areas of Resource Sensitivity in the watershed (Crown Pacific, 1999). Phase I monitoring in 1998 provides baseline reference conditions on mass wasting and prescription implementation, and reveal some preliminary results on prescription effectiveness. Future data collection under subsequent phases will help establish trends in watershed protection.

The Acme Watershed Analysis (AWA) identifies approximately 175 landslides and debris flows from aerial photos covering a period from 1970 and 1994. Roughly 80% of all landslides documented in the AWA are associated with forestry activities such as timber harvest and road construction. The analysis concludes that channel conditions, salmon habitat and water quality in the Acme watershed are severely degraded. Monitoring aims to assess the improvement of conditions under implementation of these mass wasting prescriptions.

Specifically, this effort helps to answer the following monitoring questions:

- **Question MW1.** Are road construction practices through high hazard mass wasting zones effective at preventing management related mass wasting?

- **Question MW2.** Does windthrow reduce the effectiveness of "no-cut" inner gorge mass wasting prescriptions? (Supplemental: Does buffer orientation, location and edge tree distribution influence windthrow occurrence?)
- **Question MW3.** Are selective harvest techniques in the groundwater recharge zone (GRZ) of deep-seated landslides (RSA MW-3) effective at preventing management related mass wasting?
- **Question MW4.** Are forest management prescriptions in the AWA effective at preventing management-related deliverable mass wasting?
- **Question MW5.** Is the rate of management-related mass wasting decreasing over time on a watershed scale?

These questions are addressed in the form of hypothesis testing, generally assuming that forest practices will not create mass wasting nor impact public resources using AWA prescriptions. Preliminary data show that management related landslides with delivery have been triggered under implementation of AWA prescriptions. From this we conclude that initial data do not fully support the posed hypothesis. Establishing trends in rates of mass wasting and prescription effectiveness will take one to two decades to assess, however, as the maximum loss of root strength after extraction is 5-15 years, and sufficient time must pass to capture large storm events. Over time, repeat surveys will help gage whether forest practice prescriptions are successful at promoting recovery in the Acme watershed.

5.7 Road drainage and erosion initiation in four west-Cascade watersheds.

Citation

Veldhuisen, C., and P. Russell. 1999. Forest road drainage and erosion initiation in four west-Cascade watersheds. TFW-MAG1-99-001. DNR #119. Washington Department of Natural Resources. Forest Practices Division. Olympia.

Abstract

This monitoring project was undertaken to evaluate erosion initiation at road drainage release sites along forest roads in four watersheds located across western Washington. A primary goal was to evaluate the effectiveness of regulatory approaches--Washington Forest Practices Rules and Watershed Analysis--at preventing road drainage erosion. The influence of numerous terrain attributes, geologic and hydrologic factors on erosion initiation was explored as well. Monitoring covered 4-5 road segments in each watershed; most involved roads located in relatively steep terrain and built prior to the 1970s. These road segments allowed evaluation of 200 "drainage sites", here defined as points where road runoff is diverted (sometimes unintentionally) away from the roadway onto a hillslope. Crossing structures involving any type of stream were not evaluated as drainage sites.

Among all drainage sites, we found gullies at 35%. Most gullies were less than 60 feet long and about half delivered sediment to a stream. Landslides were found at 15% of drainage sites, most of which where drainage had been temporarily diverted due to a ditch obstruction. Eighty percent of landslides reached a stream. The prevalence of erosion features (gullies plus landslides) tended to increase with hillslope gradient at the drainage release point. Gullies were found across the range of slope gradients. Although several landslides were found in the 60-79% slope range, the remaining majority occurred where slopes were 80% or steeper. Hydrologic influences to erosion initiation were explored by evaluating the road surface area draining toward each release site. Among drainage sites involving slopes of less than 60%, erosion features were not associated with the contributing road surface area, but rather with sites where sub-surface flow was intercepted by the road cut. In contrast, the contributing road surface area appeared to influence erosion initiation on slopes of 60-79%. Where drainage was released onto slopes of 80% or steeper, erosion initiation was common (66% of sites) across the range of road surface areas and slopes, suggesting that such steep hillslopes are fairly sensitive to most any quantity of road runoff. Drainage sites in areas underlain by hard geologic materials (e.g., basalt) experienced somewhat less erosion initiation within comparable road drainage contributions as sites in softer materials (e.g., glacial sediments).

We compared erosion initiation among two sub-groups of roads built prior to 1974 to evaluate the effectiveness of post-construction drainage upgrading practices. Though total erosion rates were fairly similar between the sub-groups, we found the upgraded roads to have slightly fewer landslides, but more gullies. Despite the limited extent of this test, this implies that a critical approach to drainage upgrading may be needed to achieve the sediment reduction benefits that justify the upgrading of older forest roads.

Present Forest Practices Rules, designed as they were to prevent erosion <u>within</u> the roadway, were generally found to be ineffective at preventing erosion <u>below</u> drainage sites along monitored roads. We found that Watershed Analysis (WA) erosion assessments did not specifically identify the extent of road-drainage erosion features we found. In addition, WA landslide hazard maps were not very effective at predicting the locations of erosion initiation, though this appears to result primarily from map resolution limitations. From our monitoring data we developed criteria for identifying sites needing closer drainage spacing than required by existing spacing rules.

5.8 A watershed-scale baseline inventory of LWD in the Upper Coweeman WAU.

<u>Citation</u>

Volkhardt, G. 1999. A watershed-scale baseline inventory of large woody debris in the upper Coweeman WAU. TFW-MAG1-99-005. DNR #123. Washington Department of Natural Resources. Forest Practices Division. Olympia.

<u>Abstract</u>

A large woody debris survey was conducted in the fish-bearing streams of the Upper Coweeman WAU using TFW monitoring protocols. Stream segments identified during watershed analysis were selected for surveying using a stratified random sampling

procedure that incorporated channel gradient and confinement into the stratification. Segments were further partitioned into 100-meter reach survey units. The survey resulted in a count of total wood and key-piece wood for reaches surveyed, estimates of wood density for segments, and estimates of total and key-piece wood loading at the segment, strata, and WAU scales. Precision of the estimates for total wood and key-piece wood at the segment and stratum scales averaged +/- 47% and +/- 78% for segment estimates, and +/- 39% and +/- 66% for stratum estimates, respectively at a 95% significance level. Precision of WAU-scale estimates for total and key-piece LWD was 15% and 27%, respectively at the same significance level. Post-study analysis showed no benefit from the stratification approach taken as higher precision was achieved for estimates made without stratification. Measures of riparian attributes were collected and tested to evaluate relationships with wood densities and their use in future stratification. These attributes were found to have a significant ($p<0.05$) but small influence on total wood loading. Additional evaluation of stratification and indexing approaches was recommended to reduce imprecision associated with parameter estimation. A repeat survey was recommended prior to the watershed analysis 5-year review to evaluate wood placement prescriptions and to begin monitoring the trend in large woody debris in a managed landscape.