

Type N Experimental Buffer Treatment Project in Hard Rock Lithologies – Report to Policy on Stand Structure and Tree Mortality Rates in Riparian Buffers (Chapter 5)

11 December 2017 – For CMER Review

Study Report

The results from this study are found in the following Study Report:

McIntyre, A.P., M.P. Hayes, W.J. Ehinger, D. Schuett-Hames, S.M. Estrella, G. Stewart, R.E. Bilby, E.M. Lund, J. Walter, J.E. Jones, R. Ojala-Barbour, F.T. Waterstrat, C.R. Milling, A.J. Kroll, B.R. Fransen, J. Giovanini, S.D. Duke, G. Mackenzie, R. Tarosky, J.G. MacCracken, J. Thronton and T. Quinn. 2017. Effectiveness of Experimental Riparian Buffers on Perennial Non-fish-bearing Streams on Competent Lithologies in Western Washington. Cooperative Monitoring Evaluation and Research Report **CMER XX-XXX**, Washington State Forest Practices Adaptive Management Program, Washington Department of Natural Resources, Olympia, WA.

CMER/Policy Interaction Framework Six Questions

1. **Does the study inform a rule, numeric target, Performance Target, or Resource Objective? Yes.**
2. **Does the study inform the Forest Practices Rules, the Forest Practices Board Manual guidelines, or Schedules L-1 or L-2? Yes.**

The objective of the Type N Experimental Buffer Treatment Project in Hard Rock Lithologies (Hard Rock Study) was to evaluate the effectiveness of the current westside riparian management zone (RMZ) prescriptions for Type N (non-fish-bearing) Waters in maintaining key aquatic conditions and processes affected by Forest Practices. Specifically, we evaluated whether the riparian buffer prescription for Type N streams met the following Overall Performance Goals, namely: (1) to support the long-term viability of stream-associated amphibians, and (2) to meet or exceed water quality standards. As part of this evaluation, we assessed the Forest Practices Resource Objectives (defined as a series of Functional Objectives and corresponding Performance Targets in Schedule L-1) for heat/water temperature, large wood/organic inputs, and hydrology.

The overall study design addressed the following CMER Work Plan Critical Questions:

- Are riparian processes and functions provided by Type N buffers maintained at levels that meet Forest Practices (FP) Habitat Conservation Plan (HCP) Resource Objectives and Performance Targets for shade, stream temperature, large wood recruitment, litterfall, and amphibians?
 - How do other buffers compare with the FP Type N prescriptions in meeting Resource Objectives?
 - How do Type N riparian prescriptions affect water quality delivered to downstream Type F/S waters?
3. **Was the study carried out pursuant to CMER scientific protocols?**

Yes. The study design was carried out according to the CMER and Independent Scientific Peer Review (ISPR) approved study design (including sampling methodologies, statistical

methods, and study limitations). SAGs (RSAG and LWAG), CMER, and ISPR reviewed all of the study chapters and their associated findings, and CMER approved the entire final report in September 2017.

4. A. What does the study tell us?

In the two years immediately post-harvest we saw the greatest changes in stand structure in the clearcut portions of the RMZ where all trees were removed during treatment implementation. In stream reaches that maintained a riparian buffer in the RMZ, windthrow was the primary cause of mortality and tree fall. In stream reaches that maintained a two-sided 50-ft riparian buffer, tree mortality rates were significantly higher in the FP treatment than the 100% treatment and reference sites; however, tree mortality in the 56-ft radius buffer surrounding the uppermost points of perennial flow (PIPs) increased significantly above reference levels in both the 100% and FP treatments, likely due to their exposed locations and vulnerability to windthrow.

Stand Structure and Tree Mortality Rates

The LWD/Organic Inputs Resource Objective addresses riparian stands. The Hard Rock Study reduces uncertainty for riparian stand condition with an evaluation of tree mortality and tree fall during the two years after harvest.

Functional Objective: Develop riparian conditions that provide complex habitats for recruiting large woody debris and litter.

Performance Targets: There are no Performance Targets specific to riparian condition for Type N Waters.

We can also indirectly inform the critical question regarding the frequency and distribution of windthrow in forest practices buffers on Type N Waters.

Critical Question: How do survival and growth rates of riparian leave trees change following Type Np buffer treatments?

Results:

- The greatest change in stand structure occurred in the treatments where riparian trees were completely removed to the stream edge (clearcut) and replanted with conifers (the 0% treatment and unbuffered portions of the FP treatment RMZs).
- Two year post-harvest tree mortality rates were higher in the FP buffered RMZs compared to unharvested reference sites and 100% treatment RMZs. Post-harvest tree mortality (% basal area/yr) in FP buffered RMZs was over four times greater than in unharvested reference RMZs ($P = 0.01$) and over two times greater than in 100% RMZs ($P = 0.09$). The mortality rate in the 100% RMZs was double the reference rate, but the difference was not statistically significant. The mortality (% basal area) in both the FP and 100% PIPs were significantly higher than the rate for the reference PIPs, eight ($P < 0.01$) and four ($P = 0.05$) times higher, respectively.
- Stand structure as measured by trees per acre in the FP buffered RMZs was highly variable two years post-harvest. Most (~75%) stands had densities greater than 120 trees/acre, while a subset (~25%) had densities below 120 trees/acre.

- Windthrow was the primary cause of mortality and tree fall in both RMZ and PIP buffers. There was substantial variability in windthrow mortality among and within sites. We observed higher rates of windthrow in the RMZs of the coastal blocks (Willapa 1 and Willapa 2) than in sites located further inland in both the pre- and post-harvest periods.
- Higher tree mortality in PIP buffers was likely due to their exposed locations and vulnerability to windthrow.

Conclusions:

- Removal of streamside trees in the 0% treatment and unbuffered portions of the FP treatment returned these areas to the stand-initiation stage of development and is likely to have the greatest effect on the quantity, characteristics and timing of wood input.
- Unless the rates of tree mortality change significantly over time, FP and 100% RMZ buffers, which experienced low mortality, are likely to continue developing as single cohort, conifer dominated stands. The future trajectory for the sub-set of buffer stands with higher mortality remains unclear. Since replanting is not required in these areas under Forest Practice rules, success of natural conifer regeneration will likely determine if these stands develop as multi-cohort conifer stands, or become dominated by broadleaf trees or shrubs.
- Results from the Hard Rock Study are consistent with the findings from the Westside Type N Buffer Characteristics, Integrity, and Function Project (BCIF) Study (Schuett-Hames *et al.* 2011). Post-harvest mortality rates in the FPB RMZs were similar, and both studies documented statistically significant increases in mortality in FPB RMZs compared to reference sites.

B. What does the study not tell us?

One should consider a number of study limitations when interpreting and generalizing the results.

Spatial Scope of Inference: The spatial scope of inference is limited to Type N basins dominated by competent lithologies, which comprise approximately 29% of western Washington Forests and Fish-regulated lands (P. Pringle, personal communication, September 2005). One should not assume that the results apply equally to other lithologies. Additional considerations include the fact that sites were located in second-growth forests and ranged from approximately 12 to 53 ha (30 to 130 ac). See McIntyre and colleagues (2009) for a summary of the site selection process.

Temporal Scope of Inference: The temporal scope of inference can only be made to the two year post-harvest interval. Do not assume that the results are applicable over a longer period. One can only understand the scope of potential long-term response with longer-term monitoring. Stand development is a long-term process, there will be height and diameter growth in existing buffer trees, mortality from suppression, windthrow and other factors, and regeneration and ingrowth of new trees in response to disturbance. For metrics that changed from pre-harvest levels, we do not know how much time will be needed for recovery to pre-harvest conditions.

Riparian Buffering/BMPs: Application of clearcut timber harvest included buffers for sensitive sites and unstable slopes, and followed other best management practices (BMPs), ultimately, influencing the level of buffering (width and length) in the FP treatment sites. CMER did not design this study to examine directly the influence of specific rules or BMPs, but rather to evaluate the overall influence of the FP buffer strategy as it is applied under real world circumstances. We do not know if the results for the FP buffers would have been different if only the minimum riparian buffers had been applied. We also do not know how frequently more than the minimum buffer length is applied across the managed landscape. Since the proportion of the stream length buffered in FP treatment sites was more than the minimum required under Forest Practice’s rules, some consistency in responses between the 100% and FP treatments may reflect the fact that the stream length buffered was more similar between these treatments than between the FP and 0% treatments. Furthermore, protection of unstable slopes resulted in wider riparian buffers along some portions of two of four 100% buffer treatment sites, although it should be noted that this study was designed to evaluate buffer length, not buffer width. Nonetheless, wider buffers in some 100% treatment sites may have resulted in a consistency of response between reference and 100% sites. Buffers along the FP treatments sites were 50 ft, as specified in the FPHCP. As stated above, and based on the results from sites with buffers 50 ft wide, it is very likely that sites containing buffered sections wider than 50 ft would still have experienced increases in stream temperature associated with shade reductions.

Pre-harvest Windthrow Event: Interpretation of results, especially for riparian vegetation and wood, required consideration of the timing and severity of a windthrow event that occurred 1-4 December 2007. During this time, a series of storms caused extensive windthrow throughout western Washington. The storms resulted in extensive damage to forestlands along the Washington coast, leading us to add an additional, third year, of pre-treatment sampling for some response variables. We found that study sites assigned to all treatments were impacted, including references and riparian buffer treatments. Since we had the opportunity to collect additional pre-harvest data, our data reflect the broad range of disturbances that occur throughout the managed forestlands of western Washington.

5. What is the relationship between this study and any others that may be planned, underway, or recently completed?

The results from the Hard Rock Study, BCIF Study, Soft Rock Study, Shade Study, and Amphibian Recovery Project in combination are expected to provide a thorough assessment of riparian prescription effectiveness for westside Type N Waters. They will generate data that can be used to determine if the resource objectives for heat/water temperature, LWD/organic inputs, sediment, hydrology and stream-associated amphibians (with the exception of terrestrial Dunn’s and Van Dyke’s Salamanders) are being met.

- Westside Type N Buffer Characteristics, Integrity, and Function Project [BCIF Study, completed]: The BCIF Study evaluated the magnitude of change in riparian stand conditions, tree mortality, shade and LWD recruitment when prescriptions were applied on a reach-scale at sites selected from a random sample of forest practice applications. The Hard Rock Study expanded on the knowledge gained in the BCIF Study, supplementing the results from the latter by increasing the sample of clearcut,

50-ft buffer and PIP buffer RMZ reaches. These results are particularly helpful in reducing the level of uncertainty in PIP buffer response, increasing the sample size and providing PIP reference data. Additionally, the Hard Rock Study included responses that were not incorporated in the BCIF study, including riparian-related inputs (light, litterfall, sediment, and wood) and the response of instream (amphibians, water temperature, and habitat) and downstream components (export of nutrients, organic matter, macroinvertebrates, and sediment; water temperature; and fish in the downstream fish-bearing reach). Findings through five years post-harvest are reported on in Schuett-Hames and colleagues (2011). A report on findings through 10 years post-harvest is in development.

- Type N Experimental Buffer Treatment Project in Soft Rock Lithologies [Soft Rock Study, underway]: The Soft Rock Study will expand on the knowledge gained from the Hard Rock Study by evaluating the post-harvest changes in riparian stand conditions, buffer tree mortality, LWD recruitment, shade and stream temperature, and nutrient and sediment export from westside Type N basins with sedimentary lithologies. This study differs from the Hard Rock study in that it includes only study basins underlain with sedimentary lithologies, and includes only one riparian buffer treatment (equivalent to the Hard Rock Study FP treatment; no alternative buffers are tested). Both the Hard and Soft Rock studies use a manipulative experimental design to compare effectiveness of riparian buffers with unharvested controls. Like the Hard Rock Study, the Soft Rock Study is limited to western Washington. It also does not evaluate the response of stream-associated amphibians, which are largely restricted to competent lithology types, fish, or litterfall. The Soft Rock Study will provide important confirmation of the effect of forest practices prescriptions on more erodible substrates that were not included in the Hard Rock Study.

These studies will not address the effectiveness of the riparian prescriptions for eastside Type N Waters, for which CMER needs to complete the ENREP Study (underway), Eastside Np Effectiveness Project (planned).

- Eastside Type N Riparian Effectiveness Project [ENREP Study, underway]: The ENREP study will determine if, and to what extent, the eastside riparian prescriptions are effective in achieving Performance Targets and water quality standards, particularly as they apply to sediment and stream temperature. Study objectives include: (1) quantify the magnitude of change in stream flow, canopy closure, water temperature, suspended sediment transport and wood loading within eastern Washington RMZs following harvesting, and (2) evaluate the effects of these changes on downstream waters where possible. This study complements the Hard Rock Study by evaluating Type N prescription effectiveness in eastern Washington.
- Eastside Np Effectiveness Project [planned]: The Eastside Np Effectiveness Project will determine if and to what extent the riparian prescriptions for eastside Ns streams (non-fish-bearing seasonally dry) maintain Performance Targets and water quality with a particular focus on effects in downstream typed waters. A literature review will inform a field study to examine the effect of riparian prescriptions on Ns streams on downstream Type Np and F Waters. Responses will include in-channel wood loading, channel stability, and downstream water quality (temperature, turbidity, and sediment) and quantity, stream channel stability and magnitude and frequency of scour. This

study complements the Hard Rock Study by evaluating Type N prescription effectiveness in eastern Washington.

Additional studies related to the Hard Rock Study include:

- Windthrow Frequency, Distribution, and Effects Project [planned]: Preliminary results of the BCIF Study indicated that windthrow mortality in westside Type N buffers was widespread. In response to this finding and supported by direction from TFW Policy, the intent of the Windthrow Frequency, Distribution, and Effects Project is to include a windthrow assessment in existing Type N riparian projects. While assessments of windthrow mortality were included in both the Hard and Soft Rock Studies, it was not in response to this Project *per se* but findings from these studies may inform this Project as it is scoped.

- ***Feasibility of obtaining more information to better inform Policy about resource effects.***

Opportunities exist to better inform Policy with data that have already been collected for the Hard Rock Study through eight years post-harvest (through 2016). The CMER budget for the current biennium includes funding for analyses of these data and report writing. Future and continued data collection is possible if interest exists. However, some reference sites have been or will be harvested for timber in the near future, making them unsuitable for use as references in the study. Opportunity may exist to establish new reference sites or to use nearby references from the Soft Rock study in lieu of harvested references for selected response variables, including stream temperature. This is a unique long-term data set evaluating applicable riparian buffer treatments in a BACI-designed study. Value exists in continued monitoring of treated sites for interpretation of the longer-term trajectory of change. To date, only one reference site has been harvested, one is currently being harvested, and two are expected to be harvested during calendar year 2019. Due to regulatory constraints, it is unlikely that the remaining two reference sites would ever be harvested.

- ***What are the costs associated with additional studies?***

Analysis and report development through eight years post-harvest are a part of the current CMER 2017-2019 biennium budget. Costs estimates associated with additional monitoring beyond eight years post-harvest are variable and dependent on which responses interest Policy. Budget placeholders exist in the CMER Master Schedule. We estimate that another round of sampling for riparian vegetation, wood recruitment and loading, and stream-associated amphibian demographics would be an additional \$897,000. Modifying the specific responses included, as well as the number and timing of future sampling events, affects the budget estimate.

- ***What will additional studies help us learn?***

Results from the extended study period through eight years post-harvest will provide additional information for understanding the effectiveness of the current Forest Practices rules and buffer alternatives. Additional long-term monitoring will provide a unique opportunity to evaluate the longer-term response of variables of interest to forest practices. Originally, the Hard Rock Study was proposed to cover an entire harvest rotation (i.e., 30 to 40 years in western Washington). Future monitoring would allow us to evaluate stand structure, tree mortality and associated responses in riparian buffers.

When will these additional studies be completed (i.e., when will we learn the information)?

CMER anticipates development and approval of reports from the extended period (through eight years post-harvest) during the current biennium (2017-2019) and beginning of the following biennium (2019-2021), with transmission to Policy estimated for the 2019-2021 biennium. Timing of dissemination of findings to Policy for any future sampling would depend on the number of responses for which Policy is interested in continuing to monitor and the timing of that effort. We highly encourage Policy to consider the benefits of continued or future monitoring throughout an entire harvest rotation.

• ***Will additional information from these other studies reduce uncertainty?***

Future monitoring beyond eight years post-harvest will reduce uncertainty associated with trajectories of potential changes in riparian stand conditions. Only longer-term study can provide guidance on the effectiveness of the current Forest Practices rules to meet Functional Objectives over the long-term.

6. **What is the scientific basis that underlies the rule, numeric target, Performance Target, or Resource Objective that the study informs? How much of an incremental gain in understanding do the study results represent?**

The management approach for westside Type N riparian prescriptions employs a patch-cut strategy, where a portion of the riparian stand in a Type N basin RMZ may be clearcut, providing that sensitive sites and at least 50% of the perennial stream length is buffered. CMER intended this study, along with BCIF and Soft Rock Studies, to evaluate the effectiveness of this strategy.

This study provides a substantial gain for riparian vegetation. While previous studies may have evaluated many of the metrics we included in this study as they relate to forestry practices, the Hard Rock Study provides results in context of the specific forest practices rules for riparian prescriptions required on Type N streams in western Washington.

The BACI study design provides a more precise estimate of the response to forest harvest. The inclusion of variable buffer treatments, both more restrictive and less restrictive than the current rules, was established to provide a response curve along a gradient of buffer length.

We expanded on the knowledge gained from other CMER studies, for example by supplementing the findings from the BCIF study by increasing the sample of riparian vegetation and wood recruitment clearcut, 50-ft buffer and PIP buffer RMZ reaches.

We are more confident in many of our findings because we were able to utilize new technology and sampling techniques that were not previously available, because of the duration and/or intensity of sampling, and because we were able to take advantage of more recent statistical methods.

Technical Implications and Recommendations:

Research/monitoring suggestions.

To better understand the scope of stand response to the various treatments, we highly encourage Policy to consider the benefits of extended monitoring of riparian stand conditions over time. This study covered only the first two years after harvest, which is not enough time to evaluate fully the duration of harvest effects and the long-term trajectory of response. To

understand completely the impacts of the treatments on the managed landscape one would have to monitor the response for a longer period. Substantial amounts of time and money have been invested in this study to date. Currently we have collected data through eight years post-harvest, and a report outlining those findings is in development. Data collection at existing study sites over a longer time will reduce scientific uncertainty about the duration of disturbance and the progress of recovery in Type N riparian buffers and clearcuts. Considering the amount of time and money that would be required to re-initiate a similar study from the beginning, the best opportunity for evaluating long-term recovery is with continued monitoring in the existing study. Additional data collection may be especially important for evaluating long-term mortality rates due to the continued effects of windthrow and other tree mortality processes in riparian buffers, and the effects of natural regeneration and stand development in stands impacted by disturbance. Continued study for this and other related studies (see **What is the relationship between this study and any others that may be planned, underway, or recently completed?**) would result in a more confident assessment of prescription effectiveness as we monitor response to treatments over time.

Suggested changes to rules/board manual.

A review and evaluation of the Performance Targets for westside and eastside Type N streams, both in context of the results of these studies and other current scientific research, by CMER and the Timber, Fish and Wildlife (TFW) Policy Committee would be appropriate once the studies outlined under #5 are completed. They could propose changes to Performance Targets and/or new measures if appropriate. Currently, there are no Performance Targets specific to riparian condition for Type N Waters. Related Performance Targets for some metrics are tied to the objective of providing 50% of the riparian function available within 50 feet of the stream, which is more closely related to a compliance target than a Performance Target *per se*.

References

- McIntyre, A.P., M.P. Hayes and T. Quinn. 2009. *Type N Feasibility Study*. A report submitted to the Landscape and Wildlife Advisory Group, Amphibian Research Consortium, and the Cooperative Monitoring, Evaluation, and Research Committee. Washington Department of Natural Resources, Olympia. 48 pp.
- Schuett-Hames, D., A. Roorbach and R. Conrad. 2011. *Results of the Westside Type N Buffer Characteristics, Integrity and Function Study Final Report. Cooperative Monitoring Evaluation and Research Report, CMER 12-1201. Washington Department of Natural Resources, Olympia, WA.* 93 pp.