

# Wetland Research and Monitoring Strategy: Forest Practices and Wetlands

By:  
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WASHINGTON STATE DEPARTMENT OF  
**Natural Resources**  
PETER GOLDMARK - Commissioner of Public Lands

**December 2014**



**CMER #12-1203**

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## **Washington State Forest Practices Adaptive Management Program**

The Washington State Forest Practices Board (FPB) has established an Adaptive Management Program (AMP) by rule in accordance with the Forests & Fish Report (FFR) and subsequent legislation. The purpose of this program is to:

*Provide science-based recommendations and technical information to assist the FPB in determining if and when it is necessary or advisable to adjust rules and guidance for aquatic resources to achieve resource goals and objectives. The board may also use this program to adjust other rules and guidance. (Forest Practices Rules, WAC 222-12-045(1)).*

To provide the science needed to support adaptive management, the FPB established the Cooperative Monitoring, Evaluation and Research (CMER) committee as a participant in the program. The FPB empowered CMER to conduct research, effectiveness monitoring, and validation monitoring in accordance with WAC 222-12-045 and Board Manual Section 22.

### **Report Type and Disclaimer**

This technical report contains scientific information from research or monitoring studies that are designed to evaluate the effectiveness of the forest practices rules in achieving one or more of the Forest and Fish performance goals, resource objectives, and/or performance targets. The document was prepared for the Cooperative Monitoring, Evaluation and Research Committee (CMER) and was intended to inform and support the Forest Practices Adaptive Management program. The project is part of the Eastside Type F Riparian Effectiveness Program, and was conducted under the oversight of the Riparian Scientific Advisory Group (RSAG).

This document was reviewed by CMER and was assessed through the Adaptive Management Program's independent scientific peer review process. CMER has approved this document for distribution as an official CMER document. As a CMER document, CMER is in consensus on the scientific merit of the document. However, any conclusions, interpretations, or recommendations contained within this document are those of the authors and may not reflect the views of all CMER members.

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## **Full Reference**

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*December 2014*

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*Prepared for:*

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*December 2014*

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## 1.0 Introduction

The Washington Administration Code wetland rules (WAC 222) are intended, in summary, to achieve no net loss of wetland functions by avoiding, minimizing, or preventing sediment delivery and hydrologic disruption from roads, timber harvest, and timber yarding; and by providing wetland buffers (wetland management zones, or WMZs). The application of WAC 222 rules is assumed to achieve and protect aquatic conditions and processes that meet functional objectives and consequently achieve the four performance goals of the Forest Practices Habitat Conservation Plan. The four goals are:

1. Comply with the federal Endangered Species Act for aquatic and riparian-dependent species on state and private forestlands.
2. Restore and maintain riparian habitat to support a harvestable supply of fish.
3. Meet the requirements of the Clean Water Act for water quality.
4. Keep the Washington timber industry economically viable.

The key questions driving effectiveness research and monitoring in the adaptive management program can be summarized as:

*Will the rules produce forest conditions and processes that achieve resource (functional) objectives as measured by the performance targets, while taking into account the natural spatial and temporal variability inherent in forest ecosystems?*

Collectively, the studies included in this Wetland Research and Monitoring Strategy are intended to answer this question as it relates to wetlands and wetland functions. At a project scale, effectiveness research and monitoring tests whether forest practices are successful at meeting certain Resource Objectives. Those are measured by Performance Targets. Resource Objectives and Performance Targets taken together highlight the primary wetland functions of interest in the Forest Practices Habitat Conservation Plan (FPHCP, Schedule L-1). The research strategy described herein accounts for Resource Objectives and Performance Targets while recognizing that not all Performance Targets listed in the FPHCP are fully developed. This research strategy includes



recommendations for some new wetland performance targets that will better inform the degree to which Resource Objectives outlined in the FPHCP are being met.

CMER's systematic review of literature on effects of forest practices on wetlands of the Pacific Northwest identified several key data gaps. To begin with, although many research projects have examined effects of forest practices on streams, none have examined effects of forest practices targeted specifically on wetlands. In some cases extrapolations of specific findings from studies of the effectiveness of forest practices rules in protecting streams are fraught with many interpretive difficulties. Past investigations of streams and forest practices have used a wide variety of sampling and analytical methods. Most studies have been of short duration, with some studies only evaluating post-harvest conditions. Even when pre- and post-harvest conditions have been compared, between-year differences in the amount and timing of precipitation and temperatures between years has sometimes confounded inferences one might make from the data. This interpretive problem is especially acute if unharvested reference (control) sites were not part of the study. Likewise, even when harvested vs. non-harvested landscapes are compared; differences in soils, topography, vegetation, specific harvest practices and their configuration, and other factors can limit inferences that might otherwise be made. Moreover, many studies have occurred in landscapes that were harvested previously, and for which the precise histories of harvest may be ambiguous or unknown, which limits effective comparisons between current and historical distributions of plants, amphibians, and other organisms. Too often, biological studies have considered only the presence or absence of a species, rather than analyzing its degree of dependence on wetlands and upland buffers. Few studies have measured the reproductive success and long-term sustainability of populations of species, rather than frequency of capture/detection, abundance, or density.

Studies with pre- and post-treatment data may also be affected by time lags. Effects on groundwater quantity and quality may occur distantly in space and time. Similarly, the longevity of selected wetland species may result in treatment effects not being manifest for several years following harvest. Few attempts have been made to measure the adaptability and resilience of individual members of a species to potentially harmful impacts of timber harvest. Also, some forest practice rules in the PNW have improved over the last two decades, and information about responses to current management rules is very limited.

## **1.1 Problem Statement**

CMER needs a logical framework (Wetland Research and Monitoring Strategy) that prioritizes and organizes wetland research projects. TFW Policy directed CMER to prioritize wetland research based on the highest risk to wetlands and wetland functions that relate to meeting Clean Water Act Assurance targets. Currently the CMER Work Plan lists multiple wetland research projects but these projects are not organized into a strategy for implementation. There is a need to examine the current wetland research objectives and critical questions to determine if there are more efficient ways to combine and organize them into discrete research projects than what is currently presented in the CMER Work Plan.

## **1.2 Purpose of the Wetland Research and Monitoring Strategy**

The purpose of the Wetland Research and Monitoring Strategy is to provide a logical framework for conducting research and monitoring on the effectiveness of forest practices rules at protecting wetlands and wetland functions. One of the primary goals of the research strategy is to identify where efficiencies can be found in the current Wetlands Protection Rule Group section of the CMER Work Plan by combining or revising research projects. For example, the current work plan suggests stand-alone research studies to examine downstream temperature effects, hydrological connectivity, buffer effectiveness, and post-harvest changes to forested wetlands. A revised strategy might examine downstream temperature effects and connectivity as part of evaluating the effects to forested wetlands directly.

The research strategy incorporates and reflects TFW policy directives, CMER Adaptive Management Performance Targets, different levels of protection provided to wetlands in the Forest Practice rules, and existing scientific knowledge. The Wetlands Research and Monitoring Strategy will do the following (at a minimum):

- Identify a research strategy that efficiently and appropriately combines the research objectives of all of the wetland studies into discrete studies to accelerate their implementation.
- Recommend a prioritized list of projects based on satisfying the research objectives of the identified Clean Water Act Assurance priority projects (see below).
- Illustrate in a flow chart the relationship of the research projects to each other and to the goals of the adaptive management program.

The Wetlands Research and Monitoring Strategy will evaluate, revise, add/replace, and prioritize projects listed in the CMER Work Plan. Research projects will consider priority application of Testable Hypotheses from the Wetlands Systematic Literature Review. An explanation will be provided describing the rationale for how these projects are timed and the prioritized list of hypotheses they will address. The research strategy will illustrate in a flowchart how outcomes from the studies will be used in the Forest Practices Adaptive Management Program, either by testing the effectiveness of the forest practice rules at meeting Resource Objectives and Performance Targets and protecting wetland functions and/or by informing scoping and designing follow-up projects.

The Wetland Research and Monitoring Strategy will include a description of projects and justification of the prioritization for each project. It will ultimately provide a newly revised WetSAG timeline to guide individual project implementation.

## 2.0 Critical Research Questions

In concept, the proposed projects will address three main questions:

1. To what degree do specific forest practices (see list below)<sup>2</sup> in or near wetlands affect the magnitude, duration, frequency, and timing of water quantity and quality (including temperature):
  - a) in the wetland,
  - b) in Typed Waters located up- or down-gradient (upslope, upstream, downslope, or downstream), and
  - c) in the surface and groundwater connections between the two, if any.
2. To what degree are plants and animals in the wetland and in Typed Waters near the wetland (downgradient or upgradient) affected by the listed forest practices.
3. To what degree are the effects (#1) and responses (#2) influenced by:
  - a) harvest type & configuration (cut area, remaining tree density & pattern, timing of harvest)

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<sup>2</sup> The "specific forest practices" are timber harvest, road construction, and application of silvicultural chemicals (fertilizers, pesticides)

- b) wetland type & configuration (e.g., size, position in the landscape, HGM type, vegetation type)
- c) connectivity between (a) and (b) as defined by:
  - separation distance, if any
  - water table depth (local groundwater)
  - soil runoff coefficient
  - presence of channels connecting harvest area with downslope wetland
  - frequency, duration, magnitude, seasonality of runoff, or flow in connecting channels and local groundwater paths
  - characteristics of the WMZ (if a Type A, B, or bog wetland)
- d) landscape context, as defined by:
  - climate and region
  - underlying geology
  - position in watershed (elevation, distance from divide)
  - ratio of wetland size to size of wetland's contributing basin/sub-basin area.

Most of the functions that wetlands normally provide and which are to be protected from unmitigated adverse effects of forest practices can be categorized as:

*Hydrologic Maintenance functions:* Maintain stream flow and channel forms; flood peak reduction and attenuation; groundwater recharge and discharge.

*Water Quality Maintenance functions:* Maintenance of natural regimes of water temperature, dissolved oxygen, and pH; retention of suspended sediment; substrate stabilization; nutrient retention or removal; detoxification of contaminants.

*Habitat Maintenance functions:* provision of food, cover, movement corridors, and special features necessary to sustain populations of fish, amphibians, vegetation, and other biological components and processes, e.g., primary productivity, carbon export, microclimate maintenance.

### **3.0 Wetland Research and Monitoring Strategy**

Under the Wetlands Protection Rule Group the existing CMER Work Plan identifies several research programs and projects that address wetlands. They are:

*Forested Wetland Effectiveness Program:*

Project: Wetland/Stream Water Temperature Interactions

Project: Wetland Hydrologic Connectivity

*Wetland Management Zone Effectiveness Monitoring Program:*

Project: Wetland Management Zone Effectiveness Monitoring

*Wetlands Intensive Monitoring Program:*

Project: Wetlands Intensive Monitoring

*Wetlands Mitigation Program:*

Project: Wetlands Mitigation Effectiveness

TFW Policy and the Forest Practices Board (Board) consider the projects in the Forested Wetland Effectiveness and Wetland Management Zone Effectiveness programs as critical for attaining Clean Water Act Assurance targets. The Assurances were described by Washington Department of Ecology (1999 and 2009). The other wetland programs and projects were given a lower priority and are not discussed further in this document. Unless reprioritized, the latter programs will be addressed by Policy and the Board after completion of this proposed strategy.

Considerable waste of limited fiscal resources would occur, and critical interactions would remain poorly understood, if each program and project were to be conducted independently of the others, using different research sites, methods, and/or schedules. This strategy proposes three projects that integrate the first two of the above programs:

**A1. Effects of Timber Harvest That Occurs Within Forested Wetlands:**

Effects on forested wetland water regime, water quality, vegetation, fish and wildlife, and connectivity to downgradient and upgradient waters.

**A2. Effects of Timber Harvest That Occurs Outside of Wetlands:**

Effects on wetland water regime, water quality, vegetation, fish and wildlife, and connectivity to downgradient and upgradient waters.

### **B. Effects of Forest Roads Near Wetlands:**

Effects of roads located upgradient and downgradient of wetlands on wetland water regime, water quality, vegetation, fish and wildlife, and connectivity to downgradient and upgradient waters.

An additional and separate project considered of lower immediate priority is:

### **C. Effects of Applying Silvicultural Chemicals In or Near Wetlands**

Project proposed to not proceed further at present time:

Wetland Mitigation Effectiveness Project

## **4.0 Project Prioritization and Integration**

Based on TFW Policy's prioritization process, it is proposed that the Wetlands Mitigation Effectiveness Project not proceed further at the present time. It is most closely related to Project B above, but was originally envisioned primarily as a survey rather than an experimental research study.

It is proposed that specific projects and their objectives related to the Wetlands Intensive Monitoring program be deferred until A1 and A2 are completed. It is expected that the knowledge gained in conducting these studies will be crucial to identifying any gaps in the science which need to be filled with intensive or cumulative effects level research.

The project selection and priorities described herein have been informed by best available science as reflected in the CMER Wetlands Systematic Literature Review completed in 2013. Also, the design of the projects described below may be informed by data being collected (e.g. headwater wetlands) for the Type N Riparian Prescriptions Rule Group.

Integration of the projects is proposed as follows:

- The existing project "Wetland/Stream Water Temperature Interactions" will be covered under the broader topic of "water quality effects" by all three newly proposed projects (A1, A2, and B). To the extent possible, they will examine

separately the changes in temperature and selected other water quality parameters associated with timber harvest within forested wetlands (section 3.2.1.1 of the Wetland Literature Synthesis), harvest upgradient from the WMZ's of non-forested wetlands (section 3.2.1.3 of the Wetland Literature Synthesis), and from forest roads near wetlands (section 3.2.1.2 of the Wetland Literature Synthesis).

- The existing project "Wetland Hydrologic Connectivity" will be covered under the broader topic of "hydrologic effects" by all three newly proposed projects (A1, A2, and B). To the extent possible, they will examine separately the changes in connectivity between wetlands and downgradient and upgradient waters as related to timber harvest within forested wetlands (section 3.1.1 of the Wetland Literature Synthesis), harvest upgradient from the WMZ's of non-forested wetlands (section 3.1.3 of the Wetland Literature Synthesis), and from forest roads near wetlands (section 3.1.2 of the Wetland Literature Synthesis). Changes in connectivity are especially important to fish passage, water quality, and mobility of silvicultural chemicals. Design of this project may be informed by data being collected for the Type N Riparian Prescriptions Rule Group.
- The existing project "Wetland Management Zone Effectiveness Monitoring" will be incorporated into *all* proposed projects except A1. It does not apply to project A1 because that project addresses only the timber harvests occurring within forested wetlands, as they are not required to be buffered in the Forest Practices Rules. It will address the degree to which WMZs lessen the impacts of upslope forest practices to functions of FPA Type A, B, and Bog wetlands.

The interrelationships among the proposed projects are shown in Figure 1. It is proposed that project A1 (Effects of Timber Harvest That Occurs Within Forested Wetlands) would be initiated first to isolate effects of wetland harvest from effects of upland harvesting. As data from that project begin to become available, the data would inform the design of projects A2 and B, to the degree that effects from forest roads and harvest outside of wetlands might resemble effects from harvest within wetlands. The Wetlands Intensive Monitoring Program would build on findings from earlier priority projects and their results. The Wetland Intensive Monitoring Program could seek to assess cumulative impacts of forest practices on wetlands at broader scales as well as address specific questions more quantitatively: such as what are the effects of silvicultural chemicals in or near wetlands on in wetlands and downstream functions.

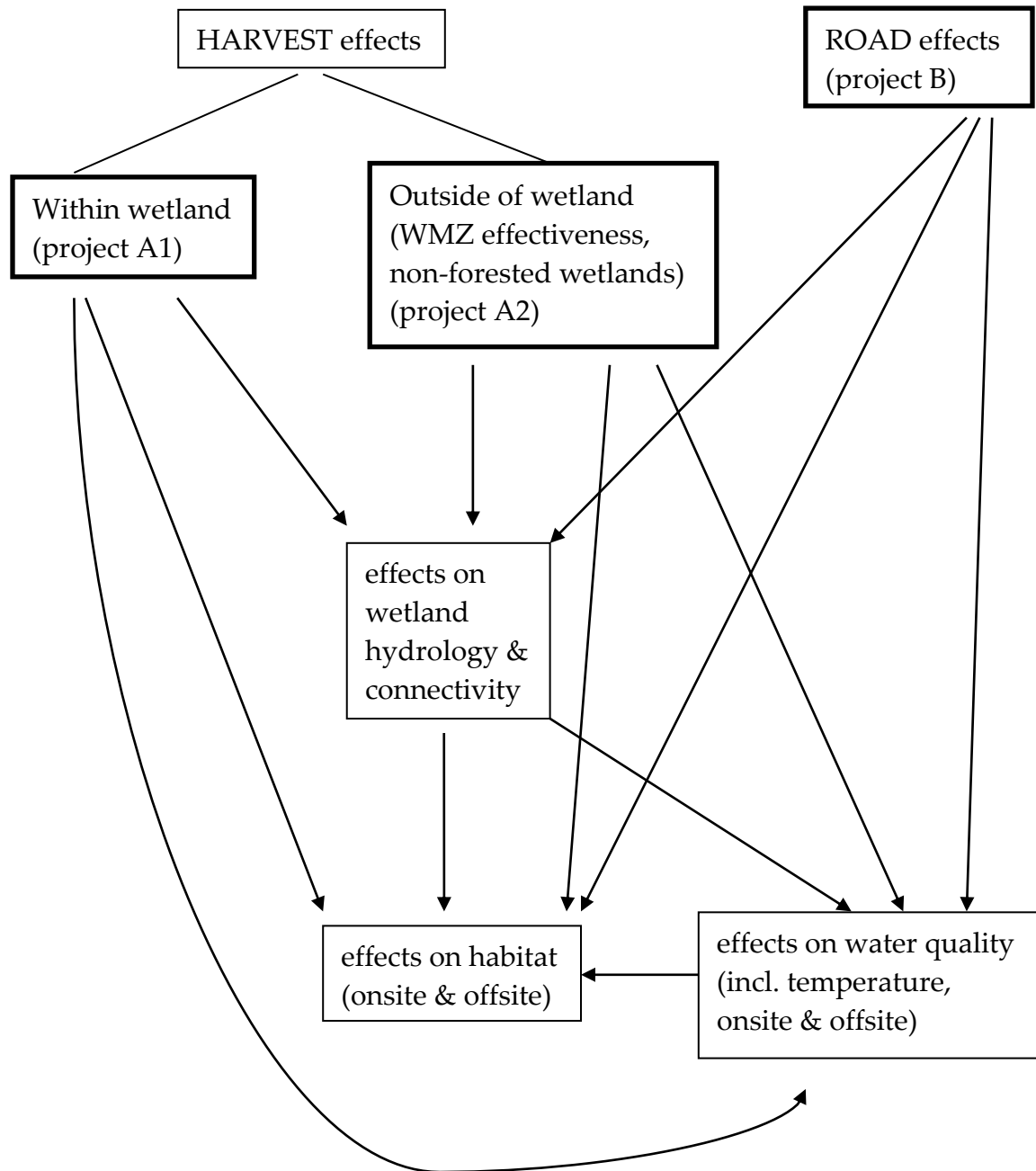


Figure 1. Interrelationships of the proposed projects (in darker boxes)

## 5.0 Research Design

This section does not present a detailed research design, but rather describes process and principles that will apply to the future development of such a design.



The proposed research and monitoring will focus initially on *forested* wetlands because these receive less protection under the current FPA and the TFW Policy has prioritized this project. Among forested wetlands, the proposed research and monitoring may focus on those belonging to the slope, flat, and depression hydrogeomorphic (HGM) classes. These wetland types are suspected of being more sensitive to impacts from forest practices than are riverine wetlands, and many or most riverine wetlands receive some protection under current FPA Riparian Rules.

An essential first step is to conduct a desktop characterization of functionally relevant attributes (e.g., number, size, distribution) of each mapped wetland within the study area. This will provide context to create a sample frame for stratifying and selecting research sites in a statistically sound manner. It also provides a coarse initial characterization of wetland exposure to forest practices across the entire study area, and locations of wetlands that may be most impacted by forest practices. Such an initial characterization was completed to address the latter objective and to inform the development of this Wetland Strategy. Results are summarized in Appendix C.

Different types of wetlands, in different landscape settings, are anticipated to respond differently for forest practices. Therefore, the final selection of research and monitoring sites should identify and consider differences in the likely sensitivity of various types of wetlands to forest practices, as well as the likelihood and extent of offsite impacts. By "sensitivity", we mean the intrinsic resilience and resistance capacity of particular wetland types, i.e., their capacity to remain unaltered when exposed to some kinds of stresses, and if impacted, the speed and completeness with which they recover. Factors that may influence this include the following:

- Likely degree of groundwater vs. surface runoff influence on each wetland's water levels;
- Hydrologic connectivity (outflow volume, variance, duration, and peaks, by season), especially to fish-bearing streams, as potentially influenced by climate, slope, soils, geology, and position in watershed;
- Wetland type (HGM and/or Forest Practices Act type, vegetation community)
- Climate, specifically: local runoff regime<sup>3</sup> and growing degree-days<sup>4</sup>;

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<sup>3</sup>Throughout Oregon, scientists from the USEPA have defined and mapped 5660 "hydrologic landscape units" with an average size of 44 km<sup>2</sup>, useful for predicting hydrologic behavior. The units were defined using cluster analysis of data on flow seasonality, snowmelt contribution, climate, aquifer permeability, terrain, and soil type (Wigington et al. 2013). An effort in Washington with somewhat similar objectives

- Wetland size;
- Size of the wetland's catchment (and ratio of that to wetland size);
- Disturbance history (management and natural).

Where feasible and appropriate, the research projects addressing different hypotheses should be implemented on the same research sites. This is because the effects of timber harvest on water quality (e.g., temperature) and on habitat functions are intricately related to effects on wetland water regimes. Using the same sites to test multiple priority hypotheses will help ensure the research is cost-effective.

The proposed research should consider using a, manipulative experimental approach to facilitate examining causal relationships between forest management and changes to wetlands functions. The literature synthesis shows that this type of literature is extremely limited in the Pacific Northwest.

## 6.0 Literature Cited

Reidy Liermann, C. A., J. D. Olden, T. J. Beechie, M. J. Kennard, P. B. Skidmore, C. P. Konrad, and H. Imaki, H. 2012. Hydrogeomorphic classification of Washington State rivers to support emerging environmental flow management strategies. *River Research and Applications* 28(9): 1340-1358.

Washington Department of Ecology. 1999. *Forests and Fish Report*. Washington Department of Ecology, Olympia, WA.

Washington Department of Ecology. 2009. *2009 Clean Water Act Assurances Review of Washington's Forest Practices Program*. Washington Department of Ecology, Olympia, WA.

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but different methods (Reidy Liermann et al. 2012) has classified all streams and rivers in that state. A map of such landscape units (or a simpler aggregation of them) could be a particularly relevant stratifier when applied to selection of research sites intended to span regional hydrologic gradients. This would improve significantly on classifying sites geographically as merely "eastside" or "westside".

<sup>4</sup> <http://pnwpest.org/wea/index.html>

Wigington, P.J. Jr., S.G. Leibowitz, R.L.Comeleo, and J.L. Ebersole. 2013. Oregon hydrologic landscapes: a classification. JAWRA Journal of the American Water Resources Association 49(1):163-182.

## Appendix A. Description of the Proposed Projects

Project A1. Effects of Timber Harvest *Within* Forested Wetlands, Critical Question A1.1: *To what degree does timber harvest in forested wetlands alter water regimes in those wetlands, in downgradient waters, and the connectivity between them?*

Potential Hypotheses:

- a) Timber removal in a wetland increases the water level depth, spatial extent of inundation, seasonal persistence (duration), and/or through flow persistence of surface water, and/or alters the seasonal timing of inundation.
- b) In doing so, it increases the connectivity of some wetlands with down gradient waters during specific times and at different frequencies and durations.

Research Objectives : To quantify the hydrologic effects in and downgradient of forested wetlands, of timber harvest occurring within the wetlands. This should be done in a manner that isolates or minimizes any hydrologic effects resulting from associated upland timber harvest and roads, and from unrelated confounding factors that simultaneously affect water regime in and downgradient from forested wetlands.

Key Covariates:

- a) groundwater (water table level and seasonality)
- b) harvest type & configuration (cut area, remaining tree density & pattern, timing of harvest)
- c) wetland type & configuration (area, HGM type, vegetation type)
- d) soil type, surficial geology, watershed position
- e) ratio of wetland size to size of wetland's contributing area
- f) distance to downslope waters and type of connectivity
- g) the pre-harvest duration, frequency, magnitude, and seasonal pattern of connection.

Linkage to Current CMER Work Plan: This project elaborates on the following question in the current CMER work plan:

*Does timber harvest in forested wetlands alter hydrology sufficiently to affect wetland functions?*

Wetland Functions Addressed: Water Storage, Streamflow Maintenance. See Appendix B for a list of specific metrics that could be used to represent or measure these functions.

Existing Performance Target(s): (a) No net loss in the hydrologic functions of wetlands, (b) West side: Do not cause a significant increase in peak flow recurrence intervals resulting in scour that disturbs stream channel substrates providing actual or potential habitat or potential habitat for salmonids, attributable to forest management activities.

Suggested Performance Target(s): Return to pre-harvest levels of these functions.

Focal Wetland Types: Forested wetlands on slopes or in depressions, with and without offsite hydrologic connections. Initial emphasis should be on forested wetlands with at least intermittent connection to fish-bearing streams (e.g. Type F), or have potential for such connection (e.g. Type N).

Rationale & Outcomes: Trees are the defining component of forested wetlands, so their harvesting them has direct effects on wetland structure and function. The specific types of effects, their duration, and mitigating factors are poorly understood. Especially in headwater locations in western Washington, timber harvest occurs commonly in forested wetlands in both headwater and lowland valley locations in western Washington. As a result of potential post-harvest rising of local water tables, regeneration success and tree growth rates may be less than on non-wetland sites, but data are sparse. Also, little is known about the effects of harvest on connectivity among wetlands. Such connectivity has the potential to profoundly affect water quality as well as salmonid populations. Post-harvest changes in connectivity can limit or extend the accessible habitat space and available food resources during salmonid rearing phases. The proposed research would clearly attribute post-harvest changes in water tables, wetland connectivity, downgradient flows, and salmonid rearing habitat to timber harvest within wetlands.

Project A1. Effects of Timber Harvest Within Forested Wetlands, Critical Question A1.2, *To what degree does timber harvest in forested wetlands alter water quality in those wetlands and in downgradient waters?*

Potential Hypotheses:

Timber removal in a wetland:

- increases water temperature\* in those wetlands and in downgradient waters
- decreases dissolved oxygen\* in those wetlands and in downgradient waters
- causes the wetland to shift from being a net retainer to a net exporter of suspended sediment

- increases phosphorus levels within the harvested wetland and causes the wetland to shift from being a net retainer to a net exporter of phosphorus
  - increases dissolved nitrogen levels within the harvested wetland and causes the wetland to shift from being a net remover to a net exporter of dissolved and particulate nitrogen
  - causes the wetland to shift from being a net source to a net sink for dissolved and particulate carbon (including large woody debris)
  - alters the level and stability of pH in those wetlands and downgradient waters.
- \* = see Appendix B for list of specific parameters that would be monitored

Research Objectives: To separate the effects on water quality in and downgradient of forested wetlands, specifically of timber harvest within the wetlands, from water quality effects resulting from associated road construction and operation, and from unrelated confounding factors that simultaneously affect water quality in and downgradient from forested wetlands.

Key Covariates:

- a) harvest type & configuration (cut area, remaining tree density & pattern, timing of harvest)
- b) wetland type & configuration (size, position in the landscape, HGM type, vegetation type)
- c) groundwater level and chemistry, soil type, surficial geology, watershed position
- d) distance to downslope waters
- e) the pre-harvest duration, frequency, magnitude, and seasonal pattern of connection.

Linkage to Current CMER Work Plan: In part, this project elaborates on the following specific question in the current CMER work plan:

*Does timber harvest in forested wetlands affect water temperature sufficiently to negatively affect stream temperatures in connected streams?*

Wetland Functions Addressed: Thermoregulation, Water Quality Maintenance.

Existing Performance Target(s): For connected waters: State water quality standards—current and anticipated in next triennial review. Provide complex and productive instream and wetland habitat by recruiting large woody debris and litter.

Suggested Performance Target(s): For the wetland: anti-degradation. No net loss of the above functions. Return to pre-harvest levels of these functions.

Focal Wetland Types: Forested wetlands on slopes or in depressions, with and without offsite hydrologic connections.

Rationale & Outcomes: Trees are the defining component of forested wetlands, so harvesting them can directly affect wetland structure and function. Little is known regarding effects of harvesting forested wetlands on water temperature and other water quality parameters, the duration and downgradient extent of such effects, and mitigating factors. In headwater and lowland valley locations in western Washington, timber harvest occurs commonly in forested wetlands and temporarily removes shade, thus allowing slow-moving water to be heated rapidly. The proposed research would clearly attribute post-harvest changes in water temperature and other parameters to harvest of trees within wetlands.

Project A1. Effects of Timber Harvest Within Forested Wetlands, Critical Question A1.3, *To what degree does timber harvest in forested wetlands alter habitat functions in wetlands, in connected waters, and in surrounding uplands?*

Potential Hypotheses: Timber removal in a wetland results in reduced growth and survival of re-established trees, as well as decreases\* in native plants, aquatic invertebrates, fish, amphibians, waterbirds, and/or songbirds in the wetland, connected waters, and/or in surrounding uplands.

\* = see Appendix B for list of specific parameters that would be monitored

Research Objectives: To separate the effects on habitat in and downgradient of forested wetlands, specifically of timber harvest in the wetlands, from effects on habitat resulting from associated road construction and operation, and from unrelated confounding factors that simultaneously affect habitat in and downgradient from forested wetlands.

Key Covariates: Species & life stage. Structure, age, & pattern of pre-harvest timber. Survival and growth of regenerating trees.

Linkage to Current CMER Work Plan: In addition to the critical question noted above, this project will address the following questions in the current CMER work plan:

*Are forested wetlands regenerating sufficiently to maintain wetland functions?*

*How does the post-harvest stand composition compare to pre-harvest condition?*

Wetland Functions Addressed: Habitat Functions

Existing Performance Target(s): For connected waters, the Habitat Conservation Plan (HCP) performance targets (pool frequency, etc.) for those waters may be applicable.

Suggested Performance Target(s): No net loss of native species diversity. No loss of state-listed Sensitive species or communities. No net loss of habitat functions. Return to pre-harvest levels of these functions.

Focal Wetland Types: Forested wetlands on slopes or in depressions, with and without offsite hydrologic connections.

Rationale & Outcomes: Especially in headwater locations in western Washington, timber harvest occurs commonly in forested wetlands. Trees are the defining component of forested wetlands, so their harvest can directly affect wetland structure and habitat function. Little is known regarding long term effects of harvesting forested wetlands on the vegetation composition, amphibians, birds, and mammals that use these wetlands. These resources can be affected by changes in wetland hydrology and water quality described above. The proposed research would clearly attribute post-harvest changes in vegetation and wildlife use of previously-forested wetlands to the hydrologic, water quality, and/or structural changes wrought by the harvest of trees within the wetlands.

A2. Effects of Timber Harvest Upslope From Wetlands, Critical Question A2.1, *To what degree does timber harvest upslope from wetlands alter the water regime of these wetlands?*

Potential Hypotheses: Timber removal upslope from a wetland increases the water level, depth, spatial extent of inundation, seasonal persistence, and/or throughflow persistence of surface water, and/or alters the seasonal timing of inundation.

Research Objectives: To separate the hydrologic effects in wetlands, specifically of timber harvest located upslope, from hydrologic effects resulting from associated road construction and operation, and from unrelated confounding factors that simultaneously affect water regime in forested wetlands.



Key Covariates: Harvest proximity, type, & configuration (cut area, remaining tree density & pattern, timing of harvest). Structure, age, & pattern of pre-harvest timber. WMZ width and configuration (for FPA wetland types A, B, and bogs). Soil runoff coefficient and partitioning of water sources as groundwater vs. surface flow. Presence of channels connecting harvest area with downslope wetland. Frequency, duration, magnitude, seasonality of runoff and flow in connecting channels. Climate, position in watershed (elevation), ratio of wetland size to size of wetland's contributing area.

Linkage to Current CMER Work Plan: This does not link explicitly with the Wetlands Protection Rules component of the current Work Plan. However, it has some characteristics in common with the Type N Riparian Effectiveness Program under the Type N Riparian Prescriptions Rule Group.

Wetland Functions Addressed: Wetland Hydroperiod Maintenance, Water Storage

Existing Performance Target(s): (a) No net loss in the hydrologic functions of wetlands, (b) West side: Do not cause a significant increase in peak flow recurrence intervals resulting in scour that disturbs stream channel substrates providing actual or potential habitat or potential habitat for salmonids, attributable to forest management activities.

Suggested Performance Target(s): No net loss of this function. Return to pre-harvest hydroperiod. Do not cause a significant increase in peak flow recurrence intervals of downgradient streams such that scour disturbs stream channel substrates providing actual or potential habitat for salmonids.

Focal Wetland Types: Wetlands on slopes or in depressions. Emphasis on wetlands in watersheds with high potential for water table rise following timber harvest.

Rationale & Outcomes: This requires a watershed-scale approach because wetlands are not alone in being affected by the upland processes that would be investigated by this project.

A2. Effects of Timber Harvest Upslope From Wetlands, Critical Question A2.2, *To what degree does timber harvest upslope from forested wetlands alter the water quality of these wetlands?*

Potential Hypotheses:

Timber removal upslope from a wetland

- decreases dissolved oxygen\* in those wetlands
- increases water temperature\* in those wetlands
- causes the wetland to shift from being a net retainer to a net exporter of suspended sediment
- increases phosphorus levels within the harvested wetland and causes the wetland to shift from being a net retainer to a net exporter of phosphorus
- increases dissolved nitrogen levels within the harvested wetland and causes the wetland to shift from being a net remover to a net exporter of dissolved and particulate nitrogen
- causes the wetland to shift from being a net source to a net sink for dissolved and particulate carbon

\* = see Appendix B for list of specific parameters that could be monitored

Research Objectives: To separate the water quality effects in forested wetlands, specifically of timber harvest located upslope, from water quality effects resulting from associated road construction and operation, and from unrelated confounding factors that simultaneously affect water quality in forested wetlands.

Key Covariates: Harvest proximity, type, & configuration (cut area, remaining tree density & pattern, timing of harvest). Structure, age, & pattern of pre-harvest timber. WMZ width and configuration (for FPA wetland types A, B, and bogs). Soil runoff coefficient and partitioning of water sources as groundwater vs. surface flow. Presence of channels connecting harvest area with downslope wetland. Frequency, duration, magnitude, seasonality of runoff and flow in connecting channels. Climate, position in watershed (elevation), ratio of wetland size to size of wetland's contributing area.

Linkage to Current CMER Work plan: This does not link explicitly with the Wetlands Protection Rules component of the current Work Plan. However, it has some characteristics in common with the Type N Riparian Effectiveness Program under the Type N Riparian Prescriptions Rule Group.

Wetland Functions Addressed: Water Quality (both within wetland and downstream)

Existing Performance Target(s): For connected waters: State water quality standards—current and anticipated in next triennial review. Provide complex and productive instream and wetland habitat by recruiting large woody debris and litter.

Suggested Performance Target(s): For the wetland: anti-degradation. No net loss of water quality functions. Return to pre-harvest levels of temperature and water quality. One specific objective is to provide cool water by maintaining shade, groundwater temperature, flow, and other watershed processes controlling stream temperature. Another is to provide complex and productive instream and wetland habitat by recruiting large woody debris and litter.

Focal Wetland Types: Wetlands on slopes or in depressions. Emphasis on wetlands in watersheds with high potential for water table rise following timber harvest.

Rationale & Outcomes: This requires a watershed-scale approach because wetlands are not alone in being affected by the upland processes that would be investigated by this project.

A2. Effects of Timber Harvest Upslope From Wetlands, Critical Question A2.3, *To what degree does timber harvest upslope from forested wetlands alter the habitat functions of these wetlands?*

Potential Hypotheses: Harvesting of upslope timber results in decreases\* in native plants, aquatic invertebrates, fish, amphibians, waterbirds, and/or songbirds in wetlands.

\* = see Appendix B for list of specific parameters that would be monitored

Research Objectives: To separate the effects on habitat in forested wetlands, specifically of timber harvest located upslope, from effects on habitat resulting from associated road construction and operation, and from unrelated confounding factors that simultaneously affect habitat in forested wetlands.

Key Covariates: Harvest proximity, type, & configuration (cut area, remaining tree density & pattern, timing of harvest). Structure, age, & pattern of pre-harvest timber. WMZ width and configuration (for FPA wetland types A, B, and bogs). Soil runoff coefficient and partitioning of water sources as groundwater vs. surface flow. Presence of channels connecting harvest area with downslope wetland. Frequency, duration, magnitude, seasonality of runoff and flow in connecting channels. Species & life stage. Survival, growth, and composition of regenerating vegetation.

Linkage to Current CMER Work plan: This does not link explicitly with the Wetlands Protection Rules component of the current Work Plan. However, it has some

characteristics in common with the Type N Amphibian Response Program (Effectiveness) under the Type N Riparian Prescriptions Rule Group.

Wetland Functions Addressed: Habitat Functions

Existing Performance Target(s): For connected waters, the Habitat Conservation Plan (HCP) performance targets (pool frequency, etc.) for those waters may be applicable.

Suggested Performance Target(s): No net loss of native species diversity. No loss of state-listed Sensitive species or communities. No net loss of habitat functions. Return to pre-harvest levels of these functions.

Focal Wetland Types: Wetlands on slopes or in depressions. Emphasis on wetlands in watersheds with high potential for water table rise following timber harvest.

Rationale & Outcomes: This requires a watershed-scale approach because wetlands are not alone in being affected by the upland processes that would be investigated by this project.

**B. Effects of Forest Roads Near Wetlands, Critical Question B, *To what degree does forest road construction and operation near wetlands alter the water regime, water quality, and habitat functions of the wetlands?***

Potential Hypotheses:

1. Forest roads upslope from a wetland:

- decrease the water level, depth, spatial extent of inundation, seasonal persistence, and/or throughflow persistence of surface water, and/or alters the seasonal timing of inundation.
- increase water temperature\* in those wetlands
- decrease dissolved oxygen\* in those wetlands
- cause the wetland to shift from being a net retainer to a net exporter of suspended sediment
- increase phosphorus levels within the harvested wetland and causes the wetland to shift from being a net retainer to a net exporter of phosphorus
- increase dissolved nitrogen levels within the harvested wetland and causes the wetland to shift from being a net remover to a net exporter of dissolved and particulate nitrogen

- cause the wetland to shift from being a net source to a net sink for dissolved and particulate carbon

2. Forest roads downslope from a wetland decrease the water level, depth, spatial extent of inundation, seasonal persistence, and/or throughflow persistence of surface water, and/or alters the seasonal timing of inundation.

Research Objectives: To separate the effects on water regime, water quality, and habitat in wetlands, specifically from forest road construction and operation, from effects on these functions resulting from timber harvest in or upslope of the wetland, and from unrelated confounding factors that simultaneously affect these functions.

Key Covariates: Road proximity, age, configuration, type of surface, soil runoff coefficients. WMZ width and configuration (for FPA wetland types A, B, and bogs). Soil runoff coefficient and partitioning of water sources as groundwater vs. surface flow. Presence of ditches or channels connecting road with downslope wetland. Frequency, duration, magnitude, seasonality of runoff. Flow in connecting channels. Climate, position in watershed (elevation), ratio of wetland size to size of wetland's contributing area.

Linkage to Current CMER Work Plan: Relevant to Roads Rule Group as well as Wetlands Protection Rule Group.

Wetland Functions Addressed: Water Storage, Streamflow Maintenance, and Habitat

Existing Performance Target(s): For connected waters: water quality standards. The wetland WMZ and road prescriptions are also intended to accomplish the following stated FP HCP functional objectives under the Hydrology Resource Objective as stated in Schedule L-1:

*Maintain surface and groundwater hydrologic regimes (magnitude, frequency, timing, and routing of stream flows) by disconnecting road drainage from the stream network, preventing increases in peak flows causing scour, and maintaining hydrologic continuity of wetlands.*  
*Prevent increases in peak flows causing scour, and maintain hydrologic continuity of wetlands.*

Consideration should be given to adapting at least some of the performance targets from the Roads Rule Group if they apply to wetlands or connected waters that could be impacted by forest practices in wetlands, for example:

- Road sediment delivered to streams: New roads — Virtually none.

- Ratio of road length delivering to streams/total stream length (miles/mile): Old roads not to exceed — Coast (spruce zone), 0.15–0.25; west of crest, 0.15–0.25; east of crest, 0.08–0.12.
- Ratio of road sediment production delivered to streams/total stream length(tons/year/mile): Old roads not to exceed — Coast (spruce zone), 6–10 tons/yr; west of crest, 2–6 tons/yr; east of crest, 1–3 tons/yr.
- Fines in gravel: Less than 12% embedded fines (< 0.85 mm).
- Road runoff: Same targets as road-related sediment; significant reduction in delivery of water from roads to wetlands.

For connected waters, the Forest Practices Habitat Conservation Plan (HCP) performance targets (pool frequency, etc.) for those waters may be applicable.

Suggested Performance Target(s): For the wetland: anti-degradation. No net loss of native species diversity. No loss of state-listed Sensitive species or communities. No net loss of the above functions. Return to pre-harvest levels of these functions.

Focal Wetland Types: Wetlands on slopes or in depressions. Emphasis on wetlands in watersheds with high potential for water table rise following road construction.

Rationale & Outcomes: The results of this study would inform rule effectiveness at a site scale while contributing to the understanding of cumulative effects at the watershed scale.

C. Effects of Applying Silvicultural Chemicals, Critical Question C: *Do the pesticide rules protect water quality and native vegetation within forested wetlands?*

Potential Hypotheses: Chemical applications result in decreases\* in non-target native plants, aquatic invertebrates, fish, amphibians, waterbirds, and/or songbirds in the wetlands.

\* = see Appendix B for list of specific parameters that would be monitored

Research Objectives: To separate the effects on wetland plants and animals of applying silvicultural chemicals (a) within forested wetlands, (b) in nearby upland forests, and/or (c) along forest, from unrelated confounding factors that simultaneously affect plants and animals in forested wetlands.

Key Covariates: Species, life stages. Type and dose of the applied chemical. WMZ width & configuration. Soil runoff coefficient, presence of ditches or channels connecting application area with downslope wetland. Frequency, duration, magnitude, seasonality of runoff. Climate, position in watershed (elevation, distance to divide), ratio of wetland size to size of wetland's contributing area.

Linkage to Current CMER Work plan: Relevant to Pesticides Rule Group as well as Wetlands Protection Rule Group.

Wetland Functions Addressed: Water Quality, Habitat Functions

Existing Performance Target(s): Excluding fertilizer and Bt: (a) No chemical entry into surface waters for large droplets; minimized for small droplets (drift), (b) No significant harm to native vegetation in core and inner zone of WMZs.

Suggested Performance Target(s): Anti-degradation. No net loss of native species diversity. No loss of state-listed Sensitive species or communities.

Focal Wetland Types: Wetlands on slopes or in depressions, with and without offsite hydrologic connections.

Rationale & Outcomes: The results of this study would inform rule effectiveness at a site scale while contributing to the understanding of cumulative effects at the watershed scale.

## Appendix B. Potential Metrics and Parameters for Quantifying Forest Practice Effects on PNW Wetland Functions

Table 1. Potential metrics and parameters for quantifying forest practice effects on PNW wetland functions

This list is not intended to be comprehensive.

Major Indicator Variable	Most Relevant to Functions:	Spatial Context (where to measure)	Temporal Context (how to describe the condition)	Associated Parameters
Water volume & velocity	Water Storage	in-wetland (surface)	frequency, duration, seasonality, flow-through time	extent, water level, distribution pattern (patchiness)
	Low Flow Support Water Cooling Habitat	in-wetland (subsurface)	percent exceedence: frequency, duration, seasonality, rate of change	depth to saturation
		input (surface)		min, max flow volume (peak flow, low flow)
		output (surface & ET) downstream		
Water & Air Temperature	Water Cooling Fish Habitat Amphibian Habitat Aq. Invertebrate Habitat	input (surface)	percent exceedence: frequency, duration, seasonality, rate of change	daily min, max ( 7 day average max), seasonality
		in-wetland (surface)		
		in-wetland (subsurface)		
		output (surface)		
		downstream		
Dissolved Oxygen/ Redox	Phosphorus Retention	input (surface)	percent exceedence: frequency, duration, seasonality, rate of change	daily min, max --> seasonality
	Nitrate Removal	in-wetland (surface)		
		in-wetland (soil/ sediment)		
		output (surface)		
		downstream		
Suspended Solids and Toxins	Sediment Retention Fish Habitat Amphibian Habitat Aq. Invertebrate Habitat	input surface	percent exceedence: frequency, duration, seasonality	TSS, turbidity, algal-generated toxins, chytrid fungus, spawning gravel
		in-wetland		
		output surface		
		downstream		
Sediment / soil	Sediment Retention	in-buffer	deposition rate (short & long-term)	bulk density, penetrability/ percolation, particle size distribution, herbicides, metals, enzymes, CEC, Ca, extractable Fe, Al
		in-wetland		
Phosphorus	Phosphorus Retention	input (surface)	percent exceedence: frequency, duration, seasonality	TDS, TP, SRP concentrations, adsorption/ desorption rate
		in-wetland (surface)		
		in-wetland (soil/ sediment)		
		output (surface)		
		downstream		



<b>Major Indicator Variable</b>	<b>Most Relevant to Functions:</b>	<b>Spatial Context</b> (where to measure)	<b>Temporal Context</b> (how to describe the condition)	<b>Associated Parameters</b>
Nitrogen	Nitrate Removal	input (surface)	percent exceedence: frequency, duration, seasonality	TDS, TN, NO <sub>3</sub> , NH <sub>3</sub> concentrations, nitrification & denitrification rate, N fixation rate (esp. if alder)
		in-wetland (surface)		
		in-wetland (soil/ sediment)		
		output (surface)		
		downstream		
Carbon	Carbon Flux Nitrate Removal	input (surface)	frequency, duration, seasonality	LPOM, FPOM, DOC, DIN concentrations, rates of decomposition & peat accumulation
		in-wetland (surface)		
		in-wetland (soil/ sediment)		
		output (surface)		
		downstream		
Aquatic Invertebrates (nekton, neuston, aerial, benthic/ subsurface) (emphasizing ones most & least likely to be harmed by forest practices)	Habitat	in-wetland	by season	abundance/density, biomass, taxa & functional group richness, colonization rate, deformity rates
Fish (by species)	Habitat	in-wetland	by season	abundance/density, biomass, growth & survival rate, residence time, deformity rates
Amphibians & Turtles (by species & life stage, emphasizing ones most & least likely to be impacted by forest practices)	Habitat	in-wetland	by season	abundance/density, biomass, egg mass counts, growth & survival rate, dispersal distance & direction, deformity rates
		in buffer		
		in treatment areas		
Waterbirds (by guild, emphasizing ones most & least likely to be impacted by forest practices)	Habitat	in-wetland	monthly	abundance/density, species richness, nesting success, frequency-duration of use
Songbirds (by species, emphasizing wetland- dependent ones most & least likely to be impacted by forest practices)	Habitat	in-wetland	monthly	abundance/density, species richness, nesting success, frequency-duration of use
		in buffer	monthly	
		in treatment areas		

<b>Major Indicator Variable</b>	<b>Most Relevant to Functions:</b>	<b>Spatial Context</b> (where to measure)	<b>Temporal Context</b> (how to describe the condition)	<b>Associated Parameters</b>
Wetland Plants (by species, native/ exotic/ invasive, WIS status, annual/ perennial, vascular vs. non)	Habitat	in-wetland		percent cover, richness, germination rate, Floristic Quality score (Rocchio 2011)
Vegetation Structure	Habitat	in-wetland		age-height-diameter relationships & class diversity, basal area, canopy closure, ground cover (bare), growth rate (tree rings etc.), LWD & snags (#, decay stage, dimensions), patchiness of veg communities and water within wetland.
		in buffer		
		in treatment areas		
Qualitative Characterization of Functions	All	in-wetland		scores for hydrologic, water quality, and habitat functions using Washington's Rating System (Hruby 2004) or other function assessment methods (e.g., Adamus et al. 2011) in other states or provinces where appropriate

## **Appendix C. Results of a Preliminary GIS Intersect of Forest Practice Permits and Possible Wetlands Throughout Washington**

Using GIS (Geographic Information Systems), an intersect was performed using the polygon boundaries of FPA (Forest Practices Act) permit areas and mapped wetlands in most of western Washington. Given the severe limitations of the data, the purpose was only to provide a preliminary qualitative estimate of interrelationships between forest practices and wetlands in western Washington. This step is important for adding context to the recommendations of CMER's Wetland Strategy and for helping prioritize future research.

The task was performed by Evergreen College student Krystle Keese working under the direction of Greg Stewart of the WDNR and Dr. Paul Adamus. Metadata and a summary description of methods are available in a separate document. For wetlands, we used not only the FPWET and FPARS layers maintained by the WDNR (building upon previous wetland maps by the NWI), but also a modeled wetlands layer (WetWRIA) for western Washington. That modeled layer includes locations of wetlands larger than 1 acre that were not identified previously from aerial imagery by the NWI.

The GIS overlay identified 691,342 mapped wetland polygons in the western Washington region. It also determined that 11,279 mapped wetlands are present within an FPA or within 200 feet of an FPA boundary.

The following tables are presented without interpretation and summarize only part of the results. The database resulting from the intersect is available separately as an Excel spreadsheet that can be queried by anyone familiar with creating Excel pivot tables. It contains several data fields not shown in the compilations below. Also, any of the compilations below could be broken out more finely by county, watershed (WAU), and a host of other co-factors.

Table 2. Number of FPA permits within or near mapped wetlands of western Washington, and area of FPA and wetland involved, by wetland class

Wetland Class	# of FPAs in Wetland	# of FPAs within 200 ft of Wetland	Acres of Wetland in FPAs	Acres of Wetland within 200 ft of FPA
Estuarine Emergent Wetland	104	295	95.95	260.23
Estuarine Forested Wetland	-	1		0.22
Estuarine Scrub/Shrub Wetland	2	3	0.14	0.44
Palustrine Aquatic Bed	75	269	29.37	132.08
Palustrine Emergent Wetland	8,241	18,527	3555.70	7712.44
<b>Palustrine Forested Wetland</b>	33,992	67,359	22211.52	49995.89
<b>Palustrine Scrub/Shrub Wetland</b>	21,176	48,129	7629.40	17685.93
Potentially Disturbed Wetlands	5,147	13,305	1818.07	4895.57
Unconsolidated Shore	456	1,743	241.82	1213.86
Water	1,775	6,721	871.33	4066.67
Grand Total	70,973	156,396	36454.68	85972.72

Table 3. Average distance to mapped streams of wetlands within or near FPA permit areas

Wetland Class	Average of Distance to Nearest Stream (ft)	Average of Distance to Nearest F or S type Stream (ft)
Estuarine Emergent Wetland	15	24
Estuarine Forested Wetland	133	133
Estuarine Scrub/Shrub Wetland	100	100
Palustrine Aquatic Bed	53	65
Palustrine Emergent Wetland	164	332
<b>Palustrine Forested Wetland</b>	96	285
<b>Palustrine Scrub/Shrub Wetland</b>	120	313
Potentially Disturbed Wetlands	244	549
Unconsolidated Shore	30	40
Water	44	69

Table 4. Number of FPA permits having mapped wetlands, by associated wetland class and WDNR water body types

Wetland Class	Fish Habitat	Non-fish Habitat	Designated Shorelines	Unknown Water Type	Not Defined as a Typed Water
Estuarine Emergent Wetland	23		195	7	
Estuarine Forested Wetland			1		
Estuarine Scrub/Shrub Wetland			2		
Palustrine Aquatic Bed	19	11	188	2	
Palustrine Emergent Wetland	4819	2329	5778	745	90
<b>Palustrine Forested Wetland</b>	19596	8463	14948	2183	214
<b>Palustrine Scrub/Shrub Wetland</b>	15269	6227	11423	1761	159
Potentially Disturbed Wetlands	4023	2521	2990	681	59
Unconsolidated Shore	48	22	1346	17	2
Water	176	171	4695	31	4
Grand Total	43974	19745	41604	5428	528

Table 5. Number of FPA permits having mapped wetlands, by associated wetland class and WDNR stream types

Wetland Class	WDNR Stream Types						
	0	1	2	3	4	5	9
Estuarine Emergent Wetland	192	3		10	2	4	14
Estuarine Forested Wetland	1						
Estuarine Scrub/Shrub Wetland	2						
Palustrine Aquatic Bed	183	3	4	8	2	4	16
Palustrine Emergent Wetland	4875	969	362	2675	1240	1508	2132
<b>Palustrine Forested Wetland</b>	11760	3488	1362	12279	5301	5704	5510
<b>Palustrine Scrub/Shrub Wetland</b>	8549	3047	1170	9381	3827	4334	4531
Potentially Disturbed Wetlands	2364	677	224	2181	1230	1637	1961
Unconsolidated Shore	1261	84	5	18	8	11	48
Water	4421	243	56	72	59	107	119
TOTAL	33646	8514	3183	26625	11669	13309	14333

Table 6. Information reported in FPA Permits (number of permits, by zone)

	Sitka Spruce Zone	Western WA	Eastern WA	Total
<b>Forested Wetland</b>	1134	6089	219	7442
Not Forested Wetland	3522	14075	1277	18874
<b>Type A Wetland</b>	580	3396	169	4145
Not Type A Wetland	4076	16768	1327	22171
<b>Type B Wetland</b>	545	2769	143	3457
Not Type B Wetland	4111	17395	1353	22859
<b>Wetland or WMZ Reported in FPA</b>	956	4626	186	5768
No Wetland or WMZ Reported in FPA	3700	15538	1310	20548
<b>Any of Above Wetlands Reported</b>	1570	8249	339	10158
None of Above	3086	11915	1157	16158
<b>Hydric Soil</b>	932	3363	9	4304
Not Hydric Soil	3724	16801	1487	22012
<b>Small Forest Landowner</b>	364	3105	256	3725
Not a Small Forest Landowner	4292	17059	1240	22591
<b>Proposed Land Use Conversion</b>	72	1169	27	1268
Not a Proposed Land Use Conversion	4584	18995	1469	25048