DRAFT STUDY PLAN

EXTENSIVE RIPARIAN STATUS & TREND MONITORING PROGRAM

Including:

Westside Type F/S Riparian Extensive Monitoring Project

Eastside Type F/S Riparian Extensive Monitoring Project

Westside Type Np Riparian Extensive Monitoring Project

Eastside Type Np Riparian Extensive Monitoring Project

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Introduction

Background on Extensive Monitoring

In 2001, the Washington State Forest Practice Board approved a comprehensive set of new forest practice rules (WFPB, 2001), based on the Forest and Fish Report (FFR, 1999), to regulate forest management activities on private forestlands. The goals of these rules were to:

1) Provide compliance with the federal Endangered Species Act for aquatic and riparian-dependent species on non-federal forest lands.
2) Restore and maintain riparian habitat on non-federal forest lands to support a harvestable supply of fish.
3) Meet the requirements of the federal Clean Water Act for water quality on non-federal forest lands.
4) Keep the timber industry economically viable in Washington State of (WFPB, 2001).

The FFR report calls for both effectiveness and trend monitoring to inform the adaptive management program, with a 10-year time window to begin trend monitoring. A monitoring framework was developed (MDT, 2002) to guide FFR monitoring and research efforts. The framework consists of three types of monitoring at different spatial scales, including:

- *Prescription monitoring*-reach scale monitoring to evaluate the effectiveness of individual FFR prescriptions under a range of different physiographic conditions and evaluate alternative treatments for meeting resource objectives.
- *Intensive monitoring*-watershed scale monitoring designed to address the cumulative effects of multiple forest practices and biotic effects by conducting concentrated monitoring and research efforts in a single location.
- *Extensive monitoring*-landscape scale monitoring to estimate the current status and future trends of key indicators of input processes and habitat conditions statewide.

The Extensive Riparian Status and Trend Monitoring Program

The extensive riparian status and trend monitoring program is one component of the extensive monitoring effort being implemented by CMER to inform FFR adaptive management.

Purpose

The purpose of the extensive riparian status and trend monitoring program is to provide data needed to evaluate the landscape-scale effects of implementing the FFR forest practices riparian prescriptions and to provide the data needed by the regulatory agencies to provide assurances that forest practices rules meet Clean Water Act requirements and achieve riparian resource objectives. This program will provide statistically valid estimates of two riparian resource indicators, water temperature and riparian stand conditions, for streams across lands covered by the Forest and Fish rules (FFR lands) and identify trends in these indicators over time.

Rationale

This program is needed because water temperature and riparian stand conditions have not been sampled in a robust and unbiased manner that provides the data necessary to estimate the distribution of stream temperature and riparian stand conditions across the FFR landscape. Until the current status of these parameters is determined to establish a baseline for trend monitoring, it will be impossible to determine if landscape-level changes are occurring in response to implementation of the FFR riparian prescriptions.

Water temperature is the most frequently exceeded water quality standard on forested lands (Wash Dept of Ecology, 2004). Clean Water Act assurances will require an assessment of the current condition and credible evidence that the forest practices rules will lead to compliance with water quality standards in a reasonable timeframe. Data from this program will provide a comprehensive assessment of water temperature across the FFR landscape and will help determine if the FFR management system is resulting in the improvements in water temperature anticipated when the new riparian rules were adopted.

Considerable uncertainty exists about the current condition of riparian forest stands on private forest lands. Current riparian forest stand conditions are a result of past disturbances, site productivity and past forest management. Implementation of the FFR rules is altering the trajectory of riparian forest stands. It is not known how much riparian conditions will change as a result of the rules, how long it will take for changed conditions to become evident, and whether the changes will contribute to salmon recovery and stream water temperature protection goals

Program Organization

The extensive riparian status and trend monitoring program is organized into four separate projects (Figure 1) by stratifying the state by region (eastside/westside) and by stream type (Type F/S-fishbearing, Type Np-perennial non fishbearing). Stratification at this coarse scale is necessary because riparian buffering strategy differs both for Type F/S (fish-bearing) and Type Np (perennial non-fish- bearing) streams and for eastern vs. western Washington forestlands. Organizing the sampling effort into four separate projects creates projects of a manageable size and allows project-specific adjustments in the sampling strategy and effort to address stratum-specific differences in variability.

Purpose of the Document

This document presents a study plan that covers the four CMER riparian extensive monitoring projects. Although implemented as separate projects, their sampling designs and methodologies are similar, so for review efficiency, they are combined into one document.

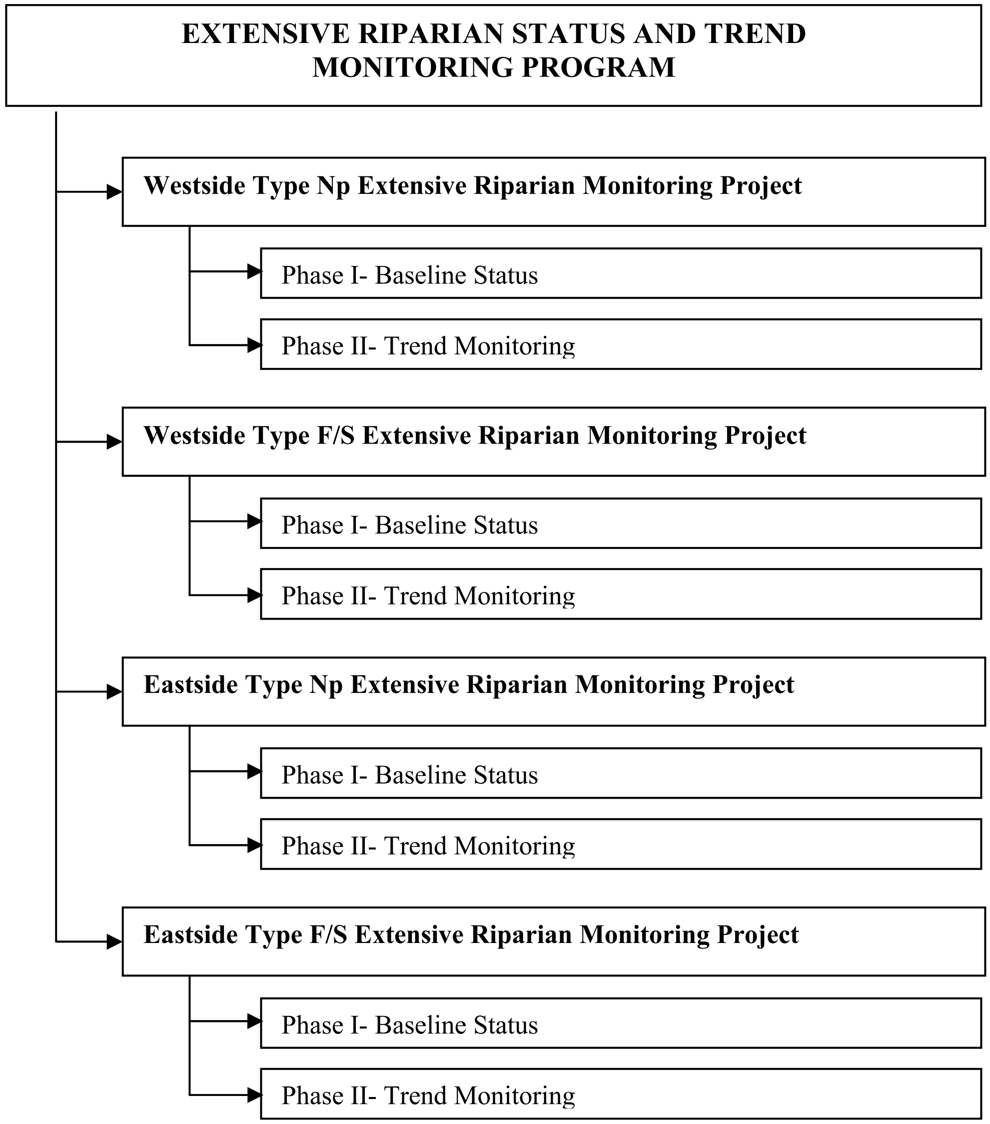

Figure 1. Organization of the Extensive Riparian Status and Trend Monitoring Program.

Goals and Objectives

The goal of the projects in the Extensive Status and Trends Riparian Monitoring Program is to document the current status (frequency distribution) of riparian shade and stream temperatures for Type F/S and Np streams across FFR lands and determine trends in these indicators over time. Quantitative data will be used to compare the frequency distribution of current maximum water temperatures with the regulatory water quality standards. Scenarios of future conditions can also be built using the current conditions and expected changes as a function of harvest rate and regulatory rules.

The projects will occur in two distinct phases. Phase I is an estimate of current status and Phase II consists of similar future sampling efforts to identify what changes may have occurred over time (trend). Phase I results will inform the need for and design of Phase II. Thus, Phase II cannot be addressed in depth.

The objectives of Phase I are to use the rigorous statistical sampling and analytical methods described in EPA's Environmental Mapping and Assessment Program (http://www.epa.gov/nheerl/arm/analysispages/techinfoanalysis.htm) to:

1. Estimate the proportion of stream length on FFR lands meeting water quality standards for water temperature, by region (east-west) and stream type (F/S-Np).
2. Determine the distribution of maximum summer stream temperature and 7-day mean maximum daily water temperature on FFR lands, by region (east-west) and stream type (F/S-Np).

Study Design

Sampling Units

Each site in this study is a randomly selected point on a stream. Water temperature will be monitored at that point and at 300 m upstream to evaluate change in temperature between temperature monitors. Channel geometry and shade measurements, used as water temperature co-variates, will be made at this point and at five additional points at 60 m intervals upstream.

Site Selection

Sites will be selected from the Statewide Stream Site Sample. This is a sample of stream locations selected by the EPA using the EMAP selection procedure (Overton et al., 1990). The sample basis was the DNR 1:24,000 Hydrolayer as of January 2006. The procedure lays a GIS grid over digital line graphs of the stream network. Stream segments within a grid cell are clipped and linked to form a line then linked with streams from nearby cells to form one continuous line. A start point is randomly selected on the line and additional points are selected at set intervals. The points are then projected on the stream network coverage. This produces a spatially balanced random sample and avoids the clumping that occurs with simple random selection. Where the attribute being measured is uniformly distributed across the geographic area being sampled, this approach produces variance estimates similar to simple random selection. Where the attribute is correlated with spatial features (e.g., elevation, latitude, ecoregion), variance estimates will be substantially lower (Overton and McDonald, 1998). The use of the Statewide Sample will assure compatibility of sampling design among different projects so that these data may be used in a statewide assessment.

Sites for these studies will be selected out of the master sample by clipping the sample to the CMERlands GIS layer (http://www.dnr.wa.gov/forestpractices/adaptivemanagement/) and then selecting based on location east or west of the state dividing line and on the stream type designated in the hydro layer (F/S and N). The CMERlands GIS layer was developed from USGS LANDSAT-based “Forest Land” area, overlain by Federal lands, lands covered by a Habitat Conservation Plan, and Urban Growth Areas in the state. Forestland not covered by one of the last three management scenarios is considered probable FFR land. Note that the USGS “forestland” designation was inclusive; if it looked like it might be forested, it was included. Also, that map layer was developed at a coarse scale, so delineations are not precise and errors are expected. Similarly, the DNR Hydro layer is known to be inexact and stream channels may or may not actually be the designated stream type, or even be in the denoted locations. Detailed screening of individual sites will therefore be done using orthophotos, tax parcel information, contacting landowners and field visits to ensure that stream is Type F and that FFR regulations apply. A large over-sample of sites in the initial selection process will ensure that enough sites will be available on FFR lands. This study will include both large and small forest landowners.

Because riparian buffers are not required on seasonal nonfish-bearing (Type Ns) streams, only perennial nonfish-bearing (Type Np) streams will be included in the sample. The WDNR stream typing GIS layer does not differentiate between perennial and seasonal nonfish-bearing streams, so the probability-based sampling procedure is applied to the entire Type N stream network and each selected site will be screened using orthophotos and field visits following the guidelines in Palmquist (2003) to differentiate between Np and Ns.

Implementation of both Eastside projects will be closely coordinated with the Eastside Type F Riparian Assessment project and the same sites will be used for both where possible in order to eliminate duplicate site selection efforts as well as to combine and support results from each (collected at different levels of detail).

Sampling Strategy and Sample Size

A tradeoff exists between estimating status and trend detection. A better status estimate may be obtained by sampling more sites while trend detection is enhanced by repeated visits to the same sites. Another option is the rotating panel design where some sites are revisited over time and a portion of sites are new (Rao and Graham, 1964; Skalski, 1990). We propose to use the results of the Phase I data analysis (status estimate) to determine the necessity for and both the design and timing of the Phase II sampling. For example, if the results of Phase I status estimate are adequate, as defined by the regulatory agencies, then future sampling could target trend monitoring. However, at this time data are insufficient to reliably plan for future sampling. Enough time will exist to incorporate the results of the first sampling event into future sampling plans because changes in riparian stands and stream temperature will occur gradually as the new buffer rules are implemented over time.

Sample size is based on the goal of estimating the proportion of stream miles meeting a specific criterion (e.g. water quality standards for stream temperature). With simple random sampling, precision is a function of the true proportion meeting the criterion (ρ) and sample size (n). For example, with a sample size of 50 streams and ρ = 50%, precision is +/- 12% with 90% confidence. If ρ = 20%, then precision is +/- 9%, with 90% confidence.

We propose to initially sample 50 sites for each project (westside Type F streams, westside Type N streams, eastside Type F streams, and eastside Type N streams). A high likelihood exists that some sites selected will be inaccessible (lack of landowner permission or safety concerns), unacceptable (misclassified), or fall outside of FFR lands. For this reason, additional sites of each type will be selected so that adequate backup sites are available. Sites for the eastside Type F portion will be selected out of the sites used by the Eastside Type F Riparian Characterization study. Sites are assigned a sample ordering when they are selected in order to achieve the spatially-distributed random element sought. Therefore, the extensive riparian study will use the first 50 sites (in order) for which additional permissions for this project can be obtained from landowners.

Methods

Stream Temperature

Stream temperature will be measured at 30-minute intervals at two locations, separated by 300m, at each sample site from early July through late October, at a minimum, with *in situ* loggers (Onset Computers 2004) using the methods described in Schuett-Hames et al. (1999). Temperature will be monitored for one full year, where possible. Riparian shade will be measured using a densiometer. Site coordinates and aspect will be noted on site and elevation, basin area, and distance to watershed divide will be estimated from topographic maps. Riparian shade, channel width and depth, substrate size category, channel morphology, and number of LWD pieces (or jams) will be measured at the temperature monitoring station and proceeding upstream at 60m intervals for 300m (or until the end of perennial flow is reached). An air temperature monitor will be located adjacent to the lower monitoring stations at 30cm height, shielded from direct sun (Schuett-Hames et al., 1996).

Two indicators (Table 1) will be used for water temperature: maximum summer stream temperature and the mean seven-day maximum stream temperature.

Table 1. Indicators used for extensive riparian monitoring.

Component	Indicator	Data collection
Water Temperature	Maximum Stream Temperature, 7-day Maximum Stream Temp, Percent canopy closure, Stream width	Temperature-*in situ* loggers Densiometer/hemispherical photos Tape

Riparian Stand Condition

Methods for evaluating riparian stand conditions using aerial photographic techniques are still being evaluated for use in this study. Categories similar to the Watershed Analysis categories of

Large/Medium/Small, Dense/Sparse, and Conifer/Hardwood/Mixed will be used to describe the riparian stands between the two stream temperature monitors.

Quality Assurance

Measures to ensure consistent data quality will be implemented throughout the data collection process. Temperature monitors will be compared to a National Bureau of Standards thermometer annually across a range of water temperatures from 0 – 20+ degrees C. Monitors outside the manufacturer's specified tolerance will be replaced. Riparian shade, and in channel measurements will be compared to repeated measures at 10% of the monitoring sites and the data will be evaluated for adequacy.

Data Analysis

Riparian stand condition and water temperature are the primary variables of interest because:

- Buffering of riparian zones is the basic strategy for protecting water quality, aquatic habitat and biota
- FFR set specific performance targets for riparian stands and water temperature (water quality standards)
- Riparian buffers are expected to provide riparian functions (e.g. LWD recruitment, litter fall, shade necessary to achieve FFR resource objectives).

An assumption exists that implementation of FFR-based forest practices rules will maintain adequate stream temperature. If a lack of riparian shade is currently impacting stream temperature, a downward shift in the distribution of temperatures over time should occur in conjunction with a shift toward more riparian shade as the existing stands mature.

Estimates of the proportion of streams meeting water quality standards can be illustrated using the frequency distribution of stream temperature by stream type. Figure 2 shows a hypothetical example of a shift in the distribution of stream temperatures. Similarly, riparian stand data can be summarized by dominant tree species, stand type (hardwood, mixed, and conifer-dominated) and basal area. Cumulative distributions and estimates of population mean and variance will be calculated and changes over time can be assessed by comparing cumulative distribution functions (Diaz-Ramos, et al. 1996).

In addition to the data summaries, regression analysis will be used to describe patterns in stream temperature due to elevation, air temperature, riparian shade, and geographic location. The results of the first analysis will be used to characterize areas or site conditions where temperature standards are (and are not) being met. This information will allow us to include these factors in interpreting the status and will also feed back into the adaptive management system to direct monitoring and research efforts or policy actions.

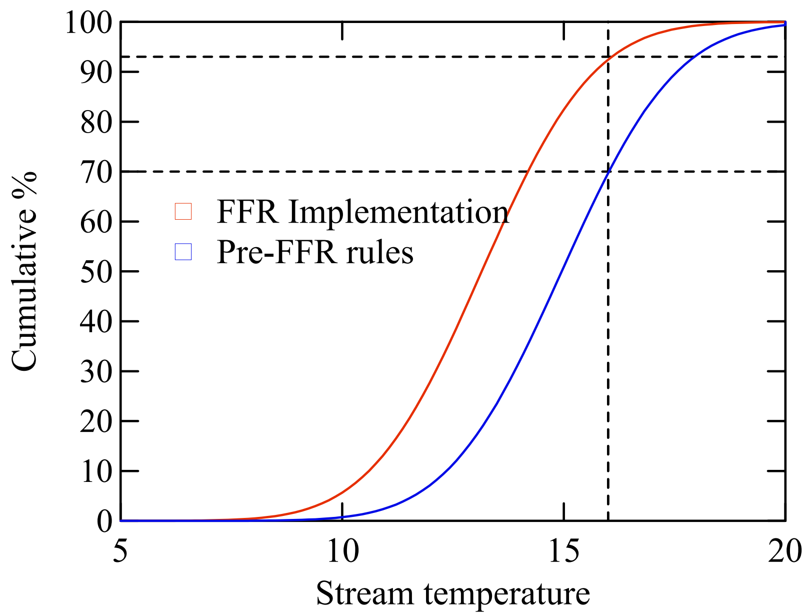

Figure 2. Hypothetical cumulative frequency distribution of maximum stream temperature prior to FFR and post-FFR implementation. This scenario shows a shift to the left (decreasing temperature) and the percentage of stream miles with maximum temperature less than 16 degrees C increasing.

Implementation

A proposed schedule for implementation of the four riparian extensive monitoring projects is shown in Table 2.

Sites for the Eastside Type F Extensive Monitoring study will be the same as those used for the Eastside Type F Riparian Characterization study and are currently being permitted and monumented in spring 2007. Temperature data loggers will be installed at these sites in May and June of 2007 in order to capture these time-critical data. Development of remote sensing methods for evaluating stand conditions can continue simultaneously with temperature data collection and will be treated as a separate project. Field data collected by the Eastside Type F Riparian Characterization study are very detailed and versatile, and so will be able to support any anticipated categorization scheme selected as we develop the remote Extensive Riparian Study riparian methods.

Table 2. Time schedule for Phase I (status) monitoring.

Task	**Eastside Type F/S Schedule (implemented in conjunction w/ Eastside Type F Riparian Characterization)**	**Westside Type F/S Schedule**	**Eastside Type Np Schedule (implemented in conjunction w/ Eastside Type N Characterization)**	**Westside Type Np Schedule**
Site selection	2006-07	Autumn-Winter 2007-08	Autumn-Winter 2008-09	Autumn-Winter 2008-09
Site evaluation	Spring, 2007	Autumn-Winter 2007-08	Autumn-Winter 2008-09	Autumn-Winter 2008-09
Deploy temperature loggers	June, 2007	May-June, 2008	May-June, 2009	May-June, 2009 or 2010
Field riparian data	Summer 2007	Summer, 2008	Summer, 2009	Summer, 2010
Retrieve temperature loggers	October-November 2007	October-November 2008	October-November 2009	October-November 2009 or 2010
Analyze data, draft report	Winter 2007-08	December 2008-February, 2009	December 2009-February, 2010	December 2010-February, 2011
Final report	Spring, 2008	Spring, 2009	Spring, 2010	Spring, 2011

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