STUDY PLAN

EASTSIDE TYPE F RIPARIAN PRESCRIPTION EFFECTIVENESS:

RIPARIAN STAND MORTALITY AND LWD RECRUITMENT

TO BE CONDUCTED IN CONJUNCTION WITH THE EASTSIDE RIPARIAN SHADE AND TEMPERATURE EFFECTIVENESS PROJECT

Prepared for the Riparian Scientific Advisory Committee

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PURPOSE

This study plan is proposed by the Riparian Scientific Advisory Committee (RSAG). The purpose of this study is to add a riparian stand mortality and LWD recruitment component to an existing Cooperative Monitoring Evaluation and Research (CMER) study on the effectiveness of eastside Type F (fish-bearing stream) riparian prescriptions (Light et al. nd). The Eastside Riparian Shade/Temperature Effectiveness Project (commonly referred to as the Bull Trout Overlay temperature study) is designed to quantify and compare differences in shade and stream temperature response between the standard eastside Type F riparian management prescriptions and special prescriptions that apply within designated bull trout management areas (the Bull Trout Overlay or BTO). This proposal involves collecting additional data at the existing set of study sites to compare the rates of riparian leave tree mortality and large wood debris (LWD) recruitment for riparian stands managed according to the two prescriptions.

The Riparian Scientific Advisory Committee (RSAG) proposes to take this opportunity to collect data to evaluate the effects of the FFR eastside Type F riparian prescriptions on stand development, tree mortality and LWD recruitment rather than pursuing a separate study as proposed in the N/F Riparian Prescription Monitoring Proposal submitted to CMER in January 2003. There are differences in the experimental designs for the two projects. The Bull Trout Shade/Temperature Effectiveness study uses a manipulative approach, with a before-after/treatment-control design comparing two FFR prescriptions with unharvested reference sites. The Type N/F design involves post-harvest random selection of FPAs submitted by forest landowners paired with unharvested reference sites. However, because the designs are similar and a large amount of resources were required to find the treatment and control sites for the Bull Trout Shade/Temperature Effectiveness Study, RSAG believes it is worthwhile to collect tree mortality, stand development and LWD recruitment data at these sites to evaluate the Eastside Type F prescriptions. Pursuing a separate, similar stand-alone study at this time, would result in delays in acquiring the information and expenditure of substantial resources to find a separate set of treatment and reference sites. Integration with other eastside riparian projects is planned.

OBJECTIVES

1. Collect and analyze stand attribute data to: a) document the magnitude and duration of changes in the stand characteristics (density, diameter, basal area) of riparian management zones (RMZs) harvested according to standard forest practices rules and special rules that apply within the Bull Trout Overlay, and b) determine if there are significant differences between stands where the prescriptions were applied and those within unharvested reference stands.

2. Collect and analyze tree mortality data to: a) estimate tree mortality rates for riparian leave trees in RMZs harvested according to standard forest practices rules and the BTO rules, and b) determine if there are significant differences in the mortality rates of stands where the prescriptions were applied and those within unharvested reference stands.

3. Collect and analyze data on LWD recruitment to: a) document the rate and type of LWD recruitment for riparian leave trees in RMZs harvested according to standard rules and BTO rules, and b) determine if there are significant differences in LWD recruitment rates in stands where the prescriptions were applied and those within unharvested reference stands.

4. Use stand data and a growth and yield model to predict future stand conditions, and evaluate the susceptibility of the projected stand conditions to crown fire, insects and pathogens.

STUDY DESIGN

The additional data collection proposed would utilize the study design framework and study sites for the Eastside Riparian Shade/Temperature Effectiveness Project (Light et al. nd). The study uses a before/after, control/impact design to test for differences between the two prescriptions. Each replicate, or site, consists of an unharvested 300 m reference reach located immediately upstream of a 300 m treatment reach where one of the two Type F riparian prescriptions is applied.

The main difference between the standard eastside Type F riparian management prescriptions and the BTO prescriptions is in the shade tree requirements. The BTO prescriptions are designed to provide more shade than the standard rules in order to maintain cooler water temperatures required by Bull Trout. The BTO prescriptions require that no trees providing shade can be harvested within 75 ft of the stream channel, while the standard eastside Type F prescriptions allow removal of some shade-providing trees beyond 30 ft as long as percent shade after harvest is at or above the level specified in the Forest Practices Board Manual (which varies by elevation and water quality classification).

The Eastside Riparian Shade/Temperature Effectiveness study design specifies 20 study sites for each treatment (standard rules and BTO rules) for a total of 40 treatment sites. Each 300 m treatment reach is paired with an adjacent 300 m unharvested reference reach located immediately upstream for a total of 40 reference reaches. All 40 paired sites will be used for this study.[1]

DATA COLLECTION

The tree mortality and LWD recruitment data will be collected following timber harvest, and comparisons between the treatment sites and reference reaches will be restricted to post-harvest differences in mortality and LWD recruitment.

The data collection effort will consist of iterative surveys. The first survey will take place the 1st spring after timber harvest, and the second survey will take place the 3rd spring after timber harvest. The first survey visit will include site layout as well as collecting data on live and dead standing trees, stumps, fallen trees and LWD recruitment. The second survey will focus on updating the live tree data and identifying and collecting data on new snags, new fallen trees and LWD recruitment that occurred since the previous visit. Additional surveys will occur over time at five-year intervals to evaluate changes in stand conditions and LWD recruitment over a longer time-frame.

Layout

Tree mortality is often patchy in nature, so in order to accurately determine tree mortality rates and LWD recruitment, a census will be made of all standing and fallen trees in the core and inner zones of the RMZs, as well as the first 25 ft of the outer zone. In order to evaluate the influence of stream proximity on stand condition, tree mortality and LWD recruitment, the riparian stand to the stream will be divided into zones based on distance-from-stream. The first step will be to determine the azimuth (compass bearing) of the stream channel through the study site. Next, a

[1] A companion study conducted by BTSAG is comparing pre-and post-harvest solar radiation at the 20 BTO sites.

two-person crew will proceed through the reach alongside the stream following the stream azimuth, using a tape or laser rangefinder to place flags at 50 ft intervals. Cell boundaries will be flagged (on each sides of the stream) at distances of 25, 50, 75, 100 and 125 ft from the edge of the bankfull channel at each 50 ft interval along the stream channel. Each cell is 50 ft in length parallel to the stream and 25 ft in length perpendicular to the stream for a per cell area of 0.029 acres. In all, there will be 200 cells per reach for a total area of approximately 5.8 acres.

This sampling layout allows for an unbiased comparison of conditions based on distance-from-stream; however some additional refinements are necessary for analysis of the data by the FFR regulatory zones. The study sites have no channel migration zones, so the cell boundaries at 75 and 100 feet from the stream will coincide with the boundaries between the inner and outer zones for small and large streams, respectively, so an additional marker is needed 30 ft from the stream to distinguish the core and inner zone trees within the second cell out from the stream.

Standing Tree and Stumps

This step consists of a census or inventory of all standing trees (live and dead) and stumps greater than 4 inches dbh by cell. The data recorded for live trees will include: species, breast height diameter class (in 2” increments), canopy class, crown type, landform, and damage code. The data recorded for snags will include: species (if discernible), breast height diameter class, crown type, decay class, landform and mortality agent. Snags will be tagged so that newly dead trees can be distinguished on subsequent surveys. The data recorded for stumps will include: species, diameter, stump height, decay class and landform.

Fallen Trees and LWD Recruitment

Data will be collected for all fallen trees by cell including: species, breast height diameter class, piece type (e.g. toppled with root wad attached or broken), condition (live/dead), fall direction, felling process, distance of base from stream, diameter where piece crosses plane of bankfull channel, length (by channel zone), and recruitment class (in-channel, suspended, spanning). Fallen trees will be tagged and marked with paint to distinguish newly fallen trees on subsequent surveys.

Channel-Site Attributes

Bankfull channel width, channel azimuth and hill slope gradient will be measured at each station (50 ft interval) along the stream channel to characterize site conditions.

DATA ANALYSIS

Data Structure

For the data analysis, a series of parameters describing stand conditions, tree mortality and LWD recruitment will be calculated for each site. In order to determine changes over time and to calculate mortality and recruitment rates, these parameters will be calculated for each sampling event; i.e. 1st year post-harvest (spring after harvest), 3rd year post harvest, and five year intervals there after. The data collected from each site during the 1st spring after harvest survey will be used as the starting point for reconstructing the stand conditions immediately prior to harvest. A data base will be constructed for each of two data types (standing trees/stumps and fallen trees) to store the data collected in the field and to calculate the metrics required for analysis.

Standing trees/stumps

Post-harvest data. The standing tree database will contain the data collected for each live tree, dead tree and stump for each post-harvest visit. The database will calculate two additional attributes for each tree or stump. A breast height diameter will be estimated for each tree based on the mid-point of the breast height diameter class in which it falls. (For stumps, a taper equation will be used to estimate the breast height diameter). A basal area (BA) will be estimated for each tree or stump using the formula: BA (ft^2) = 0.005454 dbh^2 (in).

Pre-harvest data. Stand conditions immediately after harvest will be reconstructed using the 1st year after harvest data. Any freshly cut stumps, dead or fallen trees that are classified as decay class I in the 1st year after harvest database will be assumed to be standing at the time of harvest and will be treated as live trees in the pre-harvest data set.

Fallen trees

The fallen tree database will contain the attribute data for each tree that falls during the post-harvest period and additional attribute data for trees that recruit LWD to the bankfull channel.

Metric Calculations

Stand Metrics

A series of metrics will be used to document changes in stand conditions, including: trees per acre, mean breast height diameter, basal area per acre, and quadratic mean diameter. Each of these metrics will be calculated separately for live trees and dead trees. Live and dead trees will be separated into groups (all; conifer and broadleaf; shade tolerant and shade intolerant). The percent conifer trees per acre and basal area per acre will be calculated for both live and dead trees. In addition, by using the location data, this parameter will be calculated for each of the five distance-from-stream bands (0-25 ft, 25-50 ft, 50-75 ft, 75-100 ft and 100-125 ft) and by the regulatory core, inner and outer zone areas.

Trees per Acre. Trees per acre will be calculated by tallying the number of trees and dividing by the acreage surveyed. By sorting the tree database, this parameter will be calculated separately for live and dead trees (by group).

Mean Breast Height Diameter. This parameter will be calculated by averaging the mid-point diameters of the trees in the database.

Basal area per acre. This parameter will be calculated by summing the individual basal area of all the trees in the group and dividing by the survey area in acres.

Quadratic Mean Diameter. Quadratic mean diameter (QMD) in inches will be calculated using the formula:

$$\text{QMD} = \sqrt{\frac{\overline{BA}}{0.005454}}\ .$$

Percent Live Conifer. Percent live conifer will be calculated two ways, by tree count and by basal area per acre. To calculate percent live conifer trees, the tally of conifers for the area of interest is divided by the total number of live trees. To calculate percent live conifer by basal area, the sum of the basal areas for live conifers is divided by the sum of the basal areas for all live trees.

Tree Mortality Rate Metrics

Tree mortality rates will be calculated for a series of time periods between each sampling event; i.e. the period between the pre-harvest survey and the 1st year post-harvest survey and the period between the 1st year post-harvest survey and the 3rd year post-harvest survey, etc. Tree mortality for each time period will be determined by comparing the later survey with the earlier survey to identify any trees that died or fell during the period. Mortality rates will be calculated in two ways, by trees per acre per year and by basal area per acre per year. To calculate mortality rate in trees per acre year, the number of trees that died or fell between surveys will be counted, divided by area surveyed and divided by the number of years between surveys. To calculate mortality rates in basal area/acre/year, the basal area of trees that died or fell between surveys will be summed, divided by area surveyed and divided by the number of years between surveys.

Mortality rates will be calculated by groups (all; conifer and broadleaf; shade tolerant and shade intolerant). In addition, by using the location data, mortality rates will be calculated for each of the five distance-from-stream bands (0-25 ft, 25-50 ft, 50-75 ft, 75-100 ft and 100-125 ft) and by the regulatory core, inner and outer zone areas.

Tree Fall and LWD Recruitment Rate Metrics

Tree fall rates in trees/acre/year will be calculated for each time period by counting the trees that fell during each period, dividing by the area surveyed, and dividing by the number of years. LWD recruitment rates will be calculated in several ways. Trees that recruit LWD per acre per year will be calculated by counting the fallen trees that recruit (cross the plane of the bankfull channel), divided by the area surveyed and the number of years. LWD recruitment will also be calculated as the number of pieces recruited per unit stream length (km) per year and as volume (m3) per stream length (km) per year.

Tree fall and LWD recruitment rates will be further broken down into three categories (all trees, conifers trees, and broadleaf trees). In addition, by using the location data, mortality rates will be calculated for each of the five distance-from-stream bands (0-25 ft, 25-50 ft, 50-75 ft, 75-100 ft and 100-125 ft) and by the regulatory core, inner and outer zone areas. Additional analyses will be performed to examine relationships between LWD recruitment and fall direction, distance from stream, diameter class and recruitment class.

Analysis

The analyses described below are based on the procedures in the study plan for the Eastside Riparian Shade/Temperature Effectiveness Project (Light et al. 2002). These analyses are based on the difference between the paired reference and treatment reaches (***D*** = reference reach–treatment reach). The difference is used because of the assumption that the stand characteristics of the downstream treatment reach are probably not independent of those in the upstream reference reach). Longitudinal trends in the metrics are not expected (i.e., we don't expect the metrics to consistently increase or decrease as we move downstream), therefore we expect the mean of these differences over *n* streams to be zero.

Hypotheses

If the treatment (harvest under a prescription) has no effect then we expect that, for each site, the difference between treatment and reference reaches pre-harvest (***D***D_{Pre}) would be the same as the difference post-harvest (D_{Pst}). If the difference between the reference and treatment reaches has changed then the harvest prescription has probably had an effect. If we define the effect of the prescription on a treatment reach relative to the reference reach, then the dependent variable used to measure the effect of the prescription is:

$$E_i = D_{iPre} - D_{iPst},$$

where the *i* subscript refers to an individual stream.

We can then calculate the mean effect ($\overline{E}$) for all sites in the prescription group (Figure 1).

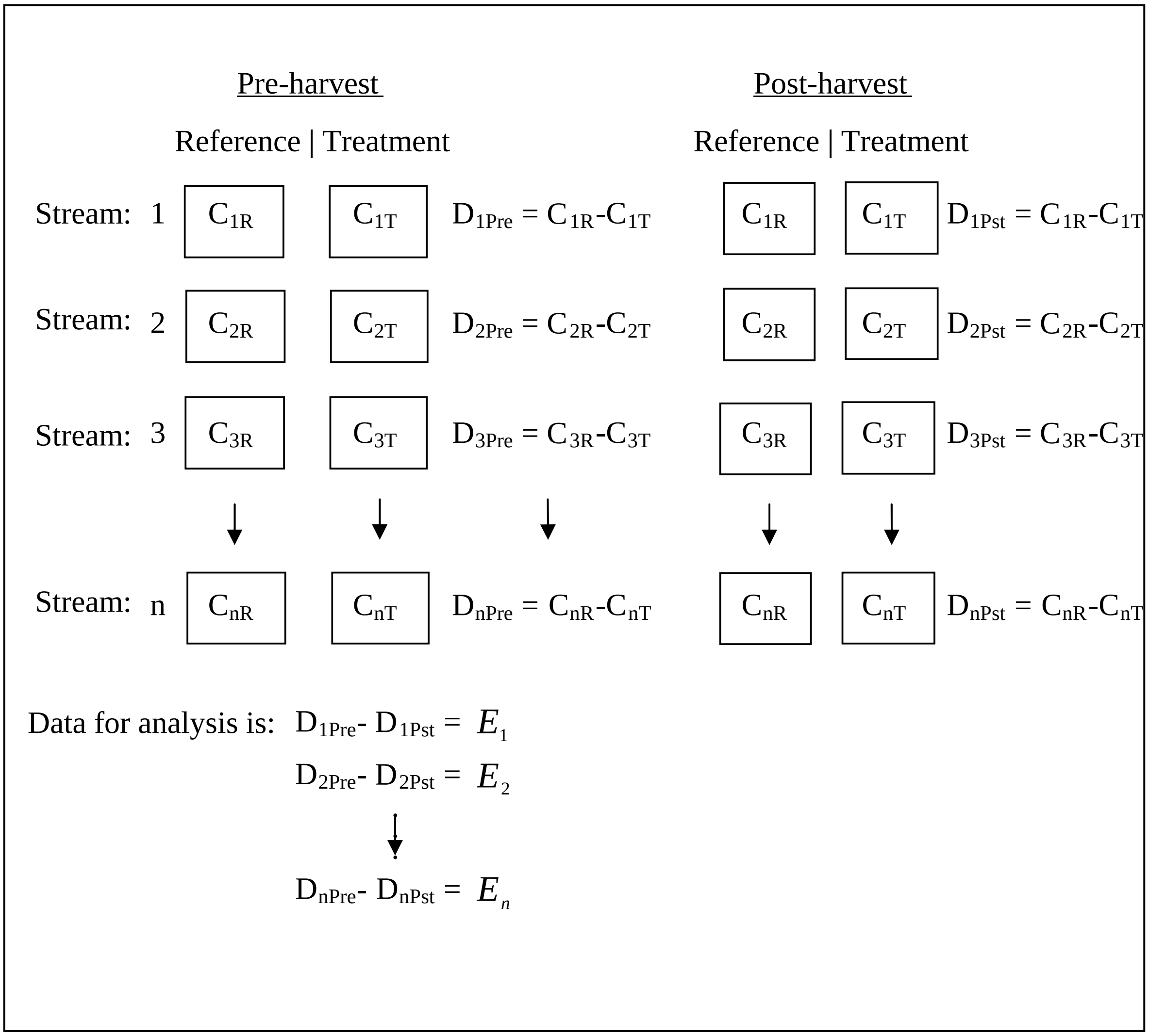

Figure 1. Schematic of the experimental design for analysis to evaluate effects of a single prescription with a pre- and post harvest data (hypothesis 1).

If $\overline{E}$ is 0 then the prescription has had no effect. If the mean effect is different from 0 there may have been a change, on average, from pre-treatment conditions. We test for a difference using the two-sided hypothesis:

$$H1_o : \overline{E} = 0$$
$$H1_A : \overline{E} \neq 0.$$

These hypotheses will be separately tested for each metric for each of the two prescription groups to determine if there is evidence that the prescription had an effect on various metrics.

To determine if there are differences in the effects of the two prescriptions, the following hypothesis will be tested for each metric:

$$H2_o : \overline{E}^{FF} = \overline{E}^{BTO}$$
$$H2_A : \overline{E}^{FF} \neq \overline{E}^{BTO}.$$

Hypothesis Testing Procedures

Hypothesis 1: The observations tested are the differences between the reference and treatment reaches for stream. Since we have paired observations (measurements are made at the same site pre-treatment and post-treatment), Hypothesis 1 will be tested using a paired test because it is more powerful than a non-paired test. A paired t-test will be used for metrics with data that are normally distributed; for metrics with data that are not normally distributed, the non-parametric Wilcoxon signed ranks test (Conover 1980) will be used.

Hypothesis 2: The observations used in this test are still the differences between the treatment and reference reaches for each stream; however the observations are no longer paired since we are comparing the standard and BTO prescriptions, i.e. two groups of sites where different prescriptions were applied. Since there are only two treatment groups in the analysis, a standard t-test will be used for metrics with data that are normally distributed. The appropriate non-parametric test is the Mann-Whitney test (Conover 1980).

Modeling

The stand conditions at each site treatment and reference site will be projected 60 years into the future at 10 year intervals using the appropriate variant of the Forest Vegetation Simulator (FVS) Model using the stand data collected at the initial site visit as the input. Separate projections will be done for the core and inner zones to assess the effects of the different management regimes applied to each zone on future stand conditions. Projected stand conditions at each prediction interval will be assessed to determine the stands susceptibility to crown fire, insects (Douglas-fir beetle and western spruce budworm), and pathogens (Armillaria, laminated root rot and white pine blister rust). Fire risk will be evaluated using the fire and fuels extension of FVS, while insect and pathogen risk will be evaluated using hazard rating procedures described in McConnell (2000).

BUDGET AND TIMELINE

The timeline for data collection and analysis is dependent on the harvest schedule for the treatment sites. Currently 7 of the 40 sites have been harvested. These sites will be sampled in the summer of 2006. There is much uncertainty as to the harvest schedule for the remaining sites. Once the sites are harvested, the 1st year post-harvest sampling event will be scheduled for the following summer. Table 1 shows the timeline and budget for the first and second sampling events.

	FY06	FY07	FY08	FY09	FY10	Total
Harvest (# Sites)	7	26*	7*			
1st yr post	$30,000	$102,000	$33,000			$165,000
3 yr post			$33,000	$102,000	$61,000	$196,000
8 yr post (begins FY13)						
Total	$30,000	$102,000	$66,000	$102,000	$61,000	$361,000

* Estimated harvest schedule

DELIVERABLES

The deliverables will include:

1. Data. A database will be provided that contains the individual records for standing live and dead trees, fallen trees and stumps. A database containing site level data for stand condition metrics, tree mortality metrics, tree fall and LWD recruitment metrics. Data will be provided in an electronic format.
2. FVS model projections and hazard ratings.
3. Progress Reports. Annual progress reports will be provided.
4. Final Report. A final report will be produced once all data collection is completed (date dependent on harvest schedule).

REFERENCES

Conover W.J. 1980. Practical Nonparametric Statistics (Second Edition). John Wiley and Sons. New York.

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