Riparian Rule Analysis: Methods for evaluating prescriptions and their geographic extent

This document describes the recommended methods for providing information on proposed prescriptions for meeting the Board of Forestry's (Board) rule objective, including the following elements:

- Predicted Temperature Change
  - Model Development
  - Model Assumptions, Limitations and Uncertainty
  - Use of Model and Other Information for Evaluating Prescription
- Change in Restrictions on Forest Practices
  - Geographic Information System (GIS) Analysis
- Change in Wood Production Values (Economic Information)
- Ecological Information
  - Large Wood Recruitment
  - Fish Response
  - Other Functions
- Geographic Extent to Which Prescriptions Apply
  - Geographic Regions
  - Stream Reach Extent

Predicted Temperature Change

The Board's rule objective is to establish riparian protection measures for small and medium fish-bearing streams that maintain and promote shade conditions that insure, to the maximum extent practicable, the achievement of the Protecting Cold Water criterion. In order to evaluate the efficacy of a proposed prescription in meeting the desired level of protection, the Board needs estimates of the expected temperature change resulting from implementation of said prescriptions. The department developed a model and simulation approach to provide estimates of temperature effect of prescriptions.

<u>Model development</u>
Data collected from the RipStream study describe features of the 33 sites. We collected measurements for stream temperatures, shade, channel characteristics, and the trees, shrubs, and downed wood in the riparian areas. At a minimum, we measured these conditions prior to harvest and post-harvest. We measured some attributes more frequently. Measurements were collected in upstream control reaches and the harvest treatment reaches. Some sites included temperature probes downstream of the treatment reaches.

Based on earlier field data analysis, we know that the change in stream temperature between the upstream and downstream ends of the treatment reach can be predicted by shade and some other variables, and that shade could be predicted with basal area and tree height. We wished to reach a point where we could ask, in a statistically defensible manner, how a specific change in basal area would affect shade, and alter stream temperatures. To answer this question we used a statistical approach called Bayesian modeling. The approach allows us to combine the temperature model with the shade model (both of which are based on field data), and may be used to predict temperature responses from different harvest simulations. Bayesian analyses have some advantages to more classic approaches. One advantage is that the results are easier to understand. If we estimate a mean temperature increase estimate of 0.8 ˚C with a 95% Credibility Interval (analogous to a confidence interval) of 0.5 ˚C to 1.2 ˚C, it is correct to interpret the interval as "there is a 50% chance the true mean lies above or below 0.8 ˚C, with a 95% probability that it lies between 0.5 ˚C and 1.2 ˚C". The interpretation in more classic statistics is less straightforward.

We developed and evaluated a number of different shade models. We selected a model for post-harvest shade that performed well and intuitively describes the riparian area (Figure 1). In the model, post-harvest shade depends on the distance from the stream to end of riparian buffer (Buffer Width), the basal area density of the remaining hardwood and conifer trees (Tree Density), tree height, percentage of remaining trees that are hardwood (Composition), and the number of sides upon which harvest occurred.

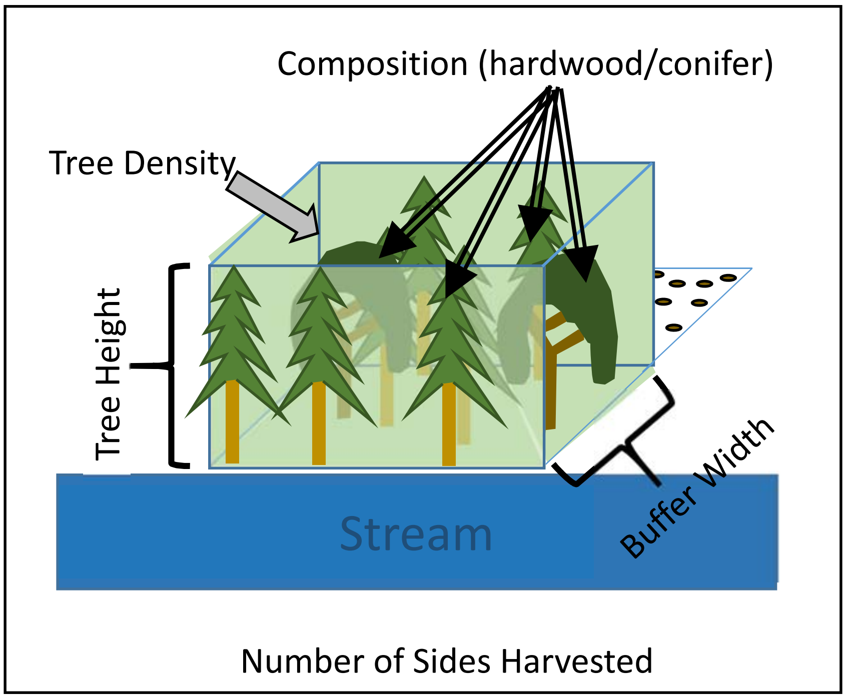


Figure 1. Parameters used in the post-harvest shade model.

The predictive model, which combines the stream temperature model and the shade model, appears to fit our field-collected data well. The model uses data from the pre-harvest period and the first two years post-harvest. Within the predictive model, the temperature model incorporates measured pre-harvest shade values and the modeled post-harvest shade to represent "shade" (Figure 2).

Temperature = Control reach temp + Treatment Length + % Gradient + **Shade**

Pre-harvest shade = pre-harvest shade

Post-harvest shade =
Buffer width + density (ba/ac) + composition (% hardwood) + average tree height + number of sides harvested

Figure 2. Stream temperature prediction model components. Pre-harvest shade values are provided as measured, while post-harvest shade values are estimated from riparian variables.

Natural variability and harvest simulations
In order to measure a harvest effect, we must estimate the natural variability of the system. To achieve this, the predictive model takes advantage of data and variables representing pre-harvest and post-harvest conditions. In Figure 3 Temperature$_1$ represents the expected temperature response if no harvest occurred. Temperature$_2$ predicts the temperature change that would occur with a simulated harvest. Subtracting Temperature$_1$ from Temperature$_2$ yields the modeled effect of the simulated harvest on stream temperature.

Temperature$_1$ = Control reach temperature + Reach Length + % Gradient + **No-harvest shade**

Temperature$_2$ = Control reach temperature + Reach Length + % Gradient + **Post-harvest shade**

Temperature$_2$ – Temperature$_1$ = HARVEST EFFECT

Figure 3. Predictions conducted to determine the effect of simulated harvests on stream temperature.

A “simulated harvest” refers to the use or manipulation of plot data in the model to represent the trees remaining in the Riparian Management Area (RMA) after implementing a prescription (harvest). The RipStream study included extensive vegetation data collection in large plots next to the harvested streams. Every treatment reach had two vegetation plots, one on each side of the stream. Each plot was 170’ wide and extended along the stream for 500’. Within this plot, a 100% inventory occurred, with diameter at breast height (DBH) and distance from the stream recorded for each tree. This level of measurement occurred pre-harvest and post-harvest. The inventory included information on tree species and height.

With this information, we are able to simulate, from the pre-harvest vegetation data, a harvest conducted according to the Forest Practices Act (FPA), the State Forest Northwest Forest Management Plan (NWFMP, 2010 version), harvests at different set distances from the stream, and variable retention harvest (e.g., harvest levels determined by available basal area). We can also use the riparian data from the post-harvest plots and use it to predict what the temperature increase should be from such a harvest – referred to as the “As-harvested” simulation below (Figure 4).

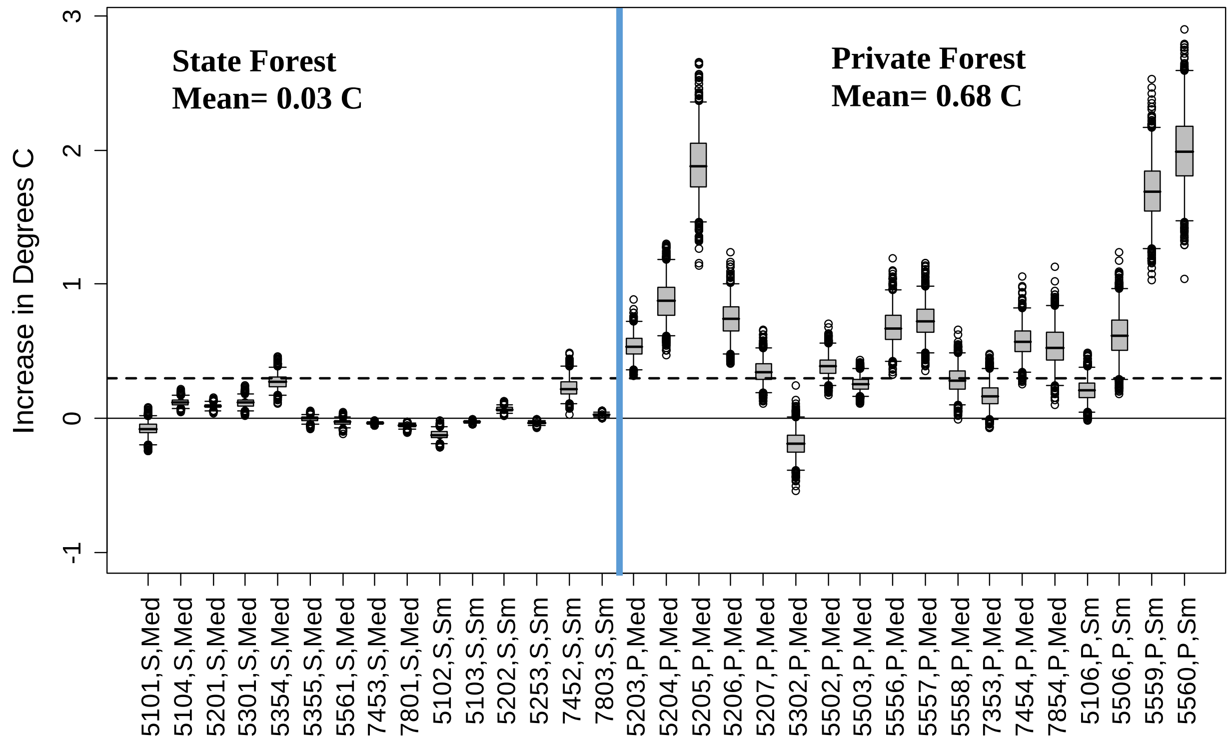


Figure 4. Predicted temperature responses for the “As-harvested” simulation. Site numbers, ownership ([S]tate, [P]rivate), and stream size ([Med]ium, [Sm]all) are provided on the horizontal axis.

The Temperature$_1$ shade component for Figure 4 mirrors the post-harvest shade model but uses the pre-harvest plot data as a 2-sided harvest in which no trees were removed. The Temperature$_2$ shade component used the post-harvest shade model on the actual post-harvest plot data. The resulting overall mean increase for state forests and private forests, +0.03 and 0.68 ˚C respectively, are similar to estimates from our earlier published study (+0.0 and 0.70 ˚C).

We performed a simulation in which we modeled all sites as implementing a state forest NWFMP prescription on both sides of the stream (Figure 5). For this and the remainder of the simulations, the Temperature$_2$ shade component used the post-harvest shade model on the plot data remaining after a simulating harvest of the pre-harvest riparian plot data. For the simulated NWFMP prescription, the mean predicted stream temperature response was + 0.19 ˚C with a 95% Credibility Interval of 0.0. ˚C to 0.37 ˚C. Aside from measurement and estimation errors, individual sites differ in their responses due to the change in the buffer width and basal area within the buffer width, as well as percent hardwood composition. Some sites achieved the NWFMP’s requirements for Mature Forest Condition, and so had no harvest within 100 feet of the stream. Others received some simulated entry within the 100 feet depending on stocking levels and tree sizes of conifers.

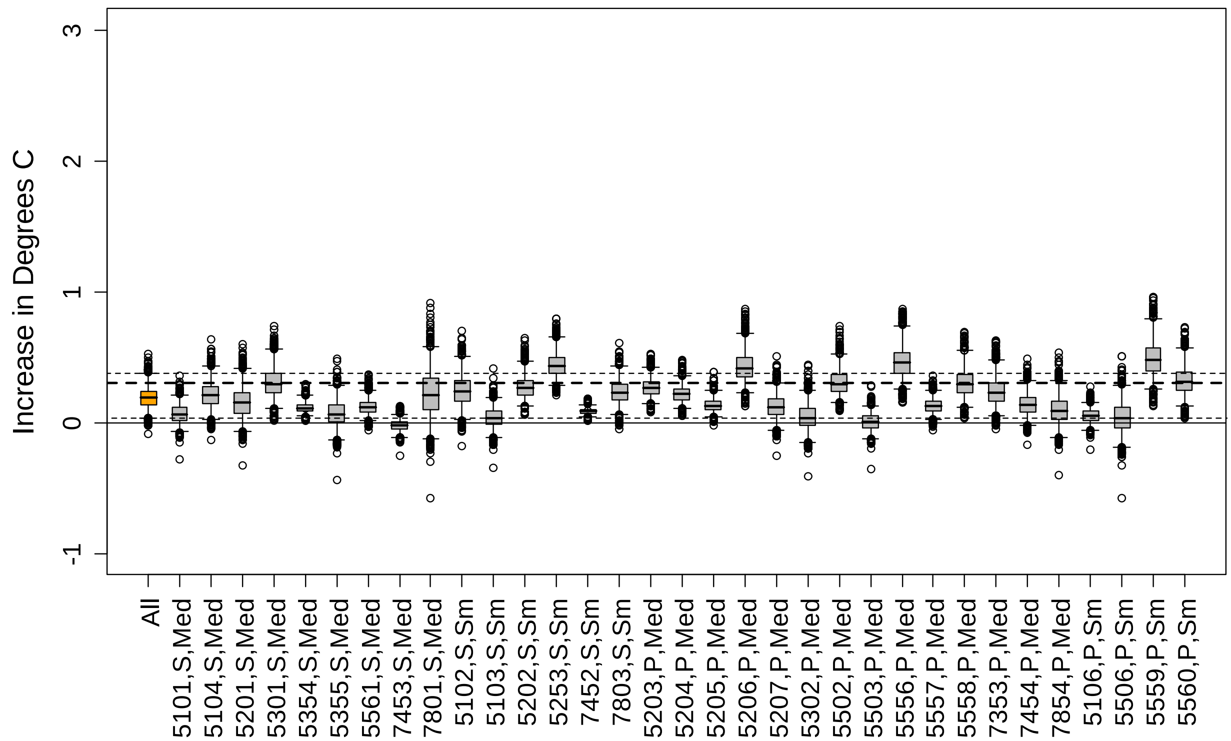


Figure 5. Temperature responses to simulated State Forest NWFMP harvest. The "All" category on the far left, with an orange boxplot, represents the estimated mean of all sites.

We performed a simulation in which we modeled all sites as implementing an FPA prescription on both sides of the stream (Figure 6). For this simulation, the mean predicted stream temperature response was +1.45 ˚C (95% CI = 1.1 to 1.8 ˚C). Simulated buffer widths were substantially narrower for the FPA harvest than for the NWFMP harvest, resulting in less predicted shade and a greater predicted temperature increase.

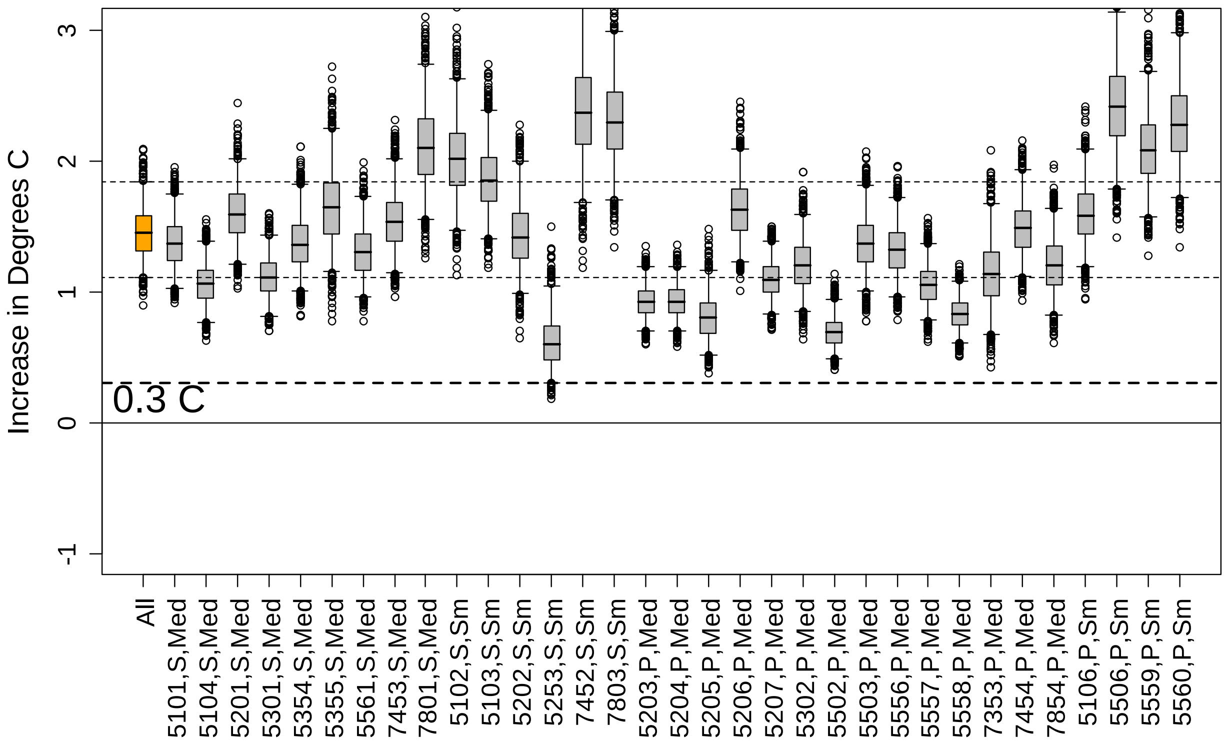


Figure 6. Temperature responses to simulated private forest FPA harvest. The “All” category on the far left, with an orange boxplot, represents the estimated mean of all sites.

Based on Board direction, the NWFMP and FPA simulations serve as bookends for this analysis, representing minimum and maximum amounts of riparian protection measures under consideration. To examine harvest scenarios that could better inform rule development, we are conducting other simulation types. One type involved predicting the mean stream temperature response to simulated harvests occurring at different distances from the stream (i.e., no-cut buffer rule alternatives). We created a scenario in which we simulated tree removal beyond slope distances of 20 to 120 feet, in 10-foot increments. Figure 7 depicts the combined results of these 11 simulations. The solid line represents the mean response of all sites combined to different harvest distances. The dashed lines represent the 50% (blue) and 95% (red) Credibility Intervals. The mean response crosses 0.3 ˚C at a no-harvest slope distance of approximately 90 feet. There is a 95% probability, according to this model, that the true mean crosses 0.3 ˚C between 75 and 110 feet, and a 50% probability that it crosses between 85 and 95 feet.

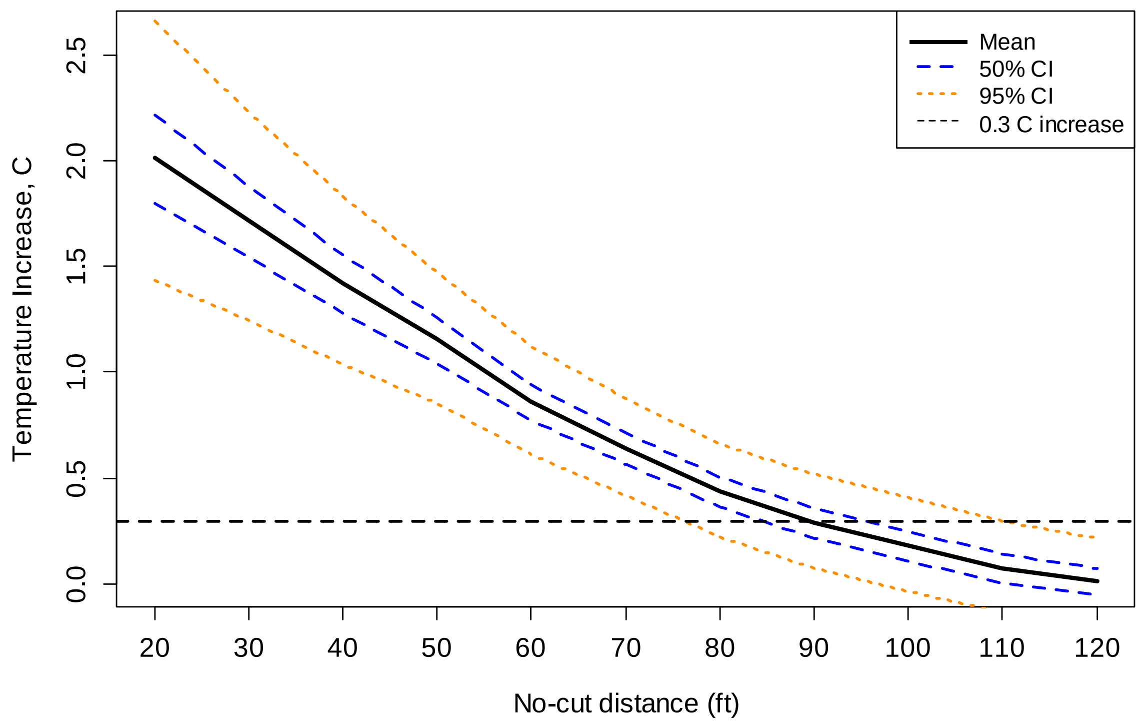


Figure 7. Mean temperature responses among all sites to simulated harvests at set slope distances from the stream. The black line indicates the mean response of the 33 sites, the dashed blue line represents a 50% Credibility Interval (CI) and the dashed orange line a 95% CI. The horizontal dashed black line indicates 0.3 ˚C.

Model Assumptions, Limitations and Uncertainty

In using this modeling approach, the Board needs to consider several assumptions and limitations. Some of these limitations and assumptions have to do with the data and study design; others have to do with the predictive model itself.

Limitation: Temperature increases are informed by hard-edged clear cuts, not thins.
Sites with temperature increases were typically those on privately owned forestland. These treatments all consisted of clear cuts, and it did not appear that RMAs were thinned. Sites that were thinned (state forest) tended to have more tree retention than private forest sites. The model therefore has greater inference for hard-edged clear cuts than for thinning prescriptions within RMAs.

Assumption: Sites are representative.
RipStream sites were not selected randomly. Statisticians rely on randomization to make inference from the sample to the larger population. RipStream sites were selected to allow for the study design and minimize the influence of major tributaries and disturbance events (e.g., active beaver influence, all sites have upstream controls that remain unharvested). However, virtually all sites that met our criteria were used meaning that our selection of sites was not

biased. While RipStream sites do not represent a random selection, they represent a well-distributed and non-biased selection of sites meeting the study criteria throughout the Coast Range geographic region.

Limitation: Pre-harvest shade and inference.
Our sites generally had pre-harvest shade levels of 80% and greater. The model may not perform well when predicting temperature responses for streams that had pre-harvest shade levels below 80%. One may raise similar inference critiques regarding any of the site selection criteria.

Assumption: Study design and causality.
The phrase “correlation does not imply causation” is familiar enough – if we simply gather data from systems without experimentally manipulating them, we do not know how relationships we discover really relate to one another. However, in a perfectly controlled experiment where we randomly assign treatments that we control, we can firmly assess causation. RipStream lies somewhere between the two extremes. We have several types of controls in place (upstream unharvested control reach, 2 years of pre-harvest data in the treatment reach), but not all factors were controlled for (treatment reach lengths, aspect, etc.). We assume that the harvest effects resulted in the temperature increases to the extent that we observed them, and we included variables in the model to take into account factors we could not control.

Limitation: model selection.
There are many different ways we have and could have formulated the shade model and the temperature model. Some models perform better than others do, while some are quite similar. We conducted several modeling exercises to select the most promising temperature and shade models, and present the one that appears best supported. However, other models may capture a truth that ours lacks.

For example, in the model presented (Figure 7), we formulated it so that the effect of buffer width on shade could diminish with distance: the difference in shade between a 30-foot buffer and a 20-foot buffer would be much greater than between a 120-foot and a 110-foot buffer. Figure 8 presents two different versions of the model used in the simulation of stream temperature increase at different no-cut buffer widths. Figure 8A is the same simulation as in figure 7, where the mean response crosses 0.3 ˚C at a no-harvest slope distance of approximately 90 feet, with a 95% probability that the true mean crosses 0.3 ˚C between 75 and 110 feet. Figure 8B depicts the results of a similar simulation, but differs in a single adjustment to the post-harvest shade component of the model (altering the functional form of the “buffer width” variable in Figure 2). For 8B, the mean response still crosses the 0.3 ˚C threshold at 90 approximately feet, but the 95% CI is narrower and the true mean crosses 0.3 ˚C between 80 and 100 feet. The model in 8B also produces higher mean temperature increases between 20 and 40 feet than model 8A. The model in 8B produced parameter estimates that were very similar to 8A, but it produced a slightly worse fit of the data than the first approach. With earlier models, the change in the functional form of the buffer width variable also changed the distance where the mean response crossed 0.3 ˚C threshold.

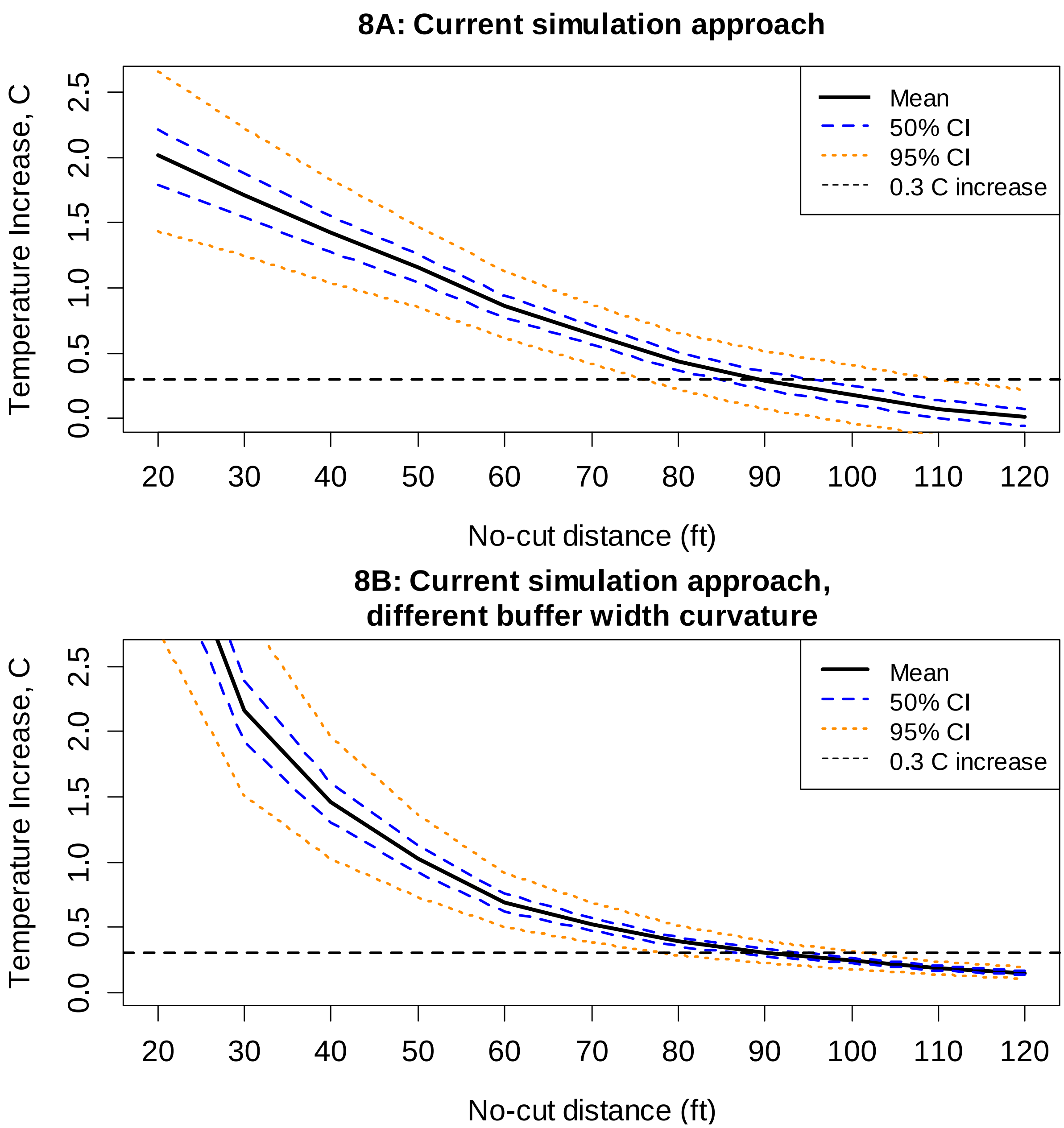
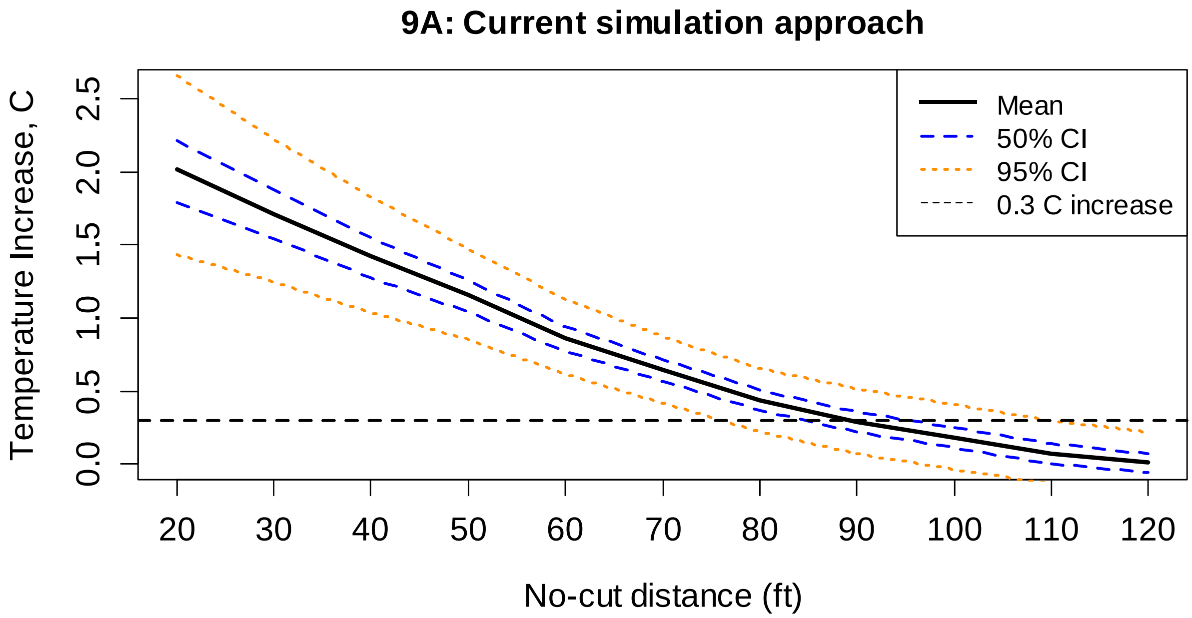


Figure 8. Mean temperature responses among all sites to simulated harvests at set slope distances from the stream. The black line indicates the mean response of the 33 sites, the dashed blue line represents a 50% Credibility Interval (CI) and the dashed orange line a 95% CI. The horizontal dashed black line indicates 0.3 ˚C. Model 8A represent the current model, while model 8B has a different curvature term for buffer width.

Figure 9 provides another example of model selection effects. Figure 9A depicts the same simulation results as presented in figure 7. Figure 9B represent results from an earlier simulation with a version of the model that only differs in how we included the pre-harvest shade data in the model. Figure 10 shows both models together on a single graph with the 95% credibility intervals of those two models.

Figure 10 shows an overlap of the means and 95% credibility intervals of those two models.



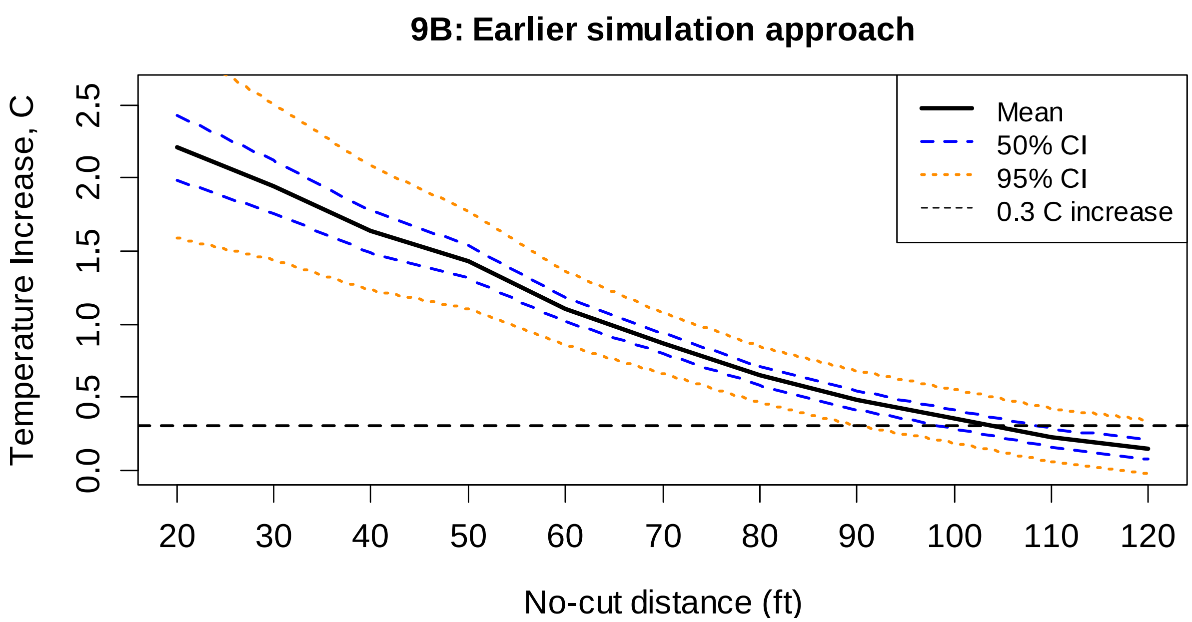


Figure 9. Mean temperature responses among all sites to simulated harvests at set slope distances from the stream. Model 9A is the same that is presented in Figure 7. Model 9B is derived from an earlier formulation of the model.

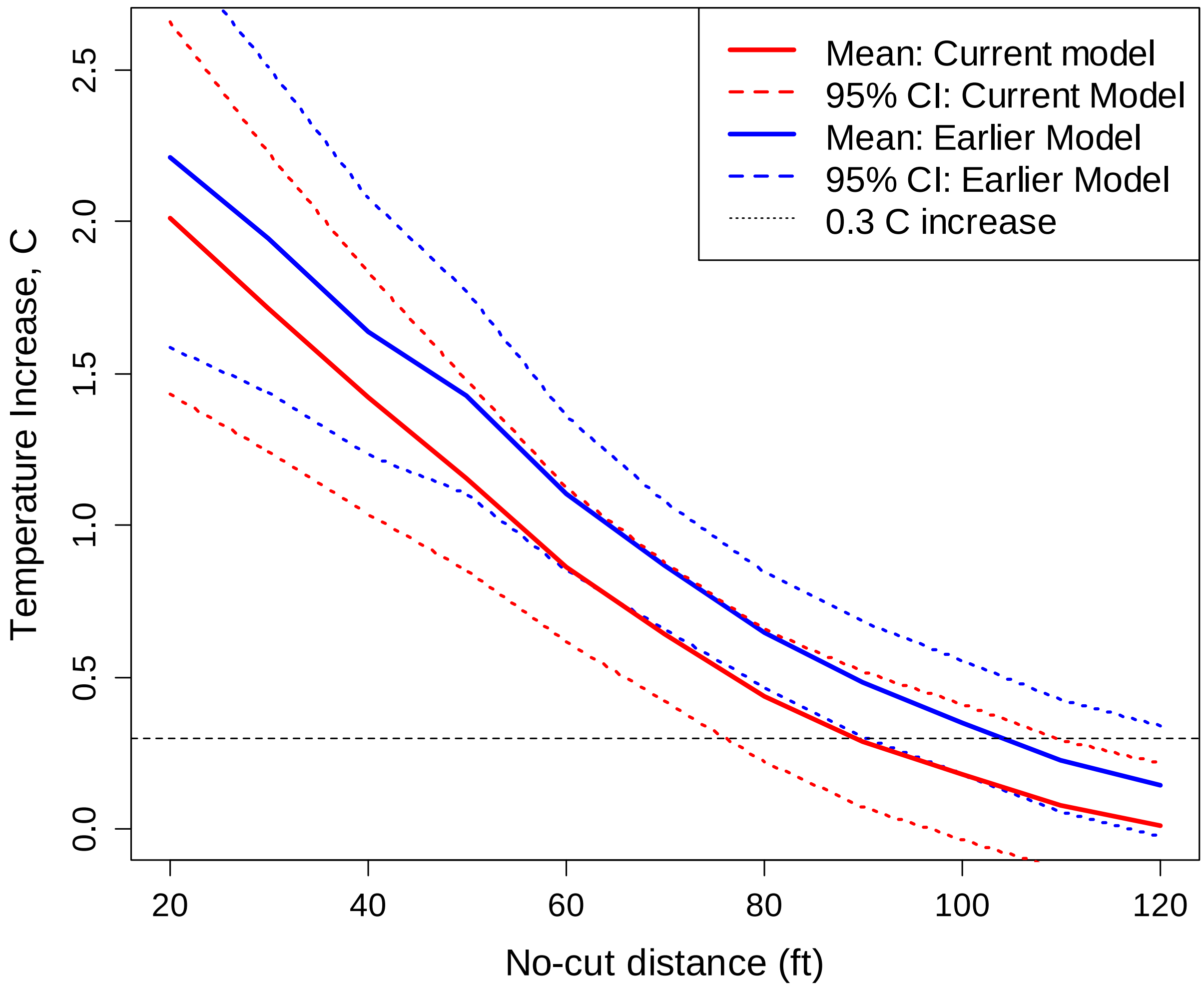


Figure 10: Models from Figure 9A and 9B overlaid, with means in solid coloration and dashed lines for 95% Credibility Intervals.

As seen in Figures 9 and 10, changing the way we treated pre-harvest shade changed the distance where the mean response crossed the 0.3 ˚C threshold by approximately 15 feet (from 90 feet in simulation 9A to 105 feet in simulation 9B). Considering results of both models suggests that the true mean crosses the 0.3 ˚C threshold between 75 and 120+ feet. Other versions of the model (not shown), that contained slightly different properties that appeared less statistically defensible, produced prediction values where the mean responses crossed the 0.3 ˚C threshold between 75 and > 120 feet.

We present Figure 8, 9, and 10 to demonstrate that our estimates that produced Figures 4-7 are from a single model. While we selected the best-performing model, we have not taken into account how our results might differ if other models were used. Therefore, our reported means may be somewhat off, and the Credibility Intervals likely deserve to be wider. To what extent, we do not know.

Model Usage, Systematic Review Results & Prescription Development

We have presented simulation results for the As-harvested, State Forest, Private Forest, and no-cut buffer scenarios. These results, taken alongside information from other studies, can be used to inform prescription development. The State Forest and Private Forest harvest scenarios represent bookends and draft rule prescriptions will describe intermediate harvest types. The cut buffer scenarios can inform the no-cut buffer prescriptions. We can develop a variable-retention to investigate a combination of no-cut distances and basal area retention targets, and consider different means for including hardwood basal area in the targets. We will present results from simulations of temperature effects to inform draft rule prescriptions. Finally, we will place these prescriptions within the context of data from studies examined in the Systematic Review. Private Forests staff will apply discretion in determining which prescriptions are appropriate for model estimates or for being assessed relative to Systematic Review information due to their relative limitations.

Change in Restrictions on Forest Practices

In this rule analysis, the Board is considering adopting a rule that would provide increased standards or restrictions on forest practices. The proposed prescriptions (to establish new riparian protection measures for small and medium fish-bearing streams) represent new restrictions on forest practices. In this case, the restrictions will limit harvests or wood production in riparian management areas.

One way to characterize these restrictions would be to estimate change in timber harvest resulting from each prescription; another would be to estimate the amount of acres removed from timber production. For no-cut buffers, it is relatively easy to estimate the acres included in a fixed-width buffer for a given length buffer. For variable retention prescriptions, one would have to have detailed stand data to estimate the change in harvest resulting from increased basal area retention requirements.

To estimate the change in restriction for the no-cut buffers, one would have to estimate the average equivalent fixed-width resulting from the current variable retention buffer. As indicated in the model limitations discussion, the current rules are often implemented as fixed-width buffer with width determined by basal area of existing stand (i.e., all 18 of the private sites in the RipStream study effectively had fixed-width, no-entry buffers of various widths). In order to maintain a consistent metric across prescription alternatives, we propose to represent change in restrictions as the acres of riparian areas removed from timber production. We will calculate this value by estimating the width of an equivalent no-cut buffer for each prescription including the current rules. The acres in that buffer can be estimated for a given length of stream. For example, a 70-foor no-cut buffer would encumber an additional 25 feet of width on a small stream if the equivalent no-cut buffer for current rules is 35 feet. We will develop the estimates for proposed prescriptions in conjunction with the Regional Forest Practices Committees (RFPCs) and stakeholders.

To estimate the total change in restrictions for a geographic region or for western Oregon, one would need to know the length of streams affected by the rule. The Board has yet to determine the stream extent and will do so as part of the rule analysis recommendation. For preliminary information, we will develop that information for the stream extent bookends set by the Board (i.e., only those streams with salmon, steelhead, or bull trout present; the entire network of small and medium fish streams). We used a Geographic Information System analysis to estimate the amount of acres in various fixed width-buffers for small and medium fish streams, and for small and medium streams with salmon, steelhead, or bull trout present.

Geographic Information System (GIS)

The purpose of the GIS analysis is to approximate the amount of riparian acres that would be encumbered by potential changes to the current riparian rule to protect the cold water criterion, which applies only under certain circumstances. For this analysis, we assumed the protecting cold water criterion would apply at a minimum, to small- and medium-sized streams where Salmon, Steelhead, and Bull trout (SSBT) are present. For a maximum, we assumed that the protecting cold water criterion would apply to all small and medium streams where ODF has determined a stream to have fish use (Type F). The main technical challenge is that ODFW’s Fish Habitat Distribution (FHD) GIS layer contains anadromous species distribution but does not contain stream size attributes while ODF's stream GIS layer, Streams FP, does not identify fish species present, but does contain stream size and upper extent of fish use attributes. In addition, the ODF stream and FHD layers are based on different source maps of the stream channels (called different “line work”).

For this analysis, we used ODFW's Fish Habitat Distribution (FHD) GIS layer which contains spatial information by species, for anadromous distribution. We also used ODF’s Streams FP GIS layer to identify stream size and upper extent of fish use. An existing model to determine the upper extent of fish use was used to determine the upper extent of fish use on streams where the end of fish use is currently unknown. Using GIS techniques, we overlaid the attributes from ODF’s Stream FP layer (small and medium Type F designation) with the species information developed by ODFW (Salmon, Steelhead, Bull trout distribution). This technique provides the number of stream miles that have SSBT distribution combined with stream size. With this process completed, we determined the number of miles of SSBT streams by stream size and determined the number of stream miles of small and medium Type F streams.

We further identified the number of acres in fixed-width riparian areas by buffering stream segments in GIS. We conducted this GIS process in increments of 20 feet, starting at 20 feet and ending at 100feet for SSBT distribution and ODF small and medium Type F distribution. Additionally, we used GIS layers to identify acres in buffers by ownership types (Private Non-Industrial, Private Industrial, State, Federal, and Tribal). The estimates of stream miles and acres encumbered were calculated separately for areas that are considered forested and non-forested. However, we assume that any potential rule changes would apply only to areas that are forested.

Change in Wood Production Values (Economic Information)

The Board directed the department to provide estimates of the economic costs of prescriptions to forestland owners. The above-described GIS analysis plays an essential role in calculating the change calculating change in wood production value. Give that each prescription will have an estimate of acres removed for timber productions, the department plans to calculate the land and timber values (LTV) of those acres using a capitalized net income value approach. The value of an acre of forestland is calculated as the present value of the net cash flow that can be produced over time (in this case in perpetuity). The approach is a value-in-use appraisal method that can represent the value of mature and immature stands, and bare land. The application of LTV to bare land is equivalent to soil expectation value (SEV), the present value of a perpetual series of timber harvest starting at age zero. The Oregon Department of Revenue (DOR) calculates an equivalent value for forestland by site index class for property tax purposes, although DOR uses a market-based appraisal approach. The DOR values provides a reference value for comparison of calculated SEVs.

The LTV calculation also requires an estimate of the distribution of restricted acres by site class and stand age or volume. The stand age and/or stand volume will be used to calculate the value of the standing timber portion. USFS Forest Inventory Analysis data can provide an estimate of the standing volume in riparian acres. The department will work with the RFPCs and stakeholders to review assumptions and estimates. The department will calculate LTV separately for industrial and non-industrial forestland, due to differences in standing volume and rotation ages. While the department does not expect the preliminary estimates will precisely represent the actual cost to individual forestland owners, singularly or in aggregate, the approach will provide a good representation of the differential economic cost by prescription.

Ecological Information

The Board also directed the department to develop ecological information related to each prescription, and in particular to look at impacts of proposed prescriptions on large woody debris (LWD) recruitment. Stakeholders also expressed interest in seeing if the department could provide information on impacts to fish.

Analogous to the approach discussed to calculate additional restrictions, the department will evaluate the ecological effects based on the equivalent buffer width of the prescriptions. The RipStream data indicates that cumulative basal area is nearly linear with respect to distance from the stream. The department plotted the mean values of cumulative total basal area for all sites as a function of buffer width (Figure 11) to allow the use of ecological function curves for both variable retention and no-cut buffer prescriptions.

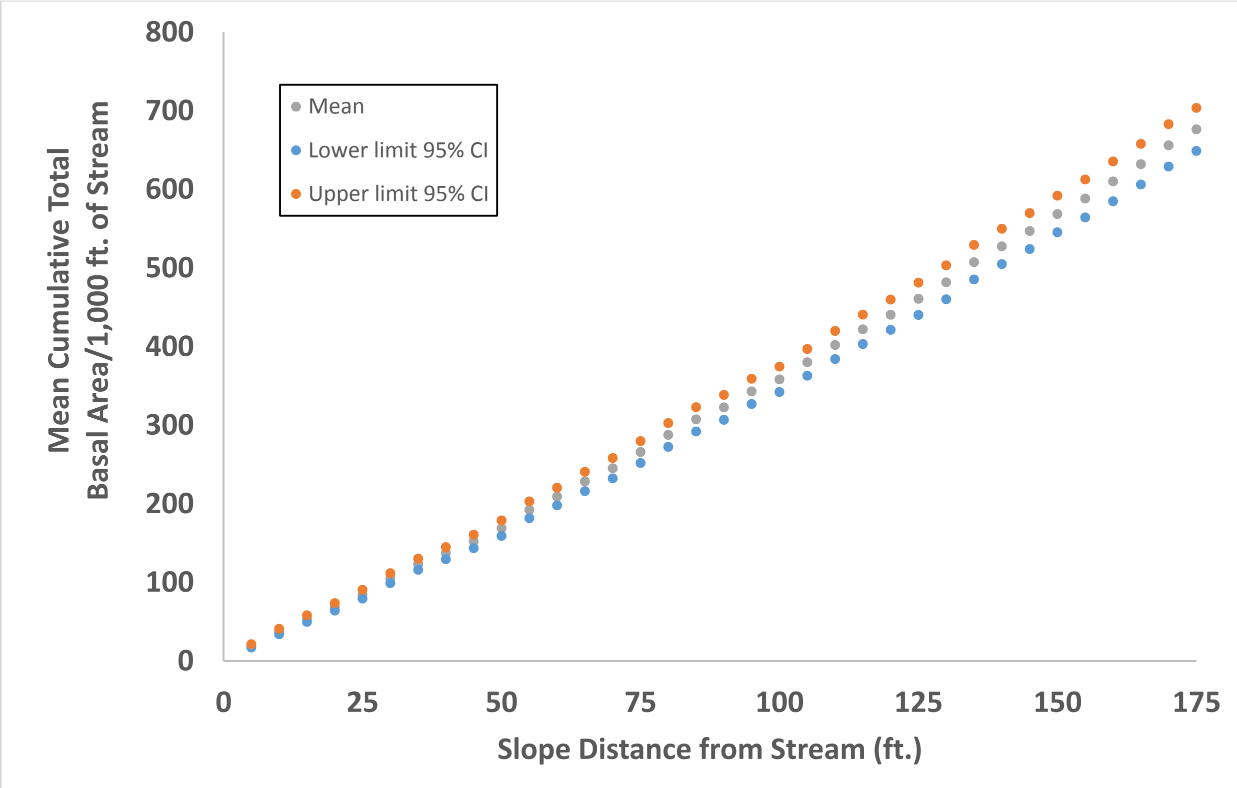


Figure 11. Mean cumulative total basal area with respect to slope distance from stream (based on 33 RipStream sites).

<u>Large wood recruitment</u>

Large wood recruited from riparian areas plays a key role in forming aquatic habitat in Oregon streams (Gregory et al. 1991). Levels of wood recruitment that are similar to mature riparian forests is an explicit goal of FPA riparian protection rules (OAR 629-640-0000 (2)). To provide insight on the effectiveness of various prescriptions at recruiting large wood, we developed a graph relating this recruitment to buffer width and mean cumulative total basal area (Figure 12). Data in Figure 12 are derived from McDade and others (1990) and Meleason and others (2003). McDade and others (1990) measured the source distance from small and medium streams for hardwood (86 pieces) and conifer (551 pieces) from unmanaged mature riparian forests. Meleason and others (2003) modeled the long-term recruitment of conifer wood from mature riparian forests for different buffer widths.

The department will use these data will to provide an estimate of the effectiveness of a prescription in recruitment of large wood, as measured as the percentage of wood recruited from mature riparian forests.

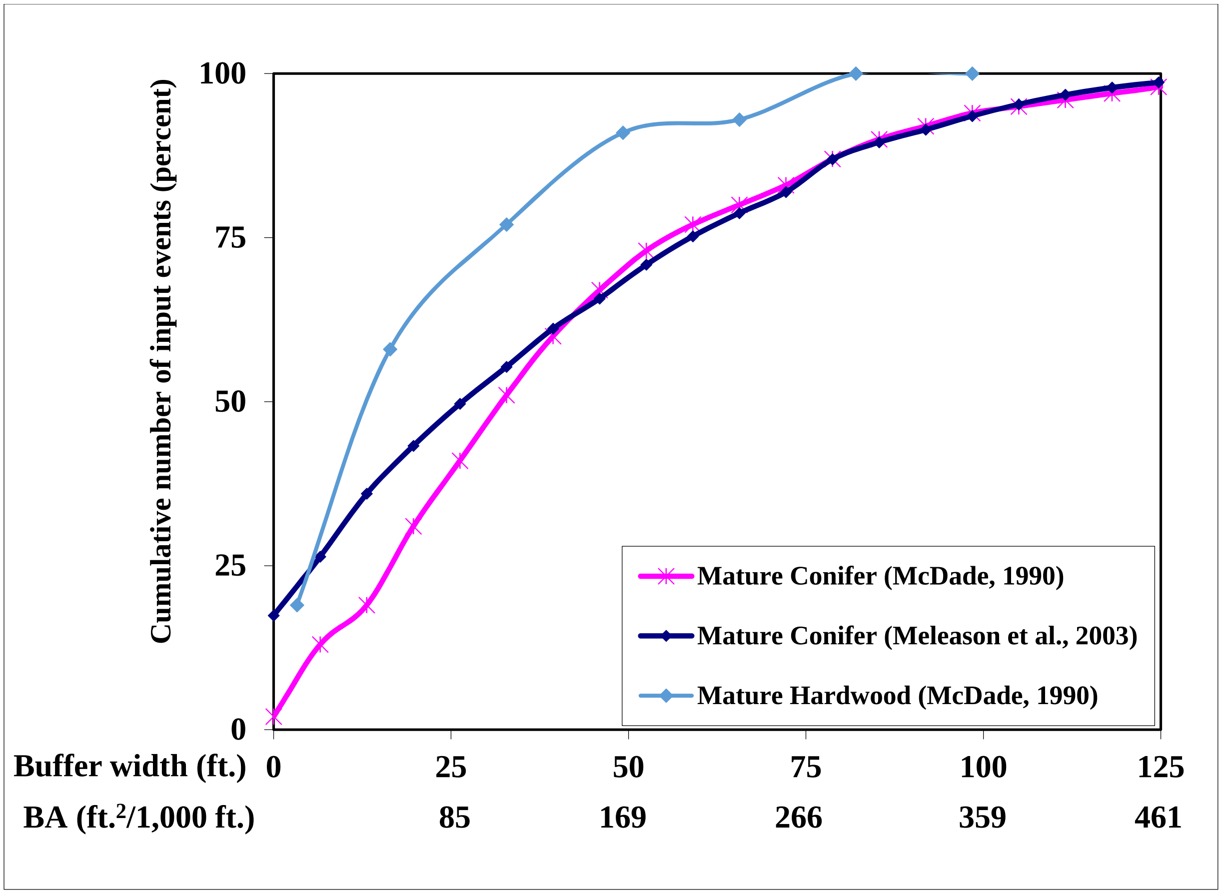


Figure 12. Cumulative recruitment of large wood (% of that from an unharvested reach) as a function of buffer width and cumulative total basal area. Note this basal area is derived from RipStream sites (see Figure 11), and does not necessarily represent the basal area found in either a mature hardwood or mature conifer riparian stand.

Fish Response

The department will gather qualitative information from a number of fish biologists to help gain perspective of potential fish response to changes in riparian protections. We have identified a number of questions to ask fish biologists that relate directly to the riparian prescriptions the Board asked the department to investigate, along with additional inquiries on potential new or altered prescriptions based on RFPCs and stakeholder discussions. We plan to include fish biologists representing state and federal agencies, landowners, and the environmental community. The possible fish response metrics may include but are not limited to changes in fish size, fish abundance, and fish distribution. We sought to align the draft questions with the Board defined range of riparian prescriptions:

1. No-Entry Buffer Prescription: Based on your professional experience, what may be likely fish responses from increasing current riparian management prescriptions from current FPA rules to a no harvest buffer of 50, 70, and 100 feet?

2. Variable Retention Prescription (Buffers with limited entry): Based on your professional experience, what may be a likely fish response from increasing current riparian management prescriptions from the current FPA basal area requirement to a variable

retention buffer with a 50% and 100% increase in the required residual basal area near the stream?

3. Based on you professional experience, what may be the likely fish response to an alternate prescription with potentially variable width buffers based on stream gradient, stream azimuth or other site factors? For example, a stream flowing east / west may receive a buffer that is wider on the south side of the stream and a narrower buffer on the north side of the stream or a stream that is relatively wide and low gradient receiving a wider buffer compared to a stream that is narrow and steeper gradient.

The department plans to finalize the questions based on input from the fish biologists, and information on prescription choices from the RFPCs and stakeholders. We will provide the biologists with background information on the riparian rule analysis process, current FPA riparian rules, the range of potential riparian prescriptions, and the geographic and stream reach scope of potential outcomes to help frame the questions. In addition to answering the questions, we will ask the fish biologists to provide a narrative description of potential fish response to varying riparian prescriptions.

Other Functions

In developing estimates for other riparian functions, we based our analysis on a report assessing the Northwest Forest Plan (FEMAT, 1993). This report assessed the cumulative effectiveness of various aquatic functions (litter fall, root strength, and shade) of riparian forests for different no-cut buffer widths expressed as a function of site potential tree height. This report was included in the technical basis for the current 1994 FPA rules (Lorensen et al. 1994). While picking a particular value for this height directly affects the response (i.e., cumulative effectiveness) with respect to buffer distance, the shapes of the curves and their position relative to one-another, are likely independent of this height. To assess ecological effectiveness using FEMAT assessments, we will analyze no-cut buffer prescriptions using a fixed maximum tree height (Meleason et al. 2003). For assessing variable retention prescriptions, we will use figure 11 to determine an equivalent fixed width buffer. Figure 13 illustrates the cumulative effectiveness of buffers with respect to both no-cut buffer width and mean cumulative total basal area (using a fixed height of 246 feet).

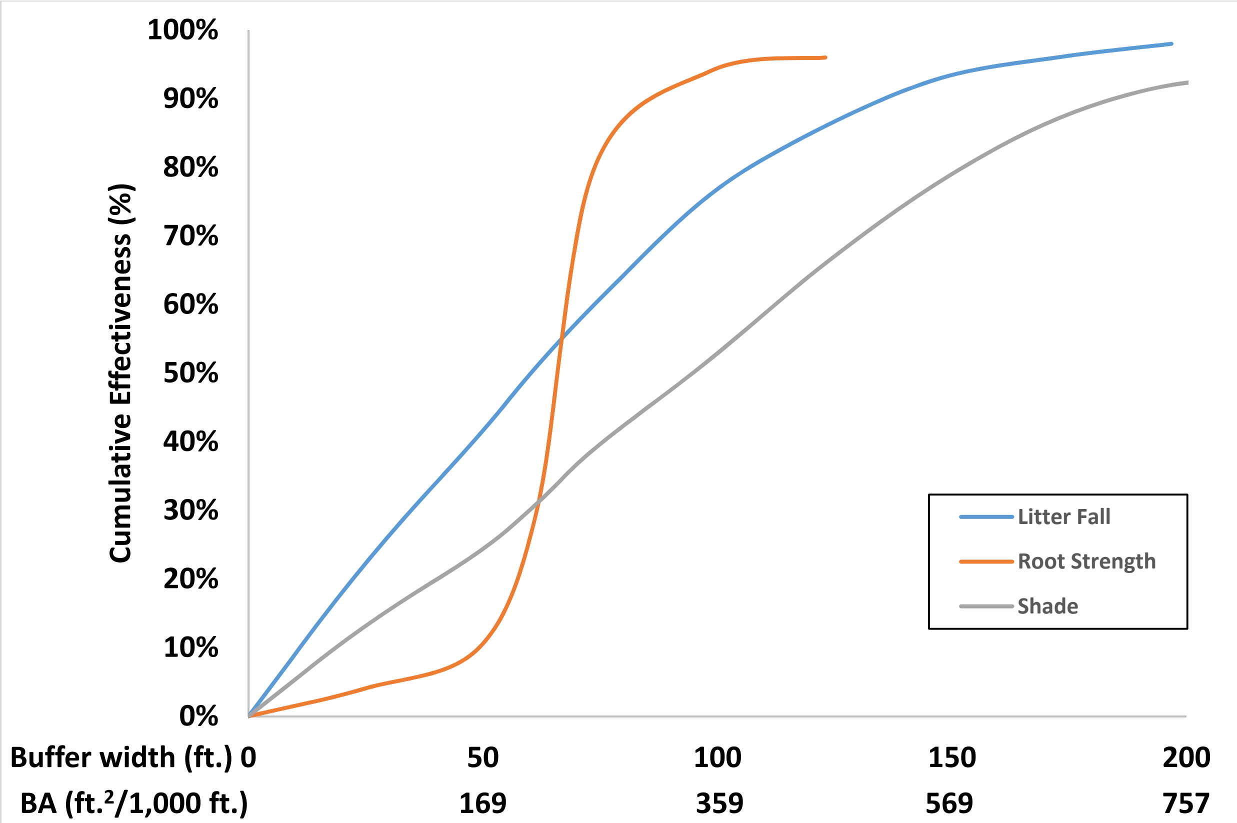


Figure 13. Cumulative effectiveness of litter fall, root strength, and shade as a function of buffer width (FEMAT, 1993; Meleason et al., 2003) measured in slope distance and mean cumulative total basal area. Note basal area is derived from RipStream sites (see Figure 11).

Geographic Extent to Which Prescriptions Apply

Geographic Regions

In September 2014, the Board directed the department to analyze to which Geographic Regions in western Oregon the prescriptions should apply (Attachment 1). The regions to consider include Coast Range, South Coast, Interior, Western Cascades, and Siskiyou (Figure 14).

The department approached this analysis from two perspectives. The first approach relies on the systematic review of buffer effectiveness at protecting stream temperature and shade (Czarnomski et al. 2013) provided to the Board at the November 2013 meeting. The systematic review had a secondary purpose, which was to inform the geographic scope of the rule analysis. Due to the geographically focus of this question, publications were limited to areas within, or similar to, western Oregon. Data assessed in the review came from three Geographic Regions: Coast Range (12 publications), Interior (11 publications), and Western Cascades (two publications).

The effectiveness of buffer prescriptions examined in the studies was compared between ODF Geographic Regions. No discernible pattern of effectiveness was found across Geographic

Regions for the various buffer prescriptions. This lack of pattern may be due to the small amount of data available.

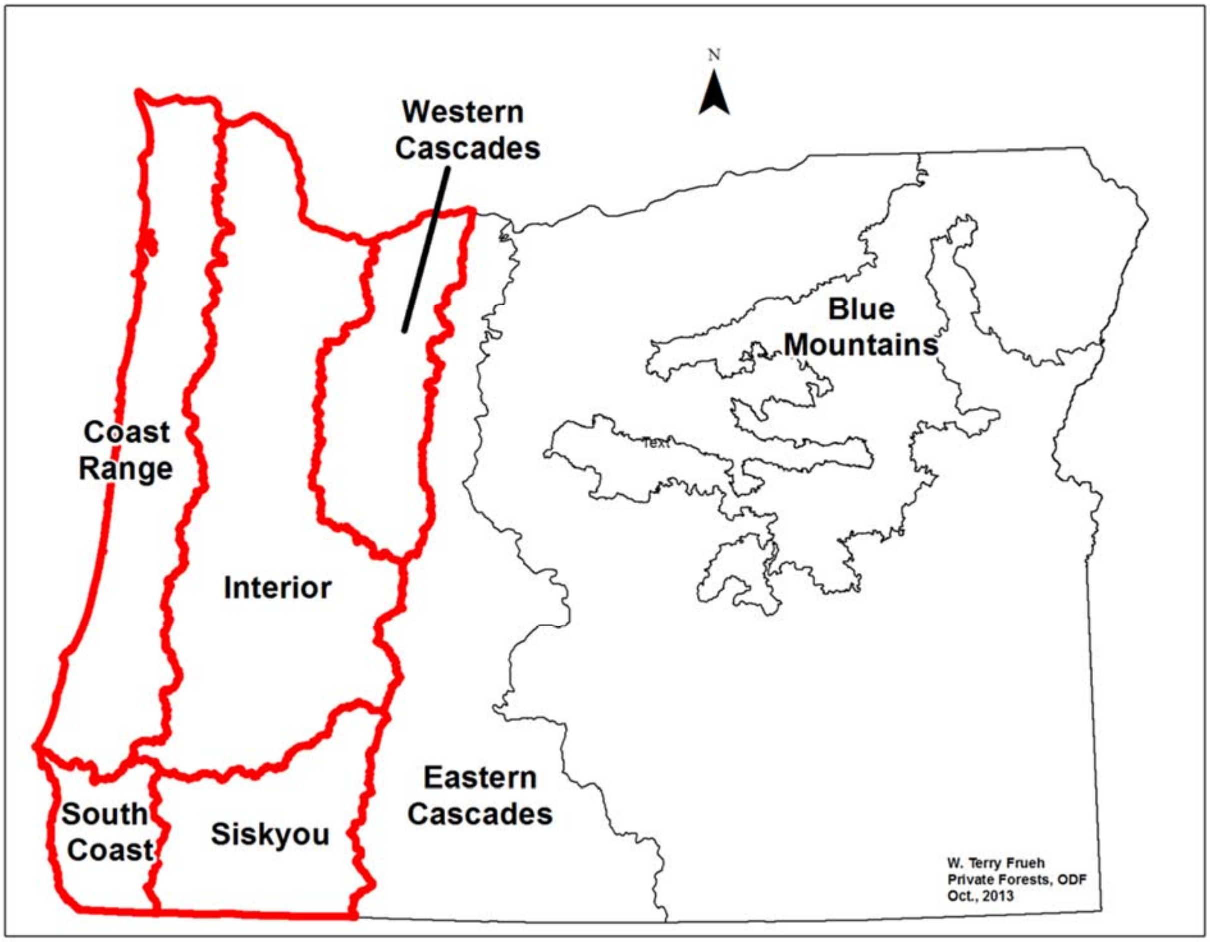


Figure 14. Geographic regions in red considered in the westside Riparian Rule Analysis.

The second approach considers the implications of current policy as identified in rule (OAR 629-640-0100 (6) (a)). These rules have standard targets of basal area as follows: all five geographic regions have the same targets (40 $ft.^2$/1,000 feet) for small fish streams. For medium streams, the targets are the same for Coast Range and South Coast (120 $ft.^2$/1,000 feet), and for Interior and Western Cascades (140 $ft.^2$/1,000 feet), with the Siskiyou having a target of 110 $ft.^2$/1,000 feet. The reason for parity in basal area requirements between particular geographic regions is the similarity of site growth potential modeled by Lorensen et al. (1994).

Stream Extent

A key aspect of defining the geographic extent of possible riparian prescriptions is determining to which stream reaches they will apply. To begin this delineation, the department considered the objective for this rule analysis:

Establish riparian protection measures for small and medium fish-bearing streams that maintain and promote shade conditions that insure, to the maximum extent practicable, the achievement of the Protecting Cold Water criterion.

And, what the PCW criterion states:

"[The PCW]…applies to all sources taken together at the point of maximum impact where salmon, steelhead or bull trout are present" [OAR 340-041-0028 (11)].

Thus, the PCW focuses on a subset of fish-bearing streams, i.e., those that have salmon, steelhead, or bull trout (SSBT) present. The Board directed the department to consider streams with a known presence of salmon, steelhead or bull trout the minimum amount of streams to which new prescriptions would apply. In contrast, all small and medium Type F streams (i.e., those mentioned in the rule analysis objective) are the greatest extent of streams to which new prescriptions would apply. The PCW provides additional guidance on where the rule should apply where it states "…all sources taken together at the point of maximum impact [POMI]…" This statement indicates that water flowing in to reaches with SSBT need to be protected such that the receiving reach of stream does not increase in temperature by more than 0.3 °C (i.e., the PCW limit).

In terms of which streams have SSBT, the Department of Fish and Wildlife has GIS data delineating SSBT habitat (both current and historic). ODF combined these data with their small and medium stream GIS data as a starting point for the stream reaches to which prescriptions should apply (see GIS analysis discussion above). To address the aforementioned incoming water to SSBT reaches, the department considered an analysis of downstream thermal recovery based on RipStream data (Davis et al. in prep), and will lay out the policy considerations related to this suite of information.

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