UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
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MEMORANDUM FOR: Nancy Munn, Ph.D.
Co-Chair, Interagency Coordinating Subgroup

FROM: Kim W. Kratz, Ph.D., Director
Oregon State Habitat Office

DATE: July 23, 2010

SUBJECT: Response to April 1, 2010, Request by the Interagency Coordinating Subgroup for Position Paper to Support the February 23, 2010 Elevation of Two Northwest Forest Plan Issues to the Regional Executives

Attached to this memorandum is a position paper that we are submitting in response to an April 1, 2010 request by the Interagency Coordinating Subgroup (ICS) that the Northwest Oregon Level 2 consultation streamlining team provide information to support the February 23, 2010 elevation of two issues to the regional executives. The position paper provides background information and a discussion of the scientific and policy aspects for each issue, and recommendations for resolution.

In the issue paper, we include recommendations for the makeup of an interagency science team to address these issues.

Your letter states that you intend to schedule a conference call or meeting to ensure your understanding of the issues. Please let us know when this will occur. In the meantime, if you have any questions about the information in the issue paper, please contact Jeff Lockwood at 503.231.2249. Thank you for the opportunity to articulate and explain our positions on these issues.

cc: Lee Folliard, BLM
Debbie A. Hollen, USDA FS
Michael Roy, USFWS

Issue Paper for Western Oregon
Oregon State Habitat Office, NMFS
July 23, 2010

Background

On February 23, the Northwest Oregon Level 2 consultation streamlining team elevated two issues pertaining to implementation of the Northwest Forest Plan to the Regional Executive Team for resolution. The first issue concerns the effects of thinning in riparian reserves with respect to wood recruitment, shade and water temperature. The second issue concerns timelines and processes for consultations under the 1999 interagency consultation streamlining agreement. On April 1, 2010, the Interagency Coordinating Subgroup (ICS) requested additional information concerning these issues. The Oregon State Habitat Office of National Marine Fisheries Service, Northwest Region, has prepared this issue paper in response to the request by the ICS.

Discussion of Issues

Issue 1: Disagreements about the identification and interpretation of the best available scientific information to determine effects of riparian forest management and restoration on salmonid fishes and their habitat are slowing interagency consultations and interfering with implementation of land management projects.

In this paper, NMFS will address the following topics that are related to Issue #1 above:
- Procedures for interagency consultations (necessary background information)
- Effects of thinning on recruitment of wood to streams
- Recommendations related to recruitment of wood to streams
- Effects of thinning on shade and water temperature
- Recommendations related to shade and water temperature

Procedures for Interagency Consultation

Section 7(a)(2) of the Endangered Species Act states that each Federal agency shall, in consultation with the Secretary (Secretary of Commerce in the case of NMFS), insure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of designated critical habitat. In fulfilling these requirements, each agency is to use the best scientific and commercial data available.

When submitting an action (such as a forest management project) to NMFS for consultation under the ESA, the agency proposing the action (action agency) first makes a determination of how the action will affect ESA-listed species and/or their designated critical habitat. The two choices are:

1. "May affect, likely to adversely affect," (LAA) and
2. "May affect, not likely to adversely affect" (NLAA).

A common disagreement between the action agencies and NMFS is whether management of riparian forests is LAA or NLAA listed species of anadromous fish and their critical habitats. According to the endangered species consultation handbook (U.S. Fish and Wildlife Service and National Marine Fisheries Service 1999):

> LAA is the appropriate conclusion if any adverse effect to listed species may occur as a direct or indirect result of the proposed action or its interrelated or interdependent actions, and the effect is not discountable, insignificant, or beneficial. In the event the overall effect of the proposed action is beneficial to the listed species, but also is likely to cause some adverse effects, then the proposed action "is likely to adversely affect" the listed species.

Also according to the endangered species consultation handbook:

> NLAA is the appropriate conclusion when effects on listed species are expected to be discountable, or insignificant, or completely beneficial. Beneficial effects are contemporaneous positive effects without any adverse effects to the species. Insignificant effects relate to the size of the impact and should never reach the scale where [incidental] take [of a listed species] occurs. Discountable effects are those extremely unlikely to occur. Based on best judgment, a person would not: (1) be able to meaningfully measure, detect, or evaluate insignificant effects; or (2) expect discountable effects to occur.

An "is likely to adversely affect" determination requires formal section 7 consultation. In a formal consultation, NMFS writes a biological opinion that analyzes the proposed action and determines whether it is likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of designated critical habitats.

Due to litigation history, the desire to avoid the additional time required to complete formal consultations, and perhaps agency cultures, the action agencies have consistently demonstrated a preference to complete consultations informally whenever possible. There are two main issues pertaining to management of riparian forests that have been the subject of repeated disputes between the action agencies and NMFS with respect to whether proposed actions are LAA or NLAA listed species and their designated critical habitats: (1) effects of silvicultural actions on recruitment of wood to stream channels, and (2) effects of silvicultural actions on stream shade and water temperature. We will address these issues in this order below.

Effects of Thinning on Recruitment of Wood to Streams

Refinement of Issues and Analysis

A draft manuscript (Pollock et al. in review, Appendix 1 to this document) analyzed forest growth and wood recruitment to streams for a thinning proposal in the Siuslaw National Forest (SNF) called the East Alsea Landscape Management Project. Although the model was based on stand characteristics, thinning prescriptions, and buffer characteristics that are specific to that project, the manuscript also provides an overview and analysis of some of the major concerns of NMFS with regard to riparian thinning projects that it has reviewed in other ESA consultations pertaining to Federal lands in western Oregon. The issues relevant to this elevation that are discussed in the manuscript and other relevant issues are briefly summarized below, but the draft manuscript contains information not presented below and both should be read to comprehensively understand NMFS's position on riparian wood recruitment issues.

<u>How much instream conifer wood is enough, when will it arrive and what will be its source?</u> These are good questions, but precise answers are challenging. For many streams, the volumes of coniferous wood in streams historically were orders of magnitude higher than they are today (many streams have little to no wood), suggesting that we are nowhere close to providing enough wood to maintain and restore anadromous fish habitat, and are not likely to be at that point any time soon (Harmon et al.1986, Sedell et al. 1991, Fox and Bolton 2007). Even with the best possible riparian management strategy, for most waterways (e.g., the Alsea River) there will be a wood deficit for well over a century, or longer. In the short-term (i.e., 50 years), many riparian forests will contribute little to the coniferous wood loads in streams. This is primarily because many riparian forests lack conifer trees close to streams. Silvicultural strategies designed to increase the number of conifers close to the stream while minimizing the loss of stream shade should be an important part of any riparian restoration strategy designed to improve stream habitat for anadromous fishes. However, it will still take many decades to centuries for such planted conifers to grow large, die and fall into streams. For many, if not most streams, the only way for instream wood levels to increase in the short term is for it to be directly placed into streams (e.g., see Roni et al. 2002). Thus, if the goal is to quickly and sustainably return wood levels to something close to what existed under natural conditions, it will involve maximizing wood inputs from existing conifer riparian forests for both the short and long-term, underplanting hardwood riparian forests with conifers for long-term wood recruitment and instream wood placement to address short-term instream wood deficits. Placed wood has a lifespan of decades and can serve as a bridge until long-term sources from riparian forests come into production (Roni et al. 2002, Reich et al, 2003).

Does heavy thinning of riparian conifer forests lead to more instream wood?

Modeling conducted by NMFS's Northwest Fisheries Science Center (NWFSC) (see Appendix 1) indicates that under most conditions, heavy thinning (i.e., below 100 trees per acre) of riparian conifer forests will probably not lead to more instream wood. (Preliminary analysis suggests moderate levels of thinning (i.e., 100-200 TPA) will not lead to more instream wood either, but this analysis is still in progress). The reasons for this are numerous. Thinning does accelerate the diameter growth rate of the remaining trees, but the tradeoff is that there are fewer trees available to fall into the stream. Thus heavy thinning provides a relatively small number of very large-diameter live trees sooner, but there are far fewer large trees over time relative to an unthinned stand. There is also the issue as to the extent to which mortality rates are reduced in a thinned stand. The overall health and stability of thinned trees (assuming they don't blow down in the first couple of decades following thinning (Grizzel and Wolff 1998, Bahugana et al. 2010) may improve from the trees being in a low-density stand, further reducing the production of instream wood. An unthinned stand will produce a high number of very large-diameter trees, but it will take a couple of decades longer relative to a heavily thinned stand. Overall, an unthinned stand will produce a higher number of both live and dead trees across a range of diameter classes and will produce far more dead wood over a much longer time frame relative to a heavily thinned stand (See Appendix 1). A strategy of thinning to accelerate the development of a few healthy, large-diameter trees does not translate into more large wood in streams.

Heavy thinning to ultimately create very large-diameter trees may, in some instances, be a worthwhile strategy in riparian forests near very large streams where very large wood (i.e., key pieces) is needed to create stable pools, but this requires thinning forests close to the stream, where erosional processes can recruit the wood or at least close enough that the base of the tree bole (and preferably the rootwad) can interact with the stream (e.g. see Fox and Bolton 2007). Thinning riparian conifer forests a distance from the stream will not necessarily accelerate the development of key pieces. While thinning increases tree diameters, it does not increase tree heights; thus, it will not increase the length of tree boles entering streams.

Further, most near-stream or floodplain forests, especially on larger streams and rivers, are a mix of hardwood and conifers, oftentimes mostly hardwoods (Pabst and Spies 1999, Hibbs and Bower 2001). There are a relatively limited number of instances where young conifer densities in such forests are so high that removing some of the conifers would accelerate the growth of the remaining conifers. That isn't to say no such instances exist, just that they are likely quite limited across the landscape. Even in those circumstances, heavy thinning of conifers near streams and on floodplains will still result in fewer larger trees over the long run. The tradeoff of getting a few more large standing live trees sooner at the expense of a continuous supply of both large and small trees over the long term period always needs to be considered.

Will riparian thinning along streams prone to debris flows increase the amount of wood (and sediment) in fish-bearing streams?

Conceptual models and empirical studies have been described suggesting that debris flows could in some cases make important contributions to the sediment and wood loads in salmon bearing streams (May and Gresswell 2003, Reeves et al. 2003, Benda, 2007) . This is an interesting idea, but the relative importance of this wood and sediment recruitment mechanism in creating salmon habitat is not well understood. Also, the time frames involved are long and recruitment relies on stochastic processes.

Heavy thinning in riparian forests along streams prone to debris flows has been advocated by the USFS and BLM in some projects as a means of creating large diameter trees faster and conditions that may lead to more sediment retention in such streams. However, the trade-off still exists that heavy thinning will accelerate the development of a relatively small number of trees at the expense of not having a higher density of large-diameter trees over longer time frames. Given the long time frames between debris flows (Benda 1990, May and Gresswell 2003), this likely is not a worthwhile trade-off, and may actually reduced the total wood volume delivered to these streams. Additional quantitative research and modeling are needed to examine the environmental costs and benefits of thinning in these areas.

Are there any kinds of riparian conifer forest where thinning might be beneficial?

Young, dense forest stands of conifers have high mortality rates, and land management agencies such as the USFS and BLM and wood recruitment models such as Riparian Aquatic Interaction Simulator (RAIS) and Streamwood suggest that many of the mortality trees are too short to fall into the stream when they die (Welty et al. 2002, Meleason et al. 2003). Additionally, field observations suggest small mortality trees in dense stands often decay in place and do not tip over, or if they do tip over, they hit another tree and do not fall to the riparian forest floor or into streams. The land management agencies have used these observations to argue for the removal of some small trees in dense stands. What needs to be determined or defined is the relationship between tree size, stand density and the likelihood of a tree falling. We are not aware of any data that would help to quantify this relationship, but it points to a shortcoming of wood recruitment models such as Streamwood and RAIS in that they assume that all wood that dies falls, regardless of diameter. In theory, growth and yield models in combination with field data could be used to determine what thinning regimes could be applied to young dense stands of conifer forests to maximize growth rates without reducing the amount of wood available to fall into streams or delaying the development of late-successional forest structure.

Isn't very large wood (e.g. 24" dbh or greater) the only size of wood needed to restore instream habitat?

This is not a debate about small wood vs. large wood; it is a debate about large wood vs. very large wood, or key pieces. Large wood generally is defined in the scientific literature as wood greater than 10-15 cm dbh and longer than 1-3 m (see summary table in Harmon (1986) and Appendix 2 to this document).

All wood and other organic material, whether large or small, is important to the proper functioning of streams; none of it is unimportant. However, empirical relationships exist between (1) the average minimum diameter of a piece of wood that can, by itself, create a pool in a stream, and stream size (Bilby and Ward 1989, Beechie and Sibley 1997) and (2) the volume of a piece of wood that can by itself remain stable during a 10-year flood, and stream size (Fox and Bolton 2007). Neither of these studies presume or conclude that other sizes of wood are unimportant. On the contrary, one of the studies (Beechie and Sibley 1997) found highly significant, positive relationships between (1) pool frequency and the total number of pieces and volume of large wood (≥ 20 cm diameter and ≥ 3 m in length) and (2) total wood volumes of large wood (≥ 10 cm diameter and ≥ 2 m in length) and the percentage of a stream that was pool habitat.

Numerous studies suggest that all organic matter, including the various sizes of wood, has functional value in streams (and riparian areas), and that these functions vary with size (Bilby and Likens 1980, Beechie and Sibley 1997, Gurnell et al. 2002). Of particular note is that large wood that cannot singly form pools will form pools in combination with other pieces of wood and other obstructions by forming "wood jams." Wood jams are common feature of natural streams of all sizes, and contain a distribution of wood sizes that, in concert, can form a semi-permeable structure that can retain sediment (such as that used for spawning), nutrients and organic material, as well as form pools upstream and downstream of the obstruction (Bilby and Likens 1980, Bilby 1981, Bilby and Ward 1991). By collecting organic material such as leaves, these sites provide a source of food for benthic invertebrates, which in turn provide food for salmonids and other taxa (Benke and Wallace 2003, Bilby 2003). These sites can also retain salmon carcasses, an important source of nutrients in many west coast streams (Cederholm and Peterson 1985).

How important is tree mortality caused by landslides?

Riparian tree mortality caused by landslides can deliver trees from beyond a site potential tree height and increase the likelihood that trees on the outer part of riparian forests are delivered to streams, which in some instances may transport wood via stream flow downstream long distances (Benda et al. 2003). The sliding itself can carry trees downslope, and trees on steep slopes are more likely to fall downslope (i.e. towards the stream) than trees on level ground. Landslide mortality is episodic and not related to competition mortality. The importance of landslides in delivering trees to stream depends on local topography and climate. In the Oregon coast range it may be a very important mechanism for wood delivery to streams.

Can large wood help to keep streams cool?

Large wood in streams can help store alluvium, which helps to create a hyporheic zone, that is, an alluvial aquifer that regularly interacts with surface water (Montgomery et al. 1996, Montgomery et al. 2003). Several studies suggest that streams with an alluvial aquifer (as opposed to bedrock streams) have cooler stream temperatures (Johnson 2004, Moore et al. 2005, Pollock et al. 2009). This suggests that riparian shade alone may not be sufficient to return some streams to their natural thermal regimes. This is another issue for which additional quantitative research would be useful and speaks to the fact that there are multiple functions of large wood that are beneficial to salmonids.

What are trigger trees?

Trigger trees are trees that fall and knock other trees into a stream, but do not fall into the stream themselves (Reid and Hilton 1998). In their study of Caspar Creek in northern California, Reid and Hilton (1998) found that 30% of the trees falling into streams were triggered by trees falling from farther upslope. More research on this subject is needed, but it speaks to the indirect importance of trees in the outer portion of the riparian zone for wood delivery to streams.

Are riparian roads an issue?

Many streams have parallel roads within the riparian forest and this substantially decreases the long-term wood recruitment potential to some streams. The mainstem of the Alsea River is a good example. An assessment of the amount of riparian forest and wood recruitment potential that has been lost as a result of roads would be helpful in assessing the potential for recovery of instream wood loads.

Does managing riparian forests for instream wood conflict with other ecological management objectives?

Generally speaking, managing riparian forests to maximize instream large wood production is consistent with management designed to create the four key elements of late successional forest structure; down wood on the forest floor, down wood in streams, snags and live trees (USDA and BLM 1994), Managing for large instream wood also results in the creation of large riparian wood and large snags, both of which are beneficial to numerous species other than salmonids, such as cavity nesting birds and certain amphibians (USDA and BLM 1994). Also of note is that when large trees fall to the forest floor they create “pit and mound” topography (Schaetzl et al. 1989) which, among other things, provides microsites (i.e. canopy gaps and suitable substrates) for the establishment of some conifers (Harmon et al. 1986, Harmon and Franklin 1989, Schrader 1998). This can be a particularly important function in forests where much of the large wood has been removed, as is the case in many riparian forests throughout the Pacific Northwest, which are likely to transition to a shrub dominated community without active intervention (Hibbs and Bower 2001). The lack of large wood on the floor of many riparian forests may be part of the reason they are lacking in conifers, due to a limited number of microsites created by these downed logs where the conifer trees can become established. Fluvially transported wood of all sizes can be deposited on floodplains, where it also can eventually be used as colonization sites for conifers.

Summary

Using SNF data, modeling and analysis by NWFSC suggested that the thinning program proposed in the East Alsea Landscape Management Project biological assessment would result in a long-term reduction in large wood to fish bearing streams and would delay, not accelerate the development of late successional forest structure. The SNF provided no data or analysis to suggest that the proposed thinning would accelerate the development of late successional forest structure or would result in an increase in the amount of instream wood. This problem isn't confined to the SNF, but a specific example, such as that provided (Appendix 1), helps to illustrate the general problems that can be created by excessive thinning of riparian forests.
The conceptual logic behind many riparian thinning programs such as the one proposed by the SNF appears to be:

1. Many young conifer-dominated riparian forests are too dense relative to natural conditions.
2. Heavy thinning of such forests will accelerate the growth of trees, leading to more larger diameter trees sooner.
3. This will lead to more larger diameter conifers falling into the stream sooner.
4. This is desirable because very large-diameter conifers are needed in streams to create and maintain salmonid habitat.
5. Thus, heavy thinning of riparian forests accelerates the creation of salmonid habitat.

While this approach may seem reasonable, there has been little analysis, data or scientific studies to support this logic chain. On the contrary, there is growing evidence to suggest that most of assumptions in the logic chain are flawed. For example, the attached analysis by NWFSC (Appendix 1) suggests that typical riparian thinning regimes will result in a mature forest with fewer large diameter trees, fewer large diameter snags, and fewer large diameter pieces of wood on the riparian forest floor and in streams, relative to natural conditions. This largely stems from excessive thinning. In regards to stream habitat, many of the negative impacts created by the existing riparian thinning proposals could be largely avoided with wider no-thin buffers (e.g., see Appendix 1) and removing far fewer trees during thinning operations. In examining forest thinning proposals designed to accelerate the development of late-successional forest conditions and restore instream fish habitat, NMFS is finding that, in many cases, they are likely to do neither.

Analysis and recommendations from the Oregon State Habitat Office of NMFS regarding instream wood recruitment issues follow below.

Use of the Analytical Process Document/NMFS's Matrix

The November, 2004, Analytical Process for Developing Biological Assessments for Federal Actions Affecting Fish within the Northwest Forest Plan Area (AP document in short) includes a Table of Population and Habitat indicators that is based in part on a "matrix of pathways and indicators" in NMFS (1996), which is to be used by the land management agencies to describe the environmental baseline and analyze the effects of forestry actions. The table includes as one indicator instream wood with a diameter of greater than 24 inches in diameter and greater than 50 ft in length. The document cites the environmental assessment for PACISH, a 1995 Federal forest management plan for Snake River basin forests, as the source of this indicator. Although NMFS included this value in NMFS (1996), and did not advocate changing the value during negotiations on the AP document, we recognize now that (1) it does not provide a target that is based on reference conditions for Westside forests, (2) this target is not sensitive to site-specific conditions (e.g., stream size and power), and (3) use of this target exclusively results in analyses that do not adequately address other sizes of wood that provide important ecological functions in streams.

The legend of the Table of Population and habitat indicators in the AP document states that values in the table of population and habitat indicators "are NOT absolute and may be adjusted based for local watersheds given supportive documentation." The table itself, immediately after identifying the target metric to consider (24-inch diameter and 50-ft length) states that "also adequate sources of woody debris are available for both long and short-term recruitment." The AP document does not say that other relevant information (e.g., the abundance of wood of other sizes) should not be considered. The exclusive use of the 24-inch/50-ft wood indicator by the USFS and BLM does not satisfy the requirement in 50 CFR 402.14 that both the action agency and NMFS use the best available scientific and commercial data, or (2) the requirement in 50 CFR 402.02 that the action agencies and NMFS analyze all effects of the proposed action, not just those described in the AP document.

The November 5, 2004, cover letter regarding AP document describes the use of the analytical process as mandatory; however, in the same sentence on the same page, it also says that it is "a supplemental tool for making ESA effect determinations." This administrative document, which was not the subject of a public notice and was not published as a regulation, cannot supersede promulgated agency regulations that require the action agencies and NMFS to consider the best available scientific information, and to analyze all of the effects of a proposed action, which would mean consideration of a broader range of sizes of wood.

Recommendations

- The USFS and BLM should include all sizes of wood in describing environmental baseline conditions and in analyzing the effects of its proposed actions, not just pieces of wood that are greater than 24 inches in diameter and greater than 50 ft in length.
- The USFS and BLM should adjust their tree diameter targets based on stream size. Data-based curves are available for both functional-sized and key pieces of wood (e.g., Fox and Bolton 2007).
- The USFS and BLM should leave more thinned trees on the ground in riparian areas, particularly close to streams, on floodplains, and on steep sideslopes where some trees are likely to slide down into streams, than are required to meet wildlife needs.
- In order to better portray environmental baseline conditions and to understand the likely effects of thinning proposals, the USFS and BLM should develop stand data separately for riparian and upland forests.
- In order to insure adequate recruitment of conifer wood to streams, the USFS and BLM should measure riparian buffers from the outer edge of streamside hardwood forests, where present.
- The USFS and BLM should work with NMFS to develop reliable methods of wood recruitment modeling and procedures that could be used routinely in ESA section 7 consultations to promote decisions based on data instead of concepts and generalizations from the scientific literature. At least until such time as these methods and procedures are in place, the USFS and BLM should routinely provide stand data to NMFS so that NMFS can complete a robust, quantitative analysis of wood recruitment.
- The USFS and BLM have pointed out that in some cases they have monitoring information that is relevant to riparian prescriptions, but have not routinely provided this information to NMFS in a manner that would be useful in analyzing the potential effects of thinning proposals. The USFS and BLM should work with NMFS to develop a protocol and format for providing relevant monitoring information in a timely manner.
- This issue likely is too complex and controversial for either of the Regional Technical Teams (RTT) under the Northwest Forest Plan streamlining procedures to rectify. Therefore, the ICS should refer this issue to a panel of scientists with demonstrated expertise in riparian forest ecology, including forest growth and structure, and the role of dead wood in riparian forests and stream function. The ICS should engage the Westside RTT in helping to frame the issues and questions for the scientist panel to evaluate, and in helping to translate their findings into land management strategies.

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Effects of Thinning on Stream Shade and Water Temperature

Background Information

Water temperature is a key factor controlling the productivity of salmon and steelhead populations, influencing physiology (McCullough 1999, McCullough et al. 2001), behavior (Sauter et al. 2001) and distribution (Dunham et al. 2001) of these fishes. Because high water temperatures are limiting the freshwater productivity of many species of anadromous fish listed under the ESA, NMFS generally has taken the position that increases in water temperature due to forest management activities would be LAA these species. Temperature thresholds for Pacific salmon and steelhead are reviewed in Poole et al. (2001a).

The water temperature within a stream is a function of both external factors, such as solar radiation, air temperature, precipitation and flow, and internal factors such as width-to-depth ratios, groundwater inputs, and hyporheic exchange (Poole and Berman 2001, Poole et al. 2001b, Moore et al. 2005a). Forest management can affect internal factors (e.g., width/depth ratios, connectivity of streams with floodplains, presence of alluvium) (Beschta et al. 1987, Bisson et al. 1987, Bilby and Bisson 1998, Johnson 2004, Pollock et al. 2009). Forest management can also affect external factors (e.g., the amount of solar radiation reaching streams) (Brown 1970, Brown and Krygier 1970, Brazier and Brown 1973, Steinblums 1977, Steinblums et al. 1984, Johnson 2004, Fleuret 2006, Teti 2006).

Issue Refinement

The action agencies and NMFS have frequently disagreed on:

(1) Whether thinning prescriptions for forest stands alongside streams with ESA-listed fish or critical habitat are likely to reduce shade and increase water temperatures, and

(2) Whether thinning prescriptions for forest stands upstream of stream reaches with ESA-listed fish or critical habitat are likely to reduce shade and increase water temperatures, and how far downstream any increases will travel.

Riparian Buffers

Stream shade correlates with the width of no-cut buffers in studies of clearcut logging (Brazier and Brown 1973, Steinblums 1977, Steinblums et al. 1984, Kiffney et al. 2003, Gomi et al. 2005, Fleuret 2006), but the relationship is quite variable, depending on site-specific factors such as stream size, channel aspect, topography, and forest structure and species composition. In some instances (such as narrow streams with dense, overhanging streamside vegetation, or stands on the north sides of streams with an east-west orientation), no-cut buffers as narrow as 30 ft adjacent to clearcuts can maintain stream shade (Brazier and Brown 1973). In Maine, a partial-removal buffer of 36 ft with adjacent clearcut showed minor, but not statistically significant increases of 1.0 –1.4°C, and a 76-ft partial-removal buffer with adjacent clearcuts and control streams showed no changes following logging (Wilkerson et al. 2006). Wilkerson et al. (2006) reported that the small size of the temperature changes might be partially explained by inflow of cold groundwater due to predominance of a glacial silt subsurface in the study area. Other studies indicate that buffers of 100 ft or greater are needed in some circumstances to protect streams from temperature increases with clearcuts (Steinblums et al.1984, Kiffney et al. 2003). Although clearcuts were used in these two studies, the results demonstrate that vegetation that is 100 ft away from streams contributes shade to streams in some situations, and that is relevant to riparian thinning projects.

There are relatively few studies of the effects of no-cut riparian buffers when forests are thinned instead of clearcut upslope of the buffer. Preliminary results of a study of thinning in western Oregon (Chan et al. 2004) found that light intensities near streams were unaffected when using “variable width” (mean 71 ft, range 40 to 70 ft) no-cut buffers. Decreases in effective shade, as measured by hemispherical photographs, from “moderate” thinning (80 residual TPA), “heavy” thinning (40 residual TPA), and from small patch cuts (i.e., openings less than 1 acre in size adjacent to the no-cut buffers) generally did not extend more than 30 to 60 ft into adjacent un-cut stands, suggesting that no-cut buffers somewhere in this range could, depending on site-specific circumstances, maintain stream shade. However, the paper cautions that the results may not apply broadly, saying

> a drawback to overlaying the Riparian Buffer study onto the DMS [density management study] framework was that sites were pre-selected and there were constraints to the random selection of streams and reaches, and constraints on randomization of various buffer treatments in relation to upland thinning treatments. As a result inferences from the study may be limited to the broader landscape (Olson et al. 2002).

Many, but not all, of the administrative units in the two action agencies use a document titled “Northwest Forest Plan Temperature Total Maximum Daily Load (TMDL) Implementation Strategies” (Strategies) (USDA Forest Service and USDI Bureau of Land Management 2005) in analyzing the effects of proposed silvicultural activities on stream shade[1].

The Strategies document provides several pathways for calculating the width of the riparian area adjacent to perennial stream channels that provides stream shade for the period of greatest solar loading (between 1000 and 1400 hours), known as the primary shade zone. It also provides the process for calculating the width of the riparian area that provides shade in the morning and afternoon (0600 to 1000 and 1400 to 1800 hours), known as the secondary shade zone. Fig. 11 of the Strategies indicates that 58% of the total solar radiation that could reach streams occurs between 1000 and 1400 hours, and that 42% of solar radiation occurs during the rest of the day.

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[1] The Siuslaw National Forest did not appear to rely on the Strategies in thinning proposals submitted to NMFS for consultation in 2009 and 2010.

Although the Strategies include a set of nomographs designed to help land managers determine the amount of "effective shade[2]" provided under varying stream orientation, tree heights, and slope in situations where the managers do not choose to model the shade provided by a thinning prescription, in practice, most projects reviewed by NMFS that have used the Strategies at all have used neither the nomographs nor a model, but default values for the primary shade zone provided in Table 3 of the Strategies, which gives a minimum width for the primary shade zone of 50-60 ft that is commonly used as the size of the no-cut buffer in thinning proposals from administrative units that use the Strategies. Outside of the no-cut buffers, some administrative units are applying silvicultural prescriptions that require retention of 50% canopy closure from the outer edge of the no-cut buffer to the outer edge of the secondary shade zone, which is defined in the Strategies (p. 21) as the area that provides shade during the "morning and afternoon hours (e.g., 0600 to 1000 hours and 1400 to 1800 hours)."

The NMFS commented on the Strategies in a May 22, 2007, letter (Appendix 3 to this document). Among other comments, NMFS noted that the Strategies lacks documentation of the data set used to develop the SHADOW model that is the basis for the Strategies, and includes no information about model validation, confidence limits and uncertainties[3]. The NMFS discussed these and other problems regarding the Strategies in a series of discussions with the USFS and BLM that culminated in a day-long workshop on September 2, 2009, that included representatives from USFS, BLM, NMFS, and EPA. In that meeting, the developer of the model described the basis of the model and how it was used to develop the Strategies. The NMFS and EPA identified the following problems with the Strategies:

- The paper advocates thinning to improve stream shade but does not explain how removal of vegetation by thinning could increase shade.
- The paper does not recommend any limit on thinning to avoid cumulative effects in heavily thinned watersheds.
- Table 3 is relied on by the land management agencies to apply the strategy, but it does not include information for trees greater than 100 ft in height, and the land management agencies have been submitting some thinning proposals with trees greater than 100 ft in height. The land management agencies have since reported that a new version of the Strategies includes trees up to 140 ft in height in Table 3, and although NMFS has seen the new table, it not seen the entire new version.

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[2] Effective shade is defined in the Strategies document as: (total solar radiation - total solar radiation reaching the stream)/total solar radiation

[3] The USFS has since provided NMFS with documentation for the model, and can provide this upon request. The NMFS has not evaluated this information to see how well it addresses our concerns regarding model documentation.

- Table 3 assumes uniform slopes adjacent to streams and uniform, dense conifer stands adjacent to streams, but in the field these assumptions are not always met. For example, where dense hardwood stands predominate the near-stream zone shade, the consequences of thinning the conifer zone may differ from those predicted in the paper. Or, where slopes shift moving away from streams to a steeper condition, the distance from the stream where a tree of a given height could provide shade would increase. The paper does not include guidance for how to deal with these common situations.

- Fig. 2 in paper shows very little difference in stream temperature between 80% shade and 100% shade, but this was a modeled result and is not based on empirical data.

- Fig. 6 also focuses on the 80% shade value, and there is a risk that land managers will focus on this number and reduce shade to 80% in areas where site-potential shade is higher, even though this value has weak empirical support.

- Fig. 8 (relationship between angular canopy density and buffer widths) is based on only one paper from 1972. Other papers containing information on this relationship (e.g., Steinblums et al. 1984) should be included in the approach.

- The citation for Fig. 10 (relationship between angular canopy density and stream shade) is not included in the References section of the paper, but according to the model's developer it is based on model runs, not empirical data. The paper should discuss available empirical data on this relationship, such as is given in Teti (2006), which shows that effective shade continues to increase steadily, even at high values of angular canopy density, unlike the model results in Fig. 10.

- The Strategies document does not provide any data describing the amount of shade provided by retaining of the 50% canopy closure in the "secondary shade zone". The NMFS understands that this was a negotiated value.

Additional information about problems with the Strategies document is in a November 18, 2004, memorandum from Peter Leinenbach, EPA (Appendix 4 to this document) and a June 19, 2007, email from Greg Pelletier, Washington Department of Ecology, that is embedded in a April 7, 2009, email from David Powers, EPA (Appendix 5 to this document).

In applying the Strategies, the USFS and BLM appear to be using Table 3 without demonstrating whether they considered the cautionary statement about Table 3 on p. 23 of the Strategies document:

Table 3 does not illustrate however, how the width of the primary shade zone may be over- or underestimated because the calculation does not account for such parameters as stream orientation or sinuosity. Thus, if for example, a stream is east-west oriented vegetation on the south bank will be more critical for stream shade than vegetation on the north bank. The calculation does not account for this. To obtain a more accurate estimate of the width of the primary shade zone analysis using the SHADOW model and not the hand calculation can be conducted.

The NMFS has not seen any documentation about how the USFS and BLM have considered these factors in designing or analyzing their thinning proposals. Modeling by EPA (Appendix 6 to this document) suggests that not only is aspect of the stream channel is important, but that the time of year and the size of the channel also influence which parts of the riparian zone provide shade, and the use of Table 3 does not account for these factors.

A number of biological assessments prepared by the USFS and BLM on thinning projects submitted to NMFS for ESA consultation describe how no-cut buffers often are larger in the field than the minimum sizes described in the Strategies document, due to factors that are identified during field layouts of timber sales. It is difficult for NMFS to analyze these potential additions to buffers since information on their location and size normally is not available to NMFS during the preparation of required consultation documents. In order to provide the benefit of the doubt to the ESA-listed species in the face of uncertainties, as is required by ESA case law, NMFS has not included these potential increases in buffer sizes in analyzing proposed thinning projects.

The NMFS is aware of one test of the SHADOW model that is the basis of the strategies in the the Rogue River−Siskiyou National Forest (Park et al. 2008). This involved measuring changes in angular canopy density as a result of thinning a riparian stand of second-growth trees that the paper characterized as:

> over-dense, 40 years old, 90 to 100 feet in height and 10 to 12 inches in diameter. The side slopes are less than 10 % with a north-south oriented intermittent stream flowing through the middle of the study area. The treatment area was selected for stand characteristic homogeneity consisting of 98% Douglas-fir with a small mix of alder and cedar.

The thinning in Park et al. (2008) brought stand densities down to 120-140 trees per acre (TPA). The Park et al. (2008) paper states that "There was no change in ACD before and after the thinning treatment with a no treatment buffer of 50 feet. This validates the specified no-treatment width recommended in Table 3 of the NFPTS for the tree height and percent hill slope of the study site." The NMFS is encouraged that some validation work related to the SHADOW model and the Strategies has been completed. However, the results likely would be different for stands that were not selected specifically due to their high uniformity, in situations with more intense thinning, or on streams with different orientations or adjacent side slopes. Also, the stream evaluated was very narrow, perhaps even intermittent, and had branches of riparian vegetation overlapping the channel (see Fig. 5 in Park et al. (2008)). The amount of light reaching the stream after thinning could be significantly higher for a wider stream that did not have overlapping vegetation.

As mentioned earlier, the results also might vary depending on time of year (see email and attachments from EPA in Appendix 6 to this document). Most of the thinning proposals that NMFS has received included thinning that was more aggressive than in this study, with average post-thinning TPA across multiple stands less than one-half of what was used in the subject study, and individual stands commonly having TPA less than one-third of what was used in the subject study. Also, the Park et al. (2008) paper did not measure radiation reaching the stream or changes in stream temperature. The SHADOW model, which is based on angular canopy density, apparently does not account for diffuse radiation that also contributes to stream warming, and apparently is not based on net radiation reaching streams. Moore et al. (2005a) explain the need to measure net radiation:

> The forest canopy changes the spectral distribution of light because plant foliage differentially absorbs and reflects the various wavelengths (Federer and Tanner, 1966; Vézina and Boulter, 1966; Atzet and Waring, 1970; Yang *et al.,* 1993). There is a greater reduction in the ultraviolet and photosynthetically active radiation ranges compared to longer solar radiation wavelengths. Longwave radiation to the forest floor increases as the canopy density increases because the forest canopy is usually warmer than the sky being blocked and has a higher emissivity (Reifsnyder and Lull, 1965). Although this increase somewhat offsets the reduction in solar radiation below the forest canopy, daytime net radiation below forest canopies is usually substantially lower than that in the open.

Moore et al. (2005b) used light meters to measure direct and diffuse radiation to determine net radiation reaching a stream. Story et al. (2003), Kiffney et al. (2003), and Johnson (2004) also used light meters to measure radiation reaching streams, as opposed to relying only on measurements of canopy density as is done under the Strategies.

Based on the information described above, the subject paper by Park et al. (2008) contributes needed information, but does not validate the approach in the Strategies other than with respect to changes in ACD under a limited — perhaps unusual — set of circumstances. The NMFS encourages the USFS to pursue additional validation work under a broader set of environmental and silvicultural conditions.

The interagency science team that reviewed of the draft environmental impact statement for the western Oregon plan revisions (WOPR) of the BLM (Drake et al. 2008) included an assessment of the information on stream that also was used to develop the Strategies document (e.g., Brazier and Brown (1972), and the "SHADOW" model). The document notes on p. 54 that:

> Analysis of stream temperature effects for the Alternatives cites an empirical study relating buffer widths to angular canopy density (ACD) (Brazier and Brown 1972), a modification of the “SHADOW” model (Park 1993) to relate ACD to effective shade, and model results relating effective shade to temperature change over a one mile stream segment (USDA and USDI 2005). There are issues with the use of these sources, their applicability across the Plan area, and the lack of model parameterization.
>
> Brazier and Brown (1972) do not provide a strong basis for a stream temperature strategy applied to the entire WOPR Plan area. This reference is over 30 years old: more recent approaches are described below. Brazier and Brown (1972) interpreted the ACDs associated with particular buffer widths based on a small sample size (n < 15), developed from < 7 streams from two parts of the Plan area (Umpqua and Siuslaw NF). Response of buffer strips > 60 feet is anchored by 2 data points (DEIS, Fig. 98). The applicability of these results to other portions of the Plan area is unknown.

The area covered by the Strategies document is even wider than the WOPR plan area, so the reliance on a small number of localized data points is even more of an issue.

There are modeling results that suggest that the Strategies will allow increases in water temperature in some situations. The Oregon Department of Environmental Quality (ODEQ) ran a model for Canton Creek using various strategies that included a 60-ft no-cut buffer and thinning to 50% canopy closure from 60 ft to100 ft away from the stream (Michie 2007). This is similar to riparian buffers and treatments used in thinning proposals that are the subject of this elevation, although the ODEQ assumed complete removal of trees beyond 100 ft, instead of thinning (under the Strategies, 100 ft would be well beyond the “primary shade zone”, so this may not be a large issue with respect to the modeling results). On the other hand, the ODEQ also assumed that non-Federal lands would have system potential vegetation from 0 to 300 ft from the stream edge, which is extremely unlikely and could minimize what actual cumulative effects on water temperature would be. The model results did show reductions in effective shade under the proposed management regime, although the increases were modest (less than 6%).

Based on the above information, application of the Strategies does not ensure that streams will be protected from water temperature increases related to forest thinning, and this remains an unresolved issue. Based on its understanding of the scientific literature, modeling results, and the need to give the benefit of the doubt to threatened and endangered species, NMFS has sometimes not concurred with the USFS and BLM that thinning proposals with 50-60 ft no-cut buffers and adjacent thinning are NLAA ESA-listed species, resulting in some cases in formal consultations. In these formal consultations, NMFS has sometimes required increasing no-cut buffers to ensure that shade is maintained and water temperatures are not increased due to reductions in the forest canopy.

Created Openings

Silviculture projects submitted for consultation or discussed in pre-consultation in recent years have frequently emphasized thinning of plantation forests, but in some cases also have included creation of forest openings or gaps, of indeterminate size, in riparian reserves of areas covered by the Northwest Forest Plan (e.g., East Alsea Landscape Management Project, SNF). The representative of the Willamette National Forest (WNF) in meetings discussing future revisions to a completed informal programmatic consultation on forest thinning actions stated the intention of the WNF to include creation of openings up to 5 acres in size under a "NLAA" determination of effect. The action agencies have not provided any analysis that demonstrates the likely effects of these openings on stream shade and water temperature, and their use remains an unresolved issue.

Extent of Downstream Effects

In cases where NMFS has decided that larger riparian buffers are necessary, it has had to decide how far upstream of the stream reaches with ESA-listed fish species the buffers should extend. Small forest streams are highly variable with respect to longitudinal temperature patterns. In a study of 36 headwater stream reaches that were not recently logged in managed forests in the Oregon Coast Range, mean stream temperatures generally increased moving downstream (Dent et al. 2008). However, changes in maximum stream temperatures moving downstream were highly variable, with some increasing, some decreasing, and some remaining the same. In some geomorphic situations, parcels of water warmed due to reductions in shade will cool partially or entirely as they move downstream due to inputs of cold tributary streams, groundwater inputs, hyporheic exchange, evaporative cooling, or conduction of heat into the streambed (Story et al. 2003, Johnson 2004). Observed rates of cooling as water warmed by clearcuts[4] moved downstream through reaches with conditions conducive to cooling have varied from 1-2 °C in 130 m, to 4 °C in 200 m, to 5°C in 300 m, to 5.5 °C in about 60 -120 m (McGurk 1989, Keith et al. 1998, Story et al. 2003, Moore et al. 2005b). In other geomorphic situations, increased heat loads from shade reductions will be transmitted downstream (Beschta et al. 1987).

Without reach-specific information about streambed characteristics and channel confinement, which is seldom available to NMFS in the information presented by the action agencies in thinning proposals, it is especially difficult to predict the extent of any downstream cooling of any warmed parcels of water. Also, case law on the ESA requires NMFS to give the benefit of the doubt in the face of uncertainties to the ESA-listed species. Therefore, NMFS has enlarged no-cut buffers to 100 feet on portions of the perennial stream network upstream of reaches with ESA-listed species in some formal consultations (these consultations can accommodate adverse effects on ESA-listed species and their critical habitats). The NMFS has commonly applied these buffers to the first 1000 feet of these streams, in order to provide maximum opportunities for

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[4] The source of the warming (clearcut or thinning) would not affect how quickly a warmed parcel of water cools below the cutting unit, although the amount of heat added could affect the cooling rate.

cooling of any parcels of water warmed by removal of shade-producing vegetation under thinning projects. The NMFS considers this biologically conservative approach to be consistent with its obligation to give the benefit of the doubt to threatened and endangered species of anadromous fish.

Recommendations

1. The USFS and BLM should adopt wider riparian no-cut buffers or retain additional vegetation to ensure that their thinning actions will not reduce stream shade or increase stream water temperatures in streams with ESA-listed fish until issues identified by NMFS in the TMDL Strategies approach are resolved.

2. The USFS and BLM should conduct additional validation monitoring for their TMDL Strategies approach under a wider variety of vegetative and topographic conditions and under thinning intensities and stream sizes that represent the range present in projects that have been submitted for consultation under section 7 of the ESA.

3. The USFS and BLM should conduct monitoring with light meters to determine if net radiation reaching streams remains constant when ACD remains constant following thinning at varying intensities.

4. The USFS and BLM should provide information to NMFS about vegetation status, stream widths, channel confinement, and extent of alluvial reaches in proposed thinning areas, where available, for perennial streams that are 1000 feet upstream or less of the habitat of ESA-listed fish. This will help in the development of site-specific buffers and in determining the likelihood of downstream cooling in these reaches.

5. This issue likely is too complex and controversial for either of the Regional Technical Teams (RTT) under the Northwest Forest Plan streamlining procedures to rectify. Therefore, the ICS should refer this issue to a panel of scientists with demonstrated expertise in riparian ecology, factors controlling stream water temperature and in water temperature modeling. The ICS should engage the Westside RTT in helping to frame the issues and questions for the scientist panel to evaluate, and in helping to translate their findings into land management strategies.

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Issue 2: **The Level 1 and 2 teams are concerned that the processes and timeframes in the 1999 streamlining agreement are not being met or implemented. The teams want the agreement updated to reflect policy changes, provide predictable timeframes, and clarify agreements, roles, and operating procedures.**

Current streamlining agreements on consultation streamlining require conclusion of consultation for non-programmatic actions within 30 days for informal consultations, 60 days for formal consultations, and 90 days for programmatic consultations. Streamlining timelines in the NW Oregon Provinces (North Coast & Willamette) have not consistently been met in recent years. This has been primarily due to workload issues with the designated Level 1 representative for the two Provinces, but also, to a lesser extent, to disagreement on how to evaluate project effects on stream temperature and wood recruitment (issue #1 of subject elevation). As these delays became apparent, NMFS notified the Federal land management agencies of the situation and encouraged them to account for the extended timelines in their project planning process.

To address the workload issue, NMFS has increased the number of staff working on Federal land management agency consultations in the NW Oregon Provinces. Due to the need to bring new staff up to speed and continued disagreement on project effects, consultation delays have persisted. At this time, NMFS staff are sufficiently trained and the agency expects a reduction in consultation delays. Resolution of the temperature and wood issues through the subject elevation is likely to further reduce process delays. However, NMFS still is unlikely to be able to always meet the streamlining deadlines under current circumstances.

While NMFS acknowledges delays in consultations have occurred, the examples of Maxfield Creek (2006), the 2008 NW Programmatic, and the 2010 Thinning Programmatic are not examples of delays associated with staff workload. The Maxfield Creek consultation was one of the first biological opinions completed in the Provinces using the procedures in the AP document. As such, no template existed for drafting the document and extensive internal review, including legal review, and coordination with the BLM was needed. The 2008 NW Programmatic has been delayed due to a decision by managers at NMFS to consolidate it with the SW Programmatic in order to increase consistency, which resulted in a new proposed action from the action agencies that NMFS received for consultation on June 14, 2010. The 2010 Thinning Programmatic was delayed because of failure to resolve the temperature and wood recruitment issues, which are included in the subject elevation as issue #1.

The July 27, 1999, Streamlining Guidance indicates that the 60-day formal consultation timeline may not always apply:

> However, exceeding 60 days may be acceptable if the consultation is very large scale and complex such as the multi-year, multiple administrative unit, programmatic type requiring extensive regulatory agency analysis and review to complete the BO. The 60-day response may also be unlikely or uncertain in other situations, such as applicant involvement or elevation of issues beyond the Level 1 team. [Streamlined Consultation Procedures, July 27, 1999]

The same guidance (July 27, 1999) also states:

> Prior to submitting the final BA, the Level 1 and 2 teams must identify the need and concur on the extension of the BO response timeframe. An agreed on response date will be established at the time. Extensions should be reported on the quarterly reporting form (see Section II.D). Teams should document the agreement in a brief note and notify their ICs.

NMFS provided a blanket notice of extended timelines during the period in question (2006-2010), but did not carry out individual agreements with the action agencies. In part, this was due to competing priorities, including competing priorities with other Federal land management agency consultations, that made the identification of completion dates problematic. This remains a problem (e.g., Siuslaw National Forest's East Alsea and Salmon/Neskowin projects, NW/SW Programmatic consultation, and elevation issue paper all being done by same person at NMFS).

Various memoranda have updated how the 1999 Streamlining Guidance is to be implemented, the most recent being a December 13, 2007, memorandum that addressed identification of priorities, programmatic consultations, use of counterpart regulations for National Fire Plan projects, and maintaining streamlining capability. Regarding one of the topics in this memorandum, NMFS has attempted to maintain streamlining capability by increasing staffing and training.

A May 27, 2003, memorandum from the Interagency Coordinators Subgroup included the following information that is relevant to the current elevation:

> Action agencies must ensure projects are fully described and their effects are identified and appropriately analyzed by Interdisciplinary Teams as part of the NEPA process. A standardized format should be considered where appropriate. It is essential that the project description and analysis of project effects be closely coordinated with FWS and NOAA Fisheries staff. The BA should be developed from the description of the proposed action and the effects analysis contained in the NEPA document where they have been closely coordinated with FWS and NOAA Fisheries Level 1 staff.

The consulting agencies should be involved early in project planning to ensure that the NEPA analysis includes a clear rationale for the effects determination and that the BA documentation is adequate. This involvement should be based on project complexity and scope, potential project effects on listed species and designated critical habitat, and the need for input into project design and identification of effects.

Recommendations:

1. The streamlining deadlines (30, 60, and 90 days) likely will not be attainable for NMFS, even with the minimal new staffing increases. The NMFS recommends extending the formal consultation deadline to 135 days, the maximum time allowed by statute. This would better reflect the time needed to draft a biological opinion for non-programmatic actions (mean 191 days, range 97 to 336 days, n=10 for calendar years 2008 through 2010, to date) and allow for the required internal reviews.
2. The NMFS should acknowledge its requirement to complete formal consultation in 135 days on non-programmatic consultations or request to extend the timeline upon mutual agreement by the action agency.
3. The NMFS recommends extending the informal consultation timeline to 45 days. This would better reflect the time needed to draft a consultation document (mean 40 days, range 6 to 55 days, n=8) for calendar years 2008 through 2010, to date) and allow for the required internal reviews.
4. The current streamlining requirement to review consultation packages for adequacy and notify the action agency within 2 weeks of receipt if inadequate is unrealistic considering staffing levels at NMFS and the complexity of many consultations. The NMFS recommends changing this deadline to 30 days after receipt of the consultation request package.
5. To improve the understanding by NMFS's biologists of proposed actions and site conditions, the USFS and BLM should engage NMFS Level 1 representatives in project field reviews prior to submittal of biological assessments to NMFS for review, and early enough to inform action agency project design decisions. Administrative units that have been arranging field visits should continue to do so, and NMFS's managers should continue to support the participation by staff by allocating time for this important function. This is consistent with direction in the May 27, 2003 memorandum from the Interagency Coordinator's subgroup.

6. To improve consultation efficiency, all administrative units of the action agencies should follow the 1999 streamlining guidance regarding providing draft biological assessments "to the Level 1 team for review and preliminary acceptance of the information and effect determinations. The objective is to ensure that the BA is complete[5] and will not result in additional requests for information after final submission."
7. The NMFS should continue to focus on identifying information needs prior to acceptance of draft BAs at Level 1, and attempt to minimize later requests. The ongoing seasoning of new employees at NMFS is likely to contribute to progress in this area, due to their becoming more familiar with NMFS's review process, although in writing biological opinions questions are always likely to arise. In turn, the action agencies should recognize that if they want NMFS to consider site-specific information in its analyses, they will need to provide that information. Not providing all of the information requested by NMFS during and after Level 1 review may result in a more conservative analysis that could result in an unnecessary formal consultation or terms and conditions that are more extensive than otherwise would be necessary.
8. To help ensure that adequate information is available to NMFS's biologists and reduce the need to request additional information, the USFS and BLM should submit all relevant reports (i.e., NEPA documents, hydrologic reports, results of watershed analyses, relevant monitoring reports, etc.) to the Level 1 consultation streamlining teams electronically (or provide links to them if they are posted on the Internet) with biological assessments.
9. There are two "big picture" recommendations:
    a. The USFS and BLM should work with NMFS to update the July, 1999, streamlined consultation procedures to address the past decade's worth of legal cases, and to accommodate NMFS's QA/QC review process that is required by its headquarters and its policy requirements for document content, with a goal of realistic and predictable time frames for completing consultation.
    b. The USFS and BLM should work with NMFS to review whether the streamlining guidance has effectively or efficiently accomplished the desired goals, to identify problems and potential solutions related to future direction, including alternative approaches, if necessary. As part of this review, each agency should review whether the existing streamlining guidance is consistent with statutory and legal requirements, and how any deficiencies can be addressed.

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[5] The NMFS interprets "complete" to mean that the document contains sufficient information to initiate consultation.

Appendix 1

Effects of Riparian Thinning on Development of Late-Successional Forest Structure in the Alsea Watershed, Oregon, USA.

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ABSTRACT

In functional Douglas-fir dominated riparian forests, key structural attributes are large live trees and abundant dead wood in the form of large snags, large wood on the forest floor and large wood in streams. Because the structure created by large dead wood is important to many aquatic and riparian dependent species, a key goal of restoration efforts has been to thin dense young conifer forests to accelerate the development of forest structure that includes large diameter live trees and large diameter dead wood. We examined a proposed riparian and upland thinning program in the Siuslaw National Forest to assess the extent to which a proposed thinning program would accelerate the development of key forest structural elements. We modeled average forest growth conditions using Organon and Streamwood and found that in the century following a typical thinning, which removed 73% of the trees in a stand, essentially all large wood delivery to streams was eliminated. One hundred years after thinning the number of live trees > 18” dbh was half that of the unthinned stand, and the number of live trees > 24” dbh was also lower in the thinned stand. One hundred years after thinning, the number of mortality trees > 18” dbh and > 24” dbh was also lower in the thinned stand, though mortality of large trees in both the thinned and unthinned stands was quite low. Thinning did accelerate the development of large diameter trees by about 20 years relative to the unthinned stand, but this benefit was short-lived because the higher number of trees in the unthinned stand allowed it to produce far more large diameter live and dead trees in the long run. A century after thinning, a 60 foot no cut buffer between a stream and the thinned forest provided 56% of the stream wood relative to an unthinned stand, while a 150 foot no cut buffer provided 91% of the stream wood relative to an unthinned stand. Our results suggest that the thinning regimes proposed by the Siuslaw National Forest will delay the development of key structural elements of forest and stream habitat by more than a century. The delay in stream habitat recovery can be minimized by creating a no cut buffer of 150 feet or more in width between streams and any forest thinning operations. Some of the delay in forest structure development caused by thinning might also be reduced by removing far fewer trees.

INTRODUCTION

In much of North America and in particular along the West Coast, riparian reserves have been established for the purpose of protecting aquatic and riparian dependent species, many of which are in population decline (Nehlsen et al., 1991; Riccardi and Rasmussen, 1999). In the vast, conifer-dominated region of the West Coast of the United States and Canada, key structural attributes of functional riparian forests are large live trees and abundant large dead wood in the form of snags, wood on the riparian forest floor and wood in streams (Harmon et al., 1986; Spies et al., 1988; USDA and BLM, 1994). In this region, large dead wood provides critical habitat for a range of aquatic and riparian dependent species, most notably the culturally and economically important salmonids, but also numerous amphibians, mammals and birds (USDA and BLM, 1994). For salmonids, instream wood is essential to the maintenance of habitat because it forms pools, traps and sorts gravels, increases hyporheic exchange, modulates stream temperature, and provides cover and increased habitat complexity (Montgomery et al., 1995; Beechie and Sibley, 1997; Moore et al., 2005).

However past forest management practices have eliminated large snags and large wood across much of the riparian network and the past practices of stream cleaning and splash damming has left most streams bereft of large wood, leading to degradation of riparian and stream habitat (Meehan, 1991; Sedell et al., 1991). Because of the number of aquatic and riparian-dependent species that rely on large wood and because of the long times involved in creating large diameter trees, there have efforts to accelerate live tree growth by thinning so as to accelerate the return of large live and dead wood to these systems (Swanson and Franklin, 1992; USDA and BLM, 1994).

On United States Forest Service (USFS) and Bureau of Land Management (BLM) lands throughout western Oregon and Washington, an Aquatic Conservation Strategy was adopted as part of the Northwest Forest Plan to protect and restore the habitat of aquatic and riparian-dependent species (USDA and BLM, 1994). Core elements of this strategy were the designation of Riparian Reserves and Late Successional Reserves. Riparian Reserves are portions of the watershed where riparian dependent resources receive primary emphasis and where silvicultural activities are allowed only if they help to restore riparian functions. The purpose of Late Successional Reserves is to protect and enhance late successional ecosystems for the benefit of species that are dependent on them. Silvicultural activities within Late Successional Reserves are allowed if they benefit the creation and maintenance of late successional ecosystems (forests > 80 years old). Riparian Reserves should also function to provide connectivity between Late-Successional Reserves (USDA and BLM, 1994). The Northwest Forest Plan identifies four major structural attributes of late successional ecosystems: large live trees, standing dead trees (snags), logs on the forest floor and logs in streams. Many aquatic and riparian-dependent species require similar structure, and in particular for aquatic species, large instream wood. Thus, management goals of Riparian Reserves and Late-Successional Reserves should largely overlap. Thinning young forest stands (< 80 years) is allowed within Late-Successional Reserves and Riparian Reserves, because if done properly, can accelerate the development of large diameter trees, which in turn can accelerate the development of large snags and large wood on the forest floor and in streams. However excessive thinning can result in the loss of these core structural attributes over long time periods, producing forests with an unnaturally low densities of large diameter trees and little in the way of snags or down wood.

While both the USFS and BLM have embarked on thinning programs in young riparian forests with the goal of accelerating the development of late-successional forest structure, there has been little assessment of the long-term impacts of the thinning and whether these goals are likely to be achieved. The operating assumption has been that since historically, low density stands of Douglas-fir produced larger trees faster relative to higher density stands, thinning to low densities will accelerate the development of late-successional forest structure by accelerating the diameter growth of trees (Poage and Tappeiner, 2002).

In this analysis, we tested the assumption that a major thinning program proposed by the Siuslaw National Forest in the Alsea River watershed (Siuslaw-National-Forest-Central-Coast-Ranger-District, 2010) will accelerate the development of late-successional forest structure. We modeled the effects of thinning on the four major structural attributes of late successional forests: large live conifers, large snags, large wood in streams and large wood on the forest floor. We examined these structural attributes in the century following thinning and compared them to unthinned stands, with a particular emphasis on the effects of thinning on instream wood recruitment.

SITE DESCRIPTION

The Alsea watershed is located in the Coastal Range of western Oregon, and most of the land is administered by the USFS, Siuslaw National Forest. The geology of the Coastal Range consists primarily of marine sandstones and shales, with isolated pockets of basalt. The terrain is mountainous and highly dissected. Elevations range from sea level to 1250 m. The climate is temperature maritime with warm dry summers, and mild wet winters. Most of the peak flows occur in late fall or winter and low flows occur in late summer. The watershed is heavily forested in conifers, with Douglas-fir (*Pseudotsuga menziesii*) the most abundant species. In these forests, the main successional pathway is characterized by Douglas-fir colonization after fire, Douglas-fir dominance during the first 200 to 300 years, and then slow succession to a “climax” forest dominated by the shade tolerant (but fire intolerant) western red cedar *Thuja plicata*, and western hemlock (*Tsuga heterophylla*) (Munger, 1940). However, because the historic fire return interval in these forests averaged between 180 and 230 years (Agee, 1993; Long and Whitlock, 2002), many of these stands were continually dominated by Douglas-fir, since stands were often reset by fire prior to succeeding to western hemlock and western red cedar dominance.

As a result of past timber harvest practices, riparian forests in the Alsea watershed and throughout the coastal range often have a band of alder adjacent to the stream on narrow floodplains, which transitions to a Douglas-fir dominated forest on hillslopes as conditions become more mesic (Pabst and Spies, 1999; Hibbs and Bower, 2001). Many of these riparian alder forests historically were dominated by conifers, but converted to hardwood stands following logging. Currently there are many alder-dominated forests where conifer regeneration is sparse and there is concern that they may not transition back to conifer-dominated forests without silvicultural treatments (Hibbs and Bower, 2001).

The majority of streams in drainage networks are small, non-migrating channels that receive little wood from forests that are further away than the maximum height that the Douglas-fir typically grow. This length, measured horizontally away from the streams approximately defines the functional width of riparian zones in terms of wood production (Van Sickle and Gregory, 1990). In the Siuslaw National Forest, Douglas fir typically grows about 250 feet high, depending on site quality, a number referred to as the site potential tree height (SPTH). The Northwest Forest Plan, which covers United States Forest Service and Bureau of Land Management lands in western Washington and Oregon, defines the riparian zone as 1-2 SPTH depending on stream size (USDA and BLM, 1994), which in the Siuslaw, translates to buffer widths of 250-500 feet.

METHODS

THINNING REGIMES

The Siuslaw National Forest has proposed to thin Douglas-fir dominated forests as part of program called the East Alsea Landscape Management Project (Siuslaw-National-Forest-Central-Coast-Ranger-District, 2010). This project proposes various levels of thinning in 135 units totaling 3,777 acres for a commercial harvest of 48 million board feet (Table 1). Much of the thinning will occur in Riparian Reserves. Most of the stands originated 30-50 years ago, when Douglas-fir was planted following clearcut harvest of the original forest. The average stand age is 39 years (sd = 9.0) and ranges from 18-68 years. Across all stands, the thinning is heavy. Stand densities currently average 226 TPA (range = 85-440 TPA) and post harvest they will average 60 TPA (range = 72-120 TPA), a 73% reduction on average.

We analyzed a proposed harvest unit (#504373) in a 37 year old Douglas-fir stand along Lake Creek, a coho bearing stream and a tributary to the Alsea River. This unit was chosen because it represented a stand close to the average pre and post harvest condition of all the proposed harvest units in the East Alsea Landscape Management Project in terms of age, diameter, height and remaining TPA after thinning (Table 1). Our analysis was hampered somewhat by the fact that the USFS would not provide us with their stand data, which should list the species, diameter, and estimated trees per acre of each tree examined, as well as the height and age of a subset of individuals. Because these data were not available, we used the stand summary data they did provide, which lists the average diameter (dbh), average tree height, TPA and age for each proposed harvest unit.

INSTREAM WOOD

For the purposes of analysis, we examined this “average” stand for its’ potential to provide instream coniferous LWD under two broad scenarios, 1) assuming that there was no alder band, that is that the Douglas-fir forest extended to the stream edge and 2) assuming that there was a 30 foot alder band between the stream and the Douglas-fir forest. Both these scenarios are common in the riparian forests of the Alsea watershed. Analyses of aerial photography indicates these riparian forests have a band of alder adjacent to the stream, averaging about 30 ft wide when present. Thus an estimation of the amount of coniferous wood provided to a stream into the future needs to account for both the width of the alder forest and the width of the no cut buffer beyond the alder forest. We then examined the effects of various no cut buffer widths on cumulative instream LWD production for a century following thinning. Because the stands are Douglas-fir, we simulated their growth using Organon, a widely used individually-based model developed and maintained by Oregon State University and specifically designed to simulate the growth of Douglas-fir (and western hemlock) stands in western Oregon and Washington (Hann et al., 2009). We used the Northwest Oregon Variant and parameterized Organon using the pre and proposed post harvest data (TPA, dbh, age and height) provided by the Siuslaw National Forest using the data from stand # 504373 (Table 1). Because the stand data provided were averages rather than a tree list, we used the tripling function in Organon to provide a distribution of tree diameters and heights and to simulate stochastic mortality not related to competition. We limited our discussion of simulated stand growth to 100 years post harvest, because: 1) that is the approximate upper limit for which Organon accurately projects stand growth 2) large wood recruitment from ingrowth following thinning is limited over this time frame and thus does not need to be modeled and 3) 100 years is a typical timeframe over which the National Marine Fisheries Service examines the effects of a proposed project on Endangered Species Act-listed species and their habitat.

We used the Streamwood model (version 2.06) to simulate the cumulative abundance of coniferous large wood (using the common definition of > 10 cm diameter and > 1 m in length) entering the stream. Streamwood is designed to read tree mortality estimates from Organon as input files and then estimate how many of those mortality trees end up falling into a stream on a decadal basis. The equations used to estimate tree fall into streams are essentially the same as those developed by Van Sickle and Gregory (1990) and McDade et al. (1990), with treefall direction assumed to be random. Because we were interested in the effects of harvest operations on wood recruitment relative to a no harvest option for the century following harvest, we compared cumulative large wood recruitment under various management scenarios relative to the no harvest option. That is, all breakage, decay and movement functions in the model were set to zero. This provides an reasonable estimate of the cumulative change in the amount of wood falling into a stream as a result of thinning operations. This in turn provides a rough approximation of the extent to which thinning operations will alter the recovery trajectory of instream habitat formed by wood in the century following harvest. All simulations assumed a

250 foot wide riparian buffer, which is consistent with the buffer sizes proscribed in the Northwest Forest Plan for much of the Siuslaw National Forest. Streamwood uses the Monte Carlo method (100 iterations) to estimate instream wood loads, so the results are not deterministic. Model simulations included for the riparian forest included a 250 ft no cut buffer, a 150 ft no cut / 100 ft thin, 120 foot no cut / 130 ft thin, 90 foot no cut / 160 ft thin, 60 foot no cut / 190 ft thin , 30 foot no cut / 220 ft thin and 250 ft thin. All thins were thinned from below to 55 TPA.

LIVE TREES AND MORTALITY TREES

The Organon model estimates live tree density and size in five year cycles, as well as the size and density of any trees that have died during a cycle. We categorized the live trees by diameter classes and looked at the number of live trees ≥ 12" dbh, ≥ 18" dbh and ≥ 24" dbh in 10 year increments in both the simulated thinned and unthinned stands from age 35 through age 135. We used 10 year mortality as a simple index of the number of snags and down wood provided by a stand each decade. This index does not differentiate between snags and down wood. It simply tabulates the number of trees that have died and will become snags and eventually fall to become down wood or will fall immediately to become down wood. We categorized the mortality trees by diameter classes and compared the number of mortality trees ≥ 12" dbh, ≥ 18" dbh and ≥ 24" dbh in 10 year increments in the simulated thinned and unthinned stands through stand age 135.

RESULTS

LIVE TREES

Thinning reduced the number of live overstory trees to 55 LTPA, eliminating competition mortality for the next 100 years (Figure 1). During this time a small number of overstory trees died from stochastic processes such that at year 135 there was 50 LTPA. These trees saw a rapid increase in diameter following thinning. By year 45, almost 50 LTPA were > 18" dbh, and by year 95 almost all the trees (50) were > 24" dbh. In contrast, in the unthinned stand there were no LTPA > 18" dbh until year 55, but by year 85, there were over 100 LTPA > 18" dbh and at year 135 there were 96 LTPA > 18" dbh. The LTPA > 12" in the unthinned stand declined from 245 LTPA at year 35 to 110 LTPA by year 135, slightly higher than the LTPA > 18" dbh, indicating that by year 135 most of the trees were > 18" dbh. By age 95 the unthinned stand had about 75% of the number of > 24" dbh LTPA relative to the thinned stand, but by age 115, the numbers were about even, with the > 24" dbh LTPA trajectory of the thinned stand leveling off, while the unthinned stand was on an increasing trajectory, and by age 135 had about 7 more LTPA > 24" dbh relative to the thinned stand.

MORTALITY TREES

Figure 2 graphically illustrates the tree mortality per acre per decade (MTPA), comparing the thinned and unthinned stand. As expected, the unthinned stand had substantially greater mortality of all trees relative to the thinned stand, peaking at about 17 MTPA > 12” dbh at year 85 and slowly declining to about 10 MTPA by year 135. In contrast, the stand thinned to 55 TPA saw very little mortality at all, beginning with no mortality after the thin and slowly climbing to 0.7 MTPA per decade by year 135. Trees in the thinned stand increased diameter rapidly, and in 20 years following thinning, had a greater number of > 18” diameter trees relative to the unthinned stand. However, from 30-100 years after thinning, the unthinned stand had more > 18” dbh trees, and by year 135 had over 5 MTPA, compared to just 0.6 MTPA in the thinned stand. Neither stand produced many trees > 24” dbh by year 135. The thinned stand produced slightly more > 24” MTPA for each decade following thinning through year 115 (e.g. 0.5 v. 0.4 > 24” MTPA at year 115), but by year 135 the unthinned stand was producing more large trees (0.7 v. 0.5 > 24” MTPA). Further, at year 135, the trend of the > 24” dbh MTPA in the unthinned stand was increasing, while in the thinned stand the > 24” dbh class had leveled off, suggesting that beyond year 135 the unthinned stand would continue to produce a greater number of large dead trees.

Comparison of the thinned and unthinned mortality curves graphically illustrates that thinning greatly reduced riparian tree mortality and thus reduces the potential for snags, forest wood and instream wood. It is noteworthy that the proposed thinning reduces tree mortality during the period of stand development when tree mortality and thus snag and wood loading, is at its’ highest. For example, for an unthinned stand at age 135, about 50 years past peak mortality, will still be producing about 10 trees per acre per decade. In contrast, a thinned stand will have about 0.5 MTPA for the same time period. Large wood and snag production from the thinned stand will come from the occasional mortality of the few remaining large, overstory Douglas-fir and eventually from the slow mortality of understory trees, primarily western hemlock and western red cedar. However, these shade tolerant species grow slowly under the a Douglas-fir overstory and mortality rates are unlikely to reach anything close to those of a stand of young, vigorously growing Douglas-fir competing for light.

INSTREAM WOOD

Figure 3 shows six simulations of cumulative instream LWD production from stand age 35-135 of a thinned and unthinned stand over that same time period. Figure 4 shows the same simulations but for a riparian stand composed of a 30 foot band of alder followed by 220 feet of Douglas-fir forest.

The recruitment curves in Figures 3 and 4 show the relative effects of various no cut buffer widths on instream wood recruitment. For example, Figure 3 shows that at stand age 115 a 60 foot no cut buffer followed by 190 feet of riparian forest thinned to 55 TPA will have delivered about 15 pieces of wood to a stream, a 90 foot no cut buffer /160 foot thin to 55 TPA will have delivered about 20 pieces and a 250 foot no cut buffer will have delivered about 25 pieces. Comparison of Figures 3 and 4 shows that the loss of coniferous instream wood production from the first 30 feet of a riparian reserve greatly reduces the potential for instream coniferous wood delivery. For example, at stand age 115, a 30 foot band of alder followed by a 220 foot no cut buffer of Douglas-fir forest will produce about the same amount of coniferous instream wood as a 60 foot no cut buffer of Douglas-fir.

Figures 5 and 6 illustrate the same data as Figures 3 and 4 but as percentages relative to an uncut buffer. Thus for example, Figure 5 shows that for a riparian forest with no alder, at stand age 125, a 120 foot no cut buffer will provide about 85% of the instream wood as a 250 foot no cut buffer. A 150 foot no cut buffer will provide about 91% of instream wood. whereas a 90 foot no cut buffer will provide about 77% relative to a 250 foot no cut buffer. Figure 6 provides the same sort of data but for a riparian forest that has a 30 foot band of alder. Note that a riparian forest with a 30 foot wide band of alder followed by a 220 no cut buffer of Douglas-fir will produce < 60% of coniferous instream wood relative to a 250 foot no cut buffer of pure Douglas-fir. This speaks to the fact that past forest practices which resulted in the replacement of stream adjacent conifer forests with even a relatively narrow band of alder forests have greatly compromised the ability of such forests to produce instream coniferous wood. Ensuring that such riparian forests can produce an equivalent supply of coniferous wood as a forest without an alder band will require a wide no cut buffer beyond the alder belt, and equivalency in wood production may not be achievable in many cases.

DISCUSSION

Simulation of stand growth following thinning of a young Douglas-fir forest suggests that such thinning will retard development of key late successional structural attributes by more than a century. Our model results suggest the proposed level of thinning will eliminate almost all tree mortality for the century following thinning and thus development of instream wood, riparian wood and snags will be minimal. Thinning accelerated the development of large diameter trees by about 20 years such that there were more live trees > 18” dbh in the two decades following thinning, relative to the unthinned stand, but this advantage was short-lived. Three decades after thinning, there were more live trees > 18” dbh in the unthinned stand and five decades after thinning there were twice as many live trees >18” dbh in the unthinned stand relative to the thinned stand. A similar trajectory was observed for the live trees > 24” dbh. The differences in the number of mortality trees was even more striking. By year 135, the number of MPTA > 18” in the unthinned stand was nearly ten times that of the thinned stand. By year 135 there were also more MTPA > 24” dbh in the unthinned stand relative to the thinned stand.

Our Streamwood simulations suggest that thinning at the level proposed reduce instream wood recruitment to <5% of an unthinned stand for the entire century following thinning. When no cut buffers were analyzed, a 150 foot no cut buffer was needed to ensure that stream wood abundance was at about 90%, relative to a 250 foot riparian reserve with no thinning. Thinning substantially reduced the abundance of stream wood for all size classes in the century following thinning. The 30 foot no cut buffer, which approximates what the Siuslaw National Forest proposed (Siuslaw-National-Forest-Central-Coast-Ranger-District, 2010), would provide less than 30% of the in stream wood relative to a 250 foot no cut buffer at year 135.

Relative to previous research, our analysis suggests that more wood comes from further distances from the stream. For example, McDade et al. (1990), found that across dozens of streams throughout western Oregon and Washington surrounded by old-growth riparian forests, on average, about 90% of instream wood came from within about 40 m (131 feet) of the stream edge. Their modeled results of a forest with a site potential tree height of 50 m (164 feet) gives a similar percentage. Our results suggest more wood comes from further out (e.g. 91% of the wood comes from within 150 feet). The difference is due in part to the fact that we estimated the cumulative delivery of wood to a stream over a 100 year period, whereas McDade et al (1990) simply examined multiple stands at a single point in time. McDade et al. would not have been able to measure wood that had fallen into the stream decades earlier and had since been transported downstream or decomposed. We also note that McDade et al. were unable to determine the source of nearly half the instream wood they observed, a potentially large source of error in the empirical data. Additionally, we estimated wood inputs from stands transitioning from a young to mature forest. This phase of stand development is the most productive in terms of the number of dead wood boles created that fall into streams. As a stand transitions from mature forest to old-growth, mortality rates decrease simply because there aren’t as many trees, but the size of the trees that do fall are generally much larger. Also, in the Siuslaw, the Site Potential Tree Height is often 250 feet (76 m), so it is reasonable to expect that where trees grow taller, the source distance of wood falling into streams will be greater than in many of the streams McDade et al. observed or modeled (e.g. a 50 m SPTH). Finally, we were estimating source distances for coniferous wood only, whereas McDade was looking at all wood. Since many streams have a band of stream adjacent hardwoods (mostly red alder), as we noted earlier, including hardwood in the large wood estimates would lead to the conclusion that narrower buffers provided a larger amount of wood. We did not include hardwoods because generally speaking, hardwood boles, in particular alder, are smaller diameter, have much smaller rootwads, are weaker, more prone to breakage and transport and are less decay resistant than conifers such as Douglas-fir. While hardwood boles can provide some ephemeral structure for streams, in general, they do not last long in a stream environment and in terms of habitat forming and maintaining capabilities, are not nearly as valued as the boles of conifers.

Although the Northwest Forest Plan does not require that all Aquatic Conservation Strategy goals be attained at all riparian sites (USDA and BLM, 2004), the fact that the proposed thinning program will delay the attainment of all of the four major structural elements of late successional forests suggests it is not a particularly beneficial restoration strategy. The only benefits to such thinning is the creation of a sparely populated stand of very large diameter trees which then allow more understory trees and shrubs to grow. While low density, large diameter Douglas-fir stands historically existed on the landscape, the vast majority of stands likely grew at densities higher than 55 TPA, and there is no evidence that such low density conifer stands were found in riparian environments. For example, Poage and Tappeiner (2002) estimated growth rates from the stumps of 505 large diameter Douglas-fir on upland sites and concluded that at age 50, about 75% of them were growing at tree densities higher than 53 TPA Since riparian forests generally are more productive and have higher tree densities than upland forests (Pollock et al., in review), we expect that the occurrence of young, low density riparian stands would be even less than in upland environments. Regardless of the extent to which young, low density stands of Douglas-fir historically occurred across the landscape, our results suggest that such stands have low mortality rates and thus produce few snags or downed wood. Since currently most streams and riparian forests throughout the Pacific Northwest are lacking in large wood and snags, creation of low density stands through heavy thinning doesn't strike us as a particularly useful restoration strategy.

If the thinning is combined with understory planting of shade tolerant species, as the Siuslaw National Forest has proposed (Siuslaw-National-Forest-Central-Coast-Ranger-District, 2010), a multi-layered canopy may develop more rapidly than would occur otherwise, but this is dependent on the size distribution of the Douglas-fir trees in the overstory. Gap formation caused by competition mortality allows shorter Douglas-fir to persist below the overstory (Spies et al., 1990; Spies and Franklin, 1991). Such gaps also allow shade-tolerant species such as western hemlock and western red cedar to become established, if there is a seed source. Although heavy thinning is often promoted as a means to develop a multi-tiered canopy, there is little data to demonstrate that such thinning accelerates development relative to the natural processes that would occur. Indeed, since "restoration" thinning typically removes smaller Douglas-fir, it may be that such efforts actually retard the development of a multi-layered canopy rather than accelerate its' development.

Because thinning essentially eliminates all instream wood recruitment for over a century, we assessed the effects of varying no-cut buffer widths on instream wood recruitment and found that a 150 ft no cut buffer was sufficient to provide about 90% of the cumulative stream wood that would be delivered to the stream in the century following thinning, even if heavy thinning occurred within the riparian reserve outside of the buffer. Narrower buffers provided progressively less wood down to a 30 foot buffer, which provided about a quarter of the large wood that would be delivered to a stream relative to a Riparian Reserve where no thinning occurred.

Streams with a 30 foot band of alder adjacent to them provided substantially less conifer wood to the streams for a given width of buffer. For example, an unthinned Riparian Reserve that contained a 30 foot alder buffer and a 220 foot Douglas-fir forest produced about 76 pieces of coniferous instream wood per 1000 feet of stream at year 135, whereas a similar reserve without the alder forest would provide about 123 pieces per 1000 feet of stream. Stated more simply, a 90 foot no cut buffer of Douglas-fir will produce more instream coniferous wood than a 250 foot wide no cut buffer where the first 30 feet are alder.

Regardless of the composition of the riparian forest, our results show that when part of a Riparian Reserve is thinned to the degree contemplated by the Siuslaw National Forest, in the century following thinning essentially all of the large wood inputs will come from the portion of the Riparian Reserve that is unthinned. Even if the uncut buffer is 150 feet wide and the thinning is confined to the outer 100 feet of the Riparian Reserve, a century after thinning, the recovery rate of instream wood will still be lowered by about 10%. This is a significant decrease for a program that is ostensibly designed to improve riparian function.

We conclude that the thinning of riparian forests to the degree contemplated in the Siuslaw National Forest will delay creation of late successional forest structure by more than a century. Of particular note is that such thinned forests will provide no large coniferous wood to streams for at least a century. Thinning treatments may exist which will accelerate the development of late successional forest structure in Riparian Reserves and that are consistent with the goals of the Northwest Forest Plan Aquatic Conservation Strategy, but they most assuredly will involve the removal of far fewer trees. In theory, silvicultural treatments exist that would accelerate development of large diameter trees, large diameter snags and large diameter downed wood on the forest floor and in streams. Future research should more comprehensively assess the conditions under which thinning accelerates or retards the development of key structural attributes of riparian forests.

Table 1. Characteristics of the 135 Douglas-fir stands in the East Alsea Landscape Management Project, Siuslaw National Forest, where thinning is proposed. HTH=Commercial Thinning, HSH = Seed Step Shelterwood of Young Stands < 80 years old.

Stand Number	Stand Age	Pre-thin TPA	post-thin TPA	Delta TPA	Pre-thin DBH (Inches)	Post-thin DBH	Delta DBH	Mean Tree Height (Feet)	Total Stand Acres	Acres Commercially Thinned	Total Volume removed (MBF)	Thinning Treatment
504349	18	325	45	280	5.0	10.0	5	35	17	15	98	HTH
504220	18	350	45	305	5.5	10.0	4.5	40	25	12	84	HTH
504332	19	350	45	305	6.0	10.0	4	40	46	27	203	HTH
504303	22	400	75	325	8.0	10.0	2	48	16	12	168	HTH
504319	23	300	75	225	6.5	10.0	3.5	40	30	21	120	HTH
504341	21	350	75	275	7.0	12.0	5	50	21	15	108	HTH
504306	24	400	80	320	8.0	11.0	3	50	10	7	63	HTH
504163	28	180	75	105	10.0	17.0	7	55	23	19	63	HTH
504112	32	210	75	135	9.5	16.0	6.5	55	59	51	200	HTH
504244	25	150	60	90	11.5	16.0	4.5	55	37	29	663	HTH
504113	26	190	75	115	9.5	14.0	4.5	55	33	23	265	HTH
504090	33	230	60	170	10.0	15.5	5.5	62	49	35	320	HTH
504262	24	175	75	100	12.0	14.0	2	70	8	4	190	HTH
504061	26	380	75	305	8.5	11.0	2.5	50	13	9	438	HTH
504359	46	225	75	150	13.0	14.0	1	75	56	43	20	HTH
504340	33	210	60	150	11.0	17.0	6	70	47	33	610	HTH
504027	37	160	70	90	11.5	16.0	4.5	65	38	11	200	HTH
504027	29	160	55	105	11.5	17.0	5.5	65	38	15	429	HTH
504286	32	165	75	90	12.0	14.5	2.5	75	68	38	24	HTH
504326	32	275	75	200	11.5	15.0	3.5	70	74	56	225	HTH
504254	32	200	75	125	12.0	14.0	2	66	62	43	472	HTH
504265	33	260	60	200	12.0	15.5	3.5	75	17	12	425	HTH
504034	34	190	75	115	12.5	16.5	4	77	126	93	299	HTH
504275	45	140	70	70	12.5	15.0	2.5	80	71	46	725	HTH
504275	25	140	50	90	12.5	15.5	3	80	71	10	348	HTH
504311	29	245	75	170	13.0	15.5	2.5	80	34	25	127	HTH
504031	29	440	50	390	9.0	12.0	3	70	29	20	195	HTH
504115	30	180	70	110	11.0	15.5	4.5	75	3	2	672	HTH
504246	32	200	50	150	11.0	15.0	4	80	79	18	276	HTH
504246	33	200	75	125	11.0	14.0	3	80	79	41	290	HTH
504164	33	240	75	165	11.5	14.0	2.5	78	32	24	63	HTH
504173	37	200	50	150	12.0	14.0	2	72	47	34	403	HTH
504181	37	245	60	185	12.0	16.0	4	72	56	39	161	HTH
504279	40	160	75	85	12.0	15.5	3.5	75	83	58	348	HTH
504298	26	220	50	170	12.5	16.0	3.5	86	46	14	20	HTH
504298	29	220	65	155	12.5	15.0	2.5	86	46	25	437	HTH
504285	31	325	45	280	9.5	13.0	3.5	70	54	40	473	HTH
504217	31	320	55	265	10.5	14.0	3.5	70	70	53	144	HTH
504221	32	220	75	145	11.0	15.0	4	65	53	34	476	HTH

Stand Number	Stand Age	Pre-thin TPA	post-thin TPA	Delta TPA	Pre-thin DBH (Inches)	Post-thin DBH	Delta DBH	Mean Tree Height (Feet)	Total Stand Acres	Acres Commercially Thinned	Total Volume removed (MBF)	Thinning Treatment
504351	32	265	75	190	11.5	13.5	2	80	40	29	507	HTH
504412	32	200	65	135	11.5	16.0	4.5	75	7	5	696	HTH
504184	33	200	60	140	12.0	17.0	5	80	39	28	364	HTH
502044	34	200	75	125	13.0	15.0	2	80	35	30	44	HTH
504249	34	260	55	205	11.0	14.0	3	85	37	26	180	HTH
504270	35	195	70	125	12.0	13.5	1.5	83	27	4	264	HTH
504270	36	195	55	140	12.0	14.0	2	83	27	15	689	HTH
504143	37	260	75	185	12.5	16.0	3.5	84	74	54	132	HTH
504204	41	220	55	165	14.0	14.5	0.5	80	16	11	594	HTH
504287	43	205	55	150	12.0	15.0	3	85	29	22	286	HTH
504114	43	180	70	110	12.5	16.0	3.5	85	56	39	156	HTH
504350	43	180	55	125	12.6	14.5	1.9	80	34	27	140	HTH
504020	44	140	75	65	13.5	15.5	2	75	54	45	495	HTH
504086	45	220	75	145	13.5	14.5	1	85	98	64	250	HTH
504388	46	172	60	112	14.0	16.0	2	75	93	67	507	HTH
504355	43	300	55	245	12.0	14.5	2.5	85	71	53	624	HTH
504417	31	245	2	243	14.0	50.0	36	95	18	14	1070	HSH
504418	31	245	2	243	14.0	50.0	36	95	6	5	552	HSH
504366	31	245	55	190	10.5	14.5	4	75	30	19	130	HTH
504373	32	245	55	190	11.6	15.5	3.9	80	56	31	196	HTH
504373	32	245	70	175	11.6	14.0	2.4	80	56	14	300	HTH
504413	34	190	55	135	12.0	12.5	0.5	70	14	12	621	HTH
504085	35	191	50	141	12.8	14.5	1.7	92	40	28	468	HTH
504305	40	195	55	140	13.5	16.0	2.5	90	35	27	351	HTH
504310	41	227	50	177	11.9	14.5	2.6	85	42	29	351	HTH
504281	42	195	50	145	12.5	14.5	2	80	37	26	322	HTH
504396	43	290	45	245	13.0	16.5	3.5	85	64	46	336	HTH
504327	43	250	60	190	12.0	13.5	1.5	90	65	44	72	HTH
504255	43	225	45	180	12.5	14.0	1.5	85	37	26	421	HTH
504012	44	215	70	145	13.5	15.0	1.5	90	54	22	525	HTH
504012	44	215	45	170	13.5	16.0	2.5	90	54	14	636	HTH
504291	46	ND	40		ND	26.0	ND	ND	26	6	585	HTH
504108	46	215	45	170	12.5	14.5	2	95	34	23	160	HTH
504372	35	235	70	165	13.0	14.5	1.5	100	22	17	324	HTH
504416	44	170	60	110	15.0	17.0	2	105	16	8	672	HTH
504342	45	315	60	255	12.0	14.0	2	100	29	22	450	HTH
504389	45	280	75	205	12.0	15.0	3	95	52	13	792	HTH
504389	37	280	50	230	12.0	16.0	4	95	52	10	308	HTH
504074	28	266	50	216	12.3	13.5	1.2	90	66	48	473	HTH
504107	31	210	45	165	12.5	14.5	2	95	31	24	300	HTH
504290	33	235	75	160	12.5	15.0	2.5	105	48	6	360	HTH
504290	40	235	50	185	12.5	16.0	3.5	105	48	29	621	HTH

Stand Number	Stand Age	Pre-thin TPA	post-thin TPA	Delta TPA	Pre-thin DBH (Inches)	Post-thin DBH	Delta DBH	Mean Tree Height (Feet)	Total Stand Acres	Acres Commercially Thinned	Total Volume removed (MBF)	Thinning Treatment
504040	42	259	70	189	13.2	14.5	1.3	90	37	26	221	HTH
504304	44	156	45	111	13.6	15.5	1.9	94	36	20	650	HTH
504304	44	156	70	86	13.6	14.0	0.4	94	36	8	48	HTH
504168	46	160	60	100	14.0	15.5	1.5	90	7	5	574	HTH
504250	46	300	65	235	14.0	17.0	3	105	88	16	125	HTH
504250	46	300	50	250	14.0	18.0	4	105	88	38	476	HTH
504010	47	160	50	110	14.5	16.5	2	105	32	19	243	HTH
504036	49	365	50	315	12.0	16.0	4	100	48	33	720	HTH
504148	43	260	55	205	12.5	17.0	4.5	95	60	42	338	HTH
504150	35	290	65	225	12.5	15.5	3	95	74	53	518	HTH
504057	35	236	50	186	12.6	15.5	2.9	100	74	48	736	HTH
504167	37	227	70	157	13.0	15.5	2.5	100	70	50	365	HTH
504167	41	227	45	182	13.0	20.0	7	100	70	3	286	HTH
504019	41	225	45	180	13.5	16.0	2.5	95	96	63	203	HTH
504028	44	210	50	160	13.5	15.5	2	105	18	13	882	HTH
504068	44	225	50	175	14.0	17.0	3	105	59	33	176	HTH
504068	45	225	70	155	14.0	16.0	2	105	59	9	84	HTH
504018	45	105	50	55	11.0	15.0	4	65	92	58	266	HTH
504145	45	290	60	230	12.0	14.5	2.5	90	28	20	149	HTH
504405	47	201	45	156	12.7	16.0	3.3	90	132	30	176	HTH
504405	48	201	70	131	12.7	14.5	1.8	90	132	66	832	HTH
504004	49	175	55	120	13.5	15.0	1.5	100	9	6	702	HTH
504009	49	175	55	120	13.5	15.0	1.5	100	24	19	120	HTH
504016	50	240	50	190	13.5	17.0	3.5	100	16	11	168	HTH
504030	43	240	45	195	14.0	18.5	4.5	105	47	32	280	HTH
504333	43	205	120	85	10.0	14.0	4	75	16	2	100	HTH
504411	34	285	75	210	12.0	15.5	3.5	100	58	39	138	HTH
504390	35	275	70	205	12.5	15.0	2.5	105	75	45	871	HTH
504390	43	275	50	225	12.5	16.0	3.5	105	75	11	55	HTH
504187	43	255	55	200	13.0	15.0	2	95	65	41	200	HTH
504187	43	255	70	185	13.0	15.0	2	95	65	10	532	HTH
504293	44	175	45	130	13.0	17.5	4.5	90	49	34	495	HTH
504130	44	175	45	130	13.0	15.5	2.5	95	23	18	117	HTH
504414	45	285	45	240	13.5	15.0	1.5	100	16	13	512	HTH
504300	47	230	45	185	14.0	17.0	3	100	28	18	252	HTH
504102	50	190	50	140	13.5	16.0	2.5	100	107	64	108	HTH
504079	52	220	45	175	14.5	17.0	2.5	105	117	84	442	HTH
504154	54	160	50	110	14.5	17.5	3	115	72	52	195	HTH
504238	54	245	45	200	13.0	16.0	3	95	74	48	396	HTH
504128	43	200	45	155	13.5	17.0	3.5	95	101	54	285	HTH
504128	48	200	70	130	13.5	16.0	2.5	95	101	10	1344	HTH
504015	48	195	45	150	13.5	15.5	2	105	16	14	754	HTH

Stand Number	Stand Age	Pre-thin TPA	post-thin TPA	Delta TPA	Pre-thin DBH (Inches)	Post-thin DBH	Delta DBH	Mean Tree Height (Feet)	Total Stand Acres	Acres Commercially Thinned	Total Volume removed (MBF)	Thinning Treatment
504152	42	200	60	140	14.0	16.0	2	100	13	9	88	HTH
504312	51	200	50	150	16.0	19.0	3	115	164	107	1659	HTH
504309	57	155	65	90	14.0	18.0	4	110	88	34	84	HTH
504203	54	235	45	190	14.0	18.0	4	120	19	13	312	HTH
504257	60	165	50	115	14.0	19.0	5	120	77	24	406	HTH
504014	68	120	45	75	19.0	21.0	2	120	30	24	780	HTH
504160	41	140	60	80	16.0	18.0	2	115	35	6	60	HTH
504013	36	85	45	40	22.0	24.5	2.5	135	32	29	280	HTH
504415	36	93	45	48	24.0	25.0	1	145	90	65	100	HTH
Mean	39	226	58.6	167.3	12.4	16.0	3.5	86	50	29	364	na
SD	9	62	14.4	63.1	2.4	4.9	4.3	19	30	20	267	na
min	18	85	2	40	5.0	10.0	0.4	35	3	2	20	na
max	68	440	120	390	24.0	50.0	36	145	164	107	1659	na
median	41	220	55	160	12.5	15.5	2.9	90	47	25	304	na
Sum	na	na	na	na	na	na	na	na	6573	3777	48063	na

Figure Legend

Figure 1. Comparison of live trees per acre of various dbh size classes (≥12” dbh, ≥ 18” dbh, ≥ 24” dbh) from years 35-135 in an unthinned stand versus a stand thinned to 55 TPA at year 35.

Figure 2. Comparison of mortality trees per acre of various dbh size classes (≥12” dbh, ≥ 18” dbh, ≥ 24” dbh) from years 35-135 in an unthinned stand versus a stand thinned to 55 TPA at year 35.

Figure 3. Cumulative pieces instream lwd/1000 ft delivered to a stream under different thinning scenarios, assuming 250 ft wide df riparian forest beginning at edge of stream.

Figure 4. Cumulative pieces instream lwd/1000 ft delivered to a stream under different thinning scenarios, assuming 30 foot wide alder forest at edge of stream, then a df riparian forest from 30-250 ft.

Figure 5. Relative amount of large wood delivered to a stream from a pure Douglas-fir riparian forest under different thinning scenarios, as a percent of an unthinned 250 ft wide Douglas-fir riparian forest. The waviness of the lines is a result of the stochastic nature of Streamwood outputs.

Figure 6. Relative amount of large wood delivered to a stream from a 30 foot red alder 220 foot Douglas-fir riparian forest under different thinning scenarios, as a percent of an unthinned 250 ft wide Douglas-fir riparian forest. The waviness of the lines is a result of the stochastic nature of Streamwood outputs.

Figure 1. Comparison of live trees per acre of various dbh size classes (≥12” dbh, ≥ 18” dbh, ≥ 24” dbh) from years 35-135 in an unthinned stand versus a stand thinned to 55 TPA at year 35.

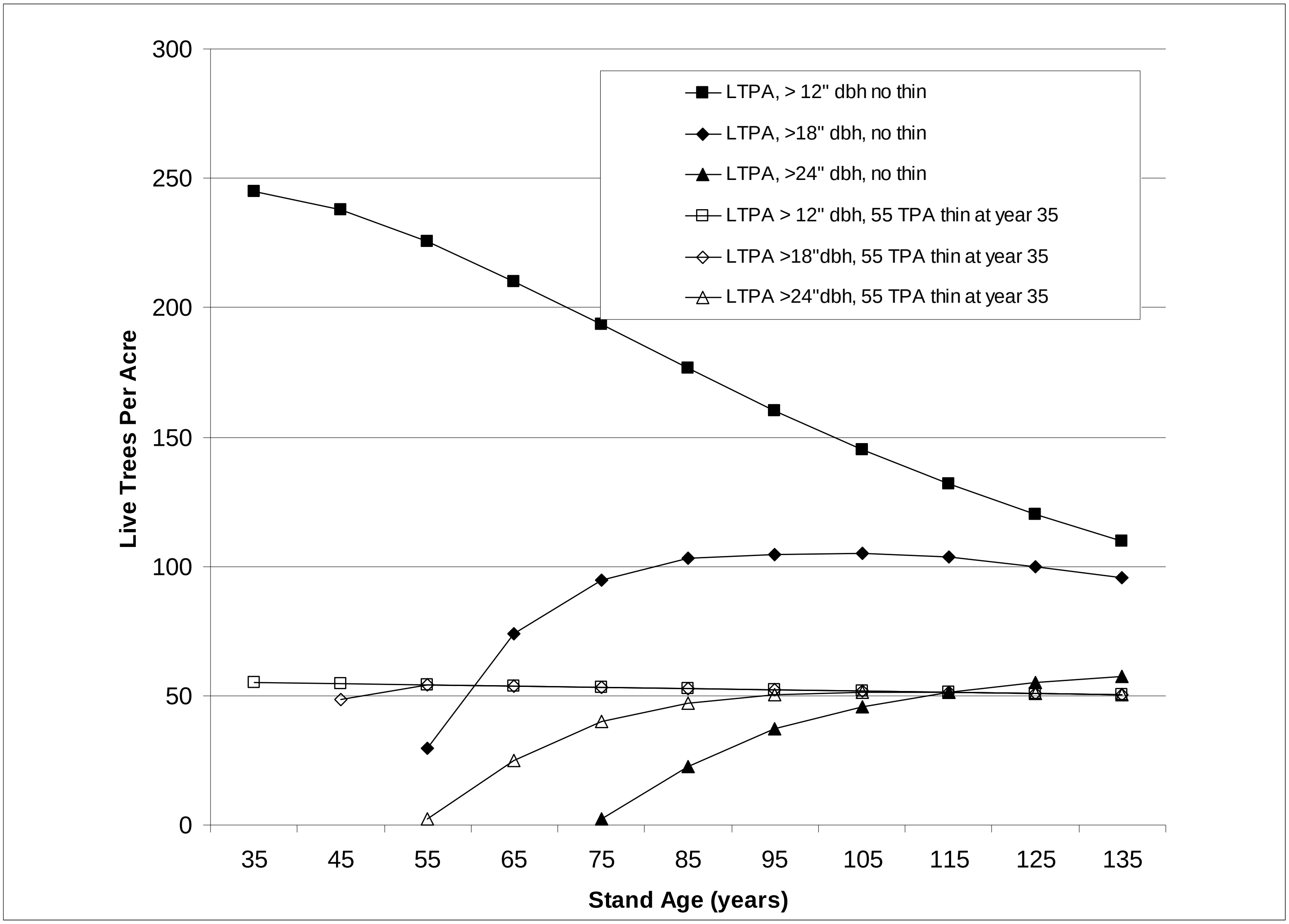


Figure 2. Comparison of mortality trees per acre of various dbh size classes (≥12” dbh, ≥ 18” dbh, ≥ 24” dbh) from years 35-135 in an unthinned stand versus a stand thinned to 55 TPA at year 35.

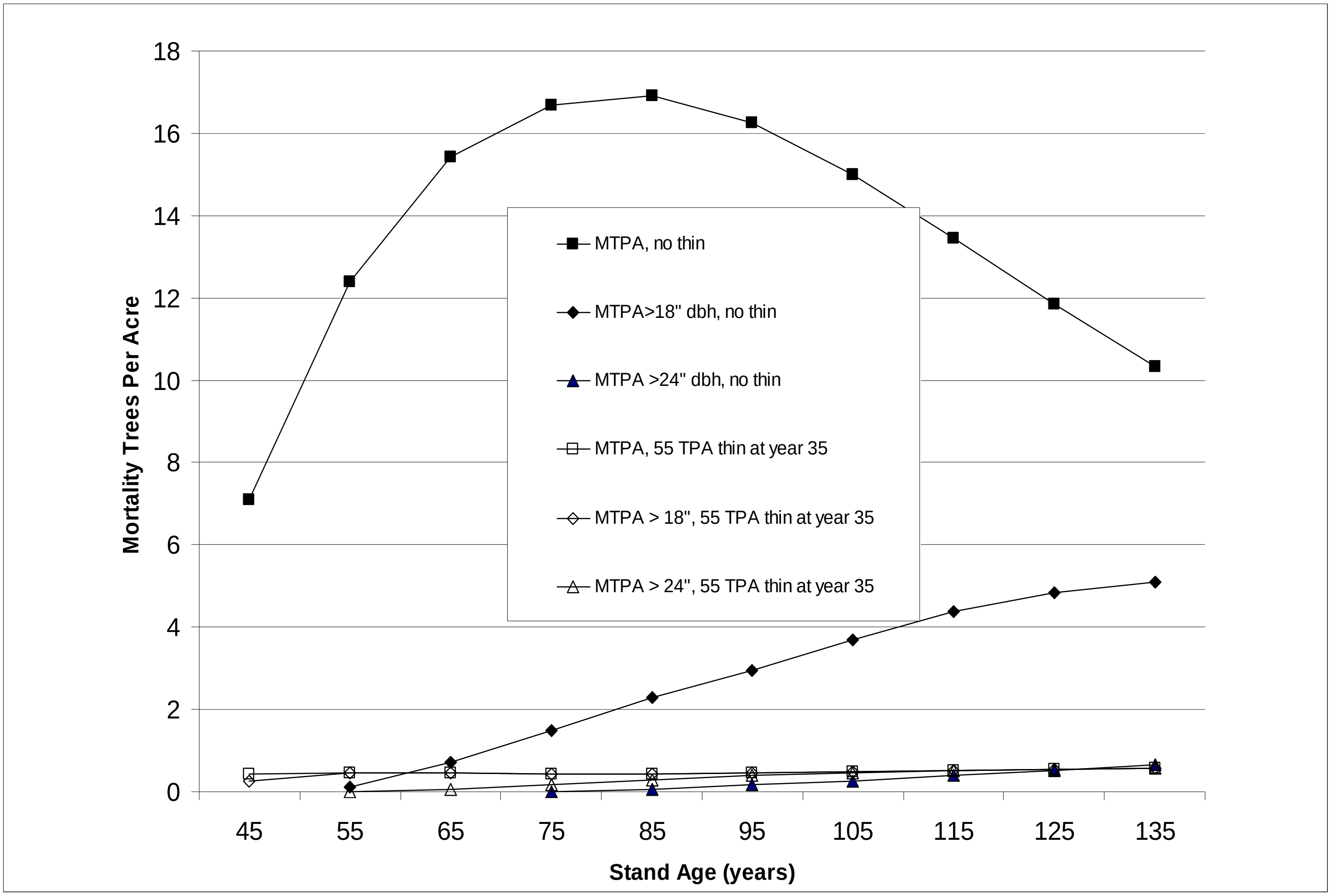


Figure 3. Cumulative pieces instream LWD/1000 ft delivered to a stream under different thinning scenarios, assuming 250 ft wide DF riparian forest beginning at edge of stream

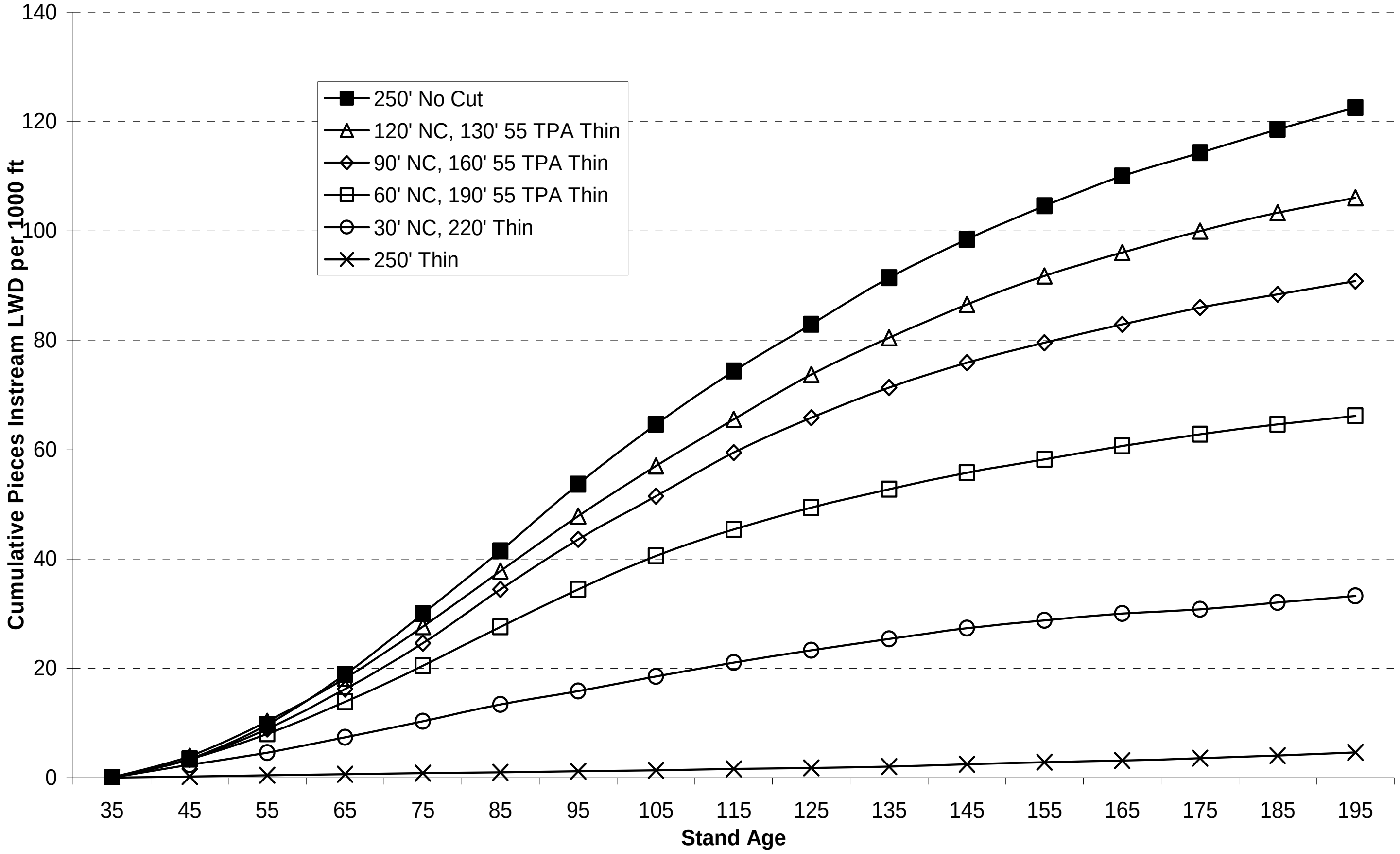


Figure 4. Cumulative pieces instream lwd/1000 ft delivered to a stream under different thinning scenarios, assuming 30 foot wide alder forest at edge of stream, then a df riparian forest from 30-250 ft.

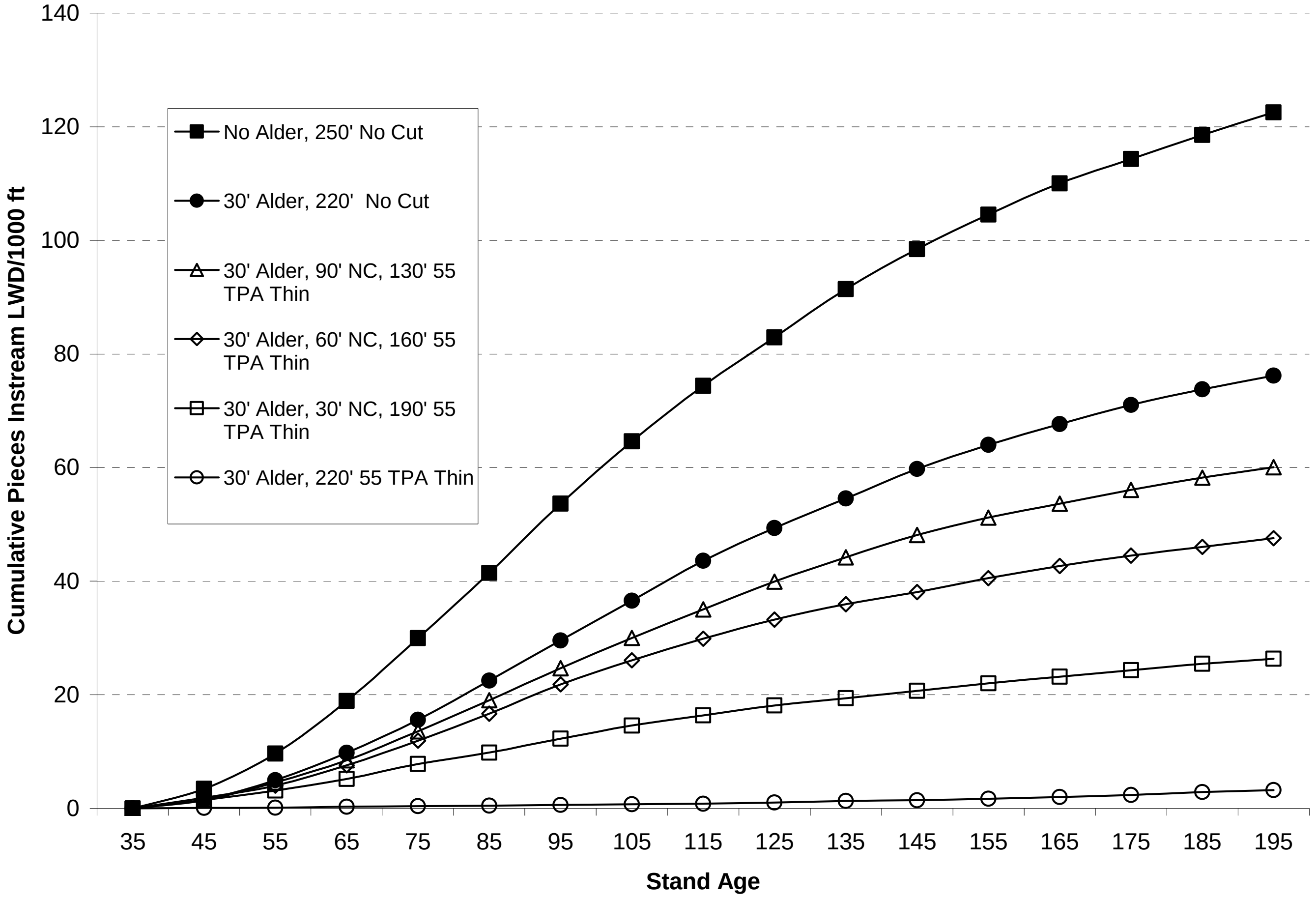


Figure 5. Relative amount of large wood delivered to a stream from a pure Douglas-fir riparian forest under different thinning scenarios, as a percent of an unthinned 250 ft wide Douglas-fir riparian forest. The waviness of the lines is a result of the stochastic nature of Streamwood outputs.

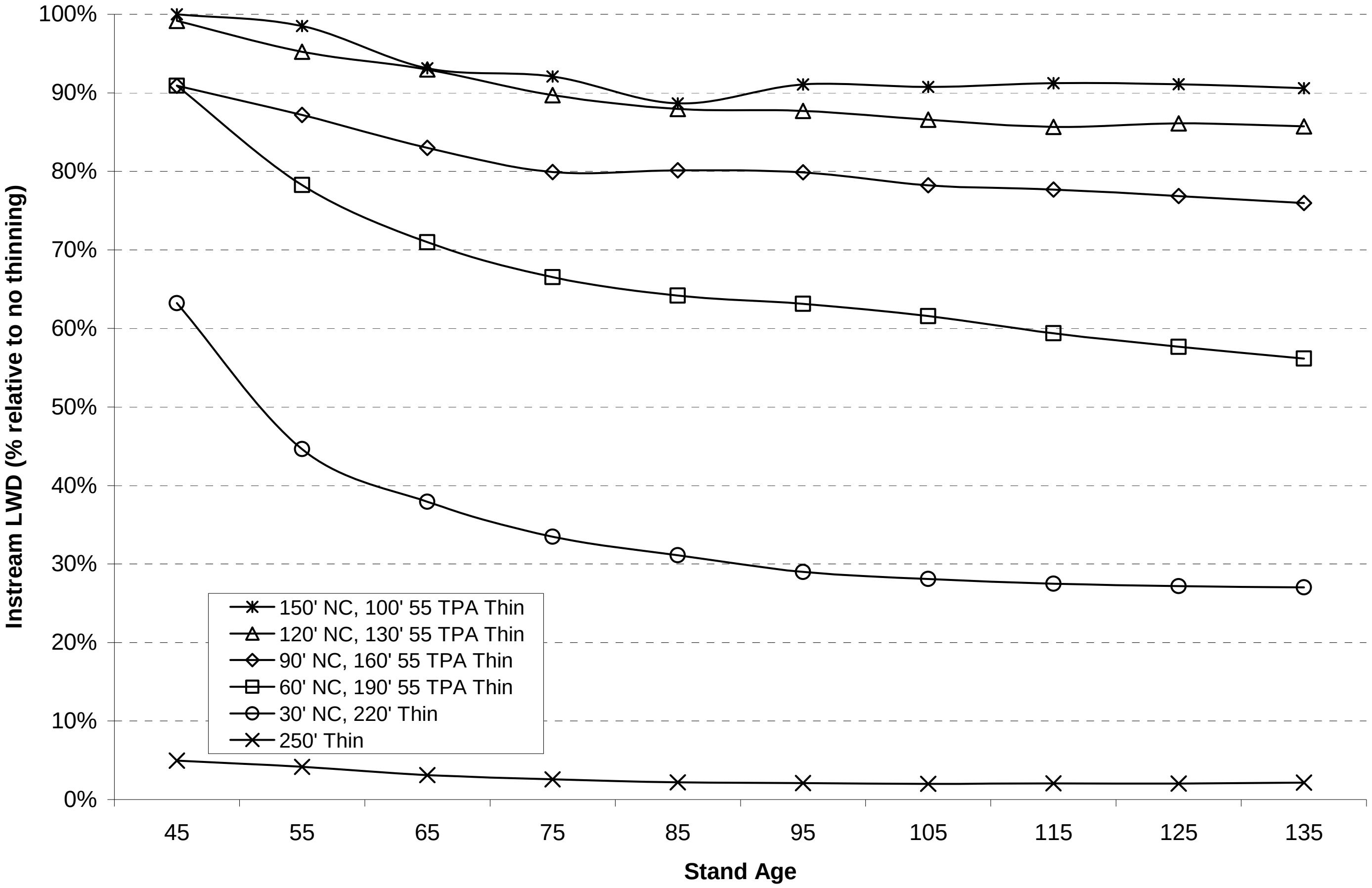
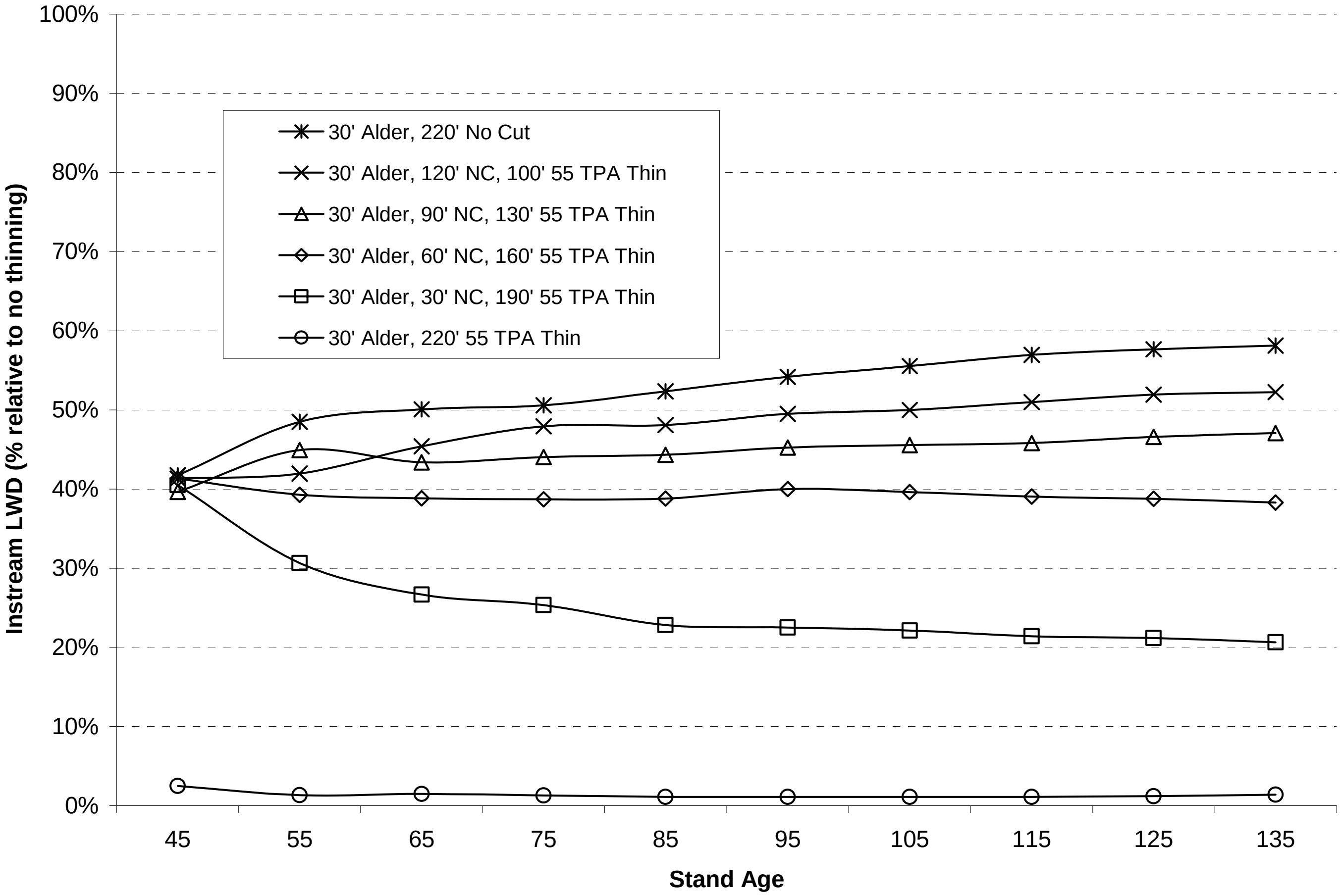


Figure 6. Relative amount of large wood delivered to a stream from a 30 foot red alder 220 foot Douglas-fir riparian forest under different thinning scenarios, as a percent of an unthinned 250 ft wide Douglas-fir riparian forest. The waviness of the lines is a result of the stochastic nature of Streamwood outputs.



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Appendix 2

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Appendix 3

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Northwest Region
7600 Sand Point Way N.E., Bldg. 1
Seattle, WA 98115

May 22, 2007

Kathryn J. Silverman
Acting Director Natural Resources
Region 6, USDA Forest Service
333 S.W. First Avenue
Portland, Oregon 97204

Mike Haske
Acting Deputy State Director
Resource Planning, Use and Protection
OR/WA, USDI Bureau of Land Management
333 S.W. First Avenue
Portland, Oregon 97204

Re: Review of 'Northwest Forest Plan Temperature TMDL Implementation Strategies'

Dear Ms. Silverman and Mr. Haske:

We have reviewed the September 9, 2005, document 'Northwest Forest Plan Temperature TMDL Implementation Strategies' (Strategy) that you sent to us with your March 19, 2007 letter addressed to Michael Crouse, the Assistant Regional Administrator for the Northwest Region of NOAA's National Marine Fisheries Service (NMFS). According to your letter, the Forest Service (FS) and Bureau of Land Management (BLM) believe that riparian tree-thinning projects in Oregon designed using the Strategy would avoid adverse effects to water temperature from riparian tree-thinning within the Northwest Forest Plan (NWFP) area. You requested that NMFS "review and evaluate whether thinning actions designed with the Strategy would likely avoid adverse effects to water temperature, supporting an effect determination of 'may affect, not likely to adversely affect' under ESA and 'would not adversely affect' under MSA." If we agree, the FS and BLM would work with us to prepare an interagency letter of direction from the agency executives to our respective administrative field units to implement the Strategy as a "project design and consultation effects determination tool."

The document is labeled as final, but we understand that it may be modified in the future. For this reason, we did not limit our comments to implementation issues, but included questions and concerns about the document itself.

Part 1
This part of the document adequately explains the physics of stream temperature, and provides a clear mechanism for determining which plants contribute to stream shade. However, although the document clearly explains procedures for determining effective shade, it lacks documentation of the data set used to develop the SHADOW model, and includes no information about model validation, confidence limits and uncertainties. Also, the document gives no indication that the model was peer-reviewed. Based on the evidence presented, and our knowledge of various studies, we agree that the default riparian reserves under the NWFP are highly likely to provide adequate shade to maintain and restore stream temperatures. Better information about the model would increase our confidence in the proposed strategy as a tool to determine potential effects on water temperature of activities within the riparian reserves.

Part 2
This section provides tools for determining which trees are contributing shade to the stream at different times of day (*i.e.*, the primary and secondary shade zones), to assist with determining effects of thinning actions. The text on page 23 explains how, in over-dense riparian areas, optimum shade can be provided by the primary shade zone alone, and the secondary shade zone may contribute little to shade since trees in the primary shade zone are already blocking the sun's solar radiation. Yet a set of recommendations on page 25 asks the reader to assume that there always are benefits to thinning in the secondary shade zone, saying that:

> If it is agreed that there are benefits due to shade from the tree behind the tree, and that that thinning in the secondary shade zone can benefit effective shade over the long term, recommendations for thinning in Riparian Reserves should be considered as long as they meet the following conditions:
> 1. Vegetation density is high and will benefit from thinning.
> 2. Vegetation thinning will not occur in the primary shade zone. Vegetation thinning in the secondary shade zone will not result in less than 50% canopy closure post harvest.
> 3. NWFP Standards and Guidelines and [best management practices] still apply.
> 4. Table 3 will be used to determine the width of the primary shade zone, unless a shade model is used for site specific analysis.

The statement above either contradicts the statement on p. 23, or implies that there is a way to determine whether the "tree behind the tree" is providing shade, without saying what the method is. The text also fails to explain how to determine whether thinning in the secondary shade zone can "benefit effective shade over the long term." This is a key issue for NMFS.

Table 3 in this section gives a range of minimum widths of the primary shade zone for a range of tree sizes and hill slopes that varies from 12 feet to 60 feet. We are aware of monitoring results from the Results from Washington Forest Practices Adaptive Management Science Conference, March 20, 2007, reporting that 75-foot no-cut buffers in eastern Washington had increases in percent available radiation of 20 to 80 percent on two of three monitored reaches after timber harvest outside of the buffers (Michael B. Bonoff, abstract at http://www.dnr.wa.gov/forestpractices/adaptivemanagement/conference/scienceconf_07.pdf). We do not know what harvest was applied outside of the buffer, or what the buffer characteristics were, but we suggest that the FS and BLM contact the author to see whether the results apply to the Strategy since the buffers were wider than the range of sizes for the primary shade zone given in Table 3.

We also are concerned that the Strategy does not adequately consider other important functions of riparian vegetation, particularly the contribution of wood material to streams. Item 1 in the above list does not specify how vegetation would need to benefit from thinning in order to apply the strategy. For example, smaller streams that are deficient in wood are likely to benefit more from heavy wood inputs in the near-term from unthinned stands, than they are from deferred inputs of larger wood decades into the future. Item 2 above could be read to imply that retaining 50% canopy closure will protect against water temperature increases, or improve stream shade, but the cutoff value of 50% is not justified in the document. We understand that additional information is available to justify this number, and we request that the USFS and BLM provide it to NMFS. Also, the intended benefit of thinning down to the 50% cutoff should be explicitly explained in the next version of the document or in the implementation guidance. Regarding item 3, although some situations are mentioned when a site-specific model might give better results, there is no clear requirement under which conditions this will be done. The next paragraph on page 25 after the above list briefly acknowledges other functions of riparian areas, but then makes a circular directive that basically says 'do an appropriate analysis of factors other than shade when it is appropriate.' This kind of discretion for individual actions makes it difficult for us to give an unqualified endorsement of the strategy.

Part 2 closes with a section on the risks and benefits of thinning, but includes no information about the risks (*e.g.*, near-term reductions in wood recruitment to streams, increased blowdown, soil compaction from equipment use, increased erosion, altered humidity, effects of road construction and/or use), only about the potential benefits. The USFS and BLM should include information about the risks of thinning in the implementation guidance or in any new version of the strategy, as well as more details about the potential benefits of thinning, including scientific citations.

Part 3

Part 3 is titled 'Tools for Treating Riparian Reserves and Protecting Water Quality.' This section includes nomographs for characterizing existing and potential shade as an alternative to using the SHADOW model. The section is not clear about when the nomographs should be used, and when the model should be used, nor does it describe the data set used to develop the nomographs. The section includes an example section titled 'Estimating Shade Conditions and Identifying Potential Restoration Sites Using the Shade Nomographs and Interagency Mapping Project Database.' This section was much less clear and complete than the preceding sections. For example, some of the steps were phrased as questions, and many details about the intent of the procedures and how to carry them out were missing. It was not apparent to us how this section would be used in planning riparian tree thinning or harvest.

The Strategy was distributed to administrative units in Oregon for application in 2005. Some administrative units are currently using the Strategy to evaluate the effects of tree-thinning prescriptions within NWFP riparian reserves on stream temperature. In reviewing some of the actions that cite the Strategy, my staff has indicated that consultation documents from the action agencies have not consistently explained how the primary and secondary shade zones were determined, how large the zones are, or described the current and post-action canopy closure values. Transparency in the use of these procedures is necessary to build experience with the Strategy and confidence in its methods and implementation.

Regarding the use of the document in interagency consultations under the Endangered Species Act (ESA) or Magnuson-Stevens Fishery Conservation and Management Act (MSA), determinations are seldom based on the effects of an action on a single environmental variable like water temperature. Because of this, and because of how the document currently is being used (described in the prior paragraph), NMFS cannot state with a high degree of confidence that using the Strategy will result in a particular outcome in consultations under the ESA or MSA. The document could be very useful, however, in helping the USFS and BLM provide the information NMFS needs in its ESA and MSA consultations, and we encourage the FS and BLM to address the technical concerns and other issues in this letter. My staff and I stand ready to assist you in understanding our comments and, when the time is right, developing appropriate implementation guidance. If you have questions concerning these comments, please contact Mr. Jeff Lockwood, Fishery Biologist in the Oregon Coast/Lower Columbia River Branch, at 503.231.2249.

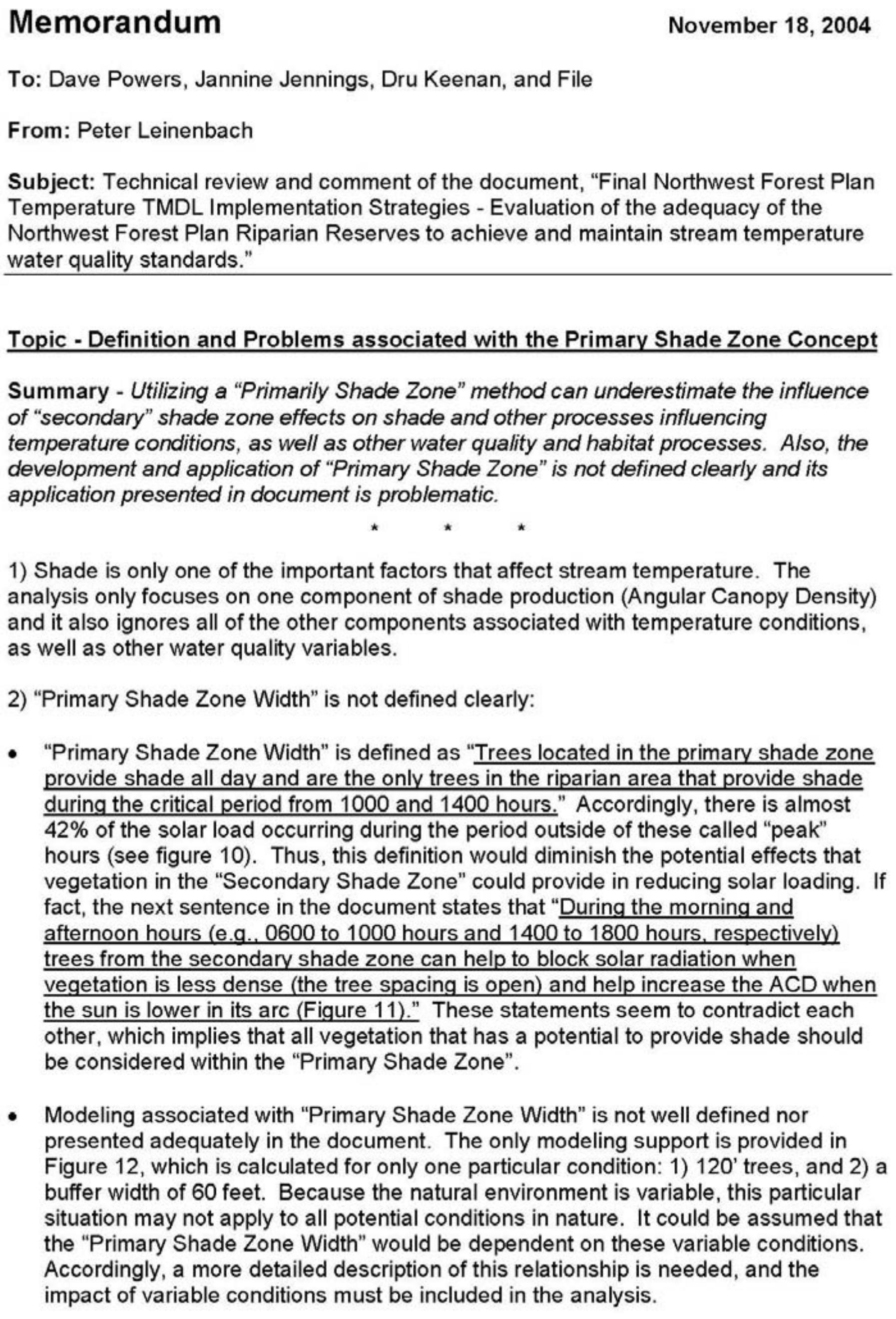
Sincerely,

Michael R Crouse

Michael R. Crouse
Assistant Regional Administrator

cc: David Powers, EPA Region 10
Larry Salata, U.S. Fish and Wildlife Service
Patrick Sousa, U.S. Fish and Wildlife Service

Appendix 4



Memorandum

November 18, 2004

To: Dave Powers, Jannine Jennings, Dru Keenan, and File

From: Peter Leinenbach

Subject: Technical review and comment of the document, "Final Northwest Forest Plan Temperature TMDL Implementation Strategies - Evaluation of the adequacy of the Northwest Forest Plan Riparian Reserves to achieve and maintain stream temperature water quality standards."

Topic - Definition and Problems associated with the Primary Shade Zone Concept

Summary - *Utilizing a "Primarily Shade Zone" method can underestimate the influence of "secondary" shade zone effects on shade and other processes influencing temperature conditions, as well as other water quality and habitat processes. Also, the development and application of "Primary Shade Zone" is not defined clearly and its application presented in document is problematic.*

* * *

1) Shade is only one of the important factors that affect stream temperature. The analysis only focuses on one component of shade production (Angular Canopy Density) and it also ignores all of the other components associated with temperature conditions, as well as other water quality variables.

2) "Primary Shade Zone Width" is not defined clearly:

- "Primary Shade Zone Width" is defined as "Trees located in the primary shade zone provide shade all day and are the only trees in the riparian area that provide shade during the critical period from 1000 and 1400 hours." Accordingly, there is almost 42% of the solar load occurring during the period outside of these called "peak" hours (see figure 10). Thus, this definition would diminish the potential effects that vegetation in the "Secondary Shade Zone" could provide in reducing solar loading. If fact, the next sentence in the document states that "During the morning and afternoon hours (e.g., 0600 to 1000 hours and 1400 to 1800 hours, respectively) trees from the secondary shade zone can help to block solar radiation when vegetation is less dense (the tree spacing is open) and help increase the ACD when the sun is lower in its arc (Figure 11)." These statements seem to contradict each other, which implies that all vegetation that has a potential to provide shade should be considered within the "Primary Shade Zone".
- Modeling associated with "Primary Shade Zone Width" is not well defined nor presented adequately in the document. The only modeling support is provided in Figure 12, which is calculated for only one particular condition: 1) 120' trees, and 2) a buffer width of 60 feet. Because the natural environment is variable, this particular situation may not apply to all potential conditions in nature. It could be assumed that the "Primary Shade Zone Width" would be dependent on these variable conditions. Accordingly, a more detailed description of this relationship is needed, and the impact of variable conditions must be included in the analysis.

- The proposal states that these conditions presented above (i.e., 120' trees, and a buffer width of 60 feet) will result in an ACD of 65%. This modeling result is not defined nor supported in the document. The document goes on to conclude that based on the fact that these conditions will produce an ACD of 65%, a shade condition of 80% will be present (see figure 9). Once again, the environment is a variable place. For example, see the range in the data presented in Figure 8. It can be assumed that these changing conditions will affect "effective shade" produced by this level of ACD, and therefore a more detailed description of this relationship is needed, and must be included in the analysis.

3) Application of the "Primary Shade Zone" provided in the document is problematic.

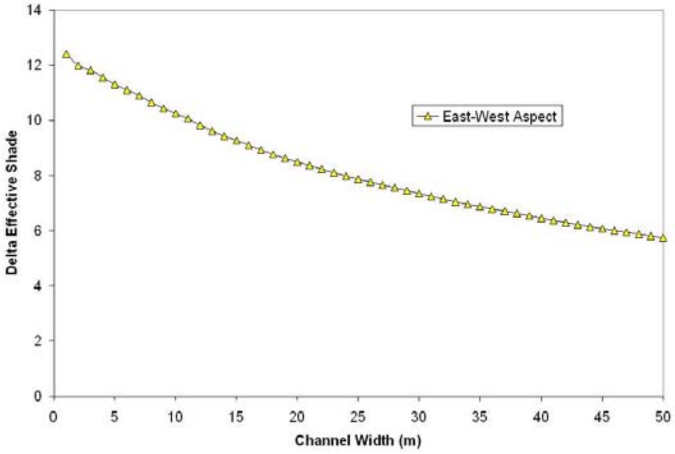
- The document proposes that the calculated "Primary Shade Zone Width" presented in Figure 12 (which is for only one particular riparian condition) will result in water quality attainment. In addition, the "tree behind tree" hypothesis is used in this document to support the notion that vegetation in the "Secondary Shade Zone" is not associated with shade production and therefore it is not associated with water quality attainment. However, these assumptions are not supported by provided examples in the document. For example, Figure 5 shows that riparian width contributing shade is close to linearly correlated with tree height, however calculated "Primary Shade Zone Width" values presented in Figure 12 are much less than 50% tree height. In addition, it is stated in the document that "Others have concluded similarly, that significant shade is produced at buffer widths of one potential tree height." (Page 8).

  Accordingly, it is important that an equal level of protection should be provided to all vegetation that can provided stream shade to the stream regardless of location.

- It was stated in the draft sufficiency analysis that vegetation on the north bank of an east-west aspect stream "provides no shade and thinning there should not affect stream shading" (Page 15). This statement is not correct due to solar arcs, seasonal changing of the solar zenith angle, and spherical nature of the earth. In fact, during much of the summer period, the north bank vegetation can be the dominant shade-producing feature during early morning and late afternoon hours. **Figure 1** shows that a very large portion of the shade is produced from vegetation from the north bank of a river (over 12% in some instances).

  Accordingly, blanket statements that north bank vegetation can be not a value for shading is not correct, nor advisable. Accordingly, it is not appropriate to universally exclude or negate the potential impact of all vegetation in the riparian zone.

Figure 1. Impact of "north-bank" vegetation on an East-West Aspect Stream[1].



Topic - Angular Canopy Density (ACD)

Summary – *Angular Canopy Density (ACD) is only one of the many factors that influence stream shade conditions produced by riparian vegetation, however ACD is the only parameter evaluated in the analysis. This can lead to an underestimation of potential impacts from vegetation in the so-called "Secondary Shade Zone" on stream shade conditions. Details are presented below.*

* * *

It is proposed in the draft sufficiency analysis "that the only limiting factor is canopy density." (Page 18) Using this assumption, analysis was presented to support the concept of "Primary" and "Secondary" shade conditions. Specifically, it was proposed "tree behind a tree" concept would result in duplicative shading from vegetation in the "secondary zone". This in turn would result in "optimum ACD provided by the primary shade zone." (Page 19) The support for this assumption was modeling results that showed that only a 3% increase in stream shade resulting in a 15% increase in ACD (from 65% to 80%) (See figure 9 in the document). **These statements in the document imply that only vegetation in the primary zone is providing shading to a stream.** However, the scatter in field data presented in Figure 8 of the draft document show that very little (if any) association is evident between buffer strip width and measured ACD. (It is important to point out that only one buffer condition was used in the modeling to establishing the relationship between ACD and Effective Stream Shade (Figure 9).)

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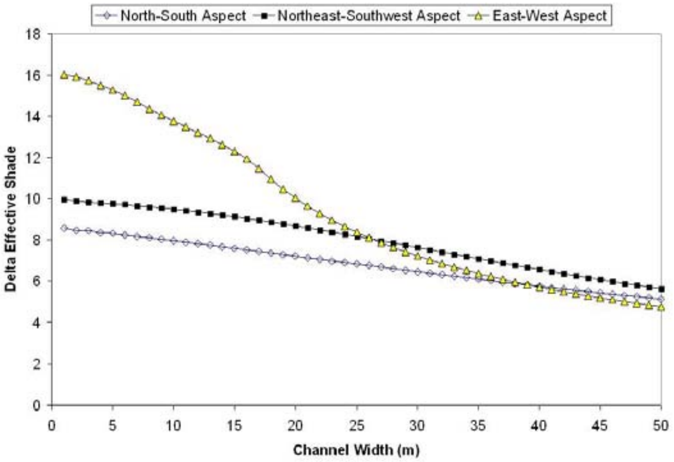
[1] The shade model used in this analysis was obtained from the Washington Ecology web page (http://www.ecy.wa.gov/programs/eap/models/index.html). This model is used during the development of shade TMDLs for the state of Washington. Input into the model were: tree height of 120 feet, ACD of 80%, buffer width of 300 feet, and the period of analysis was 6/23/2001. "Delta Effective Shade" is the difference between shade produced with 1) vegetation on both banks, and 2) vegetation only on the south bank.

Although it could be assumed that ACD of the vegetation closer to the stream will have a much greater impact on shade production, it should **not** be concluded that ACD of vegetation outside of this zone is **not** part of "optimal" shading. Like other factors that influence stream shade production, ACD is a highly variable condition in the environment and, more importantly, its impact on shade production is influenced by many factors. For example, **Figure 2** presented below illustrates how stream aspect and channel width will effect the production of shade at various ACD conditions. These results illustrate that ACD levels, as well as the context of the ACD in the environment, can be a much more important factor in shade production than implied in this draft document.

Figure 2. Change of Shade Production at higher ACD conditions for various channel width and stream aspects.[2]



In conclusion, these results illustrate that it is not advisable to downplay the significance of any portion of the riparian zone to produce shade without taking into consideration all of the factors, **as well as the interplay of these factors with each other**.

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[2] The shade model used in this analysis was obtained from the Washington Ecology web page (http://www.ecy.wa.gov/programs/eap/models/index.html). This model is used during the development of shade TMDLs for the state of Washington. Input into the model were: tree height of 120 feet, buffer width of 300 feet, and the period of analysis was 6/23/2001. "Delta Effective Shade" is the difference between shade produced with 1) 80% ACD, and 2) 65% ACD.

Topic - Interrelationship between "Primary" and "Secondary" shade zones and their effect on stream shade conditions are not defined in this version of the document.

Summary - *Although there were dramatic problems in the assessment techniques presented in earlier versions of the document, there is currently no evaluation of the specific effects of management actions on stream shade along a stream, and thus not method presented for evaluation between primary and secondary shade zones on stream shade.*

* * *

- The April, 2002 draft version of this document attempted to describe the interrelationship between "Primary and "Secondary" tree shade zones as follows:

> "The Primary Shade Tree zone can provide effective stream shade of 80% during the hours of 10am to 2pm (figure 10). The Secondary Shade Tree Zone, or area proposed for vegetative treatment, can provide an additional 20% stream shade outside the peak solar radiation hours. During the morning (6:00 am to 10:00 am) and afternoon (2:00 pm to 6:00 pm), 48% of the daily solar radiation can potentially reach the stream surface.
>
> 20% = Shade provided by the Secondary Shade Tree Zone.
> 48% = Total incoming solar radiation remaining to potentially reach the stream.
> Potential stream shade in the Secondary Shade Tree Zone = 20% x 48% = **10%**
> 50 % = Potential loss in canopy closure following treatment.
> Loss of stream shade from vegetation treatment = 50% x 10% = **5%**"

- The May, 2003 draft version of this document attempted to describe the interrelationship between "Primary and "Secondary" tree shade zones as follows:

> "The primary shade tree zone can provide 80% effective stream shade throughout the day. The secondary shade zone, or area proposed for vegetative treatment, can provide an additional 20% stream shade outside the peak solar radiation hours.
>
> Thus, the 80% primary shade zone + 20% secondary shade zone = 100% potential effective shade for a 24-hour period.
>
> Incoming solar energy blocked during the hours when shade is provided by the secondary shade zone assumes:
>
> *(80% = Shade provided by the primary shade zone),* plus
> *20% = Additional shade provided by the secondary shade zone,* and
> *(Potential radiation blocked by the primary shade zone = 80% x 42% = 34%)*
>
> Potential stream shade in the secondary shade zone = 20% x 42% = 8%, or
> 42% = Total incoming solar radiation remaining to potentially reach the stream.
>
> Treatment in the secondary shade zone would have the consequent effect of reducing stream shade as follows:
> 50 % = Potential loss in canopy closure following treatment in the secondary shade zone, or a
> Gain in solar radiation from vegetation treatment of 50% x 8% = 4%
>
> The gain of 4% solar radiation due to vegetation treatment in the secondary shade zone is within what the state considers acceptable as measurement error and will result in less than a 0.25 degree F change in stream temperature as measured over one mile of stream. For treatment within an area less than 1 stream mile in length, the temperature increase should be less. Thus, shade loss is too small to affect stream temperature and vegetative treatment that removes less than 50% of the canopy closure and occurs beyond the primary shade zone should not negatively affect effective stream shade.

Although the May 2003 version attempted to develop a more robust description of the consequences of management with the secondary zone on stream surface shade, there were significant problems with the assessment, which were presented our comments for this draft. The newest version of the document totally sidesteps this issue and the consequences on stream shade are not addressed. There is however a modeling exercise to illustrate that treatment in the secondary zone will not result in change stream temperature, however there is no description of the model and only limited design parameters are provided (Figure 13).

Although this is interesting information, there is not enough information provided in the document to evaluate the effect of management on stream shade conditions. Because it is effective shade that is the surrogate measure (which in turn has a surrogate measure of ACD), it is important that a method is developed to evaluate this effective shade change from changes in ACD. Only one scenario was run in this analysis, and it is sure that nature would have many more iteration of potential conditions. It might be possible that the response to stream temperature might be much greater at different scenarios and/or conditions.

Finally, the modeling effort used to develop this figure most likely is very simplistic and coarse in scale, inferred from the nice linear temperature response profile along the stream reach. Temperature change is much more dynamic in response with its environment, which is dependent on many interrelated factors. Thermal infrared (TIR) collected along stream reaches can attest to this dynamism. Accordingly, it is suspect that modeling results would apply to all possible situations occurring in nature.

Topic – Temperature Modeling

Summary – *It is not appropriate to set water quality targets in the Total Maximum Daily Load (TMDL) process based on simplified assumptions and generalized conditions. In addition, it is not appropriate to ignore the consequences of cumulative effects when evaluating the consequences of land use management on water quality.*

* * *

Modeling used to support a target shade condition of 80% is presented in Figure 2 in the draft document. However, it is important to point out that the paragraph describing this figure specifically states that:

> *"This conclusion should not be misconstrued to suggest that 80% effective shade represents some minimum threshold, water quality standards, or load allocation and recognizes that for shade values greater than 80% some reduction in stream temperature will result"* (Page 10)

However, it is specifically stated further in the document, "Given that there is little improvement in stream temperature beyond 80% shade (Figure 2), it demonstrates that optimum stream shade can be achieved at an ACD value of 65%." (Page 18) Accordingly, 80% effective shade is used in this analysis as the water quality target "surrogate measure"[3]. Despite the warnings highlighted above, the justification for using 80% as a "minimum threshold "is indirectly provided in this sentence:

> *"However, it should be noted that several approved TMDLs identify 80% stream shade as a threshold for optimum shading."* (Page 11)

It is true that during the late 1990's a limited number of temperature TMDLs in Oregon and Washington[4] were developed using a threshold value for shading, however almost all (if not all) temperature TMDL developed since then have utilized a site-specific analysis of "system potential effective shade"[5]. This was done in response to advances in the understanding of water temperature respond to environmental variables at a site-specific level, and how these variables are all interrelated in their effect on water temperature, as well as to address the impact of "cumulative effects". It was determined during these efforts that a limited and simplified technical analysis of water temperature response to simplified modeling scenarios cannot provide sufficient tools to accomplish these tasks.

In summary, it is possible that much of the effort presented in this draft document could easily be applied to the "system potential" approach that is used during temperature TMDL development, which could alleviate many of the problems presented in this memorandum.

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[3] Specifically, this was done through the use of a modeled association with Angular Canopy Density (ACD) and effective shade (see figure 9), which was then used to set a target ACD associated with 80% effective shade (i.e., 65% ACD). Then this target ACD is used in the calculation of a "Primary Shade Zone" width. It is then concluded that management outside of the "primary" zone will not affect shade because it will not affect ACD (This last point is not supported in the analysis – see previous point).

[4] http://www.deq.state.or.us/wq/TMDLs/TMDLs.htm, and http://www.ecy.wa.gov/programs/wq/tmdl/index.html

[5] Although there are numerous good examples of temperature modeling associated with TMDL development, the Upper Klamath Lake Subbasin TMDL available on the ODEQ web page is an exceptional example of the "system potential effective shade" approach.

Topic – Part 3 Tools for Treating Riparian Reserves and Protecting Water Quality

Summary – *This section does not provide support for the proposed development, application, and evaluation of targets associated with this effort. Material and examples provided in this section do not seem to relate closely to the document and the "Example Application" section is not clear in how it relates to the proposed process of assessment.*

* * *

The shade nomographs provided in this section are proposed to provide means "to characterize existing shade conditions and identify site potential shade". However, there is no clear description of these two applications:

- System Potential Shade - There is no apparent support on how the nomograph tool can be used to develop "system potential" conditions, not to mention the accuracy of this type of analysis.
- Existing Shade - There is no clear description of how these nomographs will support the proposed "primary" and "secondary" shade zone assessment effort. In addition, it is not clear how the nomographs will support evaluation of the ACD parameter (which is part of the "surrogate measure").

The only support provided is a comparison between current shade measured using a solar pathfinder (measured) and modeled values ("shadow" model). Although these results are good, they do indicate that the model is not very accurate within "middle conditions" of shade[6]. However, it is these "middle conditions" are most likely to be part of the target population in the assessment. That is, determine areas where and when it is "O.K." to come back in and harvest. The model is much more accurate in the extreme conditions (i.e., low and high shade conditions).

Finally, variability in nature would make utilizing such a course tool (nomograph) very problematic in the evaluation of current conditions and the development of site-specific "system potential conditions".

"Example Application" section – This section has not changed much (if at all) during the last several iterations of this document. Very little details are provided in this section, and what is provided in very limited. It is obvious that there is way more work associated with the effort than what is presented in this section. Accordingly, this section does not support the effort.

It might be possible that the nomographs may not be needed in the analysis. GIS and modeling tools are available[7] that can calculate shade conditions directly using the same data collected during the "nomograph" evaluation process. These tools are widely and often used during TMDL development in Oregon and Washington. The advantage of using these tools is that the process is automated, and thus more accurate and the data can be sampled very quickly. In addition, you would be able to include other available

---

[6] (This result would be expected, and similar results have been seen during other shade modeling efforts (see Upper Klamath TMDL).)

[7] GIS tools used to sample these GIS data sets are available on the ODEQ web page (http://www.deq.state.or.us/wq/TMDLs/WQAnalTools.htm) (which includes a very good users manual), and the model used to directly calculate shade conditions from this sampled data is provided on the Washington Ecology web page (http://www.ecy.wa.gov/programs/eap/models/index.html).

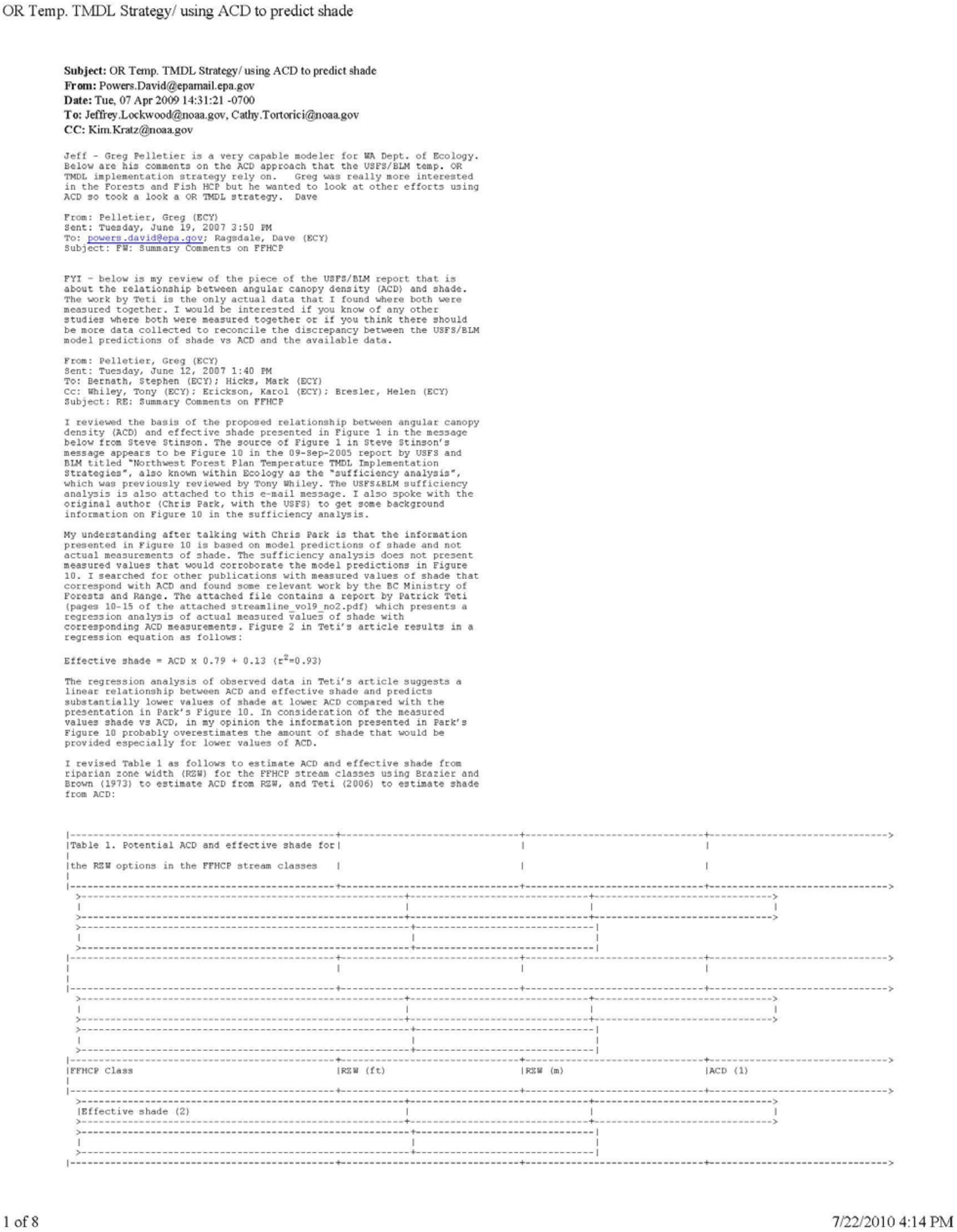
GIS datasets in the sampling and analysis (i.e., 10m DEM). In addition, there is much expertise developed for these techniques by state staff in both of these agencies, and there are many examples of the application of these tools. However, you would still need to interpret the results, but almost all of the grunt work is done for you. I would strongly suggest looking into using these tools to develop estimations of current conditions, however the interpretation of results developed from this analysis should be supported by the resolution of the data (see final comment below).

Data Resolution - One additional comment concerning data resolution - The image on page 30 of the draft document shows the pixel resolution of the IVMP dataset (30m). This is a very good dataset and has many valuable applications. For example, it could be used with aerial photographs to demark areas that are in the extremes (i.e., lots of vegetation, or low vegetation), as well as in the middle conditions (i.e., intermittent vegetation conditions).

However, this information should not be used as a site-specific determination of current and system potential conditions. Specifically, 30m pixel data may not be at a fine enough resolution to develop site specific targets to the degree required by the analysis presented in the document (i.e., "Primary" and "Secondary" shade zone analysis). The consequence of riparian vegetation on shade production is very site specific and this dataset may not provide a high enough resolution data set to accurately evaluate the consequences of minor vegetation removal (ACD) in the "Secondary Shade Zone".

However, this information could be used to highlight areas for further monitoring and/or other evaluation activities that take place in the field.

Appendix 5



Subject: OR Temp. TMDL Strategy/ using ACD to predict shade
From: Powers.David@epamail.epa.gov
Date: Tue, 07 Apr 2009 14:31:21 -0700
To: Jeffrey.Lockwood@noaa.gov, Cathy.Tortorici@noaa.gov
CC: Kim.Kratz@noaa.gov

Jeff - Greg Pelletier is a very capable modeler for WA Dept. of Ecology. Below are his comments on the ACD approach that the USFS/BLM temp. OR TMDL implementation strategy rely on. Greg was really more interested in the Forests and Fish HCP but he wanted to look at other efforts using ACD so took a look a OR TMDL strategy. Dave

From: Pelletier, Greg (ECY)
Sent: Tuesday, June 19, 2007 3:50 PM
To: powers.david@epa.gov; Ragsdale, Dave (ECY)
Subject: FW: Summary Comments on FFHCP

FYI - below is my review of the piece of the USFS/BLM report that is about the relationship between angular canopy density (ACD) and shade. The work by Teti is the only actual data that I found where both were measured together. I would be interested if you know of any other studies where both were measured together or if you think there should be more data collected to reconcile the discrepancy between the USFS/BLM model predictions of shade vs ACD and the available data.

From: Pelletier, Greg (ECY)
Sent: Tuesday, June 12, 2007 1:40 PM
To: Bernath, Stephen (ECY); Hicks, Mark (ECY)
Cc: Whiley, Tony (ECY); Erickson, Karol (ECY); Bresler, Helen (ECY)
Subject: RE: Summary Comments on FFHCP

I reviewed the basis of the proposed relationship between angular canopy density (ACD) and effective shade presented in Figure 1 in the message below from Steve Stinson. The source of Figure 1 in Steve Stinson's message appears to be Figure 10 in the 09-Sep-2005 report by USFS and BLM titled "Northwest Forest Plan Temperature TMDL Implementation Strategies", also known within Ecology as the "sufficiency analysis", which was previously reviewed by Tony Whiley. The USFS&BLM sufficiency analysis is also attached to this e-mail message. I also spoke with the original author (Chris Park, with the USFS) to get some background information on Figure 10 in the sufficiency analysis.

My understanding after talking with Chris Park is that the information presented in Figure 10 is based on model predictions of shade and not actual measurements of shade. The sufficiency analysis does not present measured values that would corroborate the model predictions in Figure 10. I searched for other publications with measured values of shade that correspond with ACD and found some relevant work by the BC Ministry of Forests and Range. The attached file contains a report by Patrick Teti (pages 10-15 of the attached streamline_vol9_no2.pdf) which presents a regression analysis of actual measured values of shade with corresponding ACD measurements. Figure 2 in Teti's article results in a regression equation as follows:

Effective shade = ACD x 0.79 + 0.13 (r^2=0.93)

The regression analysis of observed data in Teti's article suggests a linear relationship between ACD and effective shade and predicts substantially lower values of shade at lower ACD compared with the presentation in Park's Figure 10. In consideration of the measured values shade vs ACD, in my opinion the information presented in Park's Figure 10 probably overestimates the amount of shade that would be provided especially for lower values of ACD.

I revised Table 1 as follows to estimate ACD and effective shade from riparian zone width (RZW) for the FFHCP stream classes using Brazier and Brown (1973) to estimate ACD from RZW, and Teti (2006) to estimate shade from ACD:

Table 1. Potential ACD and effective shade for the RZW options in the FFHCP stream classes			
FFHCP Class	RZW (ft)	RZW (m)	ACD (1)
Effective shade (2)			

A & B	40	12.192	67%	66%
	100	30.48	84%	79%
C	35	10.668	62%	62%
	80	24.384	82%	78%
D	30	9.144	57%	58%
	80	24.384	82%	78%
Ep	25	7.62	51%	53%

```
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|                                               |50                              |15.24                           |73%
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   |71%                                                     |                                |                                |
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|Es                                             |15                              |4.572                           |35%
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   |41%                                                     |                                |                                |
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|(1) ACD = 4.146e-5 * RZW^3 - 3.223e-3 * RZW^2 |                                |                                |                                |
|+ 8.692e-2 * RZW + 1.206e-2 (after Brazier and|                                |                                |
|
|Brown 1973)                                    |                                |                                |
|
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|(2) shade = ACD x 0.79 + 0.13 (from Teti,      |                                |                                |
|
|2006)                                          |                                |                                |
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Greg

Greg Pelletier
Department of Ecology
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email: gpel461@ecy.wa.gov

From: Bernath, Stephen (ECY)
Sent: Monday, May 28, 2007 10:43 PM
To: Hicks, Mark (ECY); Pelletier, Greg (ECY)
Subject: FW: Summary Comments on FFHCP

fyi. sb.

From: steve stinson [mailto:stevestinson@familyforestfoundation.org]
Sent: Mon 5/28/2007 7:41 PM:
To: Bernath, Stephen (ECY)
Cc: 'Martin Vaughn'; Ronald Campbell; 'Bill Scheer Sr.'; 'Doug Stinson'; 'Ken Miller'; 'Steve Stinson'; 'Tom Fox'; 'Webster, Steve and Mary'
Subject: RE: Summary Comments on FFHCP
Hi Stephen,

I have reviewed my notes and have some additional input below which should help clarify our response from May 7 2007 which I had assumed responded to your April 10 request for a modeling adjustment to the View to Sky analysis.

At the last technical meeting (April 10 2007), Greg Pelletier offered a quadratic equation for calculating angular canopy density (ACD) based on Brazier and Brown (1972) to help get at buffer widths for shade:

Eqn 1. ACD = 4.146e-5 * RZW3 - 3.223e-3 * RZW2 + 8.692e-2 *RZW + 1.206e-2

Where: RZW is the riparian zone width in meters

He asked the HCP team to consider using the ACD results as a way to calculate effective tree heights for the VTS model. Our HCP approach to estimate effective tree height was in the 80% range of ORGANON Height (40). Using ACD, Greg suggested the effective tree heights would be more likely in the range of 35 to 84% depending upon channel size and whether: (1) the NHZ or (2) the NHZ + PHZ (inner zone) were considered (Table 1) below.

We responded we wished to review the request and get back to Ecology on a logical way to proceed. On May 7th 2007 I sent a note to Ecology implying ACD and Effective Shade were not comparable attributes, implying that FFF did not anticipate using ACD as a surrogate for either effective shade or as a way to approximate effective tree height to assess the level of stand opacity. ACD measurement is the projection of the crown area onto a plane perpendicular to a ray of light passing through the canopy, measured as a percent of the area occluded by leaves and branches in the canopy. On the other hand, effective shade is the total solar radiation blocked from reaching the stream. As ACD increases, more solar radiation is blocked, thus increasing effective shade. However, at some point, increases in ACD provide negligible increases in stream shading. This fact occurs since trees further from the channel do not provide additional shade when the trees close to stream already provide critical stream shade (USFS and USBLM 2005). The relationship of ACD and Effective Shade (after Park 1991) is shown in Figure 1 and ACD and buffer width is shown in Figure 2. The resulting comparison of ACD and Effective Shade in Greg's table are shown in Table 1.

(Embedded image moved to file: pic23400.jpg)

Source: USFS and USBLM (2005) after Park (1991).
Figure 1. Angular Canopy Density (ACD) and Effective Stream Shade

(Embedded image moved to file: pic00707.jpg)

Source: USFS and USBLM (2005).
Figure 2. Illustration of decreasing gains in ACD in increasing riparian buffer widths.

Table 1. Comparison of Angular Canopy Density (ACD) and Effective Shade for the FFCHP stream classes and riparian buffer scenarios.

FFHCP Class (%)	RMZ (ft)	ACD (%)	Effective Shade
A & B	40 100	67% 84%	80% 86%
C	35 80	62% 82%	78% 85%
D	30 80	57% 82%	77%% 85%
Ep	25 50	51% 73%	76% 82%
Es	15	35%	67%
The paper1/ states 15 ft zone =		45%	73%

1) USFS + USBLM (2005)

As such, the effective shade estimates of the FFHCP buffers range between 76 and 86% for streams flowing during summer months and are in line with the effective tree height reduction (80%) originally used in the FFHCP VTS model. A slight additional tweaking of the effective tree height of this magnitude will exhibit very little change with respect to the anticipated surface water temperatures.

Figure 1 shows an effective shade of 80 percent corresponds to an ACD of 65 percent. The graph illustrates only a 3 percent gain in effective shade results when ACD is increased from 65 to 80 percent. When effective shade increases beyond 80 percent, the trees furthest from the channel provide minimal additional shade. Thus, the NWFP Temperature TMDL Implementation Strategy (USFS and USBLM 2005) assumed that an insignificant change in temperature would result as a function of increasing effective shade beyond 80 percent as shown in Figure 3.

(Embedded image moved to file: pic22955.jpg)
Source: USFS and US BLM (2005)
Figure 3. Stream shade and change in water temperature.

The issues with respect to compliance with water quality standards comes down to simply one of meeting the non-degradation standard (no measurable change ± 0.3C; 0.5F). The only anticipated change in shade under the HCP would occur after stand age 50 with thinning in the inner zone. Thinning will occur from below such that the tallest trees [those providing shade beyond the NHZ] will be retained. The NWFP Temperature TMDL implementation strategy (USFS and USBLM 2005) demonstrates that thinning in the secondary shade zone (zone that provides shade outside of the critical time period of 1000 to 1400 hrs) will have no measurable increase in surface water temperatures (Figure 4).

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Source: USFS and USBLM (2005).
Figure 4. Comparison of thinning treatments and effects on increasing stream temperature.

Based on the information presented above, we anticipate the FFHCP riparian buffers will: (1) perform in a similar nature as presented in USFS and USBLM (2005) assessment of "Vegetation Treatment in the Secondary Shade Zone," and (2) be consistent with WAC 222-30-040 and Board Manual Section 1 to retain the appropriate level of shade treeswithin 75 ft. of the stream channel. As a consequence, we will stand by our original assessment of water temperatures as approximated by the landscape-scale VTS model.

Steve Stinson
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www.familyforestfoundation.org

From: Bernath, Stephen (ECY) [mailto:SBER461@ECY.WA.GOV]
Sent: Wednesday, May 23, 2007 5:50 PM
To: stevestinson@familyforestfoundation.org
Cc: George Wilhere
Subject: FW: Summary Comments on FFHCP

Steve, thanx for your request to see Mark's memo (see below). Please keep in mind the context in which this memo was written. The federal services requested both Ecology and WDFW to provide informal feedback on the HCP. This was not meant to be our formal comment on the HCP. The reason we had not shared this with you to date, was we were hoping to a have a joint strategy with the state/tribes and potentially the feds before we got back to you. That has not occurred yet.

Further we did provide you with some comments at the last technical meeting on how to improve your modeling of stream temperature/shade (density issue). You said it would taken under advisement and would get back to us..we have not heard from you on this point.

Please let me know if you have questions regarding our comments. Hopefully most of our comments will not come as a surprise, based on previous conversations and the questions/concerns we have laid out during our meetings. Sb.

From: Hicks, Mark (ECY)
Sent: Wednesday, May 16, 2007 10:14 AM
To: dan.guy@noaa.gov; James Michaels@fws.gov
Cc: Bill Vogel@fws.gov; sally butts@fws.gov; Laurie, Tom (ECY); mmobbs@quinault.org; Mankowski, John (GOV)
Subject: Summary Comments on FFHCP

Greetings,

At our meeting on May 11, you requested that Ecology summarize our concerns and provide suggestions for improving the December 2006 draft of the Family Forest Habitat Conservation Plan (FFHCP).

Ecology recognizes and appreciates all of the hard work that has gone into preparing the draft FFHCP by both the landowners and your agency. In its current form, however, it would be difficult to certify that the HCP meets the state water quality standards or that it provides comparable protection as the statewide forest practices rules. Some of the most obvious problems include:

It is based on untested theoretic and optimistic assumptions,
It lacks both adaptive management and effectiveness monitoring components,
It has reduced core and inner zone buffers, and no outer zone leave tree requirements,
It allows for extensive thinning of mature trees in the inner zone,
It does not address sedimentation and fish blockages associated with roads, and
It is not based on attributes that are unique to Lewis County or small landowners.

The following represents what we believe are the most critical issues. These issues need resolution before the FFHCP can be considered viable enough to proceed from a water quality perspective:

1. A robust adaptive management provision should be included that allows the HCP to be reopened when ongoing forest research demonstrates the prescriptions are unlikely to achieve the level of protection assumed in the analysis.

2. An effectiveness monitoring program should be added to ensure that the prescriptions are moving the waters on a target towards meeting the state water quality standards and TMDLs established for these waters.

3. The HCP provides less buffering of perennial and fish bearing waters than does the statewide forest and fish rules. If such narrow buffers are retained, the HCP should instruct that the shade rules in effect at the time of harvest be used within 75 feet of the stream (WAC 222-30-040 and Board Manual Section 1).

4. Thinning of the inner zone should not go below 60 trees per acre. Allowing the harvest of mature trees conflicts with the needs to provide full site potential shade and structural function to the streams.

5. A road management plan is needed to ensure the roads will meet the statewide target of being in compliance by 2016.

Additional issues that we believe should be addressed before approving any final HCP include:

1. The length of the HCP should be limited to only 50 years to ensure that it will adjust to potential changes in legal and technical issues.

2. The HCP analysis should be based on the 2006 water quality standards which contain more stringent fish uses and criteria. The new standards were determined necessary by USEPA, USFWS, and NOAA Marine Fisheries to prevent harm to the salmonid fish populations in Lewis County.

3. The shade model used to evaluate effects on water quality is not adequate to serve the purpose for which it is being used. The model establishes a weak relationship using only a small data set collected during a single year. The model was neither calibrated nor corroborated for the streams subject to the FFHCP. The weaknesses of this model make it all the more necessary to ensure effectiveness monitoring and adaptive management provisions be formally added.

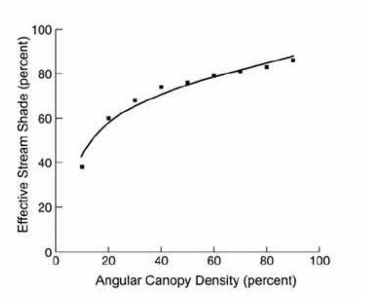
4. The HCP does not require trees be left in the outer zone which conflicts with the previous Forest and Fish negotiating position by NOAA Marine Fisheries that trees need to be left out to a full site potential tree height.

5. Ecology appreciates that the HCP will leave trees along the smaller non-fish bearing streams, but our greatest concerns remain protection of the perennial and fish bearing streams.

6. Ecology is concerned about how this HCP may affect the overall forest practices program on the Westside. It is our understanding that HCPs should be based on recognition of unique site specific conditions and considerations. The geography and forest cover associated with this HCP does not appear to be unique. By allowing more harvest opportunities than the statewide rules, the FFHCP will serve as an attractive option for use in alternative plans by both large and small landowners. This will create conflict with the negotiated forest and fish rules and ongoing research aimed at applying adaptive management.

It cannot be emphasized enough that it was only through the presence of a formal, well funded adaptive management process that Ecology could certify that the statewide forest practices regulations are likely to meet the state water quality standards. To the extent that any HCP fails to include such a process, the need to provide prescriptions that clearly and confidently meet existing and foreseeable water quality standards increases. The FFHCP provides a long-term agreement with landowners. In exchange for such an agreement Ecology believes the HCP should mandate prescriptions which are a clear improvement over the minimum statewide rules.

If you would like to discuss our comments or suggestions in more detail, please contact me (360) 407-6477 or Stephen Bernath 407-6459.



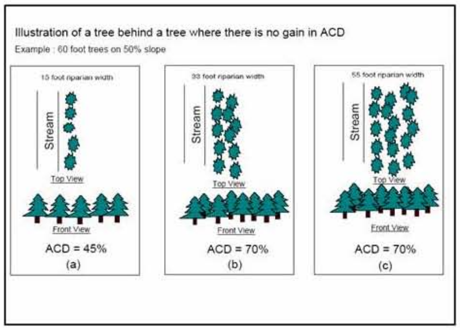
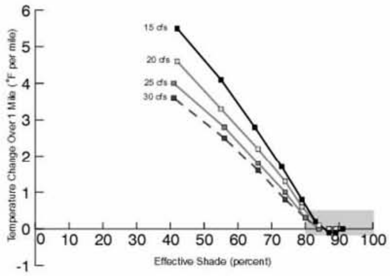
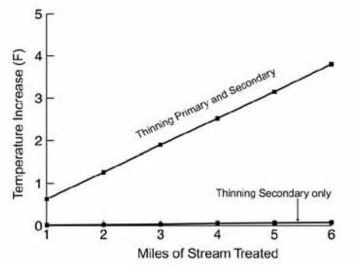


Illustration of a tree behind a tree where there is no gain in ACD

Example : 60 foot trees on 50% slope





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pic22955.jpg	**Content-Type:**	image/jpeg
	Content-Encoding:	base64

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pic20666.jpg	**Content-Type:**	image/jpeg
	Content-Encoding:	base64

Appendix 6

Subject: Fw: Background Information for upcoming meeting
From: Powers.David@epamail.epa.gov
Date: Tue, 01 Sep 2009 15:23:53 -0700
To: Jeffrey.Lockwood@noaa.gov

David Powers
Regional Manager for Forests and Rangelands
USEPA Region 10, OOO
805 SW Broadway, Suite 500
Portland, OR 97205
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----- Forwarded by David Powers/R10/USEPA/US on 09/01/2009 03:19 PM

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08/25/2009 03:53
PM

To
David Powers/R10/USEPA/US@EPA,
Teresa Kubo/R10/USEPA/US@EPA

cc
Peter Leinenbach/R10/USEPA/US@EPA

Subject
Background Information for
upcoming meeting

Dave and Teresa -

Attached below is a draft document with shade modeling results using many of the input conditions associated with the Park et al 2008 draft document. i.e., I ran two scenarios 1) low slope and 2) high slope for the largest vegetation condition group in Table 3 of the TMDL Implementation plan .

> As the channel width (i.e., tree to tree distance between the banks left and right banks) gets larger than 3 meters, there is an increasing effect of channel width conditions on the amount of shade reduction. This result could be expected - The tree overhang associated with the model runs were 1.5 meters for each bank - so basically the trees on each bank are draping over the stream and touching each other across the banks.). As it get wider the effect of management gets larger.
>
> This brings up a very large assumption with their modeling - Are they assuming that the very near stream condition will be exactly like the dense areas a couple of meters off of the stream banks? If this is not the case (for example there is a normal amount of disturbance around the stream and the very near riparian vegetation is not draping over the stream) - THE RESPONSE WOULD BE DRAMATICALLY HIGHER THAN MODELED IN THESE EXAMPLES.
>
> Also, bank slope has an effect on the response, (recall that the primary shade zone is increased by 10 feet (to 60 feet) associated with the high slope conditions), and are similarly elevated as a result of proposed management.

One thing not included in the Park et al (2008) analysis or the TMDL implementation plan is the issue of season. The result from the analysis presented below show that season has a dramatic effect on shade production for the proposed stands. For example, east-west flowing streams have almost no response to proposed management during summer solstice (June 21st), but a very large effect during late summer/early fall (August/September). Conversely, North-South facing streams are much more immune to the effect of season.

The bottom line is that the world response to these variable conditions and simplifying assumption can lead one to missing potential effects.

(See attached file: Draft_Memorandum _8_26_2009.pdf)

The pdf attached below are a couple of articles describing the difference between canopy closure and canopy cover - The model I used had canopy cover as an input but the BLM targets are 50% canopy closure.

The first document has a good background discussion associated with this issue - here is a couple of sentences from the second page

"According to the definition by Jennings et al. (1999), if canopy cover is to be measured correctly, the measurements should be made in exact vertical direction. If instruments with an angle of view are used, canopy cover is usually overestimated, because the trees seem to "fall" towards the centre of the observed area (Bunnell and Vales 1990, Cook et al. 1995, Jennings et al. 1999). As the size of the area sampled increases, the bias also increases. Another issue worth noting is that tree height and length of the live crown do not affect the estimates of canopy cover, whereas canopy closure increases as the trees become taller, and as the height to the live base of the crown decreases (Jennings et al. 1999)."

(See attached file: CC_Finland_2006.pdf)

This next pdf presents the model used to calculate canopy cover from canopy closure (i.e., Table 3). I have a little bit of discussion about this document in my write-up attached above

(See attached file: CC_OSU_2006.pdf)

Peter Leinenbach
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Draft_Memorandum _8_26_2009.pdf	**Content-Type:** application/pdf **Content-Encoding:** base64

CC_Finland_2006.pdf	**Content-Type:** application/pdf **Content-Encoding:** base64

CC_OSU_2006.pdf	**Content-Type:** application/pdf **Content-Encoding:** base64

Draft Notes **August 26, 2009**

To: Personal File

From: Peter Leinenbach

Subject: Sampling Scenarios associated with the draft document by Park, McCammon, and Brazier (2008)

Background Information

The Shade Model was downloaded from the Washington Ecology webpage

- (http://www.ecy.wa.gov/programs/eap/models.html)

The following table was obtained from NWFP TMDL Implementation Plan

Table 3. Minimum Width of Primary Shade Zone (feet) based on Slope and Tree Height

HEIGHT OF TREE	HILL SLOPE <30	HILL SLOPE 30 TO 60	HILL SLOPE >60
Trees < 20 feet	12	14	15
Trees 20 to 60 feet	28	33	55
Trees >60 to 100 feet	50	55	60

The following text describes vegetation conditions associated with the Park, McCammon, and Brazier (2008) study reach.

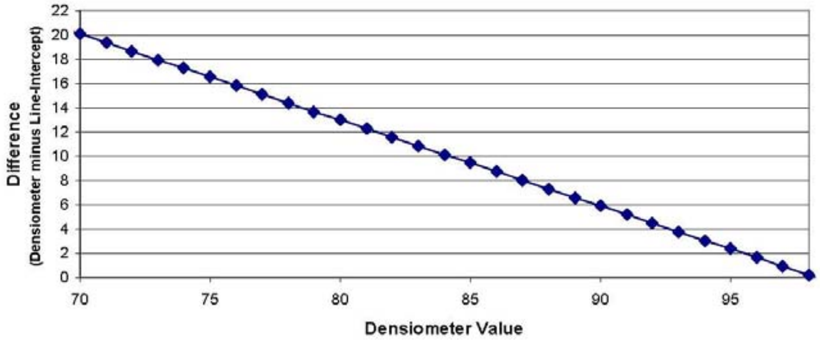
- The study site, clearcut in the early 1960s and planted with Douglas-fir, had trees 40 years old, 95 feet tall on a slope less than 30 percent.
- The lowest measured ACD condition within these stands before treatment was 89.7 (see the Results Table in this document).

Model Input Data

- Utilized Tree Height was 95 feet.
- Accordingly, the "***Primary Shade Zone***" is 50 feet for the "Hill Slope <30" Zone and 60 feet for the "Hill Slope >60" zone (see Table 3 above).

- Utilized Hill Slope in the model was 15% and 75% for the "Hill Slope <30" Zone and "Hill Slope >60" Zone, respectively.

- Although the exact canopy **closure** target was not explicitly presented in the Park, McCammon, and Brazier (2008) study write-up, but it is assumed to be 50%. A canopy **closure** of 50% was converted to canopy **cover** based on linear regressions models developed by Fiala et al (2006)[1]. The lower range associated with this model is 70% (i.e., "Densiometer Value"), but the target canopy closure is 50%. Accordingly, it was assumed that the same difference applied to the 50% canopy closure as to the 70% condition (i.e., the lowest value associated with this model). Therefore, a 30% canopy cover (i.e., 50 – 20) is associated with a canopy closure of 50%.



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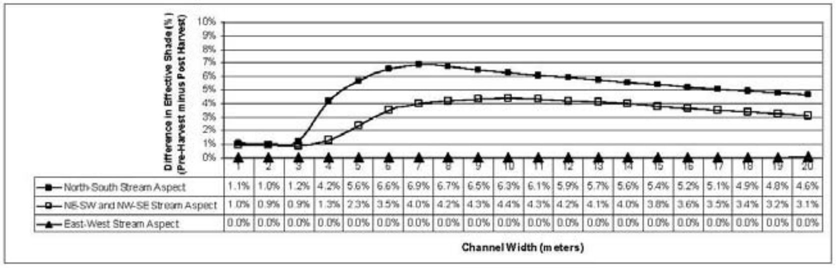
[1] **Title:** Comparison of five canopy cover estimation techniques in the western Oregon Cascades.
Author: Fiala, Anne C.S.; Garman, Steven L.; Gray, Andrew N.
Date: 2006
Source: Forest Ecology and Management. 232: 188-197
Description: Estimates of forest canopy cover are widely used in forest research and management, yet methods used to quantify canopy cover and the estimates they provide vary greatly. Four commonly used ground-based techniques for estimating overstory cover - line-intercept, spherical densiometer, moosehorn, and hemispherical photography - and cover estimates generated from crown radii parameters of the western Cascades variant of the Forest Vegetation Simulator (FVS) were compared in five Douglas-fir/western hemlock structure types in western Oregon. Differences in cover estimates among the ground-based methods were not related to stand-structure type (p = 0.33). As expected, estimates of cover increased and stand-level variability decreased with increasing angle of view among techniques. However, the moosehorn provided the most conservative estimates of vertical-projection overstory cover. Regression equations are provided to permit conversion among canopy cover estimates made with the four ground-based techniques. These equations also provide a means for integrating cover data from studies that use different techniques, thus aiding in the ability to conduct synthetic research. Ground-based measures are recommended for specific objectives. Because the FVS-estimated cover levels were consistently lower and more variable than most of the ground-based estimates (by up to 44.17% on average), ground-based measures of canopy cover may be preferable when accuracy is an important objective.
Keywords: Oregon Cascades, canopy cover, line intercept, densiometer, moosehorn, hemispherical photography, FVS
Download Location - http://www.treesearch.fs.fed.us/pubs/25503

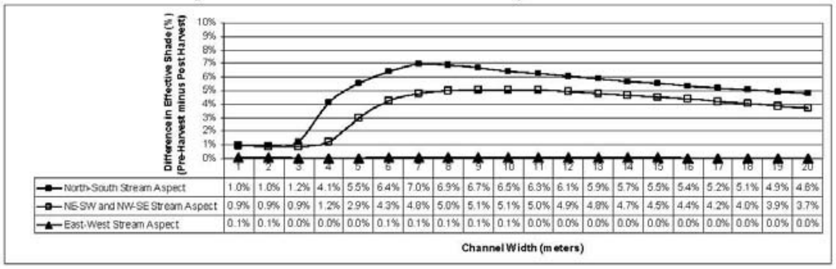
Results

Low Stream Bank Slope Scenario - Model Period – June 21st



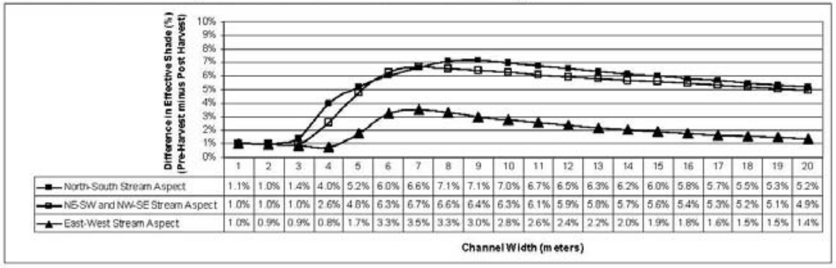
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
North-South Stream Aspect	1.1%	1.0%	1.2%	4.2%	5.6%	6.6%	6.9%	6.7%	6.5%	6.3%	6.1%	5.9%	5.7%	5.6%	5.4%	5.2%	5.1%	4.9%	4.8%	4.6%
NE-SW and NW-SE Stream Aspect	1.0%	0.9%	0.9%	1.3%	2.3%	3.5%	4.0%	4.2%	4.3%	4.4%	4.3%	4.2%	4.1%	4.0%	3.8%	3.6%	3.5%	3.4%	3.2%	3.1%
East-West Stream Aspect	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Low Stream Bank Slope Scenario - Model Period – July 21st



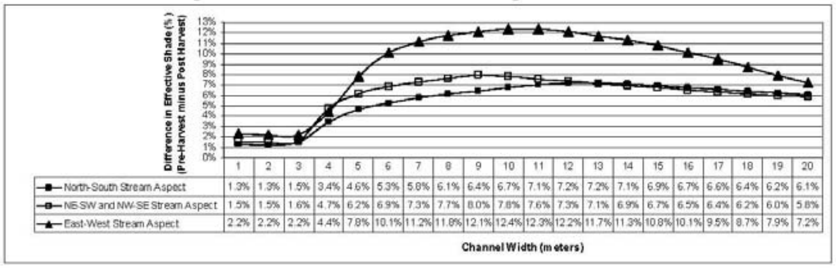
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
North-South Stream Aspect	1.0%	1.0%	1.2%	4.1%	5.5%	6.4%	7.0%	6.9%	6.7%	6.5%	6.3%	6.1%	5.9%	5.7%	5.5%	5.4%	5.2%	5.1%	4.9%	4.8%
NE-SW and NW-SE Stream Aspect	0.9%	0.9%	0.9%	1.2%	2.9%	4.3%	4.8%	5.0%	5.1%	5.1%	5.0%	4.9%	4.8%	4.7%	4.5%	4.4%	4.2%	4.0%	3.9%	3.7%
East-West Stream Aspect	0.1%	0.1%	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Low Stream Bank Slope Scenario - Model Period – August 21st



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
North-South Stream Aspect	1.1%	1.0%	1.4%	4.0%	5.2%	6.0%	6.6%	7.1%	7.1%	7.0%	6.7%	6.5%	6.3%	6.2%	6.0%	5.8%	5.7%	5.5%	5.3%	5.2%
NE-SW and NW-SE Stream Aspect	1.0%	1.0%	1.0%	2.6%	4.8%	6.3%	6.7%	6.6%	6.4%	6.3%	6.1%	5.9%	5.8%	5.7%	5.6%	5.4%	5.3%	5.2%	5.1%	4.9%
East-West Stream Aspect	1.0%	0.9%	0.9%	0.8%	1.7%	3.3%	3.5%	3.3%	3.0%	2.8%	2.6%	2.4%	2.2%	2.0%	1.9%	1.8%	1.6%	1.5%	1.5%	1.4%

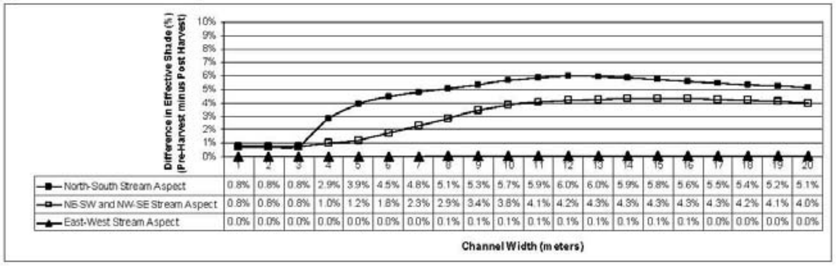
Low Stream Bank Slope Scenario - Model Period – September 21st



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
North-South Stream Aspect	1.3%	1.3%	1.5%	3.4%	4.6%	5.3%	5.8%	6.1%	6.4%	6.7%	7.1%	7.2%	7.2%	7.1%	6.9%	6.7%	6.6%	6.4%	6.2%	6.1%
NE-SW and NW-SE Stream Aspect	1.5%	1.5%	1.6%	4.7%	6.2%	6.9%	7.3%	7.7%	8.0%	7.8%	7.6%	7.3%	7.1%	6.9%	6.7%	6.5%	6.4%	6.2%	6.0%	5.8%
East-West Stream Aspect	2.2%	2.2%	2.2%	4.4%	7.8%	10.1%	11.2%	11.8%	12.1%	12.4%	12.3%	12.2%	11.7%	11.3%	10.8%	10.1%	9.5%	8.7%	7.9%	7.2%

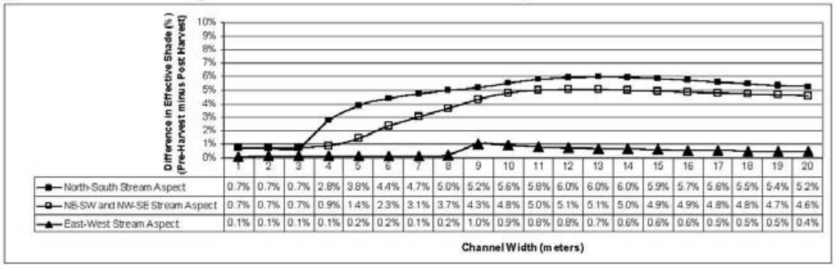
Results (Continued)

High Stream Bank Slope Scenario - Model Period – June 21st



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
North-South Stream Aspect	0.8%	0.8%	0.8%	2.9%	3.9%	4.5%	4.8%	5.1%	5.3%	5.7%	5.9%	6.0%	6.0%	5.9%	5.8%	5.6%	5.5%	5.4%	5.2%	5.1%
NE-SW and NW-SE Stream Aspect	0.8%	0.8%	0.8%	1.0%	1.2%	1.8%	2.3%	2.9%	3.4%	3.8%	4.1%	4.2%	4.3%	4.3%	4.3%	4.3%	4.3%	4.2%	4.1%	4.0%
East-West Stream Aspect	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%

High Stream Bank Slope Scenario - Model Period – July 21st



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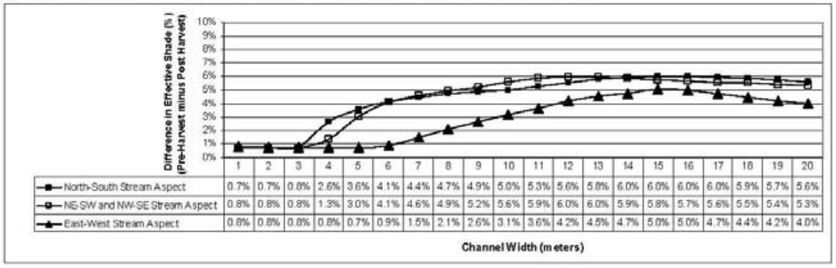
North-South Stream Aspect	0.7%	0.7%	0.7%	2.8%	3.8%	4.4%	4.7%	5.0%	5.2%	5.6%	5.8%	6.0%	6.0%	6.0%	5.9%	5.7%	5.6%	5.5%	5.4%	5.2%
NE-SW and NW-SE Stream Aspect	0.7%	0.7%	0.7%	0.9%	1.4%	2.3%	3.1%	3.7%	4.3%	4.8%	5.0%	5.1%	5.1%	5.0%	4.9%	4.9%	4.8%	4.8%	4.7%	4.6%
East-West Stream Aspect	0.1%	0.1%	0.1%	0.1%	0.2%	0.2%	0.1%	0.2%	1.0%	0.9%	0.8%	0.8%	0.7%	0.6%	0.6%	0.6%	0.5%	0.5%	0.5%	0.4%

High Stream Bank Slope Scenario - Model Period – August 21st



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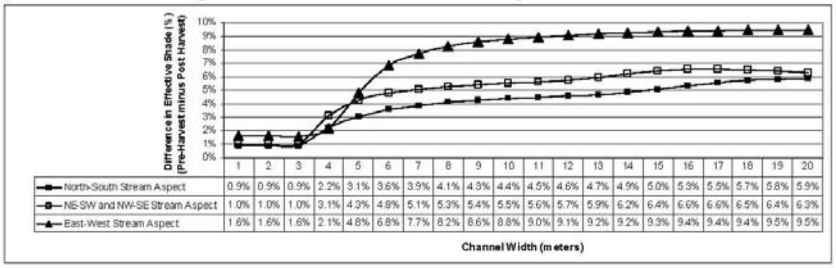
NE-SW and NW-SE Stream Aspect	0.8%	0.8%	0.8%	1.3%	3.0%	4.1%	4.6%	4.9%	5.2%	5.6%	5.9%	6.0%	6.0%	5.9%	5.8%	5.7%	5.6%	5.5%	5.4%	5.3%
East-West Stream Aspect	0.8%	0.8%	0.8%	0.8%	0.7%	0.9%	1.5%	2.1%	2.6%	3.1%	3.6%	4.2%	4.5%	4.7%	5.0%	5.0%	4.7%	4.4%	4.2%	4.0%

High Stream Bank Slope Scenario - Model Period – September 21st



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NE-SW and NW-SE Stream Aspect	1.0%	1.0%	1.0%	3.1%	4.3%	4.8%	5.1%	5.3%	5.4%	5.5%	5.6%	5.7%	5.9%	6.2%	6.4%	6.6%	6.6%	6.5%	6.4%	6.3%
East-West Stream Aspect	1.6%	1.6%	1.6%	2.1%	4.8%	6.8%	7.7%	8.2%	8.6%	8.8%	9.0%	9.1%	9.2%	9.2%	9.3%	9.4%	9.4%	9.4%	9.5%	9.5%