# Western Oregon Plan Revision
# Draft Environmental Impact Statement

# Science Team Review

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# Summary

The analysis supporting the Western Oregon Plan Revision Draft Environmental Impact Statement (WOPR DEIS) is highly technical, and portions of the analysis show great sophistication and advancement over previous planning assessments. The use of dynamic spatial models at regional scales is, in particular, at the cutting edge of planning for a resource agency. The Science Team, however, had concerns with many portions of the analysis. Many of these were based on unclear documentation and writing, and others were based on questions about assumptions, adequacy of models, risk analysis, and interpretation of current scientific understanding. The most significant of the concerns were:

Models and action Alternatives probably overestimate amounts of habitat for target species, and underestimate detrimental environmental effects. For example, projected trends in northern spotted owl habitat under any of the Alternatives do not assume that any habitat will be lost to high severity wildfire, which, according to the DEIS fire analysis, would be expected during the 100 year period of the plan. Timber production may be overestimated as well: WOPR DEIS models did not incorporate important external factors including wildfire, political, legal and budgetary limitations, and included limited consideration of constraints on operational feasibility. The descriptions of the effects of the Alternatives and the selection of the preferred Alternative do not consider these risks.

The DEIS makes limited use of existing data for key analyses outside of silvicultural/forestry measurements. Use of real world observations is fundamental to describing the affected environment, formulating and evaluating Alternatives, and evaluating the effects of Plan implementation (i.e. monitoring). Sensitive species analyses did not use species-specific population or presence data, but relied on habitat models derived from geomorphic or silvicultural (forest structural) variables. Habitat models used for many species and modeling for stream temperature were overly simple compared to existing published models. Although models of habitat availability are a practical means of estimating effects of management on species, such models need to explicitly relate habitat availability to population metrics. Furthermore, habitat models are unreliable unless they have been validated. The WOPR DEIS models and characterizations of Alternatives do not include calculations of accuracy, error, or bias. No sensitivity analyses, validation, or accuracy assessments were conducted despite the existence of relevant empirical data and growing awareness of uncertainty and development of methods to include it. Although the analysis acknowledges external risks such as wildfire and climate change, neither external uncertainty nor internal (model) uncertainty are included in the analysis of direct and indirect effects, and this uncertainty does not appear to be factored into Alternative selection.

Under the principles of science-based management, uncertainties related to wildfire, climate change, and population trends in sensitive species (e.g., northern spotted owl) and uncertainties associated with new and untested models proposed in this analysis can be mitigated with adaptive management and monitoring. The revision is partially justified on the incorporation of the “principles of adaptive management” (DEIS, p. 5). However, the WOPR seems to downplay the significance of new sources of uncertainty by not presenting a substantial adaptive management and monitoring program as part of its revision. Regardless of which Alternative is selected, it is probable that the same key monitoring questions would be selected, driven by the resources noted as DEIS Issues and by Federal regulation. A stronger commitment to quantifying change in metrics describing these resources (through monitoring), and a characterization of the degree to which

proposed actions are open to change given uncertainties would strengthen the scientific basis of this management plan. If robust adaptive management and monitoring programs are no longer important parts of the Bureau of Land Management's (BLM) management, stronger support is needed for the purported reduced margins of error (DEIS, p. 5) in prediction of changes in key resources.

The WOPR DEIS analyses employ a set of scales and data that are not fully representative of the processes occurring in the Plan area. For some resources, including Water (and perhaps Fish), extrapolation is made using data from a small portion of the Plan area, which may bias model results. Spatial and temporal scales analyzed for several physical processes (particularly peak flows) may actually obscure large effects occurring at smaller scales which are still relevant to management. Wildlife habitat analyses (particularly for the marbled murrelet and fisher) do not adequately consider the scales at which species interact with the environment or the spatial constraints on these species, and may have misclassified habitat availability. Fish habitat model outputs would benefit from interpretation in spatial and temporal scales relevant to the processes (e.g., episodic debris flow) described. Finally, by comparing rather similar management Alternatives with a narrowly defined range of past and future system states, important aspects of the cumulative effects of these Alternatives are not fully considered.

The DEIS models used to analyze fish habitat incorporate more recent scientific thought about the importance of episodic disturbance in maintaining riparian systems and the species that depend on them. However, both indices of fish habitat (measured as intrinsic potential) and fish productivity (based on intrinsic potential and estimated wood contributions) used in the DEIS are measures of habitat conditions having the potential to support (juvenile) fish productivity. Both indices are so far removed from actual fish (species) use or productivity that it is hard to gauge their utility in the analysis.

Analyses in the Water section of the DEIS are problematic. Stream temperature analysis in the WOPR DEIS does not use the most recent and relevant science on the subject, has inadequate model parameterization, and would probably not meet BLM's Management Objectives for maintaining and restoring water quality in some stream segments or basins. Analysis of sediment delivery to aquatic systems appears to ignore crucial physical processes influencing sediment response. The parameterization of the model describing peak flow response in the rain-on-snow zone is also problematic and would greatly benefit from model validation.

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# 1.0 Scope of the Science Team DEIS Review

A Science Team consisting of scientists and natural resource specialists led by a BLM Science Team Coordinator was formed in 2005 to provide scientific advice to the BLM to "enhance the quality and credibility of Resource Management Plan (RMP) revision analyses" (USDI 2005[1]). Science Team members, noted with their agencies and primary focus of their WOPR DEIS review, included:

- Doug Drake - Oregon Department of Environmental Quality
  - Focus of DEIS review: Invasive plants, Fish, Water, Fire, Soils
- Joan Hagar - USGS Forest and Rangeland Ecosystem Science Center
  - Focus of DEIS review: Wildlife
- Chris Jordan - NOAA Northwest Fisheries Science Center
  - Focus of DEIS review: Fish, Water
- Gary Lettman –Oregon Department of Forestry
  - Focus of DEIS review: Socioeconomics, Timber
- Thomas Spies - Pacific Northwest Research Station
  - Focus of DEIS review: Ecology, Wildlife, Fire, Timber
- Fred Swanson - Pacific Northwest Research Station
  - Focus of DEIS review: Ecology, Fish, Water, Soils, ACECs
- Chris Sheridan - Western Oregon BLM Science Coordinator
  - Focus of DEIS review: Technical coordination, compilation, contribution

The Science Team members included members of natural resource management and regulatory agencies, as well as scientists with backgrounds in modeling and the practice and study of natural resource management; this breadth of perspectives influence the breadth of Science Team comments on the DEIS. The Science Team members participated as subject matter experts in response to a BLM request for an objective science review of the DEIS. The Science Team DEIS Review reflects the professional assessments conducted by the Science Team members. The Science Team Review should not be considered as a complete or final review or comment on the WOPR DEIS by these agencies. Other agency review, comment, and/or official findings may be provided through NEPA and/or consultation processes beyond the scope of the Science Team Review. Some DEIS sections were reviewed by only one team member; other sections were reviewed by several, and some DEIS sections (e.g., Botany) received little scrutiny.

The Science Team charter (USDI 2005) included the following direction relevant to comments on EIS materials:

- Review effects analysis to provide input to the BLM regarding the ability of Alternatives to meet the Purpose and Need of the plan revisions and other evaluation criteria.
- Suggest methods by which the quality and credibility of the revision analysis process may be improved.
- Review Draft EIS (DEIS) material for "identified major issues" according to the following criteria:
  1. Was all the relevant scientific information considered?
  2. Were all the significant assumptions acknowledged?

[1] Full description of the WOPR Science Team charter is available at: http://www.blm.gov/or/plans/wopr/science/science1.php.

3. Were risks adequately and fairly documented?
4. Are the conclusions consistent with known science?

- Additional Science Team direction is noted in section **2.5**.

The Science Team review of the WOPR DEIS does not meet the stringent definitions of a formal science consistency evaluation, such as those described by Mills et al. (2001, p. 13, para. 2). Science Team review relied on the public DEIS materials, state-of-the-science reports, relevant primary literature, and professional opinion, and included comparing WOPR results with trends and magnitudes of effect from empirical data and other modeling efforts available for the Plan area. The Science Team did not have time to validate WOPR model parameters, repeat WOPR analyses, or investigate model sensitivities. The Science Team could not investigate every assumption inherent in the analysis nor rigorously investigate Alternative ways of performing analyses. Science Team review of ongoing research and existing primary literature in the Pacific Northwest which might be relevant to the WOPR DEIS review was not exhaustive. The Science Team held six meetings to share ideas, facilitate synthesis, and edit the Science Team report. Science Team findings were compiled and synthesized into a single document by the Science Team Lead (Sheridan); Science Team members were involved in both the editing and synthesis process. The Science Team and the WOPR interdisciplinary team (authors of the DEIS) had information exchanges regarding Science Team review that clarified some points and revealed that changes were being made to the DEIS. However, the Science Team based its review on information in the DEIS, since the nature of EIS changes were not yet finalized. Following review by the Science Team and the WOPR interdisciplinary team, the Science Team edited its draft comments following guidelines similar to those described in Mills et al. (2001) for contributions that scientists can make to successful science-based decision-making, modified as follows:

- Focus the science on key issues and communicate it in a policy-relevant form. Science Team comments should be based on precedent in the scientific literature or science-based management principles, not on NEPA or regulatory precedent.
- Use scientific information to clarify issues, identify potential management options, and estimate consequences. Avoid suggesting analysis that is more rigorous, complex or outside the scope of current published peer-reviewed science analyses.
- Avoid advocacy of any particular solution. Avoid providing Management Direction to the BLM.

The Science Team strove to follow these guidelines and especially to avoid advocacy for a particular management approach or plan Alternative. The Science Team, however, took the perspective that this was a science-based management plan and addressed issues that fell within the gray area between science and management (for example, dealing with adaptive management and monitoring).

The results of the Science Team review of the WOPR DEIS presented below incorporate review by WOPR interdisciplinary team and informal review by agencies employing several of the Science Team members. Review format includes first a description of themes common across Resources (**Section 2**), followed by Resource-specific discussions (**Section 3**).

# 2.0 Common Themes Among Resources

The analysis supporting the DEIS is highly technical, and portions of the analysis are well-founded and presented. The DEIS analysis required an impressive amount of work under tight time schedules; the WOPR Interdisciplinary Team is to be commended on their efforts. The Science Team review of the WOPR DEIS identified concerns with many sections of the DEIS, including both Resource-specific concerns discussed in **Section 3.0,** and shared issues identified by some or all Science Team members, discussed here.

## 2.1. Clarity and model detail

The Science Team review focused on significant issues relating to the science used in analysis, important assumptions, risks, and WOPR analysis conclusions (**1.0**). However, a number of sections in the DEIS are either so unclear or lacking in detail that it is impossible to apply these evaluation criteria.

*DEIS clarity*

Specific DEIS sections which are very difficult to interpret or misleading include:

- Ecology. Describing this section as "Ecology" is imprecise (**3.1**).
- Wildlife. The definition of the term "natal" is not in the DEIS glossary, "dispersal" is defined solely for northern spotted owl and "suitable" and other habitat classifications for analyzed species were not clearly articulated in the DEIS, making an assessment of underlying model assumptions difficult. Definitions used in the DEIS appear to differ from established Federal regulatory definitions. (**3.4**)
- Fish. Sections on sediment effects on fish (DEIS, p. 355) use terms unfamiliar to readers (e.g., embeddedness and nephelometric turbidity units). The distinction between fine sediment in the water column and in the bed is not presented sharply. (**3.5**)
- Extent of impact to intermittent streams. Rules for wetland determination around wetlands, ponds, and lakes are poorly written, making the extent of riparian systems considered in analysis unclear.
- Water. Review of the literature and analysis for sediment (DEIS, p. 372) and peak flow (DEIS, p. 388) are uneven and difficult to follow. The Analytical Assumptions and Water planning criteria (DEIS, p. 1095) are not described adequately for a critical review of the analysis. The Water analysis also uses citations of very limited and perhaps misleading relevance for the Planning Area. (**3.6; 3.8**).
- Fire. The description of fire regimes (e.g., DEIS, p. LXII, XLV, Map 31) is inconsistent. Some of the fire-related terms do not appear in the glossary or are poorly defined (e.g., "hazard", "resilience", "severity"). "Uncharacteristic wildfire", for example, is presented as a fire suppression effect, but more recent literature identifies climate change influence on fire regime in parts of the west, suggesting a different definition of uncharacteristic. Inconsistencies in fire definitions may lead to meaningful differences in estimated effects and in Management Direction. (**3.7**). A slight revision to the characterization of salvage logging and fire risk would better communicate the uncertainties associated with this practice.
- Areas of Critical Environmental Concern – Research Natural Areas. Writing in sections describing Management Direction for ACECs (e.g., DEIS, p. LXV) is so bureaucratic that it is difficult to understand.

*Analysis and modeling detail*

The DEIS defines modeling as a "scientific method" (DEIS, p. 863); however, the method applied here lacks many of the components of a scientific method, including estimation of error, sensitivity analysis, model validation, and monitoring and adaptive management, which are means for testing assumptions of the plan and adapting management to a dynamic world. The term "model" is applicable to a broad class of representations, ranging from a relatively simple qualitative description of a system or organization to a highly abstract set of mathematical equations". Many of the individual parameters used in WOPR DEIS models could be considered "science-based"; parameter inclusion in models was driven by their demonstrated importance through empirical, published studies. The use of these parameters in a new context (describing new treatment relationships within a different analysis area), as part of a new model, and often with less parameterization, should be considered hypotheses to be tested through a scientific model evaluation process. This review describes some important parts of such a scientific model evaluation process (**2.4**). The WOPR DEIS models generally lack documentation, sensitivity analysis, evaluation of output with empirical data, and adaptive management to test outcomes of actions. Models used for the WOPR DEIS should thus be considered as "descriptive" (following Lint (2005)), depicting the hypothesized propagation of a set of management guidelines over time and space. Modeling alone in the WOPR DEIS is not a complete science process, and reference to science in the definition seems unwarranted.

Virtually every model described in the DEIS does not provide enough metadata or model description (in the body of the DEIS or in Appendices) to fully evaluate its assumptions, functions or quality of projections. The following analyses did not provide critical information, making a clear understanding of the predicted effects of the Alternatives difficult.

- Tree/stand modeling. The ORGANON/ DBORGANON model underlies all of the other resource projections. It is important to provide sensitivity analysis and accuracy assessment for this model (**2.4**). It is unclear how ORGANON produces estimates of canopy cover (DEIS, p. Q1538), as well as estimates of legacies like snags and coarse woody debris (DEIS, p. Q1545), both in current stands and in projected (future) managed stands. Errors and uncertainties associated with these estimates are not provided. For example, both canopy cover and coarse woody debris are used in classifying northern spotted owl habitat, making the derivation of these characteristics important to analysis of wildlife effects. It is also unclear how this model (DBORGANON) performs in modeling the growth and dynamics of riparian forests which would be a mixture of hardwoods, conifers and shrubs (DEIS, p. Q1538). Uncertainties and errors associated with riparian projections would affect stream shade models and large wood delivery models. Lack of this information makes it difficult to evaluate the scientific basis of the entire modeling effort.
- Fisher habitat model. It is impossible to evaluate the science and assumptions underlying the habitat assessment for the fisher because information is lacking on the variables used to define habitat and the spatial scale of analysis. (**3.4**).
- Fish large wood delivery model. Several significant aspects of large wood modeling are not adequately explained, and significant assumptions and their ramifications are not detailed (**3.5**).
- Sediment modeling. The DEIS does not describe what size classes of streams were considered, and what sediment pathways and delivery processes were modeled. (**3.6**).
- Monitoring and adaptive management. Little detail is provided in this section, making it impossible to assess whether monitoring and adaptive management components will be effective at determining whether the Plan is achieving predicted outcomes. (**2.5**).

## 2.2. Spatial and temporal scales

The use of particular spatial and temporal scales in the DEIS analysis has implications for results of the analysis, and should bound the scope of inference for the analysis. Several broad issues with the scales considered in the DEIS were identified.

- It is unclear what the spatial resolution of the OPTIONS model is (DEIS, p. 480-486). This information does not appear in the section titled "Spatial and Temporal Scales of Analysis". It is important to know the minimum mapping unit because some issues, such as riparian forests, require a fairly small unit to adequately characterize. In addition, the error associated with spatial models may vary with the spatial grain of the analysis.

- The scales selected for many of the species analyzed are inappropriate to the natural history and population biology of these species. For example, only the northern spotted owl analysis considers larger habitat scales (e.g., blocks). (**3.4**).
- Spatial and temporal scales analyzed for several physical processes may obscure some relevant management effects. This is particularly true for peak flow analysis. (**3.6**).
- By comparing rather similar management systems within a narrow consideration of past and future and limited effects to subjects of interest (e.g., wood in streams and listed species), important aspects of the cumulative effects of Alternatives are not considered. (**2.6**). In the case of wood in streams, for example, the long history of management of streamside forests that limit wood delivery to streams and of direct wood removal from streams has had the cumulative effect of drawing down the amount of wood in streams – an important feature of the existing conditions. This is not explicitly dealt with in the modeling or assessment of existing inventories of wood in streams (**3.5.2**).
- Limited rationale is presented for utilizing the 5$^{th}$ field scale. For example, several scales of hydrology and geomorphology response to peak flow alteration are relevant (Grant et al. in press[2]). For the biological components of the DEIS, the appropriate spatial grain is a closed demographic unit or population.

## 2.3. Geographic and temporal "representativeness"

The DEIS analysis often uses results from studies describing conditions or processes in one part of the Plan area (or even outside it), and extrapolates those assumptions to other parts of the Plan area (in modeling), or extends those conclusions to other portions of Plan area generally. The value and limitations of such extrapolations should be stated explicitly as should the process by which these assumptions are tested and their implications monitored during the implementation of the Plan. Some of many specific examples are summarized below.

- A very small set (5) of "representative" watersheds was selected for fish habitat analysis (DEIS, p. 723). It is not clear how effective these 5 watersheds are in characterizing potential impacts of management activities to the fish species this section is intended to describe. (**3.5.2**). If additional watersheds are identified, they should be chosen at random to properly reflect the suite of conditions existing across the Plan area (**3.5.2**).
- Modeling of wood dynamics appears to have been based largely upon Coast Range wood dynamics concepts (**3.5.2**). It is not clear how differences in the physical dynamics and landforms in other Provinces have been incorporated into these models, nor the local fish responses to these dynamics. (**3.5**).
- In discussion of stream shade, the work of Nierenberg and Hibbs (2000) is referenced as support for limited conifer influence in riparian areas due to limited conifer growth in riparian zones (DEIS, p. 370). This study sampled a narrow range of forest age classes in one Province, so the information should be considered in this limited context. (**3.6.1**).
- Stream shade analysis appears to be based on data from a very small sample (DEIS, Water), with unknown inference to the rest of the Plan area. (**3.6.1**).

## 2.4. Empirical data, model sensitivity analysis, validation, and risk analysis

The DEIS makes limited use of existing data for key analyses outside of silvicultural/ forestry measurements, even where this data has been collected. Use of real world observations is fundamental to describing the affected environment, formulating and evaluating Alternatives, and evaluating the effects of Plan implementation (i.e., monitoring). Sensitive species analyses did not

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[2] A copy of this manuscript is available at: http://www.fs.fed.us/pnw/about/programs/ecop/index.shtml.

use species-specific population or presence data, but relied on habitat models derived from geomorphic or silvicultural (forest structural) variables. Specifically for sensitive species, northern spotted owl analyses relied on classification of forest operational polygons as habitat based on imputed stand level characteristics (**3.1, 3.41**), and marbled murrelet and fisher analyses relied on forest structural classes (**3.4.2, 3.4.4**). Stream temperature models applied relationships between buffer widths and solar radiation in a small study to the Plan area without incorporation of site-specific empirical data (**3.6.1**), and used a process-based model for assessing susceptibility to peak flow (**3.6.3**). In each of these cases, relevant empirical data exist that could be used, at a minimum, for some level of model validation (see below); the empirical data were not considered. The ability of WOPR models to accurately gauge change in the affected environment is a significant and untested assumption inherent in this analysis.

The WOPR DEIS models make very limited use of empirical data. This is not unique to WOPR analysis; regional analyses often lack full empirical data sets describing responses in new settings or under modified assumptions. However, particularly where lacking empirical data, modern environmental modeling standards generally include three major components: 1) sensitivity and/or uncertainty analysis, including model validation; 2) risk analysis associated with Alternatives and resource outcomes other than wildfire; 3) risk management strategy including an integrated approach to management that employs adaptive management and monitoring as ways to reduce uncertainties and spread risk. These components are not a strong part of the WOPR analysis. Sensitivity analysis, uncertainty, model validation and risk analysis are explored below, including examples of specific model parameters that would greatly benefit from additional analysis. Adaptive management and monitoring are addressed in Section **2.5**.

*Sensitivity analysis*

Sensitivity analysis is defined as a method for evaluating the effects of changes in an input variable or assumption (model parameter) on the model predictions (key outputs). Uncertainty analysis is defined as a method for comparing the importance of uncertainties in input variables or assumptions in terms of their relative contribution to total uncertainty in the outputs (Morgan and Henrion 1990). Without one or both of these analyses, it is difficult to evaluate the accuracy (defined below) of predicted differences among Alternatives. In a decision-making context these analyses are more than an evaluation of how assumptions or uncertainty change the result, but are distinct analyses that could influence the decision or selection of the preferred Alternative. For example, an Alternative that appears suitable to meeting the purpose and need under an assumption of no effect of wildfire might not be considered suitable if risks associated with wildfire were included.

With large complex models sensitivity analyses are difficult to do but some effort along these lines is typically made. Key model input parameters in the DEIS analysis include those that define habitat for sensitive species (northern spotted owl and marbled murrelet). Key outputs of interest in the DEIS analysis include timber volume and habitat amounts for listed species. Important uncertainties may be associated both with estimation of model input parameters as well as the model responses (output parameters). Additionally, major sources of external uncertainty also affect these parameters and their responses, including the occurrence of wildfire, land use/management changes in private lands, climate change, and invasive species and operational feasibility across a diverse landscape.

Uncertainty in input parameters: The following model parameters include important unchecked assumptions and would be predicted to result in different conclusions if these assumptions were changed, thus indicating a need for sensitivity analysis.

- IVMP imagery. The DEIS suggests in some places that 1996 interagency vegetation mapping project (IVMP) imagery was used (DEIS, p. B-946), and elsewhere that IVMP data updated to 2002 were used (DEIS, p. 186). Land cover changes occurring in the Plan area from 1996-2002, including major wildfires and changes in harvest in non-BLM ownerships, should be considered in the DEIS analysis. Ignoring these data would be an important model assumption, and would be predicted to decrease the accuracy of WOPR model predictions. The IVMP data have been updated to 2004, and these data would presumably be more accurate. It is also not clear how the accuracy of IVMP images (roughly 60-80 percent) was considered in analyses relying on this data. Accuracy assessments suggest that IVMP misclassification is > 20 percent; errors of exclusion for CR large diameter stands (20+ in DBH) were > 25 percent (Moeur et al. 2005, Table 3.1). This inaccuracy may be acceptable, as long as the information is interpreted appropriately (Fassnacht et al. 2006). It is unclear how lumping IVMP into broad structural classes might introduce biases or further decrease its accuracy. It is also unclear how this error in estimates of non-BLM forest types would influence DEIS predictions of change in habitat or process. Would being wrong by up to 20 percent influence the "margin of error" described in the DEIS as being "unnecessary" (DEIS, p. 5)?
- Northern spotted owl habitat models. Models for northern spotted owl suitable habitat use an acres-based approach, and a polygon classification scheme with limited justification for weighting the model parameters. Significant assumptions in this model are discussed in Section **3.4.1**. A sensitivity analysis of the northern spotted owl habitat model could improve the credibility of the model by determining which of these variables is really driving variation in amount (ac.) and quality of northern spotted owl habitat.
- Marbled murrelet (marbled murrelet) habitat model. The DEIS defines marbled murrelet (marbled murrelet) "suitable habitat" differently than other models and regulatory agencies (**3.4.2**). Habitat suitability models have been developed and evaluated for both the northern spotted owl (Lint 2005) and marbled murrelet (Huff et al. 2006) in the Northwest Forest Plan monitoring report, and by others; it is unclear why these models were not incorporated into the WOPR analyses. As with the northern spotted owl, without sensitivity analysis or model validation DEIS model results are difficult to interpret and lack credibility.
- Fish habitat. Large wood delivery models involve a large number of assumptions about wood delivery processes, and model wood as a future contribution without fully considering wood budgeting processes (**3.5.2**). These considerations and the consideration of fish intrinsic potential as opposed to actual habitat use (**3.5.3**) highlight how far removed this analysis is from actual conditions. Sensitivity or validation analyses would be essential to interpret the metrics[3] derived in this analysis.
- Debris flow modeling. It does not appear that the influence of roads and harvest on the initiation of debris flows was considered in debris flow modeling (DEIS, p. 1089); note that roads can be important influences on debris flow initiation and runout (**3.5.2**). It is also not clear the degree to which debris flow modeling incorporates empirical field data from the full Plan area to evaluate the model output (**3.5.2, 3.6.2**).
- TPCC and landslides. Timber Production Capability Condition (TPCC) is used in the DEIS as a screen to identify landslide prone areas and to avoid influencing them through management (DEIS, p. 763). The TPCC was developed as a way to identify BLM lands that would "contribute to the Allowable Sale Quantity" (DEIS, p. Q-1509). It is not clear how effective the TPCC screening process is at detecting and predicting potential landslide sites. How much more land will be added to this no-harvest land classification based on field investigations at the timber sale planning level? The BLM must have a feel for the accuracy of TPCC based on

[3] "Metric" is used in this review to describe a measure or set of measures that facilitates the quantification of some particular characteristic. This definition appears similar to the usage in the WOPR DEIS (e.g., WOPR, p. 209).

recent experience. Even if it is relatively accurate, site-level landslide prediction is difficult. The analysis supporting Soils Management Direction appears to assume it is 100 percent effective (DEIS, p. 742). This seems unlikely, and is contradicted in the Soils analysis, which states "areas that are judged to be of lower risk have occasionally failed in the past" (DEIS, p. 797). The TPCC withdrawn areas depicted in Figure 271 (DEIS, p. 762) seem quite limited for such a landslide-prone landscape.

- <u>TPCC and intermittent streams</u>. The TPCC layer was originally developed to identify ground unsuitable for silviculture, but is proposed in the DEIS as a guide to field staff for identifying systems likely to contribute large wood from intermittent to fish-bearing systems (DEIS, p. 80). The extent and characteristics (e.g., wood delivery) of these intermittent streams are modeled and analyzed in the DEIS using stream GIS layers and DEM (Digital Elevation Model) (DEIS, p. 1089). How will differences between ground-based mapping of specific TPCC classes and DEM-mapped debris-flow prone hollows be reconciled? Both these TPCC assumption sets would benefit from validation (**2.4**).

It is also likely that models used in the WOPR DEIS have some level of compounded error. The DEIS states "[OPTIONS] outputs were also used as data inputs for other models (such as the modeling of hydrology and fire)" (DEIS, p. 481). Fish productivity models (DEIS, p. H-1091) are based on Intrinsic Potential (IP) models which are themselves based on DEM data, wood delivery models based on DEM and wood delivery assumptions based on Coast Range empirical data, IVMP data with 60-80 percent accuracy (Moeur et al. 2005), and ORGANON data with unknown accuracy for the Plan area. Peak flow analyses have similar levels of model-based-on-model structure. There is no recognition of error in the WOPR DEIS; however, assuming merely additive errors for these compounded models would be optimistic.

*<u>External (exogenous) sources of uncertainty</u>*

Uncertainty in modeling and evaluation of management Alternatives can arise not only from internal sources (e.g. the key input parameters described above) but also from environmental and anthropogenic influences that are external to the model but may be very real to the system that the model is attempting to characterize. Major sources of external uncertainty affecting the parameters described in the DEIS may include the occurrence of wildfire, land use /management changes on all non-BLM ownerships, and climate change.

The DEIS makes a strong statement that natural disturbances, climate change, and salvage logging are matters that fall under the Council on Environmental Quality (CEQ) definition of topics of "incomplete or unavailable information", so that they can be ignored (DEIS, p. 486-487). However, the DEIS treats this issue in a very uneven manner. For example, the DEIS proceeds to give strong indication that a great deal of relevant information exists on these topics. Further, natural disturbance processes that cannot be predicted in time or locality are so integral and expected in these forests and watersheds that they seem to deserve more concerted incorporation in the plan. Also, the DEIS presents a counterpoint to this avoidance of considering disturbance processes by using an intensive analysis of episodic debris flow processes as agents of wood delivery to streams. The description of what is known (DEIS, p. 488) mainly cites other EISs, which are not primary sources. Several points are left hanging, such as the comments that insect infestations are possible after Timbered Rock and Biscuit fires - did infestations happen? Note that the DEIS discussion might be interpreted as treating all disturbances as stand replacement, which is not the case. So, it would be helpful to clarify such points in this section.

There are many ways to factor uncertainties into policy models including scenario analysis**.** The use of fire regimes can serve as a basis for some of this risk evaluation by helping to define regions where probabilities of events differ. In the absence of rigorous methods, simpler ways of characterizing uncertainty exist, including ordinal scales (L, M, H) based on expert opinion (Raphael and Molina 2007, p. 112). At a minimum it would seem that the characterizations of the effects of the Alternatives on key resources (timber, owls, sensitive species) should include a narrative that describes how changes in assumptions or uncertainties about key variables might affect the expected outcomes for key resources under the Alternatives. Without such a characterization it is impossible to have much confidence in the predicted effects of different Alternatives. It is instructive to remember that uncertain events, specifically wildfire and expansion of the barred owl, during the first ten years of the Northwest Forest Plan accounted for more change in some regions than the original main threat (harvest of old-growth forest) management was responding to (summarized in Courtney et al. 2004).

Uncertainty is a key determinant between accurate and precise predictions in modeling. Precision can be defined as the degree of agreement in a series of measurements (repeatability); accuracy describes how close measurements are to the true value; bias is a systematic, directional error (McCune and Grace 2002). The DEIS states: "the preciseness of the analysis for this draft environmental impact statement has improved…as opposed to when the current RMPs were first analyzed in 1995" (DEIS, p. L). While the preciseness of some of the management models has improved, the overall uncertainty in management as a result of climate change, wildfire, invasive species, and global social forces may have increased, or at least our appreciation of these uncertainties has increased. Consequently, this statement is misleading. A precise model can be quite wrong if there are biases or if it is based on incorrect assumptions. For example, the projections of all the Alternatives are probably biased toward the high end of timber production and older forest habitat given that wildfire, climate change, insects and disease have not been included in the models.

Uncertainties associated with parameter estimation, including estimation of a response (e.g, amount of northern spotted owl suitable habitat or percent increase in peak flow) can be investigated with sensitivity analysis and quantified using model validation and accuracy assessments. Sensitivity analysis (above) could include evaluating habitat suitability models or physical process models against criteria such as those developed by Roloff and Kernohan (1999). Validation and accuracy assessments are described below. At a minimum, qualitative listing of likely sources of uncertainty and error should be provided, and levels of risk and uncertainty should be characterized for the management Alternatives. Without error estimates for model parameters including estimates for key resource levels, there is no confidence in the estimated effects of individual Alternatives or in comparisons across Alternatives.

*Model Validation*

An important component to development of robust models is model parameter validation or accuracy assessment. Comparison of model predictions or model parameters and model predictions to empirical data is crucial; one test of a model is the amount of variation in the natural world explained by the model. It is noteworthy that the BLM performed some level of "truthing" for what it considered important, i.e. requesting districts to assess the operability of 'units' in the 10-year scenario (DEIS, 10 year scenario). No comparable level of empirical truthing or sensitivity analysis was described for the other DEIS Issues (DEIS, p. 21). For large, complex models, classic model validation often cannot be done. Examples of such large complex models may include fish productivity models. In the absence of such validation, sensitivity analysis (described above) and validation of individual model parameters becomes important. The following key individual model parameters or components would greatly benefit from some form of validation or accuracy assessment.

- TPCC and landslides. Timber Production Capability Condition (TPCC) is used in the DEIS as a screen to identify landslide prone areas and to avoid influencing them through management (DEIS, p. 763). It is not clear how effective the TPCC screening process is at detecting and predicting potential landslide sites. The quality of the TPCC protocol could be assessed for a subset of the Plan area by comparing the TPCC map with the actual landslide occurrence in areas sampled in the Oregon Department of Forestry study after the 1996 floods; this data set is used in the debris flow modeling, so it is readily available for use in the BLM planning process[4].
- TPCC and intermittent streams. A separate accuracy assessment could be performed comparing predictions of TPCC classifications used in the DEIS to delineate systems providing large wood to fish-bearing streams with both: a) the spatial signature of intermittent streams modeled in the analysis using stream GIS layers and DEM; and b) actual empirical data for hollows that produced debris flows in important events, such as 1996 flood events. Province-scale comparisons would be suggested, since these relationships change across provinces.
- Northern spotted owl, marbled murrelet, and fisher model validation. Several published, peer reviewed models for northern spotted owl and marbled murrelet habitat exist, but were not used. For example, McComb et al. (2002) developed a habitat quality model for the northern spotted owl and validated it against occurrence data. More recently, BIOMAPPER was used to model owl occurrences (Lint 2005). Similarly, a habitat suitability model was developed and evaluated for the marbled murrelet in the Northwest Forest Plan monitoring report (Huff et al. 2006). Empirical verification of northern spotted owl/marbled murrelet models used for the DEIS would justify their use in place of other published and more strongly validated models. See **3.4.1** and **3.4.2** for further detail. Similar validation would help lend credence to fisher analyses (**3.4.4**) and any other species analyses performed.
- Debris flow modeling**.** Models of debris flow probabilities and characteristics are used to estimate effects of management on large wood contributions (DEIS, p. 1089). Empirical data informed model development for some debris flow characteristics; this is laudable. However, geomorphic systems behave differently across the Plan area, increasing uncertainty in this model's predictions as applied over the geography of the Plan area (above). It is unclear whether debris flow models were validated with empirical data for systems across the Plan area.
- Wood delivery model validation. The WOPR analysis states that wood model output is "not a prediction of actual instream conditions at a specific point in time" (DEIS, p. 349). Despite the indirect link between modeled wood delivery and actual amount of wood in streams, it seems that failure to provide quantitative, empirical description of wood in streams using existing BLM data is a shortcoming of the analysis because such information provides a frame of reference for assessing model characterizations of wood amounts (e.g., do modeled wood levels exceed, underestimate, or match observed levels in unmanaged systems). Presenting empirical data on wood in streams is also relevant in describing the Affected Environment, which in some areas includes cumulative effects of past management. This is particularly important because of the use of wood in streams as a measure of management effects on salmonids (**3.5**). Given that time and budget constraints have precluded sensitivity analysis and parameter validation prior to plan development, empirical assessments of the affected modeling elements would seem to be an integral component of ongoing monitoring efforts associated with the plan. In order to support the ongoing use of the debris flow and wood recruitment models, a valid monitoring program would need to confirm the model output, given the stochastic nature of wood-recruitment events affecting the spatial and temporal variability in wood loads and the variation in wood abundance as a function of stand, channel, and valley characteristics. Applying these

[4] Note that the ODF Flood Study captured landslides produced by singular storm events (in 1996). However, accuracy assessment with this data would help quantify "producer's accuracy" or errors of exclusion (Moeur et al. 2005, p. 123) in TPCC mapping of slide-prone areas.

models in an adaptive context would require evaluating model predictions against field measurements and modifying management accordingly.

- Fish use/presence validation. Intrinsic potential (IP) and the fish productivity metric derived from it are the only descriptors of fish species (as opposed to habitat) considered in the DEIS analysis. This "potential" use metric has some bias and may not be descriptive of potential juvenile use across the Plan area, and is surely not an accurate reflection of actual populations or actual use (Section **3.5.3**). The utility of IP as a metric would be bolstered by comparison to actual fish presence and habitat use. Fish population and life history-specific presence data are collected by Oregon Department of Fish and Wildlife (ODFW) for portions of the Plan area, by some BLM Districts, and in studied watersheds in the Plan area (e.g., Hinkle Creek[5]).
- Stream temperature model validation. Concerns have been described regarding the parameterization and empirical support for stream temperature modeling (**3.6.1**). Results from both empirical studies and models trained with collected data in the Analysis Area arrive at different results than the model employed by the DEIS (**3.6.1**). Comparison of the predictions of this DEIS temperature model to actual empirical data from sites with prescriptions reflecting the Alternatives and across the Plan area would be necessary to definitively defend the model used in the DEIS; this might be better accomplished as part of a robust monitoring program (see below).

*Risk analysis and risk management*

The DEIS states: "…the 1995 RMPs erred on the side of caution regarding resources used by species considered rare, threatened or endangered. That margin of error is no longer justified" (DEIS, p. 5). It is not clear whether this decision was based on new scientific information for species suggesting increased accuracy in effects determination, or a new interpretation of the BLM's statutory requirements (DEIS, p. 6). For the northern spotted owl (Lint 2005, Courtney et al. 2004), marbled murrelet (McShane et al. 2004, p. 3-58), and salmon (Araki et al. 2007), additional and emerging threats have been identified and population levels do not suggest that less caution is now warranted than in previous Plans. The DEIS provides little substantive information on risk analysis and risk management strategies within the Plan to ensure that WOPR Alternatives meet the competing components of the Purpose and Need (DEIS, p. 3).

Risk analysis and management involves four components: 1) estimating the chance of an adverse outcome; 2) developing systems, such as adaptive management practices that monitor management effects and use those findings to learn and reduce uncertainties (see below); 3) employing a "portfolio" approach to management that spreads risk associated with uncertainties and known and unknown threats across different management holdings; 4) building redundancy into components of plans that provide some safety margins associated with different resources and risks. Risk analysis and management are becoming a standard way of approaching natural resource management (Raphael and Molina 2007, p. 117). For example, risk analysis and management was used in developing the Northwest Forest Plan and characterizing outcomes under different Alternatives. While the DEIS represents an advance over (Forest Ecosystem Management Assessment Team) FEMAT in analytical modeling, the same can not be said for how the Plan deals with risk and uncertainty. Specific examples of resource areas with issues which would greatly benefit from risk analysis and risk management are described below.

- Socioeconomic factors and the effects of not fully implementing WOPR: The accuracy of DEIS analysis of socioeconomic (and perhaps other) metrics might be improved by considering the risks of failing to fully implement Alternatives 2 or 3 as part of the sensitivity analyses for economic (**3.2**) and timber (**3.3**) predictions.

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[5] See http://www.fsl.orst.edu/cfer/research/resproj/lndscp/lnd-stdy/l06_ddct.html.

- Management of the northern spotted owl and its habitat in presence of wildfire: The predicted trends for northern spotted owl habitat (DEIS, p. 635: Fig. 216) do not assume any losses during 100 years to wildfire or other disturbances. However, it is quite likely that there will be a decline in northern spotted owl habitat area due to wildfires, and the Preferred Alternative has twice the amount of acres at high fire severity risk as the No Action (DEIS, p. 769). Thus it is quite likely that Alternative 2 will lead to a differential decline in northern spotted owl habitat area as wildfires occur (**3.4.1**). Comparisons of the Alternatives would be improved by discussions of their margins of safety relative to at-risk-resources, such as northern spotted owl.
- Marbled murrelet habitat change: Marbled murrelet suitable habitat analysis in the DEIS predicts a decline in marbled murrelet suitable habitat in the next 50 years attributable solely to the Preferred Alternative (DEIS, p. 678). There are a number of reasons to believe this is an underestimate of change (**3.4.2**). Proper risk assessment for effects of the Alternatives on this species would include cumulative effects analysis incorporating influence of management on other ownerships and changes in population status related to marine conditions.
- Botany: Risks of sensitive plant species losses associated with Alternatives 2 and 3 are noted as "moderate" in the DEIS (DEIS, p. 593). Taking the step of qualitatively addressing risk through this coarse filter is laudable. The lack of species-specificity of this threshold[6] (i.e. 20 populations used as a benchmark for all species, although "each species' unique biological requirements and threats shape the number of individuals, patch size, and distribution" (DEIS, p. 604)), the threshold's dependence on (principally) expert opinion, and the inaccuracies in projecting plant population presence due to limited survey effort (DEIS, p. 607) make the uncertainties at the species-level associated with this assessment quite large, and suggest that this strategy might not be appropriate for fine-filter management of species at risk.
- Elimination of green tree retention in Alternatives 1 and 2: Green tree retention has become a widely accepted approach in ecosystem management to maintain habitat and structural diversity in managed forests (PNW 2007) and to mitigate the severity of fire by increasing landscape-level stand type diversity (**3.7**). The development of Alternatives is a BLM management decision. However, given the significant attention paid to green tree retention in many management and scientific arenas, it may be productive to include discussion of: a) the rationale for development of Alternatives and why green tree retention was not included in Alternatives 1 and 2; and b) how particular, individual Alternative components such as green tree retention drive differences in environmental response. For example, it is difficult to differentiate in the DEIS the specific effects of eliminating green trees in harvested stands on deer and elk (**3.4.3**), landbirds (**3.4.5**), canopy lichens including their roles in nitrogen fixation (Berryman and McCune 2006), and delivery of large wood (**3.5.2**).

## 2.5. Monitoring and Adaptive Management

Previous sections of this review (**2.4**) have identified concerns with the accuracy of model predictions used in the WOPR analysis as well as the risks associated with predictions from models which have not been rigorously tested and validated in the presence of outside risks such as wildfire, pending and on-going climate change, and invasive species. Strategies identified for reducing risk in such situations (above) include monitoring and adaptive management.

[6] In this review, the term "threshold" is used as a reference level above or below which system change (loss of a species, for example) occurs. "Benchmark" is used as a reference level of management interest by which a response (such as the effects of an action) can be measured or analyzed, including historic conditions. Benchmarks may or may not be related to a system change of interest. Benchmark is defined more narrowly in Section **2.5**.

Monitoring and adaptive management are fundamental to a science-based approach to natural resource management in a changing environment. For this reason, monitoring was deemed essential to the success of the Northwest Forest Plan[7], and necessary to gauge the effectiveness of any management strategy (Gallo et al, 2005). However, sections in the DEIS that deal with monitoring and adaptive management are very short and not specific (DEIS, p. 846), and are not even carried to the DEIS Summary section (DEIS, p. XLI). The DEIS states that monitoring plans would not use random or statistically based sampling, would ignore "well enough established relationships (such as between shade and stream temperature, and stream temperature and salmonids)" and would be driven by the design principles of avoiding unnecessary detail and unacceptable costs (DEIS, p. 846). In short, no substantive commitments are made to monitoring or to adaptive management in the WOPR DEIS.

The un-validated and untested models and assertions in the WOPR DEIS, and the new management systems invoked to implement the WOPR, should be considered hypotheses to be tested in terms of the response in volume production and environmental change. The ability of the Alternatives to meet the Purpose and Need and management objectives of the Plan is a question that can only be accurately assessed using monitoring. Even if WOPR DEIS hypotheses about the environmental baseline and its response to management are wholly accurate, change in the environmental baseline is occurring rapidly (GAO 2007). Given these projected dynamics and uncertainties the most up-to-date standards for science-based management would indicate the application of a strong adaptive management and monitoring program (see below). The Science Team charter includes suggesting methods by which the quality and credibility of the revision analysis process could be improved, including review of the WOPR monitoring plan for technical quality, and recommendation of specific monitoring questions and methods (USDI 2005). The following section describes some of the elements of a robust Monitoring and Adaptive Management program.

*Monitoring plan components*
Elements of a monitoring plan which are necessary to evaluate its effectiveness include identifying key monitoring questions (DEIS, p. 846), developing a sampling design, establishing measurement benchmarks, and the physical infrastructure of the monitoring program. Given the narrow scope of issues considered in the Plan (DEIS, p. 21), development of key monitoring questions would seem quite tractable. Key monitoring questions could include quantifying changes in metrics describing resources in the Plan area; timber volumes and age class distributions, populations of sensitive plant and animal species, amount and arrangement of habitat for these same species, stream water temperature, large wood characteristics and flow regimes, extent of invasive species, and resiliency of forest ecosystems to fire are all candidate metrics. The most useful monitoring program would be designed to address significant uncertainties or inadequacies identified in the WOPR analysis, and to provide an evaluation of the effectiveness of selected management strategies.

Sampling design: The monitoring program supporting the WOPR would greatly benefit from truly representative samples of the populations of response variables (candidate metrics) in the Plan area using randomly selected samples, following a statistically valid design. The designs being used by Environmental Protection Agency (EPA) EMAP (Peck et al. 2006), the U.S. Forest Service NW Forest Plan monitoring program (Moeur et al. 2005), and the Oregon Plan for Salmon and Watersheds (ODFW 2005) offer examples of relatively robust statistical approaches.

[7] Judge Dwyer recognized the importance of monitoring to the Northwest Forest Plan and to land management planning in general, stating "Monitoring is central to the [Northwest Forest Plan's] validity. If it is not funded, or done for any reason, the plan will have to be reconsidered."

The use of benchmarks in monitoring: Environmental benchmarks are essential both for gauging the cumulative effects of the Alternatives on factors of interest (**2.6**) and as an evaluation of the effectiveness of the Plan during implementation. Benchmarks (also termed thresholds) are (preferably quantitative) metrics used to indicate whether a resource of concern has been degraded and whether the combination of the Alternatives' impacts with other impacts will result in a significant deterioration of environmental functions (EPA 1999). Appropriate benchmarks can include numerical criteria (e.g., dissolved oxygen content), qualitative criteria that consider biological components of an ecosystem, or desired management goals (e.g., "recovery"). As these examples demonstrate, benchmarks can be expressed in terms of biophysical system performance or in a social/regulatory context: this context should be clearly stated. Benchmarks have either been developed or are evident from primary literature for most of the key resources considered in the DEIS, and could be used as reference points against which to gauge changes in the key monitoring question metrics. Example benchmarks include "Recovery" for Endangered Species and Total Maximum Daily Loads (TMDLs) (DEIS, p. 12) for stream systems.

Monitoring plan infrastructure: The Plan area supports many examples of monitoring programs as well as physical settings for reference points and case studies. Existing studies on and near BLM lands (e.g., Density Management Study), monitoring activities by other agencies (e.g., US Geological Survey stream gauging and the interagency northern spotted owl demographic surveys), and other programs seem highly relevant and could be invoked as contributing to meeting BLM's monitoring responsibilities. Research Natural Areas can act as valuable reference points for evaluating effects of standard management practices on adjacent lands, and therefore can contribute to meeting the monitoring responsibilities of the agency (this point is missed on DEIS p. 436). It is unclear if BLM lands will continue to be part of ongoing Northwest Forest Plan monitoring; this program could also meet BLM's monitoring responsibilities.

Stream temperature monitoring example: As an example, consider stream temperature. Maintenance of water quality is a management objective (DEIS, p. 57), and increased stream temperature is noted as the most common impact to water quality (DEIS, p. 365). Hence stream temperature and potential changes in this metric following management would logically be a key monitoring question for the Plan. The stream temperature metric could be measured directly, as well as indirectly by quantifying effective shade (DEIS, p. 368). Benchmarks and measurement scales for this metric might include percentage of streams within a fifth-field watershed meeting 80 percent effective shade; comparison of this metric to actual stream temperature changes following management would facilitate evaluation of the Plan's shade assumptions. Infrastructure for monitoring of stream temperature could include samples from districts across the Plan area as well as case studies in instrumented systems (such as BLM's Density Management Study (DMS) sites).

*Adaptive Management*

Significant technical information has been developed regarding adaptive management concepts (Walters 1986, Gunderson et al. 1995, Carpenter et al. 1999) and the significant challenges to implementing adaptive management programs specifically in the Pacific Northwest (Stankey and Shindler 1997, Walters, 1997, Lee 1999, Johnson et al. 1999, Gray 2000). The WOPR DEIS analysis provides little substantive information on components of its adaptive management program (DEIS, p. 848), making it difficult to determine: a) whether this technical information has been considered; and b) how WOPR adaptive management would be conducted to address changes in key DEIS assumptions identified through monitoring or new science.

Discussion of the WOPR adaptive management program would be improved by clarification of what specific Plan adaptation would be "allowable without supplementing/revising/amending" the

Plan (DEIS, p. 849). The schedule for plan evaluation and added detail on "adaptive management tools and procedures" used to "make changes in the plan" (DEIS, p. 848) would facilitate determination of whether relevant technical information on adaptive management was considered, and whether the risks associated with the WOPR adaptive management plan have been documented.

The WOPR DEIS commitment to adaptive management appears substantively different and reduced from current Plan commitments. There is greatly reduced latitude in WOPR "range of activities" (DEIS, p. 848) compared with the Northwest Forest Plan: for example, interim riparian buffer widths have been eliminated. There is no identified land base such as adaptive management areas (AMAs), no information on the level of BLM commitment to implement adaptive management, and no discussion of engagement with publics and science providers who would be participants in adaptive management. Considering that Northwest Forest Plan principles of adaptive management are cited as rationale for the Plan revision (DEIS, p. 5), clarification of how the reduced adaptive management program described in the WOPR DEIS would facilitate meeting WOPR Purpose and Need and Plan Objectives would enhance the analysis. In summary, WOPR DEIS sections on monitoring and adaptive management would be greatly improved by increased detail on which issues BLM considers important and which metrics would be measured to assess change in these issues (i.e. key monitoring questions), which sampling protocols would be used to make measurements (including geographic scope and sample sizes), which benchmarks these measures would be compared to, what exceedance would consist of, and (most importantly), what would be done within the framework of the Plan if measures exceeded BLM-identified benchmarks.

## 2.6. Cumulative Effects

Robust cumulative effects analysis includes consideration of not just the direct effects of Alternatives on key resources, but also: a) interactions between affected resources leading to substantive effect; b) the effects of other Federal, state, and private actions on these key resources; and c) the effects of past actions to the extent that they influence current and future resource behavior (CEQ 1997 and elsewhere). Each of these components of cumulative effects is described below relevant to the WOPR DEIS.

*Interactions between resources*

Important interactions among DEIS-described resources are not considered in this analysis. Weaknesses in the DEIS consideration of the effects of fire regimes on other resources, including habitat for late-successional species and hydrology, are discussed above (**2.4**). Interactions between aquatic and terrestrial domains are described specifically under comments related to the riparian zone (**2.8**). Interactions among invasive species and key resources considered are also weakly addressed in the WOPR DEIS. Increased susceptibility to invasive plant infestation is predicted with increased soil disturbance associated with forest harvesting, with greatest increases attributable to the Preferred Alternative (DEIS, p. 614). The DEIS estimates a tripling of watersheds highly susceptible to invasion in riparian areas (DEIS, p. 623). Invasive species present significant risks to ecosystem health requiring active management. However, managing invasive species with herbicides may present significant risks to water quality (**3.6.4**). The differential effects of the Alternatives on invasive species would be predicted to produce a differential indirect effect on terrestrial and especially riparian habitats, leading to a differential effect on biodiversity and on fish species. Himalayan blackberry invasion into streamside riparian areas, for example, may lead to reduced shading, streamside wood contributions, and bank stability (Bennet 2007). Interactions among post-fire salvage management activities, fire behavior, and forest structure/habitat elements would also benefit from more analysis. The literature on salvage logging should be thoroughly and critically reviewed to document the range of scientific viewpoints on this issue and to clarify which viewpoints were used in the DEIS and why (DEIS, p. 489-490). The interaction between salvage and fire disturbance and their combined interactive effects of on various high-priority resources should be explored in DEIS Chapter 4.

Assumptions about policies for non-BLM Federal lands (succession in reserves and static conditions in matrix), as well as assumptions about state and private lands (static) in Oregon used in analyses for development of forest structure (DEIS, p. 477, p. 484) may not be valid given changes in forest management that could occur across the region. These include proposed changes in plans for state forest lands (ODF 2003), potential for changing management practices on private forest land, and legislative proposals for retention of mature forest (DeFazio in prep). Analyses of changes in forest structure might be more robust if they included some range in non-BLM management assumptions as part of their sensitivity analyses (**2.4**). If such a sensitivity analysis is not possible, it would be valuable to describe the degree to which the environmental consequences analyses for key resources are sensitive to assumptions about non-BLM lands. For example, are the assumptions about management of non-BLM lands a "worst-case" for particular resources? The section on incomplete or unavailable information does not identify management actions outside of BLM lands as a source of uncertainty.

It is unclear to what degree conditions in areas outside of BLM ownerships were considered in analyses of changes in wildlife habitat (especially marbled murrelet habitat), stream temperatures, or sediment yields-most figures in the DEIS descriptions of these resources refer to "BLM-administered lands"[8] . If the influences of non-BLM lands (positive and negative) have been considered in the effects analysis, the implications of the above-described set of assumptions about non-BLM lands (i.e. static conditions for private and state lands) have not been fully explored. Quantification or at least qualification of the influence of these important assumptions about the future of non-BLM lands on key resources would be a valuable inclusion to sensitivity analyses for key models (**2.4**).

*Landscape history and shifting baselines: large wood in streams example*

An important aspect of cumulative watershed effects that impinge on the Plan is the history of wood in streams from the pre-management period, into the early-management period (second half of the 20th century for most BLM lands), and into the landscape of fully implemented forestry we now enter. The early-management period has been well documented – lots of debris flows from both natural and management-related flushing of sediment and big wood from steep tributaries into mainstem channels. Intensive management in the fully implemented forestry period may result in greatly reduced delivery of wood and sediment to mainstem channels because there will be less delivery of big wood to channels and frequency of flushing by debris flows may be higher. Thus, disturbance in headwater streams can lead to changes from episodic to chronic sediment delivery (Benda et al. 2005). Is this hypothetical scenario of cumulative effects adequately represented in both narrative and modeling of the DEIS? The DEIS acknowledges some aspects of this transformation in regard to the large wood resource (DEIS, p. 340), but does not incorporate this paradigm in the analysis.

Use of the "maximum potential large wood contribution" concept (DEIS, pp. 348-349) is difficult to follow and seems to leave open the question of how historic management influences are considered (also see issues raised in last paragraph of **3.5.2**). By comparing rather similar management systems (No Action and Action Alternatives) within a narrow consideration of past and future states, the DEIS does not give sufficient consideration to some of the historical dimensions of wood in

[8] DEIS description of "areas of concern" for the northern spotted owl does consider "all lands".

streams. In the case of stream habitat conditions, for example, splash damming and stream cleaning may be practices of the past, but their legacies persist where they were used. In the case of splash damming, for example, streams subject to this practice more than a century ago show lower wood loadings than streams that were not splash dammed (Kelly Burnett, pers. comm. 11/15/07, based on work for Northwest Forest Plan monitoring). Czarnomski (2003) and Dreher (2004) showed persistent reduction of wood loading in streams 50 years after cutting of streamside forest in sampled western Cascades streams. Stating that some past disturbances like splash damming no longer occur (DEIS, p. 335) obscures the fact that these processes are not captured by mapping used in the DEIS analysis, will continue to influence responses in the Plan area, and may respond differentially to different Alternatives.

## 2.7. Climate change

Climate change is a phenomenon that may have profound effects on vegetation, hydrology, and disturbance patterns, and, therefore, deserves consideration in WOPR DEIS analyses. The DEIS states that the BLM position of not considering climate change is consistent with a 2005 Forest Service document (not found in DEIS references) that argues against addressing climate change. The recently released Government Accountability Office report (GAO 2007) calls on Federal forest land management agencies to develop policies to address climate change. Although scientific understanding and policies concerning climate change and its effects on ecosystems and natural resources systems are evolving rapidly, analyzing the influence of climate change on the Alternatives using the best available science would facilitate assessing whether the Plan is consistent with any developed climate change policies; such an analysis would be a valuable part of the Plan’s described adaptive management strategy (DEIS, p. 848).

Long-term modeling predictions in the WOPR DEIS are rendered questionable since the long term impacts of climate change were not considered. Models developed for the WOPR DEIS to describe the Affected Environment rely on disturbance-free, fixed-plant series forest successional models (for terrestrial species), maintenance of the current geomorphic and environmental determinants of fish distributions, stream temperature relationships based on current forest and climatic conditions, and hydrological relationships (for peak flows) present in the 1970s (**3.6.3**). Granted, there may not yet be clear, observed, near-term impacts of climate change in the planning area to justify specific management practices (DEIS, p. 491), and current climate change models do not provide demonstrably better (i.e. “reasonably foreseeable”) parameters for direct inclusion in developed baseline WOPR models. However, WOPR analyses considering extended time periods (e.g., 100 years) would be improved by incorporating climate change predictions in the description of uncertainties in model predictions or as a component of sensitivity and risk analyses (**2.4**). Reviews and meta-analyses by Walther et al. (2002), Root et al. (2003), Poff et al. (2002), Mohseni et al. (2003), and Parmesan (2003) summarize predicted ecological effects of climate change. Below, we present a number of key climate change predictions with clear directions of effect (and generalized magnitudes comparable to modeling underlying the WOPR analyses), with suggestions for including this information in WOPR analyses.

- Fire frequency would increase significantly in the Coast Range and Willamette Valley in Oregon in the absence of significant fire suppression in all scenarios described by Millar et al. (2006). The WOPR analyses currently do not consider the effects of wildfire on the amount and arrangement of forest habitat in the Plan area. Risk analyses for WOPR long-term habitat predictions might be improved by consideration of a range in losses in late-successional habitat due to wildfire including values comparable to the recent past (3 percent per decade (Moeur et al. 2004), for example) and values representative of more extreme climate change scenarios (15 percent loss per decade based roughly on Lenihan et al. (2003), for example).

- Predictions of year-round warming with warmer, wetter winters and hotter, drier summers in the 21st century have been tied to trends in northern spotted owl life history to predict potential effects on northern spotted owl survival (Glenn, pers comm). For species of interest, the WOPR DEIS could analyze a range in climate change scenarios and their effects on population measures; Mote et al. (2003) and Busing et al. (2007) considered lower and upper extremes (e.g., minor warming with drier summers vs. major warming with wetter conditions) to investigate the effects of a range in climatic conditions on biotic responses. Since WOPR analysis used only habitat models for species (**3.4**), climate change effects on northern spotted owl populations could be considered only qualitatively, but could be included in narrative description of assumptions (uncertainties) that might affect the expected outcomes for northern spotted owl under the Alternatives.
- Increases in water temperatures as a result of climate change will alter fundamental ecological processes and the geographic distribution of aquatic species (Poff et al. 2002), including habitat loss for cold water species, species replacement, and range shifts (Daufresne et al. 2003, Rahel et al. 1996, Moore et al. 1997). For nine species of native coldwater fish (including Pacific Northwest salmon and trout) in the continental United States, up to 40 percent of fish thermal habitat would be lost in under a climate change scenario that predicts a doubling of $CO_2$ (Mosheni et al. 2003). The WOPR fish analyses could consider climate change-induced reduction in fish habitat as part of risk analyses for long-term habitat changes associated with the Alternatives, either quantitatively (using existing stream data and modeling changes in “fish-bearing” status) or qualitatively. Climate change effects on fish habitat would be expected to have a distinct gradient (Poff et al. 2002), with greatest habitat loss in the southern parts of the Plan area.

Other climate change predictions could be analyzed only broadly and qualitatively. For example, much of the Plan area is predicted to experience expansions of alder, maple, madrone, oak, and pines (Millar et al. 2006). Climate change is also predicted to modify precipitation and runoff patterns, altering biotic components of aquatic systems (Poff et al. 2002). Such broad scale changes might best be addressed with monitoring and adaptive management strategies (**2.5**) which emphasize creating forest resilience, resisting the effects of climate change and responding to that change (Spittlehouse and Stewart 2003, Millar et al. 2006) during the life of the Plan. The WOPR DEIS descriptions of the effects of the Alternatives would be improved by risk analyses (**2.4**) which incorporate consideration of the effects of climate change, including increased uncertainty in most biotic responses (Mote et al. 2003, Millar et al. 2006), even if WOPR DEIS consideration were narrative in form. Alternative selection which incorporates climate change as part of a comprehensive risk analysis might be more likely to achieve the Purpose and Need over the life of the Plan.

## 2.8. Riparian zones and riparian networks

The WOPR DEIS provides limited analytical support for how the reduced buffers in Alternatives 2 and 3 would meet DEIS Management Objectives for maintaining and restoring riparian and wetland areas (DEIS, p. 57), particularly for intermittent streams. Many science-based recommendations on buffers designed to support a robust suite of riparian processes and biodiversity in headwaters can exceed 100 ft. and modify management in some portions of upslope areas (summarized in Everest and Reeves 2007 (Table 2), Olson et al. 2007 (Table 5)). Alternatives 2 and 3 would greatly reduce harvest buffer widths compared to current BLM management, including harvest disturbance to the edges of some intermittent streams and potentially as close as 60 feet to all streams in the BLM Plan area (DEIS, p. 111). The DEIS analysis does not clearly characterize the extent of riparian systems, and does not fully consider the indirect effects of the Alternatives on riparian zones. More broadly, riparian zones[9] are not explicitly analyzed in the DEIS, although some riparian zone physical and biotic components are considered independently. Without analyzing riparian zones as integrated systems, the DEIS cannot fully analyze the cumulative effects of changes in riparian zone biophysical functions.

*Extent of impact to intermittent streams*

More detail regarding the extent of intermittent streams in the Plan area would enhance description of the Affected Environment and Effects of the Action, specifically: a) what percentage of total stream length (by Province) consists of "debris-flow prone" intermittent (100 ft. buffer) vs. "intermittent non-debris-flow prone, non-fish bearing" (25 ft. partial buffer) systems; and b) how much of the total Plan area landscape does this equate to? Another factor complicating interpretation of the DEIS analysis is the unknown comparability of TPCC-delineated debris-flow systems (proposed as part of the buffer implementation method (DEIS, p. 80)) to DEM-modeled debris-flow systems (discussed in **2.4**).

Headwater streams comprise 60-80 percent of drainage networks, which may conservatively equate to 30 percent of humid mountain landscapes when considering the influence of slope-side processes[10] (Benda et al. 2006). The Preferred Alternative would regenerate over 143,000 ac. in the first decade of the Plan, including 4,000 ac. "along non-debris flow prone, non-fish bearing intermittent channels" (DEIS, p. 720); this would equate to >160 stream miles[11]. The DEIS states that 400 ac. of clearcut harvest would occur "along non-debris flow prone intermittent channels" (DEIS, p. 741) (it is here assumed that the 400 ac. would represent a fish-bearing subset), totaling < 3 percent of the total harvest during this period. Since both the DEIS and Benda et al. (2006) use a 100 ft. analysis mask, it is surprising to note an order-of-magnitude difference between predicted amount of riparian intermittent systems and affected systems, unless the Alternatives are actively targeting upslope areas. The 100 ft. analysis mask applied to calculate the influence of the Alternatives on reduced-buffer headwater channels (leading to the estimated 4,000 ac. influence) may adequately bracket some direct effects but probably underestimates the extent of riparian zone contributing areas which would be indirectly affected by the Alternatives. Harvest and temporary and permanent roads installed > 100 ft. from intermittent streams would influence groundwater flows (Lynch and Corbett 1990, Montgomery 1994, Sidle et al. 2000, Moore and Wondzell 2005), peak flows (Moore and Wondzell 2005, Grant et al. in press) and edge effects (Chen et al. 1999), as well as influencing headwater species dispersal (summarized in Olson et al. 2007).

Modification of forest structure in headwater riparian habitats described in the DEIS would also compound in some way each decade: in decade 2 another (perhaps) 160 miles of intermittent streams would be impacted, when the previously harvested 160 miles were only 10 years old. The need for a comprehensive effects analysis including the direct and indirect effects of this compounded habitat loss through time is discussed for Special Status Species (SSS) riparian species in **3.4.6**.

*Riparian zones: functions and interactions*

By not treating riparian zones as integrated systems (Richardson 1999), the DEIS cannot effectively analyze indirect/interrelated changes in these systems. Riparian zones are complex ecosystems beyond just the sum of their parts (Gregory et al. 1981, Naiman et al. 2005). Riparian habitats

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[9] Riparian zone here describes an ecotone, the transitional zone between two adjacent ecosystems, in this case the transitional zone between terrestrial and aquatic systems.

[10] Benda et al. (2006) use an example of 30 m 'buffer' or influence zone and a drainage density of 5 $km/km^2$. This headwater zone of influence would vary widely across the WOPR Plan area.

[11] Assuming a 100 ft. analysis window for "adjacency".

support biological and process diversity (Richardson 2000), provide refugia and act as mediators and corridors for riparian processes and species (summarized in Olson et al. 2007). The DEIS descriptions of the effects of changes in nutrients and sediment on fish production (DEIS, p. 741) appear inconclusive or based on conclusions from the Water section questioned in **3.6**. Little consideration is given to the effects of changed physical processes on other riparian-associated species (discussed for SSS aquatic/riparian wildlife species in **3.4.6**). Management strategies that consider ecosystem-level riparian functions acting in concert are more likely to achieve riparian management goals (Everest and Reeves 2007, p. 9). However, relevant science and science-based management considerations treating riparian zones as integrated systems (e.g., Elmore and Beschta 1987, Johnson and O'Neil 2001, JAWRA 2007, Olson et al. 2007) are not considered in the WOPR DEIS. The DEIS conclusions regarding the ability of the Alternatives to meet the integrated riparian Management Objectives described in the DEIS (p. 34, 57) at meaningful scales are not well-supported by the analysis.

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# 3.0 Summary of Key Points by Resource

## 3.1. Ecology

The term "Ecology" used to describe the section that characterizes only forest structure is confusing and not precise (DEIS, p. 192). It gives a misleading impression that this section deals with ecological relationships and processes, which are central to the definition of ecology. In fact, it deals only with forest structure and dynamics which are certainly an important part of the ecology of these forests, but only one part. It might be more appropriate to label this section as "forest structure and dynamics at stand and landscape scales". Other issues with the Ecology section include overly-broad classifications for forest structure, incomplete description and metadata for the vegetation modeling, and misleading discussion of disturbance effects on forest structural stages.

*Structural stages*

Key Points for the Ecology section (DEIS, p. 494) reporting limited change in the amount and arrangement of the different structural classes are dependent on the assumptions inherent in the classification scheme, and can be misleading without further discussion of specific characteristics and functions that would be changing due to the Alternatives. Although the limits of broad classifications of structurally advanced forest used in the WOPR are acknowledged, it would be good to further state that habitat changes for species or functions dependent on characteristics not described by structural class may not be well represented by these classes. For example, species associated with long times without stand-replacing disturbance and some dispersal-limited species (Sillet 1994, USDA and USDI 2004, Olson et al. 2007 (Table 3), Raphael and Molina 2007, p. 77) may not be able to colonize an 80 (or 100) year old stand, regardless of how well-developed its structure. For species dependent on early-successional habitat, the broad stand establishment (SE) stage[12] does not differentiate highly-managed stands with limited structural and species diversity from unmanaged SE stands associated with higher structural and species diversity (**3.4.5**).

Much of the predicted maintenance of mature and structurally complex forest through time (DEIS, p. 494) is predicated on the assumption that current or created managed young stands will develop into structurally complex forest comparable to what will be harvested. However, the composition and structure of existing old-growth forests is a result of disturbances and climate conditions in the

[12] Distinctions in the SE class (with/without legacies) would partially address this issue for species associated with forest legacies, but would not distinguish species responses associated with shrubs and regenerating trees (**3.4.5**).

last millennium; replacement of this composition and structure may be problematic in current or future climate and disturbance regimes (PNW 2003). Strong scientific support for the assumption that managed young stands can develop some or all of the characteristics of existing old-growth forest has not yet been developed (CCEM 1993, PNW 2002), although much management in the Pacific Northwest is predicated on this hypothesis. The WOPR DEIS descriptions of changes in forest structural cover and fragmentation should acknowledge this assumption.

Given that broad structural classes are to be used to describe the Affected Environment, their utility could be enhanced by quantifying the central tendencies, range, and variation (dispersion) in stand age and structural complexity indices for each stage. Stand age can be problematic as a descriptor (Moeur et al. 2005) and consideration of age would not replace structural descriptions (DEIS, p. 202), but age descriptions would help characterize proportions of the landscape associated with long time periods without disturbance[13]. Depiction of the central tendencies, ranges, and variation in structural complexity indices for each structural class through time would not produce an analysis of "bewildering complexity" (DEIS, p. 202) but could help in interpreting descriptions of the Affected Environment (DEIS, Table 65) and changes in forest structure described in the DEIS associated with different management Alternatives, by using a larger number of stand characteristics to quantify changes in the variability within structural stages over time.

*Vegetation modeling*

No major problems were detected in vegetation models as described (DEIS, Appendix Q). However, there is some concern about how the vegetation modeling was done and how much is known about the quality and uncertainty of the predictions that were made with DBORGANON for some of the non-timber characteristics of forests. The DEIS acknowledges that the "standard model does not produce specific structural characteristics that have utility for effects analysis other than timber production" (DEIS, p. 1537). Consequently, a version of ORGANON, DBORGANON, was developed and it is stated that this model "meets the additional BLM requirements." It would be beneficial to list the particular categories of modifications that were made to ORGANON in this Appendix. Given that the DBORGANON model underlies all of the other resource projections it seems important to provide some sensitivity analysis or data analysis to support the use of DBORGANON for these purposes. Lack of this information makes it difficult to evaluate the scientific basis of the entire modeling effort.

The variance in the estimates of key structural components attributed to these BLM polygons is not provided. Snag and downed wood densities are inherently highly variable at multiple (stand-, watershed-, province-) scales. However, describing such variance is probably not germane to the DEIS analysis considering the parameterization and classification of wildlife models (**3.41., 3.4.2, 3.4.4**)

*Disturbance (fire) and forest structure*

Discussion of salvage logging and wildfire influences on ecology and forest structure (DEIS, p. 487) is misleading (see **Section 3.7**). It would be better to lead off this discussion with the acknowledgement of the potentially variable effects post-fire management.

[13] If such descriptions were made, age in partially-harvested stands would probably best be assigned as time since full stand-resetting disturbance, since disturbed stands would still meet TPA definitions in interim old-growth definitions (USDA 1993).

## 3.2. Socioeconomics

The socioeconomic effects of the Alternatives are contrasted using an economic impact analysis for communities as well as consideration of payments to counties. Economic impact analysis included estimates of changes in employment, wages, and community well-being. Changes in payments to the counties were estimated based on predicted harvest levels and market forces.

### 3.2.1. Economic impact analysis

*Employment model*

Economic impact analysis contrasted the effects on a 2005 reference year of the Alternatives in the presence of external effects: loss of the Secure Rural Schools payments and changes in the plywood industry. The input/output model used and subsequent analyses have issues both in general construction and in its parameterization.

General comments on input/output modeling: The input/output methodology used in the DEIS provides useful information, but stops short of tying effects of DEIS Alternatives to indicators of social and economic well-being for rural communities. Although local communities are evaluated by using a social and economic well-being index following Donogue, et al. (2007), and there was some effort to describe where economic impacts might occur, there is not a direct tie from changes in BLM Alternatives to changes in community social and economic well-being. Methodology for precisely tying the two together are likely beyond the scope of the analyses, but in general, at least determining if economic activity will occur in rural or urban areas as well as forest-dependent and not forest-dependent communities and the likelihood of Alternative employment substitutability is possible. The PNW, the Oregon Employment Department, and the Oregon Department of Forestry have cooperated to develop methodology to partition economic flows to rural and urban areas and would be willing to work with BLM on integrating Western Oregon Timber Model and Options outputs into the indicator framework (Oregon Department of Forestry 2007). Results from this work suggest an 8 percent decline in forest-related employment in rural forest-dependent communities in Oregon between 2003 and 2006, before the recent economic distress caused by falling housing starts began. The decline for western Oregon was 9 percent. Total employment in these communities declined by 9 percent over this 4-year period, in spite of a growing Oregon economy.

Job substitution: Understanding local economies and how changes in economic activity affect individual economies is important. However, it is also important to understand that in healthy economies, scarce resources can be utilized by more than one sector of the economy and that scarce resources will not remain unutilized. The analysis refers to net job gains or losses. This appears to be correct only if the economy is not assumed to be dynamic, which is not the case (DEIS, p. 539). It appears that no accounting is made for job substitution (DEIS, p. 541). Changes in economic activity do not linearly translate to changes in jobs. The input/output methodology used has its strengths, but additional work, or at least recognition, needs to be made that highly skilled workers like electricians and millwrights may find other jobs and that other workers may find lower paying jobs. This was alluded to on p. 548 in noting that "The Medford economy is sufficiently diverse and robust that these job losses would be offset by growth in other economic sectors."

Non-wood products employment and values: Employment and income in industries other than wood products are acknowledged, but not well quantified (DEIS, p. 241). Returns to public agencies from recreation and other non-timber outputs are small, but there will be some employment effects. These effects are difficult to determine, but the net economic values to the users and returns to local communities in terms of water quality and other non-market values are large (see below). Would it be possible to better quantify employment and income changes resulting from these changes in net economic values? Could information be developed to give a more comprehensive picture of the current situation and of the net economic consequences of Plan Alternatives?

Effects of wood product types on employment: Employment can be different depending upon whether the logs are processed into plywood or lumber (DEIS, p. 536). Differentiating employment and income from the two different processing technologies would be useful, and should produce different response coefficients in the input/output models.

Effect types: The terminology used for effects types (DEIS, p. 539) is confusing and incorrectly used. Economic impacts can be direct, indirect and induced. The text combines indirect and induced effects into direct effects. A more accurate classification of effects might include:

- Direct Effects: impacts (e.g., change in employment) for the expenditures and/or production values specified as direct final demand changes.
- Indirect Effects: impacts (e.g., change in employment) caused by industries purchasing from industries resulting from direct final demand changes.
- Induced Effects: impacts (e.g., change in employment on all industries) caused by the expenditures of new household income generated by the direct and indirect effects resulting from direct final demand changes. (IMPLAN 1999).

Modeled plywood industry changes: Could more uncertainty be shown with conclusions about the coming severe decline of Oregon's plywood industry (DEIS, p. 540, Table 156)? Recently, the worst market to be in was studs, not plywood, and this is reflected in commodity prices. In fact, in some places plywood mills are being updated. Many mills may now be focusing on hardwood plywood and niche markets, and may be less susceptible to competition from OSB. Also, often neglected is that most statistics omit the approximately 1 billion square feet of hardwood plywood produced each year in Oregon. The market for hardwood plywood has been relatively strong and 70-80 percent of the wood used in hardwood plywood comes from softwood species. Given the uncertainty and changing currency values, development of niche markets, and the relative health of the hardwood plywood industry, would it be possible to recast the assumptions and text about the future of Oregon's plywood industry?

Pruning/fertilization: Expenditures estimated for fertilization and pruning in the economic input/output models (DEIS, p. 550) appear to be overestimated; product outputs, quality and economic activity may thereby also be overstated. Unrealistic assumptions about fertilization levels would result in overestimates about potential future harvest volumes. Pruning would improve wood quality and could result in higher log prices; however, little pruning is done in Oregon. Little fertilization is currently done in Oregon's public forests and it may be unlikely done often on BLM forests given that an up to 60 percent increase in BLM's budget would be required to implement the increased levels of timber harvesting in the DEIS Alternatives, and given the recent escalation in the price of oil, a key ingredient in producing nitrogen fertilizer.

Secure Rural Schools baseline assumption: The DEIS notes that without funding under the Secure Rural Schools Act, BLM payments to counties would fall about 90 percent. This is considered the base case. This may happen or it may not happen. The Secure Rural Schools and Community Self-Determination Act has been extended for 1-year past its 2006 expiration date. The program provides a dedicated funding stream for local municipalities and school districts dependent on forest timber receipts that have been unable to rely on consistent and sustainable payments due to the continued controversy over timber sales on Federal lands. It is unclear if and how future funding to counties and other local governments would be extended once this 1-year extension expires. Both Oregon senators have made obtaining this extension their highest priority. There is a possibility that this funding may continue, in which case the base case assumption in the DEIS would be wrong.

Secure Rural Schools parameterization: Employment derived from Secure Rural School payments and BLM timber harvesting is important to the counties, but with a relatively low unemployment rate in western Oregon, some employees in the woods and in mills and the indirect and induced employment could get other jobs if jobs in the woods and mills disappeared. Some of the higher wage jobs would be traded for lower wage jobs or for jobs with a longer commute. Also, “Dependence” should be replaced with another term; perhaps calling it what it is, percent of industrial output or percent of employment. The table does a good job of documenting this indicator and should be kept as is except for changing the title and adding more explanatory text.

Table 2 (DEIS, p. LIII) is difficult to interpret and could be misleading. Does it include only allowable sale quantity (ASQ) volume or all volume? Does it include the Portland area? I know that this information is buried in the text, but some of it is important enough to have it together with Table 2. For example, the multipliers that can be calculated from this table seem high unless it includes the State’s major metropolitan areas.

*Socioeconomic well-being*

Could the Alternatives more robustly address the importance of non-market values and the social effects of changes caused by the Alternatives?

Non-market values: Changes in non-market values, such as wildlife, recreation, and water quality, are neither well-described nor quantified in the analysis. These values and how BLM’s management of their forest lands influences these values will certainly impact the economic well-being, health and resiliency of local communities. For example, the economic well-being of local communities is influenced by their ability to attract innovative businesses and highly-qualified employees; the ability of communities to attract these employees is determined by social and environmental factors in addition to more readily analyzed measures of economic well-being. The BLM lands contribute to the employment and income in industries other than lumber and wood products. Could these contributions be more robustly included in the analyses? While it is true that market transaction information is sparse about many of these values, methodologies can and have been used to determine economic values for other forest uses other than timber-the net economic value of recreation to users for example (Garber-Yonts 2000, Thompson 2005, Spies et al. 2007).

*Social effects*

Although the DEIS states that “a more detailed analysis of social effects is beyond the scope of this analysis” (DEIS, p. 549), additional analysis could provide much useful information. A more detailed analysis of these social effects would provide information useful to both policy makers and the general public. Reliable data is not available to complete a statistically robust econometric model of employment by detailed sectors, but literature and data do exist to help understand consequences of the Alternatives, and indicators parsing employment into rural vs. urban areas have already been constructed (OBF 2007a, OBF 2007b). Could this more refined employment information be a starting place to help better determine the social effects of Plan Alternatives?

### 3.2.2. Payments to the counties

*Timber supply and log prices*

Would it be possible to evaluate use of stumpage prices from the WOPR timber supply model? The decline in U.S. Forest Service and eastern Oregon private harvests and the decreasing value of the U.S. dollar, in addition to increased competition for logs from Washington and export restrictions in Canada, may further constrain timber supply in western Oregon (DEIS, p. 241). After the housing market recovers, the timber supply and demand situation in western Oregon may be different than historical stumpage and log markets. Using supply and demand relationships in the WOPR timber supply model may provide useful information about returns to counties and the financial returns of BLM timber management.

Could analysis showing gains in area of private forest lands (DEIS, p. 957) be revisited? Incorrect analysis could mislead the reader about production of timber and other forest values from nonfederal lands. Not documented is where the information supporting a historical gain in western Oregon's private land base came from (perhaps from using different Forest Inventory and Analysis (FIA) inventories with different inventory techniques and plot designs and from ignoring sampling errors). The best information available, studies of land use for Board of Forestry Indicators of forest sustainability, show a gradual decline in the amount of forest land available for timber management and a gradual increase in the number of dwellings that exist on the land that remains wildland forest (Azuma et al. 2002).

## 3.3. Timber / Forestry

*General comments on timber modeling*[14]

The modeling work appears to reasonably project potential timber availability from the planning area given the assumptions of the different Alternatives and Sub-alternatives. Although it is not feasible to duplicate Alternative outputs, since the Plan area is rich in older timber, it is possible to generate a maximum timber output sustained yield from QMD plot information and compare it to the BLM intensive harvest OPTIONS output (**Appendix 1**, p. 74). The outputs seem similar.

A more difficult question is whether the timber and other Alternative outputs are feasible given current and reasonably foreseeable political, legal, and budgetary limitations and potential technical barriers to Plan implementation. Planned output levels from Federal and state land managers are often not achieved. Under the Northwest Forest Plan and eastside screens, approximately 1 billion board feet/year was planned to be available for harvest from BLM and U.S. Forest Service lands in Oregon; Oregon timber harvest reports show Federal harvests to be approximately 1/3 of planned levels (ODF 2006). From the Northwest Forest Plan alone, the plan called for "1.1 billion board feet of timber to be offered beginning in fiscal year 1997 from both National Forests and Bureau of Land Management Lands" (USDA 1995). In FY 1994, 233 million board feet (MMBF) were offered and have since remained at low levels.

Timber harvest fall-downs from modeled levels do not occur on just Federal lands. Initial timber output volumes for the Tillamook and Clatsop State Forests were also revised substantially downward after timber harvesting constraints were better understood. Initial modeling results for the Northwest Oregon State Forests indicated planned harvest levels of 279 MMBF per year were possible. However, after District implementation plans were completed the estimated timber volume outputs dropped to 176 MMBF (ODF 2003). Similar to considerations for biotic and functional responses to the Alternatives (**2.4**), the risks of failing to fully implement Alternatives 2

[14] The primary reviewer of the Timber Section (Gary Lettman) stated that comments in this section were made based only on reading the DEIS. Additional review of data, model formulations, and outputs would be necessary for a thorough review.

or 3 on socioeconomic metrics (**3.2**) and the possibility of reauthorization of the Secure Rural Schools Act have not been considered in the DEIS analysis. As part of the sensitivity analysis for timber projections, it might be meaningful to apply a deflation factor based on recent land management Plans (described above)-perhaps a 50 percent reduction. Such a sensitivity analysis would bound timber output expectations and would produce a range in responses to interpret in Timber and Socioeconomic analyses.

*ORGANON and vegetation modeling assumptions*

The ORGANON growth and yield model was used to determine wood volume outputs for the silviculture regimes. The ORGANON is widely-used, peer reviewed, and publicly available. However, the model may not be appropriate for some uses and further discussion of its use in the DEIS analysis for BLM holdings in the Plan area may be warranted. ORGANONs other than Model SW may have lower than expected mortality and give larger volumes than expected in older stands. Sparse data in older age classes in data sets used to calibrate the model may be a problem. Note that (Coastal Landscape Analysis and Modeling Study (CLAMS) and Interagency Mapping and Assessment Project (IMAP), landscape-level modeling efforts in western Oregon, did not use ORGANON for modeling older stands.

The ORGANON model outputs may be optimistic in some cases. For example, as noted on DEIS p. Q-1532, defaulting to ORGANON model assumptions may mean defaulting to information from unrepresentative stands.

It is true that ORGANON will project volumes similar to those in published normal yield tables (DEIS, Q-1537). This, however, does not necessarily mean that ORGANON will accurately predict volumes from stands which have developed differently than those used to calibrate ORGANON or to develop normal yield tables.

*Timber Modeling assumptions*

Modeling made a number of assumptions about silvicultural practices and disturbances which merit consideration. Future young stand management intensity and tools available for timber management may not be similar to those available in the past two decades (DEIS, p. Q1538). For example, herbicide use on public lands is limited and will likely be used at minimal levels in the future. Similarly, up to 204,400 acres of fertilization per year is assumed during the first decade of timber management; in reality, very little fertilization is occurring in western Oregon's forests, and has not for years. Another example: little pruning is occurring in Oregon's forests yet the DEIS estimates that the planning areas will have an estimated 37,600 acres of pruning in all Alternatives. Genetic growth increases beyond age 15 are speculative and dependent upon management practices that may not be feasible.

It is surprising that yield and ASQ predictions are not reduced to account for the effects of wildfire (DEIS, Fig. 113) and other potential falldowns in timber harvest. Fire mortality, stem damage, and salvage information is available for the Plan area; adjusting for probable losses due to wildfire would likely increase the accuracy of yield predictions.

*Implementation and future implementation*

Implementation feasibility may be problematic. Although paper plans were developed for the first decade to ensure that model results could be implemented on the ground, it may be imprudent to assume that this will be the case in later decades. Would it be possible to check operational feasibility for subsequent implementation on the ground for two or three decades on several small test areas? Such implementation analysis would be a meaningful addition to sensitivity and risk analyses (**2.4**) for the Plan, and could inform implementation monitoring (**2.5**) for timber metrics to ensure the Plan met its Purpose and Need in terms of forest production (DEIS, p. XLIV).

As noted in the general comments (above), on paper, first decade implementation plans bring some level of "ground-truthing" to predictions for the first decade's resource output targets. However, the procedure as documented on DEIS p. D-971 does not ensure that the Plan can be implemented in later decades, nor that future options are not foreclosed by the decisions made in decade 1. Fire issues, species migration corridors, adjacency constraints, harvest unit size limitations and other factors could limit management options after the first decade.

Under any of the Alternatives, timber harvesting will likely be the disturbance having the most impact on economic, social, and environmental values. The uncertainties in determination of harvest volumes, acres disturbed, types of harvests, feasibility of implementing the Alternatives, harvest locations, stumpage prices, and impacts on key resources, would be most prudently addressed with a robust monitoring and adaptive management plan (**2.5**). The Plan revision might be enhanced by adding detail on monitoring components (methods and data collected) to evaluate meeting of socioeconomic and timber objectives, as well as any adaptive management techniques considered to fine-tune management, to facilitate meeting these objectives in the face of new scientific information or changed environmental conditions.

## 3.4. Wildlife

The use of environmental variables in models to express habitat availability or suitability for wildlife species is a long-standing and acceptable means of assessing the potential impact of management actions. However, the Purpose and Need for the DEIS notes "survival and recovery of [listed] species" as the ultimate goal of habitat conservation (DEIS, p. 4), Wildlife Objectives include "conservation of species" (DEIS, p. 60), and benchmarks used in Federal regulations[15] for listed species include population size and change, not just habitat availability. In such a planning framework, assumptions about the relationship between habitat availability and population status should be stated in quantitative terms. These assumptions are critically important to an accurate and realistic assessment of the effects of management Alternatives on species. To ensure that these assumptions are valid, habitat models should be based on observed empirical relationships, sensitivity analyses should be used to refine model structure, and models should be verified using known locations of animals whenever possible.

The WOPR DEIS analyses for species of concern made little attempt to quantitatively relate habitat metrics to population status for northern spotted owl (**3.4.1**), marbled murrelet (**3.4.2**), fisher (**3.4.4**), or salmonids (**3.5.1**). Statements that include use of the terms "habitat needs met" or "habitat needs as at risk" (DEIS, p. LVII) are not useful for understanding and assessing impacts on populations. Furthermore, by only considering habitat availability, the DEIS analysis is unable to integrate other effects on species. A quantitative assessment of how habitat changes under each Alternative are likely to affect population change for each species would allow determination of whether Alternatives met the WOPR Wildlife Management Objectives for conservation of species (DEIS, p. 60). At a minimum, qualitative analysis of population trends (examples provided below) for focal species under each Alternative could be added to facilitate assessing whether these objectives would be met.

[15] Section 7A of the ESA suggests that the Agency ensure that its action "is not likely to jeopardize the continued existence of any endangered **species** or threatened **species** or result in the destruction or adverse modification of habitat of such species" (**emphasis** added).

### 3.4.1. Northern Spotted Owl

The Science Team review of the WOPR DEIS found shortcomings in the analysis of the northern spotted owl (northern spotted owl) in terms of the species life history and population parameters, as well as problems with development and interpretation of the northern spotted owl habitat models and habitat characterizations.

*Northern spotted owl population biology*

By only considering habitat, WOPR DEIS analysis is unable to integrate the effects of noise disturbance or other species (e.g., barred owl) on spotted owl population trends. Without consideration of population change, it is impossible to consider latitudinal gradients in northern spotted owl population trends across the Plan area. Evidence of population decline is far stronger for northern spotted owl populations surveyed in Washington than for populations surveyed in Oregon or California (Lint et al. 2005, p. 16, Anthony et al. 2006).

Existing population data for the northern spotted owl could be used in two ways to improve the quality of the effects analysis. Spatially explicit data on current northern spotted owl populations available for western Oregon could be used to train northern spotted owl classification models (similarly to Lint 2005) or in validation of the WOPR DEIS model. Testing the accuracy of the model in classifying used and unused habitat would improve the credibility of the analysis used in the DEIS. More broadly and qualitatively, northern spotted owl population trend data available for western Oregon (summarized/analyzed in Anthony et al. 2003, Courtney et al. 2004, and elsewhere) could be incorporated in the analysis to describe current population conditions. Habitat changes attributable to the Alternatives could be interpreted in the context of observed trends in northern spotted owl population parameters such as Lambda (summarized in Courtney et al. 2004, Chapter 8). Analyses for Forest Ecosystem Management Assessment Team (FEMAT) (1993) and Interior Columbia Basin Ecosystem Management Project (ICBEMP) (Marcot et al. 2001) provide examples of estimating the likelihood of attaining “stable, well-distributed populations” in response to large-scale management in the absence of exhaustive empirical data.

*Northern spotted owl habitat model*

Habitat quantification models for the northern spotted owl use polygon-based classification tables (DEIS, p. 287) to classify BLM polygons into suitable northern spotted owl habitat, dispersal-quality habitat, or non-habitat. This classification system and northern spotted owl models built from them are not strongly justified or evaluated. A major issue is that the separation of results into quantity and quality of “suitable habitat”, “dispersal habitat”, large blocks and “suitable habitat outside of large blocks” (DEIS, p. 633) fails to provide a single, integrated measure of habitat availability for the northern spotted owl. It is difficult to interpret the overall impacts on northern spotted owl populations when each habitat component is analyzed separately. Other important issues with the modeling methodology in the DEIS include: a) weak habitat definitions; b) limited consideration of spatial scale; c) lack of integration of existing population data; d) no model validation; e) no analysis of uncertainty, sensitivity, or risk. Issues with the “block analysis” of northern spotted owl habitat are also discussed.

*Classification of northern spotted owl model parameters*

Separation of polygons into habitat classes based on this particular set of derived stand characteristics represents an untested hypothesis. How were these rules for classifying northern spotted owl habitat (DEIS, p. 287) derived? Classification decisions involving forest legacy components (snags, down logs) seem arbitrary, as presented. For example, what is the rationale for the threshold of 4 snags/ac > 10 inches? For the 2 percent ground cover of down logs? It appears that the dead wood receives equal weight in the model to canopy cover and tree size: why would this be the case? The classification of forests with a quadratic mean diameter (QMD) <20 inches, no snags, and no rating for canopy layering (DEIS, p. 288) as "suitable owl habitat" is not consistent with empirically based descriptions of spotted owl habitat (see studies cited in Courtney et al. 2004). This gross classification of patches (BLM Forest Operations Inventory (FOI) polygons) based on a single classification table also ignores the fact that use of habitat by northern spotted owl varies across the Plan area. Several studies have shown fundamentally different niches for northern spotted owl from the southern to the northern parts of the Plan area, including changes in diet and edge use (Zabel et al. 1995). Other models have shown the importance of variables not included in the DEIS analysis (e.g., elevation, amount of broadleaf vegetation) in different provinces (Lint 2005).

Classification of dispersal habitat failed to incorporate relevant information on the function of dispersal habitat for spotted owls. Contrary to the statement on DEIS p. 287, dispersal habitat should function as foraging habitat (i.e., should support prey; see references cited in Buchanan 2004). Prey availability is likely to be low in the absence of snags and logs (Carey 1995, Carey et al. 1997, Feen 1997). This would indicate that areas without snags and downed wood should not be classified as dispersal habitat, as they currently are in the habitat classification scheme (DEIS Table 88, p. 287).

Most habitat-quality modeling studies developed for the northern spotted owl (e.g., McComb et al. 2002, Lint 2005, others) have found that particular variables were more important than others in predicting the occurrence of owls. A sensitivity analysis of the northern spotted owl habitat model would indicate which variables have the greatest influence on predicted area and quality of northern spotted owl habitat.

*Scales and summation of classified acres*

Northern spotted owl respond to habitat variables at multiple spatial scales, and some scales are more important than others at predicting the occurrence of owls (McComb et al. 2002). It appears that "suitable habitat" classified for spotted owls for individual polygons was summed (e.g., DEIS Fig. 216, p. 635) regardless of its landscape context; if so, the amount of suitable habitat may have been over-estimated. Habitat within individual polygons may not be suitable for nesting (or other functions) if the patch is small and isolated, even when selected stand-level[16] variables (canopy cover and layering, and dead wood presence) meet classifications of suitable habitat. McComb et al. (2002) assessed habitat in focal pixels (25m x 25m) within 0.56 ha moving analysis windows, followed by three broader analytical windows (0.3, 0.8, 2.4 km) to assess conditions in the landscape surrounding potential nesting patches. Zabel et al. (2003) found that the best-fitting model for predicting owl occupancy was at a scale of 200 ha. Davis and Lint (2005) assumed a roughly 4 ac. buffer for northern spotted owl presence data, but considered habitat suitability within and outside habitat blocks as completely separate habitat features. The overestimation of suitable habitat in the DEIS might be addressed (simplistically) by specifying a minimum patch size (or size of contiguous habitat patches) for northern spotted owl suitable habitat classification. The Alternatives vary in the amount of change in mean patch sizes from current condition (DEIS, p. 515, Fig. 151). For example, under Alternatives 2 and 3, mean patch size of mature and structurally complex forest in the Coast Range would decrease, but would increase substantially under Alternative 1. Therefore, if a minimum patch size was included as a mapping rule for owl habitat, the outcomes for each Alternative on northern spotted owl habitat would be differentially affected.

[16] Polygon-level in this analysis.

Similarly, in order to truly function as dispersal habitat, forest patches must connect blocks of suitable habitat. Spatially disjunct patches that are isolated from suitable nesting, rooting, foraging (NRF) habitat are unlikely to function as viable dispersal habitat, and thus should not be included in tallies of "dispersal habitat" acres. Summed dispersal habitat at the sixth-field-scale is an unsupported metric for assessing effects on northern spotted owl, and probably obscures some landscape-level driving factors. For example, the Willamette Valley and portions of the Columbia River Gorge have probably supported negligible dispersal habitat since Native Americans began burning. More meaningful metrics might include an analysis of changes in dispersal-quality habitat surrounding NRF habitat and/or cores. Since projections for habitat fragmentation differ among the Alternatives, an analysis that considers spatial arrangement of NRF and dispersal habitat patches is likely to change the current conclusions about differences in the amounts of dispersal habitat among Alternatives.

*Northern spotted owl model validation*

Model parameterization used for assessing northern spotted owl habitat would be more tenable if it were validated with existing species data from the region. Spatially explicit data on owl occupancy could be used to validate the habitat classification schedule used to map suitable habitat. There are several examples of models quantifying northern spotted owl habitat using location data for validation in the Plan area. McComb et al. (2002) developed a habitat quality model for the northern spotted owl and validated it against empirical occurrence data. Lint (2005) has produced a complex model of northern spotted owl habitat (BioMapper) which provides an assessment of its accuracy using actual northern spotted owl presence data. Such an accuracy assessment could be done with existing data resources. Note that although empirical data cannot be used to inform projections of future habitat, validation of the parameters used to model existing conditions would increase confidence in predictions of future conditions using those same parameters.

The WOPR DEIS does not appear to provide estimates of northern spotted owl suitable habitat for all Federal lands in each Province, making contrast with other studies (e.g., Lint 2005, McComb et al. 2002 for CLAMS area) difficult. Rough comparison to other published studies, even if only for a portion of the Plan area, would add credibility to the WOPR DEIS estimate of northern spotted owl suitable habitat. In the absence of model validation or comparison to other studies, it would be good to at least conduct a rigorous sensitivity analysis (**2.4**) and evaluate the northern spotted owl habitat suitability model against meaningful criteria such as those proposed by of Roloff and Kernohan (1999).

*Large block analysis*

It is stated that Alternative 3 would not create large blocks of suitable habitat (DEIS, p. 640, 655). It was not clear why Alternative 3 did not produce large blocks of habitat outside the reserves, given the relatively large area of suitable habitat that would be produced by Alternative 3 at 100 years (DEIS, Fig. 216). Rules defining large blocks of habitat are not evident. Do pixels need to be connected at edges or just corners?

*Risk analysis for changes in northern spotted owl habitat*

The predicted trends for northern spotted owl habitat (DEIS Fig. 216, p. 635) do not assume any losses during 100 years to wildfire or other disturbances. These projections should be viewed as ideal cases, and quite likely to be overestimates for the analysis time frame. Although predicting the exact timing and occurrence of wildlife in a landscape is not possible, that does not mean that one can assume that stand replacement fire will not occur. During the first 10 years of the Northwest Forest Plan, significant areas (48,800 acres) of older forest were transformed into young forest by high severity wildfire in SW Oregon on U.S. Forest Service and BLM lands (Moeur et al. 2005). Although fire suppression capabilities are high on the relatively well-roaded BLM checkerboard lands[17] losses of habitat to wildfire could still be expected. For example, between 1972 and 1995 nearly 18,000 acres of forest on BLM lands in SW Oregon experienced stand replacement wildfire (Cohen et al. 2002). The Fire section talks about risk associated with different management Alternatives and fire regimes, but fire disturbance analyses are not incorporated in characterizations of expected resource trends under the different Alternatives, including northern spotted owl habitat. This assumption has significant consequences in terms of expectations of habitat outcomes under the Alternatives. For example, Alternative 2 indicates that northern spotted owl habitat would stay level over the planning period. The analysis of fire severity (DEIS Fig. 273, p. 769) however, shows that acres of "high severity fire" in the Medford District, for example, would be nearly 200,000 higher by year 2106 under Alternative 2 compared with the No Action Alternative. (This fire projection does not include any possible effect of climate change, which is already increasing the frequency and area of wildfire in the western United States. (Westerling et al. 2006)). If some of this high severity fire resulted in stand replacement disturbance in owl habitat, then the estimates of level amounts of owl habitat under any of the Alternatives would be overestimates. There is no mention of how risk of loss to fire was factored into any of the Alternatives—it was apparently left out. It would be valuable to know how much habitat might be available if rates of loss to wildfire continue at the rate that they did over the last 10 years. Ager et al. (2007) have developed a risk analysis system for quantifying wildfire threats to northern spotted owl habitat that may be helpful in predicting loss of habitat under different fire-risk scenarios.

### 3.4.2. Marbled murrelet

*Marbled murrelet population biology*

As with the northern spotted owl, relationships between habitat availability and predicted population changes for marbled murrelets were not quantified, and spatially explicit data that are available on murrelet occupancy were not used to validate models. The BLM has data on occupied sites, and in fact uses these data in estimating "sites affected" for Alternatives 1 and 3 (DEIS, p. 674. Note that the Figure given on p. 674 for currently known, occupied sites (n=226) does not agree with the Figure given for the same statistic on p. 305 (n=177); which is correct?). Occupancy data could have been used both to validate habitat classifications (see below) and to make a more direct interpretation of consequences of management actions under each Alternative for populations of marbled murrelet. By not relating marbled murrelet habitat availability to effects on marbled murrelet populations, WOPR DEIS analysis is unable to quantitatively or qualitatively integrate habitat changes with other observed effects on the species, such as changes in marine conditions. Population trends have been published for the analysis area (McShane et al. 2004 (p. 3-58), BLM district unpublished data). The analysis would be strengthened by consideration of how each Alternative, in conjunction with other management and disturbance processes in the Plan area, would affect marbled murrelet population trends. The limited consideration of marbled murrelet population biology is also evident in characterizing marbled murrelet habitat as summed acres meeting structural classifications, in the consideration of fragmentation effects, and in ignoring

[17] Western Oregon BLM lands under the protection of the Oregon Department of Forestry (ODF) receive different fire management than some U.S. Forest Service lands managed under the Northwest Forest Plan, and most of the northern spotted owl habitat burned by large wildfires in the last decade (at least) has been in areas not protected by ODF; roughly 2 percent of the Biscuit Fire complex was in BLM ownership. However, there were still many wildfire starts in BLM ownerships (DEIS, fig. 113) recently, more high severity fires are likely in the near future due to land management legacies (DEIS, p. 393) and perhaps climate change (**2.7**), and due to proximity to both private and Federal land managers with different fire management objectives (DEIS, p. 396). These factors very strongly influence wildfire probabilities in the Plan area both within BLM ownership and cumulatively.

species' fidelity to nesting sites, proximity to bays, and other life history traits (see below). Key points regarding the effects of fragmentation (and other effects) for different Alternatives (DEIS, p. 633) would be more relevant to the analysis if phrased in terms of effects on marbled murrelet populations.

*Marbled murrelet suitable habitat model*

Classification of murrelet habitat: The WOPR analysis models marbled murrelet "nesting habitat" as all patches classified as Mature and Structurally Complex forest (DEIS, p. 302). This classification appears inaccurate and probably overestimates marbled murrelet nesting habitat because it encompasses too broad a range of structural conditions, including some that are inconsistent with empirically derived descriptions of marbled murrelet nesting habitat. Under this classification scheme, loss of high quality (older) habitat can be masked by the development through succession of low quality habitat at the youngest end of the spectrum of suitable nesting habitat. High and low quality habitats are not distinguished, although marbled murrelet reproductive outputs would be expected to be different in each category, affecting rates and directions of population change.

The Mature and Structurally Complex class is extremely broad, encompassing hundreds of years of stand development and succession. Marbled murrelet have shown a strong selection for old forest conditions within this broad structural class. The average stand age for patches with measured nests was 209 years (range: 180-350) (Hamer and Nelson 1995). There are strong mechanistic reasons why older stands would be predicted to lead to higher marbled murrelet reproductive success, including supporting:

- Higher densities of branches at least 60 ft above the ground that are large enough to support nests (averaging 13" in diameter) (Hamer and Nelson 1995)
- Higher density of trees with very large diameters. Mean measured nest tree diameter in one study in Oregon was 76" (range: 50"-110") (Hamer and Nelson 1995)
- Multiple levels of structure, including trees reaching full tree height (McShane et al. 2004)

The marbled murrelet habitat definitions used in the WOPR DEIS analysis (equating to QMD> 20 inches) would overestimate the potential for large platforms that the marbled murrelet uses for nesting. Only Mature-stage patches that support individual trees with potential nest platforms (McShane et al. 2004) would provide nesting habitat for murrelets. Branches of sufficient size to provide nesting platforms are unlikely to develop by age 80, especially in stands grown at high stem densities (Curtis et al. 1998). As a caveat, note that remnant overstory trees from previous stands could provide such structure.

The broad "nesting habitat" classification based on one of three forest structural classes thus includes patches with a wide range in the ability to support marbled murrelet reproduction. Patches just entering the mature and structurally complex (MSC) structural class (e.g., an 80 year old stand with few remnant trees) should not be considered equivalent to old forest patches with many platforms and complex, buffered structure. The accuracy associated with assessing change in marbled murrelet reproductive success and metapopulation structure using estimates of habitat availability might be improved by: a) stratifying this broad classification into low and high or low, moderate, and high habitat quality landscape characteristics as was done in the peer-reviewed 2006 Northwest Forest Plan Murrelet monitoring report (Huff et al. 2006); and b) incorporating model parameters directly related to marbled murrelet use (described below).

Lumping very old forest patches with developing mature and structurally complex patches into a single "suitable" class masks a differential loss of high quality (older) habitat associated with

Alternatives 2 and 3. The 16 percent decrease in marbled murrelet suitable habitat on BLM lands depicted for Alternative 2 by 2050 ( 60,000 ac., DEIS p. 676) includes a loss of almost half of the existing old forest (roughly 150,000 ac., DEIS Table 151)[18], with replacement elsewhere on the landscape by patches that enter the defined Mature and Structurally Complex class. This differential loss of high quality marbled murrelet habitat and replacement by lower quality (but still suitable, as defined) habitat needs to be explored for its differential effects on marbled murrelet reproductive success and population size.

Summation of marbled murrelet suitable habitat acres and fragmentation effects: As in the analysis of habitat for the northern spotted owl, polygons (patches) based on timber harvest units were used to evaluate murrelet habitat. However, habitat suitability for both owls and murrelets is influenced by factors outside a potential nesting patch itself. Habitat fragmentation and associated nest predation has been identified as a major cause of marbled murrelet population decline in Oregon (Raphael et al. 2002, McShane et al. 2004, Huff et al. 2006). The effects of suitable habitat patch size, fragmentation, and landscape context on marbled murrelet habitat patch suitability have not been adequately addressed in this analysis. First, minimum patch size was not considered in analyses of marbled murrelet suitable habitat. Habitat within individual polygons may not be suitable if the patch is small and isolated, even when stand-level variables suggest suitable habitat conditions. If marbled murrelet analysis continues to use simple patch addition for habitat analysis (as opposed to more complex analyses described below), a minimum patch size (based on empirical data for marbled murrelet) should be incorporated in the criteria for classification as suitable habitat. A more nuanced consideration of suitability would incorporate patch size as an influence on patch quality (see above). As a reference, Grenier and Nelson (1995) described occupied Oregon Coast Range nest stands as averaging 6.5 ha in size with a range of 2-12 ha. The Alternatives vary in the amount of change in mean patch sizes from current condition (DEIS, Table 151, Fig. 515): Alternative 1 would increase mature and structurally complex forest patch sizes from current conditions in the Oregon Coast Range, where Alternatives 2 and 3 would decrease patch size. Therefore, if a minimum patch size was included as a rule for murrelet habitat classification, the outcomes for each Alternative would be affected. The effects of these differences should be documented in terms of predicted marbled murrelet population change (e.g., reproductive success), especially in the first 50 model years (see below).

Secondly, the metric used to quantify edge-depth in the Ecology analysis may not be biologically relevant to murrelets. Patches used by marbled murrelet for nesting are characterized by lower contrast edge than comparable non-nesting patches (Ripple et al. 2003). Edge effects would be predicted to extend 50 to 150 m into stands (Meyer and Miller 2002); it is unclear in the DEIS what depth-of-edge was used for marbled murrelet. A more accurate model of edge effects for this species might include an edge effect of 150 m between Stand Establishment and Mature and Structurally Complex patches and an edge effect of 50 m between Young and Mature and Structurally Complex patches. A flat 150 m edge effect could be used as a relatively conservative edge-depth metric. Results using biologically relevant edge-depth metrics should be depicted for the 50 year time horizon (see Scales, below).

Landscape context and the importance of scale in marbled murrelet models: The landscape surrounding individual patches strongly influences their suitability for marbled murrelet nesting. Ralph et al. (1995) identify the utility of "buffer habitat" surrounding marbled murrelet suitable habitat, to provide structural cover, reduce fragmentation effects, and provide eventual replacement

[18] This is estimated; Figure shows 2106 data, but presumably most of the oldest stands to be harvested would be harvested by 2056.

for habitat lost to disturbance. The importance of buffer habitat is also addressed in the marbled murrelet Recovery Plan (noted on DEIS p. G-1030). At the sub-regional scale, marbled murrelet densities were highest in areas with large blocks (eg, > 50 ha) of old-growth within a matrix of medium-sized 2nd growth ("Young" structure) as opposed to early seral buffers (Ripple et al. 2003). This work suggests the importance of buffer habitat. A scientifically rigorous analysis of landscape (fragmentation) effects on marbled murrelet habitat in the Plan area would account for buffer habitat and depth-of-edge effects specific to marbled murrelet (e.g., 50m -150m, see above), proximity of each polygon to known nesting habitat, differences in hard and soft edges, and landscape context of polygons (see below).

Landscape context is also an important factor influencing suitability of habitat patches for marbled murrelet. Murrelets have high site fidelity, and tend to return to nest repeatedly in the same stands (Divoky and Horton 1995, Nelson and Peck 1995, Singer et al. 1995, Herbert and Golightly 2003). The significant assumption that "developed structurally complex" stands (patches) in one part of the Plan area can replace harvested old-growth stands in another area as nesting habitat is not supported by the available data on murrelet habitat use, and is not supported by analysis in the DEIS. The critical habitat units (CHUs) for the murrelet that were designated in May 1996 are considered essential to the conservation of the species (USFWS 1996). Under the Northwest Forest Plan (Northwest Forest Plan), BLM Late Successional Reserves (LSRs) accounted for 27 percent of the total critical habitat for Marbled Murrelets in western Oregon. The US Fish and Wildlife Service (USFWS) (1997) has stated that the Northwest Forest Plan, especially the LSRs, are the backbone of the murrelet recovery plan. More analysis would be needed to convincingly demonstrate that marbled murrelet habitat removal and degradation predicted under the Preferred Alternative for BLM lands designated as CHU would not increase the risk of marbled murrelet population decline.

The WOPR analysis of marbled murrelet habitat focuses solely on patch-scale habitat measures. In contrast, Meyer (2007) found that multi-scale models including landscape (800 ha) and larger spatial scales were far more accurate predictors of marbled murrelet distribution, although landscape-scale-only models had almost as high accuracy. This work is consistent with conclusions in Ripple et al. (2003) and Raphael et al. (2006), and suggests the importance of accounting for the influence of the matrix surrounding individual habitat patches on marbled murrelet reproductive success in analyses of management effects.

Marbled murrelet, a rafting species, are tied to very specific marine habitats, often strongly associated with large bays and river mouths (Meyer and Miller 2002). The Alternatives would have very different effects across the Plan area, and it appears (based on changes in habitat availability in DEIS, Fig. 234) that marbled murrelet populations in southern Oregon would be differentially impacted. This differential, geographically-bounded effect should be interpreted for its effects on the species at the both the population (i.e. marbled murrelet in the southern Coast Range Province) and meta-population (i.e. species range) scales.

Temporal scales of the analysis are also very relevant to the cumulative analysis of change in species' population characteristics. Changes in patch fragmentation metrics for marbled murrelet suitable habitat, such as mean core area, and patch size, are described for model year 2106 but not for 2050, a probable "pinch point" for marbled murrelet populations (or at least habitat conditions) according to the DEIS, p. 678.

*Comparison to other marbled murrelet models, other relevant model parameters, and model validation*

There have been many efforts to model marbled murrelet habitat (McLennan et al. 2000, Harper et al. 2001, Burger 2002, Hobb 2003, Raphael et al. 2006) and to predict the likelihood of marbled murrelet occupancy (Bahn and Newsom 2002, Ripple et al. 2003, Meyer et al. 2002, review in McShane et al. 2004, p. 4-34, Huff et al. 2006, Meyer 2007). In addition to broad stand structural classifications like those used in the WOPR DEIS analysis, these models have demonstrated the importance of stand (patch)-level characteristics such as stand age, tree height class, vertical canopy complexity, density of large diameter trees, canopy closure, site physical conditions like slope and radiation, and patch size. Correlations between these variables and WOPR DEIS structural classes are not known. This, combined with the limited (or lacking) consideration of landscape characteristics including fragmentation, structure of surrounding stands, distance to marine areas (beyond mere Zone classification), and proximity to major flyways (drainages), represents a set of significant assumptions about the marbled murrelet that have not been fully acknowledged and complicate interpretation of the DEIS analysis. Many published studies on marbled murrelet habitat relations used parameters that could be obtained from BLM GIS layers for incorporation into the WOPR DEIS analysis. Using methodology and (in particular) variables demonstrated as correlated with marbled murrelet population parameters or habitat use (through validation and accuracy assessment) would greatly strengthen the analysis.

Many published studies have validated their models with empirical data, producing accuracy assessments. For example, Huff et al. (2006) found that the level of agreement between their model predictions and actual marbled murrelet survey data ranged from 72 to 83.5 percent. The assumed link in the WOPR DEIS between coarse habitat availability (mature and structurally complex forest) and marbled murrelet use (a surrogate for population size or abundance) could be tested using the available occupancy data for marbled murrelet. Without validation of the model used in the WOPR DEIS analysis, it is difficult to determine its accuracy. Furthermore, the results from this model seem to contradict results from analyses validated with empirical data. The Northwest Forest Plan 10 year analysis modeled changes in marbled murrelet habitat (Huff et al. 2006), and reported only 289,000 ac. of murrelet habitat for the Northwest Forest Plan Plan area (BLM+U.S. Forest Service) (Huff et al. 2006; Table 4-13b). The WOPR analysis suggests 373,000 ac. for the BLM ownerships alone (DEIS, p. 302) - a large difference. Lacking validation of the WOPR model and side-by-side comparisons of model output to actual data, it is difficult to discern why such large differences exist, and consequently to support the WOPR DEIS model in place of a published model with quantified accuracy.

### 3.4.3. Deer and Elk

There is recognition that intensive forest management practices simplify the composition and structure of the stand establishment stage of forest development in the Ecology Section (**3.1**). However, the WOPR DEIS analysis does not distinguish conditions for wildlife in stand establishment-stage stands that develop following natural disturbances (e.g., widely spaced residual trees and strong shrub and herb responses following fire) from intensively managed stand establishment-stage stands with spatially and temporally limited shrub components. This has significant implications for wildlife habitat, particularly for species associated with early seral habitat, such as deer, elk, and many species of landbirds. The assumption that the creation of foraging habitat for deer and elk would occur as a result of regeneration harvests is not well supported. The stand densities and species compositions specified for the Timber Management Areas under Alternatives 1 and 2 in the DEIS (pp. 73 and 83) are unlikely to promote a high level of structural and compositional diversity. Numbers of deer have been observed to increase following timber harvest, but this has been associated with heavy browse on Douglas-fir seedlings (Crouch 1976). Black-tailed deer browse on Douglas-fir when preferred forage species are not available

(Crouch 1968), but more nutritious native forbs and shrubs are preferred (Campbell and Evans 1978, Hanley and McKendrick 1985). In fact, a major threat to Columbian white-tailed deer has been removal of ‘‘brush’’ during logging or agricultural development, which reduces the availability of both forage and cover (USFWS 1983). Campbell and Evans (1978) demonstrated that establishment of native forbs reduced browsing pressure on planted Douglas-fir seedlings to the point that deer were no longer a limiting factor on conifer regeneration. Based on this, they suggested that maintaining native forbs in plantations is a sound ecological approach to reducing browse damage in regenerating conifer stands.

### 3.4.4. Fisher

As with all species accounts in the WOPR DEIS, there is no discussion of population estimates for the fisher, and changes in classified suitable habitat for this species are not associated with changes in population parameters. Without such ties, it is difficult to assess cumulative risk to the species. Certain aspects of fisher natural history, such as its very large home range size, were not reflected in the mapping grain used in the WOPR analysis. The fisher habitat model lacked clarity, did not incorporate parameters shown to influence fisher distribution by other studies, and lacked landscape-scale specificity appropriate to known fisher distribution.

*Model clarity*
It is difficult if not impossible to evaluate the science and assumptions underlying the habitat assessment for the fisher because information is lacking on the variables used to define habitat and the spatial scale of analysis. How was habitat for each of the various life stages for the fisher (DEIS, p. 324) defined and calculated? What were the criteria for classifying habitat vs. non-habitat? How was patch size and connectivity accounted for in calculations of habitat available for fishers?

The DEIS analysis treats natal habitat and foraging habitat separately in both analysis (apparently) and conclusions. In reality, the fisher requires both components of habitat simultaneously. i.e., the value of denning habitat depends on the availability of foraging habitat, and the inverse also is true. Without a synthesis that considers the effects of changes in overall fisher habitat (natal and foraging habitat combined) on fisher population status and trend, the analysis has limited utility for assessing whether Alternatives meet Wildlife Management Objectives for conservation of this species (DEIS, p. 60).

*Model parameters and comparison to other fisher models*
Well-documented models describing fisher habitat (Allen 1983, Thomasma et al. 1991, Carroll et al. 1999, Vesely et al. 2001) are available but have not been used in this analysis. These models use parameters readily available to the BLM, including density of large live trees and snags, forest cover, and landscape-scale descriptors. The relevance of these parameters is described below.

Structure (large trees and snags): The fisher relies on very large (>80 cm) snags and logs for den sites, and uses the largest (> 70 cm dbh) live trees and snags available for rest sites (Zielinski et al. 2004, Aubrey and Raley 2002). Foraging habitat, as described in the DEIS (p. 325), is “a function of coarse woody debris and stand structural complexity…”. Given the lack of green tree and snag retention in TMAs (which occupy 51 -57 percent, respectively, of the land base in Eugene and Medford Districts where fisher are known to occur), and the allowance of salvaging in the late successional management area (LSMA) (Alternative. 2), it is difficult to understand how densities of large trees and coarse woody debris levels will be sufficient to result in increases in natal and foraging habitat (DEIS, p. 698, p. 700). Even if the amount of mature and structurally complex structural class increases as a result of succession, an increase in coarse woody debris will have a lag time of many decades (Rose et al. 2001). Analysis of the Alternatives' different effects on legacy structures within sizes and decay classes preferred by the fisher might lend additional support to the conclusions drawn in the DEIS.

Consideration of forest cover: Although older forest types in BLM-administered landscapes increase in cover across Alternatives (due to succession in Young patches), open forest (Stand Establishment) also increases, doubling to 20 percent by 2056 (DEIS, Table 156). Fisher has a tendency to "avoid habitats without overstory or shrub cover" (DEIS, p. 325). Was the impact of increasing open areas factored into estimates of effects of Alternative on fisher productivity?

Landscape-level considerations including fragmentation: The fisher is an area-limited species, due to the large size of its home range and its association with large blocks of late-seral forest (Zielinski et al. 2006). Male fisher's have home range sizes > 100 $km^2$. The BLM median "operational patch size" is probably < 1 $mi^2$, due to the checkerboard nature of the landscapes within which BLM operates. Analyzing only BLM-administered lands is completely inconsistent with the species' natural history. Likewise, the connectance metric and the entire concept of a patch size based on FOI polygons is a weak approach for estimating habitat availability for a species with a home range of this size. More appropriate would be consideration of the connectance of larger habitat areas (e.g., connectance between Siskiyous habitat and habitat in other Provinces) in support of fisher populations.

Within individual fishers' large home ranges, management actions that increase fragmentation of older forests (Alternatives 2 and 3) and reduce availability of large diameter structures (Alternative 2) cumulatively contribute to increased risk to fisher populations. This risk has not been adequately quantified and discussed in the DEIS. Although the expected decreases in availability in natal habitat for the fisher are outlined (DEIS, p. 699), there is no discussion or quantification of the resultant risk posed to fisher populations in the region. Given the small and fragmented status of fisher populations in Oregon, quantification of the risk of extirpation within the Plan area under Alternatives 2 and 3 should be documented.

Physiographic Province specificity: A more focused discussion of environmental consequences in the districts where fishers are known or suspected to occur would help clarify the effects of the Alternatives on fishers. In particular, there is no description of trends in natal habitat for the two BLM districts for which fisher populations have been documented: Eugene and Medford.

### 3.4.5. Landbirds (including forest birds in SSS Group 3)

As stated in the Plan, the BLM intends to comply with all legal regulations (DEIS, p. 12-15), presumably including (although not explicitly stated) Executive Order 13186: Responsibilities of Federal Agencies to Protect Migratory Birds (Federal Register 2001[19]). Analysis in the DEIS could more accurately assess the effects of the Alternatives on migratory birds by differentiating between Stand Establishment-stage stands created and maintained by management and those created by natural disturbance processes. Habitat for birds differs importantly between these two conditions in amounts of deciduous and other early seral vegetation. In addition, an analysis of the differential effects of green tree retention in Stand Establishment stands, and a correct description of neotropical migrants (many species in the "neotropical birds" group are residents, not neotropical migrants) would increase the accuracy of the assessment.

[19] www.eh.doe.gov/nepa/tools/guidance/volume1/2-9-eo_13186migratorybirds.pdf

The assumption that the managed Stand Establishment stands associated with the Action Alternatives will provide habitat for species associated with early seral habitat is not well-supported. It would be useful to quantify differences among Alternatives in the amounts of diverse Stand Establishment habitat (i.e., supports diversity of non-coniferous vegetation) and Stand Establishment habitat that is managed for rapid conifer establishment and dominance. For example, Stand Establishment-stage stands created in TMAs under Alternatives 1 and 2 would not be expected to support diverse early seral habitat because management actions specify the maintenance of full conifer occupancy and conversion of "undesirable tree species" to commercial species (DEIS, p. 73, 83). These management actions would be unlikely to provide habitat for diverse assemblages of land birds. Deciduous early seral vegetation is a very important habitat component for many species of migratory songbirds (Fontaine 2007). Effects of the Alternatives on deciduous vegetation were not analyzed, are expected to differ greatly between Alternatives, and would differentially impact habitat for landbirds.

A large body of research demonstrates the value of retaining green trees and snags in harvest units for wildlife (e.g., Hansen and Hounihan 1996, Chambers et al. 1999). Retained structures provide habitat in the short-term for the many species of cavity-nesters that use early seral habitat (e.g., purple martin, western bluebird, bats) and in the long-term for species that use legacy structures in closed-canopy forests (e.g., marten, fisher, marbled murrelet). The time it takes to produce trees of adequate size to support nesting habitat for several species of primary excavators (i.e., woodpeckers) is equivalent to two to three rotation lengths (Bunnell et al. 1999). Decreases in the availability of legacy structures expected under management Alternatives that do not require retention of trees pose risks to species associated with large-diameter trees that have not been adequately quantified in the DEIS.

The landbird assessment for the DEIS could thus be strengthened by analysis of the long-term negative effects on birds of replacing deciduous (shrubby) early seral habitat with young conifer-dominated stands and of not retaining legacy structures. The lack of habitat value for landbird species of stand establishment and young forest structural classes without tree and snag retention was acknowledged (DEIS, p. 707), but the consequent adverse impacts on migratory birds of Alternatives 1 and 2 are neither qualitatively nor quantitatively addressed. In addition, the provision of Alternative 2 for thinning in LSMAs and Riparian Management Areas (RMA), and for salvage in the LSMAs would further decrease opportunities for recruitment of dead wood and legacy structures. As a point of accuracy, many species in the "neotropical birds" group (DEIS, Table 100, p. 322) are residents, not neotropical migrants. Perhaps a better name for this group would be "songbirds"? Also, many of these bird species could also be grouped with "snag dependent" species.

### 3.4.6. Special Status Species

The WOPR DEIS notes that BLM goals for currently-unlisted species are to: 1) not contribute to the need to list any Special Status Species (SSS) under the Endangered Species Act (ESA); and 2) to use all methods necessary to improve conditions of these species and their habitats (DEIS, p. 317). The BLM assessment and sensitive SSS are grouped "according to habitat requirements" to facilitate analysis (DEIS, p. 320). This "habitat assemblage" approach to the problem of analyzing effects to multiple species of interest is one of twelve species assessment and conservation approaches described by Raphael and Molina (2007). There are significant assumptions associated with this approach to species management, most importantly the assumption that the response of one group member to environmental change is closely correlated with the response of other group members. The DEIS does not acknowledge the assumptions associated with this approach or mitigate the risks associated with using this method.

Lumping of species under such broad habitat associations ignores the specific, unique requirements of each species (Armstrong and McGehee 1980, Leibold 1995), and may therefore inaccurately estimate the effects of Alternatives. For example, associating Townsend's big-eared bat with "special habitats" (i.e. non-forested habitats) based on only one aspect of its natural history ignores that this species may roost in snags (Martin 2002, Raphael and Molina 2007, p. 107), has an association with late-successional forest (Thomas 1988, Christy and West 1993), has a response to thinning (Humes et al. 1999), avoids large open areas, and forages along riparian corridors (Smyth 2000, Fellers and Pierson 2002). The Alternatives vary in the amount and arrangement of late-successional and other forest types and environmental conditions provided within riparian corridors, and therefore would be expected to differentially affect the distribution and abundance of this species. "Aquatic and riparian associates" lumps species associated with large river systems (e.g., Northwestern pond turtle) with species associated with very small, high-gradient streams (two torrent salamander species). The Preferred Alternative would be predicted to affect small headwater streams very differently than large water bodies, due to greater harvest adjacent to smaller streams (DEIS, p. 79) and due to BLM ownership patterns including more headwater systems. Many other species described in this section collectively by habitat assemblage would be expected to have distinct responses to management Alternatives.

The problem of addressing the habitat needs of multiple species represents a huge challenge to managers, and most methods of multiple species assessment and conservation approaches have shortcomings (Raphael and Molina 2007). To overcome these shortcomings and mitigate the risk of single management methods, Raphael and Molina (2007) suggest combining management approaches; this is a form of risk-spreading (**2.4**). The Eastside Forest Ecosystem Health Assessment provides three examples of such a multi-species, multi-approach strategy (Marcot et al. 1994). Another (non-exclusive) approach would be to incorporate benchmarks for species and habitat conservation based on Management Objectives for SSS (DEIS, p. 317) into monitoring and adaptive management plans (**2.5**).

Alternatives 2 and 3 would be predicted to have a large effect on aquatic and riparian associates (Group 4 species) and forest floor associates (Group 5 species); it appears that relevant science regarding the autecology of these species and their habitat and microhabitat requirements was not fully considered in the DEIS. These groups are discussed specifically below.

*Aquatic and Riparian Associates (Group 4)*

Buffering only those intermittent systems predicted to provide large wood to fish-bearing systems (DEIS, p. XLVI) will have large effects on species associated with headwater areas, including some SSS Aquatic and Riparian Associates. Headwater streams are high-quality breeding habitat for many species of amphibians. Some amphibian species are resilient to disturbance. However, species susceptible to desiccation or dependent on cold, clear water (Corn and Bury 1989, Dupuis and Steventon 1999, Adams and Bury 2002, Wahbe et al. 2004, Bury 2008), and species with poor dispersal capabilities, isolated from other populations (Lehmkuhl and Ruggiero 1991, Stoddard and Hayes 2005, Richardson et al. 2005, Olson et al. 2007 (Table 3)) would be predicted to have a higher risk of (local) extirpation. Several SSS Aquatic and Riparian Associates fall into this latter category (e.g., mollusk species). The DEIS analysis gives little consideration to the cumulative effects of forest management on "Group 4" (aquatic and riparian associated) species specifically associated with headwater streams, and does not address the effects of the Alternatives on SSS riparian associates occurring outside RMA buffer areas.

Alternative 2 would regenerate 4,000 ac. within 100 ft. of 160 mi. of intermittent streams in the first decade; this habitat modification would compound in subsequent decades (described in **2.8**). A comprehensive cumulative effects analysis for the impacts of this habitat alteration on Group 4 species should at least qualitatively consider the effects of this compounded habitat loss through time in the context of a fragmented landscape overlain on a dendritic stream network. This analysis also should address the effects of resulting habitat changes and disturbance regimes on Group 4 headwater species with limited dispersal capabilities (e.g., torrent salamanders) or restricted range (e.g., Cope's Giant Salamander). Such an analysis would bolster a determination of whether the modification of headwater habitat associated with Alternatives 2 and 3 would be likely to lead to loss of (Group 4) headwater species from some watersheds, or changes in species distributions.

Past research indicates positive linear relationships between streamside amphibian abundance and richness and riparian buffer width well beyond 100 ft from stream channels (Vesely and McComb 2002). Given this relationship, riparian amphibian assemblages would be predicted to be affected by management activities in all the Action Alternatives, in systems with 100 ft. RMAs as well as along (buffered and unbuffered) intermittent systems. It does not appear that these "broader riparian" impacts were quantified or addressed for riparian species generally (**2.8**) or Group 4 species specifically.

*Forest Floor Associated Species (Group 5)*

Consideration of forest floor associates uses a rough habitat suitability index to relate structural attributes to suitability for all forest floor associates (DEIS, p. 721). Habitat scores for special status species associated with the forest floor were increased in young stands (without legacy) "when they reached 50 years of age to account for the natural development of legacy." (DEIS, p. 721). This use of the term "legacy" is not consistent with functional definitions of legacy structures, which usually refer to structures retained from the previous (pre-disturbance) stand, and therefore are of much larger diameter and more complex architecture than trees that originated post-disturbance. Dead trees at stand age 50 would be predicted to be suppression mortality, smaller than stand averages, with modest habitat potential (e.g., limited microclimatic buffering or bark development) (Spies, unpublished).

Another key assumption of forest floor species analysis is that "forest floor associates persist through harvest activities or recolonize from adjacent stands" (DEIS, p. 722). Many of these species have very limited dispersal capabilities (Lehmkuhl et al. 1991), so it is unclear how they will colonize habitat that develops following regeneration harvests without retention of legacy structures. This is a case where habitat availability may not be a reliable indicator of population size.

## 3.5. Fish

The Science Team comments on the Fish sections of the WOPR DEIS first consider listed fish life history and population measures such as fish density and distribution. Physical habitat components and processes which affect fish populations or production are considered in discussions of the large wood model (and its philosophical underpinnings), intrinsic potential models, fish productivity model, and other factors affecting fish (including sediment and stream flow).

### 3.5.1. Species analysis and life histories

Consideration of fishes of interest (listed salmonids) includes the classification of stream segments by their intrinsic potential to support different species (see below), modeling of changes in the large wood environment, and qualitative assessment of indirect effects on salmonids generally of changes in stream sediment and temperature conditions (output from models in Water section). There is no treatment of actual population data in the Plan area, other than the use of fish presence information on BLM lands to delineate stream types (see below). The analysis ignores a wealth of existing data on populations and trends and thus cannot address effects to these species outside of those associated with intrinsic habitat condition. Decades of data have been collected intensively in the Plan area on salmonid life history, including site-specific spawning and rearing data. Outmigrant densities, fish presence/use extents, and a myriad of other species-specific data have been collected for these key species. Ignoring this information means that the WOPR DEIS analysis cannot directly consider:

- Key population strongholds (e.g., Lee et al. 1997)
- Basins (or watersheds) essential to maintenance of species' ranges (i.e. strongholds)
- Basins (or watersheds) in danger of population bottlenecks or crashes
- Population process metrics that indicate short-term impacts of management and long-term population viability.

Instead of using actual fish data, the DEIS analysis develops a metric termed "fish productivity". This metric actually quantifies stream habitat predicted to be associated with spawning and rearing, not fish productivity, and is problematic (**3.5.4**).

The Action Alternatives base riparian management (buffer configuration and objectives) on fish presence data, including delimiting of a 25 foot buffer on streams classified as not contributing wood to fish systems. The accuracy of the fish presence data used to delineate these streams is not described. Have fish usage surveys been completed (by BLM districts, Oregon Department of Fish and Wildlife (ODFW), or others) for all the Plan area streams to clarify the status of intermittent streams ("non-fish" or "fish"-bearing)? If so, these data, and how they were applied, should be described in the DEIS. If not, fish usage surveys completed prior to individual management actions to validate a stream's status would be critical to ensuring management actions were consistent with assumptions in the WOPR DEIS analysis supporting the Purpose and Need and Plan Management Objectives for fish.

Intermittent streams are an important source of coho smolts in the Oregon Coast Range. Juvenile coho make seasonal use of intermittent streams, including residual pools, and move into and out of intermittent systems, making clear documentation of presence/use within a stream segment difficult without effort (e.g., tagging and trapping) (Wiggington et al. 2006). This observation suggests some caution in classifying intermittent streams as exclusively fish-bearing or not. Confidence in designations of fish use would be strengthened by documentation of frequency and intensity of BLM fish distribution surveys updating streams designations. The implications of using a "non-static" fish use data layer for implementation of the Plan should be documented. Specifically, how frequently is stream status assessed, and by what process is that information fed into the planning process for land management decision making.

Finally, the analysis cannot put the effects of the Alternatives on fish species in context without integrating the effects of the Alternatives on fish populations with other effects on those populations (including harvest and ocean conditions), leading to an assessment (quantitative or at least qualitative) of population trends for key species under different management scenarios.

### 3.5.2. Large wood model

Analysis of "Fish" in the WOPR DEIS uses a series of habitat parameter-based models. The models used (and some proposed management actions) represent a good attempt to incorporate into management more recent scientific thought about the importance of episodic disturbance in maintaining riparian systems and the species that depend on them. However, the development of models from this theoretic background and the interpretation of model results raise some issues.

*Use of large wood as a surrogate for fish population response*

The use of large wood as a proxy for fish productivity has several serious shortcomings. The scientific basis to support the use of large wood as an indicator of habitat quality comes from Roni (2001); however, this work (more fully presented in Roni and Quinn (2001a, b, c)) focuses on a reach-scale response in juvenile salmonid density in response to placement of large wood in streams (habitat restoration projects), not a population-level response. The DEIS implicitly equates habitat condition, a reach-scale response, to fish productivity, a population-scale metric. This is inappropriate without a rigorous demonstration that the reach-scale conditions represent a factor that limits population processes (see below). Without establishing that the population increased a result of these local wood placements, the response could represent an existing population of fish re-distributing themselves across a new suite of habitat conditions

The scientific literature provides few good examples of population-scale habitat metrics or on determination of habitat conditions as limiting factors for population processes; most of these are in a modeling context (Green et al. 2005, Scheuerell et al. 2006, Railsback and Harvey 2001). Nickelson and Lawson (1998) identified a habitat characteristic that can be measured and manipulated at the scale of reaches (over-wintering habitat such as side-channels) for coho salmon populations on the Oregon coast, and demonstrated that quantity and quality of this reach-scale metric was directly related to population-scale metrics. However, similar links have not been demonstrated for large wood for other salmonids; this should inform the use of large wood as a metric in habitat analyses.

*"Representative watersheds" used as a sample*

No rationale is presented for using the fifth-field scale for analysis of large wood delivery, nor is there any known scientific basis for selecting such a grain. Studies that have tried to link habitat condition to fish productivity metrics have found a strong dependence on spatial scale (Steel et al. 2004, Pess et al. 2002); i.e., the spatial scale of analysis strongly affects which habitat parameters appear as important in fish responses.

Five representative watersheds were selected for fish habitat analysis, based primarily on percentage of BLM ownership within a watershed and secondarily on physiographic province (DEIS, p. 723). Although BLM ownership amongst the selected watersheds ranged from 6 percent to 93 percent, three of the five "representative" watersheds were selected from the Klamath Province; they are not well distributed across the entire Plan area, and are not necessarily "representative" of other aspects of BLM lands. It is not clear how effective these five watersheds are in characterizing wood delivery or potential impacts of management activities to fish species this section is intended to describe. Wood delivery to streams by debris flows is influenced by forest condition, topography, soil properties, and other factors that vary substantially among the provinces in the plan area. Also, the term "representative" should be used carefully. Definition of the selected representative watersheds is provided on DEIS p. 348, but then the term "representative watershed" is elsewhere in the document in other contexts.

We strongly recommend using a much larger sample size of watersheds, representing a meaningful percentage of the Plan area (> 10 percent), stratified by physiographic province, BLM ownership, and other relevant geomorphic/fish parameters. This sample should be investigated prior to analysis to ensure that it truly is representative of the range in geomorphic and forest/habitat type conditions in the Plan area.

*The response variable (large wood) and its interpretation*

Response variables in fish habitat analysis include principally wood, characterized as mean number of pieces delivered to the stream per year. Several issues are associated with this variable and its interpretation. First, the number of pieces per year doesn't tell us anything without reference to surface area of channel or some other spatial measure. Also, the function and fate of a piece of wood would be quite different depending on the piece size and length in relation to stream characteristics; a given piece could be spanning, marginal, or in the floodplain depending on this relationship. Without an explicit determination of the volume of wood in functional classes by stream order, the total number of pieces of wood per year is not a very useful metric as an influence on juvenile fish production.

This response, large wood pieces delivered by debris flows, is delivered stochastically in nature as very large, infrequent contributions, but is modeled and interpreted as an annual metric. Wood delivery, whether to aquatic or terrestrial systems, must be interpreted in appropriate temporal scales; what is the consequence for the analysis of the annual averaging approach? The pieces here presented as yearly averages are deposited in infrequent events, and their longevity as habitat creators and features is driven by later disturbance and decay processes (see below).

The measure wood pieces per watershed is used as a partial surrogate for generalized salmonid population productivity in this analysis. The DEIS states that "improved habitat complexity correlates to improved fish survival and production" (DEIS, p. 343). This supposition ignores concepts of limiting factors on species' population and production (Wilson and Bossert 1971, ODFW 2007, others)[20]. Observations that augmenting wood densities did not lead to increases in smolt production (DEIS, p. 343) substantiate the limiting factors concept. The Alternatives are actually influencing multiple in-stream habitat factors which limit adult fish reproductive success and juvenile survival and growth, and specific factors which limit fish production may differ by watershed.

*Wood delivery process modeling – geographic considerations*

The model developed to predict mean number of pieces transported to a reach has a number of assumptions about processes and parameters which should strongly influence its interpretation. This process model includes components for chronic (trees falling in from streamside stands) and "episodic" large wood input by debris flows. This model uses field observations following the 1996 flood sampled mainly in the Coast Range (Robison et al. 1999, Miller and Burnett 2007) and expands work presented in Burnett and Miller (2007) and other primary literature describing modeling studies in the CLAMS analysis area within the Coast Range. However, it appears that this parameterization did not consider geomorphic differences in wood delivery process across the Coast Range, Klamath, and Cascades Provinces, which may have quite similar topography, but can have quite different potential for debris flow production, depending on soil and other site properties. May (2007) describes three dominant processes for routing of sediment and wood in headwater

[20] Note that limiting factors include not only broad controls on fish production at the species-scale such as those defined under the Oregon Plan (http://nrimp.dfw.state.or.us/OregonPlan/) or species listing factors (http://swr.nmfs.noaa.gov/recovery/Coho_SONCCC.htm), but also ecological/ biological limiting factors on fish production operating at unit-, reach-, and larger spatial scales.

systems, including earthflows, gully erosion, and debris flows, which have different effects on wood delivery to streams. It is not clear how well the modeling deals with other Provinces and processes.

*Debris flow modeling – the role of roads*

The role of roads in the debris flow modeling to assess wood delivery to streams is not clear in the DEIS, but it is critical to evaluating past and future management impacts on stream habitat. Roads are common sites of debris flow initiation and may also block their downstream passage (for some Cascade Range examples, see Swanson and Dyrness 1975, Wemple et al. 1996, Wemple et al. 2001, Wemple and Jones 2003). The DEIS states that roads are included in some unspecified manner as an impediment to wood routing (DEIS, p. H-1089). The role of a given road segment as a source of debris flows may change over time as a result of various factors that may increase or decrease road stability (Swanson et al. 1998). These issues are further complicated by differences among land owners/managers in how they each deal with roads over time (this includes road location, construction, maintenance, and decommissioning). This is especially significant if the ODF 1996 flood inventory of slides (Robison et al. 1999) is used in modeling, because it may be important to distinguish road-related sliding and debris flows among ownerships to accurately distinguish the performance of BLM roads from roads of forest industry and the U.S. Forest Service.

*Debris flow modeling – the role of harvest*

The DEIS wood model uses "topographic characteristics" from a 10-meter DEM to identify debris-flow initiation points across the landscape (DEIS, p. H-1089). Forest cover and time-since disturbance of vegetation influence debris flow processes (Sidle et al. 1985, ODF 1999). Are the influences of forest stand age on debris flow occurrence adequately considered in the model? Note also that Weaver and Hagans (1996) is probably not representative of the relative occurrence of debris flows in forested and cut areas. This study used aerial reconnaissance overflight sampling, so the view of some slides in forested areas may have been obscured by the tree canopy.

Wood model results implementation: The 25 percent of intermittent systems buffered for model analysis are based on digital elevation model analysis. However, management direction for buffering of these systems in the field depends on timber production capability condition (TPCC) classification. This assumes that TPCC classification, designed for preservation of growing stock, can adequately capture debris-flow prone geomorphic features. Empirical validation would determine whether this is true (see **2.4**).

*Modeling large wood input-output relations*

Wood delivery to streams (input rate of wood pieces to watersheds) is modeled. Standing stock of wood appears to be modeled to accumulate without consideration of the processes of wood loss as a result of decay and other processes. Is this assumption the reason that "large wood contributions would increase over time under all four Alternatives…" (DEIS, p. 729)? Is this a real, net change in wood conditions or an artifact of an incomplete modeling framework? In this context modeling of wood in streams should balance of inputs vs. outputs, including decomposition with distinction between hardwoods (fast decomposition) and conifers (slower decomposition) (Benda et al.2003)

*Past and future conditions – benchmarks and "maximum potential"*

Analysis of wood dynamics focuses on future wood recruitment. Other important components of a cumulative consideration of wood dynamics in the Plan area would include characterizing the influence of history on current conditions (the Affected Environment) and future conditions, characterizing both historical (in unmanaged stream reaches) and current environmental baseline, and identifying benchmarks against which to assess changes in the wood environment associated with Alternatives. Wood in channels in the Plan area is characterized by BLM, Aquatic and

Riparian Effectiveness Monitoring Program (AREMPS), and ODFW data. Fish and other aquatic organisms respond to standing stock of wood, not the promise of wood to come. The history of stream cleaning, salvage logging for wood value, and intensive forest management has reduced wood-created habitat in streams.

The DEIS (p. 349) uses a concept of "maximum potential large wood contribution" and uses it as a benchmark to compare the effects of Alternatives, but both the definition and the implications for stream conditions are not clearly considered. "Maximum potential large wood contribution is the maximum potential of the watershed to provide large wood to streams", assuming all forested acres in a watershed were capable of delivering large wood. The measure is number of pieces per year that could be delivered to fish-bearing streams in a fifth-field watershed. This definition leaves several unresolved issues: 1) Have all relevant processes been incorporated in the model? 2) What is the time period to achieve equilibrium in the model output (this is relevant in terms of the time horizon of the WOPR)? 3) What stand age classes qualify as large-wood producing? 4) How does the maximum potential compare to benchmark levels observed in stream surveys in unmanaged systems? The DEIS (second paragraph, p. 349) refers to maximum potential large wood by Province and refers to the Ecology section (apparently Table 66, p. 207), which concerns forest age-class distributions by Province and does not directly address wood in streams.

### 3.5.3. Salmonid Intrinsic Potential (IP)

Intrinsic potential of stream reaches is defined as a "scientific, topographical approach used to determine the potential for a stream to provide high-quality habitat for salmonids" (DEIS, p. H-1082). Intrinsic potential (IP) is estimated in the WOPR DEIS analysis using species-specific models of rearing habitat suitability (DEIS, p. 1083) based on flow, valley width and gradient (Burnett et al. 2007). These models make some attempt at acknowledging species-specific differences in habitat associations (DEIS, p. H-1083). However, use of this metric as the sole descriptor of stream suitability for salmonids is problematic: this measure is biased towards juvenile life-stages, may not be applicable across the Plan area, may be biased by base data used to inform it, and (most importantly) does not address actual fish usage.

_Base data used to generate IP_

The IP index scores for the illustrated species (coho and steelhead) rely on relatively fine geomorphic changes, at least for channel gradient (DEIS, p. H-1083). Does 10 DEM have sufficient resolution to show meaningful changes between the key values of 4 percent-7 percent slope? Accuracy assessment using actual species data would help to answer this question (see below), as would model sensitivity analyses to indicate the degree to which input data quality affects the IP classification of stream reaches within the Plan area.

The IP index scores were based on "empirical evidence from published studies regarding the relationship between a stream attribute and juvenile fish use" (DEIS, p. H-1082); no citation is given. Presumably this empirical evidence comes from research in the CLAMS analysis area. If so, were comparable empirical relationships developed for the Klamath/Siskiyou or Cascades Provinces? Is there evidence that the same factors are important in ordering suitability for juvenile life stages in these provinces? Do these relationships stay the same for each species? How does the IP modeling effort consider the well-established arguments against using density as an indicator of habitat quality (Van Horne 1983, Fausch et al. 1988, Rose 2000)? As a result, mapping fish distribution and IP score will not show a one-to-one correspondence between degree of fish use and IP – how will this uncertainty in the IP score be incorporated? Also, note that by using a DEM-based index to produce IP, IP is static and cannot change under modeled management scenarios.

Therefore, the effects due to roads, sediment, changes in flow (due to vegetation changes), or wood loading that result from the different Alternatives evaluated in the DEIS would not be captured by this index. It may be possible to develop an index for comparing the effects of the Alternatives on fish habitat by quantifying the amount of IP-stream (score weighted sum) within a buffer or catchment area associated with (i.e., surrounding) the footprint of each Alternative. These "IP impact" scores could be compared between Alternatives to rank the potential overall impact. In this way, the IP mapping could be used to represent the potential benefit to modeled fish habitat that each stream reach may play, and the total weighted sum of IP impact for these areas could index each Alternative's effect.

*Intrinsic potential vs. actual fish presence (and productivity)*
Moving beyond a simple IP stream classification system is recommended because the modeling of potential habitat may obscure changes in actual fish presence and demography. The IP represents a suitability estimate. Suitable habitat may be very different than habitat actually used. Salmonids may or may not be using streams in the Plan area in a manner predicted by the IP classification; this would need to be validated (see below). For example, high IP (HIP) reaches are predicted to be providing high quality habitat for fish; however, current temperature, substrate composition, and available large woody debris may limit the actual utility of such streams for fish species. Because the quantification of IP in watersheds is based on landscape variables derived solely from DEM (elevation models), the current habitat conditions will not be well represented. It is essential in the discussion and interpretation of IP values to be very clear in distinguishing between the "potential" to support fish population processes and an actual demonstration that the predicted conditions exist and that fish populations respond in the manner suggested. Bjorkstedt et al. (2005) concluded that temperature limitations prevented coho on the Northern California Coast from responding to competitive release. Similarly, it is not clear how much habitat identified as HIP for coho, steelhead, or chinook is in actuality limited by temperature, sediment, lack of wood or other stream conditions, and how this reduction in total HIP would influence the assumptions in the DEIS analysis.

*Intrinsic potential model validation*
However it is used, IP designations should be considered as a hypothesis; one that needs to be evaluated with actual fish presence data in order to determine its actual utility. In essence, it is a classification of steam reaches for their ability to provide geomorphic characteristics (including flow area) predicted to be associated with juvenile salmonid production. It is a valid place to start, and should be contrasted with actual salmonid presence or (better yet) demographic data. A comparison of current stream condition and usage by salmonids to IPs needs to be a part of model evaluation, though this needs to be done with care so as not to use fish data to refine the IP designations. Such tautologically defined classifications cannot be used in a predictive context. Empirical model validation needs to be performed across the Plan area, since responses would be predicted to be different in (for example) the northern Coast Range vs. the Siskiyous.

*Restoration and IP*
Assuming that HIP stream reaches are critical for fish productivity, the DEIS explores the role of actively restoring stream habitat to maintain or generate areas of high intrinsic potential. Instream restoration is stated to be "11 miles" (DEIS, p. 740) under all four Alternatives, yet it is not clear what these 11 miles represent-- annual amounts of restoration, first decade of the Plan, annual per 5$^{th}$ field watershed – and how relevant 11 miles of stream restoration would be across a unit as large as the Plan area? Without more information it is impossible to assess the value of instream restoration. Priority for restoration is reported to be given to areas already defined as high intrinsic potential by the assertion that, "increasing large wood in HIP streams would be more effective in

improving habitat complexity and fish productivity than in other streams." However, no support for this prioritization scheme is given, nor is there any discussion as to why large wood is the limiting factor or why restoration is equated with large wood addition.

### 3.5.4. Fish productivity model

A metric for assessing fish productivity was developed in the WOPR DEIS using channel surface area, IP, and modeled wood influence. This metric is highly problematic in its conceptualization, parameterization, and interpretation.

*General observations on fish productivity metrics*

The DEIS analysis suggests that the use of this metric is "in the absence of species-specific population models" (DEIS, p. 351). In fact, there are many salmonid population dynamics models that include more extensive parameterization and model training with empirical data in the Plan area. For example, models have been developed for Chinook (Ratner et al. 1997), Coho (Nickelson 1998, Nickelson and Lawson 1998), and steelhead (Chilcote 1998); many other models exist besides the ones mentioned here.

Calling this metric a "fish productivity index" is misleading. This metric is based solely on DEM-inferred geomorphology, with large wood contributions estimated from forest cover relationships. Without validation there is no evidence that this metric has any correlation with actual fish population processes. In contrast, productivity is a whole life-cycle metric, rather than a stage-specific survival or individual condition measure, that might be more readily linked to habitat conditions resulting from the proposed action. Further, productivity measures are only a component in population persistence or viability (McElhany et al. 2000). Species diversity and spatial structure are also influenced by habitat conditions and equally important in predicting long-term population response to change.

*Development, parameterization, and calculation of the fish productivity metric*

In response to management actions or other disturbance, the only factor in the Fish Productivity Index that is allowed to change is the amount of large wood (DEIS, p. H-1082-1092), and only in a positive direction. Change in fish habitat suitability due to the Alternatives would also be expected to include responses to sediment regime changes associated with roads, changes in debris flow characteristics (see below), as well as changes in flow regime (**3.6.3**). Since the IP component of the fish productivity index does not change and no other habitat metrics are included, the DEIS equates a modeled wood-in-streams index to a fish productivity index: a biologically unjustifiable step**.** There is no biological foundation for relying on large wood as a surrogate for fish production. Large wood can be an important component of freshwater habitat. However, fish production depends on many complex biotic and abiotic factors. Which of these may limit fish production in any particular watershed at any particular time is unknown and difficult to determine.

*Fish productivity model validation and utility*

Validation and accuracy assessment for this highly-derived metric would be very difficult. What would a high "fish productivity" mean in terms of juvenile densities, escapement, or returning spawners? Considering its unknown relationship with actual salmonid population descriptors and habitat conditions, this metric as it is currently constructed appears to have limited utility in describing portions of the Affected Environment relevant to fish populations. Its utility in differentiating between Alternatives and their ability to meet Plan Purpose and Need and management Objectives for fish species is questionable.

### 3.5.5. Other environmental effects on fish habitat

The effects of changes in fine sediment delivery (DEIS p. 741, 762, Fig. 271), temperature and stream flow characteristics on fish (DEIS, p. 358) due to the Alternatives receive very little consideration for such important topics. The assumption of negligible effects on fish populations is dependent on negligible changes in these environmental conditions due to the Alternatives; analyses in the Water section supporting this assumption are questioned below (**3.6**).

Effects of forest management on peak flows and related change in fish habitat are germane to the DEIS and are considered in a BLM-commissioned review of findings from small, experimental watershed studies and other information sources (Grant et al. in press). This analysis offers a link between the peak flow and fish habitat aspects of the DEIS. Experimental watershed studies in Grant et al. (in press) reveal that peak flows commonly increase in response to cutting and roads. However, other observations indicate that channel change is contingent in part on the ability of the channel to adjust, which is related to stream gradient and the size distribution of sediment in the stream bed and banks. The analysis suggests that there is a rather narrow range of flow and channel conditions that have strong potential for channel adjustment to management-related changes in discharge. Further, these potential changes may be masked or complicated by effects of management and natural processes on factors in addition to altered streamflow, such as sediment load and large wood in channels.

## 3.6. Water

The Science Team observations concerning the Water section of the DEIS relate to both primary literature support and modeling assumptions for stream temperature, sediment, and peak flow sections of the analysis. These are discussed below by topic.

### 3.6.1. Stream Temperature

Stream temperature analysis in the WOPR DEIS did not use the most recent science on the subject, used questionable model parameterization, and used an arbitrary effective shade benchmark which would probably not meet BLM's Management Objectives for maintaining and restoring water quality (DEIS, p. 57), and might be insufficient to meet water quality standards (DEIS, p. 12) in some stream systems or basins.

*Citations and studies used in stream temperature modeling*

Primary literature used to support analysis of stream temperature changes are poorly documented or incorrectly presented in the WOPR DEIS analysis; more recent research analyzing optimal widths of stream buffers for shade retention has been overlooked (see below). Most of the results referenced are for one physiographic province or set of conditions, and need to be interpreted cautiously when applied to the entire WOPR Plan area. We have concerns about the primary literature support for graphs relating buffer width to stream temperature (DEIS, Figs 98-100). The Brazier and Brown paper is dated (published in 1972). The data points on the graph in the original paper differ from the set of points in the graph in DEIS (n=11 versus n=13 in DEIS, P. 367). Use of Brazier and Brown (1972) for Plan-scale analysis of stream temperature effects has significant issues (see below). The graph relating effective shade and buffer width (DEIS, Fig. 311) is not referenced but appears to be from a report conditionally approved by Oregon Department of Environmental Quality (ODEQ) (U.S. Forest Service and BLM 2005) for Sucker Creek in the Illinois basin, not from a peer-reviewed, published study. Not only is that graph for a specific stream, it was also developed under the old temperature standard. A significant claim that 80 percent effective shade is sufficient to keep stream temperatures from rising meaningfully within the Plan area with a range of Alternatives should be better supported.

More recent primary literature based on empirical data and describing riparian buffers and their effects on stream temperature has been overlooked. Chief among the recent work that appears overlooked is a review by Moore et al. (2005). The review concludes that riparian buffers decrease the magnitude of stream temperature and riparian microclimate warming associated with harvest, and that substantial warming has still been observed in both un-thinned and partial retention buffers. The review also suggests that application of heat budget models (e.g. Heat Source, see **Appendix 2**, p. 75) could be used to diagnose the reasons for temperature variations in response to stand treatments. Further, the models could be used as a tool for confident extrapolation to new situations by evaluating a one-size-fits-all target and the inherent problem of extrapolating experimental results across other landscapes.

The few cited studies may have limited applicability across the geographic range and range of forest successional stages of WOPR. Nierenberg and Hibbs (2000) is cited to characterize natural vegetation conditions in riparian zones in the Coast Range, and as support for limited conifer growth in riparian areas (DEIS, p. 370). This study is specific to a particular set of successional conditions (including shrub fields possibly following alder dominance and then senescence 145 years post-wildfire), in one Province (the Coast Range), and a particular range in stream sizes. Pabst and Spies (1999) described the forest structure in Oregon Coast Range headwater systems and found conifer predominance.

*Meaningful benchmarks for stream temperature*

The DEIS concludes that maintaining 80 percent effective shade would correspond to roughly 0.2°F increase (over a 1 mile segment) and that this is "within the range of natural variability" (DEIS, p. 750). We know of no citations describing the historic range and variability in stream temperature, but this range would be large at spatial scales smaller than the Province, including both periods with widespread absence of riparian vegetation and periods with nearly full riparian canopy cover. Such a benchmark may not be meaningful to analyze the effects of the Alternatives. In the absence of historic benchmarks or benchmarks based solely on verified scientific relationships, BLM could use total minimum daily load (TMDL) standards (DEIS, p. 12). The TMDLs represent a regulatory benchmark that is based on the support of aquatic communities and pertain to two of the issues identified as important in the WOPR DEIS: support of listed fish species and maintenance of water quality (DEIS, p. 21). The TMDL load allocations have been established for a number of basins within the WOPR planning area (http:// www.deq.state.or.us/wq/TMDLs/basinlist.htm). Reduction of existing effective shade or a 0.2° F increase in stream temperature would be in conflict with TMDL load allocations established for some basins[21] (>500 systems in Oregon have approved temperature TMDLs (Drake pers. comm.)). The DEIS analysis of stream temperature changes would be improved by comparison to benchmarks based on (or assumed to be relevant to) aquatic functions, such as TMDL standards.

*The DEIS temperature modeling parameters, contrast with empirical data and other models*

[21] The March 2006 Science Team comments stated: "80 percent effective shade - A lot seems to be anchored to this number in terms of protecting stream temperature, and a target of 80 percent shade provides a substantive amount of shade. However, Figure C [from the Planning Criteria] implies that smaller streams could have up to 0.5 F increase in temperature over a 1 mile distance if nothing else other than solar radiation is influencing **stream temperature.** DEQ's TMDLs generally call for site potential shade. The use of 80 percent shade target would be consistent if BLM ensures that on both spatial and temporal scope of the management activities **do not increase heat load** or temperature. " (**Emphasis** added).

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. A more recent study from the Cascades (n=40) produced a comparable but different relationship between buffer strip width and ACD (Steinblums et al. 1984). The methods in Brazier and Brown (1972) are based on empirical data from a group of small streams selected to be similar; the authors omit two locations with "flat valleys rather than v-shaped canyons" (Brazier and Brown (1972), p. 5, Fig. 2-4). Geomorphic variation is typical in the Plan area. The relationship graphed in DEIS Fig. 100 is from an ODEQ model for one system (Sucker Creek) in the Plan area. The results presented for this system (presumably from HEATSOURCE) were not meant to be applied across the entire Plan area. Measures of variance or sample size are not provided for this relationship, nor are they provided for the relationship between ACD and effective shade (DEIS, Fig. 99).

The stream temperature analysis in the WOPR DEIS ignores several key parameters in riparian ecotones affecting temperature, including stream discharge and propagation, stream geomorphology, geometry and topography. Stream temperature is a function of energy and water exchanges across the water surface, stream bank and bed (summarized in Moore et al. 2005). Key processes missing from the DEIS analysis which would be predicted to influence stream temperature at the watershed-scale include stream discharge and the influence of stream size. Point increases in temperature propagate downstream (illustrated in Moore et al. 2005, Fig. 2) other factors being equal; thus consideration of changes in stream temperature at a point (as was done in the DEIS analysis) cannot capture the cumulative effects of changing overstory conditions on stream temperature (noted in Allen et al. 2007)[22]. Stream size influences both discharge and incident solar radiation. Equations provided are primarily for "small streams" (DEIS, p. 367); this obscures both the point impact of incident solar radiation on stream systems too large to have overtopping canopies and the complex effects of small systems which would experience greater temperature fluctuations. Small systems with lower discharge experience greater temperature fluctuations and are susceptible to temperature increases at 80 percent effective shade; many intermittent systems in the Planning area would receive minimal buffers under the Preferred Alternative (DEIS, p. 80). Does the DEIS analysis assume that these systems would all be dry during critical heat loading periods, and that there would be no downstream propagation of this temperature increase?

Recent models for stream temperature have used topography, stream geometry, discharge, hyporheic flow, and empirical (observed) temperature data to model temperature, in addition to tree

[22] Moore et al. (2005) note that streams can cool downstream by dissipation (by entering shaded, cooler environments) or via dilution with cooler ground or tributary water, but do not describe a mechanism by which streams would be predicted to recover to pre-harvest temperature conditions downstream.

height variables (Boyd and Kasper 2003, Allen et al. 2007). The WOPR DEIS analysis did not build geomorphic specificity into the temperature analysis and published models have not considered WOPR specific buffers, so while a direct comparison of WOPR results to these models is impossible, relative responses can be compared (see below, **Appendix 2**). DEIS stream temperature change predictions can be compared to empirical studies with treatments similar to WOPR Alternatives. The WOPR DEIS stream temperature change predictions are lower than empirical studies with similar buffer widths cited in Moore et al. (2005). Moore et al. (2005, Table 1) describe temperature responses following harvest with 100 ft. (30 m) buffers ranging from an increase of 0.5° F (in British Columbia) to an increase of 3.6° F in Oregon, for temperature metrics including the mean of warm season monthly temperature maxima[23].

As part of the DEIS review process, the ODEQ performed an analysis of a 3rd-order stream in the Umpqua Basin (ODEQ, **Appendix 2**). The ODEQ evaluated the WOPR Alternatives using the mathematical model Heat Source Version 7.0. Heat Source simulates open channel hydraulics, flow routing, heat transfer, effective shade, and stream temperatures (Boyd and Kasper, 2003). Modeling was performed for a stream segment roughly 18 km in length. Modeling simulated base conditions verified with empirical data sets for surface and instream temperature. Predictions of stream temperature under Alternative scenarios meant to emulate those presented in the WOPR DEIS were developed. Alternatives varied vegetation only. This simulation suggested that for this reference stream segment:

- Current (baseline) conditions are 1-2° C above "natural thermal potential"[24]
- Model results emulating WOPR Alternative 1 buffer widths produced small changes in stream temperature, far below ODEQ TMDL benchmarks
- Model results emulating WOPR Alternatives 2 and 3 buffer widths produced changes in stream temperature in excess of 0.7° F, and moved several kms of the modeled stream segment above ODEQ TMDL benchmarks. These results are more than double the estimates in the DEIS (< 0.2° F, DEIS p. 750).

Thus the DEIS analysis for stream temperature predicts lower effect than published empirical data with comparable prescriptions (Moore et al. 2005), as well as lower predicted changes than for distributed models using empirical data for model training and (arguably) better parameterization (HeatSource**, Appendix 2**). Complex models are not essential for a planning document such as the WOPR. However, it is difficult to give credence to WOPR DEIS analysis in the absence of validation or accuracy assessment (**2.4**) or in the face of results which seem contrary to our observations, other cited studies, and empirical data.

### 3.6.2. Sediment in the aquatic environment

The WOPR DEIS analysis of sediment delivery to aquatic systems is difficult to follow in places, and did not make use of extensive and relevant science on the subject. The DEIS analysis appears to devote more attention to processes of low importance (e.g., overland flow) that processes of high importance (debris flow and landslide processes), and did not fully investigate the role of riparian buffers in sediment detention.

*Sediment section clarity and accuracy*

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[23] The metric for temperature response in the WOPR DEIS (fig. 100, p. 368) is labeled only as "temperature change over 1 mile (° F per mile)", without temporal bounding.

[24] Stream temperature average incorporating vegetation covers associated with natural disturbance levels (NRV).

The content and chain of thought processes in the Sediment portion of the Water section of Affected Environment (DEIS, p. 372-382) is difficult to follow, so it is not possible to judge the usefulness of findings. The following is a limited sample of points of concern about content of this section of the DEIS:

- Figure 103 is a map labeled "Geology within the planning area", but the mapping units are not geologic units, but rather are "Erosion class geologic category" units. The types of erosion processes considered are not specified, but since the Willamette Valley floor is shown as ranked high, it appears to be for surface erosion by overland flow. This raises the question of how relevant the map and erosion processes are to steep, forest land conditions of the DEIS and plan area.
- Table 114 presents "Basic erosion rates for roads based on underlying geology", but has several significant shortcomings: 1) the erosion processes considered are not specified; 2) the geologic parent materials identified are not very relevant to the planning area (i.e., types that do not occur in the plan area are listed and types that do occur extensively in the plan area are not considered); 3) the erosion categories do not correspond between Table 114 and Figure 103, because the geologic units do not match; 4) erosion rate is shown on a per acre basis, but it is not clear whether that unit of area refers to area of road surface, road right-of-way, or total watershed area that includes an average density of roads.
- Modeling is introduced on p. 376 using a Washington Department of Natural Resources (DNR) approach, but it is not clear how this relates to the information in Figure 103 and Table 114. The modeling discussion proceeds to present values in units that include "per square mile" and "per mile" without saying whether these are on the basis of road or watershed area and road or stream length.
- Figure 105 shows watersheds with highest fine sediment delivery from roads, but some of these appear to be in the areas of low erosion class in Figure 103.
- Other issues include: 1) discussion of the Timber Productivity Capability Classification (TPCC) as a means of identifying sites susceptible to sliding raises important questions about its suitability for that task (see comments elsewhere in this review) and 2) reference is made to Weaver and Hagans (1996), an analysis which probably over-predicts slides in clearcuts because of greater visibility in open areas (**3.5.2**).

*Citations and studies used in sediment delivery modeling*

The body of literature on sediment delivery distance and buffer strip efficacy is larger and more diverse than that suggested in the DEIS sediment analysis, including studies from the region and elsewhere (Belt and O'Laughlin 1994, Bren 1998, Lynch and Corbett 1990, Swanson et al. 1987); many of these studies arrive at different conclusions than the DEIS. The DEIS cites studies with varying "runout lengths" (poorly defined), from many parts of the country with very different soil types, climate and geologic conditions, and site treatments (DEIS, p. 380). It is unclear which studies are actually relevant to the Plan area. Better synthesis of these various studies, emphasizing the ones most comparable to conditions in the Plan area under the Alternatives, would facilitate their use (see below).

*Sediment Delivery Modeling*

Concerning the sediment delivery modeling in the DEIS, we are concerned about: the justification of the 200-foot assumed source distance of sediment reaching streams, ignoring sediment transport other than overland flow, the effectiveness of the narrow streamside buffers prescribed in the DEIS, the value of TPCC as a landslide site evaluation tool, disregard of debris flows as sources of fine sediment, and the assumption that road traffic will be moderate. Several of these points are discussed at greater length below.

The response (sediment) considered in the DEIS is not well-defined. No clear distinction is made between fine sediment in the water column and sediment in the bed: these two dispositions of fine sediment have very different effects on biological processes.

The assumption that road segments > 200 feet from GIS-identified stream segments would not contribute sediment to aquatic systems seems optimistic, and seems to ignore flow paths. The DEIS analysis assumes "sources of sediment delivery in this analysis are assumed to be within 200 feet of channels" (DEIS, p. 1108), although the same page references Wemple's work (Wemple 1998, Wemple and Jones 2003) who observed hydrologic connectivity between roads and streams, transporting sediment. There does not seem to be empirical or mechanistic theoretical grounds for application of this 200-foot analysis mask. It is also not clear which "streams" were included in this 200-foot analysis mask.

<u>Riparian buffers and sediment detention</u>: Are "filter strips" the same as "buffer strips"? The DEIS cites studies with varying "runout lengths" (not clearly defined), depending on soil type/ geology, climate, and site treatment (DEIS, p. 380). Cited average runout lengths measured overland flow, and do not include significant potential sources of sediment including development of new channels (Belt and O'Laughlin 1994, Gomi et al. 2006), or contribution from gullies and skid trails (Rivenbark and Jackson 2004). Additionally, windthrow in narrow buffers can be significant (up to 33 percent of stand density) for at least 2 years following harvest and can contribute sediment (Grizzel and Wolff 1998) and decrease stream buffer widths.

The WOPR analysis of the effects of broadcast burning on sediment delivery would benefit from additional support. Studies of post-burning sediment travel presented (DEIS, p. 380) are not relevant to the Plan area and consider only overland flow; erosion in western forests is more likely to occur as channelized flow through buffer strips (Brown 1985). Also, intermittent and ephemeral channels would receive greatly reduced or no buffers during site preparation burns and would be expected to contribute both sediment and water flow to downstream systems (Bren 1998).

<u>Effects of harvest on sediment delivery:</u> "Landsliding, mass failures, and debris torrents" are noted as potential results of harvest (DEIS, p. 378), but sediment delivery effects of these processes are ignored in sediment analyses (see below). The DEIS analysis assumes "the rate of susceptibility to shallow landsliding from timber harvests…would not increase…because fragile soils that are susceptible to landsliding…would be withdrawn" (DEIS, p. 763). This assumes that non-TPCC harvested areas have no increased risk of landslide, which is an important assumption that could be tested using 1996 debris slide data and BLM's GIS layers (TPCC and harvest layers).

<u>Debris flows as a source of sediment:</u> Extensive use of debris flow modeling is made in predicting wood contribution to fish habitat (Fish section, **3.5.2**). However, debris flow modeling is not used in analysis of sediment delivery, where it would be equally if not more relevant. Debris flow rates would be predicted to increase both in response to increased harvest (DEIS, p. 379, described above), as well as increased road density. On the other hand, the tendency of a given road segment to be a source of debris flows may change over time in response to changing road drainage configuration and other factors influenced by natural processes or human action (Swanson et al. 1998). Therefore, the role of roads as sources of both coarse and fine sediment to streams deserves further attention in the DEIS.

<u>Road effects on sediment production:</u> The DEIS treatment of road effects on sediment delivery relies simply on proximity of roads to streams to analyze effects and Best Management Practices to limit effects (DEIS, p. 761). This analysis fails to consider the role of roads and road density on

rates and characteristics of debris flows, the effects of differential road usage on sediment delivery ("traffic level" is assumed to be moderate, without explanation (DEIS, p. 376)) and restoration activities that could mitigate increased sediment delivery. Roads are treated in terms of impediments to debris flow runout (DEIS, p. 1089), but not as initiation sites of debris flows. The association between increased road and debris flows is not modeled, although past inventories suggest a strong relationship (Sidle et al. 1985, Swanson et al. 1987).

The Alternatives would have very different levels of road usage, both on newly-constructed road segments and existing roads. The differential effects on sediment delivery to aquatic systems from road traffic are included in the sediment modeling assumptions (DEIS, p. I-1107, I-1108), but not in the comparison of Alternatives. There is no mention of differences in road sediment delivery based on amount of (log truck) traffic differences between the new roads among the Alternatives. A robust sediment delivery analysis would include road effects increasing debris flow and sedimentation, as well as the effects of road removal, road restoration and increased maintenance, and stream crossing improvements that could reduce the frequency of debris flows and sediment delivery.

Sediment Analysis Conclusions: The analysis suggests that the Preferred Alternative would include 80,000 acres more regeneration harvest and a doubling of road construction over the No Action Alternative (DEIS, p. 493), yet have much less sediment production (DEIS, p. 760). This conclusion rests on assumptions that: a) no sediment enters streams from channels or road segments > 200 feet from streams; and b) debris flows and shallow landslides would not increase with increased harvest and road density and use. Some validation of these assumptions would lend credibility to these assumptions. Comparison of the sediment volumes to a meaningful benchmark or threshold would allow the effects of road decommissioning and stream crossing improvements, the effects of harvest and site preparation, and the effects of road construction and increased road use to be placed in an overall picture. Both regulatory benchmarks (such as ODEQ TMDL standards) and instream biological or physical benchmarks (such as percent fines or substrate $D_{50}$) might be useful in analyzing how changes in sediment levels may affect fish foraging, production, or spawning.

### 3.6.3. Peak Flows

The DEIS analysis of peak flows uses different analyses for different hydroregions. Parts of this section of the DEIS are hard to follow (**2.1**). The Science Team review had concerns with the primary literature used to support this analysis, peak flow model parameterization for both rain-dominated and rain-on-snow systems, the spatial and temporal scales employed in the analysis, the failure to consider all aspects of the flow regime, consideration of road effects, and cumulative changes in flow regime.

*Citations and studies used in peak flow analysis*

Review of literature on peak flows is uneven and difficult to follow (DEIS, p. 388). Some of the primary literature used is either inappropriate or there are more germane studies. In several parts of the analysis, relevant science has either not been represented or has not been placed in the proper context.

- The DEIS cites studies done in the 1970s (DEIS, p. 388) by Rothacher (1979) and Harr (1976) to support analysis on management effects on five-year return period events. These studies were performed too soon post-logging to have a record that could be used to evaluate five-year events. More recent papers examine much longer records that better represent the properties of five-year return period events (Jones 2000) and other papers would be more appropriate sources).

- Equations for flood frequency developed from Harris and Hubbard (1979) may not be appropriate for present climate conditions (see below).
- Ziemer (1981) is not an appropriate reference for peak flow effects in the Plan area. Ziemer (1981) analyzed hydrology of redwood forests in coastal California, in an area strongly affected by fog/cloud water interception. This condition is present in only a small fraction of the BLM planning area, and could obscure management effects if incorrectly applied to areas outside the coastal fog-belt. Jones (2000) reports significant peak flow increases in experimental watersheds with partial cutting in Coyote Creek (South Umpqua Experimental Forest), a system within the BLM planning area.
- Jones and Grant (1996), Bowling and Lettenmaier (2001), and Wemple and Jones (2003) estimated the effect of roads on peak flow responses. It is not clear that the results from these studies were considered in the DEIS analysis.
- Results from the unpublished report by Weaver and Hagan (1996) on slide frequency in clearcut vs. partial cut units (DEIS, p. 379) should not be used (see comment on its shortcomings above).

*Peak flow model and model parameterization*
Rain-dominated hydroregion model: Peak flow analysis for the rain-dominated hydroregion is performed through comparison to empirical results from paired watershed studies (DEIS, p. 384), using OPTIONS and interagency vegetation mapping project (IVMP) data to estimate amount of disturbance (Equivalent Clearcut Area (ECA)). The ECA is compared to peak flow response from small watershed studies (roughly 25 acres-250 acres) to make inference about predicted response in sixth-field watersheds (roughly on the order of 5,000 acres). The DEIS uses a 40 percent ECA cut-off to classify fifth-field watersheds susceptible to peak flow increases. The quantification of ECA, the interpretation of its influence on peak flow responses, and the use of arbitrary cutoffs in ECA as predictors in the DEIS are problematic.

As above, we here assume that IVMP data used in this analysis was updated to 2002. Using IVMP from 1996 for non-BLM ownerships would probably substantially underestimate ECA (i.e., in response to the surge in private land harvest as the NW Forest Plan went into effect). Also, considering peak flow response as a binary categorical variable (susceptible/not susceptible) may not be appropriate. The analysis in the DEIS suggests that few sixth-field watersheds in this hydroregion would be at risk for peak flow changes, since few would have 40 percent ECA. Jones (2000) reports peak flow increases in small watersheds at lower ECAs; see also Jones and Grant's (1996) work on larger basins[25]. In the Coyote Creek watershed study, a 30 percent patch cut had a roughly 35 percent increase in peaks for all events pooled and roughly 36 percent increase for > 1 year events in the 0-12 year post cut period. Grant et al. (in press) reviewed all paired watershed studies germane to the Plan area. Their meta-analysis detected peak flow responses in this hydroregion in the presence of roads exceeding detectable levels of change at ECAs > 29 percent (Grant et al. in press, fig. 9). Significant caveats are associated with the conservative envelope described in Grant et al. (in press). We would not advocate for 29 percent vs. 40 percent ECA, but instead propose a more nuanced consideration of management effects on flow regime (see below).

Rain-on-snow hydroregion model: The WOPR DEIS modeling of susceptibility to peak flow change in the rain-on-snow hydroregion used a process model using estimated winter snowpack (from empirical data) and forest cover data. Snow melt was simulated for "average environmental

[25] Caveats for use of this work, which covers both rain-dominated and rain-on-snow zones, include Thomas and Megahan (1998) papers challenging their conclusions, based in part on raising the standard for statistical significance.

conditions" in a two-year storm event. Water equivalents from this analysis were converted to rainfall and used to estimate streamflow. This streamflow value was compared to five-year event data. Sixth-field watersheds that exceeded five-year event flow levels were considered susceptible to peak flow change. Concerns with this analysis include the extent of the mapped intermittent snow zone, the applicability of gauged watershed data used for comparison, the response metric, and (most importantly) the use of an untested process model when other models and empirical results are available.

A critical issue in analysis of peak flows influenced by rain-on-snow processes is the size of peak flows considered, in part because they tend to produce the largest floods (Harr 1981) and therefore have the greatest potential to alter stream and riparian habitat. Smaller, more frequent peak flows may be influenced by less extensive snow at the beginning of a storm; larger floods may be fed by more extensive snow at the beginning and its melt. Therefore, the extent of the rain-on-snow zone may be more extensive than that used in the DEIS analysis (DEIS Fig. 109). Large floods have greater capacity to modify channels and fish habitat, but the likelihood of modification depends on channel conditions (e.g., gradient, size distribution of bed material) (Grant et al. in press). Limiting the flow size considered to five-year events may miss important aspects of potential management effects.

Equations for flood frequency developed from Harris and Hubbard (1979), used for comparison of rain-on-snow model flood flows under different harvest levels, may not be appropriate for present conditions, given climate variability (e.g., the Pacific Decadal Oscillation (PDO)). The database used by Harris and Hubbard (1979) ended 30 years ago and there has been a major PDO shift since that period. Did WOPR DEIS analysis consider how representative this pre-1979 period is for the current period being modeled (based on conditions in the past decade, for example)?

The WOPR DEIS analysis of peak flow response in rain-on-snow hydroregion used a unique process model (described above) although other more detailed process models (Lewis et al. 2001) and spatially distributed dataset models (Bowling and Lettenmaier 2001, Tague and Band 2001) have been developed, validated, and published. It is difficult to assess the efficacy of this modeling approach since it represents an untested hypothesis with a series of untested parameters. Has BLM tested Washington DNR's methodology using empirical data, preferably from the Plan area? Does ignoring the effects of roads on peak flow response in the process model affect the modeled response? Is it meaningful to apply an average climatic condition to emulate a 2-year event? Is a two-year event having flow characteristics of a five-year flow event a meaningful metric (see below)? Finally, why was a modeling approach used for this hydroregion, but comparison to empirical data was used in the rain-dominated hydroregion? Results from meta-analysis of empirical studies in the rain-on-snow hydroregion suggest that peak flow responses in this hydroregion exceed detectable levels of change at ECAs > 15 percent (Grant et al. in press, Figure 10), although caveats apply to this potentially conservative envelope.

*Scale considerations in peak flow analysis*

It seems appropriate to evaluate management effects on peak flows at watershed sizes smaller than the sixth-field scale, which is a scale so large that it fails to reveal possibly significant effects. Streams are most susceptible to change in peak flows at scales smaller than sixth-field subwatersheds (10,000-40,000 ac) (Grant et al. in press). Because headwater catchments (on the order of 25-250 ac) can experience peak flow changes due to management (Benda et al. 2005, May 2007; Grant et al. in press), it is feasible that individual logged catchments within a sixth-field watershed could have peak flow increases that are masked by uncut catchments sharing the same $6^{th}$ field subwatershed. The cumulative effects of multiple small catchments having increased peak flows may include limited stream geomorphic change since most small watersheds are dominated by large particle size, logs, and bedrock (Grant et al. in press), but would be predicted to lead to increased fine sediment transport, with downstream deposition. Flow increases following harvest have been shown to increase sediment yield in two cases (Troendel and Olsen 1993, Lewis et al. 2001); these cases are from outside the Plan area, and have quite different hydrological and sediment regimes.

*Road effects on peak flow responses*

Roads are extensively developed in virtually all sixth-field watersheds with BLM ownership. Empirical and modeling studies summarized in Grant et al. (in press) suggest that roads may increase peak flows; modeling studies for several study areas in Washington suggest an approximate doubling of harvest-only effects (Grant et al. in press, p. 15). Road effects on peak flow responses in the rain-on-snow zone appear to have been considered solely as "open areas" in rain-on-snow model parameterization, using (10m) raster data. This treatment would be expected to obscure road openings (due to averaging of cell conditions in cells crossed by roads) and (more importantly) entirely ignore the role of roads in increasing drainage density, which is thought to facilitate water routing and increase flow peaks. Error in estimates of canopy openings due to road areas would also affect ECA estimates for the rain hydroregion; envelopes of peak flow effect in Grant et al. (in press) would (to some degree) incorporate road influence in interpreting peak flow response to ECA. Note that road effects including permanent and temporary construction, renovation, and decommissioning would vary substantially among Alternatives at spatial scales (small watersheds) shown to experience detectable peak flow responses by Grant et al. (in press).

*Other aspects of change in flow regime*

The DEIS analyzes only peak flow size; however, other aspects of flow regime, such as low flows, may be of interest either biologically (Novick 2005) or in modifying stream physical processes such as sediment yield (discussed in Moore and Wondzell 2005). Optimally, an overall consideration of flow regime changes would include comparison of flow regimes under the Alternatives with historic conditions, inter-annual conditions in the current baseline, and identified biological or physical benchmarks or thresholds. As an example of consideration of changes in other aspects of flow regimes, Lewis et al. (2001) found that the return interval for the largest peak flows was halved following clearcutting, increasing the geomorphic work on the channel; however, this study is from a hydroregion outside of the Plan area[26].

*Cumulative effects and interpretation of changes in flow regime*

The assertion in the WOPR DEIS that only 1 out of 635 subwatersheds in the rain hydroregion (DEIS, p. 385) and only 3 out of 471 subwatersheds in rain-on-snow hydroregion (DEIS, p. 387) within the Plan area are currently susceptible to peak flow increases appears to be an underestimate of the effect of management on peak flows. Conducting an analysis over a rather large area and over a rather short period of time (e.g., a decade), reduces the potential to detect change caused by incremental treatments in a watershed. However, the analysis of Jones and Grant (1996) in large basins in the Cascades revealed some peak flow increases as a cumulative response to logging and

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[26] Although the effects of peak flow on stream physical characteristics have been considered (Grant et al. in press, Moore and Wondzell 2005), work remains to clarify both these relationships and the relationships between other components of flow response and stream physical characteristics. Relationships between harvest-induced changes in flow regime and biotic response have not been clearly demonstrated. However, there are mechanistic reasons to believe that harvest-induced changes in flow response, such as increases in duration and frequency of bankfull discharges (Troendle and Olsen 1994), might lead to changes in species habitat (e.g., increased redd scour) or changes in species behavior (Giannico and Healey 1998, Bell et al. 2001).

roads (but see Footnote 25, above). The effects of roads are also not modeled or considered, and would be predicted to increase peak flow responses (Johnson and Jones 2000, Grant et al. in press).

Considering the importance of this issue in determining the consistency of the Alternatives with both the Plan's Purpose and Need and Management Objectives for water, robust analysis of the effects of management on the flow regime might consider not only the cumulative decrease in peak flow response at large watershed scales (Grant et al. in press), but also:

- The cumulative effects of many small catchments (< 10 $km^2$) dispersed within target landscapes experiencing increases in peak flows (as have been observed in published watershed studies). We would predict management issues to arise at the scale of project planning, which is a scale at which peak flow changes. Geomorphic effects of these dispersed increases might be small due to resilience of channels (Grant et al. in press); biological or small sediment transport effects might not be.
- The interactive effects of alterations to flow regime and the quantity and size distribution of sediment and large wood both at the site of management treatments and downstream.
- Cumulative changes in aspects of the flow regime (not just peak flows, but also low flows and durations of flows) of physical or biological importance in the Affected Environment, including the indirect effects of changes in flow regime on species of interest[27] (**3.5.5**).

Results of both paired small watershed studies and process models such as those used in the DEIS should be interpreted cautiously. Sample size described in the meta-analysis by Grant et al. (in press) relevant to the Plan area is quite small (e.g., n=3 for 40-80 percent ECA rain-dominated systems), with a large amount of variability. Grant et al. (in press) state that peak flow responses can be highly variable due to management factors including roads, types and arrangements of harvest (e.g., clearcut vs. thinning, clumped vs. dispersed), as well as landscape pattern (Grant et in press, p. 53). Hydrologic process models (Lewis et al. 2001) and spatially distributed dataset models (Bowling and Lettenmaier 1991, Tague and Band 2001) have been developed and used in the Pacific Northwest and can incorporate some of these parameters. Rain-on-snow modeling used in the WOPR DEIS analysis did not incorporate these parameters. Lack of validation or accuracy assessment (**2.4**) makes it difficult to evaluate the WOPR DEIS model.

### 3.6.4. Pesticides and toxics

The BLM currently makes some use of pesticides/herbicides, with different levels of use in individual districts. Westside Oregon BLM is currently limited to four herbicides due to a 1987 court injunction. The WOPR DEIS contains no information about the use of toxic chemicals, such as pesticides, and their potential impacts on water quality. Is it then true that the individual chemicals used, their use levels, their areas of application, and their effects would be similar to the No Action Alternative (i.e. the Northwest Forest Plan)?

It is logical to assume that the potential effects of pesticide use would differ among the Alternatives. Alternatives 2 and 3 would have more harvest closer to streams than the other Alternatives, and more road work than the No Action. It would therefore be anticipated that toxic loading to aquatic systems would be increased, with potential adverse effects on beneficial uses, (i.e., macroinvertebrates, fish and human health). Toxics would also exhibit interactions with other Resources discussed in the DEIS. For example, higher wildfire frequency and/or severity may lead

[27] (Grant et al. in press) suggest that many of the changes in peak flow measured following harvest are within the yearly range of flows in studied watersheds, and thus are within ranges that biophysical stream systems have "adapted to". This may not be true for the full range of changes in flow regime that occur following treatment.

to greater use of toxic fire retardants that may end up in waterways. In general, WOPR DEIS analysis would be strengthened by some level of quantification of the amounts of toxic input associated with each of the Alternatives.

## 3.7. Fire and fuels

Concerns with the treatment of fire in the WOPR DEIS included confusing descriptions and classifications of fire regimes, discussions that did not reflect the variable effect of salvage on risk of future fires, nor the effects of the Alternatives on fire behavior. Integration of fire effects in discussions of other resources also was inadequate.

*Terminology and description of fire regimes*
The description of fire regimes is inconsistent and may lead to incorrect management conclusions. "Stand replacement" fire regime includes the Coast Range and a small northern tip of Cascades (DEIS, Map 31). The Coburg Hills area is shown as having a stand replacement regime with a 200-year return interval, but this seems more likely to be a mixed-severity regime system. Extensive areas of mixed-severity fire are not addressed or mapped and a reader may incorrectly assume that the entire area is under a stand replacement regime. This inaccuracy has ramifications for management (see below). Map 31 (p. LXII) describes fire regimes as "low frequency and low to mixed severity" or "high frequency and low to mixed severity" but the text often says the two regimes are either high severity or low severity. These regimes might be better referred to as mixed to high severity and low to mixed severity. The fire regime of the Klamath Province might be better classified as "low to mixed severity". In any case, consistency in fire regime terminology would facilitate interpretation.

The fire regime of the central and northern parts of the planning area is identified as extensively stand-replacement (DEIS, p. 394), but much of the area is in mixed severity regime, as noted elsewhere in the DEIS (Map 31). Correctly describing fire regime in the Plan area is relevant to the effects analysis for the following reasons:
1. Studies of fire regimes in western Washington, which may support extensive truly stand-replacement fire regimes, may not be relevant to much of the Plan area.
2. Green tree retention levels estimated based on historic landscape conditions for a stand-replacement system would be different (and presumably lower) than for a mixed severity regime.
3. Temporal variability of levels of wood in streams, and perhaps other aspects of the affected environment, would be different in a stand-replacement regime than for a mixed severity regime.

Fire-related terms are not well defined and do not appear in the glossary. Undefined or poorly-defined terms include "hazard", "resilience", "severity", and "uncharacteristic wildfires" (DEIS, p. XLV). As an example of a term needing definition, severity can refer to degree of loss of live vegetation or damage to the soil or both. Clarification of these terms would better allow readers to understand the effects analyzed, and would facilitate decision-making.

Fire Regime Condition Class (FRCC): Fire Regime Condition Class (FRCC) is a standardized tool for determining the degree of departure of stands and landscapes from reference condition vegetation, fuels and disturbance regimes (Hann et al. 2003, Menakis et al. 2004) . Assessing FRCC can help guide management objectives and set priorities for treatments. The U.S. Forest Service and to some extent BLM have made efforts to adopt FRCC categorizations. Why was the "fire hazard" system used (without primary literature support) in place of FRCC in the WOPR DEIS analysis?  It is also unclear if peer reviewed literature supports the statement comparing the amount of landscape that would burn under high severity today compared with the past (DEIS, p. 393).

*Salvage logging effects on fire characteristics and the environment*
The DEIS description of salvage generally covers the relevant literature and issues pretty well. However, the status of knowledge could be better communicated by slightly revising the topic sentence and sequencing of the points.  For example the second paragraph on page 489 leads off by stating that salvaging "…can potentially reduce the risk of a future high severity fire…"  The reader learns later in the paragraph that "there is little evidence that directly evaluates the effectiveness of salvage logging…", and that some studies indicate that salvage logging can increase fine fuels elevating fire risk for a period of time.  In fact, a recently published study (Thompson et al. 2007) suggests that fuel conditions at 15 years could result in managed stands that burn with somewhat higher severity than unmanaged stands.  Given the state of knowledge it would be more appropriate to lead off this paragraph with a sentence or two that states in effect that the effects of salvage logging on probability of future high-severity fire are poorly understood and that they will vary: sometimes increasing the risk of a future high-severity fire and sometimes decreasing it, depending on time since fire and post-fire management activities (e.g. fuel reduction actions and stand establishment practices) and measure of fire severity.  The remainder of the DEIS section describing salvaging could continue as is.

*Fire resiliency and fire effects*
The DEIS analysis of effects of the Alternatives on fire regime characteristics including fire resiliency and effects in riparian areas is incomplete.  It is apparent that Alternative 2 would produce the largest amount of area at risk of high severity fire of any of the Alternatives, largely due to the increase in Stand Establishment stages in plantations and because of the lack of retention of large trees, which reduce the resistance of forests to fire according to the DEIS fire analysis (table 215, page 772).  This fact seems to be downplayed in the Summary section of the report on fire and fuels, where the Alternatives are described in terms of how much they might reduce fire risk (fire hazard) and not in terms of absolute differences between the Alternatives in fire risk. It is different than analyses of other Resources, which describe the relative changes in metrics among Alternatives but ignore comparison to a global benchmark.  According to the DEIS (p. 769), the acres at risk of experiencing high-severity fire are more than twice as high under Alternative 2 than under the No Action Alternative.  Note that retention of green trees in Alternatives 1 and 2 might reduce the probability of high severity fire by increasing the diversity of stand types on the landscape, thus reducing the risk of fire spread (**2.4**).

The DEIS conclusion that all Alternatives would increase fire resiliency appears to be based on classification into resiliency groups based on structural conditions.  Conclusions regarding increased resiliency are based solely on estimated reductions in the amount of stand establishment and young structural stage forest in BLM ownerships from conditions in 2006 to conditions estimated for the 2106 time step (DEIS, p. 768).  Why is 2106 the only future time horizon analyzed for fire resiliency?  An estimated 143,000 acres of mature and structurally complex forest would be converted to stand establishment stage in the first 10 years under Alternative 2; limited succession or density management treatment would be occurring in the same period (especially with such an ambitious regeneration program).  Given this proposed management scenario, it would seem highly relevant to also analyze and contrast fire resiliency between the Alternatives for the 2016 and 2023 time horizons, roughly 10 and 25 years from the present.

Also, fire resiliency analysis fails to consider cumulative effects.  It is inadequate to address fire resiliency and hazard only for BLM ownerships.  Most of the large wildfires in recent memory

(Biscuit, Quartz, Apple, Silver, etc.) have occurred outside of BLM jurisdiction. The spatial relationship between BLM areas classified as "fire hazard" and other lands likely to be initiation points would be essential for a meaningful consideration of the effects of the Alternatives on fire behavior in the Plan area, and the indirect effects of changes in fire frequency and intensity on key resources.

*Integration of fire with other resources*

Fire is the only disturbance process given its own resource status in the DEIS although peak flows and debris flows are discussed in the Water section; this demonstrates its importance in ordering landscape structure and vegetation. The indirect effects of changes in fire characteristics on other systems, processes and key resources should be analyzed for each of the Alternatives. The need for incorporating fire into risk analysis for northern spotted owl has been discussed (**2.4**). Similar treatment should be considered for other key species dependent on fire-prone structures or affected by fire processes, including fire effects on debris flow frequency and large wood delivery, and salmonid association with certain stream turbidity levels.

Changes in fire frequency and intensity would have indirect effects on riparian systems. The Action Alternatives would all include regeneration harvest and site preparation in closer proximity to streams than the No Action Alternative, including management disturbance 100 feett. from perennial streams and as close as 25 feet. to some intermittent systems (Alternativess 2, 3). Regeneration cuts would produce standard establishment stands with large slash loads initially, followed by dense, small diameter trees: both are more susceptible to fire (Thompson et al. 2007). High intensity fires from slash burning or wildfire reduce rainfall infiltration, increase overland and reduce subsurface flows, and carry more sediment into streams (Lewis et al. 2001). Simultaneously, "non-commercial vegetation" retained around intermittent (non-debris flow prone) streams in Alternative 2 (shrubs and small diameter trees) would burn readily, especially in southern portions of the Plan area.

Considering proximity and intensity of treatments under the Action Alternatives, there are likely higher risks to riparian forests under Alternatives 2 and 3 in the event of wildfire. Impacts to water quality including elevated temperature and fine sediment loads become highly likely in the event of wildfires that destroy or damage riparian forests (Karr et al. 2004, Reeves et al. 2006).

In managed areas, the Preferred Alternative proposes harvest with retention of 12 trees per acre (TPA) within 25 feet of channel edges for some non-fish-bearing intermittent stream systems, and some level of thinning in areas 25-100 feet. from intermittent fish-bearing streams and perennial streams (DEIS, p. 79). Retention of the largest trees following harvest or disturbance is important to the development of more fire-resilient riparian forests (Hummel and Agee 2003, Brown et al. 2004, Reeves et al. 2006), and has been proposed as a management tool to increase both riparian zone fire resiliency and long-term large woody debris recruitment (Karr et al. 2004, Reeves et al. 2006). Were the merits of this management technique considered in the development of the Alternatives? Were the risks in terms of effects on fire resiliency in riparian systems associated with not adopting this technique considered in the DEIS?

## 3.8. Soils

The Key Point statement that "Soil productivity would be maintained or improved under all four Alternatives" (DEIS, p. 794) is not supported by any of the material in the Soils section of DEIS (p.

794-797). The bulk of the text of this section describes many ways in which past management practices and proposed practices in all Alternatives would negatively impact soils. Brief mention is made of amelioration of degraded soil conditions when they are discovered (DEIS, p. 794), but it is not clear how existing sites of degraded soils will be detected or ameliorated. It is difficult to understand how Alternative 2 could result in 60,000 (37 percent) more acres harvested than the No Action Alternative, yet only 29 percent more impact on soil (Table 226), despite the higher intensity of logging (i.e., no green tree retention) under Alternative 2. This calls into question the efficacy of the measure of soil conditions and management impact.

No examination of long-term soil fertility/productivity issues is made beyond acknowledging some effects of logging and grazing. Issues such as soil organic matter, nutrient retention or depletion, water holding capacity, exclusion of early successional species and consequent effects, and the effects of large scale biomass removal are left unexplored. The DEIS does not mention the potential long-term, cumulative effect of reducing the influences of early- and late-seral, nitrogen-fixing plants (e.g., red alder, Lobaria spp., snowbrush, and others) on site productivity under intensive culture of conifers. Native nitrogen-fixing species may be eliminated or significantly reduced on sites where early- and late-seral stages are lost to continuous, short-rotation crops of even-aged stands of conifers. Berryman and McCune (2006) observed that even 15 percent green tree retention can retain canopy lichen communities, including native nitrogen fixing species, in harvest units. The viability of forest fertilization may increase as cost of petroleum for production and application increase. These ecological and site productivity issues seem appropriate for consideration.

Disturbance processes such as fire (DEIS, p. 795) and harvest (DEIS, p. 794) affect soil characteristics including soil productivity. Considering demonstrated decreases in long-term site productivity following overstory removal and slash burning (Barnett 1989), it is difficult to understand how Alternative 2, with a doubling of permanent new road construction and prescribed burning, 80,000 ac. more regeneration harvest, and 5,000 ac. more ground-based activity in the first decade compared to the No Action Alternative (DEIS, p. 493) would lead to the same result of maintaining or improving soil productivity. This implies that the metric used to measure change in the soil environment is not sensitive to assessing soil productivity for this period. Also, the summed harvest numbers in DEIS Table 226 do not seem to match DEIS Table 149, and do not seem to reflect the differences in treatment and their effects on soil characteristics. As with other resources, cumulative effects on the soil resource would optimally include the extent of historic effects (DEIS, p. 794) and comparison to meaningful benchmarks (**2.6**).

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# 5.0 Appendices

## 5.1. Appendix 1

# Spreadsheet used to contrast WOPR Alt 2 with FIA data

**11/13/2007** **Comparison of BLM Intensive Harvest Benchmark With FIA Plot Calculations (DRAFT)**

<u>Forested Acreage Comparison (M Acres)</u>

| | |
|---|---|
| FIA Timberland Acreage | 2,326 |
| WOPR Acreage | 2,317 |

<u>Calculated Max SY</u>

| | Site Class | M Acres | Yield MMBF (Short Log) |
|---|---|---|---|
| | 20-49 | 249 | 45 |
| | 50-84 | 437 | 153 |
| | 85-119 | 525 | 280 |
| | 120-164 | 473 | 350 |
| | 165-224 | 522 | 528 |
| | 225+ | 121 | 148 |
| | | 2327 | 1505 |
| Adjust yield to account for 18% not in suitable | | | 1234 |
| **BLM Max Timber SY** | | | **1201** |

5.2 Appendix 2

# Evaluation of the Western Oregon Plan Revision (WOPR) – Draft Environmental Impact Statement (DEIS) Alternatives for Stream Temperature

Pursuant to Oregon Revised Statute 468B.035, Oregon Administrative Rules -040 to 340-041, and Memorandum of Understanding between the Bureau of Land Management Oregon State Office, the State of Oregon and State Agencies, as Cooperating Agencies, for Revision of the Resource Management Plans and Associated Environmental Impact Statements for the Western Oregon BLM Districts

DEQ
State of Oregon
**Department of Environmental Quality**

Prepared by: Ryan Michie
Oregon Department of Environmental Quality
November 26th, 2007

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# Introduction

The Oregon Department of Environmental Quality (ODEQ) evaluated the WOPR DEIS alternatives for their adequacy in meeting TMDL load allocations and Oregon's water quality standards for temperature. The mathematical model Heat Source Version 7.0 (Heat Source) was used to make these evaluations. Heat Source simulates open channel hydraulics, flow routing, heat transfer, effective shade, and stream temperatures (Boyd and Kasper, 2003). Heat Source has been used in numerous TMDLs in Oregon.

# 1. Modeling Procedure

ODEQ chose Canton Creek in the North Umpqua Subbasin as a case study (Figure 1). Canton Creek is within the WOPR Plan area, and BLM administers land management activities within O&C lands in the Canton Creek watershed. ODEQ developed a Heat Source model for Canton Creek for the Umpqua Basin TMDL which was approved by EPA in April 2007. The same model and time period (July 12-31, 2002) was used in this analysis of the WOPR Alternatives. Modeling was performed from Pass Creek to the mouth of Canton Creek.

Two changes were made to the original TMDL model.

- The riparian vegetation was modified to simulate the WOPR RMA alternatives.
- The model distance step was changed from 100 meters to 50 meters to offer higher resolution results for evaluating changes in effective shade at the harvest unit scale. Changing the model step did not change any of the input model parameters. Because n was effectively doubled, the RMSE error increased from the original TMDL calibration. The higher RMSE error however is still within acceptable bounds (see section 2.1)

### 1.1. Model accuracy and current condition simulation

In order to ensure the model's ability to predict stream temperatures, ODEQ simulated current conditions and compared the results to field data. The error statistics and the comparison of model results to field data are discussed in the Umpqua Basin TMDL Appendix 3 on page 32. For Canton Creek, the TMDL current condition model root mean square error (RMSE) was 0.57 $^{0}$C (0.32 $^{o}$F), When the model distance step was decreased the RMSE increased to 0.89 $^{0}$C (0.49 $^{o}$F). DEQ considers an RMSE below 1.00 $^{0}$C for this stream class to be a good model calibration. Based on this goodness of fit, ODEQ assumed that the Canton Creek model captured the dominant physical processes.

Current conditions model inputs included stream morphology, vegetation conditions, climate data, tributary inflows and tributary temperatures. Field measurements were used to corroborate the current condition simulation. Field data sets include: Canton Creek surface temperatures which were derived from thermal infrared radiometry (TIR), instream continuous temperature probes that recorded stream temperatures every hour, instream flow measurements, channel geometry, vegetation heights, and effective shade. Comparison of the simulated current condition to the TIR data and instream flow are shown in Figures 2 and 3

**Figure 1. Canton Creek study area.**

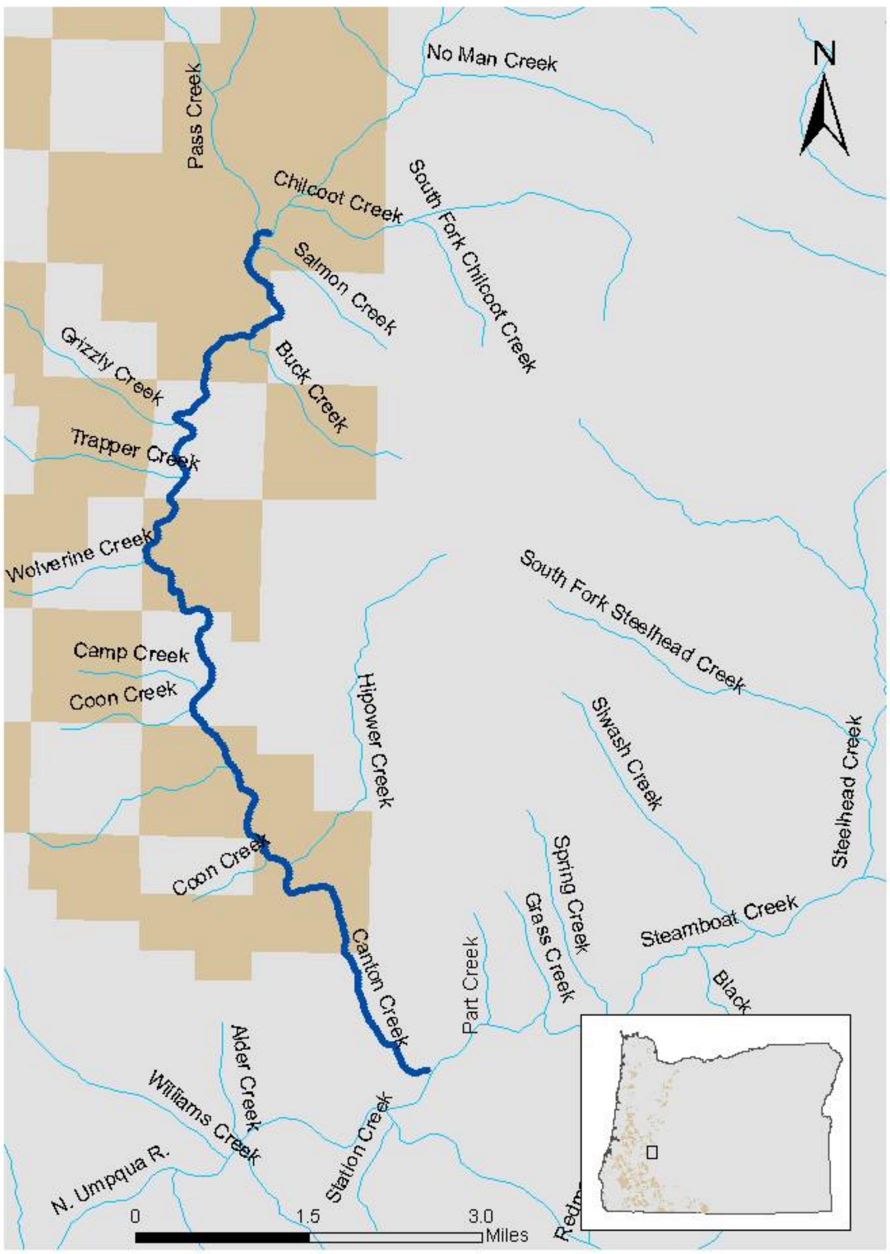


**Figure 2. Canton Creek TMDL temperature simulations results compared to Thermal Infrared Radiometry (TIR) data. Umpqua Basin TMDL Appendix 2, page 37**

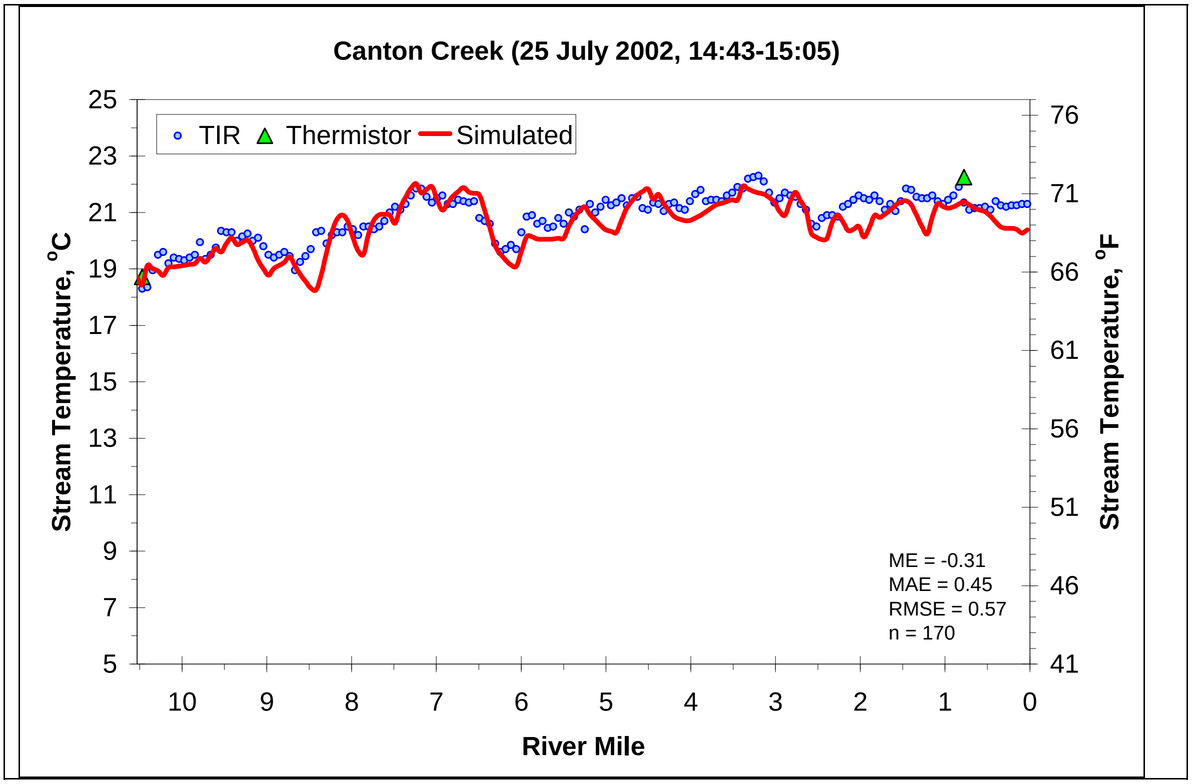
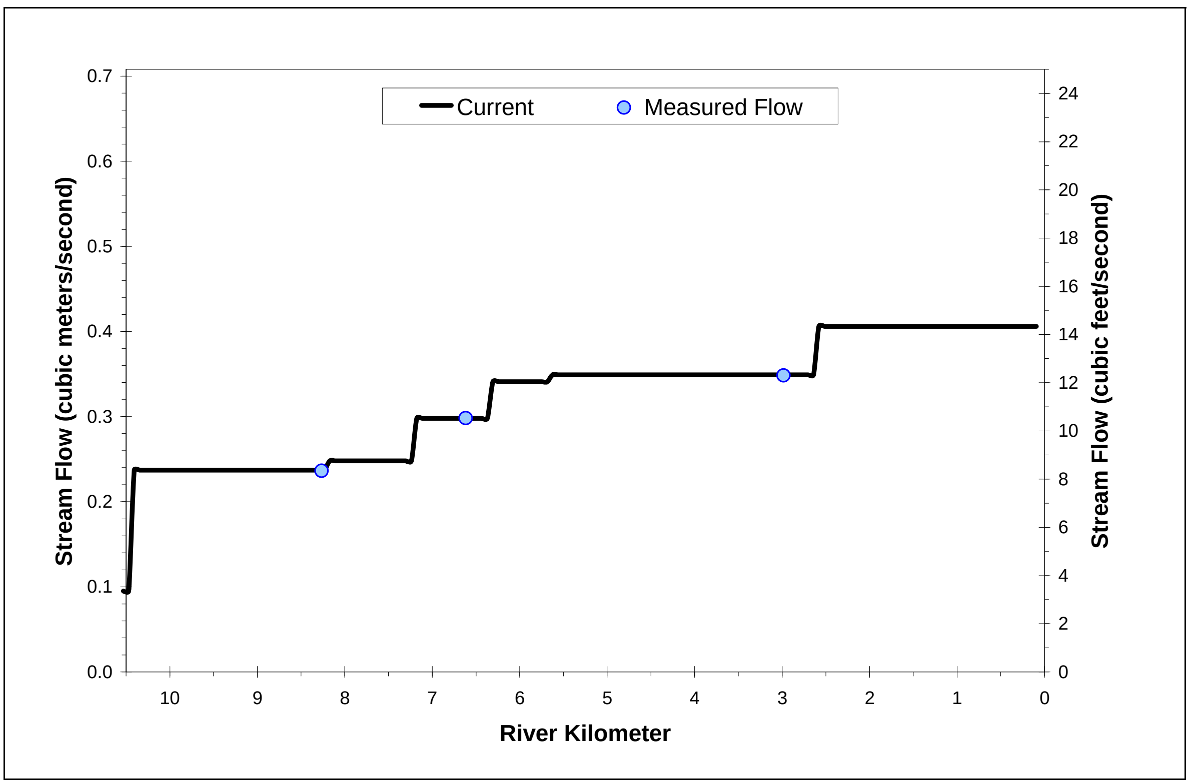



**Figure 3. Canton Creek model flows compared to field measurements**



**Prediction of the natural thermal potential temperatures**

The Umpqua Basin TMDL predicted the natural thermal potential temperatures by replacing current condition vegetation with system potential vegetation (Table 1). System potential vegetation has all anthropogenic impacts removed. System potential vegetation was developed with guidance from the Umpqua TMDL technical committee consisting of local experts, scientists, and land managers.

**Table 1. Canton Creek System Potential Vegetation**

| Land Cover Name | Height (m / ft) | Canopy Closure (%)[1] |
|---|---|---|
| Large Mixed Conifer -Hardwood | 30.5 / 100 | 65% |
| Large Hardwood | 24.4 / 80 | 60% |
| Large Conifer | 45.7 / 150 | 80% |
| Upland Shrubs | 1.5 / 5 | 75% |
| Grass | 0.9 / 3 | 75% |
| [1]. Canopy Closure is relative to the height of the land cover, not from a human observer. . The 75% canopy closure for grass refers to the canopy closure grass provides from the ground to 0.9 meters. | | |

The TMDL acknowledged that natural disturbance would reduce system potential vegetation and that it is not possible for an entire stream to be at its maximum potential everywhere, all the time. In this analysis system potential vegetation was disturbed by modeling a 50 year interval historical disturbance regime. The severity of disturbance ranged from low to very high. For more information about the natural disturbance methodology refer to the Umpqua TMDL Appendix 2.

The modeled maximum 7-day moving average of daily maximum (7DADM) natural thermal potential (including natural disturbance) is approximately 1-2$^{o}$C cooler than the current condition temperatures (see Figure 4).

The cooler natural thermal potential temperatures are a result of increased shading from riparian vegetation. The increased shading decreases the amount of solar radiation received by the stream allowing stream temperatures to stay cooler.

## 2. Evaluation of the WOPR DEIS alternatives

ODEQ reduced the system potential vegetation as identified by each alternative to evaluate the effects of each alternative on temperature and effective shade for comparison to the TMDL temperature load allocations and temperature water quality standard. The temperature and effective shade outputs for the WOPR alternatives were compared to the temperature and the effective shade outputs for the natural thermal potential model run that included natural disturbance. The differences between the natural thermal potential model output and the alternatives outputs were used to determine if the WOPR DEIS alternatives would be expected to meet the TMDL load allocations applicable temperature standard.

Additionally, the simulations did not include an increase to tributary temperatures that may occur as a result from BLM harvest activities on those tributaries. This conservative assumption (i.e.

more protective) is one of the margins of safety implicit to the modeling exercise. Additional margins of safety are discussed for each simulation.

**Figure 4. Canton Creek TMDL temperature simulations results**

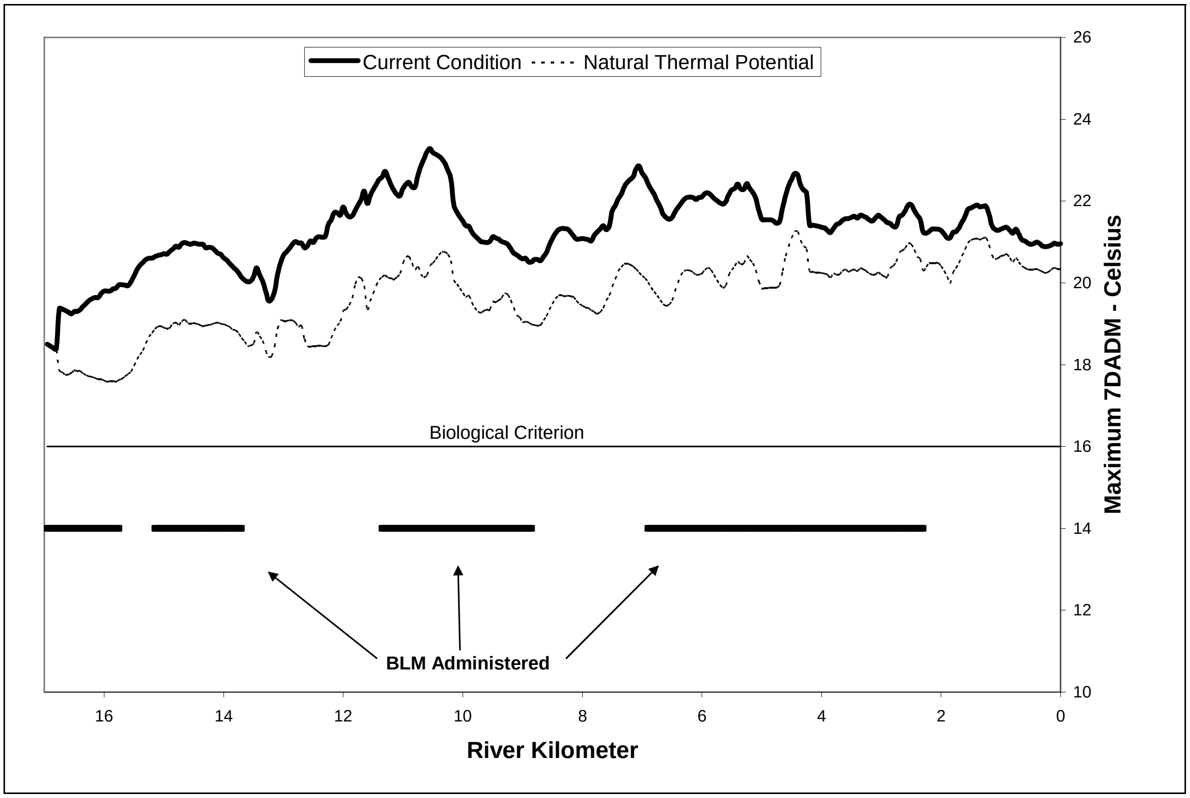
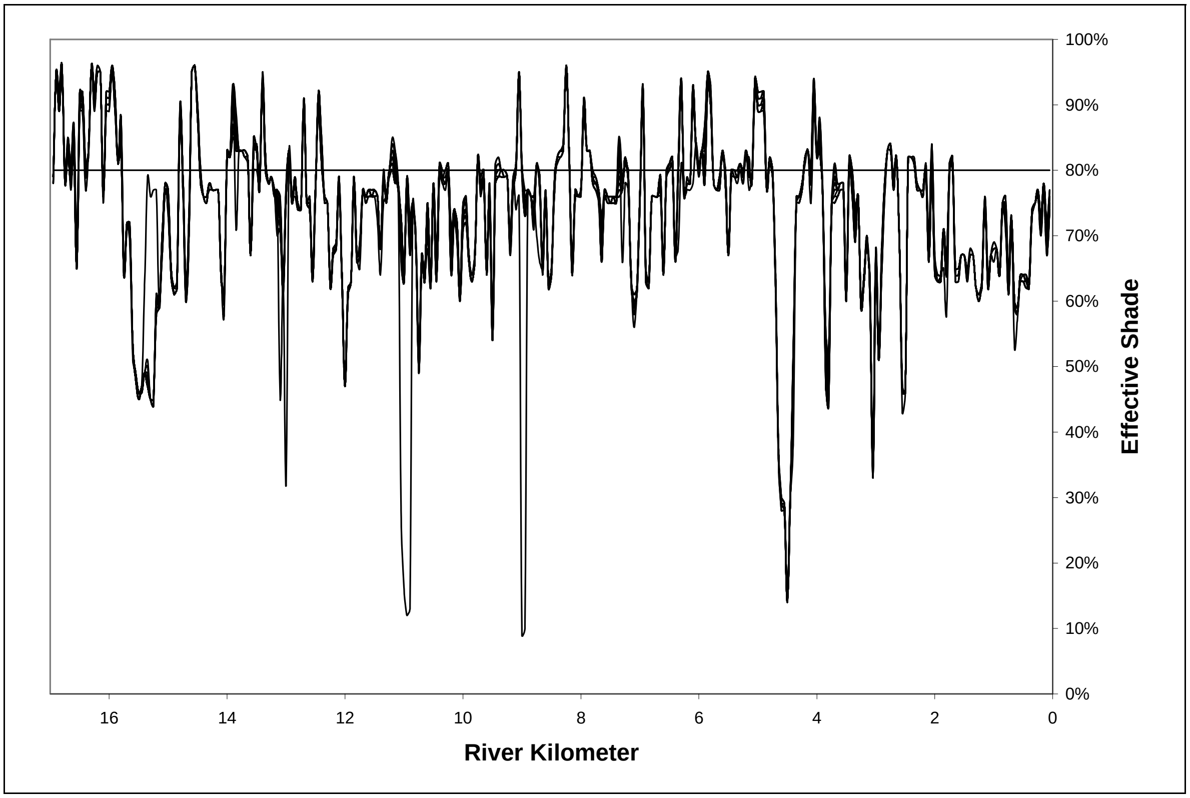


**Figure 5. Canton Creek system potential vegetation effective shade**




### 2.1. Applicable Temperature Standards and TMDL Load Allocations

The Umpqua Basin TMDL allocated all non point sources (including BLM) water temperature increases no greater than 0.1 $^{o}$C above the: 1) biological criterion or; 2) the seven day average daily maximum natural thermal potential temperatures, which ever is greater (page 3-26 Umpqua TMDL). In the summer during the modeling period the natural thermal potential is the applicable standard because it is always greater than the 16$^{o}$C core cold water biological criterion. Effective shade (shown in Figure 5) was also used as a surrogate measure to determine compliance with the load allocation.

More information on Oregon's temperature standard and the Umpqua TMDL load allocations may be found on the following ODEQ websites.

http://www.deq.state.or.us/wq/standards/temperature.htm
http://www.deq.state.or.us/wq/tmdls/docs/umpquabasin/umpqua/chpt3temp.pdf

## 2.2. Evaluation of Alternative 1

The vegetation conditions used for modeling Alternative 1 are in Table 2. A site potential tree height of 150 feet was used and tributary temperatures were unchanged.

**Table 2. Alternative 1 RMA conditions**

| Ownership | Riparian Buffer Notes |
|---|---|
| BLM Administered | 0 – 150 ft System Potential Vegetation |
| BLM Administered | 150 – 300 ft Harvest |
| Private/ Other | 0 – 300 ft System Potential Vegetation |

Two modeling scenarios were simulated for Alternative 1.

| SIMULATION 1 |
|---|
| All vegetation is at system potential except for a single randomly selected harvest unit derived from BLM's harvest land base GIS layer. This particular harvest unit parallels Canton Creek's right bank riparian area for about a half kilometer starting at about kilometer 2.6. The WOPR ID for this unit is 209000012. The vegetation on this harvest unit is simulated as described under Alternative 1. Results shown in Figure 6 and 7 |

| SIMULATION 2 |
|---|
| All vegetation on BLM/ administered lands is simulated as described under alternative 1. All other lands are left at system potential vegetation. This simulation is to demonstrate the overall cumulative impact in Canton Creek. Results shown in Figure 8 and 9. |

**Figure 6. Temperature increase due to a single harvest unit managed according to Alternative 1.**

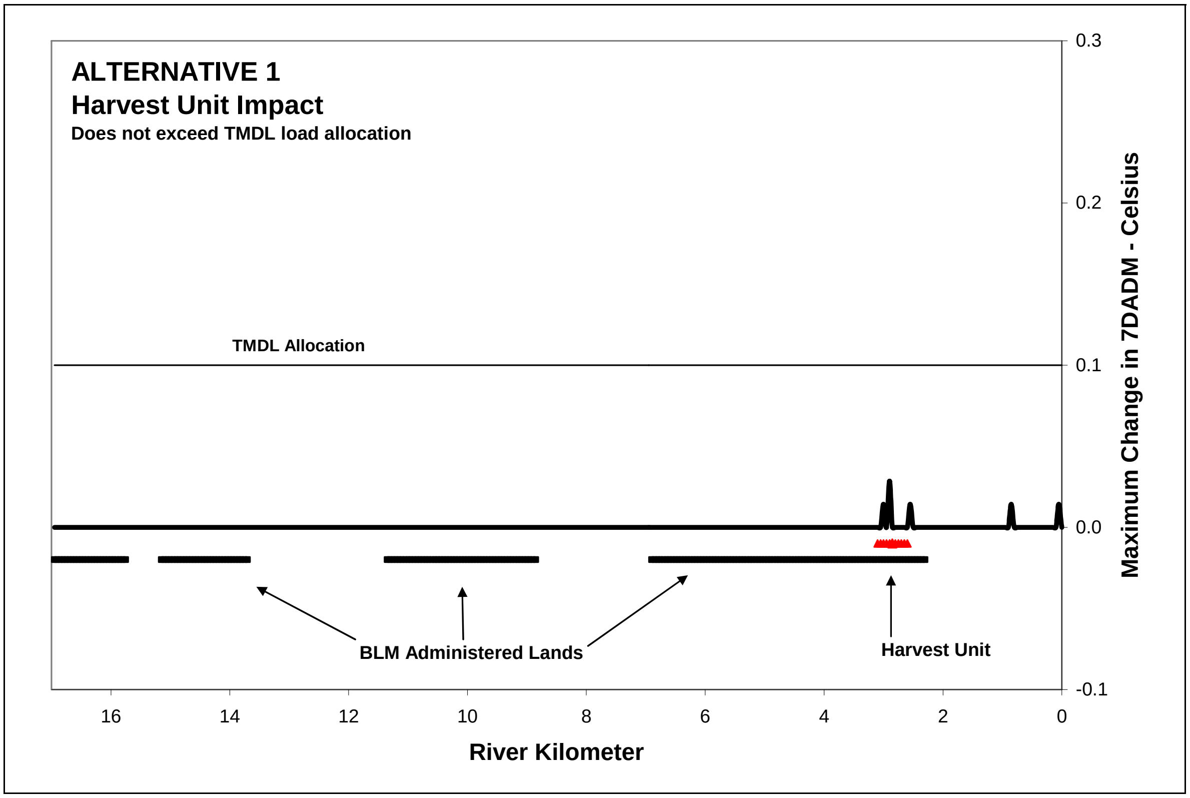



**Figure 7. Reduction to effective shade due to a single harvest unit managed according to Alternative 1**

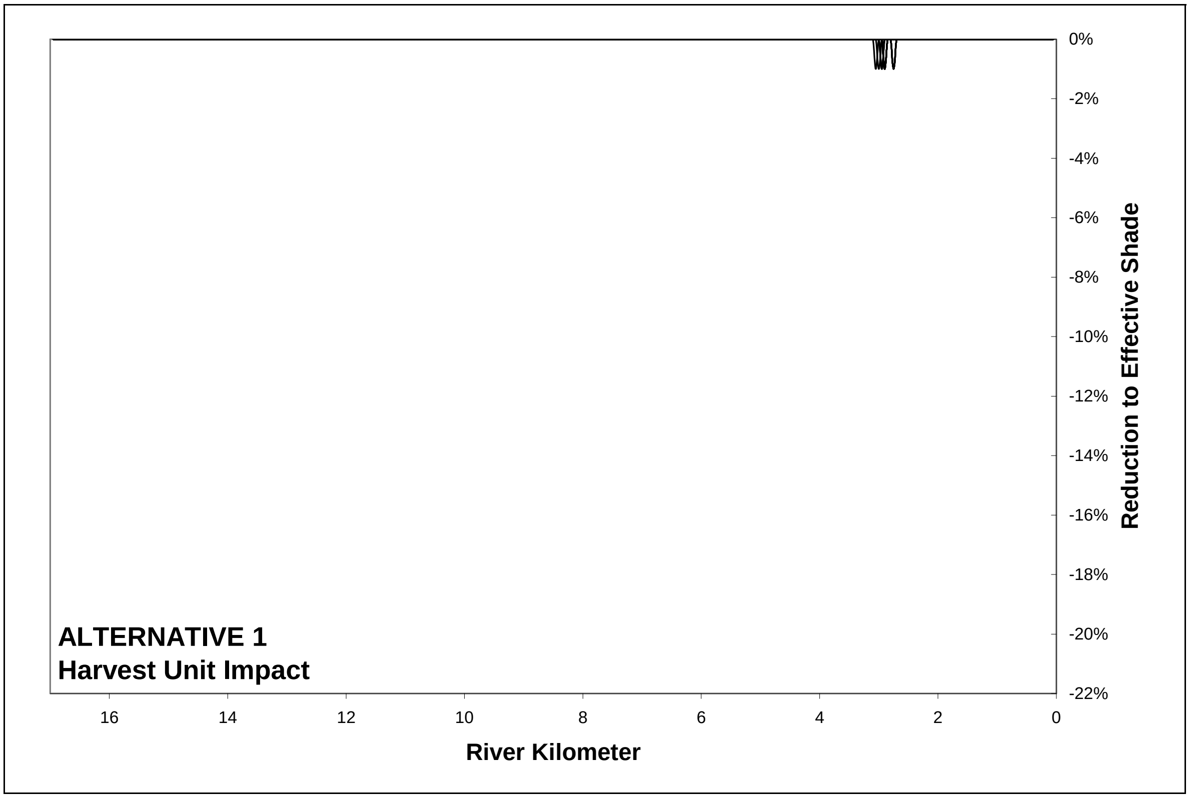


**Figure 8. Temperature increase due to harvest on all BLM administered land managed according to Alternative 1.**

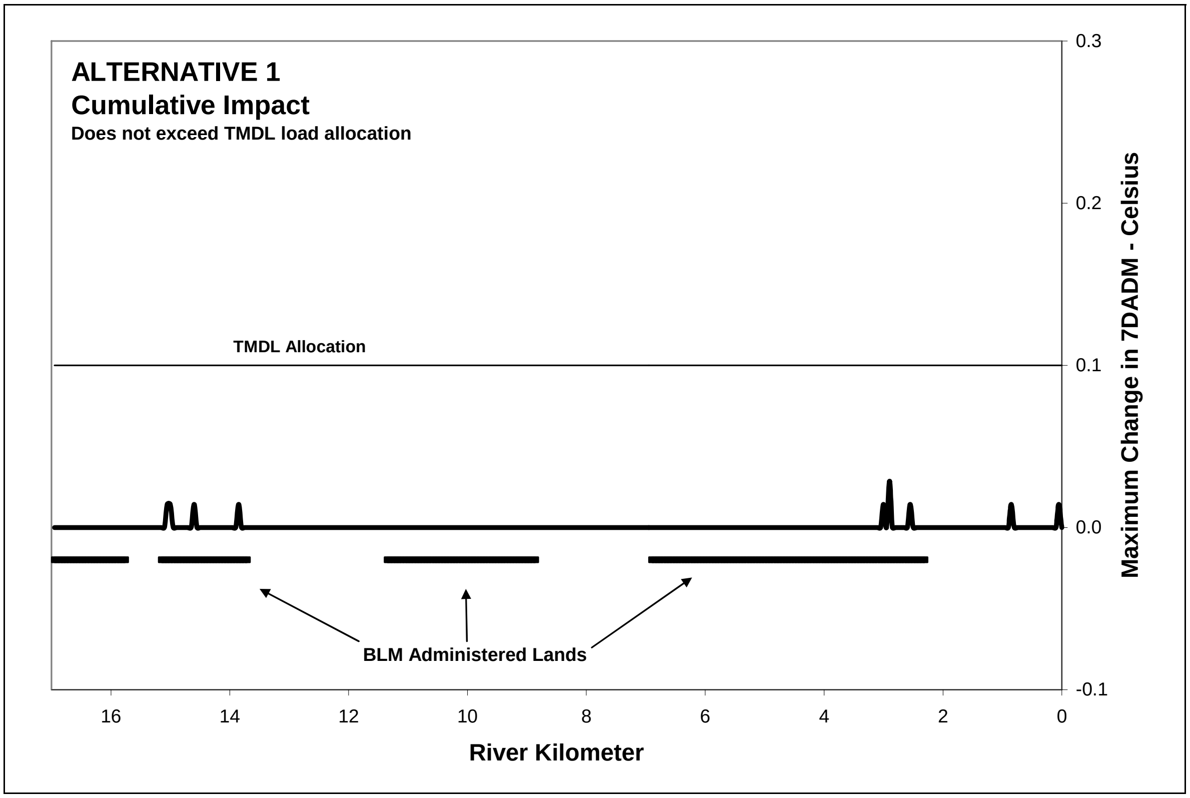
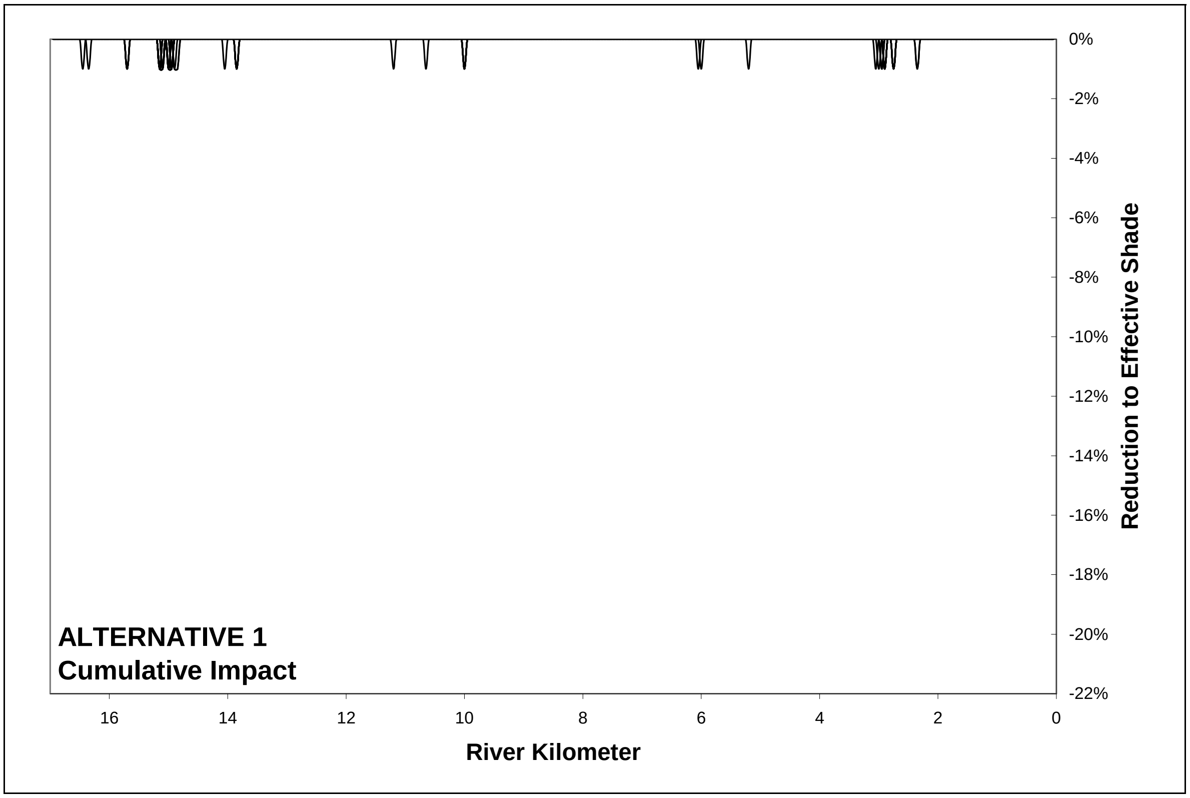



**Figure 9 Reduction to effective shade due to harvest on all BLM administered land managed according to Alternative 1.**


ALTERNATIVE 1
Cumulative Impact
0%
-2%
-4%
-6%
-8%
-10%
-12%
-14%
-16%
-18%
-20%
-22%
Reduction to Effective Shade
16
14
12
10
8
6
4
2
0
River Kilometer

### 2.3. Evaluation of Alternatives 2 & 3

Table 3 describes the vegetation conditions modeled for Alternatives 2 and 3. Since both alternatives have the same riparian management for perennial streams, DEQ chose to evaluate Alternatives 2 and 3 together. Although management for intermittent streams varies between Alternatives 2 and 3, the tributary temperatures were unchanged.

**Table 3. Alternative 2 & 3 RMA conditions**

| **Ownership** | **Riparian Buffer Notes** |
|---|---|
| BLM Administered | 0 – 25 ft System Potential Vegetation |
| BLM Administered | 25 – 60 ft System Potential Vegetation (see *note 1*) |
| BLM Administered | 60 – 100 ft System Potential Vegetation reduced to 50% Canopy Closure |
| BLM Administered | 100 – 300 ft Harvest |
| Private / Other | 0 – 300 ft System Potential Vegetation |
| Note 1: Alternatives 2 and 3 are to provide at least 80% effective shade in the RMA between 25 and 60 feet from the stream. It is difficult to model the vegetation conditions that would equal 80% effective shade because the height and canopy closure of trees would vary from location to location. It would take numerous model iterations to determine the proper vegetation conditions at each location. ODEQ left vegetation between 25 and 60 feet at system potential. This assumption represents an additional margin of safety for this simulation. | |

| SIMULATION 1 |
|---|
| All vegetation is simulated at system potential except for a single randomly selected harvest unit derived from BLM's harvest land base GIS layer. This particular harvest unit parallels Canton Creek's right bank riparian area for about a half kilometer starting at about kilometer 2.6. The WOPR ID for this unit is 209000012. The vegetation on this harvest unit is simulated as described under Alternative 2 and 3. Results shown in Figures 10 and 11. |

| SIMULATION 2 |
|---|
| All vegetation on BLM administered lands is simulated as described under alternatives 2 and 3. All other lands are left at system potential vegetation. This simulation demonstrates the overall cumulative impact in Canton Creek. Results shown in Figures 12 and 13 |

**Figure 10. Temperature increase due to a single harvest unit managed according to Alternative 2.   .**

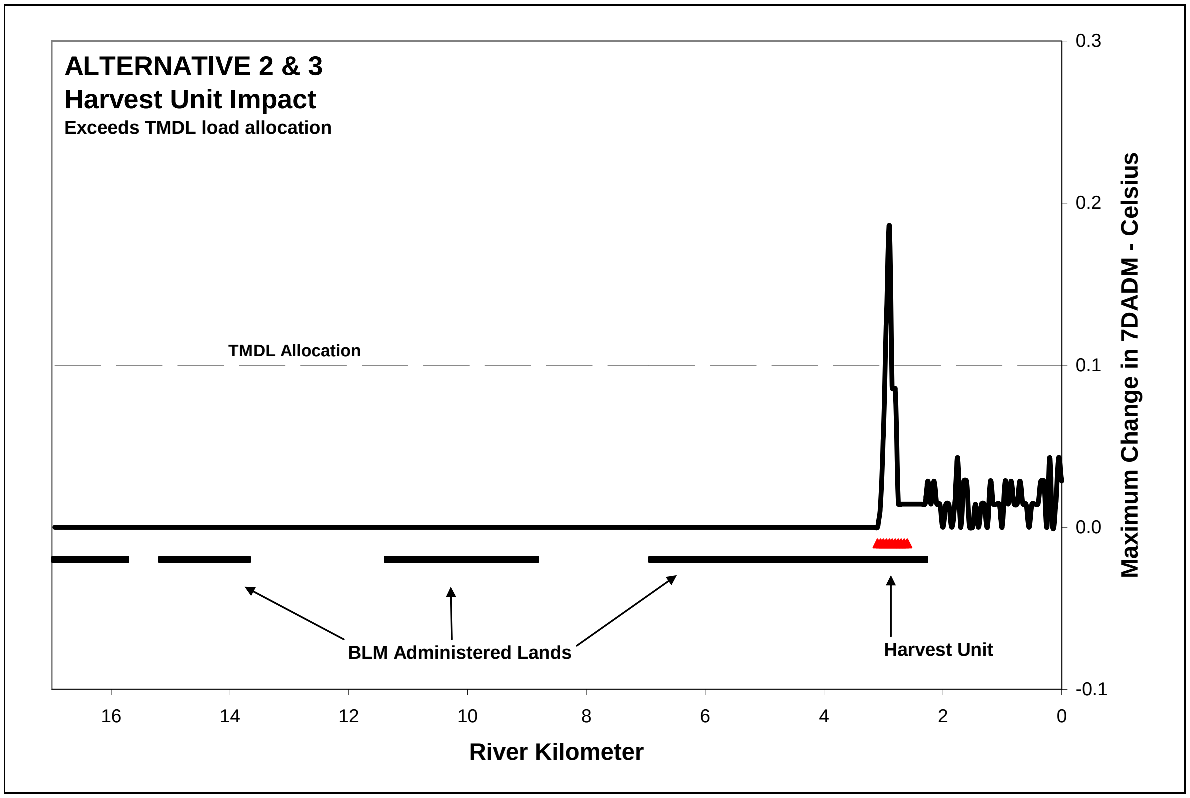



**Figure 11. Reduction to effective shade due to a single harvest unit managed according to Alternative 2.**

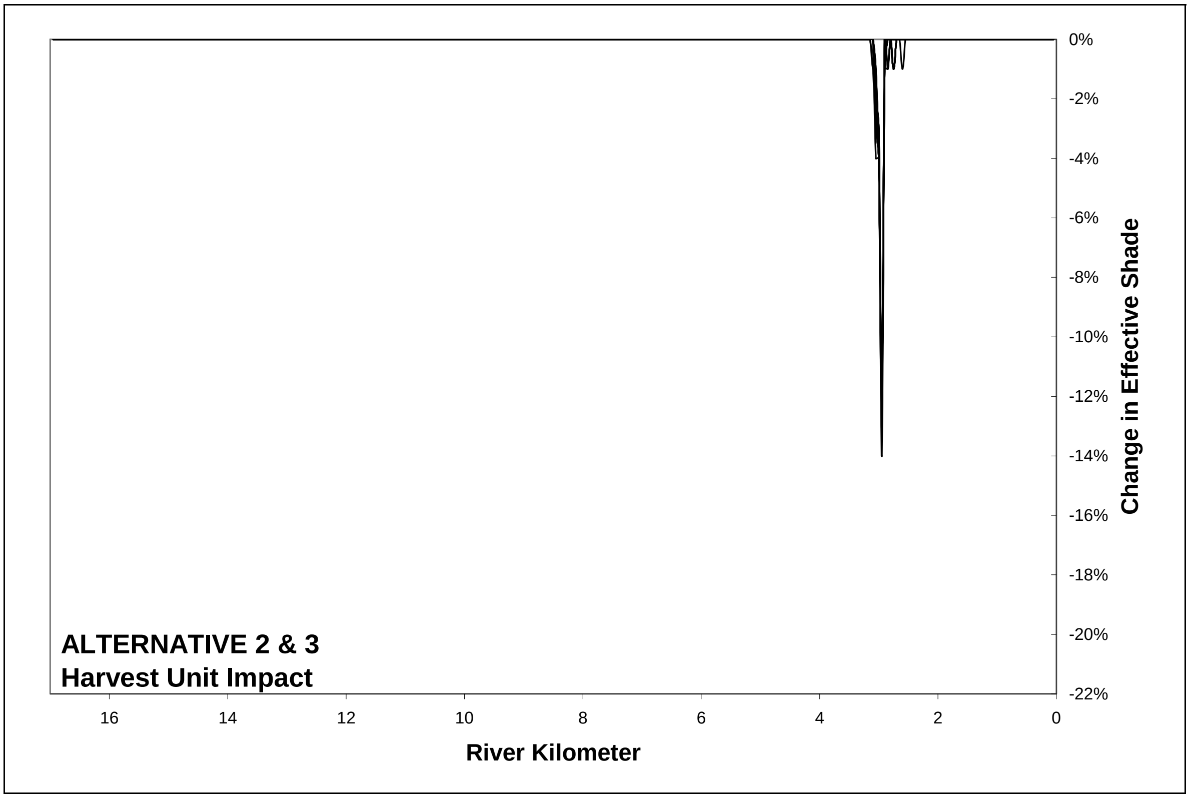


**Figure 12 Temperature increase due to harvest on all BLM administered land managed according to Alternative 2**

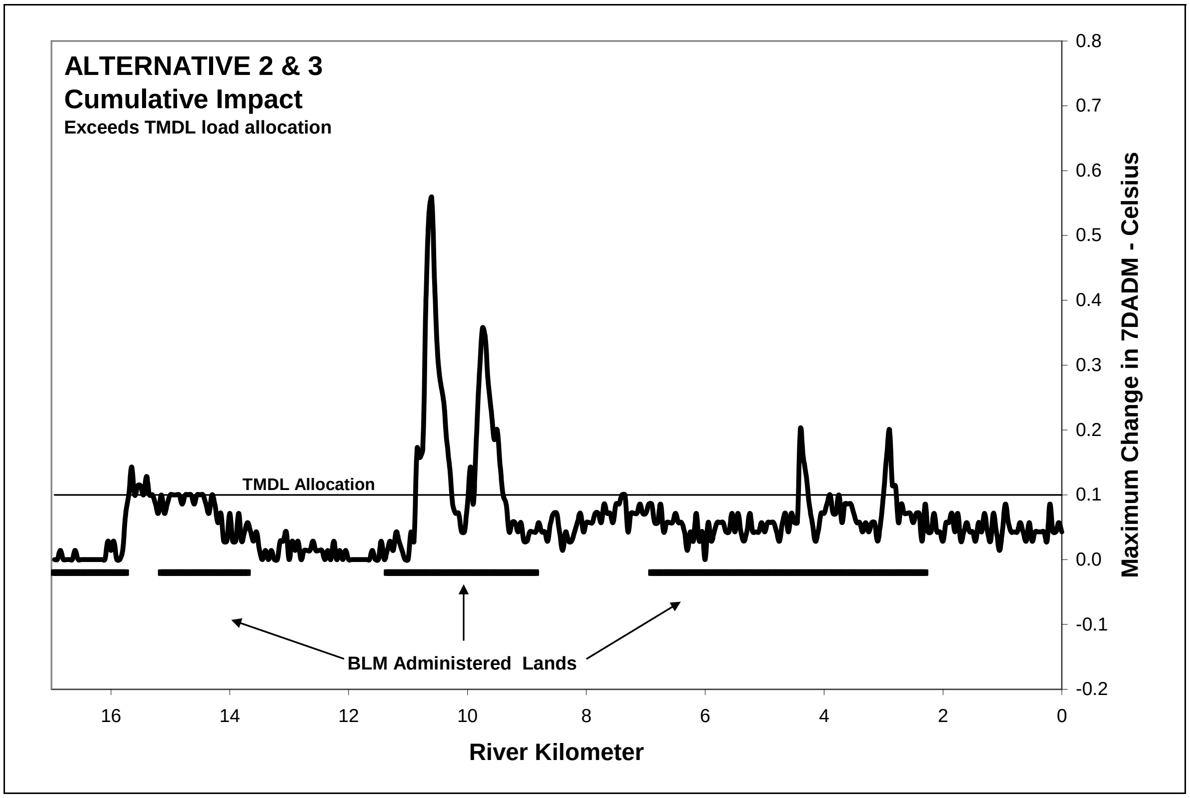
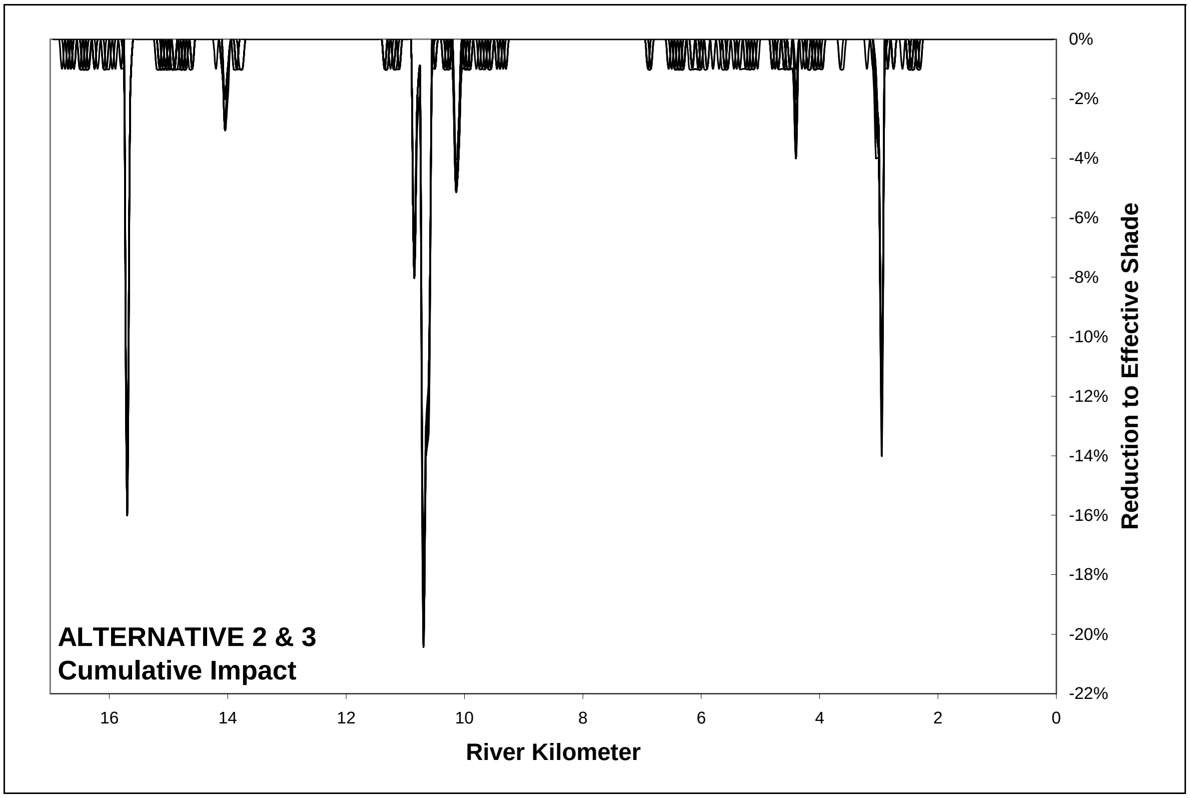



**Figure 13. Reduction to effective shade due to harvest on all BLM administered land managed according to Alternative 2.**


ALTERNATIVE 2 & 3
Cumulative Impact
0%
-2%
-4%
-6%
-8%
-10%
-12%
-14%
-16%
-18%
-20%
-22%
Reduction to Effective Shade
16
14
12
10
8
6
4
2
0
River Kilometer

### 2.4. Evaluation of 100 Foot Buffers

The following stream temperature analysis evaluates a hybridized version of Alternatives 1, 2 and 3. Table 4 describes the vegetation conditions modeled in simulation 1.

| SIMULATION 1 |
|---|
| Vegetation on BLM administered lands 100 feet from the stream is left at system potential. Beyond 100 feet are harvest units. All other lands are left at system potential vegetation. Results shown in Figures 14 and 15. |

**Table 4. 100 Foot Buffer RMA conditions**

| Ownership | Riparian Buffer Notes |
|---|---|
| BLM Administered | 0 – 100 ft System Potential Vegetation |
| BLM Administered | 100 – 300 ft Harvest |
| Private / Other | 0 – 300 ft System Potential Vegetation |

**Figure 14 Temperature increase due to harvest on all BLM administered land and managed with 100 ft buffers.**

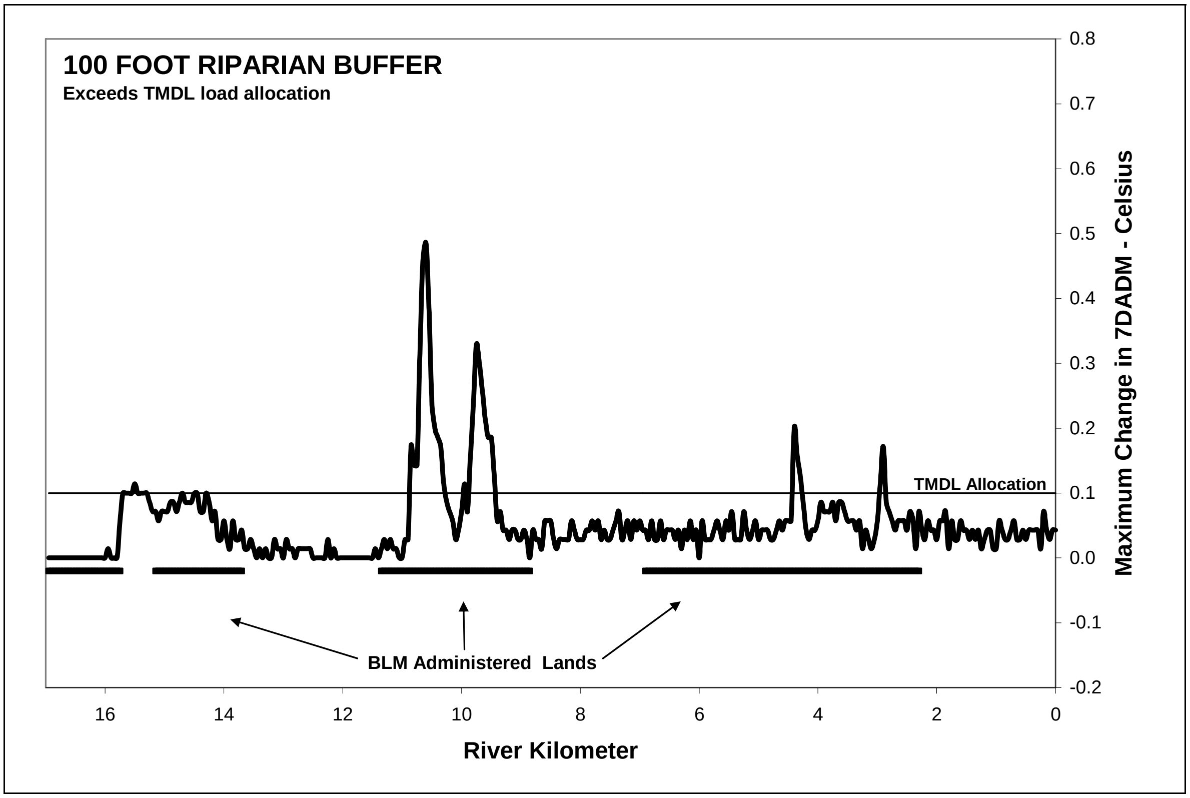
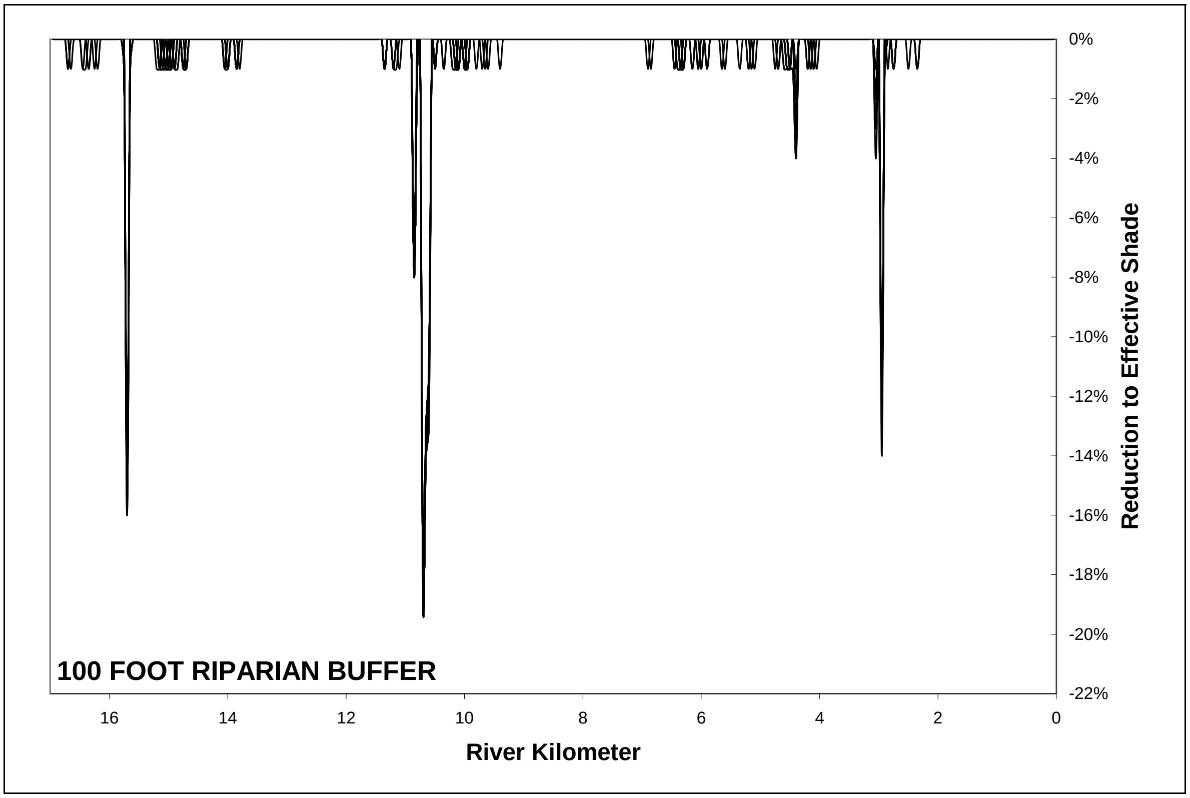



**Figure 15 Change to effective shade due to harvest on all BLM administered land**


100 FOOT RIPARIAN BUFFER
Reduction to Effective Shade
0%
-2%
-4%
-6%
-8%
-10%
-12%
-14%
-16%
-18%
-20%
-22%
16
14
12
10
8
6
4
2
0
River Kilometer

# 3. Modeling Conclusions

## 3.1. Alternative 1

The modeling results (see Figures 6 through 9) show increases to temperature where harvests occurred. However these increases are less than 0.1$^{o}$C and therefore not considered to exceed the TMDL load allocation. Assuming there are no other impacts from other nonpoint sources, and Alternative 1 is implemented according to the assumptions ODEQ used (no reduction in current effective shade as a result of management activities), it is likely that Alternative 1 would be protective for temperature in other streams similar to Canton Creek. This is because the 150 foot buffer width is sufficient to block incoming solar radiation, thereby providing enough system potential effective shade and protecting the riparian microclimate and stream temperatures.

## 3.2. Alternatives 2 and 3

The modeling results (see Figures 10 through 13) show temperature increases and reductions to effective shade that exceed the TMDL load allocation and therefore do not meet Oregon's temperature standard. This occurs at a single harvest unit and cumulatively. Analysis found the largest temperature increases occur in areas where there are "naturally" occurring grassy meadows, wetlands, or open canopy forest. These areas already have naturally low effective shade so when harvests occur adjacent to them the reduction to effective shade is magnified. The buffer widths in Alternative 2 and 3 are not wide enough to protect such areas from increased solar radiation.

As proposed, the BMP of 80% effective shade is not a protective metric. A more appropriate BMP would maintain TMDL system potential effective shade or current effective shade as long as the thinning does not hinder the development of system potential vegetation. Based on the data analysis from Canton Creek, ODEQ has made an estimate that reducing the canopy closure by 10%-15% would maintain current or system potential effective shade but still allow some thinning in the riparian area

Additionally, the modeled vegetation conditions in the 25-60 foot buffer range are more conservative (i.e. more protective) than what is allowed under Alternatives 2 and 3. It means that the predictions contain an inherent margin of safety to compensate for uncertainty. Because the modeling results indicate Alternative 2 and 3 exceed the TMDL load allocations, it is likely that alternative 2 and 3 would exceed the temperature standard in streams similar to Canton Creek.

## 3.3. 100 Foot Riparian Buffers

The modeling results shown in Figures 14 and 15 indicate that 100 foot buffers are not sufficient to keep river temperatures in Canton Creek from exceeding the TMDL load allocations. Similar to Alternatives 2 and 3 most of the large temperature increases occur in areas where effective shade is naturally less than 80%. A comparison between simulation 2 for Alternative 1 and the 100 foot buffer simulation suggests an extra 50 feet is important to minimize temperature increases.

## 4. References

**Boyd, M. and B. Kasper. 2003.** Analytical Methods for Dynamic Open Channel Heat and Mass Transfer: Methodology for Heat Source Model Version 7.0

**Oregon Department of Environmental Quality. 2006.** Umpqua Basin TMDL. Portland, OR. Oregon Department of Environmental Quality