Appendix K
Final Environmental Impact Statement
Tripod Fire Salvage Project

Response to Papers Submitted by Commenters

CHANGES BETWEEN DRAFT EIS AND FINAL EIS

Updated to review additional papers
Minor editorial changes to the text

Many of the reports and articles mentioned by commenters (in their response to the Proposed Action) apply to a wide variety of resources, topics or issues (aquatic ecosystems, terrestrial wildlife habitat, etc.); any response provided below to these reports or articles is from the perspective of specifically forest vegetation, wildlife, or hydrology as noted.

VEGETATION

Science Criteria
The Eastside Screens are interim direction used to amend the Land and Resource Management Plans for every national forest located east of the Cascade Mountains in Oregon and Washington. The current version of the Eastside Screens is Regional Forester's Forest Plan Amendment #2 (USDA Forest Service 1995a).

After the Eastside Screens were issued, the Pacific Northwest Regional Forester appointed an Eastside Screens Oversight Team (Norris 2005) and charged them with reviewing and monitoring Screens implementation. The team's objective was to ensure that the Eastside Screens were being applied consistently across all of the Eastside national forests.

The Oversight Team provided clarification and interpretation of the Eastside Screens by periodically reviewing sample projects on each national forest, producing a letter describing their findings, and then circulating the letter to other Eastside national forests as a "lessons learned" communication tool. These letters, which are signed by the Regional Forester or the Director of Natural Resources, are not considered advisory because they are used as administrative direction for Eastside Screens implementation.

The Eastside Screens has a requirement to consider "best available science" (item 4 in scenario A of the wildlife screen) and during Screens implementation, questions arose about how to interpret this phrase.

In response to the Colville National Forest's request for clarification about the "best available science" requirement, the Oversight Team produced an administrative policy letter stating that (Devlin 1998a):

> "Science of course means peer reviewed and published by credible sources, and does not include articles, comments, or input that is simply opinion or editorials by scientists. 'Expert opinion' can be helpful, but is not the same as 'new science'."

Although the criteria provided by the Oversight Team (Devlin 1998a) are not the only ones that could be used to identify "best available science," it is our judgment that:

1) They are suitable for this purpose; and
2) Using them for this purpose is consistent with administrative policy of the Pacific Northwest Region of the USDA Forest Service since at least 1998 (Devlin 1998a).

For these two reasons, the Devlin (1998a) science criteria will be used in this appendix to identify if reports and articles mentioned in comments to the Tripod Fire Salvage Recovery Project are peer reviewed and published by credible sources, and whether they are articles, comments, or input considered to be opinion or editorials by scientists.

Noss, R.F. and D.B. Lindenmayer. 2006. *The ecological effects of salvage logging after natural disturbance*. Conservation Biology, 20(4):946-948.
The peer-reviewed journal Conservation Biology, considered a credible source, published a series of reviews which this article introduces. These articles include analyses, interpretations, and recommendations based on other work, including some original research, that appeared in either peer reviewed journals, Forest Service Research publications or various interest publications.

The series begins with a general review of the potential negative effects of salvage logging. Subsequent articles review "preemptive salvage" in the northeast US, the implementation of a "natural-disturbance model" relative to salvage logging in Canada's boreal forest; the relationship between snags and birds in burned forests; salvage logging in riparian areas; and clearcut-style salvage logging in Australia.

<u>Relevance and application of this information to the vegetation portion of the Tripod Fire Salvage Project:</u>
These articles are relevant to the Tripod Fire salvage project on two levels. First, much of the literature cited by them is included in the research relied upon by the resource specialists on the ID Team. In fact, some of it was generated by Forest Service employees working in north central Washington. Second, many of the inferences drawn by these authors relative to salvage effects (e.g. "Components of an ecologically defensible salvage policy" from the review by Noss and Lindenmayer 2006) were applied to develop the alternatives.

The analytical processes followed by the team considered the "components of an ecologically defensible salvage policy" (Noss and Lindenmayer 2006). Those "components" are paraphrased as follows:

1) "Exclude salvage from some areas such as lightly roaded ones, natural reserves, and sensitive soils
2) "Salvage only lightly, if at all, within unburned and partially burned areas."

3) "Retain biological legacies, particularly large trees." .
4) "Limit removal of legacies from some special areas."
5) "Schedule salvage logging and replanting so they don't interfere with natural recovery."
6) "Ensure that habitat exist for "species of concern"."
7) "Provide adequate riparian buffers and retain logs and slash to limit erosion." .
8) "Limit the use of ground skidding equipment."

These principles, along with other others, were applied during the EIS process. The ID Team conducted a landscape analysis (Chapter 3.6) that included stratification of the landscape into different soil, hydrologic and forest types. This process revealed areas where limited or no salvage logging was appropriate (Chapter 2) along with the presence and needs of wildlife "species of concern". These types were then scaled down to the stand level (Chapter 3.5) to identify treatment areas to meet the Purpose and Need. Through this process, logging methods were selected, and prescriptions for riparian area buffers, upslope salvaging and reforestation were developed. Finally, ecological effects of the Proposed Action were analyzed--using tools such as DecAID (A model described by Mellen and others (2006) that relates wildlife species to their snag and down-wood requirements.)--and presented in Chapter 3.

Abella, S.R., P.Z. Fule, and W.W. Covington. 2006. *Diameter caps for thinning Southwestern ponderosa pine forests: viewpoints, effects and tradeoffs*. Journal of Forestry, 108(4): 407-418.
The Journal of Forestry, considered a credible source, published this analysis of the effects of diameter caps in its policy section. This article includes analysis, interpretation, and recommendations based other work, including original research, that appeared in either peer reviewed journals, Forest Service Research publications or various interest publications.

The analysis was of unburned stands with a range of densities and the effect diameter caps for removed timber would have on their ecological restoration and economic yield. The paper found that diameter caps affected post-treatment density and pattern as a function of initial stand density and pattern. In general, high initial density of trees larger than the diameter cap limited the ability of thinning to restore fine-grain pattern (meadows and canopy openings) and ecosystem components/processes (understory herbs and shrubs, some wildlife species, nutrient cycling, water yield) and economic yield. Conversely, caps resulted in higher snag densities and favorable habitat for some wildlife species. In many cases the effect of diameter caps was ambiguous or had desirable effects, depending on the objectives. To summarize, the paper does not favor diameter caps and points out that "caps are a one-size-fits-all policy which seems at odds with the diversities of sites and management objectives of western forests".

<u>Relevance and application of this information to the vegetation portion of the Tripod Fire Salvage Project:</u>
This article is not relevant to the Tripod Fire Salvage because it addresses ecological restoration in unburned forests and logging within unburned areas is not proposed for this project.

Dellasala, D.A., J.E. Williams, C. Deacon Williams, and J.F. Franklin. 2004. *Beyond smoke and mirrors: a synthesis of fire policy and science*. Conservation Biology, 18(4):976-986.
The journal Conservation Biology, considered a credible source, published this article which suggests some ecological approaches to wildland fire policy and critiques some aspects of current ones. This article includes analysis, interpretation, and recommendations based other work, including original research, that appeared in either peer reviewed journals, Forest Service Research publications or various interest publications.

The authors focus on historic and current wildland fire policies and the ecological outcomes of them. Most of the discussion centers on identifying priorities and treatments for unburned forest, particularly the need for ecosystem specific treatments that restore/support characteristic fire regimes and ecosystem components and patterns. The section on "post-fire treatment policies" stresses the importance of "biological legacies" for recovery. Although it states that natural forest disturbances almost always leave more such legacies than industrial even-aged management, it does not address the effect of actions above that zero-point on the legacy retention continuum. They suggest that where conifer planting is required, it should be at low and variable density for sustained tree growth and to avoid creating a future fire hazard. They acknowledge that salvage "done right" can be acceptable but add the caveat that large trees are often targeted for removal.

<u>Relevance and application of this information to the vegetation portion of the Tripod Fire Salvage Project:</u>
This article is relevant to the Tripod Fire salvage project in only the broadest sense. It is focused on policy and prioritization for unburned forest and that discussion is based mostly on general, conceptual references. However, it does include a brief discussion of post-fire treatment policies. Again, the discussion and references are general – as opposed to the more specific ones found in the Noss and Lindenmayer paper (2006) above.

The primary post-fire approaches discussed were retention of biological legacies and not overwhelming successional processes with "rapid establishment of dense conifer stands'. The ID Team addressed these concerns: by using DecAID (Mellen et al. 2006) to evaluate large tree removal effects on wildlife; and by applying site-specific historical observations to develop reforestation prescriptions in order to meet legal requirements and minimum stocking levels. Salvage units that have sufficient residual seed source would depend on natural regeneration.

The IDT Team conducted a landscape analysis (Chapter 3.6) that included stratification of the landscape into different soil, hydrologic, and forest types. These types were then scaled down to the stand level (Chapter 3.5) to identify treatment areas to meet the Purpose and Need. Both of those processes included an analysis of the condition of biological legacies (snags and coarse woody debris) (Chapters 3.2, 3.4, and 3.10) and forest regeneration processes and legal requirements for it. Finally, ecological effects of the Proposed Action were analyzed --using tools such as DecAID (A model described by Mellen and others (2006) that relates wildlife species to their snag and down-wood requirements.) and site-specific reforestation experience--and presented in Chapter 3.

Franklin, J.F. , K. Cromack, Jr, W. Denison, A. McKee, C. Maser, J. Sedell, F. Swanson, and G. Juday. 1981. *Ecological characteristics of old-growth Douglas-fir forests*. General Technical Report, PNW-GTR-118. Portland, OR: PNW Forest and Range Experiment Station, USDA Forest Service.
This General Technical Report describes the characteristics of old-growth Douglas-fir forests of the west slopes of the Cascades—with some references to forests of the Blue Mountains. It was published by the PNW Station, subjected to peer review, and is considered credible. The bulk of the report is original research although the last section contains recommendations for applying the research results to create/maintain old-growth Douglas-fir forests in the Douglas-fir region. Consequently, it is an amalgam of original research and interpretation. This paper was written at a time when National Forest management practices, including salvage, removed as much large wood as possible and dramatically simplified stand structure.

Although the composition, function (e.g. carbon and nitrogen cycling rates and pathways), and structure of west-side forests is very different from that of the Tripod Fire area, some species, e.g. some of the same vertebrates are found in both regions and, as Oliver and Larson (1996) observe, similar stand development processes and patterns can be observed in many parts of the world. Major conclusions of this publication, relative to structure, are that these old forests display more spatial heterogeneity than young ones (particularly those managed as plantations) and that large live-old trees and large snags and down logs are key features which provide habitat for a variety of species and support ecological functions. They cite research indicating similar structural and functional characteristics for east-side forests as well: the use of snags and logs as wildlife habitats in the Blue Mountains (Thomas 1979); the importance of large ponderosa pine snags for cavity nesters (Scott 1978); that some cavity nesters prefer one tree species over another in Douglas-fir/larch forests (McClelland et al. 1979). The Scott and McClelland references could not be located.

<u>Relevance and application of this information to the vegetation portion of the Tripod Fire Salvage Project:</u>
It is not specifically relevant to the Tripod Fire salvage project because it addresses the characteristics of old-growth forest in the Douglas-fir region. However, the discussions of spatial heterogeneity, biological legacies as components of most regenerating forests, and the requirement for “large” wood by some wildlife are generally relevant. The ID Team addressed these issues in a more site specific context using tools such as DecAID (Mellen and others 2006).

The ID Team conducted a landscape analysis (Chapter 3.6) that included stratification of the landscape into different soil, hydrologic, and forest types. (The Eastside Screens specifically exempt salvage projects from the requirement to conduct a stand structure analysis.) These types were then scaled down to the stand level (Chapter 3.5) to identify treatment areas to meet the Purpose and Need. The condition of biological legacies (snags and coarse woody debris) and wildlife requirements for them were evaluated (Chapters 3.2, 3.4, and 3.10). The result was a Proposed Action (Chapter 2) that addressed landscape pattern, biological legacies (snags and down wood), wildlife requirements and successional processes while meeting the Purpose and Need. Specifically, the Proposed Action would retain 40% of representative forest habitat in and adjacent to harvest units, does not harvest in any old growth stands or in any stands with late and old structure. Finally, ecological effects of the

Proposed Action were analyzed--using tools such as DecAID (a model described by Mellen and others (2006) that relates wildlife species to their snag and down-wood requirements.)--and presented in Chapter 3.

Lindenmayer, D.B. and J.F. Franklin. 2002. *Conserving Forest Biodiversity: A Comprehensive Multiscale Approach*. Island Press, Washington DC.

This book was published by Island Press. They specialize in environmental topics and published Fire Ecology of Pacific Northwest Forests (Agee 1993). Although the authors thank several reviewers, the review process probably wasn't to the same standards as for peer-reviewed journals. It is well-referenced, with many from the northwest, and discusses general principles for forest biodiversity conservation. The most relevant case study is from the range of the northern, California and Mexican spotted owls. There is a brief discussion of salvage following "intense stand-replacing disturbances". It is useful to parse the language used to evaluate such salvage.

Words such as "inappropriate" and "excessive" were used to characterize the kinds of salvage that can have undesired effects. It is reasonable to infer then, that some kinds of salvage may not have undesired effects. They write that it "may be appropriate to limit salvage and reforestation activities on some areas subject to stand-replacing disturbances" leading to the conclusion that the effects of salvage are a function of how and where it is done. They refer to salvage constraints described by the Forest Ecosystem Management Assessment Team (FEMAT 1993) that would assure retention of adequate structural legacies. They use the words "rapid and uniform…large areas" to describe the kinds of post-disturbance reforestation that may have undesired effects. This does indicate a blanket renunciation of reforestation.

Finally, the authors point out that "…naturally developed early-successional forest habitats, with their rich array of snags and logs and non-arborescent vegetation, are probably the scarcest habitat in the regional landscape."

<u>Relevance and application of this information to the vegetation portion of the Tripod Fire Salvage Project:</u>
The relevance of this book to the Tripod Fire Salvage Recovery is similar to that of "Forest Stand Dynamics" (Oliver and Larson 1996) and Fire Ecology of Pacific Northwest Forests (Agee 1993) which are frequently referred to in documents addressing unburned forest management projects. As discussed for other articles, the ID Team based much of the Proposed Action (Chapter 2) on many of the post-fire management principles presented by these authors.

Ingalsbee, T. 2003. *Salvage timber; scuttling forests: the ecological effects of post-fire salvage logging*. Unpublished report from the Western Fire Ecology Center.
This review was not published in a credible, peer-reviewed journal. Its discussion and recommendations are based on other work, including original research, that appeared in either peer reviewed journals, Forest Service Research publications or various interest publications. It relies heavily on references to Beschta et al (1995) and is similar in tone – although Beschta et al do, under certain conditions tolerate removal of up to 50 percent of dead trees from the range of diameters while Ingalsbee appears to have a zero-tolerance approach to salvage.

The author refers to the negative effects of salvage logging on several ecosystem components. As negative effects to vegetation, he cites delayed and altered revegetation patterns and he infers these from the measured effects to microclimate from salvage logging in the Klamath Basin and Southwest Oregon. One of Ingalsbee's sources (Sexton 1998, unpublished MS Thesis) actually quantified these effects on pumice soils within the Klamath Basin. However, he excluded them from this discussion. Of the five citations in Ingalsbee's vegetation section, two are unpublished Forest Service documents, one is an unpublished MS Thesis, one is from the proceedings of a FS conference, and the remaining one is the 1995 Beschta paper (reviewed elsewhere in this Appendix).

Relevance and application of this information to the vegetation portion of the Tripod Fire Salvage Project:
Because this paper is not peer-reviewed, it has limited relevance to this project. The author's site-specific examples are too different from the Tripod Fire area to be applicable and general ecological principles are presented better in the articles reviewed above.

Maser, Chris, 1997. *Salvage logging: The loss of Ecological Reason and Moral Restraint*. Ecoforestry: The Journal. Vol. 12, No. 1.
This article was published under the aegis of the Ecoforestry Institute, a Canada-based organization, and is in the category of "…editorials by scientists". This paper couches biological information--usually presented in more formal and structured language and context--in a philosophical/poetic one. It employs a financial analogy to contrast "economic" and "biological" investment. Salvage logging is condemned because it will: be allowed in roadless areas; employ "clearcutting" methods that remove all biologically important structure; inflict an unacceptable insult to soils already sensitized by previous logging and wildfire; have no ecological constraints. The article concludes with a condemnation of traditional economic theory as it is applied to forestry although he makes no distinction between public and private forestry.

Relevance and application of this information to the vegetation portion of the Tripod Fire Salvage Project:
The biological information contained in this article is presented in a more traditional form by Ecological characteristics of old-growth Douglas-fir forests (Franklin et al. 1981) which is more easily responded to, as reviewed above. Although this article is a thoughtful integration of biology, economics, ethics and politics, it is most relevant in the sense that all resource professionals should consider the nexus of these factors in their practice.

Woodruff et al. 2004. *1994 Wildfires Monitoring the Recovery, 10 years later*. Internal Forest Service Report. On file at the Methow Valley Ranger District.
This paper documents the subjective evaluation of lynx and woodpecker habitat and tree regeneration within 4 large fires 10 years after their occurrence. It did not include a formal hypotheses, study design or data collection and analysis nor is it a review and synthesis of other work so it does not meet the definition of science applied here.

Key observations of the paper were:
Snag durability was greater than anticipated and woodpeckers were active.

Conifer regeneration and growth were sparser than anticipated and that effect was more notable in salvaged than non-salvaged areas. This observation was confounded by the plethora of vegetation, including conifers, in a 100 foot wide, mineral-soil, fireline.
Lynx habitat recovery would not be complete for another 10-15 years.

Relevance and application of this information to the vegetation portion of the Tripod Fire Salvage Project:
This paper does not meet the 1998 standard for science (Devlin 1998a), it is not in the category of opinion or editorial. However, the information in it is very relevant to the Tripod Fire Salvage Project. Notwithstanding the caveats for its interpretation, this monitoring and evaluation report provides valuable information. The ID Team used this information to set the context for the project design and analysis: it served as a real-world, site-specific frame through which to view the "science" they applied to the project; it provided a constant reminder that ecosystems are complex and outcomes of natural and anthropogenic processes can not always be well predicted; finally, it demonstrated that site diversity will probably result in diverse outcomes.

Beschta, R.L, J.J. Rhodes, J.B. Kauffman, R.E. Gresswell, G.W. Minshall, J.R. Karr, D.A. Perry, E.R. Hauer, and C.A. Frissell. 2004. *Postfire management on forested public lands of the Western United States*. Conservation Biology, 18(4):957-967.
This review and analysis was published in the credible, peer-reviewed journal, Conservation Biology. It is a referenced version of an earlier paper commissioned by the Pacific Rivers Council. The 2004 article was published in the Forum section of Conservation Biology, which is reserved for commentary, policy advocacy, and related articles based on scientific research and professional observations.

The authors evaluate other work, including some original research, which appeared in either peer-reviewed journals, Forest Service research publications or various interest publications to support their recommendations. Basic to their recommendations is that fire, among other disturbances, is a keystone ecological process and one to which native species are adapted. Further, they point out that management practices on western landscapes have often degraded ecosystems to the point that some species are perched on the brink of survival. Considering these factors, they conclude that, in many (if not most) cases, passive post-fire management is least likely to push species over that brink. The paper discusses the effects of several activities they consider "not likely to be consistent with ecosystem restoration". Those activities include: seeding non-native species, livestock grazing, installation of instream structures, ground-based logging and soil disruption, removal of large trees, road and landing construction, logging of roadless, riparian, and moderate to severely burned areas.

Relevance and application of this information to the vegetation portion of the Tripod Fire Salvage Project:
The authors' enumeration of activities "not likely consistent with ecosystem restoration" is, almost literally, the negative image of the positive actions recommended by Noss and Lindenmayer (2006). Although they seem to focus more on soil and water concerns, their image is essentially the same as that described by Noss and Lindenmayer but seen a different way and, as with that paper, many of their recommendations were applied to develop the alternatives.

The ID Team conducted a landscape analysis (Chapter 3.6) that included stratification of the landscape into different soil, hydrologic and forest types. This process revealed areas where limited or no salvage logging was appropriate (Chapter 2) along with the presence and needs of wildlife. These types were then scaled down to the stand level (Chapter 3.5) to identify treatment areas to meet the Purpose and Need. Through this process, logging methods were selected, and prescriptions for riparian area buffers, upslope salvaging and reforestation were developed. Finally, ecological effects of the Proposed Action were analyzed--using tools such as DecAID (A model described by Mellen and others (2006) that relates wildlife species to their snag and down-wood requirements.)--and presented in Chapter 3.

Quigley, T.M., R.W. Haines, and R.T. Graham, eds. 1996. *Integrated scientific assessment for ecosystem management in the Interior Columbia Basin and portions of the Klamath and Great Basins*. General Technical Report, PNW-GTR-382. Portland, OR: Pacific Northwest Research Station, USDA Forest Service.
This report was published by the PNW Research Station, appears to have been peer reviewed and is considered credible. It includes analysis of research and inferences and judgments based on that analysis.

The referenced section of this report suggests that, considering past management practices and the importance of increasingly scarce large wood, salvage that removes large dead trees is not likely consistent with "ecosystem-based management". The report advocates post-fire removal of small and medium sized trees, or, better yet, preventive treatments in green forest.

<u>Relevance and application of this information to the vegetation portion of the Tripod Fire Salvage Project</u>:
This report was reviewed and specifically addresses the Interior Columbia Basin so is relevant to the Tripod Fire Salvage project, albeit only broadly. The ID Team developed a strategy to maintain large wood on the landscape (Chapter 2) using DecAID (Mellen and others 2006). The analysis (Chapter 3) reveals the ecological effects of removing large trees.

Donato, D.C., J.B. Fontaine, J.L. Campbell, W.D. Robinson, J.B. Kauffman, and B.E. Law. 2005. *Post-wildfire logging hinders regeneration and increases fire risk*. Science, 311(5759):352. 2 pp.
This article was published in Science, a peer reviewed journal, so is considered credible. However, there are unresolved questions regarding analysis methods used in this study..

> Donato reported that "…postfire logging, by removing naturally seeded conifers… can be counterproductive to goals of forest regeneration…."

<u>Relevance and application of this information to the vegetation portion of the Tripod Fire Salvage Project:</u>
Although the study was conducted in southwest Oregon, a region considerably different from north central Washington, Donato's observations may have application in the Tripod Fire Salvage Project area. The absolute values would probably be lower and the magnitude of the logging effect would be different. The reduced regeneration effect was suggested by the monitoring Woodruff and others conducted as discussed above.

The Proposed Action relies on natural regeneration to re-establish forest cover in areas where there is a residual seed source that is adequate to ensure timely regeneration following salvage harvest. The probability of natural regeneration success following wildfire salvage harvest is based on over 30 years of observations on similar forest habitats on the Okanogan National Forest (Chapter 3.5). The analysis discloses that it would take 20 years for natural regeneration in proposed salvage harvest areas to be similar to comparable unsalvaged areas in the montane forest habitat within the Tripod Fire (Chapter 3.5).

The analysis discloses that little or no logging damage to post-fire natural regeneration would occur because salvage operations would be completed within one to three years after the fire. Regardless of the timing and effects of salvage logging, reforestation of those areas to a minimum density (Chapter 2) is required by law.

Lindenmayer, D.B., D.R. Foster, J.F. Franklin, M.L. Hunter, R.F. Noss, F.A. Schmiegelow, and D. Perry. 2004. *Salvage harvesting policies after natural disturbance*. Science, 303(5662):1303.
This review and comment was published in the Forum section of Science, a credible journal, which is reserved for commentary, policy advocacy, and related articles based on scientific research and professional observations.

Several worldwide examples of the negative effects of salvage logging on native taxa and are presented in support of the argument natural disturbances and the processes and patterns they create are important for maintaining biological diversity. The article concludes with the recommendation that salvage policies be formulated before major disturbances so post-fire responses can be both thoughtful and timely.

<u>Relevance and application of this information to the vegetation portion of the Tripod Fire Salvage Project:</u>
This paper is too broad in scope to be relevant to the Tripod Fire project. However, the broad-scale salvage concerns it summarizes are presented in finer-scale by several of the papers reviewed here and were considered during development of the Alternatives.

Larsson, S., R. Oren, R.H. Waring, and J.W. Barret. 1983. *Attacks of mountain pine beetle as related to tree vigor of ponderosa pine.* Forest Science, 29(2): 395-402.
This article was peer reviewed and published in Forest Science, a credible source. The authors investigated the relationship between tree vigor and susceptibility to mountain pine beetle attacks in a stocking level experiment of young ponderosa pines in Oregon. Tree vigor decreased as tree density increased and low vigor trees were more often attacked by beetles than high vigor trees. Bark beetle populations were believed to be at endemic levels during the study. The few trees that were killed by beetles were found primarily on low vigor plots, and these observations support the hypothesis that few beetles are needed to kill low vigor trees. The authors conclude that susceptibility of ponderosa pine forests to damage from the mountain pine beetle is closely related to tree vigor, which has been demonstrated to respond to stocking control.

Relevance and application of this information to the vegetation portion of the Tripod Fire Salvage Project:
This information is not specifically relevant to the Tripod Fire salvage project because it addresses stands of trees that were not affected by wildfire. However, the discussions of increased bark beetle susceptibility in low vigor trees and the notion that few beetles are needed to kill low vigor trees are generally relevant. Post-fire bark beetle populations are expected to increase in the Tripod Fire area in response to large numbers of fire damaged trees currently present on the landscape. Fire damaged trees determined by the timber marking guides to have a low probability of survival are expected to have low vigor following the fire and increased susceptibility to post-fire mortality caused by bark beetle attacks. Trees with a low probability of survival would be removed in proposed salvage harvest units. The Tripod Fire salvage project would retain trees in salvage harvest units determined by the marking guides to have a moderate or high probability of survival. It is likely that many of these trees would respond favorably to post-fire stocking levels and reduced inter-tree competition resulting in improved vigor and reduced susceptibility to post-fire bark beetle attacks.

Stone, J.E., T.E. Klob, and W.W. Covington. 1999. *Effects of restoration thinning on presettlement Pinus ponderosa in northern Arizona.* Restoration Ecology, 7(2): 172-172.
This article was peer reviewed and published in Restoration Ecology, a credible source. This paper addresses whether restoration of pre-Euro American stand structure by thinning can reverse the decline in vigor of the pre-settlement ponderosa pines. The thinning treatment removed most post-settlement trees to emulate the more open stand conditions typical before Euro-American settlement. The research results demonstrate that the thinning treatment improved the condition of pre-settlement ponderosa pines by increasing canopy growth and the uptake of water, nitrogen, and carbon which indicated improved tree vigor.

Relevance and application of this information to the vegetation portion of the Tripod Fire Salvage Project:
This information is not specifically relevant to the Tripod Fire salvage project because it addresses the effects of a restoration thinning treatment without the application of prescribed fire, and the sampled trees were not subjected to any fire effects. However, the discussion that older, large diameter ponderosa pines responded favorably to a reduction of tree density and inter-tree competition for resources is generally relevant. The Tripod Fire salvage project would retain all live trees larger than 28 inches DBH (≥ 21 inches DBH in Alternative E) in all proposed salvage harvest units and all live trees greater than 18 inches DBH in proposed harvest units CE01-03, CE08, GA01, and GA 07. Some of these trees (particularly those that did not sustain high levels of fire caused damage) are expected to respond favorably to post-fire conditions resulting in improved vigor. The Tripod Fire salvage project also would retain trees determined by the marking guides to have a moderate or high probability of survival. A high proportion of these trees are expected to respond favorably to post-fire stocking levels and reduced inter-tree competition resulting in improved vigor.

Skov, K.R., T.E. Kolb, and K.F. Wallin. 2004. *Tree size and drought affect ponderosa pine physiological response to thinning and burning treatments.* Forest Science, 50(1): 81-91.

This article was peer reviewed and published in Forest Science, a credible source. The authors investigated responses of pre-settlement (established before Euro-American settlement) and post-settlement (established after Euro-American settlement) ponderosa pines in northern Arizona to three levels of thinning followed by prescribed burning over two years with different precipitation levels. Thinning and burning improved water availability to both pre-settlement and post-settlement trees particularly during drought conditions by decreasing tree to tree competition. The research results indicate that thinning and burning increased net photosynthetic rates only when soil water availability was lowest and increases were greater in younger post-settlement trees than older pre-settlement trees.

Relevance and application of this information to the vegetation portion of the Tripod Fire Salvage Project:
This information is not specifically relevant to the Tripod Fire salvage project because it addresses the effects of restoration thinning followed by prescribed burning where fire intensities were intentionally controlled to minimize damage to residual tree roots, boles, and crowns. As such, the prescribed burning treatment did not replicate fire intensities and fire severity that occurred on the vast majority of burned forest in proposed salvage harvest units in the Tripod Fire salvage project. However, the discussion of improved water availability in thinned and burned stands and increased net photosynthetic rates attributed to reduced stocking levels and tree to tree competition is generally relevant. The Tripod Fire salvage project would retain trees with low and moderate levels of fire damage in salvage harvest units where tree stocking levels were reduced by the fire. A high proportion these trees are expected to respond favorably to reduced levels of tree to tree competition and increased soil moisture availability.

vanMantgem, P.J., N.L. Stephenson, L.S. Mutch, V.G. Johnson, A.M. Esperanza, and D.J. Parsons. 2003. *Growth rate predicts mortality of Abies concolor in both burned and unburned stands.* Canadian Journal of Forest Research, 33: 1029-1038.
This article was peer reviewed and published in the Canadian Journal of Forest Research, a credible source. The authors investigated the relationship of radial growth rates and crown scorch on tree mortality in both burned and unburned stands in the Sierra Nevada Mountains of California. Their results indicated that radial growth rate was a significant predictor of white fire mortality in unburned stands, and both crown scorch and radial growth prior to the application of prescribed fire were significant predictors of mortality in burned stands. These results imply that trees already experiencing long-term stress, as measured by low radial growth rates, have higher mortality probabilities when challenged with additional fire-related damage.

Relevance and application of this information to the vegetation portion of the Tripod Fire Salvage Project:
This information is not specifically relevant to the Tripod Fire salvage project because it addresses white fir mortality following prescribed burning. White fir does not occur in the fire area and the Tripod Fire was a wildfire. However, the discussion that the radial growth rate of a tree (an expression of tree vigor) prior to prescribed burning affects the probability of post-fire mortality is generally relevant. The research results indicate that trees with higher growth rates and presumably pre-fire vigor were more likely to survive similar levels of fire damage than trees with lower growth rates. The Scott Guidelines (Scott et al. 2002, 2003 and Scott and Schmitt 2006), which are being applied in the Tripod Fire salvage project, do consider

pre-fire vigor, growth rate, and site quality when estimating the survival potential of fire damaged trees. Tree vigor, growth rate, and site quality (which affects tree growth and vigor) are collectively evaluated as one tree survival prediction factor during the application of the Scott Guidelines.

Various reports cited as alternatives to, or criticisms of, **Factors Affecting Survival of Fire Injured Trees: A Rating System for Determining Relative Probability of Survival of Conifers in the Blue and Wallowa Mountains (Scott et al. 2002, 2003; Scott and Schmitt 2006), aka the "*Scott Guidelines"***

The "Scott Guidelines", were prepared by the Forest Service's Blue Mountains Pest Management Service Center in 2002 and modified by Amendment 1 on June 26, 2003 and Amendment 2 on August 30, 2006. They are a protocol, based on modeling and research, to guide tree marking for salvage logging by evaluating an individual tree's probability of survival. They have not been formally peer-reviewed so would not meet Devlin's (1998a) definition of science. However, they are defined as scientific by the current Regional Forester (Goodman 2005). Several respondents commented that the Tripod Fire Salvage Project's basis for predicting tree mortality is either inaccurate or untenable for scientific and other reasons. Alternative post-fire tree mortality prediction models were recommended for use in the project by respondents.

Literature Proposed as Alternatives to the "Scott Guidelines"

Critics of the Scott Guidelines contend that they overestimate tree mortality when compared with alternative tree mortality prediction models. Alternative peer reviewed models frequently mentioned by respondents to the Tripod Fire Salvage Project are McHugh and Kolb (2003), Ryan and Reinhardt (1988), Ryan et al. (1988), Stephens and Finney (2002), and Thies et al. (2006).

Ryan, K.C. and E.D. Reinhardt. 1988. *Predicting postfire mortality of seven western conifers*. Canadian Journal of Forest Research, 18(10):1291-1297

The Ryan and Reinhardt (1988) model was developed to predict tree mortality following prescribed fires in Idaho, Montana, Oregon and Washington. It includes seven conifer species and it relates predicted tree mortality to two factors: bark thickness, and crown volume killed by fire.

Several fire effects and fire behavior computer software applications have adopted the Ryan and Reinhardt (1988) model to predict post-fire tree mortality, thus making it widely available to fire analysts. It has been used to predict tree mortality in applications such as the "First Order Fire Effects Model" (FOFEM) (Reinhardt et al. 1997) and "BehavePlus" (Andrews and Bevins 1999).

The Ryan and Reinhardt (1988) equations are based on the assumption that differences in fire-caused tree mortality can be accounted for primarily by differences in bark thickness and the proportion of tree crown killed (Reinhardt et al. 1997). This model mainly addresses first-order fire effects – those occurring as a direct result of the fire combustion process (Reinhardt et al. 2001).

The authors of the Scott Guidelines used the Ryan and Reinhardt (1988) model when developing their rating procedure, in addition to other models and criteria that better account

for the totality of fire effects (including root damage). It is well established that accurate predictions of tree mortality should account for injuries to all of the primary physiological systems of a tree: the crown, stem and roots (e.g., Fowler and Sieg 2004, Johnson and Miyanishi 2001, Ryan 1990, Wagener 1961).

It is our judgment that the Ryan and Reinhardt (1988) model is inappropriate for use with the Tripod Fire Salvage Project for the following reasons (Figure K-1):

1) It assesses the crown and stem systems only, whereas the Scott Guidelines account for injuries to all three physiological systems (crown, stem, and roots) (Ryan and Frandsen 1991); and
2) It does not assess the effect of Douglas-fir beetle populations and may significantly underestimate post-fire delayed tree mortality when Douglas-fir beetle populations are active nearby (Hood and Bentz 2007). The Scott Guidelines do assess the effects of basal cambium injury and proximity of bark beetle populations on post-fire tree survival.

Ryan, K.C., D.L. Peterson, and E.D. Reinhardt. 1988. *Modelling long-term fire-caused mortality of Douglas-fir*. Forest Science, 34(1):190-199.
Ryan et al. (1988) developed a model to predict Douglas-fir mortality following the application of spring and fall prescribed fires in Montana. The model relates predicted tree mortality to four factors: tree diameter, scorch height, crown volume killed by fire, and number of bole quadrants with dead cambium at DBH. The best predictor of Douglas-fir post-fire mortality was the number of quadrants with dead cambium.

The authors sampled cambium damage at DBH (1.4m bole height) and mention that it is possible that trees with more than one quadrant of dead cambium could have been completely girdled near the ground. Because most of the fuel that burns and the greatest energy release in prescribed fires is near the ground, additional damage on the bole should be expected below DBH.

It is our judgment that the Ryan et al. (1988) model is inappropriate for use with the Tripod Fire Salvage Project for four reasons (Figure K-1):

1. Its geographical scope is limited (one stand in western Montana);
2. Its tree species coverage is limited (Douglas-fir only);
3. It assesses the crown and stem systems only; and
4. It lacks a measure addressing fine root damage or basal stem girdling at the root crown (Ryan and Frandsen 1991).

McHugh, C.W. and T.E. Kolb. 2003. Ponderosa pine mortality following fire in northern Arizona. International Journal of Wildland Fire, 12(1):7-22.
The McHugh and Kolb (2003) model was developed using data from three wildfires in northern Arizona. It includes one conifer species (ponderosa pine) and it relates predicted tree mortality to two fire effects: total crown damage (scorch plus consumption), and bole char severity.

It is our judgment that the McHugh and Kolb (2003) model is inappropriate for use with the Tripod Fire Salvage Recovery Project for four reasons (Figure K-1):

1) Its geographical scope is limited (northern Arizona)

2) It assesses the crown and stem systems only (no direct consideration of the root system);
3) Its tree species coverage is limited (ponderosa pine only); and
4) It lacks a measure addressing fine-root damage or basal stem girdling at the root crown (Ryan and Frandsen 1991).

Stephens, S.L. and M.A. Finney. 2002. *Prescribed fire mortality of Sierra Nevada mixed conifer tree species: effects of crown damage and forest floor combustion*. Forest Ecology and Management, 162(2-3):261-271.
The Stephens and Finney (2002) model was developed to predict tree mortality following prescribed fire in the southern Sierra Nevada Mountains of California. It includes five conifer species and it relates predicted tree mortality to four factors: tree diameter, percent crown volume scorched, forest floor (duff) consumption, and crown scorch height.

It is our judgment that the Stephens and Finney (2002) model is inappropriate for use with the Tripod Fire Salvage Recovery Project for two reasons (Figure K-1):
1) Its geographical scope is limited (southern Sierra Nevada Mountains); and
2) Its tree species coverage is limited (of the five conifers included in this model, only ponderosa pine occurs in the Tripod Fire area).

Thies, W.G., D.J. Westlind, M. Loewen, and G. Benner. 2006. *Prediction of delayed mortality of fire-damaged ponderosa pine following prescribed fires in eastern Oregon, USA.* International Journal of Wildfire. 15:19-29.
The Thies et al. (2006) model was developed to predict tree mortality following prescribed fire in the southern Blue Mountains of northeastern Oregon. It includes one tree species (ponderosa pine) and it relates predicted tree mortality to five factors: live crown proportion, needle scorch proportion, bud kill proportion, basal char, and bole scorch proportion.

The size class variation for trees included in this study is quite limited due to similar stand replicates: pre-treatment tree diameter at breast-height (DBH) for control units averaged 28.4 cm (11.2 inches), and the diameters for trees in the fall and spring burning treatments averaged 26.6 cm (10.5 inches) and 27.4 cm (10.8 inches), respectively. The authors of this study also caution about extrapolating its results, and using its mathematical models, beyond the geographical area of the sampled stands or with tree species other than ponderosa pine, until datasets are produced to validate the models for other geographical areas or tree species.

It is our judgment that the Thies et al. (2006) model is inappropriate for use with the Tripod Fire Salvage Recovery Project for four reasons (Figure K-1):
1) Its tree species coverage is limited (ponderosa pine only);
2) ts geographical scope is limited (a specific set of sampled stands in the southern Blue Mountains);
3) The tree-size variation included in the model-development dataset (a range of 10.5 to 11.2 inches average stand diameter across all replicates) is limited when compared with tree-size variation encountered in the Tripod Fire area; and
4) It assesses the crown and stem systems only (no direct consideration of the root system).

Literature Critiquing the "Scott Guidelines"

Waring Report

Dr. Richard Waring prepared a report in 2005 describing an evaluation of the Scott Guidelines for the Easy and High Roberts salvage sales on the Malheur National Forest. The Waring report was apparently not peer-reviewed or published in a credible source.

In this report, Waring concluded that using indirect indicators (such as the "crown and bole scorch" factors from the Scott Guidelines) to assess a tree's predisposition to fire-caused mortality is inappropriate, and that direct measurement of a tree's physiological processes (photosynthesis or transpiration) provides a better estimate of survival potential. Waring's report contends that measurements of water stress, using either a pressure chamber (Waring and Cleary 1967) or by collecting increment cores and then analyzing the sapwood's relative water content (Waring and Running 1978), provides definitive estimates of tree health and survival potential.

We disagree with Waring's contention. Assessing the moisture status of fire-injured trees, such as measuring moisture stress with a pressure chamber (Waring and Cleary 1967) or by analyzing sapwood water content (Waring and Running 1978), indicates only that the tree's vascular system was functional when the measurement is taken. It provides no assurance that the tree's vascular system will continue to function in the future.

Ryan (2000) studied the effects of varying levels of fire-caused cambium injuries on the water relations of ponderosa pine, and he found that crown scorch and basal girdling had only minor effects on summer water relations. He found that trees in the 100% basal-heating class, which experienced cambium kill over an average of 95% of the circumference at their base, had higher midday xylem pressure potentials (i.e., less stress) than non-girdled trees (Ryan 2000). This result was apparently due to phloem unloading that created a net water flow to the xylem tissue (Kozlowski 1992).

For the 100% basal-heating class, half of the trees died quickly and the other half were still alive at the end of the second growing season (two growing seasons was the length of the study period). The six surviving trees suffered no apparent decline in water relations despite the fact that three of them had basal girdling affecting 96% or more of their circumference. If we assume that an extreme amount of basal girdling (96% or more of the circumference) will eventually result in tree death, then one possible conclusion from this study is that the ultimate effect of extreme basal girdling was not exhibited within two growing seasons of the injury (Ryan 2000).

Mortality of basal-girdled trees can be delayed for several years (Agee 2003; Kaufmann and Covington 2001; Kolb et al. 2001; McHugh and Kolb 2003; Ryan and Amman 1994, 1996; Sackett and Haase 1998; Swezy and Agee 1991; Thies et al. 2005, 2006; and Thomas and Agee 1986). It is our judgment that the Ryan (2000) study supports the Scott Guidelines as a physiologically appropriate protocol for predicting tree mortality and because the Scott Guidelines specifically address this basal-injury issue.

E.B. Royce

Dr. E.B. Royce prepared a "Declaration In Support of Motion for Summary Judgment" that was submitted to the U.S. District Court in Oregon with regard to the High Roberts salvage sale on the Malheur National Forest. The declaration is not dated and appears to have been prepared in 2005. In the declaration, Royce reviewed and commented on the Scott Guidelines (Scott et al. 2002) and Amendment 1 to the Scott Guidelines (Scott et al. 2003). Royce compared the tree mortality predictions made by the guidelines with predictions of other peer-reviewed models based on comparable levels and types of fire-caused tree damage. He concluded that the Scott Guidelines over estimate the contribution of crown scorch, cambial damage, and duff burning to individual tree mortality predictions based on his comparison with the scientific literature.

In a paper dated September 24, 2006, Royce critiques the 2006 version of the "Scott Guidelines" which include Amendment 2 (Scott and Schmitt 2006). He writes that the changes made for ponderosa pines ≥ 21 inches dbh "…bring the guidelines generally into agreement with some of the most credible results found in the peer-reviewed literature". However, discussion continues over some methods used by the guidelines: the weighting of duff consumption, evaluation of bole char, cambial damage and crown scorch effects on fire damaged ponderosa pines under 21 inches diameter. Royce seems to suggest that refining these methods would be procedurally correct but would have a minor affect on the outcome of predicting tree survival.

<u>Relevance of literature cited as alternatives to or criticism of the Scott Guidelines with regard to the Forest Vegetation portion of the Tripod Fire Salvage Project</u>

The decision to use the "Scott Guidelines" to predict post-fire tree survival follows administrative policy for the Pacific Northwest Region of the US Forest Service. In 2005 Pacific Northwest Regional Forester Linda Goodman issued a letter referring to the Eastside Screens Oversight Team letters (Devlin 1998a, 1998b) stating that:

> "These 'Scott' guidelines establish a scientific basis for determining the relative probability of post-fire tree survival."

It is our judgment that this administrative policy and direction means that:

1) The Regional Forester states that the Scott Guidelines establish a scientific basis for determining the relative probability of post-fire tree survival. (Goodman 2005);
2) The Scott Guidelines were prepared by entomologists and a pathologist assigned to the Forest Health Protection group, so they qualify as a Forest Pest Management-written standard;
3) Although dead trees are used to meet the snag and down wood requirements, most of the Eastside Screens amendment applies to live trees only (Norris 2005, USDA Forest Service 1995a);

The Tripod Salvage Project FEIS is proposing a non-significant Forest Plan amendment which would allow live trees greater than or equal to 21 inches diameter at breast height (dbh) to be salvage harvested. The diameter threshold is identified in Interim Wildlife Standard Scenario A #2a of the *Regional Forester's Eastside Forest Plan Amendment #2 "Interim Management Direction for Establishing Riparian, Ecosystem and Wildlife Standards for Timber Sales, Appendix B"* (USDA Forest Service 1995a), commonly referred to as the Eastside Screens. The intent of the Tripod Fire Salvage Project is to cut only dead and fire-injured trees expected to die within one year of project implementation. A dying tree is one in

which any or all of the critical parts of the tree (crown, stem or roots) are irreversibly damaged and the tree cannot recover (Schmitt and Filip 2005). Determination of the probability that trees are dying will be made with a scientifically researched and validated approach commonly referred to as the Scott Guidelines (Scott et al. 2002, 2003, 2006). Using the Scott Guidelines, as adjusted for this project, dying trees are described as those with a "low" probability of survival; only these and dead trees would be included in the salvage harvest. This Forest Plan Amendment would allow salvage harvest of those fire-injured trees greater than or equal to 21 inches dbh with a low probability of survival. It acknowledges that these trees are currently living and that a small percentage of these trees that are identified as having a low probability of survival might actually survive. This amendment would allow economic recovery of those fire-injured trees 21 inches dbh and larger with a low probability of survival. The Ninth Circuit Court recently confirmed that amendment of the 21 inch diameter upper harvest limit for live trees was appropriate.

Using the Scott Guidelines for the Tripod Fire Salvage Project is consistent with similar projects in the Pacific Northwest Region of the USDA Forest Service. The Scott Guidelines have recently been used with the Flagtail, Monument, High Roberts, and Easy fire salvage projects (Malheur National Forest); the B&B complex (Deschutes National Forest); the Fischer Fire (Okanogan-Wenatchee National Forests); and the School Fire salvage recovery project (Umatilla National Forest).

Critics of the Scott Guidelines contend that they overestimate tree mortality when compared with alternative tree mortality prediction models. Alternative models frequently mentioned by respondents to the Tripod Fire Salvage Project are McHugh and Kolb (2003), Peterson and Arbaugh (1986), Ryan and Reinhardt (1988), Ryan et al. (1988), Stephens and Finney (2002), and Thies et al. (2006).

In the context of the Tripod Fire Salvage Project, we believe that the Scott Guidelines are more appropriate for predicting tree mortality than any of the alternative models individually. Our basis for this belief is that a comprehensive assessment of tree injury, and any associated prediction of fire-caused tree mortality, must consider the effect of fire injuries on the whole tree rather than just one or more of its parts (Dieterich 1979, Fowler and Sieg 2004, Johnson and Miyanishi 2001, Regelbrugge and Conard 1993, Ryan 1990, Wagener 1961, Weatherby et al. 2001). It is possible for a tree to survive if the cambial tissue is destroyed on only a portion of its circumference (Peterson and Arbaugh 1986, 1989, Peterson and Ryan 1986, Durcey et al. 1996, McHugh and Kolb 2003), but the combined effects of root, crown, and stem damage may kill a tree, even if the stem itself is not completely girdled (Ryan 2000, Dickinson and Johnson 2001, McHugh and Kolb 2003).

It is well established in the scientific literature that a comprehensive model of post-fire tree mortality should account for injuries to fine roots caused by smoldering combustion during duff consumption (e.g., Brown et al. 1991, Fowler and Sieg 2004, Hille and Stephens 2005, Johnson et al. 2001, Miller 2000, Miyanishi 2001, Miyanishi and Johnson 2002, Pyne et al. 1996, Ryan and Frandsen 1991, Stephens and Finney 2002, Swezy and Agee 1991, and others). Cambial damage accompanying surface fire does not account for fine-root injury because surface fires are rarely of sufficient duration to cause this type of tree injury in the absence of smoldering combustion (Peterson and Ryan 1986).

Summary

Tree mortality following fire depends on the type and degree of fire-caused injuries, initial tree vigor, and the post-fire environment, which includes the influence of insects, diseases, and weather (Amman and Ryan 1991, Hood and Bentz 2007, Rasmussen et al. 1996). As fire injuries increase, the probability of tree death increases (Amman and Ryan 1991, Rasmussen et al. 1996). Trees that are only moderately injured by fire and capable of recovery can subsequently be attacked and killed by bark beetles (Furniss 1965). The Scott Guidelines provide a methodology for predicting the relative probability of survival for fire-injured trees growing on a wide variety of site conditions, exposed to varying levels of pre-fire factors that can predispose a tree to fire-induced mortality depending upon their severity or magnitude (occurrence of dwarf mistletoe, root disease, and bark beetles), and experiencing widely varying levels of first-order fire effects to their crowns, stems and roots.

The possible combinations of these factors are almost limitless, leading inevitably to a decision to develop a prediction system relating site and tree factors (explanatory variables) to some type of probabilistic estimate of tree mortality. This regression or modeling approach is commonly used in science, particularly for complex situations such as wildland ecosystems (Rubinfeld 2000). Since it is not possible to account for every combination of variables that could potentially result in tree death, there will always be some amount of uncertainty associated with a probabilistic rating system such as the Scott Guidelines. This same statement about uncertainty applies to the alternative modeling approaches suggested by respondents and Royce (2006) to the Tripod Fire Salvage Project (i.e., McHugh and Kolb 2003, Ryan and Reinhardt 1988, Ryan et al. 1988, Stephens and Finney 2002, and Thies et al. 2006) because they provide an estimate (prediction) of tree mortality or tree survival, not an absolute or definitive determination.

Figure K-1: Comparison of Post-Fire Tree Mortality Models.

	McHugh and Kolb (2003)	Ryan and Reinhardt (1988)	Ryan et al. (1988)	Scott et al. (2002, 2003, and 2006)	Stephens and Finney (2002)	Thies etal. (2006)
Geographical area included	Northern Arizona	Idaho, Montana, western and southwestern Oregon, Washington	Western Montana (Lubrecht Exp. Forest)	Northeastern Oregon (Blue and Wallowa Mountains)	Central California (Sequoia NP)	Northeastern Oregon (southern Blue Mountains)
Tree species included	Ponderosa pine	Douglas-fir Western larch Engelmann spruce Lodgepole pine Subalpine fir Western red cedar Western hemlock	Douglas-fir	Ponderosa pine Douglas-fir Engelmann spruce Lodgepole pine Western larch Grand/white fir Subalpine fir Western white pine	White fir Sugar pine Ponderosa pine Incense cedar Giant sequoia	Ponderosa pine
Fire type used for model development	Wildfire (spring, early summer, late summer)	Prescribed fire (May through October)	Prescribed fire (spring and fall)	Wildfire (mid to late summer)	Prescribed fire (fall)	Prescribed fire (spring and fall)
Tree mortality prediction factors or variables used	Crown damage Bole char severity	Crown volume killed Bark thickness	DBH Scorch height Percent crown volume scorched Season of burn Dead cambium at DBH	Season of fire Pre-fire vigor, growth rate, site quality Down woody material Dwarf mistletoe occurrence Root disease occurrence Bark beetle pressure Crown volume scorch Bole scorch/char Total scorch height Duff consumption Bole/root char at ground surface	DBH Percent crown volume scorched Duff consumption Crown scorch height	Live crown proportion Needle scorch proportion Bud kill proportion Basal char severe Bole scorch proportion
Tree physiological	Crown Stem/bole	Crown Stem/bole	Crown Stem/bole	Crown Stem/bole	Crown Stem/bole	Crown Stem/bole

	McHugh and Kolb (2003)	Ryan and Reinhardt (1988)	Ryan et al. (1988)	Scott et al. (2002, 2003, and 2006)	Stephens and Finney (2002)	Thies etal. (2006)
systems included				Roots	Roots	
Considers insect or disease agents	No	No	No	Yes	No	No
Other comments		Widely used for fire effects modeling (FOFEM, BehavePlus, etc.)				Tree size variation included in study replicates was very narrow.

Sources: McHugh and Kolb (2003), Ryan and Reinhardt (1988), Ryan et al. (1988), Scott et al. (2002, 2003), Stephens and Finney (2002), and Thies et al. (2006).

WILDLIFE

Forman, R.T. and L.E. Alexander. 1998. *Roads and their major ecological effects*. Annual Review of Ecological system, 29:207-231.
The Forman and Alexander (1998) publication was reviewed. Road density and ecological considerations are a major consideration for wildlife habitat impacts.
It is a very thorough literature review and contains valid ecological concepts.

Relevance and application of this information to the Tripod Fire Salvage project
Some of this paper's references are applicable. Some of the work in other countries (Norway, Australia, Netherlands, South Africa, etc.) is less applicable. Some of the ecological effects and implications discussed are valid for highways (which are not present in this project). Some of the effects and implications; including barriers, road density, and fragmentation, are key considerations that were included in the Tripod Fire Salvage analysis. These concepts, presented in this paper were incorporated in the design of the alternatives considered.

A similar reference that has more local applicability (Gaines et al. 2003) was used extensively in the analysis and guided project design directly.

Hutto, R.L. 2006. *Toward meaningful snag-management guidelines for postfire salvage logging in North American conifer forests*. Conservation Biology, 20(4):984-993.
Revision of standards to incorporate new thinking and new research regarding burned forest is the subject of the Hutto (2006) paper.

Relevance and application of this information to the Tripod Fire Salvage project
This paper was a very valuable reference and was specifically used to design the strategy used to salvage of some burned trees in the Tripod Fire Salvage project area. Indeed, the title of the Chapter 3.2 wildlife section is "Burned Forest and Snag Habitat" exactly because of the issues raised in Hutto (2006). The specific applications of this paper to the Tripod Fire Salvage project are:

1) Design criteria for retention of Black-backed woodpecker reserves,
2) Discussion of the benefits of large proportion of watershed, subwatersheds, and 'neighborhoods' left in a unsalvaged condition allowing all natural processes to occur including soil erosion, mass wasting, snag falldown, and sometimes slow plant recovery,
3) Acknowledgement of salvage harvest units being considered more valuable to species that prefer open habitat.

Other similar key references also used for Tripod project design were Brown et al. 2004, Lindenmeyer and Noss 2006, and Rose et al. 2001.

HYDROLOGY

Elliot, W.J., D.E. Hall, and D.L. Scheele. 2000. *Disturbed WEPP: WEPP Interface for disturbed Forest and Range Runoff, Erosion and Sediment Delivery*. Technical Documentation. Rocky Mountain Research Station and San Dimas Technology and Development Center, USDA Forest Service. 22 pp. February 2000.
Specifically, the commenter suggested using the GEO WEPP interface of the WEPP model, and reporting the 10-year return period values rather than the average annual values.

Relevance and application of this information to the Tripod Fire Salvage project
GeoWEPP is a GIS interface of the WEPP model which essentially segments watersheds into individual hill slopes based on topography, soils and vegetative cover (variables supplied by the user, typically applied at a 30m resolution). The interface then runs the WEPP model multiple times for each hill slope and tallies the resulting erosion, sediment and runoff outputs for the watershed. Disturbed WEPP on the other hand, is an interface of the WEPP model with more limited input requirements, and is designed to speed up the application of the WEPP model. Topography, soil texture, and vegetative cover inputs are still required by the user, however only limited values of the variables found to be most influential are used. The important point to realize is that both interfaces use the same model, WEPP, to arrive at estimates of erosion and sediment delivery.

For the Tripod Fire Salvage, the Disturbed WEPP interface was used to estimate erosion, sediment delivery and runoff. The subwatersheds that surround the fire perimeter were stratified based on soil texture, treatment type (low severity fire, 20 yr forest, etc.), percent ground cover (vegetative cover), and slope. This stratification scheme resulted in about 470 individual scenarios modeled with Disturbed WEPP. A similar process was used to develop scenarios for the WEPP:Road Batch interface. In this case, about 1270 different road scenarios were developed and run through the model. Results were then tallied for the subwatersheds.

As noted, in Disturbed WEPP (Draft 02/2000) WEPP Interface for Disturbed Forest and Range Runoff, Erosion and Sediment Delivery, Technical Documentation (Elliot et al. 2000):

> If the year is normal or dry, then it is unlikely for there to be any significant erosion. If the year has above average precipitation, however, then there could be significant soil erosion. With such variation from one year to the next, the concept of "average annual erosion" is not appropriate as there is no such thing as an "average" year. The erosivity of a given year is either above average, or below average. A more appropriate analysis of soil erosion following a forest disturbance may be the probability of a given level of erosion occurring. For example, some recent estimates of runoff and erosion after a wild fire required an estimation of a 5-year return period event (an exceedance probability of 0.20).

Consequently, displayed sediment delivery figures are the modeled result of the 6 year return period values as opposed to the annual average values. For each year in the analysis, the WEPP model was initialized with specific starting conditions representing the degree of expected vegetation recovery following the fire and project activities. The model was then run for a time span that represented 30 years of probable climatic events. The 5th largest values

for erosion, sediment delivery, and runoff for the 30 year run are then reported as the 6 year return period results (Elliot et al. 2000) and represent an exceedance probability of 0.20.

SOILS

Rumbaitis-Del Rio, Cristina and Wessman, Carol A., *Impact of compound disturbances on N-cycling and forest reorganization in a wind-disturbed and logged forest*, Paper presented to the 86th annual meeting of the Ecological Society of America. August 6-10, 2001.

This is a peer-reviewed paper...

Relevance and application of this information to the Tripod Fire Salvage project
This paper is not applicable to the Tripod Fire Salvage project as it applies to blowdown events in a green forest. The Tripod Fire Salvage project does not specifically identify blow down areas to be salvage harvested. Only merchantable trees between 10" to 28" dbh would be removed and remaining snags would be considered for future coarse woody debris recruitment and N-cycling. Existing down wood material in low and moderate burn severity areas that would be salvage harvested would not be removed. The analysis in Chapter 3.4 considers soil productivity and coarse woody debris contribution.

The analysis in Chapter 3.4 also considered past logging, burn severity and soil erosion. Detrimental soil conditions are discussed and mitigations are being required to meet Regional and Okanogan Forest Plan soil standards and guidelines. Winter logging is an option but not required. Areas with high erosion potential have been recognized and the majority of these areas have skyline or helicopter logging systems proposed, which would limit machinery and lower soil erosion and compaction concerns. Other areas such as Bluebuck and Beaver drainages were removed from salvage consideration due to their high erosion concerns.

Maser, Chris, 1997. Salvage logging: The loss of Ecological Reason and Moral Restraint. Ecoforestry: The Journal. Vol. 12, No. 1. Available online at http://ecoforestry.ca/jrnl_articles/12-1-Maser.htm (March 5, 2007).
This article was published under the aegis of the Ecoforestry Institute, a Canada-based organization, and is in the category of "…editorials by scientists". An additional review is listed under the Vegetation Section. The author discusses "Soil rent" philosophy. He also mentions that the economics of salvage logging do not take into account the ecological variables and that any merchantable tree falling to the ground is an economic waste and not a reinvestment of its nutrient capital into the soil.

Relevance and application of this information to the vegetation portion of the Tripod Fire Salvage Project: This article makes a lot of assumptions concerning salvage logging. The author does point out soil concerns such as soils fertility, soil mycorrhizal fungi and concerns of long-term soil productivity and salvage re-entries into previous sale areas.

The author points out that normal logging compacts soils. This was considered in logging design and tractor based operations which will cause compaction. The amount of compaction will vary with soil type. Soils were grouped based on compaction with soils that are prone to

compaction due to ash caps separated from soils with mixed ash caps. Specific mitigations are also in place to deal with the ash soils. Refer to DEIS pages 3-202 through 3-205 and soil maps Figures 3.4-1 and 3.4-2. Soil mitigations for ash cap (sensitive soils) are listed in DEIS page 2-23.

The discussion on “soil rent” was not incorporated into the Tripod soil analysis. The authors comment on,” the depth and fertility of the soil in which the forest grows is nondegradable”, can only loosely referred to a discussion on Soil productivity in the Tripod Analysis. The concept in the paper does not have any scientific guidelines or site specificity.