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TO: Lyn Medley, Detroit District Planner, Willamette National Forest

VIA: <https://cara.ecosystem-management.org/Public/CommentInput?Project=56803>

Subject: Divide Project [mdash] scoping comments

Please accept the following scoping comments from Oregon Wild concerning the Divide Project, <https://www.fs.usda.gov/project/?project=56803>. Oregon Wild represents 20,000 members and supporters who share our mission to protect and restore Oregon's wildlands, wildlife, and water as an enduring legacy. Our goal is to protect areas that remain intact while striving to restore areas that have been degraded. This can be accomplished by moving over-represented ecosystem elements (such as logged and roaded areas) toward characteristics that are currently under-represented (such as roadless areas and complex old forest).

The proposed action alternative involves:

- * 1661 acres of commercial logging
- *
- * Thinning (unknown acres)
- * Regen, 15? acres
- * Dominant tree release (unknown acres)
- * Sugar Pine habitat restoration (unknown acres)
- * [frac14] to 3 acre patch and gap cuts, 58 acres

- * 34 mmbf
- * 4 miles of road construction
- * 5 miles road reconstruction
- * 7 miles road closure
- * 3 miles road decommissioning
- * 78 miles work on existing roads
- * 386 acres underburning
- * 568 acres machine piling
- * 147 acres replanting in regen areas
- * Girdling, 15 acres
- * 41% ground-based logging
- * 42 acres of fall and leave in riparian reserves
- * Meadow restoration, 10 acres

The project description is confusing and misleading. It says 15 acres of regen harvest, but also 147 acres of replanting in regen units. It also describes several things like patch cuts, gaps, DTR, and sugar pine restoration that are probably forms of regen.

The project description is also missing key information, in particular the age and origin of affected stands, but also species composition, density, management history, slope, aspect, elevation, land allocation, proximity to streams, road access, etc. These are all known to the agency but not shared with the public. This is key information for scoping because logging has trade-offs, and those ecological trade-offs switch from net positive to net negative at around 80 years of age. We would like to make our scoping comments as helpful to the Forest Service as possible, but not knowing the age and origin of the stands prevents us from knowing whether to thank the forest for focusing on variable thinning of dense young stands or discourage logging of mature forests that are self-organizing and have all the building blocks necessary for developing high quality habitat, high quality carbon stores, and sources of high quality water, without intervention or logging.

Conserve Unroaded Areas

The project area contains at least one large (>1,000 acre) unroaded area, such as the 3900 acre Bachelor Mountain area shown in purple polygon on the map below. Units 350 and 66 are a concern. Large unroaded areas like this should be conserved and protected from commercial logging in the preferred alternative because such areas are rare on the landscape and wildlife evolved with more large blocks of unmanaged habitat like this. Unroaded areas also conserve clean water and store carbon to help stabilize the climate.

The agency cannot limit its analysis of roadless areas to inventoried areas >5,000 acres, because smaller roadless areas that were not inventoried are ecologically relevant and potentially significant. The NEPA analysis must reflect the growing scientific evidence (cited below) indicating the significant value of roadless areas smaller than 5,000 acres and larger than 1,000 acres. Recent scientific literature emphasizes the importance of unroaded areas greater than 1,000 acres as strongholds for the production of fish and other aquatic and terrestrial species, as well as sources of high quality water. Commercial logging and/or road building within large unroaded areas threatens these significant ecological values.

Large unroaded areas are important simply due to the fact that they better represent the historic condition that species evolved with but they are now rare on the landscape due to human activities that have degraded and fragmented the majority of the landscape. The Northwest Forest Plan LSOG Effectiveness Monitoring Plan says that [“perhaps 80 percent or more [of the historic late-successional old-growth forest] would probably have occurred as relatively large (greater than 1,000 acres) areas of connected forest.”] Miles Hemstrom, Thomas Spies, Craig Palmer, Ross Kiester, John Tepley, Phil McDonald, and Ralph Warbington; Late-Successional and Old-Growth Forest Effectiveness Monitoring Plan for the Northwest Forest Plan, USFS General Technical Report PNW-GTR-438; December 1998; http://www.fs.fed.us/pnw/pubs/gtr_438.pdf. Currently, these 1,000 acre and larger patches are rare on the landscape.

World Wildlife Fund and the Conservation Biology Institute summarized the important attributes of small roadless areas (1,000-5,000 acres).

Small roadless areas share many of attributes in common with larger ones, including:

- Essential habitat for species key to the recovery of forests following disturbance such as herbaceous plants, lichens, and mycorrhizal fungi

[bull] Habitat refugia for threatened species and those with restricted distributions (endemics)

[bull] Aquatic strongholds for salmonids

[bull] Undisturbed habitats for mollusks and amphibians

[bull] Remaining pockets of old-growth forests

[bull] Overwintering habitat for resident birds and ungulates

[bull] Dispersal [ldquo]stepping stones[rdquo] for wildlife movement across fragmented landscapes

WWF CBI 200x. Importance of Roadless Areas in Biodiversity Conservation: A Scientific Perspective - Executive Summary.

<http://magicalliance.org/download/ecological-importance-of-roadless-areas.pdf>

In a 1997 letter to President Clinton, 136 scientists said:

There is a growing consensus among academic and agency scientists that existing roadless areas[ndash]irrespective of size[ndash]contribute substantially to maintaining biodiversity and ecological integrity on the national forests. The Eastside Forests Scientific Societies Panel, including representatives from the American Fisheries Society, American Ornithologists[rsquo] Union, Ecological Society of America, Society for Conservation Biology, and The Wildlife Society, recommended a prohibition on the construction of new roads and logging within existing (1) roadless regions larger than 1,000 acres, and (2) roadless regions smaller than 1,000 acres that are biologically significant[hellip]. Other scientists have also recommended protection of all roadless areas greater than 1,000 acres, at least until landscapes degraded by past management have recovered[hellip]. As you have acknowledged, a national policy prohibiting road building and other forms of development in roadless areas represents a major step towards balancing sustainable forest management with conserving environmental values on federal lands. In our view, a scientifically based policy for roadless areas on public lands should, at a minimum, protect from development all roadless areas larger than 1,000 acres and those smaller areas that have special ecological significance because of their contributions to regional landscapes.

Letter to President Clinton from 136 scientists (Dec. 10, 1997).

https://docs.google.com/open?id=0B4L_-RD-MJwrRzhFcm5QcFR0MHM

To the list of special values found within unroaded areas must be added carbon storage. European policy leaders consider roadless areas effective for carbon storage and climate mitigation:

[T]he European Parliament has agreed to raise the issue of roadbuilding in intact forests at the UN Climate Change Conference to be held next month in Warsaw (Poland); it calls on parties to use the existence of roads in forest areas as an early negative performance indicator of REDD+ projects, and to prioritise the allocation of REDD+ funds towards road free forests.

Oct 24, 2013 Press release: EUROPEAN PARLIAMENT BACKS THE PROTECTION OF ROADFREE AREAS. <http://kritonarsenis.gr/eng/actions/view/european-parliament-backs-the-protection>. Federal land managers should recognize the tremendous carbon values in unroaded/unmanaged forests and avoid actions that would threaten these values. See also, William R. Moomaw, Susan A. Masino, and Edward K. Faison. 2019. Intact Forests in the

United States: Proforestation Mitigates Climate Change and Serves the Greatest Good Front. For. Glob. Change, 11 June 2019 | <https://doi.org/10.3389/ffgc.2019.00027>;
<https://www.frontiersin.org/articles/10.3389/ffgc.2019.00027/full>.

There are tremendous co-benefits from conserving large blocks of unmanaged forests, such as climate mitigation and biodiversity conservation.

Based on the species–area relationship, regarded as one of ecology’s few universal laws, protection of [too] little habitat will condemn thousands of species to extinction if habitat outside them is converted, degraded or lost. It is this logic that underpins calls for [Nature Needs Half] [26], together with an understanding that ecosystem processes and services of the scale needed to sustain the well-being of life on Earth require large wildlife populations and huge expanses of intact and restored habitat. ... Climate change adds a new dimension to the question of how much protected area coverage is needed to assure conservation of wild nature. Climate change is already reducing wildlife population sizes and forcing range shifts as conditions alter [28,29]. Protected areas counter such stresses by building up populations, and connectivity of populations and habitats is emerging as a key property in securing species persistence and resilience to rapid change [5]. Hence networked protected areas, especially where embedded within well-managed land or seascapes, provide crucial stepping stones to accommodate range shifts and, where no further movements are possible, refuges of last resort [5]. Analyses suggest that adequate levels of population viability and connectivity can be achieved only with marine protected area coverages of 30% or more [27]. ... [G]iven that many ecosystems are already degraded, ensuring continued provision of ecosystem services requires not only the precautionary protection of currently intact habitats, but also large-scale habitat restoration.

Providing greater space for recovery of intact, vibrant nature is not altruistic conservation, but is, we argue, an indispensable act of self-preservation, reducing a cascade of benefits that will help maintain the habitability of the biosphere as the climate changes, thereby securing the well-being of generations to come.

Roberts CM, O’Leary BC, Hawkins JP. 2020 Climate change mitigation and nature conservation both require higher protected area targets. *Phil. Trans. R. Soc. B* 375: 20190121.
<http://dx.doi.org/10.1098/rstb.2019.0121>. See also, Soto-Navarro C et al. 2020 Mapping co-benefits for carbon storage and biodiversity to inform conservation policy and action. *Phil. Trans. R. Soc. B* 375: 20190128.
<http://dx.doi.org/10.1098/rstb.2019.0128> showing the congruence of high carbon value and high biodiversity value in PNW forests.

Avoid Roadbuilding

The preferred alternative should avoid road construction, except for very short spurs needed to reach large patches of dense young stands in need of variable density thinning.

Problems with roads/culverts include:

- * Soil disturbance, erosion, compaction, loss of forest productivity
- * Pollution: sedimentation, thermal loading
- * Hydrologic modification: flow interception, accelerated run-off, peak flows
- * Impaired floodplain function
- * Barrier to movement of wood and spawning gravel
- * Habitat removal
- * Reduced recruitment of snags and down wood habitat
- * Fragmentation: wildlife dispersal barrier

* Human disturbance, weed vector, hunting pressure, loss of snags, litter, marbled murrelet nest predation, human fire ignition, etc.

Logging always has unavoidable adverse impacts on soil, water, weeds, and wildlife, and carbon stores. In order to support the assertion that logging is really restoration and not just timber production under a new name, these adverse impacts must be mitigated with clear conservation benefits. Road building has many adverse and long-lasting impacts on soil, water, weeds, wildlife and carbon. When roads building is a part of a restoration logging project, it becomes much more difficult for the benefits to clearly off-set the additional adverse impacts.

Nothing is worse for sensitive wildlife than a road. Over the last few decades, studies in a variety of terrestrial and aquatic ecosystems have demonstrated that many of the most pervasive threats to biological diversity - habitat destruction and fragmentation, edge effects, exotic species invasions, pollution, and overhunting - are aggravated by roads. Roads have been implicated as mortality sinks for animals ranging from snakes to wolves; as displacement factors affecting animal distribution and movement patterns; as population fragmenting factors; as sources of sediments that clog streams and destroy fisheries; as sources of deleterious edge effects; and as access corridors that encourage development, logging and poaching of rare plants and animals. Road-building in National Forests and other public lands threatens the existence of de facto wilderness and the species that depend on wilderness.

Noss, Reed; The Ecological Effects of Roads;

<http://www.wildlandscpr.org/ecological-effects-roads>; <http://www.eco-action.org/dt/roads.html>

Especially in light of climate change and its interactions with the transportation system, the NEPA analysis should review and consider the information and recommendations made in the scientific literature.

The following literature review summarizes the most recent thinking related to the

environmental impacts of forest roads and motorized routes and ways to address them. The literature review is divided into three sections that address the environmental effects of transportation infrastructure on forests, climate change and infrastructure, and creating sustainable forest transportation systems.

I. Impacts of Transportation Infrastructure and Access to the Ecological Integrity of Terrestrial and Aquatic Ecosystems and Watersheds

II. Climate Change and Transportation Infrastructure Including the Value of Roadless Areas for Climate Change Adaptation

III. Sustainable Transportation Management in National Forests as Part of Ecological Restoration

...

As climate change impacts grow more profound, forest managers must consider the impacts on the transportation system as well as from the transportation system. In terms of the former, changes in precipitation and hydrologic patterns will strain infrastructure at times to the breaking point resulting in damage to streams, fish habitat, and water quality as well as threats to public safety. In terms of the latter, the fragmenting effect of roads on habitat will impede the movement of species which is a fundamental element of adaptation.

...

Transportation infrastructure and carbon sequestration

The topic of the relationship of road restoration and carbon has only recently been explored. There is the potential for large amounts of carbon (C) to be sequestered by reclaiming roads. When roads are decompacted during reclamation, vegetation and soils can develop more rapidly and sequester large amounts of carbon. A recent study estimated total soil C storage increased 6 fold to 6.5×10^7 g C/km (to 25 cm depth) in the northwestern US compared to untreated abandoned roads (Lloyd et al. 2013). Another recent study concluded that reclaiming 425 km of logging roads over the last 30 years in Redwood National Park in Northern California resulted in net carbon savings of 49,000 Mg carbon to date (Madej et al. 2013, Table 5).

The Wilderness Society. 2014. Transportation Infrastructure and Access on National Forests and Grasslands - A Literature Review. May 2014. https://www.fs.usda.gov/nfs/11558/www/nepa/96158_FSPLT3_3989888.pdf, <https://www.sierraforestlegacy.org/Resources/Conservation/ProjectsPlans/ForestPlanRevisions/SFL%20et%20a.%20FPR%20comments%20part%205%20of%205.pdf>

Science indicates that the erosion from roads is far worse than that from severe fire.

Colombaroli, D. and D.G. Gavin. 2010. Highly episodic fire and erosion regime over the past 2000 years in the Siskiyou Mountains, Oregon. *Proceedings of the National Academy of Sciences of the United States of America* 107: 18909-18914. <http://www.pnas.org/content/early/2010/10/13/1007692107.full.pdf>.

Avoid Regen Harvest

Carefully consider all of the potentially significant impacts of logging and roads listed below, and develop alternatives that will mitigate these trade-offs, especially when the proposed action involves regen logging or logging mature forests (>80 years old):

1. Logging and roads will reduce carbon storage and increase carbon emissions, exacerbating both global climate change and ocean acidification. William R. Moomaw, Susan A. Masino, and Edward K. Faison. 2019. Intact Forests in the United States: Proforestation Mitigates Climate Change and Serves the Greatest Good Front. *For. Glob. Change*, 11 June 2019 | <https://doi.org/10.3389/ffgc.2019.00027>; <https://www.frontiersin.org/articles/10.3389/ffgc.2019.00027/full>; Oregon Governor's Natural Resource Office. Oregon's Ocean Acidification and Hypoxia Action Plan. August 2019. <https://www.oregonocean.info/index.php/ocean-documents/oah-hypox/june-2018-oah-action-plan-public-comment-documents/1924-draft-oregon-s-oah-action-plan-2019/file>. The significant and widespread effects of global climate change threaten to violate the agency's multiple mandates under the National Forest Management Act and MUSYA. The NWFP FEIS did not adequately address this issue. We urge the agency to include carbon storage for climate change mitigation as part of the purpose and need, to consider alternatives that treat fewer acres and retain more trees to accomplish this purpose, and to fully and accurately disclose the carbon consequences of logging alternatives, including not logging;
2. Logging and roads will reduce recruitment of snags and dead wood and all the ecosystem services they provide. One of the most significant and lasting effects of stand replacing disturbance, including regeneration logging, is to bring the process of snag recruitment to a virtual standstill for many decades. Especially when trees are removed by logging, the snag population is directly reduced to ensure safe conditions for workers, and remains low for many decades because the pool of green trees available for snag recruitment is greatly reduced. This results in a multi-decade "snag gap" that has serious adverse consequences for habitat and many other ecological processes. See Rose, C.L., Marcot, B.G., Mellen, T.K., Ohmann, J.L., Waddell, K.L., Lindely, D.L., and B. Schrieber. 2001. *Decaying Wood in Pacific Northwest Forests: Concepts and Tools for*

Habitat Management, Chapter 24 in *Wildlife-Habitat Relationships in Oregon and Washington* (Johnson, D. H. and T. A. O'Neil. OSU Press. 2001)

<http://web.archive.org/web/20060708035905/http://www.nwhi.org/inc/data/GISdata/docs/chapter24.pdf>. The

agency should make snag habitat conservation and recruitment part of the purpose and need, consider alternatives that treat fewer acres and retain more green trees to mitigate for snag losses from logging; and fully and accurately disclose the long-term loss of snag recruitment caused by commercial logging;

3. Logging and roads will increase fire hazard for many decades by leading to the establishment of dense young stands with dense continuous fuels close to the ground. See Harold S. J. Zald, Christopher J. Dunn. 2018. Severe fire weather and intensive forest management increase fire severity in a multi-ownership landscape. *Ecological Applications*. Online Version of Record before inclusion in an issue. 26 April 2018.

<https://doi.org/10.1002/eap.1710>. Also, <https://phys.org/news/2018-04-high-wildfire-severity-young-plantation.html>;

4. Logging and roads will increase peak flows immediately after logging. Artificial peak flows cause erosion, turbidity, and adverse impacts on fish populations. Grant, Gordon E.; Lewis, Sarah L.; Swanson, Frederick J.; Cissel, John H.; McDonnell, Jeffrey J. 2008. Effects of forest practices on peak flows and consequent channel response: a state-of-science report for western Oregon and Washington. Gen. Tech. Rep. PNW-GTR-760. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 76 p. http://www.fs.fed.us/pnw/pubs/pnw_gtr760.pdf;

5. Logging, roads, and tree planting will cause reduced summer stream flows due to development of dense young stands that have high rates of transpiration and high rates of water use. Artificially low summer stream flows cause adverse effects on stream temperature, reduced water availability, and reduced quantity and quality of fish habitat. Perry, T. D., and Jones, J. A. (2016) Summer streamflow deficits from regenerating Douglas-fir forest in the Pacific Northwest, USA. *Ecohydrology*, doi: 10.1002/eco.1790. <http://onlinelibrary.wiley.com/doi/10.1002/eco.1790/full>;

6. Logging and roads will adversely affect listed species. Removing or degrading suitable habitat for the spotted owl will increase adverse competitive interactions with barred owls. To mitigate for the invasion of the barred owl into the entire range of the spotted owl, scientists recommend retention of more suitable habitat, not just the small subset of high quality suitable habitat. Forsman, E.D., Anthony, R.G. et al [Idquo]Population Demography of Northern Spotted Owls.[rdquo] DRAFT COPY 17 December 2010. This draft manuscript is in press at the University of California Press with a projected publication date of July 2011. It will be No. 40 in *Studies In Avian Biology*, which is published by the Cooper Ornithological Society.

http://www.reo.gov/monitoring/reports/nso/FORSMANetal_draft_17_Dec_2010.pdf; See also, Wiens, J.D., Anthony, R.G., and E.D. Forsman. 2014: Competitive Interactions and Resource Partitioning Between Northern Spotted Owls and Barred Owls in Western Oregon. *Wildlife Monographs* 185:1[ndash]50; 2014; DOI: 10.1002/wmon.1009.

<https://ir.library.oregonstate.edu/xmlui/bitstream/handle/1957/48214/AnthonyRobertFisheriesWildlifeCompetitivelnteractions.pdf>.

7. Logging and roads will adverse impacts to spotted owl prey base, e.g., flying squirrel, red tree vole. Wilson, Todd M.; Forsman, Eric D. 2013. Thinning effects on spotted owl prey and other forest-dwelling small mammals. In: Anderson, Paul D.; Ronnenberg, Kathryn L., eds. *Density management for the 21st Century: west side story*. Gen. Tech. Rep. PNW-GTR-880. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 79[ndash]90. https://www.fs.fed.us/pnw/pubs/pnw_gtr880.pdf;

8. Logging and roads will fragment interior forests with adverse effects on wildlife due to altered microclimate, predation, nest predation, etc. We urge the agency to identify blocks of [rdquo]interior forest,[rdquo] consider alternatives to reduce fragmentation of forest in or near interior forest, prioritize roads that could be decommissioned (or not built) in or near interior forest, identify and protect potential wildlife corridor stands that could provide connectivity between interior forest. Ontario Extension Notes. *Conserving The Forest Interior: A Threatened Wildlife Habitat*. LRC 70. http://www.lrconline.com/Extension_Notes_English/pdf/forInterior.pdf; BC Ministry of Forests 1998. Extension Note 21. *Biodiversity and Interior Habitats: The Need to Minimize Edge Effects*. <https://www.for.gov.bc.ca/hfd/pubs/docs/en/en21.pdf>.

1. Logging, roads, and heavy equipment, and burn piles will degrade soil functions and increase erosion. These activities kill native vegetation that normally share carbohydrates and feed a vast below-ground ecosystem. Soil compaction and disturbance reduces the flow of air and water vital to the below ground ecosystem. Ingham, Elaine, *The Soil Foodweb: Its Importance in Ecosystem Health*, <http://www.rain.org/~sals/ingham.html>; See also, Amaranthus, M.P.; Molina R.; and Trappe J. M. 1990. Long-term forest productivity and the living soil. Chapter 3. In Perry D.A. ed. *Maintaining Long-term Forest Productivity in the Pacific Northwest Forest Ecosystem*. Timber Press. Portland, OR 97208; See also: Wall DH, V Behan-Pelletier, AP Covich, and P Snelgrove. 2007. Hidden Assets: Biodiversity Below-Surface. UNESCO & SCOPE. http://www.icsu-scope.org/unesco/USPB05_SOIL_En.pdf;
2. Logging and roads will spread weeds by exposing mineral soil, transporting seeds, and removing native vegetation thus giving more light and nutrients to weeds. Inventories show that weeds are closely associated with roads and recently logged areas. Consider alternatives that avoid creating the conditions that spread weeds. Parendes, L. A. and J. A. Jones. 2001. Role of Light Availability and Dispersal in Exotic Plant Invasion along Roads and Streams in the H. J. Andrews Experimental Forest, Oregon. *Conservation Biology*. Vol. 14, No. 1 (Feb., 2000), pp. 64-75. <https://doi.org/10.1046/j.1523-1739.2000.99089.x>; See also, Gray, Andrew N. 2005 Nonnative Plants in the Inventory of Western Oregon Forests. In: McRoberts, Ronald E.; Reams, Gregory A.; Van Deusen, Paul C.; McWilliams, William H.; Cieszewski, Chris J., eds. *Proceedings of the fourth annual forest inventory and analysis symposium*; Gen. Tech. Rep. NC-252. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Research Station. 11-16. http://ncrs.fs.fed.us/pubs/gtr/gtr_nc252/gtr_nc252_011.pdf;
3. Logging and roads will degrade water quality and fish habitat, including increase stream temperature and increase sediment and turbidity. Logging and roads reduce stream shade, reduce stream flow both leading to an increase in stream temperature. Erosion and sediment from logging and roads also adversely affect stream morphology and fish habitat;
4. Logging and roads in and adjacent to stream buffers will degrade the microclimate in riparian reserves, reduce wood recruitment in and near streams, degrade water quality and fish habitat. See 1993 FEMAT Report, pp V-13, V-25; Anderson, Paul D.; Larson, David J.; Chan, Samuel S. 2007. Riparian Buffer and Density Management Influences on Microclimate of Young Headwater Forests of Western Oregon. *Forest Science*, Volume 53, Number 2, April 2007 , pp. 254-269(16). <http://www.ingentaconnect.com/content/saf/fs/2007/00000053/00000002/art00012>; Pollock, M. 2013. An analysis of the effects of riparian forest harvest on the development of late-successional forest structure and instream wood production - A review of timber harvest in Riparian Reserves proposed by the Bureau of Land Management for federal lands in the Coquille watershed in southwest Oregon as part of the Lone Pine Biological Assessment; v.08.23.2013. NMFS; Thomas Spies, Michael Pollock, Gordon Reeves, and Tim Beechie 2013. Effects of Riparian Thinning on Wood Recruitment: A Scientific Synthesis - Science Review Team Wood Recruitment Subgroup. Jan 28, 2013, p 36. <http://www.mediate.com/DSConsulting/docs/FINAL%20wood%20recruitment%20document.pdf>;
5. Logging and roads will degrade the quality of the recreation experience in the Extensive Recreation Management Area. People who recreate on BLM land tend to be seeking a recreation setting that is dominated by natural features and natural processes, not logging, weeds, stumps, eroded soils, degraded streams, etc.;
6. Consider logging in ways that are least harmful to the ecosystem by restoring ecological features that are in short-supply and by mimicking natural processes. This means leaving mature forests unlogged, so that natural mortality processes and snag recruitment are not adversely affected. In young stands, BLM should thin variably while retaining generous unthinned skip where mortality processes and dead wood recruitment can continue to mitigate the cumulative effects of widespread logging on public and private lands.
7. Please consider all reasonable alternatives, including thinning a portion of stands that are dense and young, and leaving older stands unlogged. Thinning young stands will extend culmination of mean annual increment and provide a more harmonious mix of public benefits where production of timber volume is required. Logging older stands will virtually always lead to net negative effects on the public interest. Any land allocation or purpose-and-need to obtain timber volume from logging older stands must be reconsidered in light of the urgent need to address the climate crisis by retaining carbon in the forest and avoid carbon emissions from forest degradation.

(See Moomaw et al 2019 cited above).

8. Many of the effects described above may be significant and may become significant when logging and roads are considered cumulatively across the landscape.

9. Many of the effects listed above will interact unfavorably with global climate change making effects much worse than they would be in the absence of climate change. Dalton, M.M., K.D. Dello, L. Hawkins, P.W. Mote, and D.E. Rupp (2017) The Third Oregon Climate Assessment Report, Oregon Climate Change Research Institute, College of Earth, Ocean and Atmospheric Sciences, Oregon State University, Corvallis, OR. http://www.occri.net/media/1042/ocar3_final_125_web.pdf;

The Purpose and Need should Address The Unmet Need for Carbon Storage

The agency says one of the purposes of this project is provide a supply of wood products to the public. The agency should reconsider timber targets in light of the fact that the public needs carbon storage to reduce global climate change much more than they need wood products. The NEPA analysis also needs to account for the fact that managing forests for water quality, water quantity, quality of life, and carbon storage for a stable climate will contribute far more to community stability than propping up the timber boom-bust industry with subsidized logging.

The agency must recognize that wood products are already under-priced and over-supplied due to [ldquo]externalities[rdquo] (costs that are not included in the price of wood, so those costs are shifted from wood product producers and consumers to the general public who suffer the consequences of climate change without compensation from those who profit from logging related externalities). Ecosystem carbon storage on the other hand is under-supplied because there is not a functioning market for carbon storage and climate services. The agency is in a position to address these market imperfections by focusing on unmet demand for carbon storage instead of offering wood products that are already oversupplied.

Land protection, both public and private, provides substantial ecological benefits by avoiding conversion of natural systems to intensive, developed uses. These benefits include carbon sequestration, watershed functioning, soil conservation, and the preservation of diverse habitat types (e.g., Daily 1997, Brauman et al. 2007, Kumar 2012, Watson et al. 2014). Land protection also solves a key market failure: private markets tend to underprovide socially beneficial land uses such as natural forests, agricultural lands, or managed timberlands. The reason for this failure is that many of the benefits of these lands go to the public in general, not individual landowners. When private values and market transactions determine land uses, less land will be devoted to socially beneficial uses than if citizens could collectively determine use on the basis of social values (e.g., Angelsen 2010, Tietenberg and Lewis 2016).

Katharine R.E. Sims, Jonathan R. Thompson, Spencer R. Meyer, Christoph Nolte, Joshua S. Plisinski. 2019. Assessing the local economic impacts of land protection. *Conservation Biology*. 26 March 2019 <https://doi.org/10.1111/cobi.13318>,

https://harvardforest.fas.harvard.edu/sites/default/files/Sims_et_al-2019-Conservation_Biology.pdf.

Do not rely on the flawed boilerplate climate analyses

As explained below, the Forest Service[rsquo]s standardized NEPA language regarding carbon and climate change fails to take a hard look that NEPA requires. The analysis makes several highly misleading statements about forest carbon and climate change. The analysis inappropriately mischaracterizes the role of individual logging projects in the cumulative problem of global GHG emissions. The analysis misstates the effects of logging related carbon emissions that are not related to [ldquo]deforestation.[rdquo] The analysis grossly misstates the climate effects of logging intended to reduce disturbance. The analysis misleadingly implies that logging benefits the climate by increasing forest productivity.

The NEPA analysis should consider the adverse climate consequences of GHG emissions caused directly and indirectly by logging. The Forest Service should not rely on the boilerplate NEPA language from the regional office which is flawed in many ways. Instead the Forest Service:

- * Must recognize the cumulative nature of the GHG emissions and climate problems. It does not matter that this project is small in the global scheme because all emissions matter when the causation is global and cumulative;
- * Cannot credibly assert that this project is harmless because it's not causing deforestation. This is immaterial. All GHG emissions, regardless of the source or how it is labelled, are part of the problem and cause the same climate impacts.
- * Cannot credibly assert that thinning for forest health justifies or mitigates emissions from logging. Logging does not increase the capacity for growing trees. To the contrary, logging harms soil and reduces site productivity.
- * Must not compare carbon before and after logging. That is an improper framework for NEPA analysis. The proper NEPA framework is to compare the effects of different alternatives (over time), so the agency must describe the carbon emissions and carbon storage in the forest over time with logging and without logging.
- * Logging to reduce fire effects does not result in a net increase in forest carbon storage. The agency cannot predict the location, timing, or severity of future wildfires, so most fuel treatments will cause carbon emissions without any offsetting benefits from modified fire behavior. Studies clearly show that the total carbon emissions from logging (plus unavoidable wildfire) are greater than carbon emissions from wildfire alone.
- * Cannot credibly assert that carbon storage in wood products is a useful climate strategy. Logging kills trees, stops photosynthesis, and initiates decay and combustion, with the end result being a significant transfer of carbon from the forest to the atmosphere. In stark contrast, an unlogged forest continues to grow and transfer more carbon from the atmosphere to the forest. Carbon emissions caused by logging far exceed the small fraction of carbon transferred to wood products. Carbon accounting methods that attempt to account for substitution of wood for other high-carbon building materials are fraught with uncertainty and too often represent maximum potential substitution effects rather than lower realistic estimates.

Why Mature Forests Must be Protected.

"As recognized by FEMAT, a conservation strategy for the Pacific Northwest must consider mature forests as well as OG. Forests are considered to enter maturity when their mean annual increment culminates, following which time they begin developing the characteristics that ultimately produce OG. Mature forests serve various important ecologic functions. They serve as future replacements for old-growth, help protect existing OG by reducing the starkness of age-class boundaries, and provide landscape connectivity and transitional habitat that compensate to some degree for the low levels of OG. Moreover, they are almost certainly more resistant to crown fires than younger forests, and hence contribute to buffering the landscape."

Late-Successional and Old-Growth Forests in the Pacific Northwest. Statement of DAVID A. PERRY Professor Emeritus. Department of Forest Science, Oregon State University, before the Subcommittee on Public Lands and Forests of the Committee on Energy and Natural Resources, United States Senate. March 13, 2008.

All logging, including thinning stands of any age, include some adverse impacts and trade-offs. Some impacts of logging are unavoidable, so there is no such thing as a logging operation that is 100% beneficial. Depending on how thinning is done thinning can have adverse impacts such as soil disturbance, habitat disturbance, carbon removal, spreading weeds, reduced recruitment of snags, road-related erosion and hydrologic impacts, moving fuels from the canopy to the ground, creating a hotter-drier-windier microclimate that is favorable to greater flame lengths and rate of fire spread, etc. Some of these negative effects are fundamentally unavoidable, therefore all thinning has negative effects that must be compensated by beneficial effects such as reducing competition between trees so that some can grow larger faster, increased resistance drought stress and insects, increasing

species diversity, possible fire hazard reduction, etc. It is generally accepted that when thinning very young stands, the benefits outweigh the adverse impacts and net benefits are likely. It is also widely understood that thinning older stands tends to have greater impacts on soil, water, weeds, carbon, dead wood recruitment so the impacts very often outweigh the benefits, resulting in net negative outcome on the balance sheet. As we move from young forest to older forests, the net benefits turn into net negative impacts, but where is that line? The authors of the Northwest Forest Plan took all this into account and determined that 80 years is a useful place to draw the line between forests that are likely to benefit from silviculture and those that are likely to experience net negative consequences. There is no new science to change that conclusion. In fact, new information developed since 1994 shows that dead wood is probably more valuable than previously thought - being important for a wide variety of ecological functions, not least of which is providing complex habitat that supports prey species for spotted owl and a variety of other predators both east and west of the Cascades. As stands become mature at around 80 years of age, they begin accumulating snags and dead wood from natural mortality processes. Thinning [ldquo]captures mortality[rdquo] and removes it from the forest thus preventing those trees from ever becoming snags and dead wood and interrupting the critical process whereby mature forests accumulate dead wood. The loss of recruitment of dead wood habitat when logging older stands is a long-term impact and provides a very strong argument against logging in stands over 80 years old. For further information see 1993 SAT Report pp 146-152. AND February 1991 Questions and Answers on A Conservation Strategy for the Northern Spotted Owl (prepared in response to written questions from the Senate Energy and Natural Resources Committee to the Interagency Scientific Committee on the May 1990 ISC Report. AND Jerry Franklin, David Perry, Reed Noss, David Montgomery, Christopher Frissell. SIMPLIFIED FOREST MANAGEMENT TO ACHIEVE WATERSHED AND FOREST HEALTH: A CRITIQUE. National Wildlife Federation. <http://www.coastrange.org/documents/forestreport.pdf>.

The agency needs to recognize the distinction between thinning young plantations and thinning mature forests. Robert Anthony reminded the regional executives in 2013 that:

The long-term benefits of thinning in young plantations to create forests with characteristics of late-successional forests (e.g. large diameter standing and down wood) may outweigh any short-term negative effects on owls or their prey. However, as the age of forests selected for thinning increases, the short-term negative effects of such activities will likely increase and the benefits decrease. The Northwest Forest Plan specified a maximum age of 80 years for forests that are slated for thinning. The reasons for this guideline were that (1) it was unclear if thinning could actually accelerate the rate at which naturally regenerated mature forests developed old forest conditions, and (2) spotted owls forage in mature forests, and thinning of these forests will likely reduce their quality as spotted owl habitat both in the short and long term. If these young forests are not currently good foraging habitat, they are gradually developing late-successional characteristics that will provide foraging habitat in the near future. Consequently, thinning in riparian forests >80 years old or any younger forests where thinning is not likely to accelerate the development of late-successional forest structure is not recommended. If these young forests are not currently good foraging habitat, they are gradually developing late-successional characteristics that will provide foraging habitat in the near future. Consequently, thinning in riparian forests >80 years old or any younger forests where thinning is not likely to accelerate the development of late-successional forest structure is not recommended.

Anthony, R.G. 2013. [ldquo]Effects of Riparian Thinning on Marbled Murrelets and Northern Spotted Owls.[rdquo] Part III of the Science Review Team for the identification and interpretation of the best available scientific information to determine effects of riparian forest management. 28 January 2013.

The agency must carefully review and document their consideration of all the reasons not to log mature forests set forth in this paper: Doug Heiken 2009. The Case for Protecting Both Old Growth and Mature Forests. Version 1.8 April 2009.

<https://www.dropbox.com/s/4s0825a7t6fq7zu/Mature%20Forests%2C%20Heiken%2C%20v%201.8.pdf?dl=0>.

Skeena Watershed Council in British Columbia note that "Old growth forests are now a non-renewable resource. They will not be replaced with new growth due to climate change. While the forest will grow, we will not see trees get as large or as old as the ones we have now."

"We must make clear that natural forests are managed for biodiversity and the full set of ecosystem services that forests provide. And, by the way, which biodiversity are we shortest of? The biodiversity that's associated with older forests." FEN MONTAIGNE 2019. Why Keeping Mature Forests Intact Is Key to the Climate Fight. Yale e360 OCTOBER 15, 2019. <https://e360.yale.edu/features/why-keeping-mature-forests-intact-is-key-to-the-climate-fight>.

Lutz (and 95 co-authors!) compiled detailed forest plot data from 48 sites around the world and found that large trees play critical roles in forest structure and function (especially carbon storage), yet they are vulnerable to disturbance (especially logging) and take a long time to replace, so they need to be conserved.

Main conclusions: Because large-diameter trees constitute roughly half of the mature forest biomass worldwide, their dynamics and sensitivities to environmental change represent potentially large controls on global forest carbon cycling. We recommend managing forests for conservation of existing large-diameter trees or those that can soon reach large diameters as a simple way to conserve and potentially enhance ecosystem services.

...

Concentration of resources within a few individuals in a community is a pervasive property of biotic systems (West, Brown, & Enquist, 1997), whether marine (Hixon, Johnson, & Sogard, 2014), terrestrial (Enquist, Brown, & West, 1998) or even anthropogenic (Saez & Zucman, 2016). The concentration of total forest biomass in a few large-diameter trees is no exception (Pan, Birdsley, Phillips, & Jackson, 2013). Large-diameter trees in forests take many decades or even centuries to develop, but human or natural disturbances can decrease their abundance, rapidly changing forest structure (Allen et al., 2010; Lindenmayer, Laurance, & Franklin, 2012; Lutz, van Wagtendonk, & Franklin, 2009; van Mantgem et al., 2009).

... Previous studies have showed that large-diameter trees comprise a large fraction of the biomass of many forests (Bastin et al., 2015; Brown et al., 1995; Clark & Clark, 1996; Lutz, Larson, Swanson, & Freund, 2012) and that they modulate stand-level leaf area, microclimate and water use (Martin et al., 2001; Rambo & North, 2009). Large-diameter trees contribute disproportionately to reproduction (van Wagtendonk & Moore, 2010), influence the rates and patterns of regeneration and succession (Keeton & Franklin, 2005), limit light and water available to smaller trees (Binkley, Stape, Bauerle, & Ryan, 2010), and contribute to rates and causes of mortality of smaller individuals by crushing or injuring sub-canopy trees when their bole or branches fall to the ground (Chao, Phillips, Monteagudo, Torres-Lezama, & Vasquez Martınez, 2009; Das, Stephenson, & Davis, 2016). Large-diameter trees (and large-diameter snags and large-diameter fallen woody debris) make the structure of primary forests and mature secondary forests unique (Spies & Franklin, 1991). Large-diameter trees occur at low stem densities, yet influence spatial patterns over long inter-tree distances (Das, Larson, & Lutz, 2018; Enquist, West, & Brown, 2009; Lutz et al., 2014). ...

... Changes in climate, disturbance regimes and logging are accelerating the decline of large-diameter trees (e.g., Bennett, McDowell, Allen, & Anderson-Teixeira, 2015; Lindenmayer & Laurence, 2016; Lindenmayer et al., 2012). The dynamics of large-diameter trees is dependent on at least two factors: (a) presence of species capable of attaining a large size, and (b) conditions, including disturbance regimes, that permit the development of large-diameter individuals. If the species richness of the large-diameter assemblage is high, a forest may be better able to respond to perturbations (Musavi et al., 2017) and maintain its structure and ecological function. However, if the large-diameter species richness is low, then a forest could be susceptible to any change that affected those few species.

...

DISCUSSION

The relationship between the large-diameter threshold and overall biomass (Figure 2a) suggests that forests cannot sequester large amounts of aboveground carbon without large trees, ...

...

Temperate forests featured a higher density of trees > 60 cm DBH (Table 1), consistent with the presence of the very largest species of trees in cool, temperate forests (Silleet et al., 2015; Van Pelt et al., 2016). Temperate forests also exhibited considerably lower densities of small trees (e.g., 1 cm < DBH < 5 cm; Supporting Information Table S3.2) and lower total stem density.

...

There is still considerable uncertainty as to what will happen to large-diameter trees in the Anthropocene when so much forest is being felled for timber and farming, or is being affected by climate change. Bennett et al. (2015) suggested that the current large-diameter trees are more susceptible to drought mortality than smaller-diameter trees. Larger trees, because of their height, are susceptible to sapwood cavitation and are also exposed to high radiation loads (Allen, Breshears, & McDowell, 2015; Allen et al., 2010), but vigorous large-diameter individuals may also still be sequestering more carbon than smaller trees (Stephenson et al., 2014). Both Allen et al. (2015) and Bennett et al. (2015) suggested that larger trees will be more vulnerable to increasing drought than small trees, and Luo and Chen (2013) suggested that although the rate of mortality of larger trees will continue to increase because of global climate change, smaller trees will experience more drought-related mortality. These last two conclusions need not be in conflict as the background mortality rates for smaller trees are higher than those of larger trees within mature and old-growth forests (Larson & Franklin, 2010). What remains generally unanswered is whether the increasing mortality rates of large-diameter trees will eventually be offset by regrowth of different individuals of those same (or functionally similar) species. ...

... The conservation of large-diameter trees in tropical and temperate forests is therefore imperative to maintain full ecosystem function, as the time necessary for individual trees to develop large sizes could preclude restoration of full ecosystem function for centuries following the loss of the oldest and largest trees (Lindenmayer et al., 2012). Clearly, areas that have been recently logged lack large-diameter trees, and therefore have less structural heterogeneity than older forests. That the largest individuals belong to relatively few common species in the temperate zone means that the loss of large-diameter trees could alter forest function [ndash] if species that can attain large diameters disappear, forests will feature greatly reduced structural heterogeneity (e.g.,

Needham et al., 2016), biomass, and carbon storage.

Lutz et al (2018). Global importance of large-diameter trees. *Global Ecology and Biogeography*. 2018:1-16. DOI: 10.1111/geb.12747.

http://www.columbia.edu/~mu2126/publications_files/Lutz_et_al-2018-Global_Ecology_and_Biogeography.pdf

Conservation of mature & old-growth trees helps achieve social goals. The social importance of conserving large trees is often under-appreciated. See Blicharska et al. (2014).

Abstract: In addition to providing key ecological functions, large old trees are a part of a social realm and as such provide numerous social-cultural benefits to people. However, their social and cultural values are often neglected when designing conservation policies and management guidelines. We believe that awareness of large old trees as a part of human identity and cultural heritage is essential when addressing the issue of their decline worldwide. Large old trees provide humans with aesthetic, symbolic, religious, and historic values, as well as concrete tangible benefits, such as leaves, branches, or nuts. In many cultures particularly large trees are treated with reverence. [hellip] Although the social and cultural role of large old trees is usually not taken into account in conservation, accounting for human-related values of these trees is an important part of conservation policy because it may strengthen conservation by highlighting the potential synergies in protecting ecological and social values.

Recognition of Social and Cultural Values of Large Old Trees

Large old trees have important ecological functions (Lindenmayer et al. 2012, 2013), but they often have enormous social significance as well; therefore, protecting them for ecological reasons also supports maintenance of aesthetic, symbolic, religious, and historic values (i.e., these different kinds of values can be protected in a synergetic manner).

Many conservation policies already highlight the necessity to include people, their needs, and values in conservation decisions. [hellip] both tangible and intangible benefits provided by large old trees can be directly translated into the ecosystem services concept.

[hellip] The context in which issues are represented has the potential to affect the actual action because context induces particular ways of understanding the issue and thus may lead to new types of actions in the policy process (Hajer 1995). Therefore, framing the conservation of large old trees from a human perspective, for whom they are protected and for whom they deliver important services,

may facilitate creation and implementation of relevant policies.

[hellip] This flagship function of large old trees appears to be more universal than that for other types of flagship species. The latter are usually limited to a particular

environment and geographic area, whereas large old trees are highly valued by humans across cultural and environmental realms.

Blicharska, M.; Mikusinski, G. 2014. Incorporating social and cultural significance of large old trees in conservation policy. *Conserv. Biol.* 28(6):1558-1567.

http://www.researchgate.net/profile/Grzegorz_Mikusinski2/publication/264673453_Incorporating_social_and_cultural_significance_of_large_old_trees_in_conservation_policy/links/5495bc800cf29b9448241278.pdf

The complex structure and multi-layered canopy of mature & old-growth forests provides a buffer against thermal extremes which means that older forests can serve as climate refugia as the climate warms. OPB interviewed one of the authors of the study and reported:

[hellip] the kind of forest makes a big difference on temperature.

[ldquo]The more structurally complex the forest, the more big trees, the more vertical layers [ndash] the cooler it was,[rdquo] he says.

The research showed differences as much as 4.5 degrees on warm days. Old growth forests also held in heat during cold weather. Overall, these forests have a moderating effect on temperature extremes.

One reason, researchers suspect, is that tree plantations, even mature ones, don[rsquo]t have nearly the understory material [ndash] small trees, shrubs, ground cover [ndash] as more complex stands. Nor do these single-age plantations have a lot of big trees [ndash] unlike old growth stands.

[ldquo]We think one of the mechanisms causing this is thermal inertia,[rdquo] Betts says. [ldquo]That takes these trees longer to warm up and longer to cool down. And that could be providing some of the buffering capacity of these older forests.[rdquo]

Betts says these stands of old growth could provide refuges for temperature-sensitive wildlife in the face of climate change.

Jes Burns 2016. Old-Growth Forests Provide Temperature Refuges In Face Of Climate Change: Study. OPB/EarthFix | April 22, 2016 [http://www.opb.org/news/article/forest-refuges-climate-change/citing Sarah J. K. Frey, Adam S. Hadley, Sherri L. Johnson, Mark Schulze, Julia A. Jones, Matthew G. Betts. 2016. Spatial models reveal the microclimatic buffering capacity of old-growth forests. SCIENCE ADVANCES. 22 APR 2016 : E1501392. <http://advances.sciencemag.org/content/advances/2/4/e1501392.full.pdf>.](http://www.opb.org/news/article/forest-refuges-climate-change/citing%20Sarah%20J.%20K.%20Frey,%20Adam%20S.%20Hadley,%20Sherri%20L.%20Johnson,%20Mark%20Schulze,%20Julia%20A.%20Jones,%20Matthew%20G.%20Betts.%202016.%20Spatial%20models%20reveal%20the%20microclimatic%20buffering%20capacity%20of%20old-growth%20forests.%20SCIENCE%20ADVANCES.%2022%20APR%202016%20:%20E1501392.%20http://advances.sciencemag.org/content/advances/2/4/e1501392.full.pdf)

Pre-fire nesting/roosting habitat had lower probability of burning at moderate or high severity compared to other forest types under high burning conditions. Our results indicate that northern spotted owl habitat can buffer the negative effects of climate change by enhancing biodiversity and resistance to high-severity fires, which are predicted to increase in frequency and extent with climate change. Within this region, protecting large blocks of

old forests could be an integral component of management plans that successfully maintain variability of forests in this mixed-ownership and mixed-severity fire regime landscape and enhance conservation of many species.

Lesmeister, D. B., S. G. Sovern, R. J. Davis, D. M. Bell, M. J. Gregory, and J. C. Vogeler. 2019. Mixed-severity wildfire and habitat of an old-forest obligate. *Ecosphere* 10(4):e02696. 10.1002/ecs2.2696. <https://esajournals.onlinelibrary.wiley.com/doi/pdf/10.1002/ecs2.2696>. The PNW Research Station put out a press release on this study on July 2, 2019 which said:

Old-growth forests have more vegetation than younger forests. Researchers expected that this meant more fuel would be available for wildfires, increasing the susceptibility of old-growth forests to severe fire, high tree mortality, and resulting loss of critical spotted owl nesting habitat. However, the data suggested a different effect.

Lesmeister and his colleagues classified fire severity based on the percentage of trees lost in a fire, considering forest that lost less than 20% of its trees to fire subject to low-severity fire and those with more than 90% tree loss subject to high-severity fire. They found that old-growth forest was up to three times more likely to burn at low severity—a level that avoided loss of spotted owl nesting habitat and is generally considered to be part of a healthy forest ecosystem.

“Somewhat to our surprise, we found that, compared to other forest types within the burned area, old-growth forests burned on average much cooler than younger forests, which were more likely to experience high-severity fire. How this actually plays out during a mixed-severity wildfire makes sense when you consider the qualities of old-growth forest that can limit severe wildfire ignitions and burn temperatures, like shading from multilayer canopies, cooler temperatures, moist air and soil as well as larger, hardier trees.”

Because old-growth forests may be refuges of low-severity fire on a landscape that experiences moderate to high-severity fires frequently, they could be integral as biodiversity refuges in an increasingly fire-prone region.

U.S. Forest Service Pacific Northwest Research Station 2019. Old-growth forest may provide valuable biodiversity refuge in areas at risk of severe fire. July 8, 2019. <https://yubanet.com/california/old-growth-forest-may-provide-valuable-biodiversity-refuge-in-areas-at-risk-of-severe-fire/>; <https://www.fs.usda.gov/pnw/news-releases/old-growth-forests-may-provide-valuable-biodiversity-refuge-areas-risk-severe-fire>.

Betts et al (2017) also found old growth to be of value to wildlife in terms of microclimate buffering:

Results

We found a significant negative effect of summer warming on only two species. However, in both of these species, this relationship between warming and population decline was not only reduced but reversed, in old-growth-dominated landscapes. Across all 13 species, evidence for a buffering effect of old-growth forest increased with the degree to which species were negatively influenced by summer warming.

Main conclusions

These findings suggest that old-growth forests may buffer the negative effects of climate change for those species that are most sensitive to temperature increases. Our study highlights a mechanism whereby management strategies to curb degradation and loss of old-growth forests—in addition to protecting habitat—could enhance biodiversity persistence in the face of climate warming.

Matthew G. Betts, Ben Phalan, Sarah J. K. Frey, Josée S. Rousseau, Zhiqiang Yang.

2017. Old-growth forests buffer climate-sensitive bird populations from warming.

Diversity and Distributions. Volume 24, Issue 4. April 2018. Pages 439-447, <https://doi.org/10.1111/ddi.12688>. See also, USDA/USDI 1994. Final Supplemental Environmental Impact Statement on Management of Habitat for Late-Successional and Old-Growth Forest Related Species Within the Range of the Northern Spotted Owl. Vol I, pp 3&4-29 -31. <https://www.blm.gov/or/plans/nwfpnepa/> ([ldquo]Small patches of old-growth forest can provide thermal and mesic refugia for a variety of organisms. Understory habitats in old-growth forests can escape freezing conditions due to the thermal buffering of dense tree canopies. Deer and other vertebrates may rely on these thermal refuges during harsh storms or during dispersal to larger forest stands of suitable habitat. Many invertebrates migrate locally to mesic refugia during summer. During very dry periods in forests east of the Cascade Range, many invertebrates may require dense forest cover and mesic understory habitats to avoid desiccation[rdquo]).

Tree height is an indicator of old growth habitat suitability. This is likely because tree height is a direct measure of 3-dimensional habitat volume below the tree tops. North, Kane, Kane, et al 2017. Cover of tall trees best predicts California spotted owl habitat. *Forest Ecology and Management*. 405: 166-178. <https://doi.org/10.1016/j.foreco.2017.09.019>, <https://www.fs.fed.us/psw/pubs/55075>, https://www.fs.fed.us/psw/publications/north/psw_2017_north004.pdf, https://www.fs.fed.us/psw/news/2017/20171005_spottedowl.shtml ([ldquo]Although total canopy cover was high in nest stands and PAC [protected activity center] areas, the cover in tall (>48m) trees was the canopy structure most highly selected for, while cover in lower strata (2[ndash]16m) was avoided compared to availability in the surrounding landscape. [hellip] High canopy cover ([ge]70%) mostly occurs when large tree cover is high, indicating the two variables are often confounded. ... [T]he cover of tall trees may be a better predictor of owl habitat than total canopy cover because the latter can include cover in the 2[ndash]16 m strata [ndash] conditions that owls actually avoid.[rdquo]) This study seems to indicate that California spotted owls, and maybe northern spotted owls, are OK with relatively simple stands of tall trees with high canopy cover in the overstory. They don[rsquo]t necessarily need or prefer complex stands with multiple cohorts and lower canopy layers. The agencies therefore should NOT intervene with logging to reduce canopy cover of tall trees in order to establish new cohorts to benefit spotted owls.

Conservation of mature forests is an important step toward conservation of fungal diversity. Antonio Tomao, Jos[eacute] Antonio Bonet, Carles Casta[ntilde]o, Sergiode-Miguel, 2020. How does forest management affect fungal diversity and community composition? Current knowledge and future perspectives for the conservation of forest fungi. *Forest Ecology and Management*, Volume 457, 1 February 2020, 117678, <https://doi.org/10.1016/j.foreco.2019.117678> ([ldquo]Highlights [ndash] [bull] We review the effect of forest management practices on fungal diversity. [bull] Fungal diversity is positively related with canopy cover, basal area and tree species diversity. [bull] Diversity of deadwood size and decomposition stage is positively related to richness of wood-inhabiting fungi. [bull] The higher is the forest management intensity the lower is the diversity of fungal species. ... If no management practices are performed for a long time, stands may gradually evolve into so-called [ldquo]old-growth forests[rdquo]. In the absence of anthropogenic disturbances, forests may slowly recover the natural disturbance dynamics (forest fires and windstorms, parasite outbreaks, fungal decay, gap creation due to insects) and develop those stand structural features (large living trees, large amount of deadwood, canopy gaps of various size, coexistence of senescent, mature and initial stages) typical of primary forests (Burrascano et al., 2013). ... Old-growth forests are recognized as an important reserve of fungal diversity for several fungal functional guilds. Indeed, a very large number of ectomycorrhizal species can be hosted in old growth stands (Richard et al., 2004; Zhang et al., 2017).[rdquo]). Thus literature review explains that the adverse

effects of logging on fungi populations has at least three causes: (i) loss of ectomycorrhizal-hosts and the associated reduction in carbohydrate production and carbohydrate transfer from living trees to the fungal community, (ii) reduction in quantity and diversity of dead wood substrate, and (iii) adverse modification of the microclimate, e.g., rapid wetting and drying, soil compaction, reduced water retention, reduced gas exchange, etc.

The importance of fungal diversity will increase as climate stress increases. As explained by Peter et al (2013)[ndash]

New emerging techniques allow to study the functional diversity of mycorrhizal fungi under natural conditions in forests (Courty et al. 2010). One of the most important functions of these fungi is the enhanced nutrient uptake of forest trees. Therefore, the functional abilities of nutrient mobilisation from organic material were tested in several forest ecosystems and under diverse environmental conditions (Pritsch and Garbaye 2011). These studies show that species do have different functional abilities in enzymatic activities, e.g. for nitrogen acquisition by degrading proteins in the soil or in lignin degradation (see Figure 57, Hutter et al. in prep). Whereas some mycorrhizal species complement each other, some are redundant in these functions but are sometimes adapted to other soil conditions and might be complementary in additional functions such as water uptake (Buée et al. 2007, Jones et al. 2010, Rineau and Courty 2011). Therefore, on the one hand, high diversity in the mycorrhizal fungal community is of great importance for forest trees to optimally exploit soil resources through the different functional abilities of single species. On the other hand, a high diversity allows the mycorrhizal community to respond to changing environmental conditions and disturbances by modifying the community towards better-adapted species that maintain important ecosystem functions. ... With climate warming, it is expected that the severity and duration of drought will increase, and therefore the maintenance of intact mycorrhizal networks will become more critical to the stability of forest ecosystems (Simard and Austin 2010). ... Several factors, such as natural disturbances, forest management, and anthropogenic pollution, impact this diversity and structure, in most cases by changing the competitiveness and dominance of the species present. Under severe disturbances, species richness is impacted, lowering the potential resistance to additional stresses or even reducing ecological function. ... Although the effect of climate change factors and their interaction on mycorrhizal communities is complex and difficult to predict, it is likely that these communities will help stabilize forest ecosystems under the predicted climatic scenarios (Simard and Austin 2010). Management practices should therefore consider the functional importance of mycorrhizal fungi and their networks in the natural regeneration and resilience of forests.

Martina Peter, Marc Buée and Simon Egli 2013. Biodiversity of mycorrhizal fungi as a crucial player in forest ecosystem functioning. In Daniel Kraus and Frank Krumm (eds.) 2013. Integrative approaches as an opportunity for the conservation of forest biodiversity. European Forest Institute. 284 pp.

http://www.integrateplus.org/uploads/images/Mediacenter/integrate_book_2013.pdf.

The importance of conserving mature forest is highlighted by Riitters et al (2012) who compared the decline in total forest area to the decline in interior forest conditions from 2001 to 2006 at 5 spatial scales and found that interior forest is declining faster than total forest at all spatial scales, with greater losses in the largest spatial scales.

These fragmentation effects are clearly evident in the Pacific Northwest.

Riitters, K.H. & Wickham, J.D. (2012) Decline of forest interior conditions in the conterminous United States. Sci. Rep. 2, 653; DOI:10.1038/srep00653. https://www.srs.fs.fed.us/pubs/ja/2012/ja_2012_riitters_002.pdf

The agency must protect mature forests because they are the best candidates to grow and develop into old-growth habitat in the shortest time frame.

1. There is a serious region-scale deficit in mature and old-growth forest habitat. Over time, the Northwest Forest Plan seeks to re-establish 3.44 million acres of mature and old-growth forest (<http://web.archive.org/web/20030402090844/http://www.fs.fed.us/land/fm/oldgrow/oldgrow.htm>). By continuing to log mature forests we are significantly delaying this recovery. If we are going to make a timely recovery from that deficit, and give struggling species a chance to survive the habitat bottleneck that we have created, we must protect mature forests so that they can become old-growth, and we must manage young forest so they can become mature.
2. The transition from mature forest to old growth is a process that takes time and varies depending on factors such as location and species and disturbance events. In a mature forest, all the ingredients are there to make old growth (e.g., large trees) and the scientists agree that these forests need protection to help meet the current old-growth forest deficit.
3. The architects of the Northwest Forest Plan found that many of our best large intact forest landscapes are mature forests, not old-growth. Some large forest fires burned westside forests between 1840 and 1910 and many such areas were skipped over by the timber harvest planners because they were more intent on converting the very old forests to tree plantations. These former fire areas, now mature forests, offer some of our best hopes of recreating large blocks of intact older forest.
4. Cutting mature forests is not needed for ecological reasons. These forests are already exhibiting the characteristics that provide excellent habitat and they continue to develop and improve without human intervention. As recognized in the Northwest Forest Plan standards and guidelines for Late Successional Reserves, stands over 80 years old do not need to be manipulated to become old-growth. All the ingredients are there, they just need time.
5. Mature forests provide essential habitat for the species we are most concerned with such as: spotted owl, marbled murrelet, Pacific salmon, and most of the [survey and manage] species.
6. Protecting mature and old-growth forest leads to a real ecological solution, while protecting only old-growth is merely a partial solution to an ecological problem that is bigger than just old-growth.
7. Cutting mature forest will remain controversial and socially unacceptable. If we seek to resolve conflict over management of older forests, protecting the old-growth while leaving mature forests unprotected would be only half a solution and would lead to more conflict. Shifting to a restoration paradigm gets everyone at the table working toward the same goal.
8. If mature forest is left unprotected, some members of the environmental community will distrust the agencies and oppose them on many fronts.
9. Leaving mature forests unprotected would leave substantial areas of roadless lands subject to future conflict. Many westside roadless areas may not qualify as old-growth, but still provide important values as roadless and mature forests.
10. Complicated environmental analysis will be required for logging mature forests compared to thinning plantations. Wildlife surveys will be needed. Environmental Impact Statements will more often be needed instead of abbreviated Environmental Assessments. Formal consultation under the Endangered Species Act will more often be triggered.
11. We do not need to log mature forest to provide jobs. Less than 2% of the jobs in Washington and Oregon are in the lumber and wood products sectors, and only a small fraction of those are on federal land and only a fraction of those are related to mature forest logging. Many more environmentally benign jobs are available in restoring roads, streams, thinning young plantations, and managing fire and recreation.
12. We do not need to log mature forest to prop up the economy. The NW economy has greatly diversified in the last decade. Our economy typically creates more new jobs every year than exist in the entire lumber and wood products sectors.

13. We do not need to log mature forest to prop up the timber industry. Less than 10% of the logging in Oregon and Washington in recent years has been on federal lands. Only a fraction of that is mature forest. Much more environmentally benign and socially acceptable timber can be derived from thinning young plantations or small diameter fuel reduction where it is appropriate.

14. Since managing these stands is not "needed" for any ecological reason or any economic or social reason, what would be the objective?

15.

Standing in a mature forest, once gets the distinct feeling that [ldquo]this beautiful place should not be destroyed by logging.[rdquo]

Plantation thinning recommendations

We encourage the Forest Service to focus on thinning dense young plantations where net ecological benefits are more likely to be realized.

Oregon Wild makes the following recommendations to enhance the restoration benefits of young stand thinning prescriptions:

1. When conducting commercial thinning projects take the opportunity to implement other critical aspects of watershed restoration especially pre-commercial thinning, restoring fish passage, reducing the impacts of the road system, and treating invasive weeds.

2. Use projects as an opportunity to learn by conducting monitoring and research on the effects of thinning. There are many information gaps that need filling. Every project should generate useful information to inform future projects.

3. Young stands do not exist in isolation, so be sure to consider the effects of thinning on adjacent mature & old-growth habitat which may provide habitat for spotted owls, marbled murrelets, and other species. Spotted owls may use young stands for dispersal, foraging, and security from predators. It may be helpful to create a [ldquo]risk map[rdquo] that identifies areas that are more or less suitable for thinning based on criteria such as: existing habitat characteristics, proximity to occupied habitat or activity centers, proximity to suitable habitat, and proximity to recently thinned areas, non-habitat, and roads. The agency should also consider adjusting both the location and timing of thinning to minimize the cumulative effects of widespread thinning on the sensitive and listed species.

4. Focus on treating the youngest stands that are most "plastic" and amenable to restoration.

5. Generally retain all the largest trees, and some of the smaller trees in all age-size classes. This can be accomplished in part by retaining untreated [ldquo]skips[rdquo] embedded within the stand.

6. Retain and protect under-represented conifer and non-conifer trees. Protect shrubs as much as possible, especially deciduous and tall shrubs, and those that produce insects, berries and mast. "Although usually classified as a shrub and not considered in discussions of forest composition or structure, *A. circinatum* [vine maple] dominated the angiosperm component, and although comprising only 0.9% of the basal area, it was the most abundant woody species in terms of stem count. This is important because *A. circinatum* makes a disproportionate contribution to biodiversity in this evergreen conifer forest, for example by providing food for folivore geometrid larvae that feed Neotropical migrant birds [26] and by providing substrate for epiphytic lichens and bryophytes [27]." Lutz JA, Larson AJ, Freund JA, Swanson ME, Bible KJ (2013) The Importance of Large-Diameter Trees to Forest Structural Heterogeneity. PLoS ONE 8(12): e82784.

doi:10.1371/journal.pone.0082784.http://ctfs.arnarb.harvard.edu/Public/pdfs/LutzEtAl_PLoS2013.pdf

7.

Strive for a variable density outcome. Be creative in establishing diversity and complexity both within and between stands. Use skips and gaps within units to help achieve diversity. Gaps should be small, while skips should be a little larger, but even small clumps and patches of trees are desirable. Gaps should not be clearcut but rather should retain some residual structure in the form of live or dead trees. Landings do not make good

gaps because they are clearcut, highly compacted and disturbed, more likely subject to repeated disturbance, and directly associated with roads. Using [ldquo]designation by description[rdquo] results in a small amount of within stand variability, but it is a significant compromise compared to the amount of variability that is ecologically desired both within and between stands and that could reasonably be accomplished with a little more effort.

An example showing that old growth trees are not widely or evenly spaced, highlighting the need for variability and retaining clumps of trees.

8. The scale of patches in variable density thinning regimes is important. Ideally variability should be implemented at numerous scales ranging from small to large, including: the scale of tree fall events; pockets of variably contagious disturbance from insects, disease, and mixed-severity fire; soil-property heterogeneity; topographic discontinuities; the imprint of natural historical events; etc.

9. Retain abundant snags and coarse wood both distributed and in clumps so that thinning mimics natural disturbance. Retention of dead wood should generally be proportional to the intensity of the thinning, e.g., heavy thinning should leave behind more snags not less. Retain wildlife trees such as hollows, forked tops, broken tops, leaning trees, etc.

10. Thinning does not always accelerate development of late successional forests, in particular commercial thinning has an adverse effect on snags and dead wood that are defining characteristics of late successional habitat. Thinning might produce the first large trees, but those trees would be vigorous and less likely to experience mortality, so developing large snags is not direct and immediate result of growing large trees. Thinning also dramatically reduces the pool from which future mortality can be recruited so thinning actually retards development of some attributes of late successional forest and spotted owl habitat including snags and down wood. NEPA analyses often assert that "As a result of thinning, growth of retained live trees would be accelerated, so larger trees would be available sooner for recruitment as snags and CWD than without thinning." This is only half the story and it is very misleading. The agency is not being fully honest about the effects of logging unless statements like this are followed by a loud and clear acknowledgement that accelerating development of a few larger live trees (that might become snags if a few of them happen to die) comes at the cost of a significant reduction in the number of medium and large snags over time. From an ecological perspective, the net result of commercial logging is undeniably adverse to snag habitat. The agency cannot present logging as a benefit to snag habitat when it is really a cost that needs to be mitigated.

1. Continuous recruitment of snags is critical to development of old growth forest habitat. We urge the agency to adopt a process-based approach to snag habitat. Instead of focusing on how many snags there are now and immediately after logging, it is better to focus on (i) whether the project will retain an adequate pool of green trees from which to recruit snags and (ii) whether the project will retain the ecological processes that cause mortality, including density dependent mortality and other mechanisms. Commercial logging will significantly harm both of these snag recruitment factors, so mitigation measures are needed. Green tree retention, including generous unthinned [ldquo]skips[rdquo] where density dependent mortality will play out, is necessary to support this process. This is especially critical in previously logged uplands that are already short of snags and in riparian areas where recruitment of large wood is important to stream structure. It is often asserted that thinning grows big trees faster and therefore results in more rapid recruitment of large snags, but FVS and other tools show this NOT to be true. In fact, thinning both reduces and delays recruitment of snags, first by removing trees that would otherwise suffer suppression mortality, and second by increasing stand vigor and postponing overall mortality. See this online slideshow which shows the modeled effects of thinning on dead wood habitat. Heiken, D. 2010. Dead Wood Response to Thinning: Some Examples from Modeling Work. https://www.dropbox.com/s/m4671mhsstg61ss/dead_wood_slides_2.pdf?dl=0. The implications are that heavy thinning should be used sparingly and generous unthinned patches should be retained WITHIN thinned stands in order to continue the snag recruitment process and mitigate for captured mortality. To inform the decision, please conduct a stand simulation model to fully disclose the adverse effects of logging on dead wood, especially large

snags >20[rdquo] dbh, and then mitigate for these adverse effects by identifying areas within treated stands and across the landscape that will remain permanently untreated so they can recruit adequate large snags and dead wood to meet DecAID 50-80% tolerance levels as soon as possible and over the long-term.

2. Artificial snag creation is often proposed as mitigation for the loss of snags during logging, but snags fall down and dead wood decays, so a one-time snag creation effort provides very short-term benefits. Since logging has long-term adverse effects on snag recruitment, it is necessary to adopt mitigation with long-term effects, such as retaining generous untreated [ldquo]skips[rdquo] embedded within treatments areas where natural mortality processes can flourish.

3. Recognize that dead wood values are sacrificed in thinned areas due to the effect of [ldquo]captured mortality,[rdquo] while other late successional values, such as rapid development of large trees and understory diversity may be delayed in unthinned areas, so an important step in the restoration process is to identify the most optimal mix of treated (thinned) and untreated (unthinned) areas. We think this should be a conscious and well-documented part of the NEPA analysis, not just an accidental byproduct of what[rsquo]s economically thinnable. Tools like DecAID might be used to identify goals for large and small snags that need to be met over time and at the geographic scale of home-ranges of focal species. This can help identify the scale and distribution of untreated [ldquo]skips.[rdquo]

4. Thin heavy enough to stimulate development of understory vegetation, but don[rsquo]t thin too heavy. Recognize that thinning captures mortality and that plantation stands are already lacking critical values from dead wood due to the unnatural stand history of all clearcut and planted stands. Tom Spies made some useful observations in the Northwest Forest Plan Monitoring Synthesis Report: [ldquo]Certainly, the growth of trees into larger diameter classes will increase as stand density declines (Tappeiner and others 1997). At some point, however, the effect of thinning on tree diameter growth levels off and, if thinning is too heavy, the density of large trees later in succession may be eventually be lower than what is observed in current old-growth stands. In some cases, opening the stand up too much can also create a dense layer of regeneration that could become a relatively homogeneous and dominating stratum in the stand. Furthermore, if residual densities are too low, the production of dead trees may be reduced (Garman and others 2003). Thinning should allow for future mortality in the canopy trees.[rdquo] <http://web.archive.org/web/20070808101639/http://www.reo.gov/monitoring/10yr-report/documents/synthesis-reports/index.html>.

5. If using techniques such as whole-tree yarding or yarding with tops attached to control fuels, the agency should top a portion of the trees and leave the greens in the forest in order to retain nutrients on site. Achat, Deleuze, et al 2015. Quantifying consequences of removing harvesting residues on forest soils and tree growth [ndash] A meta-analysis. *Forest Ecology and Management* Volume 348, 15 July 2015, Pages 124[ndash]141. <http://www.sciencedirect.com/science/article/pii/S0378112715001814> ([ldquo]Our study showed that, compared with conventional stem-only harvest, removing the stem plus the harvesting residues generally increases nutrient outputs thereby leading to reduced amounts of total and available nutrients in soils and soil acidification, particularly when foliage is harvested along with the branches. [hellip] Soil fertility losses were shown to have consequences for the subsequent forest ecosystem: tree growth was reduced by 3-7% in the short or medium term (up to 33 years after harvest) in the most intensive harvests (e.g. when branches are exported with foliage). Combining all the results showed that, overall, whole-tree harvesting has negative impacts on soil properties and trees that may have an impact on the functioning of forest ecosystems.[rdquo])

6. Thinning creates activity fuels that can be treated (or not treated) in a variety of ways. Strive to treat fuels in ways that provide public benefits such as wildlife habitat (e.g., complex woody structure) and charcoal production (e.g., enhanced soil carbon storage), and reduce detrimental soil impacts from machine piling and hot burn piles. Deborah S. Page-Dumroese et al. 2017. Methods to Reduce Forest Residue Volume after Timber Harvesting and Produce Black Carbon. *Scientifica*. Volume 2017 (2017), Article ID 2745764, <https://doi.org/10.1155/2017/2745764>; <https://www.hindawi.com/journals/scientifica/2017/2745764/>

7. Recognize and mitigate adverse effects of thinning on spotted owl prey such as flying squirrels, red tree voles, and chipmunks. Avoid impacts to raptor nests and enhance habitat for diverse prey species. Train marking crews and cutting crews to look up and avoid cutting trees with nests of any sort and retain trees with defects such as forks, broken tops, etc...

8. Take proactive steps to avoid the spread of weeds. Use canopy cover to suppress weeds. Avoid soil

disturbance and road construction. Scarifying landings and tempera roads and planting with native seeds is a good idea but please take steps to ensure that it is effective.

9. Buffer streams from the effects of heavy equipment and loss of bank trees and trees that shade streams. Mitigate for the loss of LWD input by retaining extra snags and wood (and green trees for recruitment) in riparian areas. Recognize that thinning [ldquo]captures mortality[rldquo] and results in a long-term reduction in recruitment of functional down wood, and that effect is not mitigated by future growth.

10. Avoid road construction. Building new roads will cause degradation that typically erases any alleged benefit of treatments. Roads have a variety of long-lasting adverse impacts on soil, water, and wildlife. Focus treatments on areas accessible from existing roads. Inaccessible areas can be treated non-commercially or become part of the landscape mosaic that is untreated and serve important ecological values such as dense forest cover, carbon storage, and natural rates of snag recruitment.

11. Where road building is necessary, ensure that the realized restoration benefits far outweigh the adverse impacts of the road. Carefully consider the effects of roads on connectivity, especially at road/stream crossings, across ridge tops, and midslope hydrological processes (such as large wood delivery routes). The NEPA analysis should rank new road segments according to their relative costs (e.g. length, slope position, soil type, ease of rehabilitation, weed risk, native vegetation impacts, etc.) and benefits (e.g. acres of restoration facilitated), then use that ranking to consider dropping the roads with the lowest ratio of benefits to costs. Avoid log hauling during the wet season. Once the relative acres accessed per mile of road is determined, take the analysis one step further and determine the [ldquo]effective road density[rldquo] of each segment. In other words, extrapolate as if that much road were required to reach each acre of the planning area, then compare the resulting road density to standards for big game, cumulative hydrological impact, etc? For example, if a new spur road accesses thinning opportunities at a rate of 200 acres of forest per mile of road, then divide 640 acres per section by 200 acres per mile to determine the effective road density of 3.2 mi/mi².

12. If this project involves biomass utilization, the impacts need to be clearly disclosed. How will the biomass be moved from the remote corners of the treatment areas to the landings? Will there be extra passes made by heavy equipment? Will the landings be enlarged to make room for grinders, chip vans, and other equipment? Can the local forest roads accommodate chip vans? Will the roads be modified to make them passable by chip vans? What are the impacts of that? What are the direct, indirect, and cumulative impacts on soil, water, wildlife, and weeds?

13. Adopt a purpose and need to maintain and increase carbon storage in forest ecosystems. Develop an alternative that addresses carbon and climate by (a) deferring harvest of older forests to store carbon and provide biodiversity and connectivity and (b) thin younger stands to increase forest resilience and diversity and connectivity. Recognize that there is a carbon cost associated with thinning. As stands develop from young to mature to old, they recruit large amounts of material from the live tree pool to the dead wood pool and this pool continues to accumulate large amounts of carbon for centuries. Logging, even thinning, can dramatically affect the accumulation of carbon in the dead wood pool by capturing mortality, diverting it from the forest, and accelerating the transfer of carbon to the atmosphere. Carbon stays out of the atmosphere much longer if it remains in the forest as live and/or dead trees, instead of being converted to wood products and industrial and consumer waste.

14. If the stands to be thinned are younger than 80 years, the agency may rely on the Pechman exemption and not complete surveys for rare and uncommon species. However, this exemption is intended to apply to even-aged stands. If there are distinguishable legacy trees (more than 2 per acre) those areas are not part of the younger stand, and not eligible for the Pechman exemption, therefore the agency must survey for red tree voles and other survey and manage species.

15. Descriptions of the effect of NOT thinning dense young stands should incorporate the information presented in Lutz. J.A. 2005. The Contribution of Mortality to Early Coniferous Forest Development. MS Thesis. University of Washington. http://faculty.washington.edu/chalpern/Lutz_2005.pdf. This MS Thesis looked at long-term transect data from young forests in Western Oregon and found that non-competitive mortality and gap forming processes are very much in operation in dense young planted stands. This indicates that in young stands the homogenizing influence of stand growth and competitive mortality is significantly counter-balanced by non-competitive mortality that tends toward heterogeneity and structural diversification. This means that if young

stand management is to effectively mimic natural patterns and processes, that variable density treatments must be the rule, and the scale of the mosaic must be very fine scale. Note: The study sites were located in the HJ Andrews Experimental Forest and were not naturally regenerated, so it is likely that in young stands that are naturally regenerating after disturbance such as fire, the heterogeneity and gap-forming processes would be even more pronounced. See also Lutz & Halpern 2006. Tree Mortality During Early Forest Development: A Long-Term Study Of Rates, Causes, And Consequences. Ecological Monographs, 76(2), 2006, pp.

257[ndash]275. http://cfr501.jamesalutz.com/Lutz_Halpern_Mortality_EM_2006.pdf and Franklin, J. F., T. A. Spies, R. Van Pelt, A. B. Carey, D. A. Thornburgh, D. R. Berg, D. B. Lindenmayer, M. E. Harmon, W. S. Keeton, D. S. Shaw, K. Bible, and J. Chen. 2002. Disturbances and structural development of natural forest ecosystems with silvicultural implications, using Douglas-fir as an example. Forest Ecology and Management 155:399-423. http://www.fs.fed.us/pnw/pubs/journals/pnw_2002_franklin001.pdf

16. Focus the analysis on [ldquo]trade-offs[rdquo] related to logging. All logging, including thinning stands of any age, include some adverse impacts and trade-offs. Some impacts of logging are unavoidable, so there is no such thing as a logging operation that is 100% beneficial. Depending on how thinning is done, it can have adverse impacts such as soil disturbance; habitat disturbance; damage to the shrub layer; carbon removal; spreading weeds; reduced populations of prey for carnivorous species; reduced recruitment of snags; road-related impacts on soil, water, site productivity, and habitat; moving fuels from the canopy to the ground, hotter-drier-windier microclimate that is favorable to greater flame lengths and rate of fire spread, etc. Some of these negative effects are fundamentally unavoidable, therefore all thinning has negative effects that must be compensated by beneficial effects such as reducing competition between trees so that some can grow larger faster, increased resistance drought stress and insects, possible increasing species and structural diversity, possible fire hazard reduction, etc. It is generally accepted that when thinning very young stands, the benefits outweigh the adverse impacts and net benefits are likely. It is also widely understood that thinning older stands tends to have greater impacts on soil, water, weeds, carbon, dead wood recruitment so the impacts very often outweigh the benefits, resulting in net negative outcome on the balance sheet. Thus, as we move from young forest to older forests, the net benefits turn into net negative impacts. See Klaus J. Puettmann, Adrian Ares, and Erich Dodson. 2011. Over- and understory vegetation responses to thinning treatments: Can we accelerate late successional stand structures? Symposium: Density Management In The 21st Century: West Side Story.

<http://oregonstate.edu/conferences/event/densitymanagement2011/agenda.pdf> ([ldquo]growth of large trees was less responsive to thinning and low mortality rates for larger trees resulted in little recruitment of large snags or coarse woody debris (down wood). In general, thinning increased abundance and diversity of early-seral understory species, with little effect on late-seral species. On sites where shrub cover was already high harvesting initially reduced the cover, but shrubs recovered over time. Exotic species slightly increased in response to treatment [hellip][rdquo]); and Erich K. Dodson, Adrian Ares, and Klaus J. Puettmann. 2011. Thinning effects on tree mortality and snag recruitment. Symposium: Density Management In The 21st Century: West Side Story. <http://oregonstate.edu/conferences/event/densitymanagement2011/agenda.pdf> ([ldquo][hellip]thinning did little to accelerate the development of large snags and coarse downed wood that provide critical wildlife habitat[hellip][rdquo]) These are some of the trade-offs that must be disclosed and weighed in the NEPA document.

17. Provide clear and detailed rationale that connects proposed actions to desired conditions. Test the rationale for actions and effects analysis against the scientific evidence, including the full range of evidence, reasonable opposing viewpoints, and the evidence presented in these comments. For each treatment unit, provide clear descriptions of silvicultural prescriptions and marking guides in the NEPA document.

18. Make the NEPA analysis thorough, explicit, and transparent on all these issues.

Focus on the younger stands, defer the older stands.

We encourage the Forest Service to develop a preferred alternative that focuses on thinning young stands where there are potential net ecological benefits, instead of logging older forests where the adverse effects are highly likely to outweigh any benefits, especially when the social cost of carbon emissions are considered.

Recent research by Tappeiner, Poage, and others indicates that a substantial portion of a tree's size and character at several hundred years of age can be explained by the tree's rate of growth at age 50. This leads to a tentative conclusion that thinning stands younger than 50 years old should be a higher priority than thinning stands older than 50 years.

Recent modeling also found it difficult to alter the development trajectories of well-established young stands that were first managed at age class 50 [years] and concluded that earlier intervention would have promoted deeper crowns and lead to greater diameter class differentiation. Andrews, Perkins, Thrailkill, Poage, Tappeiner. 2005. Silvicultural Approaches to Develop Northern Spotted Owl Nesting Sites, Central Coast Ranges, Oregon. West. J. Appl. For. 20(1):13-27.

The 1992 draft recovery plan for the Northern Spotted Owl urged early intervention in young stands because they are more "plastic" before crowns become too small and management option diminish. See 1992 Final Draft recovery plan for the Northern Spotted Owl pp 487-489.

Trees that still have a lot more growing to do are far more likely to respond well to thinning because they can put a lot more growth into their still-developing crowns, whereas older trees that are not expected to grow much higher have much less responsive crowns so will not respond as well to thinning. J.C. Tappeiner II, W.H. Emmingham, and D.E. Hibbs. Silviculture of Oregon Coast Range Forests. Chapter 7 in Forest and Stream Management in the Oregon Coast Range. Edited by Stephen D. Hobbs, John P. Hayes, Rebecca L. Johnson, Gordon H. Reeves, Thomas A. Spies, John C. Tappeiner II, and Gail E. Wells, 2002.

Thinning the harvest units that are less than 50 years old will hopefully have minimal impact on the environment (especially soil, water, and wildlife) and thinning such young stands will likely have long-term ecological benefits in terms of accelerating late successional forest characteristics.

However, thinning the harvest units that are over 50 years old is more likely to have significant environmental impacts and the long-term benefits in terms of accelerating development of late-successional characteristics is uncertain at best. Recent science tells us that thinning in older stands is less likely to change the trajectory of the stands. The agency should refocus its efforts on younger stands where the results are likely to be on balance more beneficial.

There is scientific controversy over the question of whether and to what degree it is beneficial to thin older trees to accelerate late-successional characteristics. An EIS is needed to address this question.

Stimulating the development of a diverse understory is often used as a justification for thinning, but this may not be justified in stands older than about 40 years. A systematic review of 917 Forest Inventory and Analysis (FIA) plots in western Oregon (mostly on non-federal lands) found, [ldquo]Contrary to expectations of canopy closure, mean canopy cover by age class rarely exceeded 85 percent, even in unthinned productive young conifer forests. Possibly as a result, effects of stand age on understory vegetation were minimal, except for low levels of forbs found in 20- to 40-year-old wet conifer stands. [hellip] Although heavily thinned stands had lower total cover, canopy structure did not differ dramatically between thinned and unthinned stands. Our findings suggest potential limitations of simple stand succession models that may not account for the range of forest types, site conditions, and developmental mechanisms found across western Oregon.[rdquo] McIntosh, Anne C.S.; Gray, Andrew N.; Garman, Steven L. 2009. Canopy structure on forest lands in western Oregon: differences among forest types and stand ages. Gen. Tech. Rep. PNW-GTR-794. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 35 p. http://www.fs.fed.us/pnw/pubs/pnw_gtr794.pdf. This seems to indicate that the benefits of thinning may be best realized in dense stands younger than 40 years old. This study also showed that in wet conifer stands the mean Canopy Height Diversity Index and the mean Simpson[rsquo]s Diversity Index of tree heights leveled off at about age 65. This study also looked at canopy conditions after three levels of thinning intensities (heavy, light, and none). [ldquo]Mean cover of the lower canopy layer was nominal for all three thinning intensities. [hellip] There were no evident trends between understory cover and thinning history; both shrub and forb cover were fairly similar among the three thinning intensities. [hellip] The lack of a strong effect of crown closure on understory cover may be related to our finding that mean crown cover did not exceed 85 percent. [hellip] We expected greater cover of understory vegetation in thinned than in unthinned stands but did not detect significant differences in this analysis.[rdquo]

Scientists have also presented findings that many young densely stocked stands may not develop into late-successional stands as projected in the Northwest Forest Plan. This is new information that must be addressed in a new EIS to consider the consequences of more thinning of young stands (or the lack thereof) on spotted owls and all the other species dependent upon late-successional habitat.

The NEPA analysis should have a good discussion (in light of recent research results) of the anticipated impacts and benefits of thinning on the different age classes of trees in the different harvest units. The NEPA analysis should include another alternative that considered deferring harvest of the older stands.

[ldquo]Within stands [hellip] lacking in late-successional habitat, those stands that would respond to treatment by accelerated development into late-successional habitat. Younger stands are generally more responsive to treatment, and should be considered higher priority than older mid-successional stands, relative to this objective.[rdquo] Shasta-Trinity Forest-wide LSR Assessment. 8-26-1999.

A study of the effects of thinning on tree stability and height/diameter ratios found:

The results suggest that plantation H/D values can be lowered and stability promoted through reduced planting densities or early thinning; however, later thinnings may not be effective in promoting stability, since they do not appear to lower H/D values. Higher initial planting densities shorten the time period during which thinning can be expected to effectively lower future H/D values. [hellip] [H]igh density stands have limited stand-height window during which thinning can be used to improve future stand stability substantially.

Wilson, J.S., and C.D. Oliver. 2000. Stability and Density Management in Douglas-fir Plantations, *Can. J. For. Res.* 30(6): 910-920 (2000).

See Muir, P.S., R.L. Mattingly, J.C. Tappeiner II, J.D. Bailey, W.E. Elliott, J.C. Hagar, J.C. Miller, E.B. Peterson, and E.E. Starkey. 2002. Managing for biodiversity in young Douglas-fir forests of western Oregon. U.S. Geological Survey, Biological Resources Division, Biological Science Report USGS/BRD/BSR[ndash]2002-0006. 76 pp. http://www.fsl.orst.edu/cfer/pdfs/mang_bio.pdf.

The Eugene BLM described the expected result of thinning a dense stand of 77 year old Douglas-fir[mdash]

Thinning [hellip] by itself, would not speed development of late-successional forest structure. Thinning would retain a relatively high overstory density and would result in only a modest increase in diameter growth of the retained trees. Additional thinning or other disturbance that would substantially lower overstory density would be needed before the stand would develop late-successional structure, such as multiple canopy layers, shade-tolerant conifer understory, or a wide range of tree diameters (Spies and Franklin 1991; see also BLM 2003, pp. 66-69, 171-174).

Eugene BLM. Bear Creek Timber Sale EA, April 2004.

<http://www.edo.or.blm.gov/planning/nepa/documents/BearCrkEA.pdf> (link broken 7/31/2012).

The age at which a forest is thinned has a strong effect on aboveground C storage. Evidence from the few PCT studies that considered timing of thinning shows that total stem volume, which is a large component of the aboveground C (Harmon et al., 2004), is greater in stands thinned early as compared to stands thinned later (Varmola and Salminen, 2004). This is consistent with stand dynamics theory, which suggests that wood volume growth rates recover more quickly from early thinnings than from late thinnings (Oliver and Larson, 1996; Long et al., 2004; Varmola and Salminen, 2004).

Michael S. Schaedel, Andrew J. Larson, David L.R. Affleck, R. Travis Belote, John M. Goodburn, Deborah S. Page-Dumroese. 2017. Early forest thinning changes aboveground carbon distribution among pools, but not total amount. *Forest Ecology and Management* 389 (2017) 187[ndash]198.
https://www.fs.fed.us/rm/pubs_journals/2017/rmrs_2017_schaedel_m001.pdf.

All logging, including thinning stands of any age, include some adverse impacts and trade-offs. Some impacts of logging are unavoidable, so there is no such thing as a logging operation that is 100% beneficial. Depending on how thinning is done thinning can have adverse impacts such as soil disturbance, habitat disturbance, carbon removal, spreading weeds, reduced recruitment of snags, road-related erosion and hydrologic impacts, moving fuels from the canopy to the ground, hotter-drier-windier microclimate that is favorable to greater flame lengths and rate of fire spread, etc. Some of these negative effects are fundamentally unavoidable, therefore all thinning has negative effects that must be compensated by beneficial effects such as reducing competition between trees so that some can grow larger faster, increased resistance drought stress and insects, increasing species

diversity, possible fire hazard reduction, etc. It is generally accepted that when thinning very young stands, the benefits outweigh the adverse impacts and net benefits are likely. It is also widely understood that thinning older stands tends to have greater impacts on soil, water, weeds, carbon, dead wood recruitment so the impacts very often outweigh the benefits, resulting in net negative ecological outcome on the balance sheet. As we move from young forest to older forests, the net benefits turn into net negative impacts, but where is that line? The authors of the Northwest Forest Plan took all this into account and determined that 80 years is a useful place to draw the line between forests that are likely to benefit from silviculture and those that are likely to experience net negative consequences. There is no new science to change that conclusion. In fact, new information developed since 1994 shows that dead wood is probably more valuable than previously thought - being important for a wide variety of ecological functions, not least of which is providing complex habitat that supports prey species for spotted owl and a variety of other predators both east and west of the Cascades. As stands become mature at around 80 years of age, they begin accumulating snags and dead wood from natural mortality processes. Thinning [ldquo]captures mortality[rdquo] and removes it from the forest thus preventing those trees from ever becoming snags and dead wood and interrupting the critical process whereby mature forests accumulate dead wood. The loss of recruitment of dead wood habitat when logging older stands is a long-term impact and provides a very strong argument against logging in stands over 80 years old. For further information see 1993 SAT Report pp 146-152. AND February 1991 Questions and Answers on A Conservation Strategy for the Northern Spotted Owl (prepared in response to written questions from the Senate Energy and Natural Resources Committee to the Interagency Scientific Committee on the May 1990 ISC Report. AND Jerry Franklin, David Perry, Reed Noss, David Montgomery, Christopher Frissell. SIMPLIFIED FOREST MANAGEMENT TO ACHIEVE WATERSHED AND FOREST HEALTH: A CRITIQUE. National Wildlife Federation. <http://www.coastrange.org/documents/forestreport.pdf>.

Robert Anthony reminded the regional executives in 2013 that:

The long-term benefits of thinning in young plantations to create forests with characteristics of late-successional forests (e.g. large diameter standing and down wood) may outweigh any short-term negative effects on owls or their prey. However, as the age of forests selected for thinning increases, the short-term negative effects of such activities will likely increase and the benefits decrease. The Northwest Forest Plan specified a maximum age of 80 years for forests that are slated for thinning. The reasons for this guideline were that (1) it was unclear if thinning could actually accelerate the rate at which naturally regenerated mature forests developed old forest conditions, and (2) spotted owls forage in mature forests, and thinning of these forests will likely reduce their quality as spotted owl habitat both in the short and long term.

Anthony, R.G. 2013. [ldquo]Effects of Riparian Thinning on Marbled Murrelets and Northern Spotted Owls.[rdquo] Part III of the Science Review Team for the identification and interpretation of the best available scientific information to determine effects of riparian forest management. 28 January 2013.

Another study that supports the emphasis on early intervention is Peter, David H.; Harrington, Constance A. 2010. Reconstructed old-growth forest stand structure and composition of two stands on the Olympic Peninsula, Washington state. Res. Pap. PNW-RP-583. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 22 p. http://www.fs.fed.us/pnw/pubs/pnw_rp583.pdf ([ldquo]These sites appear to have multiple developmental pathways determined by events early in their stand histories that affect stand structure and composition for hundreds of years. This has implications for the possibilities of, and methodologies for, restoration of old-growth structure and function. But, naturally or through silvicultural manipulation, diversification in at least these plant associations is encouraged by lower early conifer density, patchy spacing of dominant trees, and prevention of immediate conifer occupancy of openings.[rdquo])

Thinning in the Matrix must be Restorative and Variable

In the NWFP conservation scheme the role of matrix lands is primarily to support owl dispersal, but also:

- * To provide connectivity for dispersal and interaction of owls among HCAs. [hellip].
- * To maintain options for returning owls to the forest matrix by retaining older forest structures in the managed landscape.
- * To develop and apply experimental silvicultural treatments that may support a viable owl population in the forest matrix.
- * To contribute toward a short-term viable population (less than 50 years).

(ISC Report p 318). The quality of matrix lands for meeting these objectives is directly related to the extent that it resembles nesting, roosting, and foraging habitat. If structurally simple stands in the matrix can be modified to be more complex in terms of species diversity, niche diversity, and dead wood abundance, they will support better foraging opportunities which will greatly improve the quality of dispersal habitat.

The agency should not rely on outdated science suggesting that 40% canopy cover represents owl dispersal habitat. New information indicates that spotted owl dispersal habitat should be managed for [ldquo]at least 80%[rdquo] canopy cover. See Stan G. Sovern, Eric D. Forsman, Katie M. Dugger, Margaret Taylor. 2015. Roosting Habitat Use and Selection By Northern Spotted Owls During Natal Dispersal. The Journal of Wildlife Management 79(2):254[ndash]262; 2015; DOI: 10.1002/jwmg.834. ([ldquo]Roost Site Selection. In contrast to the assumption that stands with relatively open canopies provide suitable dispersal habitat for spotted owls, our results suggest that dispersing juveniles selected stands for roosting that had relatively high canopy closure ($x = 66 + 2\%$). [hellip] Two hypotheses could explain why dispersing owls selected closed-canopy stands. First, several researchers (Barrows 1981, Forsman et al. 1984, Weathers et al. 2001) have shown that temperature and precipitation appear to influence selection for roost trees and attributes within a roost tree, such as perch height and percent overhead cover. [hellip] Second, juvenile northern spotted owls may have selected for closed-canopy forest because their preferred prey were most abundant [hellip] Landscape Scale Selection. [hellip] [O]ur mean estimate of canopy closure from plots at roosts (66%), which was likely an underestimate of canopy cover, was considerably higher than the minimum values recommended by Thomas et al. (1990) [i.e. 50-11-40]. [hellip] Management Implications. [hellip] Based on our study, we recommend that managers should pursue a strategy that exceeds the canopy cover guidelines recommended by Thomas et al. (1990) when managing dispersal habitat for spotted owls. Based on our estimate of mean canopy closure (66%), and our estimate of mean canopy cover from overlaying a dot grid on the same areas (approx. 14% larger), we recommend that the target for canopy cover in stands managed for dispersing spotted owls should be at least 80%.[rdquo])

Owl habitat is characterized by large trees, high canopy closure, abundant dead wood, well-developed understories. A few of these qualities can be attained with traditional uniform thinning (large trees and canopy closure), but all of them are more likely to be attained with variable density thinning and managing for decadence. In particular, canopy closure and well-developed understories are best achieved with variable density thinning.

The agency should design matrix thins to support abundant and diverse populations of owl prey species. [ldquo][H]abitat elements that support prey [include] (mistletoe, snags, down wood, forage lichens, truffles abundance)[rdquo] NSO FRP p 114. Where owl prey base is diverse and abundant spotted owl home ranges

tend to be smaller which is energetically advantageous and enhances owl survival rates. Carey, A. 2004 Relationship of Prey and Forest Management. Appendix 5 pp 3-24, 3-25 in Courtney, SP; J A Blakesley. 2004. Scientific evaluation of the status of the Northern Spotted Owl. <http://www.sei.org/owl/finalreport/finalreport.htm>. [ldquo]Numerous patches of low foraging quality can have negative impacts on owl demography and behavior (Carey et al 1992).[rdquo] id. and this is precisely what uniform thinning that [ldquo]captures mortality[rdquo] will do to current and future spotted owl home ranges. A large number of owl prey species have some association with snags and down wood either as sites for denning or as a source of fungal food supplies. Traditional thinning will reduce the recruitment of dead trees and down wood and further simplify the forest structure for many decades. Establishing diverse micro-habitats and creating and retaining large numbers of snags and down wood will help the spotted owl through the habitat bottleneck that it is now going through.

Small mammal populations also appear to increase with understory cover which can follow some forms of thinning. Waldien and Hayes. 2006. Influence of Alternative Silviculture on Small Mammals. USGS/CFER Fact Sheet. July 2006. <http://www.fsl.orst.edu/cfer/pdfs/CFERFS05.pdf>.

North et al. (1999) noted in a study of foraging habitat selection by northern spotted owls, [ldquo]In our study area, stands with high use by owls typically included many [lsquo]legacies[rsquo] (large trees and snags) that survived a fire or windstorm that destroyed much of the previous stand. They found that [ldquo]stands with 142 m³/ha of intact snags and a high diversity of tree heights had medium or high foraging use by spotted owls. In these old-growth stands, biological legacies (e.g., large trees and snags) produced by past disturbance provide important forest structures associated with spotted owl foraging.[rdquo] North, Franklin, Carey, Forsman, Hamer. 1999. Forest Stand Structure of the Northern Spotted Owl[rsquo]s Foraging Habitat. For. Sci. 45(4):520-527.

Some have concluded that light, uniform thinnings in young stands are unlikely to attain biodiversity conservation objectives. See Duncan S. Wilson, and Klaus J. Puettmann. Density management and biodiversity in young Douglas-fir forests: challenges of managing across scales. DRAFT submitted to Forest Ecology and Management. August 2006.

Given all the new information on the risks and uncertainties faced by spotted owls, thinning projects in the Matrix should apply variable density thinning techniques because variable density thinning and managing for decadence will help increase the complexity of the forest (structural complexity and plant species diversity) thereby increasing populations of owl prey species and enhancing owl foraging opportunities within owl dispersal/foraging habitat.

VDT will not conflict with matrix objectives. Matrix objectives include timber production as well as habitat and species diversity. Variable thinning will produce potentially more wood products in the short-term as well as significant wood products in the long-term. There is absolutely no requirement that the agencies MAXIMIZE timber production. The ecological benefits of variable density thinning are significant and should not be forgone. There are operational challenges with implementing effective variable thinning prescriptions but the agencies must embrace the challenges and instead of retreating from the ecological objectives of the matrix, the agencies must apply their best thinking and creativity to the objective of creating species-diverse and structurally rich and complex mid-seral forest habitat.

The matrix is supposed to provide wildlife habitat and connectivity and VDT will help the matrix achieve these objectives while also improving the growth of favored commercial tree species. Matrix is not a tree farm. It still has a role to play in providing diverse habitats, so don't just grow trees, grow forests.

The matrix is an integral part of the management direction included in these standards and guidelines. Production of timber and other commodities is an important objective for the matrix. However, forests in the matrix function as connectivity between Late-Successional Reserves and provide habitat for a variety of organisms associated with both late-successional and younger forests. Standards and guidelines for the matrix are designed to provide for important ecological functions such as dispersal of organisms, carryover of some species from one stand to the next, and maintenance of ecologically valuable structural components such as down logs, snags, and large trees. The matrix will also add ecological diversity by providing early-successional habitat.

[hellip]

Matrix objectives for silviculture should include: (1) production of commercial yields of wood, including those species such as Pacific yew and western red cedar that require extended rotations, (2) retention of moderate levels of ecologically valuable old-growth components such as snags, logs, and relatively large green trees, and (3) increasing ecological diversity by providing early-successional habitat.

[hellip]

Stands in the matrix can be managed for timber and other commodity production, and to perform an important role in maintaining biodiversity. Silvicultural treatments of forest stands in the matrix can provide for retention of old-growth ecosystem components such as large green trees, snags and down logs, and depending on site and forest type, can provide for a diversity of species. Retention of green trees following timber harvest in the matrix provides a legacy that bridges past and future forests. Retaining green trees serves several important functions including snag recruitment, promoting multistoried canopies, and providing shade and suitable habitat for many organisms in the matrix.

1994 NWFP ROD pp B-1 to B-6 (emphasis added). Clearly VDT, will meet matrix objectives by providing wood products, and by promoting multistoried canopies, providing diversity of species, creating and maintaining structural features such as snags, logs, and large trees, and providing opportunities for early-seral species to persist in mid-seral stands.

According to the 2003 Draft SEIS for survey and manage, [ldquo]Matrix was also expected to provide for ecologically diverse early-successional conditions and planned timber harvest.[rdquo] (DSEIS page 68). Variable density thinning is appropriate in the matrix because VDT expands future options for multiple-use/sustained yield in its fullest dimension and VDT does not foreclose any matrix objectives.

Variable Density prescriptions will also improve connectivity by enhancing foraging opportunities for dispersing predators such as spotted owls (and other raptors), marten, fisher, etc. Young and mid-seral forest may not provide ideal nesting/denning conditions but they often do provide for important dispersal functions. If these young and mid-seral forests are species-diverse and structural complex, they are more likely to have healthy populations of small mammals, birds, and other prey species relied upon by predator species of concern.

Variable density thinning can create a variety of micro-habitats that may be suitable for different species. Andy Carey found that VDT could establish patchy habitat patterns that could lead to the development of small mammal populations that are not only more dense but more diverse compared to uniformly thinned stands.

Our results support hypotheses that: (1) biocomplexity resulting from interactions of decadence, understory development, and overstory composition provides pre-interactive niche diversification with predictable, diverse, small mammal communities; (2) these communities incorporate numerous species and multiple trophic pathways, and thus, their integrity measures resiliency and sustainability.

Thus, increasing complexity of the environment through increasing horizontal and vertical heterogeneity in vegetation structure, species diversity in vascular plant composition, and forest-floor structure with coarse woody debris may simultaneously (1) increase multidimensional habitat space (Carey et al., 1999a), (2) reduce frequencies and intensities of interspecies interactions (Grant, 1972; Carey et al., 1980), (3) increase or maintain the already high abundance and diversity of seed fall, fungal fruiting bodies, and invertebrates characteristic of mesic, temperate coniferous forests (Church field, 1990), and (4) allow not only coexistence, but abundance of potentially competing species within communities (Carey and Johnson, 1995, this study). As a result of this complexity, Pacific Northwest forests support the greatest diversity of shrews in North America (Rose, 1994)

[hellip]

These studies do suggest that management can homogenize and simplify (reduce decadence, amounts of coarse woody debris, variety of tree species, diversity and abundance of understory vegetation, and spatial heterogeneity) forest ecosystems. We found local extirpations of a number of species and particularly absence of *G. sabrinus* and *T. townsendii* in multiple plots. These absences raise questions about long-term viability of these species in managed landscapes. Management-induced homogeneity and simplification (1) is a real danger to diversity, resiliency, and susceptibility to invasions of exotic plants (Carey, 1998; Carey et al., 2000; Halpern et al., 1999; Heckman, 1999; Thysell and Carey, 2000), (2) may result in small-mammal communities non-supportive of predators populations (Carey et al., 1992; Carey and Peeler, 1995), [hellip]

Andrew B. Carey, Constance A. Harrington; Small mammals in young forests: implications for management for sustainability; *Forest Ecology and Management* (2001) 154(1-2): 289-309;
http://www.fs.fed.us/pnw/pubs/journals/pnw_2001_carey003.pdf.

High density and diversity of prey species is clearly advantageous for spotted owls. Dense populations of prey allow for smaller home ranges which is energetically advantageous, while diverse populations reduces the risk that any one species population will decline and leave the owl vulnerable. [ldquo][E]xperiments in both terrestrial and aquatic microcosms have tended to find that increasing the number of prey items enhances stability.[rdquo] Kevin Shear Mccann, The diversity[ndash]stability debate. *Nature* 405, 228 - 233 (11 May 2000).
http://www.iterations.com/protected/download_files/diversity_stability_debate.pdf. Thinning variably will enhance the habitat for more than one prey species. If one species declines, the owl has other options so diverse prey base tends to have a stabilizing effect on owl populations. The agency can have all these ecological benefits

from restoration silviculture and still support some jobs and produce some wood products.

Use small, heavily thinned [ldquo]gaps[rdquo] to add complexity.

Small [ldquo]gaps[rdquo] can be used to increase habitat diversity within stands. Gaps should be small - on the order of a few acres or less than an acre. Smaller gaps need less retained structure. Larger gaps need more retained structure. Gaps should not be mini-clearcuts but should retain abundant structure. Try to mimic disturbances such as fire or beetles killed trees but did not remove them. It is not always desirable to replant conifers in gaps, so that complex early seral conditions can be prolonged. Jo[uml]rg Mu[uml]ller, Heinz Bu[szlig]ler, Martin Go[szlig]ner, Thomas Rettelbach, Peter Duelli. 2008. The European spruce bark beetle *Ips typographus* in a national park: from pest to keystone species. *Biodivers Conserv* (2008) 17:2979[ndash]3001. http://www.toek.wzw.tum.de/fileadmin/1_Datein/PDF_Publikationen/2008-17.pdf ([ldquo]As a recommendation to forest management for increasing insect diversity even in commercial forest, we suggest that logging in recent gaps in medium aged mixed montane stands should aim at retention of a part of the dead wood. Planting should be avoided, to lengthen the important phase of sunlit conditions. [hellip] For all taxa, our results showed higher species density only in bark beetle gaps [as compared to meadows and clearcuts]. [hellip] In [beetle-created] gaps most of the recorded species were inhabitants of complex habitats and occurred only where inflorescences, trees and dead wood are available together.[rdquo])

Planting these openings with red alder would delay occupation by shade-tolerant conifers. The natural fertilization from the red alder trees would further encourage conifer size diversification. Shrub and herb understory development under red alder is greater and more diverse than under conifers (Franklin and Pechanec 1968), and conifer replacement of red alder is relatively sparse and slow (Newton et al. 1968) facilitating shrub and herb retention.

Peter, David H.; Harrington, Constance A. 2010. Reconstructed old-growth forest stand structure and composition of two stands on the Olympic Peninsula, Washington state. Res. Pap. PNW-RP-583. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 22 p. http://www.fs.fed.us/pnw/pubs/pnw_rp583.pdf.

The Mt Hood NF uses a creative and highly flexible method to increase variability within treatments. In addition to the DxD, they sparingly use colored flagging to mark individual or a few trees with the intent that all trees within X feet of marked trees will be retained. They use different color of flagging to mark individual or a few trees with the intent to remove all trees within X feet of a marked tree. This allows specialists a flexible and scalable tool to create skips and gaps at various scales and it retains valuable structure within the gaps because the marked trees do not get cut.

Each substantive issue discussed in these comments should be (i) incorporated into the purpose and need for the project, (ii) used to develop NEPA alternatives that balance tradeoffs in different ways, (iii) carefully analyzed and documented as part of the effects analysis, and (iv) considered for mitigation.

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Sincerely,

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1. Continuous recruitment of snags is critical to development of old growth forest habitat. We urge the agency to adopt a process-based approach to snag habitat. Instead of focusing on how many snags there are now and immediately after logging, it is better to focus on (i) whether the project will retain an adequate pool of green trees from which to recruit snags and (ii) whether the project will retain the ecological processes that cause mortality, including density dependent mortality and other mechanisms. Commercial logging will significantly harm both of these snag recruitment factors, so mitigation measures are needed. Green tree retention, including generous unthinned [ldquo]skips[rdquo] where density dependent mortality will play out, is necessary to support this process. This is especially critical in previously logged uplands that are already short of snags and in riparian areas where recruitment of large wood is important to stream structure. It is often asserted that thinning grows big trees faster and therefore results in more rapid recruitment of large snags, but FVS and other tools show this NOT to be true. In fact, thinning both reduces and delays recruitment of snags, first by removing trees that would otherwise suffer suppression mortality, and second by increasing stand vigor and postponing overall mortality. See this online slideshow which shows the modeled effects of thinning on dead wood habitat. Heiken, D. 2010. Dead Wood Response to Thinning: Some Examples from Modeling Work. https://www.dropbox.com/s/m4671mhsstg61ss/dead_wood_slides_2.pdf?dl=0. The implications are that heavy thinning should be used sparingly and generous unthinned patches should be retained WITHIN thinned stands in order to continue the snag recruitment process and mitigate for captured mortality. To inform the decision, please conduct a stand simulation model to fully disclose the adverse effects of logging on dead wood, especially large snags >20[rdquo] dbh, and then mitigate for these adverse effects by identifying areas within treated stands and across the landscape that will remain permanently untreated so they can recruit adequate large snags and dead wood to meet DecAID 50-80% tolerance levels as soon as possible and over the long-term.

1.

Artificial snag creation is often proposed as mitigation for the loss of snags during logging, but snags fall down and dead wood decays, so a one-time snag creation effort provides very short-term benefits. Since logging has long-term adverse effects on snag recruitment, it is necessary to adopt mitigation with long-term effects, such as retaining generous untreated [ldquo]skips[rdquo] embedded within treatments areas where natural mortality processes can flourish.

2.

Recognize that dead wood values are sacrificed in thinned areas due to the effect of [ldquo]captured mortality,[rdquo] while other late successional values, such as rapid development of large trees and understory diversity may be delayed in unthinned areas, so an important step in the restoration process is to identify the most optimal mix of treated (thinned) and untreated (unthinned) areas. We think this should be a conscious and

well-documented part of the NEPA analysis, not just an accidental byproduct of what's economically thinnable. Tools like DecaID might be used to identify goals for large and small snags that need to be met over time and at the geographic scale of home-ranges of focal species. This can help identify the scale and distribution of untreated [Idquo]skips.[rdquo]

3.

Thin heavy enough to stimulate development of understory vegetation, but don't thin too heavy. Recognize that thinning captures mortality and that plantation stands are already lacking critical values from dead wood due to the unnatural stand history of all clearcut and planted stands. Tom Spies made some useful observations in the Northwest Forest Plan Monitoring Synthesis Report: [Idquo]Certainly, the growth of trees into larger diameter classes will increase as stand density declines (Tappeiner and others 1997). At some point, however, the effect of thinning on tree diameter growth levels off and, if thinning is too heavy, the density of large trees later in succession may be eventually be lower than what is observed in current old-growth stands. In some cases, opening the stand up too much can also create a dense layer of regeneration that could become a relatively homogeneous and dominating stratum in the stand. Furthermore, if residual densities are too low, the production of dead trees may be reduced (Garman and others 2003). Thinning should allow for future mortality in the canopy trees.[rdquo] <http://web.archive.org/web/20070808101639/http://www.reo.gov/monitoring/10yr-report/documents/synthesis-reports/index.html>.

4.

If using techniques such as whole-tree yarding or yarding with tops attached to control fuels, the agency should top a portion of the trees and leave the greens in the forest in order to retain nutrients on site. Achat, Deleuze, et al 2015. Quantifying consequences of removing harvesting residues on forest soils and tree growth [ndash] A meta-analysis. Forest Ecology and Management Volume 348, 15 July 2015, Pages 124[ndash]141. <http://www.sciencedirect.com/science/article/pii/S0378112715001814> ([Idquo]Our study showed that, compared with conventional stem-only harvest, removing the stem plus the harvesting residues generally increases nutrient outputs thereby leading to reduced amounts of total and available nutrients in soils and soil acidification, particularly when foliage is harvested along with the branches. [hellip] Soil fertility losses were shown to have consequences for the subsequent forest ecosystem: tree growth was reduced by 3-7% in the short or medium term (up to 33 years after harvest) in the most intensive harvests (e.g. when branches are exported with foliage). Combining all the results showed that, overall, whole-tree harvesting has negative impacts on soil properties and trees that may have an impact on the functioning of forest ecosystems.[rdquo])

1. Thinning creates activity fuels that can be treated (or not treated) in a variety of ways. Strive to treat fuels in ways that provide public benefits such as wildlife habitat (e.g., complex woody structure) and charcoal production (e.g., enhanced soil carbon storage), and reduce detrimental soil impacts from machine piling and hot burn piles. Deborah S. Page-Dumroese et al. 2017. Methods to Reduce Forest Residue Volume after Timber Harvesting and Produce Black Carbon. Scientifica. Volume 2017 (2017), Article ID 2745764, <https://doi.org/10.1155/2017/2745764>; <https://www.hindawi.com/journals/scientifica/2017/2745764/>

1.

Recognize and mitigate adverse effects of thinning on spotted owl prey such as flying squirrels, red tree voles, and chipmunks. Avoid impacts to raptor nests and enhance habitat for diverse prey species. Train marking crews and cutting crews to look up and avoid cutting trees with nests of any sort and retain trees with defects such as forks, broken tops, etc...

2.

Take proactive steps to avoid the spread of weeds. Use canopy cover to suppress weeds. Avoid soil disturbance and road construction. Scarifying landings and tempera roads and planting with native seeds is a good idea but please take steps to ensure that it is effective.

3.

Buffer streams from the effects of heavy equipment and loss of bank trees and trees that shade streams. Mitigate for the loss of LWD input by retaining extra snags and wood (and green trees for recruitment) in riparian areas. Recognize that thinning [ldquo]captures mortality[rdquo] and results in a long-term reduction in recruitment of functional down wood, and that effect is not mitigated by future growth.